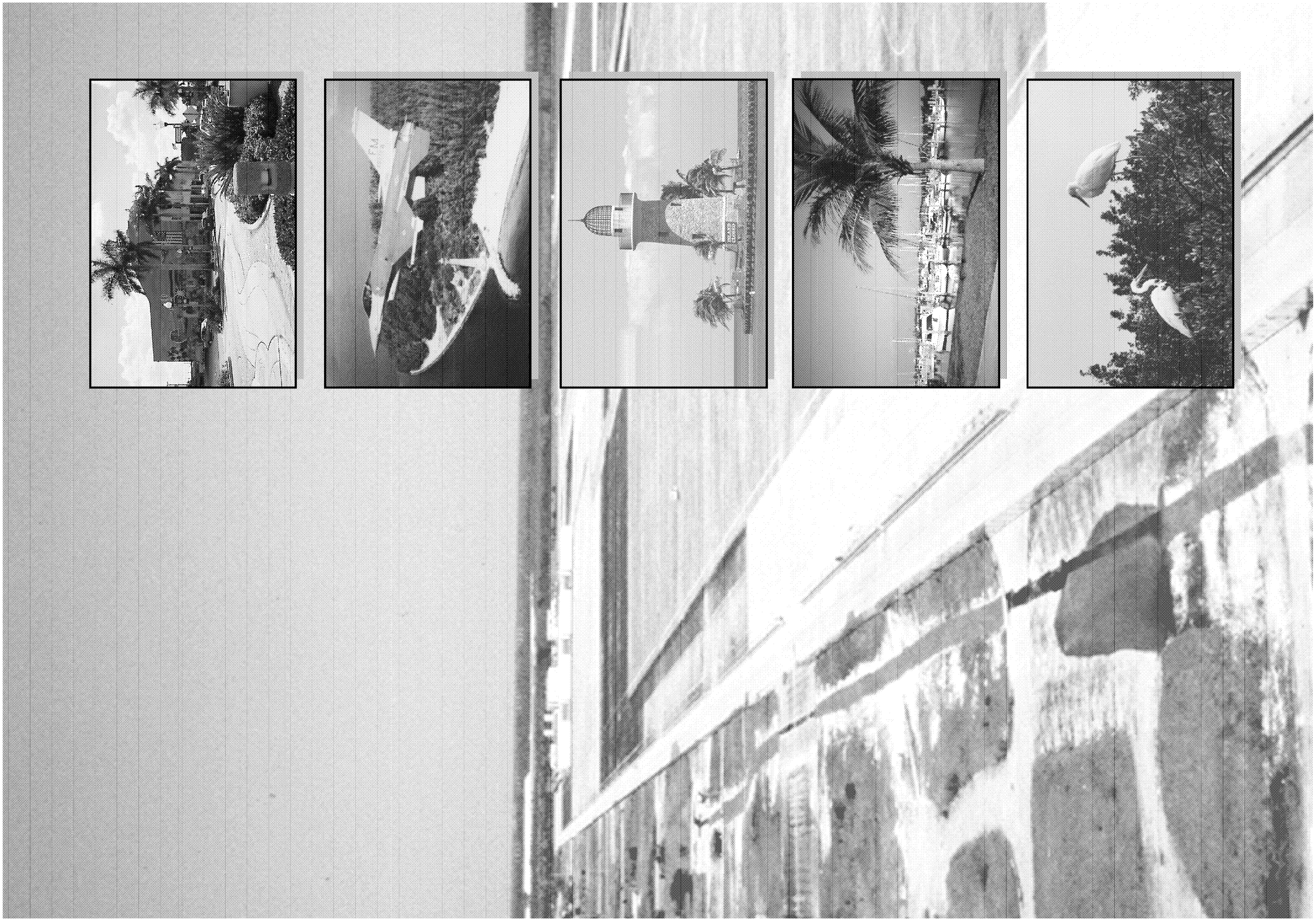
H WYLE RESEARCH REPORT



WYLE RESEARCH REPORT
WR 99-17
THE SOUNDSCAPE IN SOUTH FLORIDA NATIONAL PARKS

This appendix presents a technical report completed by Wyle Laboratories for the National Park Service in June 2000 entitled, "The Soundscape in South Florida National Parks" (Wyle Report 99-17), to assist NPS in resolving methodological issues associated with defining the natural soundscape in the national parks. It includes a re-analysis of the ambient noise data collection and assessment programs conducted by FAA/John A. Volpe National Transportation Systems Center in 1998 and by NPS/Sanchez Industrial Design in 1997 and 1998 and used in the SEIS. The report also analyzes data from Wyle's south Florida noise monitoring conducted in June 1999.

The Wyle report expresses confidence in the FAA and NPS measurement data and indicates other areas of agreement, for example, that nighttime sound levels tend to be higher than daytime due to nocturnal activity by insects, amphibians, reptiles, and birds. The report, however, suggests that the data could be interpreted differently to characterize the natural ambient. The report also bases its analyses on L_n statistical metrics—L_{90}, L_{50}, and L_{10}—and suggests that the L_{90} could be used to calculate the natural ambient.

Wyle's suggested approaches are a departure from the observer-based ambient noise methodology that has been used in other federal studies, including in national parks, and was used for the SEIS. The FAA believes that observer-based measurements, as used in the SEIS, provide high quality and accurate data. The FAA also believes that observer-based measurements that distinguish the natural ambient from other sounds are preferable to using generalized statistical procedures in data analysis. The FAA's review of the Wyle report is included in this appendix in a January 19, 2000, letter to NPS and an October 24, 2000, addendum to the January comments. The FAA does not agree with Wyle's methodology. Accordingly, the Wyle report has been included in the SEIS but has not served as a basis for the noise analysis.

FAA Review of the Final Report
"The Soundscape in South Florida National Parks"
prepared by Wyle Laboratories
for the National Park Service

October 24, 2000

This is an Addendum to FAA's review of the draft Wyle report. FAA's review was performed prior to completion of the Draft SEIS and FAA's detailed comments were submitted to NPS by letter dated January 19, 2000.

This addendum was prepared in response to the final Wyle Research Report (WR-99-17) submitted by the National Park Service (NPS) to the Federal Aviation Administration (FAA) on July 31, 2000. NPS's transmittal of the final report to FAA included a summary of changes between the final version and the draft document of August 1999 (Draft SEIS Appendix H). Changes noted by the NPS were: clarification of statements about acoustical zoning, two new tables on variance analysis for acoustical zones; placement of L90 time-of-day variations in summaries; and corrected tabular data. Other than these few changes, the final report is similar to the draft report.

In reviewing the final report, there are some important contextual issues that need to be revisited briefly. Several of these issues were discussed previously in the FAA January 19 letter of response to the NPS on the draft report.

<u>Focus of the Wyle Report</u>

The Wyle report addresses a small aspect of the SEIS noise analysis—natural ambient data, which are considered as supplemental data. It must be emphasized that the focus of the SEIS ambient noise methodology is on the traditional ambient sound level (all sounds except aircraft). The values for traditional ambient were the only ambient values used in the SEIS to calculate noise impacts. The Wyle report does not examine or question the collection or accuracy of traditional ambient sound data used in the SEIS analysis. Rather, it looks at the measurement and interpretation of natural ambient sound levels, which are of interest to the NPS for park natural soundscape planning. Data collected by FAA on natural ambient levels is included in the SEIS on a supplemental basis so that the public can compare traditional and natural ambient levels at different parks and sites. From such comparisons, one can see where human and mechanical activity causes the traditional ambient sound levels to be higher than the natural ambient. It also shows how traditional and natural ambient levels may be similar or even the same at places where natural sounds dominate.

In addition to the focus on natural ambient data, the Wyle report precipitates other needs for clarification. For instance, it is incorrect to describe the Wyle report as a "reanalysis" because it is a *new* analysis for the most part. The report makes extensive use of new monitored data collected by Wyle subsequent to the SEIS noise analysis. Using these data, Wyle undertakes a series of comparisons with newly created statistical methods that have received no outside or scientific review. FAA concerns about the new Wyle methodology are discussed in more depth in our January 19 response to the draft report.

<u>General Agreement of Data Despite Differences of Methodology</u>

It should be noted that the NPS and Wyle received all of the FAA ambient measurement data, but analyzed only a partial set of the data. This is not explained adequately in the report and is omitted from the Executive Summary. Specifically, the Wyle report looks at 15 of the FAA's 29 measurement sites. The FAA sites not analyzed are the open water sites and four land-based sites that experience higher exposure to non-natural sound sources. The rationale for their omission is not clearly stated in the report. Moreover, for 3 of the 15 FAA sites used, the Wyle analyzed only part of the acoustic data, specifically 68 percent of the data for Chekika (Everglades National Park), 62 percent for Hidden Lake (Everglades National Park), and 32 percent for Boca Chita (Biscayne National Park).

The combination of new monitoring data, new statistical methodology, and partial analysis of FAA measurements creates a complicated and confusing result in the report. The analysis is hampered by its effort to evaluate disjointed data sets that are difficult to compare accurately. Amid the volume of tabular and statistical data analyzed, it lacks a clear and reasonable basis for some of its comparisons.

Despite these limitations, the overall conclusion drawn from the report is that the various data for natural ambient are consistent. For example, FAA/Volpe Center and NPS/Sanchez Industrial Design (SID) noise measurements, conducted with similar methods, were in close agreement at many common sites. The shared use of observer-based methodology insured the complete absence of aircraft in traditional ambient sound levels—the focus of the SEIS noise analysis. A full comparison of Volpe Center and SID measured data is contained in Section 6.8.1 of the Volpe technical report, "Ambient Sound Levels at Four Department of Interior Conservation Units," June 1999. There is no basis for the sweeping conclusion in the NPS cover letter to the final Wyle report that sound pressure data in the Volpe Center technical report are incorrect. NPS evaluations and prior statements have supported the accuracy and reliability of basic FAA/Volpe measurements. Areas of difference noted by Wyle focus on greater weightings for the use of natural ambient data. The FAA continues to have confidence in all of the ambient data collected by Volpe and believes that alternative techniques proposed in the NPS/Wyle report should undergo further development, testing, and scientific review.

In spite of differences in approach, the NPS/Wyle report shows a good fit between the Wyle analysis and Volpe Center measurements (see Table 3.1 of the Wyle report). The comparison indicates a small average difference of 1.4 dB for the 15 FAA measurement sites analyzed by Wyle. An average difference would need to approach 5 dB to raise a concern about inconsistency. Even the standard deviation of 4.1 dB reported by Wyle was surprisingly small and indicated constancy and uniformity of the Volpe Center data.

Wyle's noise monitoring data also reinforces confidence in the reliability and accuracy of Volpe Center measurements. Wyle's L90, L50, and L10 statistical comparison of Volpe Center measured data and Wyle monitored data showed average differences of 2.2 dB, 3.4 dB, and 4.0 dB, respectively (see Table 4.7 of the Wyle report). Another indicator of reliability is found in overall averages for natural ambient. Wyle states that the average 24-hour L50 (the median statistical level) for its sound level data was 42 dB. Volpe Center's average Leq for natural ambient data was 42.4 dB.

In summation, there are many ways to dissect and compare the data. However, despite Wyle's exclusive focus on natural ambient data, there is general agreement and consistency between data in the many ways analyzed. The biggest differences reported involve Wyle's use of the statistical L90 (quietest 10 percent of the data) in comparison with Leq values obtained by Volpe Center. Further comments about the L90 descriptor are included below.

Acoustic Zone Characterization for Variance Analysis

The subject of ambient mapping procedures represented the main area of revision between the draft and final Wyle report. Wyle questions the basis for the use of acoustic zones and the process of ambient mapping. The ambient mapping methodology used in the SEIS noise analysis is described in detail in the Volpe technical report (June 1999). The Volpe report notes that: "Similar studies in the national parks have established an extremely strong correlation between land cover, wind speed, and ambient sound level." The report states that in a low-level ambient sound environment, such as national parks, the vast majority of the natural sound contribution to the ambient level results from wind blowing through the vegetation or creating stronger wave action in the aquatic environment.

The basis for ambient mapping by land cover in national park environments is supported by several recent studies. The most recent study is the Final Supplemental Environmental Assessment for the Grand Canyon National Park (GCNP, February 2000). For the noise analysis in this study, the NPS provided the FAA with variable A-weighted ambient sound level data based on three vegetative categories: pinyon/juniper woodland, desert scrub, and sparse conifer forest. The NPS supported this work using its own analysis tool, the Noise Overflight Decision Support System (NODSS), which categorizes ambient sound levels for the Grand Canyon based solely on vegetative cover and wind speed.

Another study cited in the Volpe report is the FAA July 1998 study "Development of Noise Dose/Visitor Response Relationships for the National Parks Overflights Rule: Bryce Canyon National Park Study." The field measurements in this study showed an excellent correlation between increased wind speeds and increased ambient levels. Further supporting research is noted in the quotation from the Wyle report on the following page (i.e., references to the work of Fleming, Sneddon, and Reddingius).

The methodology used in the SEIS for ambient mapping began with the selection of noise measurement sites by representative land cover and geographic coverage. Regional mapping for the national parks was performed by referencing the measured data with eight representative categories of land-cover data obtained from the Florida Game and Fresh Water Fish Commission (FGFWFC), unit boundary data from the NPS, and site observations with photographs. Due to higher reflectivity of water surfaces, no cross-over assignments were made between open water and land-based measurements.

It is impossible to accurately assess the Wyle variance analysis (i.e., ANOVA) because of the extent to which Wyle reassigned SEIS FGFWFC land-cover data for the analysis. Although Wyle claims that its reclassification of Volpe and SID land cover data was similar (see below quote from Wyle report), there is little similarity between the FGFWFC acoustic zone classifications used in the SEIS and the reassigned categories by Wyle, as shown in Table 1.

> "Since natural sounds are related to the type of nearby vegetation (Fleming et al., 1998, Sneddon et al., 1994 and Reddingius, 1994), the population of animals that are drawn to the vegetation, and the interaction of the wind with vegetation, the reanalyzed data from Volpe 1998 and SID 1997 were classified into acoustical zones similar to the grouping used by Volpe in its analysis as shown in their Table 10 (Fleming et al., 1999)."

Table 1 lists the eleven FAA/NPS measurement sites in Everglades National Park (ENP) evaluated by Wyle and draws a comparison between the Volpe FGFWFC and Wyle land-cover categories for these sites. Land-cover was an important factor in developing the ENP ambient map, more so than Biscayne National Park (BNP) or Crocodile Lake National Wildlife Refuge (CLNWR), because of the fact that ENP is so large geographically and supports a wide variety of vegetation and land-based surfaces that influence sound attenuation. Of the eight FGFWFC land-cover categories used by Volpe Center, seven were applied in the ENP ambient mapping (see Table 10, Mapping of Land-Cover Categories for ENP in the Volpe technical report, June 1999). For the ANOVA variance analysis, Wyle uses its own system of seven categories, of which six are applied to ENP sites (see Wyle report Table 3.3).

There is no clear rationale for imposing a different classification scheme for the ANOVA analysis, especially because the FGFWFC was considered to be the best source of land-cover data available in the south Florida region. The lack of consistency in the land-cover reclassification by Wyle raises concerns about the findings of the Wyle variance analysis.

Although Wyle's use of ANOVA may be appropriate given the structure of the acoustic zone data sets and may be technically accurate for the data used by Wyle, it is possible that the Wyle ANOVA results would be quite different if Wyle kept the FGFWFC classes or made a more consistent reclassification.

<u>Unmanned Monitoring Approach</u>

In contrast to the SEIS use of observer-based measurements, the Wyle report relies primarily on unmanned noise monitoring, which requires software and statistics to replace the human ear in estimating the noise content of the sound level data.

Table 1: Wyle Reassignments of Volpe FGFWFC Land-Cover Categories used in the Wyle ANOVA analysis

ENP measurement site	Volpe (V) or SID (S) site	Acoustic Hard (H) or Soft (S)	Volpe FGFWFC Land Cover Category For SEIS	Wyle Land Cover Reassignment for ANOVA
Eastern Sparrow	V	H	Freshwater Marsh and Wet Prairie	Prairie, Slough
Hidden Lake	V	H	Freshwater Marsh and Wet Prairie	Open Forest
North Nest Key	V & S	H	Freshwater Marsh and Wet Prairie	Open Shoreline
Pa-hay-okee	S	H	Freshwater Marsh and Wet Prairie	Open Forest
Eco Pond	V& S	H	Mangrove Swamp	Dense Forest
Nine Mile Pond	S	H	Mangrove Swamp	Open Forest
Pavilion Key	V	H	Open Water	Dense Forest
Shark Valley	V	H	Scrub Swamp	Prairie, Slough
Chekika	V	S	Hardwood Hammocks & Forests	Prairie, Slough
Anhinga Trail	V & S	S	Grasslands	Intruded
Pinelands/Long Pine Key	V & S	S	Pineland	Open Forest

It is difficult to track the use of the unmanned monitored data in the Wyle document because there is no clear summary or description of the statistical procedures and assumptions used in the analysis. For example, it is unclear how transient aircraft events were treated in calculating the various average sound levels. In addition, the report suggests in the Executive Summary that there is a 20 dB difference between the L90 ambient value of 33 dB and the Volpe Center Leq value. This implies a Leq of 53 dB, and yet the Volpe Center measurements for Leq averaged about 42–43 dB.

While a monitoring approach may be appropriate for approximations and relative comparisons of data for internal park management of noise, it is not a good stand-alone tool for noise impact analysis. Unmanned monitoring produces less accurate data than observer-based measurements and does not identify the sources of sound.

Noise Descriptors and Low-Level Impact Criteria

TA versus Leq–The correlation of the time above (TA) metric with important human responses such as annoyance is poor, especially at the lower levels of aircraft noise affecting regions analyzed outside of airport noise contours. Leq and changes in Leq have the best predictive value for annoyance that is available at this time.

L90 versus Leq–The Wyle report does not present an effective argument for the use of an L90 descriptor, rather than Leq, to characterize typical natural ambient noise levels. The FAA believes that Leq offers a more reliable average of existing sound conditions for more of the time. It is a better predictor of what a person is likely to hear during a visit to the park. The fact that the acoustic-based Leq accounts for higher noise events is actually a strength in the metric because it is the higher sound level events that drive human annoyance. This is why Leq is also a better predictor of human response to aircraft noise than TA.

L90, Audibility, and Annoyance–The Wyle report contends that the statistical L90 noise descriptor provides an improved threshold for characterizing the natural soundscape and for assessing noise events. The report attempts to make a case for the establishment of new impact assessment methodology based on unmanned noise monitoring and the L90 (minimum) sound level average. This case is not persuasive either technically or procedurally. Also notable, there are no criteria suggested for the characterization of the *impact* of excursions above any of the experimental threshold levels (L90 plus 10, 20, 30, and 40 dB).

The application of Time Above (TA) L90 with noise monitored data to approximate the time of audibility of sound is inappropriate. The statistically derived L90 could be *below* hearing audibility for appreciable periods of time. It is unscientific and unrealistic to establish a threshold level for sound intrusions that is so low that sounds cannot be heard by attentive listeners at times. It separates noise from hearing detection and ignores masking effects of ambient sound. Furthermore, the audibility of sound does not equate to adverse effect. People and animals are physically capable of hearing sounds that are not loud enough to produce an adverse reaction (commonly referred to as "annoyance" on the part of people). The application of Wyle's methodology would classify various man-made sounds (including, but not limited to, aircraft noise) as an impact on the natural soundscape without relating those sounds to any negative consequences based on human or wildlife reactions to noise.

U.S. Department
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**Federal Aviation
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JAN 19 2000

William B. Schmidt, Special Assistant
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1849 C Street, NW.
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Dear Bill:

Thank you for the opportunity to review and comment on the draft report prepared by Wyle Laboratories entitled "The Soundscape in South Florida National Parks". Our understanding is that the purpose of this report is to assist the National Park Service (NPS) in defining the "natural soundscape," which is further defined in your November 2 letter as "the conditions that do or would exist in national parks in the absence of human-caused noise". The report includes a review of data from earlier studies in south Florida parks and questions whether some of the methodology and assumptions in these earlier studies should be used to obtain the most accurate assessment of the natural soundscape.

The Federal Aviation Administration (FAA) has reviewed this draft report from two perspectives. One perspective is to offer our comments on the suggested new methodological approach to defining the natural soundscape in all national parks, which is a distinct departure from current NPS methodology. The second more immediate perspective has been to review Wyle's re-analysis of previous south Florida data and additional Wyle data based on monitoring in south Florida to consider the implications for all of the previous work done by FAA and NPS in that area, including the data used in the Homestead Draft Supplemental Environmental Impact Statement (Draft SEIS). The FAA has been assisted in our review of the Wyle report by the John A. Volpe National Transportation Systems Center (Volpe) that has done a great deal of work in the area of sound measurements in national parks, including the south Florida parks.

As you know, the Homestead SEIS uses traditional ambient noise measurements (i.e., all sounds except aircraft) together with computer-modeled aircraft noise to describe the existing noise environment in the south Florida national parks. Our purpose, under the National Environmental Policy Act (NEPA), is to describe a baseline affected environment—including all components that contribute to current noise levels—in order to evaluate how potential alternative reuses of Homestead would change noise within the affected environment. We continue to believe that the natural ambient alone does not fully describe the affected noise environment in the parks, particularly in Biscayne National Park which is influenced by boating noise, current aircraft noise from Homestead and Miami International Airports, and other visitor noises. We do not consider it reasonable at this point to base a NEPA analysis on a baseline natural ambient noise level under the assumption, put forward in your July 21 letter, that all non-natural noise sources—visitor noise, park operation noise, concessionaire noise, and aircraft noise—could be eliminated over time.

We recognize that the NPS has a quite different purpose in preparing national park soundscape plans, which leads you to focus on the natural ambient (i.e., the sounds of nature absent human and mechanical sounds) and has caused you to engage in a review of natural ambient data that was collected, along with traditional ambient data, in south Florida studies that contributed to the Homestead analysis. We were pleased to hear at the September interagency meeting on Homestead that the NPS has confidence in the accuracy of FAA measurement data used in the Homestead analysis, based on Wyle's work, and that NPS concerns essentially rest with the interpretation of the data for natural ambient.

Wyle's Reanalysis of South Florida Ambient Noise Measurement Data

To describe ambient noise conditions in south Florida, the FAA and NPS with the support of expert acoustic consultants undertook a major noise measurement program that encompassed 37 sites in four national parks and refuges. While the Homestead SEIS noise analysis is based on the traditional ambient measurements, it also presents three other categories of ambient measurements for comparison and information (SEIS Table 3.5-1). These categories are existing ambient (all sounds including aircraft), natural ambient (e.g., wind, waves, wildlife, insects), and natural plus visitor self-noise (e.g., voices and footsteps of visitors).

Ambient data was collected and analyzed using FAA guidelines for measuring and assessing low-level ambient noise. These guidelines set forth equipment specifications, data collection procedures, and analysis methods. The procedures outlined in the guidelines have undergone years of interagency and technical scrutiny. They evolved from NPS noise measurement programs at Grand Canyon and Hawaii National Parks in 1992, from Rocky Mountain National Park planning efforts in 1997, and from FAA dose-response studies at Bryce Canyon and Grand Canyon National Parks in 1997 and 1998. The guidelines insure improved quality and consistency of data sets collected by different organizations. Such consistency made it possible to combine FAA and NPS noise measurement data for use in the Homestead SEIS.

The Wyle report reanalyzes the ambient noise data that was collected by the Volpe National Transportation Systems Center in 1998 for FAA and by Sanchez Industrial Design (SID) in 1997 and 1998 for NPS. The original analysis of the data is presented in the technical report, *Ambient Sound Levels at Four Department of Interior Conservation Units: In Support of Homestead Air Base Reuse Supplemental Environmental Impact Statement* (June 1999).

The Wyle report adds confidence to the accuracy of FAA/Volpe and NPS/SID ambient measurement data, which Wyle tested independently. Wyle, however, suggests that the data could be interpreted differently to characterize the natural ambient. Wyle's draft report includes a statistical, computer-assisted method for increasing the amount of time and data classified as natural ambient. Using this method, acoustic data of less than 3 decibels over calculated average background levels are considered to be part of the natural ambient. The result is that the natural ambient is considered to occur for longer periods of time because man-made noises, including aircraft, continue to be counted as natural so long as they are less than 3 decibels over average background sound levels.

Wyle's natural ambient calculations contain aircraft noise and other man-made sounds. This appears to FAA to be inconsistent with the NPS definition of the natural soundscape, i.e., the natural condition that would exist in the absence of human caused noise. It is not the way that NPS work to date has distinguished aircraft sounds from natural sounds, and it is not clear to us that NPS would prefer such an approach. In addition to "contaminating" natural ambient data with man-made noises, it is somewhat arbitrary to take acoustic data of less than 3 decibels over computed average background levels and assign it to natural sound. In any case, Wyle's reanalysis of the Volpe south Florida measurement data using this approach shows an overall difference of only 1.4 decibels in ambient noise level for all of the measurement sites and sessions analyzed. This essentially shows close agreement between the results of both methods.

Noise Monitoring Versus Noise Measurement

In addition to the reanalysis, the Wyle report presents findings of its noise monitoring program conducted in south Florida in June 1999. While more data is always better, the report does not always distinguish clearly between the different data sets and how they contributed to the report's conclusions.

Wyle discusses the observer-based noise methodology that was used by both FAA/Volpe and NPS/SID for the south Florida noise measurement program. The observer-based techniques applied to this effort originated with NPS. For years, Federal agencies, including FAA, NPS, and the U.S. Air Force, have agreed that noise measurements with trained observers produce higher quality and more accurate data than unmanned noise monitoring. Trained acoustic observers can certify the presence of intruding sounds, the source of the sounds (such as aircraft), and how long the sounds last. The capacity of the human ear to identify and distinguish aircraft sounds, especially in low-level sound environments such as national parks, is better than unmanned noise monitors and statistical applications. This was reaffirmed in a recent noise validation field test at Grand Canyon National Park. An advisory committee of acoustic scientists and technicians enlisted by NPS and FAA at Grand Canyon recommended observer-based measurements rather than noise monitoring.

This is not to suggest that unmanned noise monitoring is inappropriate or not useful in certain circumstances if measurements cannot be done. Indeed, noise monitoring is less expensive than measurements and can be used for longer periods of time. However, the quality of data obtained from noise monitoring is less than that obtained from trained observer-based measurements and should not be regarded as a preferred, or even equivalent, substitute methodology.

In looking specifically at the category of natural ambient, the FAA's reasons for performing and preferring an observer-based methodology—where it is reasonable to do so—remains data quality.

This methodology guarantees that natural ambient data are uncontaminated and free of non-natural sounds. It also avoids distortions inherent in Wyle's suggested generalized statistical procedures for separating and defining noise events after-the-fact.

Metrics

With regard to metrics, Wyle provides analysis on L_n statistical metrics (L_{90}, L_{50}, and L_{10}) and uses the noise-monitored data to compare L_n levels with acoustic-based Leq levels. The Leq metric, which FAA used in the south Florida parks analysis, is the equivalent or average sound level incorporating all noise events, their duration, and the magnitude of sound. In a steady state sound environment, Leq and L_n levels tend to converge, particularly the Leq and L_{50}. Louder impulsive sounds, natural or otherwise, influence the acoustic-based Leq.

We believe that the Leq metric is an appropriate descriptor for several reasons. Research has shown that response to aircraft noise is related to loudness and frequency of noise events (Federal Interagency Committee on Aircraft Noise report, 1992). As stated, Leq is sensitive to loudness. In addition, the widely used Leq offers greater comparability with other studies. Conversely, analyzing noise monitored data with a simple statistical L_n metric is inadequate for quantifying specific components of the sound environment—an important element of noise analysis.

In situations where it is not practical to employ other than a simple statistical metric in conjunction with remote noise monitoring, L_{50} appears to be more appropriate than L_{90}. The L_{90} should not be used generally because it represents the quietest ten percent of the data and, as such, is a minimum level that does not reflect average natural sound levels in a park setting. L_{90} has not been used to evaluate ambient noise in the Grand Canyon for this reason. L_{50} provides a more representative statistical calculation of the natural ambient than L_{90}.

Wyle reports an average 24-hour natural sound level for south Florida national parks of 42 decibels, with a standard deviation of 4 decibels, based on an L_{50}. The average natural ambient levels reported in the SEIS, using the Leq metric, are similar. SEIS average natural ambient sound levels are approximately 43 decibels in Everglades National Park and 45 decibels in Biscayne National Park. These results show close broad agreement between Wyle and Volpe average natural ambient values, particularly when considering differences in methodology and in sites selected for data collection. It is only when Wyle applies the L_{90} to its monitored data—resulting in a minimum value, rather than median or average value—does it appear that the natural ambient would be lower than measured in previous studies. We do not believe that additional on-site measurements would verify that natural ambient levels in the south Florida parks are as low as statistically calculated using L_{90}.

Other Comments

Wyle indicates other specific areas of agreement with FAA/Volpe and NPS/SID data, for example, that nighttime sound levels in the south Florida national parks tend to be higher than daytime levels due to nocturnal activity by insects, amphibians, reptiles, and birds.

Attached are additional detailed comments on the draft Wyle report prepared with the assistance of acoustic experts at Volpe, plus further comments on the July 21, 1999 NPS letter. Among the comments is information on the consistency between the Volpe and SID measured data. The comments also note the agreements by our agencies on the benefits of observer-based data, the use of similar acoustic-state identification hierarchies (aircraft, non-aircraft, human, natural), and the selection of measurement sites. The selection of measurement sites in south Florida included many natural resource and wildlife locations recommended by the NPS. Site selection criteria also included representative land cover, geographic coverage, and access. For water sites, Volpe followed NPS advice for conducting boat-based measurements, with NPS supplying the boats and pilots. The comments confirm that the sound of wave action against boats was not classified as natural ambient.

Summary Conclusion

In summary, there was reasonable agreement in many major respects between Wyle's results and the previous studies. However, the FAA does not regard the methodology in the draft Wyle report as an approach that will result in a more accurate assessment of the natural soundscape than the approach that has been used to date.

We are cognizant that the NPS has a substantial task before it to characterize the natural soundscapes for many national parks, and that less expensive and resource-intensive tools may be needed to accomplish this entire task. Noise monitoring can be an appropriate alternative methodology, if used with representative measurements and adjusted for local conditions. If a L_n metric is used for statistical interpretation of monitored data, the L_{50} offers a more reasonable approximation of natural ambient sound levels than the L_{90}. There should be a level of confidence that statistical calculations of natural ambient can be verified by actual on-site measurements.

Various points in the Wyle report deserve further review and discussion among the agencies and members of the acoustic community engaged in national park noise. The NPS may find it useful to request a scientific peer review of the report. It is important to have a scientifically valid, consistent, and broadly-accepted methodology for assessing noise in national parks.

Sincerely,

Lynne Sparks Pickard

Lynne Sparks Pickard
Manager, Community and
Environmental Needs Division, APP-600

cc: Mr. Nat Wood, NPS
Mr. Doug Heady, USAF

Attachment

Additional Detailed Technical Comments

Acoustic State Logging

For measurements of the scope of those undertaken in southern Florida, the need for accurate, repeatable acoustic state identification is crucial. Section 2.0 of the Wyle Report makes reference to a "difference in collection schemes" between the FAA/Volpe and NPS/SID data sets. We cannot account for Wyle's view that the two data collection schemes were different. We believe they were, in fact, entirely consistent.

FAA/Volpe have emphasized the use of consistent measurement protocols in the development of the "Draft Guidelines for the Measurement and Assessment of Low-Level Ambient Noise" (Guidelines Document). Both the FAA/Volpe and NPS/SID measurement teams used the acoustic state hierarchy outlined in the Guidelines Document to consistently log the acoustic environment. In the "Purpose of Study" section of the NPS Technical Report, it is stated "the contractor followed the draft FAA/NPS protocol..." This is further supported by subsequent discussions between FAA/Volpe and NPS/SID. During the July 1998 scoping meetings with NPS that took place prior to the FAA/Volpe measurements, the measurement team emphasized the necessity for consistency. NPS subsequently reviewed the FAA/Volpe test plan and considered the plan reasonable, feasible and consistent with their previous work.

The FAA/Volpe team utilized an automated, macro-driven spreadsheet on a laptop computer to implement an acoustic-state hierarchy approach, while the NPS/SID team utilized the button-box assembly, which is a component of the LOWNOMS system. Section 3.3.1 of the Wyle Report purports to attribute differences in the two data sets to a time delay associated with the use of Volpe's spreadsheet. However, as with the LOWNOMS button-box system, only a single button is required to accurately establish the time of an acoustic state change, and as such, there is *no lag* in time associated with the FAA/Volpe hardware/software system. There may be a small and probably negligible time lag associated with a delay in *human response*, but this is inherent in both the FAA/Volpe and NPS/SID systems. Further, the FAA/Volpe spreadsheet version allows the user to view a brief history of the acoustic states in real-time and to correct any mistakes that may have been made while still fresh in the observer's mind. LOWNOMS does not offer this capability. Also, as is documented in the "Ambient Sound Levels at Four Department of Interior Conservation Units" report (Florida Ambient report), the differences between the FAA/Volpe and NPS/SID data sets are small and explainable. Section 6.8.1 of the Florida Ambient report highlights some of these reasons, including temporal and seasonal variations, and difference in sound level due to changes in insect activity.

A potential inconsistency between the FAA/Volpe and NPS/SID measurements is cited in Section 3.3 of Wyle's report. Here Wyle states that SID "judged [which acoustic state was] loudest at the time," rather than utilizing the audibility hierarchy outlined in the Guidelines Document. This conflicts with the LOWNOMS User's Manual, which instructs the user to "[listen] and [push] the appropriate intruding or background button when a sound is heard." Additionally, the NPS/SID Technical Report actually highlights an instance (propeller aircraft at EVER1 at 13:24) where the rise of the A-weighted sound level starts approximately 30 seconds after the acoustic state was identified by the trained acoustic observer as Propeller Aircraft. This indicates consistency with the FAA/Volpe hierarchy-based logging approach, and further is consistent with all similar NPS measurement studies over the last decade. Further discussions among FAA/Volpe, NPS/SID, and Wyle could help to clarify data collection practices.

Boat-Based Measurements

In section 4.5.5, Wyle makes reference to the inappropriateness of boat-based measurements for locations on the water. Boat-based data were collected during both the FAA/Volpe and NPS/SID measurement programs. By measuring from a boat, it is understood that the measurement team can introduce sounds into the environment (i.e., the sound of waves slapping against the hull of the boat). Generally it is advisable for the field-measurement team not to affect the acoustic environment, thus arguing against the use of a boat for water-based measurements. However, after expressing concern about this very issue to the NPS during the scoping meetings, including suggesting alternative approaches to performing water-based measurements, the NPS insisted, for the sake of consistency with previously collected NPS data, that all water-based measurements be conducted on boats. As such, the FAA/Volpe team reluctantly agreed.

The Wyle Report continues on to ascertain that "the natural sound levels were distorted because of wave slaps against the hull of the boat." Section 3.4 of the Florida Ambient document clearly outlines the fact that sounds generated by boats and the sound of waves against the hull of a boat were classified as "Non-Aircraft - Human", *not* "Natural", thus introducing no distortion into the FAA/Volpe natural data. In other words, the natural ambient sound levels reported in the Florida Ambient document do not include the sounds of waves slapping against the boat. They are truly representative of the sounds of nature.

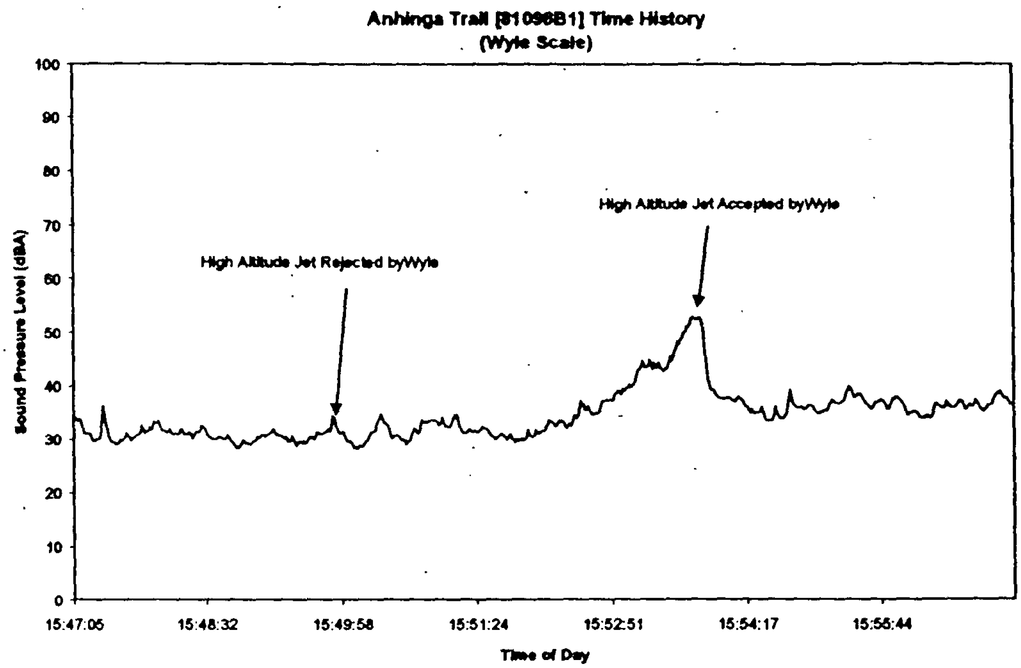
Natural Ambient

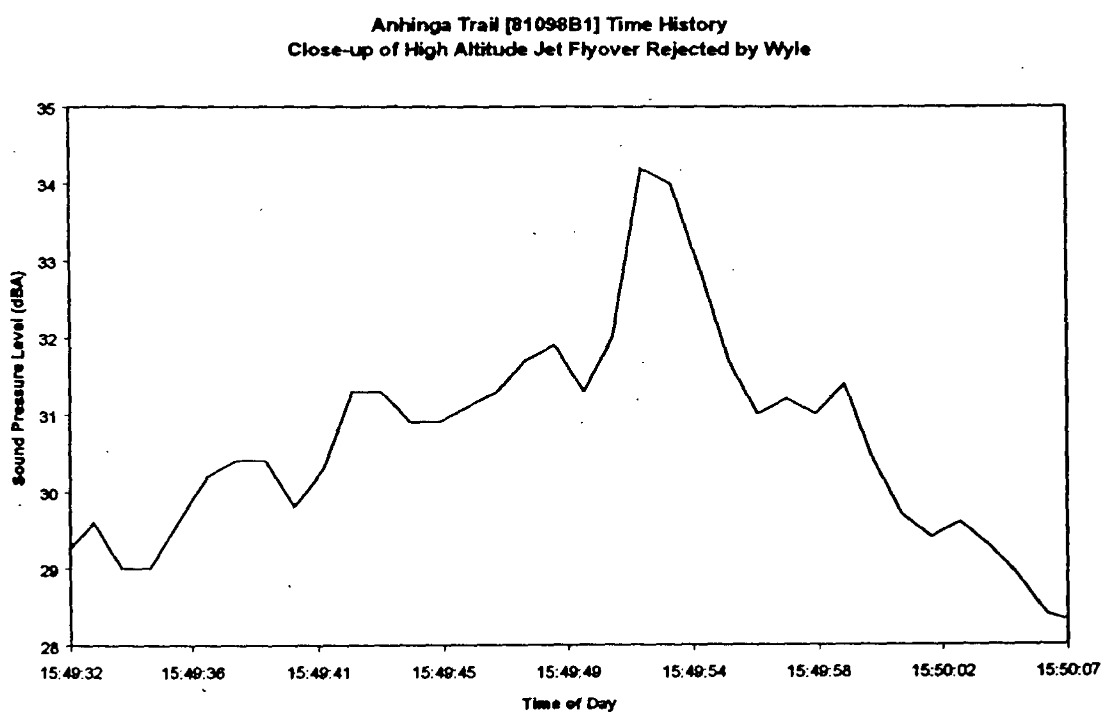
Section 3.1 of the Wyle Report documents what it terms a "misidentification" on the part of the FAA/Volpe data by stating "the lowest levels ascribed to non-natural sounds were often lower than the lowest levels ascribed to natural sounds. This cannot be the case..." As documented in the Florida Ambient report, we found the sounds of nature to be greater than man-made sounds at times at several sites. In particular, changes in the natural ambient sound levels by as much as several decibels due to changes in insect activity were not uncommon. This is further corroborated by the NPS/SID data for EVER1 (Broad River Campground- 10/3/97). These data illustrate that the natural ambient (insects and birds) can in fact be some 15 dBA greater than all intruding sound levels measured at that site, including low level noise from distant commercial jets and propeller aircraft. In effect, even though aircraft may be present, their noise can be acoustically "masked" by the sounds of nature.

Section 1.0 of the Wyle Report refers to "the bias [associated with] using the L_{eq} of the totality of sounds as a descriptor of the natural soundscape..." in the FAA/Volpe analysis. The Florida Ambient report rather utilizes the L_{Aeq} of only the sounds of nature, as observed in real-time by trained acousticians, to describe what the NPS refers to as the natural soundscape. Declaring that a "totality of sounds" was used illustrates a clear misunderstanding of that document and the four ambient definitions presented in Section 5.1 of the Guidelines Document.

Wyle Re-Analysis Methodology

Wyle's re-analysis of Florida ambient data, outlined in section 3.2 of the Wyle Report, distorts the meticulously collected data sets. As illustrated in the figures below, the Wyle procedure uses an exaggerated y-axis scale that washes out detailed sound level information collected during the measurements. Using this exaggerated scale, Wyle incorrectly classified audible aircraft sounds (identified in the field by trained acoustic observers) as natural ambient. Effectively, this attributes sound energy *generated by aircraft* and other non-natural sources to natural ambient or natural quiet. The following figures illustrate our concerns with the Wyle re-analysis methodology.[1]





[1] The precise criteria for determining the surrounding ambient sound levels is not identified in the Wyle Report. As such, some assumptions were made in this discussion of their re-analysis.

The sound level time-history of the example jet reassigned as natural ambient in the Wyle re-analysis is considered to be typical of high altitude jets in an environment such as southern Florida. It is obvious from the close-up of the time-history that there is a substantial amount of aircraft sound energy associated with this event. Although in the purest sense it would not be a completely uncontaminated event, the aircraft energy rises above the surrounding natural ambient by some 5 to 6 dB. It is inappropriate to relegate this energy to data associated with the natural soundscape of the park.

The need for consistently measured and analyzed ambient sound level data throughout the national parks and other low-level sound environments cannot be stressed enough. Otherwise, the FAA and NPS will continue to collect disjointed data sets that are difficult to accurately compare and contrast.

Keeping in mind the need for the collection of consistent ambient data throughout the parks, it is interesting to note some issues with the Wyle re-analysis, as it relates to aircraft audibility. The NPS has promoted the use of audibility metrics for the analyses done for Grand Canyon National Park (GCNP). To further illustrate the potential gross anomalies which can result from an analysis of this type, a subset of ambient sound level data from the recently completed GCNP measurement study was re-analyzed. Specifically, data collected during the joint FAA/NPS Model Validation Project at the Grape Vine site (9/10/99) were subjected to our interpretation of the Wyle re-analysis criteria. The results are summarized in the following table:

Hour	Measured Time Audible (%)	*Re-Analysis* Time Audible (%)	*Difference*
0900	61	12	*49*
1000	44	2	*42*
1100	39	4	*35*

The data suggest that measured time audible of the range 39% to 61% would be reduced to between 2% and 12% for the three hours of data analyzed. Given the example data and the "error" associated with the Wyle re-analysis technique, GCNP would likely already have achieved the NPS goal of 50% of the park having natural quiet at least 75% of the time. As you know, there are considerable research funds from both FAA and NPS dedicated to achieving this goal.

<u>Measurement Site Selection</u>

As you are aware, every effort was made during the FAA/Volpe measurements to ensure that data collection and analysis methods would result in the most accurate and representative ambient sound levels being reported. As such, several measurement locations were chosen at the request of NPS, directly related to resource/wildlife protection. This is contradictory to the assertion in Wyle's "Reanalysis Results" section which states "...measurements were carried out primarily in areas where there was human activity..." Further evidence of the conservative nature of the results are the facts that measurements were made during the general time of year: (1) of least visitation to the area; and (2) of lowest winds. Both visitation and wind are likely to result in an increase in ambient sound levels during other times of the year.

Use of Statistical Noise Descriptors

The Wyle Report suggests the use of one or more of the L_n family of noise descriptors for describing the natural soundscape. It is important to recall the various issues related to use of L_n descriptors. First, the use of these descriptors generally means the use of unmanned acoustic monitors, which produces lower quality data than manned measurements. Second, when trying to quantify a specific component to the acoustic environment, e.g., the natural ambient, the use of statistical measures presents many limitations. For example, in a park environment where aircraft and other intruding sounds are often audible, use of statistical measures will result in the inclusion of aircraft sound in the statistical measures describing the natural ambient soundscape. Third, the use of the L90 descriptor, which represents the quietest 10 percent of data, is a minimum level that does not include the full range of natural sounds.

As part of the model validation effort at Grand Canyon National Park, a Technical Review Committee (TRC), hand-picked and agreed upon by the FAA and NPS for their expertise in transportation-related acoustics, was assembled. During an August 1999 pre-measurement meeting, the TRC intimated that an L_{eq} is preferable to a statistical measure in describing ambient sound levels. Further, it was the TRC's opinion that if an L_n were to be used, an L_{50} would be preferable to an L_{90} for approximating ambient sound levels. The use of the L_{90} descriptor is also not supported by the NPS' own acoustic consultant, whose stated reasoning is that L_{90}, by definition, only includes a small percentage of the original data set.

Other Observations

The Wyle Report suggests further noise monitoring is needed in order to best describe the southern Florida soundscape. The objectives highlighted would be to: (1) increase coverage area; (2) investigate seasonal variations; (3) investigate seasonal effects on diurnal patterns; (4) investigate seasonal effects on visitation; and (5) develop a transient event database. It is agreed that more data is always better in defining an ambient environment. The FAA/Volpe measurements did, however, cover the vast majority of areas of interest. Data is lacking on seasonal effects for both the natural ambient and visitation, but evidence points to the fact that the current data is conservative with respect to those effects (i.e., their effect would likely be to raise ambient sound levels). Further, the un-manned monitoring data collected for NPS suggests that although human-related activity (and associated sound levels) may typically decrease during nighttime hours, insect activity and other "natural" phenomena actually seem to at least partly compensate for this change.

As is illustrated by many of the issues raised herein, there exists a significant and pressing need for standardization of ambient sound level measurement and analysis. A significant step has already been taken by FAA/Volpe in the preparation of the draft Guidelines Document. Its methodologies and procedures have been tested several times by the FAA, NPS and the US Army. It is now hoped that the NPS and other federal (and international) agencies will collaborate in an effort to finalize a protocol for the collection and analysis of ambient sound level data that reflects the current technical knowledge base.

Integrated Noise Model

Another subject of the July 21, 1999 NPS letter was the Integrated Noise Model (INM). FAA modeling enhancements for the SEIS were based on INM Version 5.2. Virtually all of these enhancements, as with earlier INM enhancements for Grand Canyon analysis, were incorporated into public version INM 6.0. While INM noise calculations remain primarily A-weighted, INM noise computations will increasingly use the model's new aircraft spectral database. This database will support growing capabilities for advanced acoustic effects such as terrain shielding, meteorology, and new excess attenuation algorithms, currently under formal review by the Society of Automotive Engineers (SAE) Aviation Noise Committee.

With respect to INM validation, the INM has been the FAA's standard methodology for predicting and assessing noise impacts for over two decades. Over 700 government and private organizations throughout the United States and 40 foreign countries use INM. The FAA used the model for this analysis because of its: 1) widespread scientific acceptance; 2) conformance with industry and international standards; 3) measurement-derived noise and performance data; 4) large civil and military aircraft data base; and 5) adaptability and reliability for assessing a variety of situations, including southern Florida's high percentage of acoustically hard and mixed surfaces.

Formal INM validation involved three major airports and more than 50,000 aircraft flight events over a six-month period. It consisted of extensive field measurement programs correlated with actual aircraft position and performance data. For Homestead and surrounding park environments, we believe that INM provides very accurate estimates of noise impact. Reasonableness checks indicate that the modeled results for south Florida correlate well with the noise measurements taken by the FAA. More information will be available soon from two independent test efforts--the INM validation program with the NPS at Grand Canyon NP and an INM field measurement program with the National Aeronautics and Space Administration (NASA) at Boston Logan Airport.

Audibility

Finally, on the complex issue of audibility, the use of this concept for noise assessment has major limitations in both theory and practice. These limitations include historical roots not in psychoacoustics, but in physical detection of enemy assets. Audibility is an extreme measure of minimum change in the sound environment and assumes that the average person is actively listening for aircraft. As a frequency-based measure, audibility is extremely sensitive to weather and atmospherics, aircraft type, flight procedures, and terrain. It is costly and difficult to implement because it depends on proprietary aircraft manufacturer data, local measurements, and additional analysis. Understanding the audibility metric, d', is difficult by acousticians, let alone government representatives and the public. And most importantly perhaps, audibility has no established relationship with human response. In short, further research on audibility is needed.

United States Department of the Interior

NATIONAL PARK SERVICE
1849 C Street, N.W.
Washington, D.C. 20240

IN REPLY REFER TO:

July 12, 2000

Robin Brandin
SAIC
2109 Air Park Rd.,
Albuquerque, NM 87106

Dear Ms. Brandin,

I am writing to transmit the final version of the report by Wyle Laboratories entitled “The Soundscape in South Florida National Parks” for inclusion in the homestead Supplemental Environmental Impact Statement. Because this letter provides a link between the draft Wyle report that was part of the draft SEIS and because of the additional explanations provided below, we would like it included with the attached Wyle report in the final version of the SF15.

The more significant changes, i.e., other than typographical errors and rewording to clarify points in the draft, are as follows:

Acoustical Zoning: Statements about the independence of sound levels to acoustical zones have been modified. Instead of stating a certain independence exist, the report now states that no evidence of dependence between sound levels and acoustical zones was found in the data. The rewording appears in Sections 3.3,4. 4.5.4, and 5.1.

Additional Tables:
Two tables were added to Section 4 to demonstrate the ANOVA (analysis of variance) for time of day’ and acoustical zones for unmanned measurements. Table 4.5. ANOVA for L90 versus time of day shows that the different periods are statistically different. Table 4.6 ANOVA for L90 versus Acoustical Zones shows that no dependence was observed.

Corrected Tables:
Table 4.2: Acoustical Zone Labels were corrected.
Table 4.4b: Average Leq numbers have been corrected. The numbers in the draft for this table were wrong.

Section 4.4.1: Sound level values for B3 (Hiking North of Elliott Key) and B4 (Hiking Trail South of Elliott Key) have been corrected.

Values for the time of day variations in L90 are included in the summaries.

In addition, some points were raised by reviewers that warrant comment but do not neatly fit within the framework of the report itself. We would like to deal with the more relevant of these here.

A basic question is why does the interpretation of the same data differ so much between the report "Ambient Sound Levels at Four Department of Interior Conservation Units" (Volpe report) funded by the FAA and this report by Wyle labs funded by The National Park Service. The answer is that the Volpe report inexplicably misinterprets the data by mixing audibility and sound pressure level information. It appears that the root of the problem is the rigid adherence by the Volpe observers to the hierarchy of sounds as described on page 47 of their report. As a consequence. the observers continued to record the presence of mechanical noise well below the ambient sound levels. Had the report merely presented the time a source, e.g., an aircraft, was audible, there would have been no problem. Unfortunately the authors went beyond that and assigned the sound pressure level for that entire time period to that event, even though an examination of their energy logs clearly shows that other sources were actually controlling the sound pressure level during a portion (or even all) of that period of time. As a consequence the NPS is confident that. all of the sound pressure data presented on pages 61 through 72 of the Volpe report are incorrect and, to the extent that those data are incorporated in the SEIS and related analyses. those elements are also incorrect.

Another question raised was why the NPS didn't use the audibility approach used for the ongoing studies of "restoration of natural quiet" at Grand Canyon National Park for the South Florida study. The answer lies in the definition of "restoration of natural quiet," a term specific to Grand Canyon. In that ease the issue of restoration specifically turns on the percentage of time that aircraft are audible. The issue for the NPS in South Florida is the restoration and preservation of the natural soundscape.

Another issue raised was why the NPS report asserted that the methodological differences between the data collected by Sanchez Industrial Design (SID) using the LOWNOMS system and that collected by Volpe using the VOLARE system accounted for the reanalysis difference between the two systems when both used the same "hierarchy of sounds" approach. The answer is that LOWNOMS and VOLARE do not use the same approach. As indicated above, the VOLARE approach required strict adherence to the aircraft/non-aircraft human/natural hierarchy regardless of the level of other competing sounds. The LOWNOMS approach requires the observer to log the dominant sound source.

The final question we would like to deal with is that of Leq versus an exceedance metric such as L_{90}. As commenters noted, the Leq corresponds very well with loudness and is frequently used in near-airport locations. The answer is that the NPS concern is with the protection of the natural soundscape — quietness rather than loudness.

Thank you.

cc: Lynne Pickard, FAA
Doug Heady. Air Force

Sincerely,

William B. Schmidt
Special Assistant to the Associate Director,
Natural Resource Stewardship and Science

WYLE RESEARCH REPORT

WR 99 – 17

The Soundscape In South Florida National Parks

Prepared For:

U. S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
1849 C STREET, NW
WASHINGTON, DC 20240

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Acknowledgments

The authors would like to acknowledge the staffs at Biscayne and Everglades National Parks for their assistance in the field measurements. We give special appreciation to Patrick Lynch, Janice Lynch, and Karyn Ferro for successfully coordinating the logistics of the field study. We also acknowledge input and advice of Gonzo Sanchez, Dr. William Bowlby, and Dr. Jim Foch. And, lastly, we appreciate the assistance and support of William Schmidt for his role as project manager for the National Park Service.

1 EXECUTIVE SUMMARY

The National Park Service (NPS) has been concerned about noise intruding on the natural soundscape within its parks for a long time. They have actively engaged in the measurement of intruding sounds and the natural ambient levels in the parks for more than 15 years. The NPS has developed policies related to soundscape management, preservation, and restoration, which require information about the natural ambient sound levels, referred to as soundscapes, in all of their properties throughout the country. Measurement of the south Florida parks have been undertaken to refine acoustical metrics that best describe the natural soundscape and to develop general procedures for measuring the natural soundscape. Coincidentally, the proposed conversion of Homestead Air Force Base to a civilian airport has brought the issue of preserving and restoring natural soundscape to the forefront.

In connection with the Supplemental Environmental Impact Statement (SEIS) for the proposed conversion action, several series of sound measurements have been made by NPS and Federal Aviation Administration (FAA) contractors: John A. Volpe National Transportation Systems Center Acoustics Facility (Volpe) and Sanchez Industrial Design, Inc. (SID). Two of these studies used manned observation stations to continuously measure the sound levels over limited periods (generally, one to three hours) and to identify the source of each sound. These measurement studies concentrated on the audibility of intrusive sounds on the natural soundscape.

This report investigates the natural soundscape using an acoustical energy basis[1] rather than audibility. As part of this change in approach, the sound level data from the previous studies are reanalyzed from an acoustical energy perspective. Also, additional unmanned measurements were conducted to provide a better understanding of the variations inherent in the natural soundscapes in the south Florida parks. From these additional measurements, the A-weighted sound levels due to natural sources are found to be reasonably consistent over the region for the time period monitored. The average 24-hour L_{90} for all of the Wyle monitored sites was 33 dBA, while the average 24-hour L_{50} was 42 dBA. Quantitatively, the protected shorelines were the quietest sites while the loudest sites were the dense forests, but no statistically significant dependence of any 24 hour sound level metric on acoustical zone (i.e. type of local ecosystem) was found. However, diurnal dependence was found with the daylight hours being the quietest period in general, and the nighttime hours being the loudest. The average

[1] The acoustical energy described in this report refers to the A-weighted acoustical energy

daytime L_{90} was 32 dBA, and the average nighttime L_{90} was 40 dBA with average sunrise and sunset L_{90}s falling in between at 36 and 35 dBA, respectively.

The unmanned measurements, along with the reanalyzed manned measurements, demonstrate that L_{90} provides a baseline for assessing the natural soundscape on an acoustical energy basis. L_{50}, on the other hand, represents the median levels occurring at a site and adds an indication of the range of sound levels. From the reanalysis of the SID and Volpe manned measurements, L_{90} of the subset of natural sounds was the same as that of the total data set, and it was not affected by human-caused noise. The reanalysis also demonstrated that the L_{50}, although a good representation of the total noise environment, generally overestimated the L_{50} of the natural sounds. Moreover, during periods of minimal intrusions, the difference between the hourly L_{50} and the hourly L_{90} was less than 5 dBA at most sites. Thus, characterizing the natural soundscape by L_{90}, rather than L_{50}, does not overly bias the characterization toward lower levels. Thus, for assessment purposes, the L_{90} of the totality of sounds provides an accurate baseline upon which to establish threshold levels for defining transient and/or intruding events. This finding differs from the reported results in the Volpe report (Flemming et al, 1999), which described the traditional ambient in terms of L_{eq} with variations based on vegetation.

The bias in using the L_{eq} of the traditional ambient as a descriptor of the natural soundscape is much more significant. Typically, hourly L_{eq} values were similar to the hourly L_{10} values. This relation means that the L_{eq} is biased toward the louder events. As an example, if the sound levels were 30 dBA for 95% of the time with some loud events of 60 dBA for 5% of the time, the corresponding L_{eq} for that time period would be 47.1 dBA. From the unmanned measurements, the difference between the average L_{90} and L_{10} was 20 dBA, which is significant in terms of acoustical energy. Use of L_{eq} or L_{10} as a baseline for natural sound levels is not appropriate since these values represent the loudest events occurring in the soundscape. Thus, use of these values to assess potential intrusions could prevent the NPS from achieving its goal of preserving and restoring the natural soundscape in its parks.

The unmanned sound level measurements demonstrated a diurnal pattern, with the highest levels occurring at night and the lowest during the day. This difference probably results from more active animal vocalization occurring during the night. Intruding transient sound events exhibited the opposite diurnal trend in that they increased during the day and decreased at night. This trend suggests that human-based activity generated most of the transient events.

This report provides details of a reanalysis of some of the acoustic data that has been acquired in south Florida with an eye toward defining the soundscapes in the measured properties. It also provides an analysis of additional acoustic data collected over a longer measurement period than in the earlier studies. Finally, based on the totality of acoustic data measured in the south Florida properties, it recommends general procedures for refining the definition of the soundscapes of these properties.

Park personnel can now start to establish criteria for assessing intrusions to the natural soundscape by using L_{90} as an objective basis for defining intruding event thresholds. The assessment of intruding sound events needs to include the maximum sound level of each event, the duration of each event, and the number of events occurring within a given time period. For our analysis, thresholds were set at 10 dBA, 20 dBA, 30 dBA, and 40 dBA above the hourly L_{90}. These thresholds act as filters and provide a good description of the intruding sound events that rise above the natural background level. Exact thresholds for assessment should be formulated so that the goals of soundscape preservation and restoration can be met. The exceedance metrics, e.g. L_{50} and L_{10}, should also be examined to ascertain the level at which the intruding events have an impact on the natural soundscape.

For assessing aircraft noise impacts, noise models such as INM and NoiseMap may be used to calculate aircraft noise intrusiveness based on the established guidelines. For INM, the Time Above calculation can be used to determine potential intrusiveness. For NoiseMap the top contributor calculation can be used to determine intrusiveness although some work would be required to translate the calculated data into individual transient events. Also, for a complete assessment, additional information is required on the hourly operational rates that are not included in the data bases of either of these aircraft noise models.

Chapter 2 provides background information relating to the previous acoustic measurement programs. Chapter 3 describes the reanalysis that was carried out on these measurements, and discusses general conclusions that can be made from this reanalysis. Chapter 4 summarizes the results of the unmanned field measurements that were conducted in south Florida. Chapter 5 provides recommendations for acoustic metrics, and the related acquisition procedures, to be used in refining the definition of the soundscapes in the NPS south Florida properties.

2 BACKGROUND

The NPS is developing noise and soundscape management plans for its parks in south Florida – Everglades National Park, Biscayne National Park, and Big Cypress National Preserve. An essential tenet is the definition of the natural ambient soundscape as a resource to be managed per the NPS Organic Act of 1916 and other relevant mandates. The key to this concept is the development of a credible and defensible description of that resource.

There have been at least three significant sound monitoring efforts in one or more of the parks that have collected data on the nature of the sound environment. The first was by Sanchez Industrial Design, Inc. (SID) in September-October of 1997 (Sanchez, 1997), the second was by the John A. Volpe National Transportation Research Center (Volpe) in August of 1998 (Flemming et al, 1999), and the third was by SID in November of 1998 (Sanchez, 1998).

The first two of these studies employed trained observers to acquire acoustic data at 1-second intervals for short periods of time (1 to 3 hours) along with meteorological information (temperature, humidity, and wind speed and direction) and to identify the sound source that was heard at each instant of time. For the Volpe study, emphasis was on separating periods of time in which no human or mechanical sounds were heard from periods of time in which intruding sounds from non-natural sources, such as aircraft, boats, and human activity were audible. Thus, natural sounds were identified when no other human or mechanical sound could be heard. In addition, the intruding sounds were identified based on a hierarchy of sounds that placed greatest emphasis on aircraft noise followed by “human noise,” and lastly on natural sounds.

For the SID 1997 data, the separation of the sound levels into two groups, natural and intrusive, was based on the dominant sound source as determined by the listener at the time of data collection (Sanchez, 1999). For the Volpe data, the data were grouped according to a hierarchy of sounds heard without regard of the dominant sound source. Therefore, a difference exists between the two data sets because of difference in collection schemes. It is also important to note that with audibility based measurements, the observer notes “natural” sounds when he is really noting the absence of intruding human-caused noise. Thus, “natural” should be the quietest period of the record. There are exceptions, such as thunder and birdcalls, but they generally do not cause the overall natural sound levels to be louder than the intruding levels.

For the third study, SID 1998, unmanned monitors were used to collect 24 hours of sound level data at a limited number of sites along with some one-hour duration manned measurements. The unmanned approach was used to obtain an understanding of how the sound levels varied throughout the day, which was lacking in the previous studies. It demonstrated that unmanned monitoring provided a good picture of the hourly variations and diurnal dependence of the sound levels.

The acoustic metric used to quantify the intensity of the measured sound in these studies was the A-weighted sound level. This measure approximates the frequency response of the human ear, which is most sensitive at frequencies between 1,000 and 6,000 Hz and less sensitive at other frequencies. The A-weighted sound level is the most common measure used to quantify environmental sounds - both natural and man-made. The ranges of sound levels ascribed to natural and non-natural sound sources was described in terms of various statistical acoustic metrics, such as L_{eq}, the energy-average sound level and L_x, the sound level exceeded x-percent of the time.

3 REANALYSIS OF PREVIOUS MEASUREMENTS

3.1 Criteria for Natural vs. Intrusive Sound Events

One's ability to detect a given noise source does not depend on the magnitude of its A-weighted sound level alone. The human mind can discriminate between two sounds of different frequencies even though one may be at a much lower A-weighted sound level than the other. Consequently, a human can detect a given sound source even though that source may not be the dominant source which controls the measured A-weighted sound level. Because of this fact, the procedure used to identify sources of sound in the south Florida studies often resulted in A-weighted sound levels from natural sources being identified as being from non-natural sources since some of the intruding sound energy was below the natural background sound energy. This distinction is important when considering audibility versus acoustical energy based measurements.

For example, suppose an observer hears something and reports the identity of the source in a time-based log, and at the same time independently records the A-weighted sound levels. A difference can appear when the observer log is compared to the recorded sound levels, since the observer may have heard a certain sound source that did not dominate the sound level at that particular time. At this instance, the natural sound is intruded upon based on audibility, but on an acoustical energy basis, the natural soundscape levels are not affected. The error occurs when this affected sound level is associated with an intrusive source although that source does not significantly contribute to the overall sound level. This difference between audibility-based and acoustical energy-based approaches is the reason for the reanalysis since in the original analysis a sound level is identified as intrusive just because the listener could hear an intrusion.

This misidentification of acoustical energy had two consequences. First, the amount of acoustic data ascribed to natural sounds was much less than actually occurred, resulting in less statistical confidence in the range of natural sound levels occurring at a site. Second, the lowest levels ascribed to non-natural sounds during a given measurement period were often lower than the lowest levels ascribed to natural sounds during that period. This cannot be the case since natural sounds are what remain when non-natural sounds are no longer present. Thus, this misidentification can erroneously skew the non-natural population of sound levels toward lower levels, and it can erroneously skew the natural population of sound levels toward higher levels. In fact, in Table 4 of Volpe's report (Flemming et al, 1999), there are several measurement points where the traditional ambient (everything but aircraft) is less than the natural ambient. This would mean that the addition of some man-made sounds would reduce the average sound levels. This finding does not appear to accurately assess the natural soundscape.

In order to correct this potential identification error, the acoustic data acquired in the south Florida parks by SID, Inc. in 1997 and by the Volpe National Transportation Research Center in 1998 were reanalyzed using an energy-based definition of an intruding event. The ambient level was determined based on the observer's identification of the periods of natural sounds to anchor the acoustic data and place them in a more accurate context. This new definition identifies a sound intrusion when the intruding source is seen to increase the overall A-weighted sound level from what it was just before and just after the identified event. An event is not identified as intruding if an increase in sound level is not apparent in the acoustic time history.

This energy-based identification procedure only identifies an intruding event if the total sound level (intruding plus background) is equal to or greater than 3 dBA above the background level. This 3 dBA increase occurs when the intruding and natural sound energies are equal (i.e. if both the intruding and background levels are 40 dBA, then the overall sound level is 43 dBA). This discrimination ensures that the acoustic energy of the intruding event is equal to or greater than that of the background. Thus, for example, even though a passing aircraft may be audible at levels, which are well below the A-weighted sound levels of the background, it is not identified as an intruding source until its A-weighted sound level is equal to or greater than that of the background.

3.2 Reanalysis Procedures

The reanalysis was accomplished by inspection of the one-second L_{eq} time histories, the observer notes, and the temperature and wind speed records. Using the criterion described above, each one second L_{eq} was identified as being either natural or intrusive.

To reanalyze the manned data of Volpe and SID 1997 in accordance with these criteria, computer software was developed to simultaneously display on a computer monitor the one-second L_{eq}, information from the source observation logs, the temperature, and the wind speed. Elevated wind speed would could indicate the presence of the natural sounds of wind rustling leaves or grass. Temperature could potentially be related to animal activity and vocalizations. Simultaneous observation of each of these pieces of information allowed the analyst to identify when an intruding event caused the total A-weighted sound level to rise above the background A-weighted sound level just before and just after the sound event.

Figure 3.1 is an example of the output display of this computer software. The A-weighted sound level during a 10-minute time period from 15:47:07 to 15:57:07 is displayed in the figure, as is the temperature (at top) and wind speed (at bottom). The scales for sound level and temperature are on the left vertical axis; that for the wind speed is on the right. The horizontal axis shows the local time during the observation. Vertical lines (with identifying letters near the bottom of the line) delineate the noise source identified by the observer.

The figure starts at 15:47:07 with an aircraft (A-A) being identified as present, followed by a very short period of time in which the source is identified as natural (N-N). Next, a short period of time in which the source is identified as aircraft is again followed by a very short period of time in which the source is identified as natural. Throughout each of these periods, the sound level varies between 30 and 35 dBA. There is no apparent difference in the range of sounds levels between those segments identified as aircraft and those segments identified as natural. During this time, an aircraft was audible but it does not appear to have effected the overall levels occurring at this site during this time period.

Next is a large period of time in which the source is identified as aircraft, followed by a short period of time, beginning about halfway from 15:52:07 to 15:57:02, in which the source is identified as natural and a similar period of time in which the source is identified as human activity (H-H). During the remainder of the time to 15:57:07 natural, human, and aircraft sounds are identified. Note that, during this time period, the A-weighted sound level varies from about 35 dBA to about 40 dBA with no apparent change as different sources are identified.

The only event in the figure that can be clearly identified as intruding is an aircraft, which caused the gradual rise from around 35 dBA to about 53 dBA and return to 35 dBA that occurs just before 15:54:07. This is the only portion of the 10-minute A-weighted sound level time record that one might conclude is not natural. Thus, the reassignment identified all other portions of this time period as natural.

This reassignment is done interactively within the computer program. While scrolling through the observation data, the user can set cursors at two times and reclassify the contained time period as natural or intrusion. In the figure, the horizontal line just below 70 dBA represents the reclassification. The solid portion of the line denotes natural sources and the dashed portion of the line denotes intrusions. This method is not totally objective but requires the analyst to use judgement in re-identifying the sound levels.

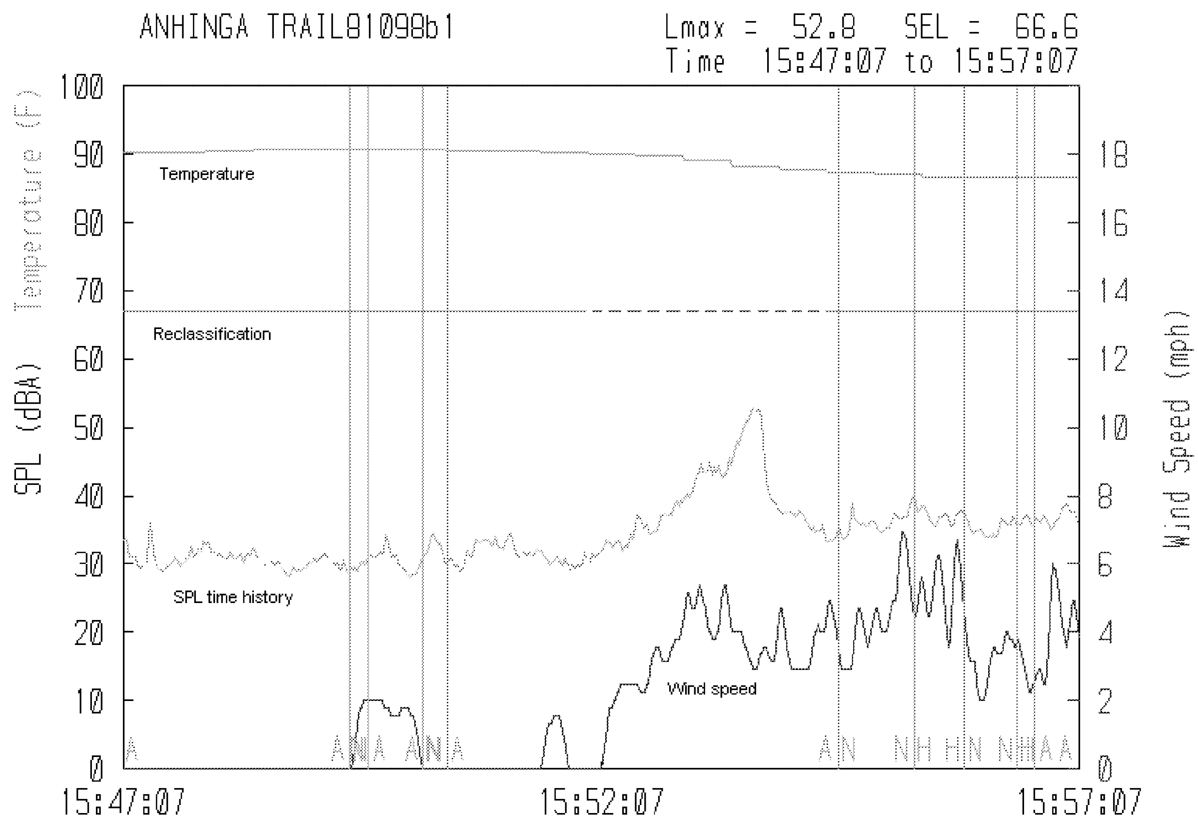

Figure 3.1. Example of the Reanalysis Procedure

Several examples were performed independently by three people in order to test the reproducibility of this approach. This comparison showed that the general results were stable with some variations in the exact identifications. These variations did not effect the overall statistical results.

3.3 Reanalysis Results

The SID 1997 and Volpe 1998 studies focused on the audibility of aircraft noise intrusion, although their discrimination schemes were slightly different, with Volpe focusing on their hierarchy of noise sources rather than the dominant sound. At some sites, measurements were made during weekdays and weekends to quantify the effects of increased visitor activity on the sound levels.

The measurements were performed while observers were present so that sound sources could be identified. For the Volpe measurements, a hierarchy of identification was used which went from aircraft to mechanical to human to natural. Thus, whenever an airplane was heard, the resulting sound levels were identified as aircraft noise even though (a) other noise sources, such as boats, humans, or birds, could also be heard or (b) the aircraft noise did not change the measured overall A-weighted one-second L_{eq} from what it had been prior to the onset of the aircraft noise.

For the SID 1997 measurements, the observer identified as the sound source that source which was judged the loudest at the time. Again, no effort was made to determine whether or not a new noise source changed the A-weighted one-second L_{eq} from what it was for the previous noise source.

The SID 1997 and Volpe 1998 measurements were generally carried out between 08:00 and 16:00, thus precluding any identification of diurnal variation in the natural soundscape. Several of the SID 1998 measurements were made over periods of at least 24 hours. The associated diurnal variation will be discussed below.

During the SID 1997 and Volpe 1998 studies, measurements on open water were carried out in a boat. The sound level data appeared to be influenced by noise from the wave action on the boat hull. Recordings of these measurements were not made available so that times where the sound levels were not distorted by the wave slap on the hull were not determined. Accordingly, sites in which measurements were conducted from a boat were not reanalyzed. However, a comparison of data obtained from these sites with Wyle's unmanned measurements is provided in Chapter 4.

3.3.1 Comparison of Volpe and SID Analysis with Wyle Reanalysis

Table 3.1 compares the natural ambient L_{eq} from Volpe's analysis of 23 of its non-boat measurements with the natural ambient L_{eq} from Wyle's reanalysis of those data. The average difference in L_{eq} between Volpe and Wyle is 1.4 dBA, with a standard deviation of 4.1 dBA. The largest positive difference (Volpe L_{eq} > Wyle L_{eq}) is 11.5 dBA at Elliot Key on August 15, 1998; the largest negative difference (Volpe L_{eq} < Wyle L_{eq}) is -3.2 dBA at Mangrove Inlet on August 18, 1998. This results shows that the L_{eq} is insensitive to changes in the quieter noise levels in an overall distribution of levels since the L_{eq} is controlled by the louder events. Thus, this small difference in L_{eq} from the reanalysis is expected since the reanalysis recovers the lower sound levels.

Of more interest, in terms of defining the natural ambient, is the time recovered by the Wyle reanalysis. This figure represents the time that was attributed to non-natural sources by Volpe's identification system, but for which the A-weighted sound level did not change from the range it occupied during nearby time periods in which the source was identified as natural. For all of the reanalyzed data, an average of 5484 seconds were recovered, representing 49 percent of the total observed measurement time. This demonstrates the misidentification error of using audibility based observations and applying them to energy based levels.

For the most extreme case, the Soldier Key measurement on August 16, 1998, Volpe identified only 228 seconds of the 10,894 second measurement period as being due to natural sources, whereas Wyle's reanalysis identified 9734 seconds as being due to natural sources. This raised the percentage of time for which natural conditions dominated at this site from 2% to 89%. This represents a reassignment of 87 percent of the measurement period from intrusion to natural.

The least extreme cases were the August 18, 1998 measurements at Eastern Sparrow and North Nest Key, both of which were remote sites that would be expected to be dominated by natural sounds. Even then, in each case, 29 percent of the measurement period was reassigned from intrusion to natural. For Eastern Sparrow, the percentage of time of natural levels was corrected from 46% to 74%, and for North Nest Key, the percentage was corrected from 57% to 86%.

These differences mean that the Volpe identification skewed the intrusive levels inappropriately toward low values by including large amounts of natural sound levels into the intrusive grouping. Moreover, this recovered time demonstrates that natural ambient

Table 3.1. Comparison of Natural Ambient L_{eq} - Volpe Measurements vs. Wyle Reanalysis

							Natural - Volpe Measurement			Natural - Wyle Reanalysis			Volpe-Wyle	Time	Total	
Data File	Site ID	Site Name	Acoustical Zone	Date	Start Time	Stop Time	Leq (dBA)	Duration (seconds)	% of time	Leq (dBA)	Duration (seconds)	% of time	Difference (dBA)	Recovered (seconds)	Duration (seconds)	% Time Recovered
81098C1	C	Boca Chita	6	08/10/1998	12:13:13	14:59:46	42.0	1677	17	42.6	5668	57	-0.6	3991	9993	40
81298I1	I	Elliot Key	7	08/12/1998	9:34:59	12:37:02	49.2	1397	13	42.2	7616	70	7.0	6219	10923	57
81598I1	I	Elliot Key		08/15/1998	14:13:28	17:09:25	58.0	228	2	47.3	6061	57	10.7	5833	10557	55
81798I1	I	Elliot Key		08/17/1998	13:26:53	16:27:06	56.4	706	7	44.9	8026	74	11.5	7320	10813	68
81198F1	F	Fender Point	7	08/11/1998	7:18:48	10:20:16	42.2	3905	36	40.9	7682	71	1.3	3777	10888	35
81498F2	F	Fender Point		08/14/1998	11:12:14	14:12:31	33.1	564	5	34.1	5228	48	-1.0	4664	10817	43
81398L1	L	Soldier Key	6	08/13/1998	10:49:46	13:34:19	54.4	510	5	57.4	8466	86	-3.0	7956	9873	81
81698L1	L	Soldier Key		08/16/1998	9:41:48	12:43:22	58.1	228	2	59.8	9734	89	-1.7	9506	10894	87
81098B1	B	Anhinga Trail	1	08/10/1998	15:21:52	18:22:02	40.7	3913	36	39.3	7530	70	1.4	3617	10810	33
81298B1	B	Anhinga Trail		08/12/1998	7:57:08	10:32:59	65.6	620	7	58.6	5381	58	7.0	4761	9351	51
81598B1	B	Anhinga Trail		08/15/1998	7:32:55	10:08:03	56.2	1513	16	51.3	7536	81	4.9	6023	9308	65
81098O1	O	Chekika	4	08/10/1998	8:52:42	13:01:56	40.6	5034	34	39.9	9996	67	0.7	4962	14954	33
81898V1	V	Eastern Sparrow	4	08/18/1998	9:41:18	14:55:34	31.2	8603	46	31.6	14004	74	-0.4	5401	18856	29
81498Q1	Q	Eco Pond	3	08/14/1998	8:44:40	14:39:32	48.1	5372	25	48.6	18407	86	-0.5	13035	21292	61
81598R1	R	Hidden Lake	2	08/15/1998	11:55:29	14:55:24	35.1	2808	26	35.6	8822	82	-0.5	6014	10795	56
81898X1	X	North Nest Key	6	08/18/1998	14:34:24	17:30:03	40.1	6020	57	40.3	9026	86	-0.2	3006	10539	29
82098AA1	AA	Pavilion Key	3	08/20/1998	8:07:21	11:06:16	45.5	5267	49	45.5	10075	94	0.0	4808	10735	45
81398N1	N	Shark Valley	4	08/13/1998	9:26:15	12:31:10	43.2	1824	16	41.4	6805	61	1.8	4981	11095	45
81698N1	N	Shark Valley		08/16/1998	8:05:23	11:04:49	46.3	4783	44	47.3	9622	89	-1.0	4839	10766	45
81898AC2	AC	Mangrove Inlet	3	08/18/1998	14:39:41	16:09:43	33.4	198	4	36.6	2238	41	-3.2	2040	5402	38
81698S1	S	Golightly Campground	1	08/16/1998	12:52:40	15:40:48	36.0	2044	20	38.4	5234	52	-2.4	3190	10088	32
81798S1	S	Golightly Campground		08/17/1998	7:59:03	10:58:55	42.7	6659	62	42.9	9991	93	-0.2	3332	10792	31
82098AE1	AE	National Scenic Trail	1	08/20/1998	8:43:50	11:21:27	44.6	541	6	42.9	7394	78	1.7	6853	9457	72
												Average	1.4	5484	11261	49
												St. Dev.	4.1	2383	3197	17
												Count	23	23	23	23

Acoustical Zone Key
1 = Intruded
2 = Open Forest
3 = Dense Forest
4 = Prairie, Slough
5 = Open Water
6 = Open Shoreline
7 = Protected Shorline

levels are present within the park for most of the time and are more likely to be impacted by additional noise intrusions.

Table 3.2 shows similar information for the SID 1997 data. Differences between the SID analysis and the Wyle reanalysis of that data were not as extreme as for the Volpe data. The average L_{eq} difference for 11 non-boat measurements was 0.0 dBA with a standard deviation of 0.4 dBA. The largest positive difference (SID L_{eq} > Wyle L_{eq}) was 0.8 dBA at North Nest Key on October 5, 1997; the largest negative difference (SID L_{eq} < Wyle L_{eq}) was -0.7 dBA at Elliott Key on September 20, 1997.

The remarkable difference in how each of the two analysis with Wyle's reanalysis may be due to the different assignment hierarchies used in the two studies. Volpe identified the measurements as being due to an airplane whenever an airplane could be heard; SID identified the measurements as being due to whatever noise source was judged the loudest at each second of time.

Additionally, differences in technique may have affected the identifications. SID used a button box to log the identification of the dominant noise source and , as a result, was able to keep track of short periods of time in which that source changed by pressing a single button. Volpe entered source identification data into a spreadsheet in a laptop computer. Because of the time required to type in source identification comments, short periods of time in which aircraft (or other sources in the hierarchy) could no longer be heard may have been omitted. The omission would result in more time associated with an intruding sound instead of natural sound.

3.3.2 Comparison of Exceedance Plots for All and Natural Only Sounds

Figures 3.2 and 3.3 are examples of sound level exceedance plots, which show the percentage of the measurement time during which a given A-weighted sound level is exceeded. The abscissa of the plots is a linear scale showing the A-weighted sound level; the ordinate is a normal probability scale showing the percentage of time (or probability) that each sound level is exceeded. A normally distributed set of data would appear as a straight line on such a plot, with the median value of the data being at the 50 percent level. Thus, the straightness of the distributions curve (or lack thereof) demonstrates how normal the distributions are.

Figure 3.2 shows data taken by SID, Inc. at the Anhinga Trail in Everglades National Park from 15:22:31 to 16:33:11 on October 5, 1997. The dashed line represents all of the acquired data; the solid line represents the subset of data that was identified in the reanalysis as being due to natural sounds. Note that, at low sound levels, corresponding

Table 3.2. Comparison of Natural Ambient L_{eq} - SID Measurements vs. Wyle Reanalysis

							Natural - SID Measurement			Natural - Wyle Reanalysis			SID-Wyle	Time	Total	
Data File	Site ID	Site Name	Acoustical Zone	Date	Start Time	Stop Time	Leq (dBA)	Duration (seconds)	% of time	Leq (dBA)	Duration (seconds)	% of time	Difference (dBA)	Recovered (seconds)	Duration (seconds)	% Time Recovered
Bis-1	B1	Visitor Center BISC	1	9/18/97	13:50:34	14:47:47	48	2216	65	47.8	2827	82	0.2	611	3433	18
Bis-8	B8	Elliott Key	7	9/20/97	11:25:33	12:38:18	44	1260	29	44.7	1939	44	-0.7	679	4365	16
Bis-8(2)	B8			9/22/97	12:49:04	13:54:21	36	2651	68	35.6	2853	73	0.4	202	3917	5
Ever-2(2)	E2	Anhinga Trail	1	10/5/97	15:22:31	16:33:11	40	2691	63	40.2	3049	72	-0.2	358	4240	8
Ever-3(2)	E3	Long Pine Key	2	10/1/97	12:20:52	13:23:11	34	3155	84	34.5	3261	87	-0.5	106	3739	3
Ever-4	E4	Pa-hay-okee O'look	2	10/1/97	10:05:22	11:07:04	38	3177	86	38.3	3382	91	-0.3	205	3702	6
Ever-4(2)	E4			10/4/97	17:45:27	18:49:54	41	2826	73	41	3076	80	0	250	3867	6
Ever-5	E5	Nine Mile Pond	2	10/1/97	17:53:57	18:58:25	34	1878	49	33.9	1831	47	0.1	-47	3868	-1
Ever-6	E6	Eco Pond	3	10/1/97	7:39:52	8:42:08	35	2774	74	35.3	2961	79	-0.3	187	3736	5
Ever-6(2)	E6			10/3/97	17:27:58	18:35:32	42	2512	62	41.7	3262	80	0.3	750	4054	19
Ever-8	E8	North Nest Key	6	10/5/97	10:05:20	11:15:18	39	3191	76	38.2	3322	79	0.8	131	4198	3
												Average	0.0	312	3920	8
												St. Dev.	0.4	258	274	7
												Count	11	11	11	11

Acoustical Zone Key
1 = Intruded
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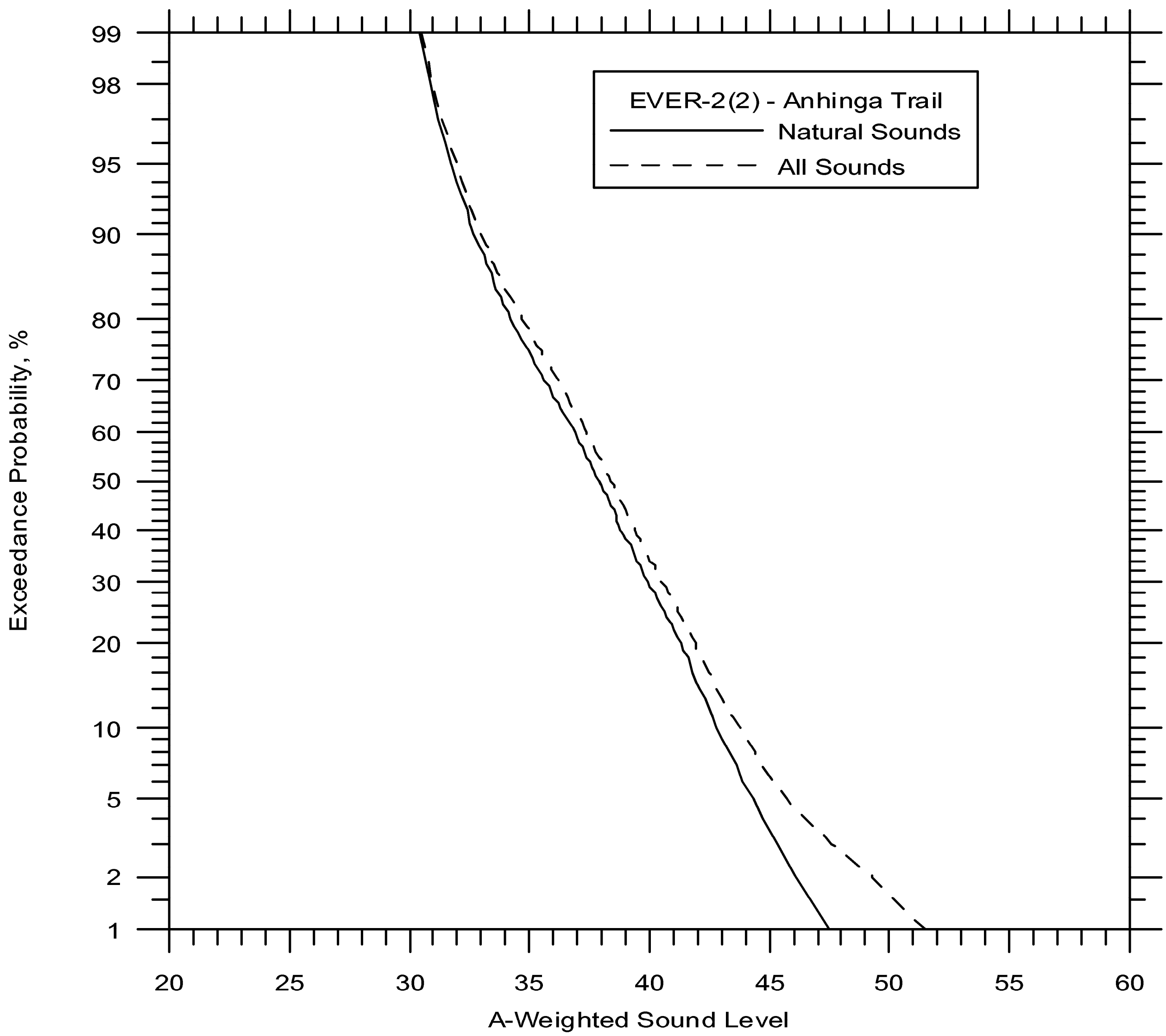


Figure 3.2. Exceedance Plot for SID Data at Anhinga Trail

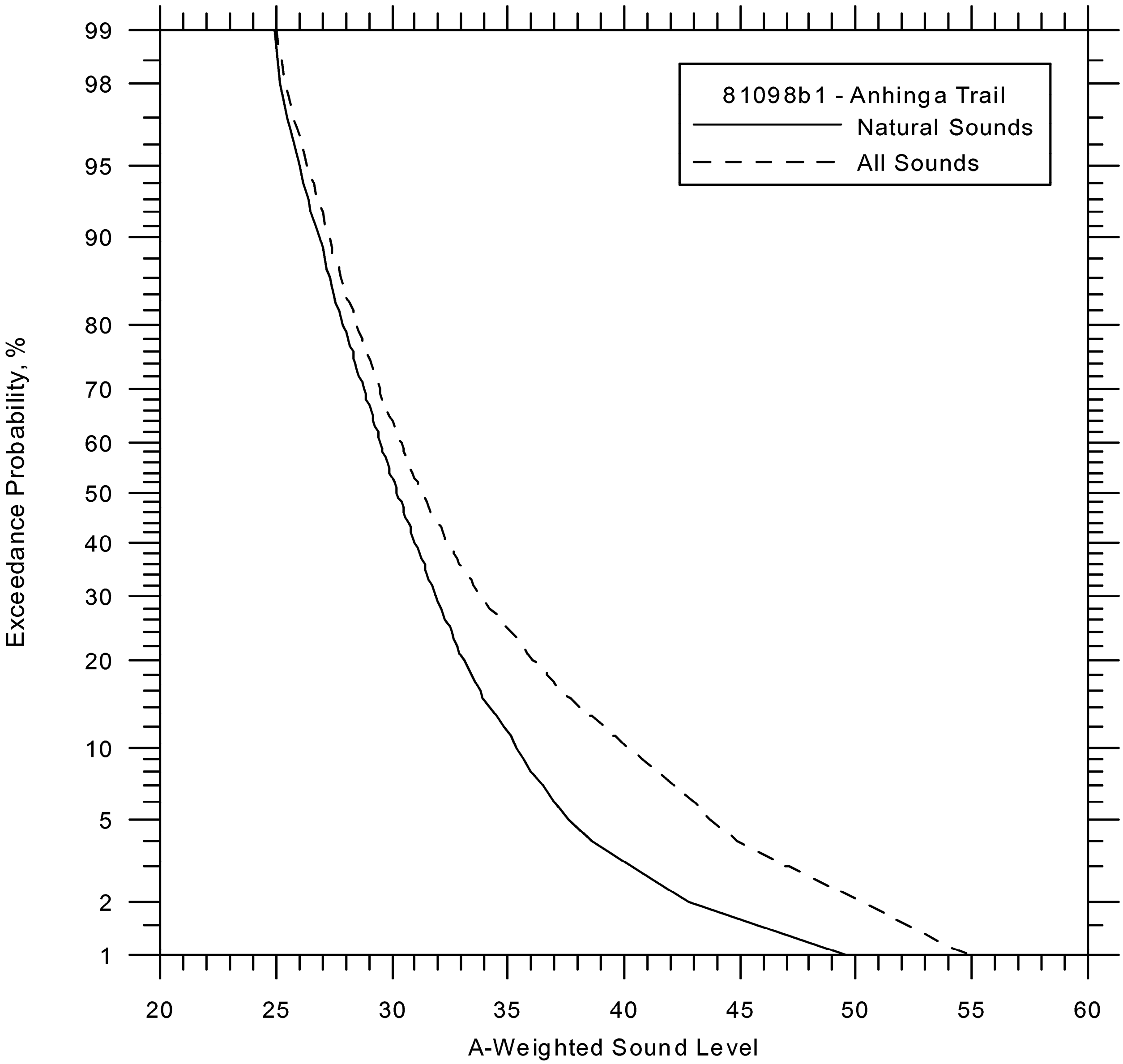


Figure 3.3. Exceedance Plot for Volpe Data at Anhinga Trail

to exceedance levels L_{99}, L_{95}, and L_{90}, which metrics are typically used to characterize ambient or background sounds levels, there is little difference between the two sets of data. It is only at higher sound levels, corresponding to exceedance levels L_1, L_5, and L_{10} (metrics typically used to characterize intrusions), that appreciable differences occurred because of intruding sounds.

Exceedance plots for each of the non-boat measurements acquired by SID in 1997 are contained in Appendix A.

Figure 3.3 shows similar data taken by Volpe at the Anhinga Trial form 15:21:52 to 18:21:52 on August 10, 1998. Although the behavior to the two curves is similar to that of the SID data in the previous year, the range of sound levels differs. For the SID data, the A-weighted sound levels ranged from 30.5 dBA to 51.5 dBA; for the Volpe data, these levels ranged from 25 dBA to 55 dBA. Thus, the range of daytime sound levels is on the order of 20 to 20 dBA.

Exceedance plots for each of the non-boat measurements acquired by Volpe in 1998 are contained in Appendix B.

Exceedance curves for the exclusive subset of natural sounds can only be obtained with manned measurements. Observations are required to identify sources of the sound so that the levels may be divided into two distinct subsets (natural and intrusive) from the totality of sound levels. It is much less labor-intensive (and more cost effective) to use automatic data recording instruments site. In order to determine how accurately various exceedance levels for the total set of sounds approximate the corresponding exceedance levels for the subset of natural sounds, the average differences between L_x of the total data set and L_x of the natural sounds were computed for both the SID 1997 and the Volpe 1998 data.

Figures 3.4 and 3.5 show the average differences as a function of exceedance percentile for the SID data and the Volpe data, respectively. At each exceedance percentile in these figures, a solid circle indicates the average value of the difference: $(L_x)_{total} - (L_x)_{natural}$. The vertical bars represent ± one standard error of the mean about the average value.

From these figures, it can be seen that the value of L_{90} for the natural sounds differs from that of the totality of sounds by less than one-half dBA. The value of L_{50} for the natural sounds differs from that of the totality of sounds less than 2 dBA.

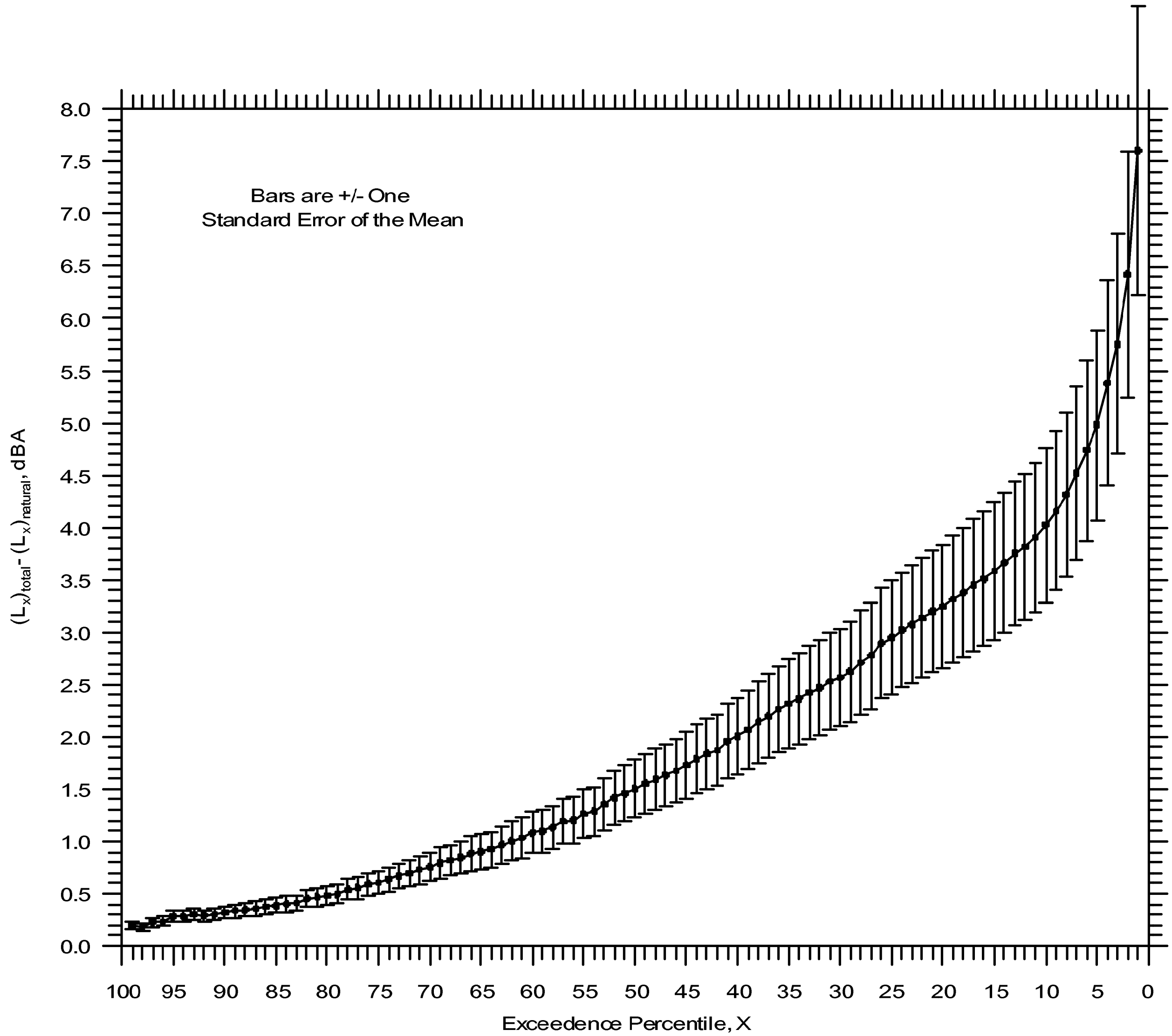


Figure 3.4. Average Differences Between Total and Natural Exceedance Levels for SID Data

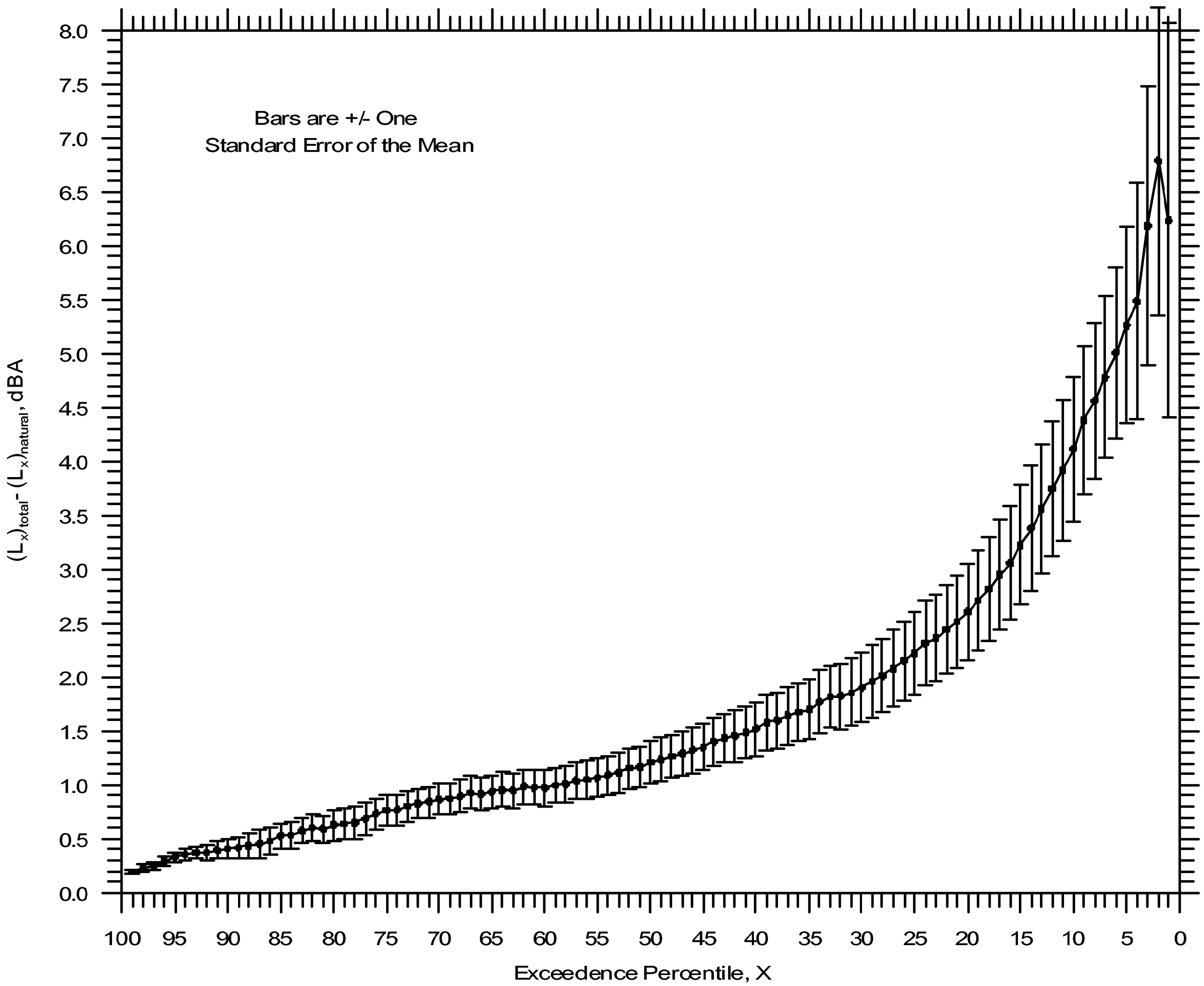


Figure 3.5. Average Differences Between Total and Natural Exceedance Levels for Volpe Data

These accuracy estimates can probably be considered upper bounds, since the data were taken during daylight hours during which intruding, non-natural sounds were relatively common. Figure 3.6 show the hourly L_{50}, L_{90} and Leq values made at the Anhinga Trail by SID in November 1998. Note that, during nighttime hours when there were relatively few intruding noise sources, the hourly L_{50} and L_{90} values are nearly identical. This fact indicates a near constancy of sound level which, absent nearby constant non-natural noise sources (such as HVAC equipment), implies that L_{50} and L_{90} of the total data set are equal to the L_{50} and L_{90} of the subset of natural sounds.

Appendix C contains plots of hourly L_{50}, L_{90}, and L_{eq} values for each of the seven measurement sites in the SID 1998 study.

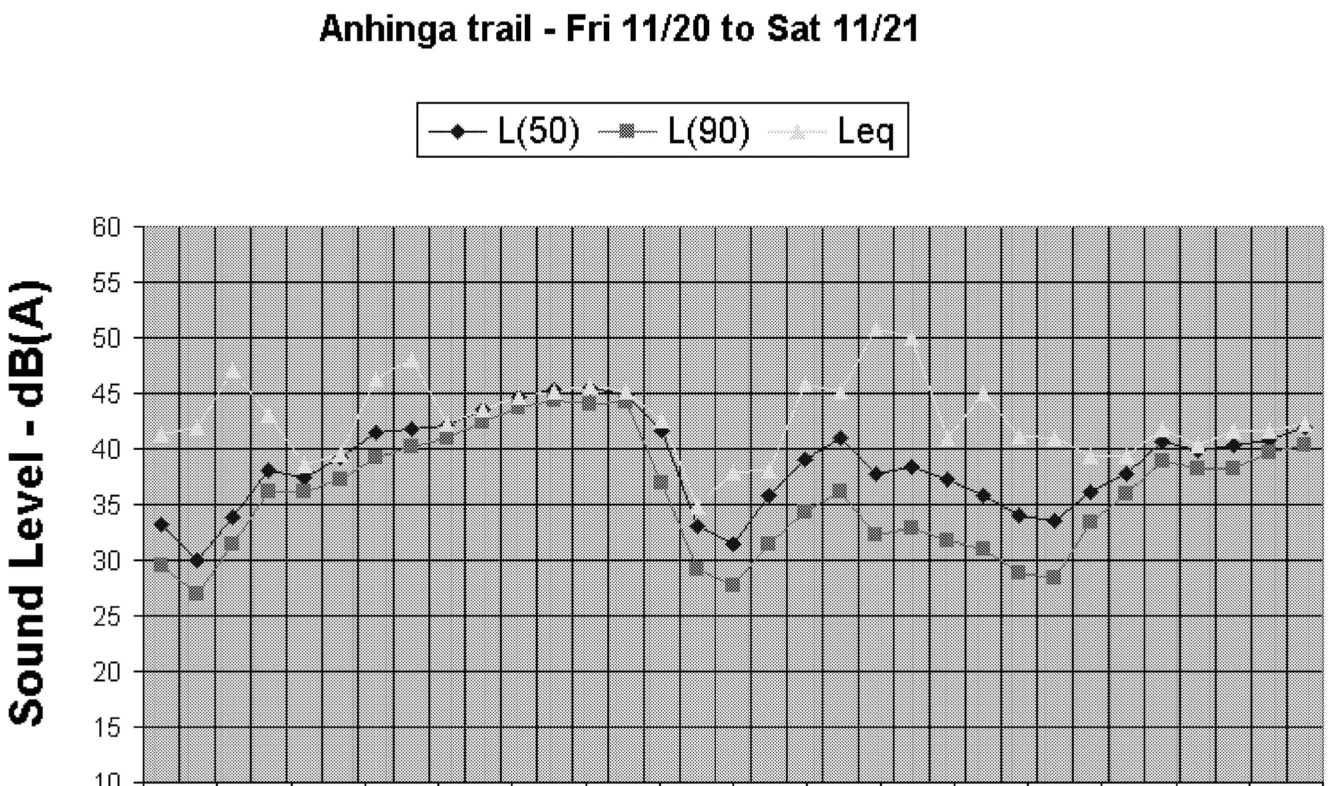
3.3.3 Exceedance Plots for 24-Hour Measurements

The SID 1998 study measured 1-second Leq values at seven sites for periods in excess of 24 hours. From these data, 24-hour exceedance plots have been developed. Figure 3.7 shows an example of such a plot from the data taken at the Anhinga trial on 16-17 Nov 1998. The solid curve shows the exceedance plot for the entire 24-hour period, with levels ranging from 27 dBA to 54 dBA. Exceedance plots for two subsets of the data are also shown in this figure - hours corresponding to darkness (dashed line) and hours corresponding to day light (dot-dashed line). Note that, except for levels above L_{10}, the darkness hours are louder than the daylight hours. Thus , the natural soundscape is louder at night at this location than in the daytime, and the total sound levels, as defined by the L_{10} are louder during daylight hours. This difference probably results form insects being more active at night and human caused intrusions occurring during the daytime.

Appendix D contains exceedance plots for each of the sites in the SID 1998 study.

3.3.4 Dependence of Acoustic Metrics on Acoustical Zone

Since natural sounds are related to the type of nearby vegetation (Flemming et al, 1998, Sneddon et al, 1994 and Reddingius, 1994), the population of animals that are drawn to the vegetation, and the interaction of the wind with vegetation, the reanalyzed data from Volpe 1998 and SID 1997 were classified into acoustical zones similar to the grouping used by Volpe in its analysis as shown in their Table 10 (Flemming et al, 1999). These classifications allow the data to be tested for any dependence of the overall natural sound levels on the local area conditions.



	16:00	18:00	20:00	22:00	0:00	2:00	4:00	6:00	9:00	11:00	13:00	15:00	17:00	19:00	21:00	23:00
L(50)	33.3	33.9	37.4	41.4	42.1	44.6	45.5	41.6	35.8	40.9	38.4	35.8	33.6	37.8	39.9	40.8
L(90)	29.5	31.5	36.1	39.2	41	43.7	44.1	36.9	31.4	36.2	32.9	31	28.4	35.9	38.2	39.7
Leq	41.3	47.1	38.6	46.3	42.2	44.7	45.6	42.6	38.1	45.1	50	45	40.9	39.4	40.3	41.6

Hour

Figure 3.6. SID 1997 Anhinga Trail 24-hour Measurements

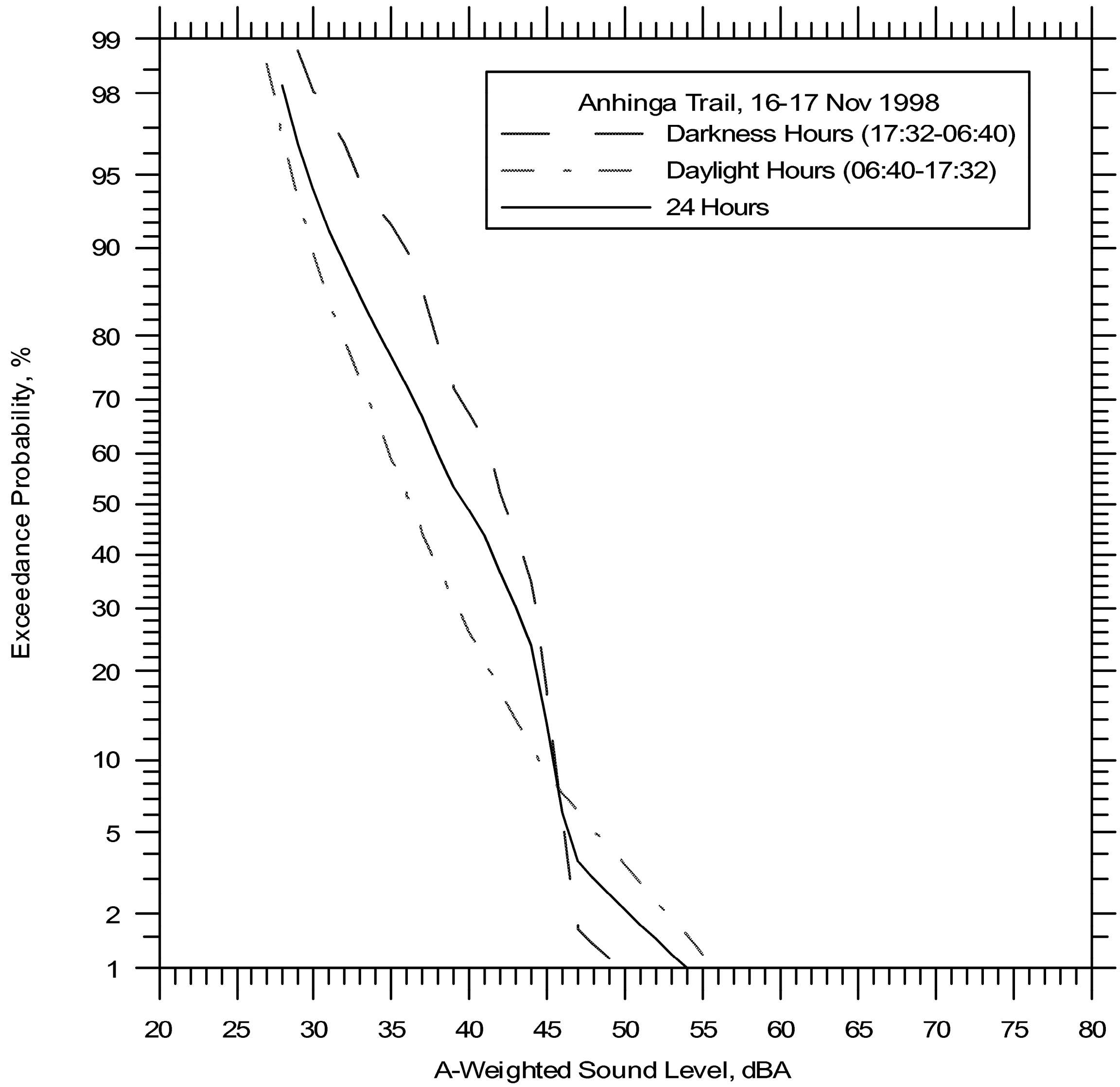


Figure 3.7. 24-Hour Exceedance Plot at the Anhinga Trail

These acoustical zone classifications are a relatively simple set that represents the types of vegetation occurring in the south Florida National Parks. This grouping looks at potential differences between natural sound sources might include leaves fluttering in the wind, insects, frogs, rainfall on the leaves, and birds.

For the reanalysis, the following acoustical zones descriptions were used to group the data: intruded , open and dense forests, prairie, open water, and open and protected shoreline. Simple statistical analyses of variances (ANOVA) were carried out to investigate whether or not the values of these metrics differ between acoustical zones. Table 3.3 shows the L_{eq}, L_{90}, and L_{50} that resulted form the reanalysis of the SID 1997 and Volpe 1998 data as a function acoustical zone.

Table 3.4 shows the results of a single-factor analyses of variance of L_{eq} as a function of acoustical zone classification at the 95 percent level of confidence, no dependence of the L_{eq} on acoustical zones is demonstrated. Tables 3.5 and 3.6 show similar results for L_{90} and L_{50}.

Although on-site experience has shown that the timbre of the natural sounds in many of these acoustical zones are different, the A-weighted sound level is apparently not a sufficiently precise measure to reflect those differences. This is not surprising, given that all spectral information, which defines the quality of the sound, is removed once the A-weighting filter has been applied to the sounds.

On the other hand, this lack of dependence of acoustic metric on acoustical zone may simply result from seasonal variations in the vocalizations of the animal populations. It must be recalled that the SID 1997 and Volpe 1998 data were gathered over short periods - usually from one to three hours during daylight hours when natural sounds were lower and more intrusions occurred. Differences between acoustical zones that might be evident for longer times, such as 24 hours, might be obscured by the short samples collected in these studies. In addition, the data may not be statistically robust enough to demonstrate a dependence. This point is examined in more detail in Section 4.0 which describes the unmanned 24-hour measurements that were carried out by Wyle Laboratories in 1999.

Table 3.3. Reanalyzed SID/Volpe Metrics as a Function of Acoustical Zone

Site Name	Acoustical Zone	Date	Leq (dBA)	L90 (dBA)	L50 (dBA)
Boca Chita	6	08/10/1998	42.6	30.7	36.3
Elliot Key	7	08/12/1998	42.2	28.3	31.9
		08/15/1998	47.3	33.8	37.3
		08/17/1998	44.9	29.8	32.5
Fender Point	7	08/11/1998	40.9	28.6	34.3
		08/14/1998	34.1	28.0	32.2
Soldier Key	6	08/13/1998	57.4	38.2	52.5
		08/16/1998	59.8	53.5	57.3
Anhinga Trail	1	08/10/1998	39.3	26.9	30.2
		08/12/1998	58.6	28.3	31.3
		08/15/1998	51.3	35.9	38.2
Chekika	4	08/10/1998	39.9	32.1	35.3
Eastern Sparrow	4	08/18/1998	31.6	22.9	28.2
Eco Pond	3	08/14/1998	48.6	41.2	47.3
Hidden Lake	2	08/15/1998	35.6	29.3	32.0
North Nest Key	6	08/18/1998	40.3	24.1	30.7
Pavilion Key	3	08/20/1998	45.5	34.0	43.0
Shark Valley	4	08/13/1998	41.4	36.1	38.5
		08/16/1998	47.3	43.1	45.3
Mangrove Inlet	3	08/18/1998	36.6	29.2	34.6
Golightly Campground	1	08/16/1998	38.4	29.2	32.9
		08/17/1998	42.9	33.0	37.2
National Scenic Trail	1	08/20/1998	42.9	35.2	40.1

Site Name	Acoustical Zone	Date	Leq (dBA)	L90 (dBA)	L50 (dBA)
Visitor Center BISC	1	09/18/1997	47.8	44.8	46.9
Elliott Key	7	09/20/1997	44.7	38.9	41.7
		09/22/1997	35.6	27.2	30.6
Anhinga Trail	1	10/05/1997	40.2	32.7	37.9
Long Pine Key	2	10/01/1997	34.5	22.9	31.7
Pa-hay-okee O'look	2	10/01/1997	38.3	31.0	35.8
		10/04/1997	41.0	34.9	38.6
Nine Mile Pond	2	10/01/1997	33.9	23.0	27.3
Eco Pond	3	10/01/1997	35.3	31.5	33.7
		10/03/1997	41.7	38.3	39.9
North Nest Key	6	10/05/1997	38.2	36.1	37.3

Acoustical Zone Key
1 = Intruded
2 = Open Forest
3 = Dense Forest
4 = Prairie, Slough
5 = Open Water
6 = Open Shoreline
7 = Protected Shoreline

Table 3.4. ANOVA of L_{eq} vs. Acoustical Zone

SUMMARY				
Acoustical Zone	Count	Sum	Average	Variance
1	8	361.4	45.2	48.6
2	5	183.3	36.7	8.7
3	5	207.7	41.5	32.2
4	4	160.2	40.1	41.9
6	5	238.3	47.7	102.9
7	7	289.7	41.4	24.3

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	397.6	5	79.5	1.9	0.1	2.6
Within Groups	1187.1	28	42.4			
Total	1584.7	33				

$F < F_{crit}$ means that we must acept the hypothesis that the means of each population are equal at the 95 percen level of confidence.

Table 3.5. ANOVA of L_{90} vs. Acoustical Zone

SUMMARY				
Acoustical Zone	Count	Sum	Average	Variance
1	8	266.0	33.3	32.3
2	5	141.1	28.2	27.3
3	5	174.2	34.8	24.0
4	4	134.2	33.6	71.1
6	5	182.6	36.5	119.9
7	7	214.6	30.7	17.9

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	230.7	5	46.1	1.0	0.4	2.6
Within Groups	1231.0	28	44.0			
Total	1461.7	33				

$F < F_{crit}$ means that we must acept the hypothesis that the means of each population are equal at the 95 percen level of confidence.

Table 3.6. ANOVA of L_{50} vs. Acoustical Zone

SUMMARY				
Acoustical Zone	**Count**	**Sum**	**Average**	**Variance**
1	8	294.7	36.8	29.3
2	5	165.4	33.1	18.6
3	5	198.5	39.7	32.7
4	4	147.3	36.8	50.4
6	5	214.1	42.8	130.8
7	7	240.5	34.4	15.1

ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	331.7	5	66.3	1.6	0.2	2.6
Within Groups	1175.7	28	42.0			
Total	1507.4	33				

$F < F_{crit}$ means that we must acept the hypothesis that the means of each population are equal at the 95 percen level of confidence.

4 UNMANNED FIELD MEASUREMENTS

4.1 Objectives

In order to describe the energetics of the natural soundscape in the south Florida National Parks, unmanned monitors were employed to collect the sound level data to characterize the natural soundscape. The few 24-hour measurements conducted by SID in 1998 demonstrated that the unmanned measurements provided a clear picture of the variations in the sound levels at a site. Recent studies have demonstrated the robustness of employing unmanned monitoring to describe and define the natural soundscape. (Foch, 1998 sand Gdula Gudorf, 1998). Observer based measurements were not used as the primary data collection method because of their limitations in describing the variation of the natural sounds.

One major limitation of observer based data collection is the short time periods of data collection. From these small data samples, it is difficult to determine the range of the naturally occurring sound levels. In addition, the previous observer-based data were limited to daylight periods that preclude any comprehension of the diurnal variations of the sound levels. Another pitfall of observer-based measurement is confusing audibility based metrics with energy based metrics as demonstrated by results from the reanalysis in Chapter 3.

Acoustical data collected with unmanned monitors deployed over longer periods provide a clear picture of the variations within the natural soundscape. This acoustical data helps to estimate sound levels associated with park maintenance, visitors, and intruding sounds, such as aircraft. Data from these unmanned measurements can demonstrate the diurnal variations in the sound levels, can highlight transient events occurring throughout the day, and can examine the dependence of sound levels on acoustical zones.

Unmanned monitoring of the sound levels can be used to address the following questions about the natural soundscape:

- What is the level of dependence of the natural soundscape acoustical energy levels of on the local ecosystem of acoustical zone (i.e. grassy prairie vs. forest)?
- What is the diurnal dependence of the soundscape?
- How do day-to-day variations in the soundscape compare to diurnal variations?

Since other studies (Fleming, et al, 1998, Sneddon et al, 1994, and Reddingius, 1994) have hypothesized a dependence of sound levels on acoustical zones, the first item addressed with the unmanned measurements was testing the statistical independence of acoustical zones that was not found in the reanalysis. (Strictly speaking, the results derived from this data set are limited to the summer season in south Florida and should not be extrapolated to other seasons at this time until seasonal variations are evaluated. Continued monitoring should be a part of the NPS soundscape management activity that will help to perform this seasonal variation evaluation.)

4.2.1 Measurement Methods and Equipment

Sound levels were measured at selected sites within Biscayne National Park and Everglades National Park, each representing an acoustical zone. In order to address the first question, two spatially independent sites were selected for each acoustical zone. At each site, the microphones were placed above the ground and secured so that no branches or leaves would interfere with the microphone. A four-inch diameter spherical foam windscreen was placed over the microphone to reduce wind noise. This windscreen provided shielding from artificial wind induced noise. This type of windscreen is effective for wind speeds up to 10 knots. For faster wind speeds, artificial wind noise will increase the recorded sound levels.

Two-second L_{eq} time histories were recorded using a Larson-Davis 820 Sound Level Monitor (Larson Davis, 1991). The two-second time interval was selected to increase monitoring periods to four days before the units memory would be filled and would need to be downloaded. The units were time synched to the local time to facilitate comparisons between sites and with supporting data. The sound level data were stored in the monitor and were downloaded to a laptop computer for detailed analysis. The two-second time histories were used to calculate the different acoustic metrics used to assess the natural soundscape.

Supporting weather data was obtained from Homestead Air Force Base, Homestead General Airport, several weather reporting station in the Everglades National Park, and a USGS monitoring site in Taylor Slough near the Ernst Coe Campsite. These supporting weather data ranged in detail from daily values to 15 minute averaged values for temperature, wind speed, relative humidity, and precipitation.

At some of the sites, manned observations were made for short periods to identify the local sounds sources. During some of these observations, a DAT recorded was used to document the sounds heard at the site and to verify the recorded levels of the sound level meters.

4.3 Selected Sites

Sites were selected based on representative acoustical zones, access to site, and park limitations on human intrusions. The areas covered did not include all areas of the park but did include all of the major acoustical zones environments found at the parks. Table 4.1 provides a listing of the sites with the site identification, location, acoustical zone, and dates of monitoring. The locations are highlighted in Figure 4.1 along with the sites from the previous studies.

4.3.1 Biscayne NP

At Biscayne National Park, the following acoustical zones were monitored: open water, forest on key, key shoreline, and shoreline of mangrove key. Appendix E contains pictures of the sites, which shows the placement of the sound level monitor within each acoustical zone.

The site at Convoy Visitor Center, B1, represents an intruded acoustical zone since humans, office buildings, cars, and boats are present. Three sites were located on Elliot Key. One site, B2, was in the picnic area away from the docs and close to the hiking trails.

This site was in an open forest acoustical zone, an area with an open canopy and ample light. Air conditioners and generators were audible in this area and the exact monitor location was chosen to minimize acoustic energy received from the units. The other two sites, B3 and B4, were placed along the hiking trail approximately ½ mile from the Elliot Key Visitor Center. Both sites were in dense forest acoustical zones since the tree canopy shielded most of the sunlight.

The next sites were located along the shoreline of mangrove keys. One monitor, B5, was on Long Arsenicker Key. The microphone was placed on the top of a mangrove and was approximately ten feet from the edge of the key. The key is near open water. However, the shoreline was considered protected since shallow water surrounded the key for most of the time. The other site, B6, was located on Old Rhodes Key along a narrow channel. The microphone was place atop an old mangrove branch at the edge of the key. This site was also considered protected since it was only accessible during high tide.

Table 4.1 Site Identification and Measurement Dates

Sites		Acoustical Zone	Jun 7	8 T	9 W	10 T	11 F	12 S	13 S	14 M	15 T	16 W	17 T	18 F	19 S
B1	Visitor Center	1	SU	Bad	Bad/SU	Bad/TD				SU	+	TD			
B2	Elliot Key	2	SU	+	V	V	V	+	+	TD					
B3	Hiking Trail North of B2	3	SU	V	V	+	TD								
B4	Hiking Trail South of B2	3	SU	V	TD										
B5	Long Arsenicker Key	7	SU	V	+	TD									
B6	Rhodes Keys	7	SU	V	+	V	V	+	+	TD					
B7	Adam's Key	6	SU	V	+	V	V	+	+	TD					
B8	Shoal Marker Open water	5	SU	V	V	V	V	+	+	TD					
B9	Shoal Marker Pelican Bank	5			SU	+	TD								
E1	Open water key	6											SU	TD	
E2	Coastal Prairie	4									SU	+	+	TD	
E3	South Joe River Chickee	7								SU	+	+	TD		
E4	N. Harney River/ mangrove	7								SU	+	+	TD		
E5	In mangrove	3								SU	+	+	TD		
E6	Mahogany Hammock (outside)	2			SU	+	TD								
E7	Mahogany Hammock (inside)	3			SU	+	TD								
E8	Prairie near Ernest Coe	4					SU	+	+	TD					
E9	Hidden Lake Education center	2					SU	+	TD						
E10 A&B	Pineland fire road	4 & 2									SU*	+*	+*	+*	TD
E11	Long Pine Key campground	2									SU	+	V	TD	
E12	Anhinga Trail	1					SU	+	TD						
E14	L67 canal in Shark Valley	4										SU	+	+	TD
E15	Chekika	1										SU	+	+	TD

(SU = setup site, V = visit, + = continue measurement, TD = tear down site.)

Acoustical Zones
1 = intruded
2 = open forest
3 = dense forest
4 = prairie
5 = open water
6 = open shoreline
7 = protected shoreline

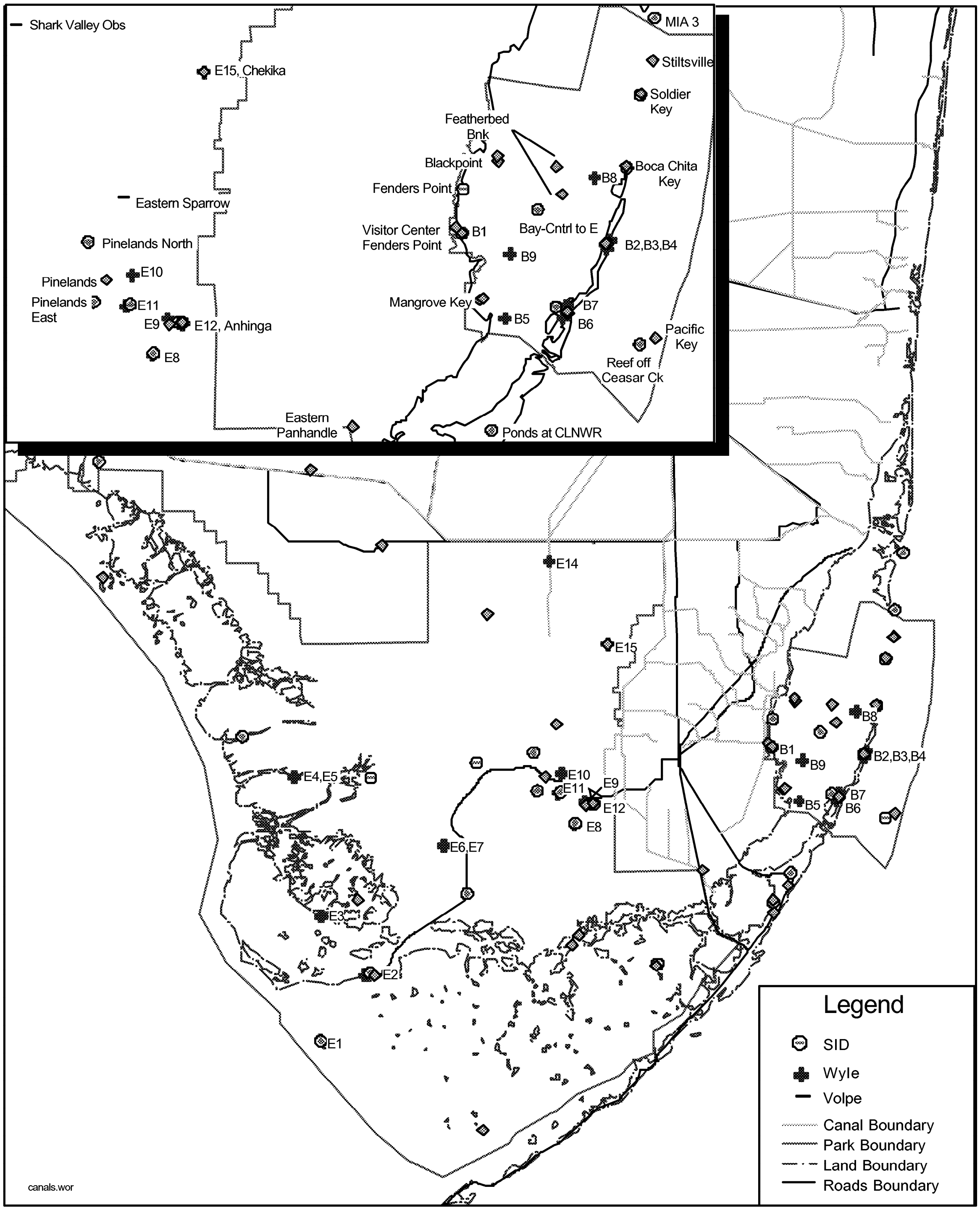


Figure 4.1 Location of Monitored Sites in South Florida Parks

The site at Adam's Key, B7, was considered open shoreline since it was close to a major channel for boat traffic to and from the open ocean waters. The microphone was placed approximately 20 feed from the shoreline and sway from the docks. The soundscape was influenced by an operating generator that provides power for the residences on the key and for a picnic area.

Two sites, B8 and B9 were located in the open water. Monitors were placed on shoal warning markers near the Feather Bank shoal. And the Pelican Bank shoal. The microphones were secured to each post about eight feet above the water and about ten inches from the post.

4.3.2 Everglades NP

At Everglades National Park, the following acoustical zones were monitored: pineland forest, mangrove forest, prairies, slough, hardwood hammock, and protected and open shoreline. Appendix E contains pictures of the sites which shows the placement of the sound level monitors within each acoustical zone.

The first group of sites was located in the southwestern portion of the park near Flamingo. Site E1 was located on Carl Ross Key, which is a key in the open waters of the Florida Bay. The microphone was placed five feet above the ground and was 20 feet away from the open shoreline on two sides. Site E2 was located near the Coastal Prairie Trail in the open prairie. The microphone was placed five feet above the ground and away from small groups of brushes. Site E3 was placed on the South Joe River Chickee, which is a campsite (an elevated wooden platform with a roof constructed over open water) located about 30 feet from the shoreline. This site is considered a protected shoreline since it is in a cove well away from any major boat traffic channel. Sites E4 and E5 were placed close to an environmental monitoring station on the North Harney River. Site E4 was placed at the shoreline about six feet above the water surface. Site E5 was placed about 300 feet into the dense mangrove forest.

Two monitors were located at the Mahogany Hammock. Site E6 was placed at the border of the forest and the slough. Site E7 was placed inside the dense hammock along the boardwalk trail.

The next group of sites was located in the eastern section of the park. Site E8 was sited in the open prairie near Taylor Slough and about two miles northeast of Ernest Coe campsite. Site E9 was in the Hidden Lake Education Center. This site can be characterized as either open forest or intruded acoustical zone depending on the use of facilities at the time. During the monitoring period, there were no environmental education activities, and therefore the site is categorized as open forest. The site is surrounded by trees and has open stage areas for the educational activities. Two sites, E10 A&B, were placed at the transition zone between the Long Pine Key and the open marl prairie. The two monitors were separated by approximately 1000 feet. Site E10A was placed in the open prairie whereas site E10B was placed within a dense stand of trees. These two monitor sites were selected to help assess any spatial variation in the soundscape. Site E11 was in the open forest areas of the campgrounds in Long Pine Key. This site was not influenced by visitor intrusions during the monitor period since the campground was closed.

Two intruded sites were monitored in the Everglades. One, E12, was along Anhinga Trail and the other, E15, was near the Chekika parking lot. Anhinga Trail is a boardwalk that allows visitors to observe some of the wildlife and plants found in the Everglades. For the most part visitors tend to be quiet as they walk along the boardwalk. At Chekika, the site was placed at the edge of the parking lot and about 5 feet into the sawgrass. The sound levels at this site could be affected by cars as visitors entered and left the recreational area.

The last site at Everglades was in the Shark River Slough, E14. The actual location was 2 miles south of Highway 41 along the L-67 extension canal, which cuts through the center of Shark River Slough. This site is characterized as open prairie.

4.4 Acoustic Data

The acoustic data were analyzed and hourly, daily, and total L_{90}, L_{50}, L_{10} and L_{eq} metrics were calculated and transient sound events above a threshold were determined. The hourly metric analysis provides a good way to observe the diurnal variations occurring in the soundscape. Appendix F contains all of the monitored time histories.

Figure 4.2 shows a representative plot of these temporal variations. These data are from site B5 on Long Arsenicker Key. In this plot it can be seen that all of the metrics are within 5 dBA of each other during the evening hours and diverge during the daylight hours.

To assess diurnal variations the 24-hour day was separated into four periods:

- nighttime (2200 to 0459)
- sunrise (0500 to 0759)

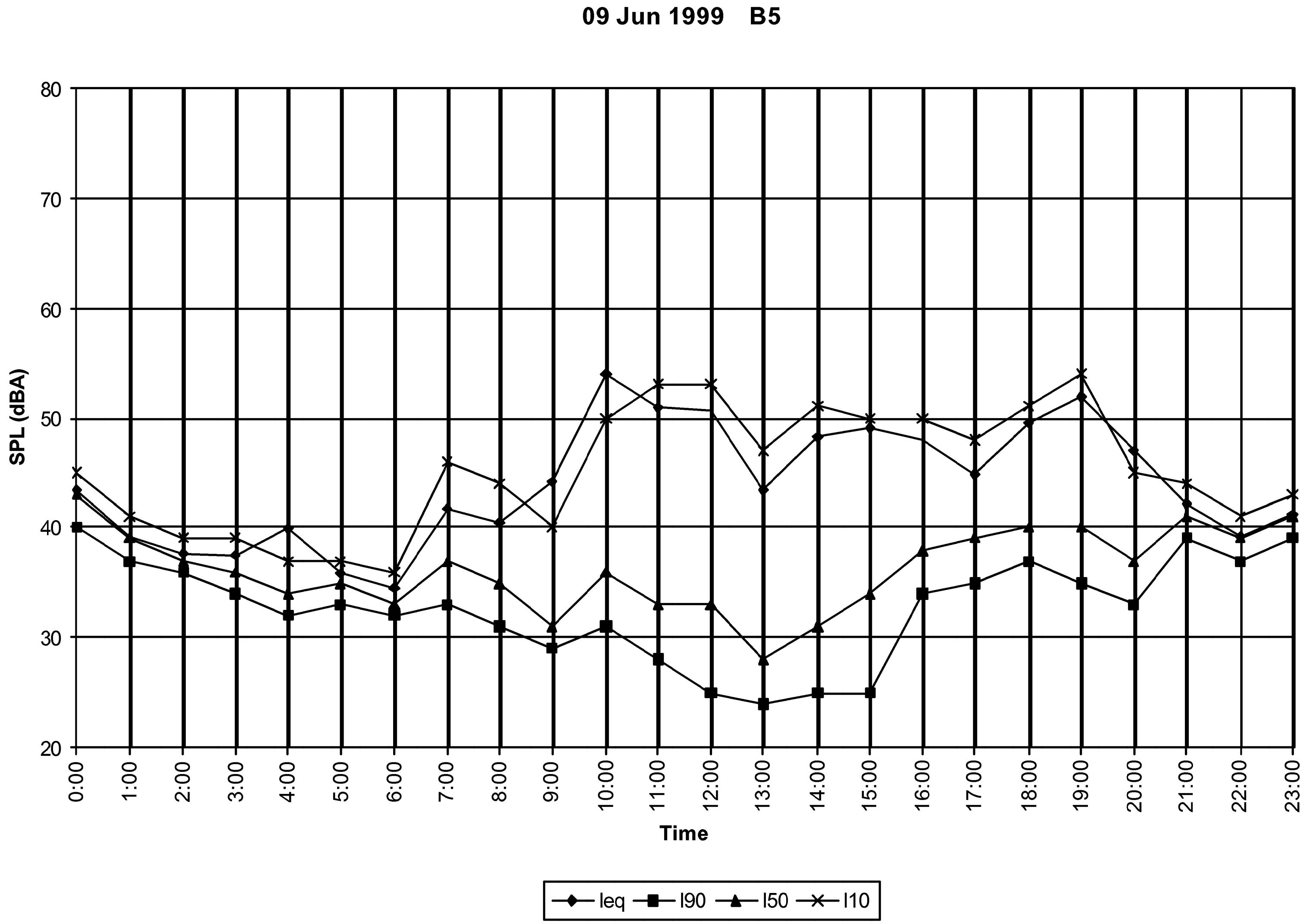


Figure 4.2. Example of Hourly Variation in Acoustic Metrics – Long Arsenicker Key

- daytime (0800 to 1859)
- sunset (1900 to 2159).

Table 4.2 provides the period breakdown along with the total values for all of the sites.

The total L_{90}, L_{50} and L_{10} metrics were determined from the entirety of the measured data at that site. These metrics are used to assess variations occurring among sites. L_{90} shows the variations occurring in the background sound levels, or the levels, occurring at a site. L_{50} demonstrates how the median sound levels vary. And, L_{10} and L_{eq} illustrate the variations occurring in the higher levels. When these three metrics are within 5 dBA, the total soundscape is fairly consistent over the recorded period. When they diverge, transient events are occurring that rise well above the background sound levels.

In the final data analysis, individual sound events that exceeded thresholds above the hourly, L_{90} at a site were identified. The hourly L_{90} was selected as the threshold basis since the reanalysis in Chapter 3 showed the L_{90} form the total populations of sound levels was essentially equal to the L_{90} of the subset of natural sound levels. Thus, the L_{90} determined from the unmanned data is a very good measure of the L_{90} of the natural soundscape.

This individual exceedance analysis shows when the natural background sound levels are concealed by louder transient sound events. Transient events are those events whose sound energy rises out of the background towards a maximum then diminish into the background over some short period. Examples of transient events are aircraft overflights, car drive bys, and thunder. This process does not judge the source of the transient event, but it does provide an assessment of the number and nature of transient occurring at a site.

Exceedance thresholds for transient identification were set at 10 dBA, 20 dBA, 30 dBA, and 40 dBA above the hourly L_{90}. These thresholds present exclusive groupings so that the first group would be for transient events that had an L_{Amax} between 10 and 20 dBA above the hourly L_{90}. The first 10 dBA step was chosen to identify transient events that would be perceived as twice as loud as the natural ambient background. The increasing thresholds represent events that are perceived to be approximately twice as loud as the preceding threshold.

To be identified as an intrusion, an event had to have a duration between 10 seconds to 15 minutes. For each such transient event, the actual duration was determined along

Table 4.2 Total and Period L_{90}, L_{50}, and L10 for Unmanned Measurements

Site	Acoustical Zone	L_{90}					L_{50}					L_{10}				
		Total	Night	Sunrise	Day	Sunset	Total	Night	Sunrise	Day	Sunset	Total	Night	Sunrsie	Day	Sunset
B 1	1	36	36	35	38	36	39	38	38	43	38	51	44	52	55	44
B 2	2	39	44	39	38	39	44	47	42	43	44	51	52	48	51	49
B 3	3	30	42	29	29	33	40	46	37	35	41	47	48	47	46	45
B 4	3	34	40	34	32	34	41	43	40	39	40	46	46	50	46	44
B 5	7	32	34	32	30	37	40	39	34	41	43	49	44	40	52	49
B 6	7	29	32	32	28	28	38	40	40	35	37	45	44	45	46	46
B 7	6	33	33	32	34	33	36	34	35	39	36	49	41	51	52	48
B 8	5	34	31	29	35	41	48	46	46	49	49	55	54	56	56	56
B 9	5	33	34	28	34	41	44	47	36	44	47	54	54	41	55	53
E 1	6	34	36	41	31	32	41	38	44	46	36	52	43	47	53	45
E 2	4	30	39	42	28	31	41	45	46	35	40	47	48	49	44	46
E 3	7	25	28	26	24	24	32	32	29	35	30	46	40	34	49	48
E 4	7	33	44	37	31	37	43	49	43	38	45	51	51	45	45	49
E 5	3	39	55	48	36	44	51	63	51	46	58	69	76	62	52	64
E 6	2	28	42	29	26	32	40	46	36	32	47	54	61	41	44	69
E 7	3	28	53	35	26	33	44	55	42	32	54	60	61	58	45	65
E 8	4	28	38	31	26	30	38	41	38	34	39	47	48	44	44	47
E 9	2	33	50	39	31	33	45	51	42	38	49	52	52	49	46	54
E 10A	4	39	44	45	37	40	46	48	48	44	46	56	55	52	58	64
E 10B	2	36	47	40	34	40	47	53	42	41	53	61	69	49	56	63
E 11	2	35	42	43	32	36	43	45	45	39	45	47	47	48	46	48
E 12	1	35	38	39	34	33	41	41	41	40	42	48	43	45	53	48
E 14	4	35	38	38	33	39	42	43	41	39	56	57	56	45	50	63
E 15	1	39	45	43	37	37	47	49	48	44	44	54	54	53	52	59
average		33.2	40.2	36.1	31.8	35.1	42.1	45.0	41.0	39.6	44.1	52.0	51.3	48.0	49.8	52.8
st dev		3.9	6.9	6.0	4.1	4.7	4.2	6.8	5.1	4.6	6.8	5.7	8.8	6.1	4.5	8.0

with the maximum A-weighted level and the L_{eq} for the event. Figure 4.3 provides an example of the transient event identification. This example shows 20 minutes of the sound level time history obtained at Anghinga Trail on 12 June 1999. During this hour the L_{90} was 41 dBA: thus the threshold levels are set at 51 (L_{90} + 10 dBA), 61 (L_{90} + 20 dBA), 71 (L_{90} + 30 dBA), and 81 (L_{90} + 40 dBA). One transient event which starts at 8:10:00 is identified in Figure 4.3. This event rises above the first threshold level for 46 seconds (8:10:12 to 8:10:58) which is greater than the 10 second duration threshold. For this transient event, the maximum level was 56 dBA, and its sound exposure level was 71 dBA. It is also important to note the very short event that occurs at 8:09:26. Even though the maximum level of this event is 52 dBA, it is not classified as a transient event because its duration is less than one second.

The one-hour averaged values of the transient events are provided in Section 4.5.2. The number of individual exceedances occurring are grouped by hour to show temporal variation of these transient sound events. the number of events was averaged for each hour based on the number of times that hour was monitored. Appendix H contains the plots of number of occurrences for each hour for each site.

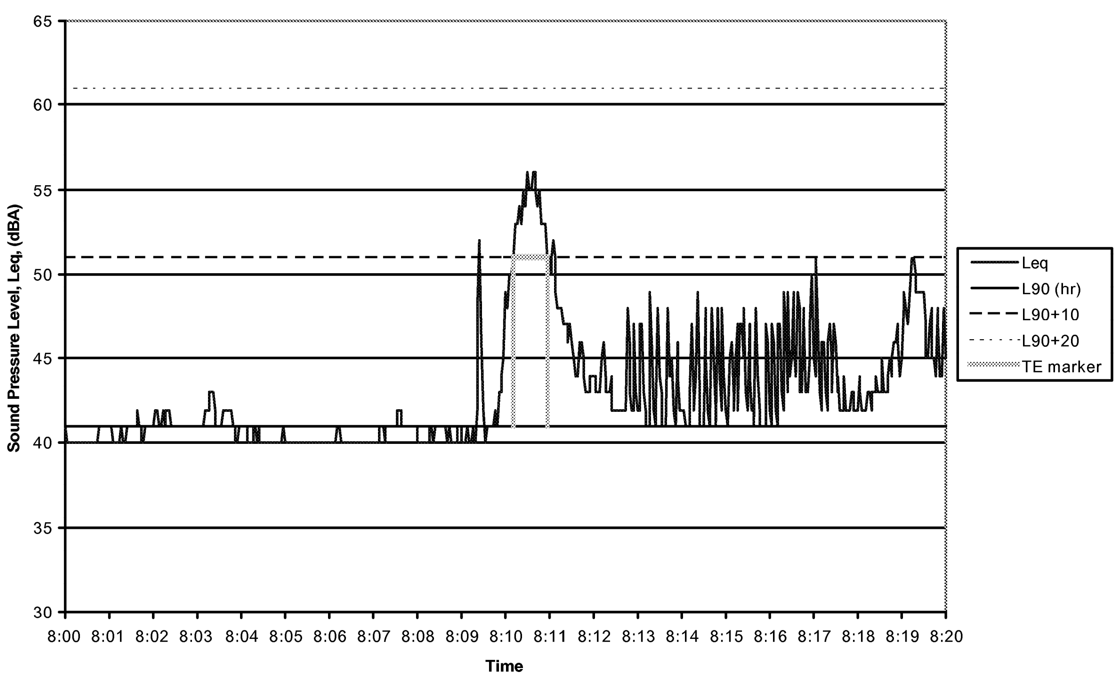


Figure 4.3. Transient event identification example: Anhinga trail on 12 June 1999

4.4.1 Biscayne NP

B1 Convoy Point: This site was monitored for 49 hours between 14 and 16 June 1999. During this period, the L_{90} of 38 dBA with a daytime L_{90} of 38 dBA being the loudest and with a nighttime, sunrise and sunset L_{90} of 36 dBA, 35 dBA, and 36 dBA, respectively. The L_{50} was 39 dBA with the high of 43 dBA also occurring during the daytime. The L_{10} was 51 dBA with a maximum of 55 dBA occurring during the daytime period. For a threshold of 10 dBA above the L_{90} the average hourly number of transient events was 3.9 with an average duration of 49 seconds. Transient events were greatest during the daytime with an average of 8 events per hour. For this exceedance threshold, the maximum number of occurrences per hour was 10. For the hourly variation, L_{90}, L_{50}, L_{10}, and Leq were within 5 dBA during the night and separated during the daytime. The separation started around 0600 and ended around 1900, which agree with the variation in the number of exceedances. These findings agree with expectations that visitors impact the natural soundscape during the daytime at this site.

B2 Elliot Key: This site monitored for 162 hours between 7 and 14 June 1999. During this period the L_{90} was 39 dBA with a nighttime L_{90} of 44 dBA being the loudest and with a sunrise, daytime, and sunset L_{90} of 39 dBA, 38 dBA, and 39 dBA, respectively. The L_{50} was 44 dBA with the high of 47 dBA also occurring during the nighttime. The L_{10} was 51 dBA with a maximum of 52 dBA occurring during the nighttime period. for a threshold of 10 dBA above the L_{90} , the average hourly number of transient events was 5.3 with a duration 32 seconds. These low threshold events occurred throughout the day; the events with a threshold of 20 dBA above the L_{90} were also greatest during the daytime. The greatest number of events was 13 per hour for the exceedance threshold of 10 dBA above the L_{90} and 5 per hour for a threshold of 20 dBA above L_{90}. for the hourly variation, L_{90}, L_{50}, L_{10}, and L_{eq} were within 5 dBA during most of the monitoring period except for a few times during the daytime. These finds demonstrate that the sound levels are fairly constant over the day with most intrusion occurring during the daylight hours. Also, it is important to note that the air conditioners and generators at the nearby building probably increased the sound levels at this site. This increase can be seen by comparing the L_{90} measured at this site to the L_{90} measured at sites B3 and B4 described later.

B3 Hiking Trail North of Elliot Key: This site was monitored for 94 hours between 7 and 11 June 1999. During this period the L_{90} was 30 dBA with a nighttime L_{90} of 42 dBA being the loudest and with a sunrise, daytime, and sunset L_{90} of 29 dBA, 29 dBA, and 33 dBA, respectively. The L_{50} was 40 dBA with the high of 46 dBA occurring during the nighttime. The L_{10} was 47 dBA with a maximum 48 dBA occurring during the nighttime period. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 4.9 with a duration of 22 seconds. The number of events was greatest during the daytime with a peak occurring around noon. For this threshold, the maximum number of occurrences was 37 during 1200 to 1300. For the hourly variation, L_{90}, L_{50}, L_{10} and L_{eq} were within 3 dBA during the nighttime hours with the L_{90}, and L_{50} decreasing during the daylight hours. The sound levels at this site showed a definite diurnal pattern with the quietest background noise occurring during the daytime.

<u>B4 Hiking Trail South of Elliot Key:</u> This site was monitored for 45 hours between 7 and 9 June 1999. During this period the L_{90} was 34 dBA with a nighttime L_{90} of 40 dBA being loudest and with a sunrise, daytime, and sunset L_{90} of 34 dBA, 32 dBA, and 34 dBA, respectively. The L_{50} was 41 dBA with the high of 43 dBA occurring during the nighttime. The L_{10} was 46 dBA with a maximum of 50 dBA occurring during the sunrise period. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 4.6 with a duration of 33 seconds. The events were greatest during the daytime with peaks occurring around sunrise, and from 1300 to 1400. For the hourly variation , L_{90}, L_{50}, L_{10}, and L_{eq} were within 3 dBA during the nighttime hours with the L_{90} and L_{50} decreasing during the daylight hours. The sound levels monitored at site B4 are greater than the corresponding levels at site B3. These increased levels may have resulted from a generator that was just audible at the site during set up and tear down. The sound levels at this site showed a diurnal pattern with the quietest background noise occurring during the daytime.

<u>B5 Long Arsenicker Key:</u> This site was monitored for 69 hours between 7 and 10 June 1999. During this period, the L_{90} was 32 dBA with the highest L_{90} of 37 dBA occurring at sunset and with a nighttime, sunrise, and daytime L_{90} of 34 dBA, 32 dBA, and 30 dBA, respectively. The L_{50} was 40 dBA with the high of 43 dBA occurring during sunset. The L_{10} was 49 dBA with a maximum of 52 dBA occurring during the daytime. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 5.0 with a duration of 52 seconds. The events were greatest during midday. For this threshold, the maximum number of occurrences was 22 during 1500. For the hourly values, L_{90}, L_{50}, L_{10}, and L_{eq} were within 5 dBA during the nighttime hours with the L_{90} and L_{50} decreasing and the L_{10} and L_{eq} increasing during the daylight hours. The sound levels at this site showed a diurnal pattern with the quietest background noise occurring during the day time. Also, this site had significant increase of transient events during the daytime as can be seen in the 20 dBA separation between the L_{90} and L_{10} values.

<u>B6 Old Rhodes Key:</u> This site was monitored for 163 hours between 7 and 14 June 1999. During this period the L_{90} was 29 dBA with the highest L_{90} of 32 dBA occurring at

nighttime and sunrise and with a daytime and sunrise L_{90} of 28 dBA. The L_{50} was 38 dBA with the high of 40 dBA occurring during nighttime and sunrise. The L_{10} was fairly constant at 45 dBA throughout the day. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 8.1 with a duration of 60 seconds. The number of events was greatest during the daylight hours and was fairly constant during these hours with some events occurring during nighttime. For the hourly variation, L_{90}, L_{50}, L_{10}, and L_{eq} did not show a strong diurnal pattern. The levels were close for some nights although this did not occur all of the time. There appears to be a general increase in the sound levels form 0300 to 0600.

B7 Adam's Key: This site was monitored for 166 hours between 7 and 14 June 1999. During this period the L_{90} was 33 dBA with the highest L_{90} of 34 dBA occurring at daytime and with a nighttime, sunrise, and sunset L_{90} of 33 dBA, 32 dBA, 33 dBA, respectively. The L_{50} was 36 dBA with the high of 39 dBA occurring during daytime. The L_{10} was 49 dBA with a maximum of 52 dBA occurring during the daytime. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient event was 5.0 with a duration of 47 seconds. The events were level during the daylight hours with some minor peaks at 1100 and 1400 hours. For this threshold, the maximum number of occurrences was 20 during 1100. for the hourly variation, L_{90}, L_{50}, L_{10}, and L_{eq} were within 5 dBA during the nighttime hours with the L_{10} and Leq increasing during the daylight hours. For most of the monitoring period the L_{90} and L_{50} were within 3 dBA of each other except during the weekend daylight hours when they were separated by 5 to 10 dBA. The sound levels at this site showed a diurnal pattern in L_{10} and Leq with the quietest background noise defined by L_{90} remaining constant over the entire monitoring period. It should be noted that this site was influenced by the power generator utilized on the key. In addition, this site had significant increase of transient events during the daytime as can be seen in the 15 dBA separation between the L_{90} and L_{10} values.

B8 Shoal Warning Post at Feathered Bank: This site was monitored for 166 hours between 7 and 14 June 1999. During this period, The L_{90} was 34 dBA with the highest L_{90} of 41 dBA occurring at sunset and with a nighttime, sunrise, and daytime L_{90} of 31 dBA, 29 dBA, and 35 dBA, respectively. The L_{50} was 48 dBA with the high of 49 dBA occurring during daytime and at sunset. The L_{10} was 55 dBA with a maximum of 56 dBA occurring during the daylight hours. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 5.3 with a duration of 38 seconds. For this threshold, the events were common throughout the day with an increase in the early daylight hours. for the higher thresholds, the events were prevalent during the daylight hours and were minimal at night. For the exceedance threshold of 10 dBA above the L_{90}, the maximum number of occurrences was 14 during 0700. There was a large day to day variation observed in the hourly L_{90}, L_{50}, L_{10}, and L_{eq} values. Most of the time they were within 10 dBA of each other but with no real dependence found with time of day. The wide variations observed suggest that the monitored levels were possibly controlled by the wind. The type of windscreen utilized would lose it effectiveness for wind speed above 10 mph.

B9 Shoal Warning Post at Pelican Bank: This site was monitored for 166 hours between 7 and 14 June 1999. During this period, the L_{90} was 33 dBA with the highest L_{90} of 44 occurring at sunset and with a nighttime, sunrise and daytime L_{90} of 34 dBA, 28 dBA, and 34 dBA, respectively. The L_{50} was 44 dBA with the high of 47 dBA occurring at sunset and during nighttime. The L_{10} was 54 dBA with a maximum of 56 occurring during the daylight hours. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 7.7 with a duration of 51 seconds. Events occurred throughout the day for the low threshold and during the daylight hours for the higher thresholds similar to the observations at site B8. For the exceedance threshold of 10 dBA above the L_{90}, the maximum number of occurrences was 31 during 1400 to 1500. There was a large day to day variation observed in the hourly L_{90}, L_{50}, L_{10}, and L_{eq} similar to that seen at site B8. Most of the time they were within 10 dBA of each other but with no real dependence found with time of day. Comparison with site B8 shows similar results in the levels. Thus, the monitor levels were consistent across the open water.

4.4.2 Everglades NP

E1 Carl Ross Key: This site was monitored for 24 hours between 17 and 18 June 1999. During this period, the L_{90} was 34 dBA with a L_{90} of 41 dBA at sunrise being the loudest and with a nighttime, daytime, and sunset L_{90} of 36 dBA, 31 dBA, and 32 dBA respectively. The L_{50} was 41 dBA with the high of 46 dBA occurring during the daytime. The L_{10} was 52 dBA with a maximum of 53 dBA occurring during the daytime period. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 7.7 with a duration of 38 seconds. Events were greatest during the midday with other peaks occurring around sunrise and sunset. For this threshold, the maximum number of occurrences was 32 during 1200. For the hourly variation, L_{90}, L_{50}, L_{10} and L_{eq} were within 8 dBA during the nighttime hours. The limited monitoring period precludes any strong statement about time of day variations.

E2 Coastal Prairie Trail: This site was monitored for 71 hours between 15 and 18 June 1999. During this period, the L_{90} was 30 dBA with the highest L_{90} of 42 dBA occurring at sunrise and with a nighttime, daytime, and sunset L_{90} of 39 dBA, and 31 dBA, respectively. The L_{50} was 41 dBA with the high of 46 dBA occurring at sunset. The L_{10}

was 47 dBA with a maximum of 49 dBA occurring at sunrise. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 8.4 with a duration of 45 seconds. Events ere greatest during the daylight hours for all threshold levels. For this threshold, the maximum number of occurrences was 25 during 1100. For the hourly values, L_{10} and L_{eq} were somewhat constant during the monitored period, and the L_{90} and L_{50} exhibited a diurnal pattern with decreases during the daylight hours. During the nighttime, all of the levels were within 5 dBA of each other . Thus, the daylight hours had the quietest background levels as defined by the L_{90} and L_{50}.

<u>E3 South Joe River Chickee:</u> This site was monitored for 71 hours between 14 and 17 June 1999. During this period, the L_{90} was 25 dBA with the highest L_{90} of 28 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 26 dBA, 24 dBA, and 24 dBA, respectively. The L_{50} was 32 dBA with the high of 35 dBA occurring during daytime. The L_{10} was 46 dBA with a maximum of 49 dBA also occurring daytime. For threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 9.6 with a duration of 27 seconds. Events were greatest during the late afternoon (1500-1800). For this threshold, the maximum number occurrences was 36 during 1600. For the hourly values, L_{90}, and L_{50} are within 5 dBA except for the period where there are many exceedances. As for L_{10} and L_{eq}, there is a large scatter in the data. The pattern suggests loud transient events are occurring during the morning to late afternoon periods at this site. L_{90} and L_{50} showed diurnal pattern with decreases during the daylight hours. During the early morning hours, the exceedance levels were within 5 dBA of each other. The quietest hours were between midnight and noon. This site had the lowest observed L_{90} values of the study.

<u>E4 North Harney River Shoreline:</u> This site was monitored for 70 hours between 14 and 17 June 1999. During this period, the L_{90} was 33 dBA with the highest L_{90} of 44 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 37 dBA, 31 dBA, and 37d BA, respectively. The L_{50} was 43 dBA occurring during nighttime. The L_{10} was 51 dBA with a maximum of 51 dBA also occurring during nighttime. Transient events occurred between 1300 and 1900. At all other hours the number of transient events was negligible. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 2.4 with a duration of 37 seconds. For this threshold, the maximum number of occurrences was 18 during 1400 and 1500. For the hourly values, L_{90}, L_{50}, L_{10}, and Leq ere within 5 dBA except for the periods where there were transient events. The values were loudest during the nighttime and quietest during the daytime. Thus, a diurnal pattern exist at this site. Also, during observations at this site several commercial aircraft overflights were seen and heard. During the hour of observation, aircraft noise was above the natural background for 16 minutes.

<u>E5 Mangrove Forest along North Harney River:</u> This site was monitored for 70 hours between 14 and 17 June 1999. During this period, the L_{90} was 39 dBA with the highest L_{90} of 55 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 48 dBA, 36 dBA and 44 dBA, respectively. The L_{50} was 51 dBA with the high of 63 dBA occurring during nighttime. The L_{10} dBA 69 dBA with a maximum of 76 dBA also occurring during nighttime. For a threshold set 10 dBA above L_{90}, the average hourly number of transient events was 3.1 with a duration of 43 seconds. Transient events occurred between 1300 and 2000 with minor events during 0400 and 0500. At all other hours the number of transient events was negligible. For this threshold, the maximum number of occurrences was 21 during 1800. For the hourly value, L_{90}, L_{50}, and L_{10} were within 8 dBA except for the periods where there were transient events. However, it should be noted that during the nighttime the levels were unexpectedly high. For two of the three nights, the L_{90} was above 70 dBA whereas it was 57 for the other night. Weather records indicate that there were local rain showers during the quietest night, which probably limited animal sounds. Since no direct observation were made during this period, the exact source of the high sound levels can not be identified. No obvious equipment problems were found, so the sound levels at this site need to be directly observed to verify or to correct the monitored levels. Otherwise, it can be stated that a diurnal pattern exists with the levels loudest during the nighttime and quietest during the daytime.

<u>E6 Outside Mahogany Hammock:</u> This site was monitored for 44 hours between 9 and 11 June 1999. During this period, the L_{90} was 28 dBA with the highest L_{90} of 42 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 29 dBA, and 32 dBA, d respectively. The L_{50} was 40 dBA with the high of 47 dBA occurring at sunset. The L_{10} was 54 dBA with a maximum of 69 dBA also occurring at sunset. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 10.0 with a duration of 26 seconds. Large numbers of transient events occurred during the daylight hours at this site. During the night, the number of transient events was negligible. For this threshold, the maximum number of occurrences was 40 during 1000 to 1100. For the hourly values, L_{90}, L_{50}, L_{10} and L_{eq} were within 3 dBA during most of the nighttime hours. Large differences in the values were present during the day light hours as a result of the large number of transients events. L_{90} and L_{50} show a diurnal dependence as the levels were lowest during the day and increased at night.

<u>E7 Inside Mahogany Hammock</u>: This site was monitored for 44 hours between 9 and 11 June 1999. During this period, the L_{90} was 28 dBA with the highest L_{90} of 53 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 25 dBA, 26

dBA, and 33 dBA, respectively. The L_{50} was 44 dBA with the high of 55 dBA occurring during nighttime. The L_{10} was 60 dBA with a maximum of 65 dBA occurring at sunset. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 6.8 with a duration of 25 seconds. Similar to site E6, large numbers of transient events occurred during the daylight hours at this site. During the night, the number of transient events was negligible. For this threshold, the maximum number of occurrences was 30 during 0900. For the hourly values, L_{90} and L_{50} are within 3 dBA for most of the time and they show a strong diurnal dependence between night and day. The daytime values are about 25 dBA lower than the nighttime values. During the night, all of the metrics are within 5 dBA. Large differences in the values were present during the daylight hours as a result of the large number of transient events. L_{90} and L_{50} show a diurnal dependence as the levels were lowest during the day and increased at night. Compared to site E5, this site also had loud sound levels during the night as seen with L_{90} values greater than 50 dBA.

E8 Prairie in Taylor Slough near Ernest Coe Campsite: This site was monitored for 74 hours between 11 and 14 June 1999. During this period, the L_{90} was 28 dBA with the highest L_{90} of 38 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 31 dBA, 26 dBA, and 30dBA, respectively. The L_{50} was 38 dBA with the high of 41 dBA occurring during nighttime. The L_{10} was 47 dBA with a maximum of 48 dBA also occurring at nighttime. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 10.4 with a duration of 29 seconds. Many transient events occurred between 0700 and 2000 with strong peaks at 0700 and 1400 at this site. During the night, the number of transient events was negligible except for some peaks at 0100 and 2300 hours. For this threshold, the maximum number of occurrences was 44 during 1500 to 1600. For the hourly values, L_{90} and L_{50} are separated by 5 dBA for most of the daytime and are within 3 dBA during the nighttime. A strong diurnal dependence between night and day was present with the daytime values being 10 to 15 dBA lower than the nighttime values. During the night, all of the exceedance metrics are within 5 dBA. Large differences in the values were present during the daylight hours as a result of the large number of transient events. L_{10} and L_{eq} show a weak diurnal dependence as the levels were below 40 dBA through the day and higher than 40 dBA at night. The USGS monitoring station was near this site and provided weather data for comparison to the sound levels. No strong relationship was found for any weather parameter, even wind speed. Wind speeds varied from 0 to 10 knots, and recorded sound levels were independent of the wind speed.

E9 Hidden Lake Education Center: This site was monitored for 43 hours between 11 and 13 June 1999. During this period, the L_{90} was 33 dBA with the highest L_{90} of 50 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 39 dBA, and 33 dBA, respectively. The L_{50} was 45 dBA with the high of 51 dBA occurring during nighttime. The L_{10} was 52 dBA with a maximum of 54 dBA occurring at sunset. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 4.5 with a duration of 39 seconds. Many transient events occurred between 0600 and 1900 at this site. During the night, no exceedances were monitored. For this threshold, the maximum number of occurrences was 31 during 1100 to 1200. For the hourly values, L_{90}, L_{50}, L_{10}, and L_{eq}. All of the metrics showed a diurnal pattern with the daytime being the quietest time and the dependence was strong for L_{90} and L_{50}. During the night, the levels were loud with an L_{50} of 50 dBA..

E10A Transition Zone between Marl Prairie and Pinelands: This site was in the open prairie part of the transition zone. This site was monitored for 90 hours between 15 and 19 June 1999. During this period, the L_{90} was 39 dBA with the highest L_{90} of 45 dBA occurring at sunrise and with a nighttime, daytime and sunset L_{90} of 44 dBA, and 40 dBA, respectively. The L_{50} was 46 dBA with the high of 48 dBA occurring during nighttime and sunrise. The L_{10} was 56 dBA with a maximum of 64 dBA occurring at sunset. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 3.8 with a duration of 38 seconds. Most transient events occurred between 0800 and 1100 at this site. For this threshold, the maximum number of occurrences was 17 during 0800. For the hourly values, L_{90}, L_{50}, L_{10}, and L_{eq} were within 2 dBA during the entire monitoring period. L_{90} and L_{50} are separated by 3 dBA for most of the time. Variations are seen but no string diurnal effect was observed. One day the levels are constant throughout the entire day while for another day they are elevated during the evening hours.

E10B Transition Zone between Marl Prairie and Pinelands: This site was in a stand of pine and other trees in the transition zone. This site was monitored for 90 hours between 15 and 19 June 1999. During this period, the L_{90} was 36 dBA with the highest L_{90} of 47 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 40 dBA, 34 dBA, and 40 dBA, respectively. The L_{50} was 47 dBA with the high of 53 dBA occurring during nighttime and at sunset. The L_{10} was 61 dBA with a maximum of 69 dBA occurring during nighttime. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 6.6 with a duration of 40 seconds. Most transient events occurred between 0200 and 1700 at this site. For this threshold, the maximum number of occurrences was 18 at 1200. During the night, L_{90}, L_{50}, L_{10} and L_{eq} were within 5 dBA and the levels were high especially around midnight where the levels were around 70 dBA. During the day, the spread in the values was about 10 dBA although there were some time when the values were within 2 dBA of one other. The levels were consistently high during the night and low during the day. The daily variations were not the same for the four-day monitoring period, which means other factors beside diurnal effect were influencing the sound levels at this site.

<u>E11 Long Pine Key Campground</u>: This site was monitored for 69 hours between 15 and 18 June 1999. During this period, the L_{90} was 35 dBA with the highest L_{90} of 43 dBA occurring at sunrise and with a nighttime, daytime, and sunset L_{90} of 42 dBA, and 36 dBA, respectively. The L_{50} was 43 dBA with the high of 45 dBA occurring during nighttime, sunrise and sunset. The total L_{10} was 47 dBA with a maximum of 48 dBA occurring at sunrise and sunset. For a threshold of dBA above the L_{90}, the average hourly number of transient events was 4.5 with a duration of 41 seconds. Most transient events occurred between 0800 and 2000 at this site. For this threshold, the maximum number of occurrences was 15 that occurred at 1000 to 1100. During the night, L_{90}, L_{50}, L_{10} and L_{eq} were within 4 dBA. During the day, L_{90} and L_{50} decreased about 10 dBA on average and they were separated by 3 dBA.

<u>E12 Anhinga Trail</u>: This site was monitored for 69 hours between 11 and 13 June 1999 which was the weekend when the site is expected to have the most visitation and therefore significant amount of noise intrusions should have occurred. During this period, the L_{90} was 35 dBA with the highest L_{90} of 39 dBA occurring at sunrise and with a nighttime, daytime, and sunset L_{90} of 38 dBA, 34 dBA, and 33 dBA, respectively. The L_{50} was 41 dBA with the high of 42 dBA occurring at sunset. The L_{10} was 48 dBA with a maximum of 53 dBA occurring during the day. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 6.4 with a duration of 27 seconds. Most transient events occurred between 1000 and 2000 as expected. During the nighttime, minimal events were observed. For this threshold, the maximum number of occurrences was 35 that occurred at 1500 to 1600. During the night, L_{90}, L_{50}, L_{10} and L_{eq} were within 4 dBA. During the daylight hours, L_{90} and L_{50} decreased slightly, and L_{10} and L_{eq} increased slightly as a result of visitors. The quietest period as defined by L_{90} occurred during late afternoon.

<u>E14 Prairie in Shark Valley</u>: This site was monitored for 73 hours between 16 and 19 June 1999. During this period, the L_{90} was 35 dBA with the highest L_{90} of 39 dBA occurring at sunset and with a nighttime, sunrise, and daytime L_{90} of 38 dBA, 38 dBA, and 33 dBA, respectively. The L_{50} was 42 dBA with the high of 56 dBA occurring at sunset. The L_{10} was 57 dBA with a maximum of 63 dBA also occurring at sunset. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 9.0 with a duration of 32 seconds. Transient events occurred throughout the day except for the hours of 2100 and 2200. For this threshold, peaks of 26 events occurred at 1100

to 1200. For the hourly values, L_{90} was about 10 dBA lower than L_{10} and 2 to 5 dBA lower than L_{50}. L_{90} was highest during sunset and lowest during daytime. The increased levels observed at sunset were repeatable. Field observation at this site noted low rumbles of airboats and aircraft. This site was close to several air tour boat operators who are along Highway 41 directly north of the park.

E15 Chekika: This site was monitored for 74 hours between 16 and 19 June 1999. During this period, the L_{90} was 39 dBA with the highest L_{90} of 45 dBA occurring during nighttime and with a sunrise, daytime, and sunset L_{90} of 43 dBA, 37 dBA, and 37 dBA, respectively. The L_{50} was 47 dBA with the high of 49 dBA occurring during nighttime. The L_{10} was 54 dBA with a maximum of 59 dBA occurring at sunset. For a threshold of 10 dBA above the L_{90}, the average hourly number of transient events was 6.2 with a duration of 33 seconds. Transient events occurred between 1000 and 2000. For this threshold, about 14 events per hour occurred during this period. For the hourly values, L_{90} was 2 to 5 dBA lower than L_{50} L_{90} and L_{50} were highest during sunset and lowest during the afternoon. The increased levels observed at sunset were repeatable.

4.5 Observations

4.5.1 Overall

The collected sound level data describes the sound energy that currently exists at Biscayne and Everglades National Parks. Sound energy data demonstrate the range of levels occurring within the parks and provides a basis for defining potential intrusive sound events. It is important to understand that these data are based on sound energy and not on audibility. The sound levels were collected with an A-weighting filter and nothing can be inferred about the frequency content of the monitored sound spectra. Therefore, these data should not be used to define the audibility of a particular sound source such as a boat or an airplane. Figures 4.4, 4.5, and 4.6 show the L_{90}, L_{50}, and L_{10}, respectively, of the monitored sound level data.

Table 4.2 in Section 4.4 provided the average of the total L_{90}, L_{50} and L_{10} measurements at each site. The average L_{90} was 33 dBA with a standard deviation of 4 dBA. Thus, the overall L_{90} occurring within the parks has minimal variation. The L_{90} had an absolute measured range from a low of 25 dBA at E3 (South Joe River Chickee) in the Everglades to a high of 39 dBA at B2 (Elliot Key picnic area), at E10A (transition zone between the Marl Prairie and the Pinelands), and at E15 (Chekika).

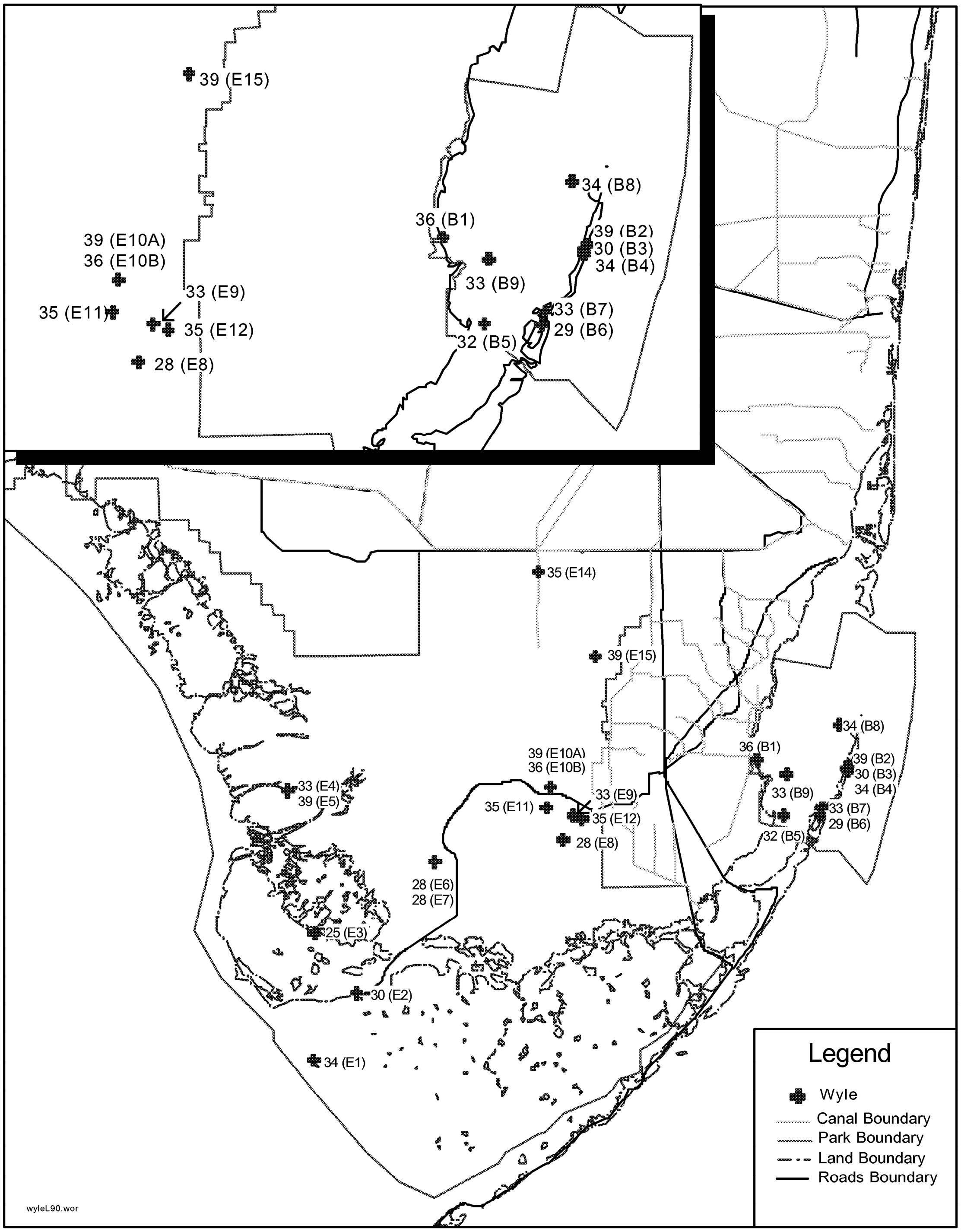


Figure 4.4. Map of L_{90} Based on Unmanned Measurements

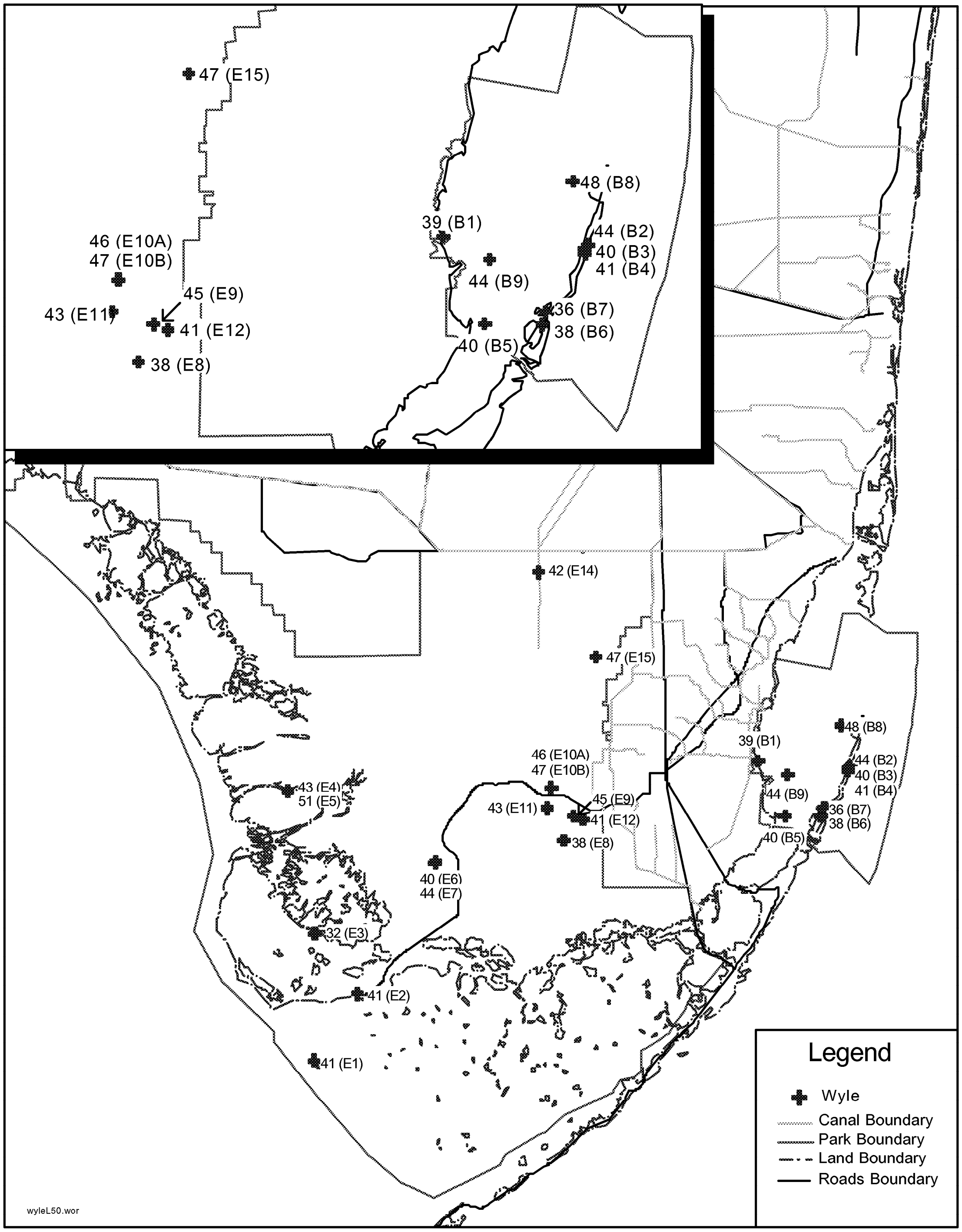


Figure 4.5. Map of L_{50} based on Unmanned Measurements

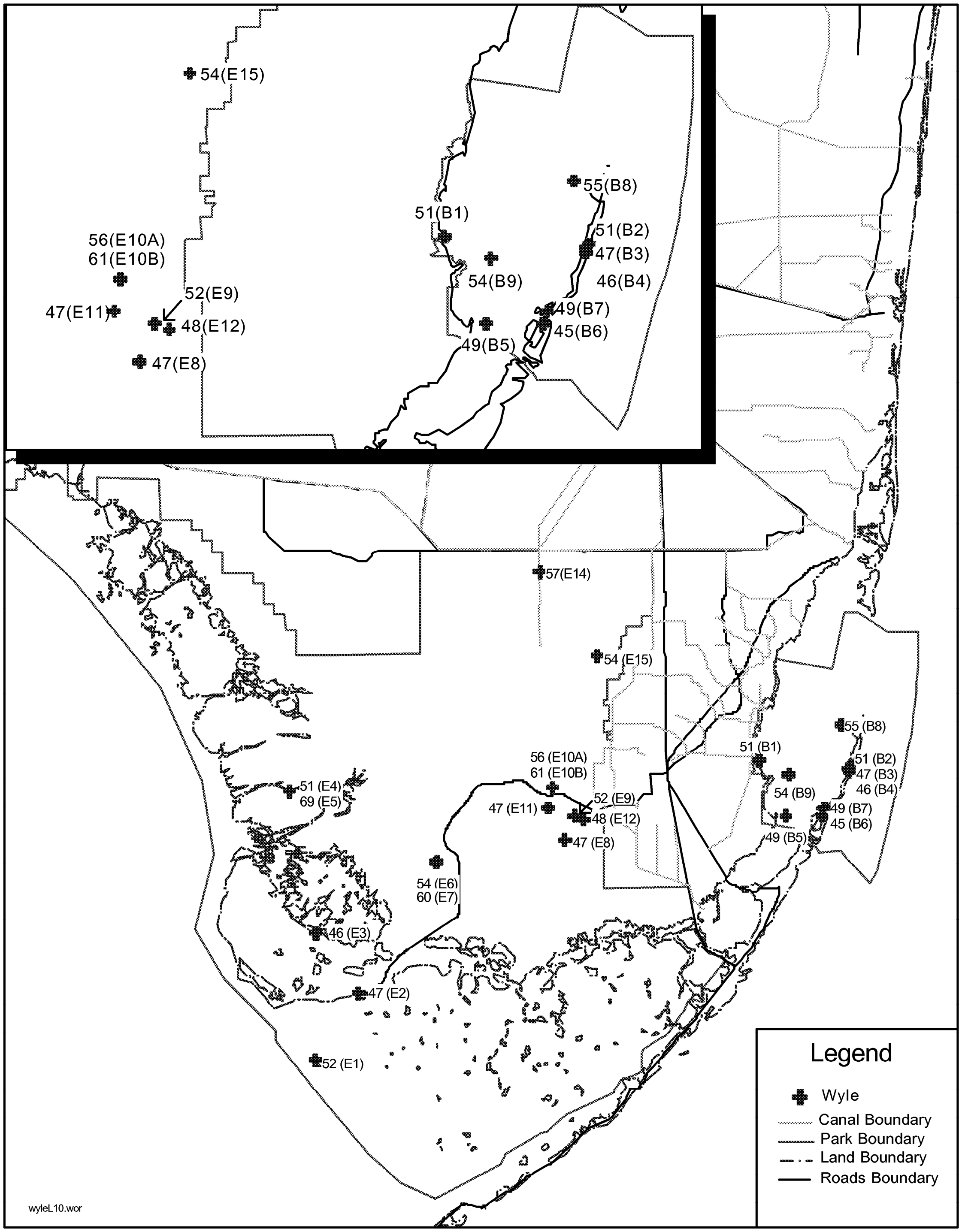


Figure 4.6. Map of L_{10} based on Unmanned Measurements

The average L_{50} was 42 dBA with a standard deviation of 4 dBA, again showing that the median sound levels varied little throughout the area. The measured range of the L_{50} was a low of 32 dBA also at E3 (South Joe River Chickee) and a high of 51 dBA at E5 (Mangrove Forest along North Harney River). The average L_{10} was 52 dBA with a standard deviation of 6 dBA. The measured range of L_{10} was from 45 dBA at B6 (Old Rhodes Key) to 69 dBA at E5 (Mangrove Forest along North Harney River). Thus, the L_{10} was more variable than the L_{90} and L_{50}, most likely because it was influenced by different sets of intrusive events at each site.

An important finding to note is the similarity between L_{10} and L_{eq}. For the hourly values, these two metrics were similar in magnitude. This equivalent relationship means that using L_{eq} to represent the average acoustical energy for a given period as the basis for defining the background sound levels inappropriately skews the definition of natural ambient toward higher levels. For this data set, using L_{eq} to define the baseline for natural ambient sound levels would set the baseline sound levels about 20 dBA higher compared to using L_{90}. This difference is significant in terms of acoustical energy.

The L_{90} hourly levels were close to the L_{50} and L_{10} levels when the sound level was constant. This occurred mostly at night and indicates the absence of intruding non-natural sources. The diurnal variation observed in L_{10} correlates with the number of hourly transient events. This result is as expected since transient events will cause a separation between L_{90}, L_{50}, and L_{10} by creating a greater distribution of observed sound levels.

From the reanalysis in Chapter 3, it was noted that the L_{90} of the totality of sounds is an accurate measure of the L_{90} of the natural sounds. The total L_{50} was shown to be above the natural L_{50} due to intrusive events. Thus, in using L_{50} as a basis one must adjust the unmanned measurements of L_{50} to account for the effect of intrusive events, whereas the unmanned measured L_{90} needs no adjustment. Therefore, the L_{90} obtained by unmanned monitoring provides the natural background sound levels and furnishes a solid basis for determining intrusive event threshold levels.

The soundscape at Site B2 appears to be effected by the air conditioners and generators at the visitor area. The L_{90} level recorded here was 5 to 9 dBA higher than levels recorded ½ mile north and south of this location (sites B3 and B4). Also comparing with similar acoustical zones (open forest), this site had the highest L_{90} of the group but its L_{50} and L_{10} values were lower within the group. This finding suggests that air conditioners and generators are effecting the background levels, thereby making it impossible to determine the natural soundscape at this location.

Another observation about potential impact is for Anhinga Trail. Visitors do not appear to greatly increase the sound levels as expected. The L_{90}, L_{50}, and L_{10} values are similar to those in the open forest acoustical zones (except B2 as noted above). Transient events are noted to occur primarily during the daylight hours when visitor are present but their disruptions do not greatly impact the natural soundscape. Thus, it can be inferred that most visitors are quiet and respectful as they observe the environment at this location.

4.5.2 Transient Events

The measured number of transient events provides an assessment of the level of intruding sound events occur3ring during a given period. Transient events were defined by thresholds with offsets of 10, 20, 30, and 40 dBA above the hourly L_{90}. These events were also defined by their durations. The minimum duration was set at 10 seconds with a maximum of 15 minutes. The minimum limit filters out short events such as birdcall, and the maximum limit filters out sound level shifts that result from shifts in the background from daytime to nighttime levels. These long duration events were natural transitions between daytime lower levels to higher levels at nighttime. This identification of transient events does not attempt to identify the sources of the transient events. A series of detailed observations are required to develop a source identification methodology before statistical judgements can be made about the source of the transient sound events.

For the analysis, the following thresholds were set: L_{90}(hr)+10dBA, L_{90}+20dBA, L_{90}(hr)+30dBA, and L_{90}(hr)+40dBA. This range of thresholds provides a good description of the magnitude of the transient events occurring within the parks. Table 4.3 provides a summary of the overall average of events per hour and their duration for each park.

Table 4.3. Transient Event Overall Summary

	Everglades		Biscayne	
Threshold	#/hr	Duration	#/hr	Duration
L_{90}+10 dBA:	6.6	35 s	5.5	43 s
L_{90}+20 dBA:	1.9	65 s	1.7	105 s
L_{90}+30 dBA:	0.4	102 s	0.5	163 s
L_{90}+40 dBA:	0.1	95 s	0.1	217 s

The overall average shows that few very loud events (i.e., 20 dBA or greater above L_{90}) currently occur within the parks on an hourly basis. Also, these numbers show that the average durations are different between the two parks. Everglades NPA has shorter duration events compared to Biscayne, yet the number of events per hour are very similar. This difference in duration may result from the boat traffic occurring near most of the Biscayne sites. The explanation of this difference can be confirmed with a few observations at some of the different sites.

Table 4.4a and 4.4b provide the averages for the transient events at each site. The average values include the number of events per hour, duration, and event L_{eq}.

At most of the sites, an increase during the daylight hours was observed as expected since human intrusions occur mostly during the daylight hours as well as birds and wind generated sounds. Transient events were also reduced during the night because of the increase in the background levels. In general, the analysis of transient events provides a credible basis on which to base acceptable levels, numbers, and duration of intrusive events, since any proposed intrusive event can be evaluated in terms of its additional disruption to the natural soundscape.

4.5.3 Temporal Variations

The data were separated into four time periods since the sound levels at most sites demonstrated a diurnal pattern. The periods were defined as the following: Nighttime (2200 to 0459), Sunrise (0500 to 0759), Daytime (0800 to 1859) and Sunset (1900 to 2159). This grouping separates out Sunrise and Sunset periods since animals tend to be very active during these transitional times. Table 4.5 shows the results of a single-factor analysis of variance of L_{90} as a function of time of day at the 95% confidence levels. This analysis if the time-based group showed that a significant difference exists between the four periods for L_{90}. Nighttime had the highest levels at most sites. The average L_{90} for the nighttime period was 40 dBA with a standard deviation of 7 dBA. These levels were primarily natural since they were constant during most of the observed nights. A few sites, however, were impacted by continuously operating air conditioners or electrical generators. Insect, amphibians, reptiles and, possibly, birds are probably the main contributors for the natural nighttime levels.

The natural ambient was quietest during the daytime at most sites. The average daytime L_{90} was 32 dBA with a standard deviation of 6 dBA. The average daytime L_{50} was 40 dBA with a standard deviation of 5 dBA. L_{90} generally decreased during the day at most sites, which suggests that the natural levels decreased during the daylight hours.

Table 4.4a. Transient Event Summary for Biscayne National Park

Hourly Average Number of Intrusions						total hours
Site	Aco. Zone	L90+10	+20	+30	+40	observed
B1	1	3.9	1.3	0.5	0.1	49
B2	2	5.3	1.9	0.3	0.0	162
B3	3	4.9	1.8	0.5	0.1	94
B4	3	4.6	1.2	0.2	0.1	45
B5	7	5.0	1.5	0.7	0.1	69
B6	7	8.1	2.3	0.7	0.1	163
B7	6	5.0	3.0	0.5	0.1	166
B8	5	5.3	1.0	0.3	0.1	166
B9	5	7.7	1.5	0.5	0.1	47
average/hr		5.5	1.7	0.5	0.1	

1=intruded
2=open forest
3=dense forest
4=prairie
5= open water
6= open shoreline
7= protected shoreline

Average Durations (seconds)					
Site	Aco. Zone	L90+10	+20	+30	+40
B1	1	49.4	97.5	278.3	266.4
B2	2	31.5	46.8	44.5	98.0
B3	3	22.4	78.9	198.6	360.8
B4	3	33.0	133.8	67.8	86.7
B5	7	51.6	104.1	144.6	307.1
B6	7	60.3	94.4	163.4	225.0
B7	6	46.7	122.8	202.1	221.1
B8	5	37.7	116.7	186.7	171.1
B9	5	51.2	152.6	180.5	217.3
average		42.7	105.3	162.9	217.1

Average L_{eq} of Events					
Site	Aco. Zone	L90+10	+20	+30	+40
B1	1	49.0	55.7	64.0	65.6
B2	2	52.6	59.8	67.2	68.4
B3	3	41.6	47.3	55.3	65.7
B4	3	45.8	53.2	62.7	65.5
B5	7	45.3	51.0	55.3	62.5
B6	7	41.0	47.1	54.1	57.7
B7	6	46.4	52.3	58.3	67.0
B8	5	47.0	52.8	56.9	62.9
B9	5	46.1	53.6	57.1	67.2

Table 4.4b: Transient Event Summary for Everglades National Park

Hourly average of intrusions						total hours
Site	Aco. Zone	L90+10	+20	+30	+40	observed
E1	6	7.7	2.0	0.5	0.0	23
E2	4	8.4	1.5	0.3	0.0	71
E3	7	9.6	2.9	0.2	0.1	71
E4	7	2.4	0.7	0.3	0.1	70
E5	3	3.1	0.8	0.3	0.1	70
E6	2	10.0	4.3	0.9	0.2	44
E7	3	6.8	3.3	1.0	0.2	44
E8	4	10.4	2.0	0.6	0.1	74
E9	2	4.5	1.9	0.1	0.1	43
E10A	4	3.8	0.5	0.1	0.0	90
E10B	2	6.6	0.8	0.0	0.0	90
E11	2	4.5	0.7	0.1	0.0	69
E12	1	6.4	2.2	0.4	0.1	49
E14	4	9.0	4.1	0.8	0.1	73
E15	1	6.2	1.3	0.2	0.0	74
average/hr		6.6	1.9	0.4	0.1	

1=intruded
2=open forest
3=dense forest
4=prairie
5= open water
6= open shoreline
7= protected shoreline

Average Duration					
Site	Aco. Zone	L90+10	+20	+30	+40
E1	6	38.4	39.9	52.2	22.0
E2	4	44.5	80.3	104.3	120.0
E3	5	26.8	89.3	183.9	100.0
E4	5	36.5	57.1	39.7	45.8
E5	3	43.4	34.2	39.2	37.2
E6	2	25.5	57.0	106.4	42.3
E7	3	25.2	49.7	58.1	62.6
E8	2	29.2	77.4	120.2	44.4
E9	4	39.4	58.3	41.5	420.7
E10A	4	37.7	75.8	83.1	0.0
E10B	2	40.1	73.8	309.0	119.3
E11	2	40.5	89.0	126.3	268.0
E12	1	27.0	49.4	68.2	114.4
E14	4	32.4	65.4	100.3	29.7
E15	1	32.9	83.2	103.4	0.0
average		34.6	65.3	102.4	95.1

Average Leq					
Site	Aco. Zone	L90+10	+20	+30	+40
E1	6	45.1	57.0	106.4	42.3
E2	4	41.7	49.7	58.1	62.6
E3	5	42.8	77.4	120.2	44.4
E4	5	43.0	58.3	41.5	420.7
E5	3	55.0	75.8	83.1	0.0
E6	2	39.5	73.8	309.0	119.3
E7	3	39.3	89.0	126.3	268.0
E8	2	41.2	49.4	68.2	114.4
E9	4	45.7	65.4	100.3	29.7
E10A	4	50.7	83.2	103.4	0.0
E10B	2	50.5	0.0	0.0	0.0
E11	2	46.1	0.0	0.0	0.0
E12	1	46.7	0.0	0.0	0.0
E14	4	47.5	0.0	0.0	0.0
E15	1	49.9	0.0	0.0	0.0

This result may arise because most animals tend to be less active during the daylight hours for this time of year. In addition, it should be noted that transient events increased during the daylight hours, which corresponds to human activity. Thus, transient events are most apparent during the daylight hours.

Sound levels occurring during sunrise and sunset were distinct from nighttime and daytime levels and usually as a transition between the two. The average sunrise L_{90} was 36 dBA with a standard deviation of 6 dBA, and the average sunset L_{90} was 35 dBA with a standard deviation of 5 dBA.

Table 4.5. ANOVA of L_{90} vs. time of day for unmanned measurements

SUMMARY				
Time of day	*Count*	*Sum*	*Average*	*Variance*
Nighttime	30	1270.0	42.3	49.2
Sunrise	30	1128.0	37.6	26.9
Daytime	30	1062.5	35.4	26.7
Sunset	30	1170.3	39.0	33.2

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	757.0	3	252.3	7.4	0.0	2.7
Within Groups	3942.8	116	34.0			
Total	4699.8	119				

4.5.4 Acoustical Zones

The measurement sites were selected to test the reanalysis finding that no dependence of the natural sound levels on acoustical zones were found. Table 4.6 shows the results of a single-factor analysis of variance of L_{90} as a function of acoustical zone at the 95% confidence level. For the unmanned monitored data, the variation within the data did not demonstrate a significant difference between the acoustical zones. Therefore, no dependence on acoustical zones was found in the data. Qualitatively, the protected shoreline data had the lowest average L_{90} of 3 dBA and the intruded sites had the highest L_{90} of 37 dBA.

This finding agrees with the lack of dependence on acoustical zone determined from the reanalysis of the Volpe and SID data. Thus, for the summer season single A-weighted metrics may be used to set general levels throughout large areas of a park since they are independent of acoustical zones. From this finding one can not say that the different acoustical zones have the same sound quality. A-weighted levels only define the acoustical energy occurring at a site and do not say anything about the timbre of the sounds occurring at a site.

This finding needs to be tested for other periods of the year to verify this apparent independence of acoustical zones. More detail statistical methods may be required to determine if an acoustical dependence exists for Everglades and Biscayne National Parks.

Table 4.6. ANOVA of L_{90} vs. acoustical zones for unmanned measurements

SUMMARY

Acoustical Zones	*Count*	*Sum*	*Average*	*Variance*
Intruded	3	118.3	39.4	8.3
open forest	6	241.2	40.2	11.6
dense forest	5	196.6	39.3	35.3
prairie	4	151.4	37.9	21.6
open water	4	163.6	40.9	7.5
open shoreline	3	106.6	35.5	5.5
protected shoreline	5	167.1	33.4	17.9

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	199.8	6	33.3	2.0	0.1	2.5
Within Groups	386.0	23	16.8			
Total	585.8113	29				

4.5.5 Comparison with Volpe and SID data

To link these new findings to the previous measurements, Table 4.7 provides a comparison between existing sound levels for all of the data sets. This comparison uses the daytime period from the Wyle measurements and land-based measurement sites from the previous SID and Volpe measurements. The comparison points were further restricted to locations that were near each other.

This comparison shows that the average differences in L_{90}, L_{50}, and L_{10} were 2 dBA, 3dBA, and 4dBA, respectively, with standard deviations between 5 dBA and 6 dBA. These differences show good overall agreement, and no general discrepancies exist between the three data sets. The size of the variation in the differences, as represented by the standard deviations, is what can be typically expected in outdoor environmental noise measurements. Sources of the variation were from differences in sample size and potentially from rainfall and seasonal changes.

It should be noted that the Wyle measurements included periods of rain, which were excluded from the SID 1997 and Volpe 1998 measurements.

Several SID and Volpe sites included boat-based measurements. At these sites, the natural sound levels were distorted because of wave slaps against the hull of the boat. Sites B8, B9, B6, and E3 from the Wyle measurements are compared to Volpe and SID measurements to assess the potential effect of the wave slaps. It should be noted that no recordings were available to directly assess the effect of the wave slaps. Table 4.8 provides a comparison of measured daytime values of L_{90}, L_{50}, and L_{10}.

It was noted (Sanchez, 1999) that there was no wave slap for the measurements of Bis-7(2) because the water surface was still. The levels recorded at this site are similar to the monitored levels at site B6, Old Rhodes Key. These sites had very similar surroundings and were within ½ mile of each other.

For the other measurements made at Rubicon Key when the water surface was not still, the L_{90} and L_{50} levels are greater but the L_{10} is similar to the L_{10} at site B6. This trend suggests that the wave slap increased the background sound levels by adding acoustical Energy to the measurements. Moreover, the comparison between the measurements in Whitewater Bay also shows this same trend. The L_{10} levels are similar, but the L_{90} values are on the order of 10 dBA higher for the boat-based measurements. This trend was also observed at the open water site at B8. During observations, a sound level meter was used on the boat that was 1000' from the shoal marker. The sound meter recorded levels of 43 dBA whereas at site B8 the recorded level was 35 dBA.

However, the overall comparison between the open water sites, does not show as strong a difference in the data as expected. For both of the boat-based and shoal marker measurements, the sound levels are similar in magnitude. For the shoal marker based monitors, the effect of surface winds may explain this result via a natural or artificial manner. First, surface wind generated waves on the open water may have created levels comparable to the wave slap noise. Second, the surface winds that are higher on the open water may have distorted the readings by generating interference noise on the microphone.

Table 4.7: Comparison between Wyle Unmanned Sound Levels and Volpe and SID Data (Daytime period from Wyle data used)

Acoustical Zone	Volpe/SID Site	L_{90}	L_{50}	L_{10}	Wyle Site	L_{90}	L_{50}	L_{10}	Differences Between Sites ΔL_{90}	ΔL_{50}	ΔL_{10}
1	**Bis-1**	45	48	52	**B1**	38	43	55	-7	-5	3
1	**Bis-1(2)**	40	46	63					-2	-3	-8
1	**Bis-8**	40	47	58	**B2**	38	43	51	-2	-4	-7
1	**Bis-8(2)**	27	32	40					11	11	11
1	**81298I**	29	34	46					9	9	5
1	**81598I**	34	39	52					4	4	-1
1	**81798I**	30	34	49					8	9	2
4	**81898V**	23	29	38	**E8**	26	34	44	3	5	6
2	**81598R**	30	33	40	**E9**	31	38	46	1	5	6
2	**Ever-3**	23	32	39	**E11**	32	39	46	9	7	7
1	**Ever-2**	33	38	44	**E12**	34	40	51	1	2	7
1	**81098B**	27	31	40					7	9	11
1	**81298B**	29	33	45					5	7	6
1	**81598B**	36	39	45					-2	1	6
4	**81398N**	36	39	45	**E14**	33	39	50	-3	0	5
4	**81698N**	43	46	50					-10	-7	0
1	**81098O**	32	37	43	**E15**	37	44	52	5	7	9
							Average		2.2	3.4	4.0
							St.dev		5.9	5.5	5.4

Table 4.8. Assessment of Wave Slap on Background Sound Levels

Location	**Previous**	**L_{90}**	**L_{50}**	**L_{10}**	**Wyle**	**L_{90}**	**L_{50}**	**L_{10}**
Feathered Bank	81298P1	42	48	53	B8	35	49	56
	81498P1	25	36	46	B9	34	44	55
	81598P1	31	40	50				
	Bis-5	50	53	57				
Old Rhodes Key					B6	28	35	46
Rubicon Key	Bis-7(2)*	29	35	45				
	Bis-7	36	42	47				
	81198D1	36	43	52				
	81498D1	40	50	55				
Whitewater Bay	81798T1	38	41	45	E3	24	35	49

* denotes still water surface measurement conditions

For boat-based measurements near open and protected shoreline areas, the effect of the wave slap appears to have increased the background levels on the order of 10 dBA in terms of A-weighted sound energy. For the open water measurements, no effect was observed, but it is possible that measurement error obscured the effect. To ascertain the exact distortion of wave slaps on the background sound levels measured in the open water, further measurements will be required to determine the undistorted wind influenced sound levels occurring in the open waters.

5 CONCLUSIONS AND RECOMMENDATIONS FOR REDEFINING SOUTH FLORIDA NATIONAL PARKS SOUNDSCAPES

5.1 Conclusion about South Florida Ambient Data

In the south Florida National Parks, the A-weighted sound levels due to natural sources are reasonably constant over the region. The average 24-hour L_{90} for all of the monitored sites was 33 dBA with a standard deviation of 4 dBA, while the average 24-hour L_{50} was 42 dBA with a standard deviation of 4 dBA. Quantitatively, the protected shorelines were the quietest sites and the loudest sites were the dense forests, but no statistically significant dependence of sound level on acoustical zone (i.e., type of local ecosystem) was determined. This finding suggests that single A-weighted L_{90} exceedance value can appropriately describe the natural background acoustical energy occurring in large areas of the park. The unmanned measurements, along with the reanalyzed manned measurements, demonstrate that L_{90} provides a baseline for assessing the natural soundscape on an acoustical energy basis.

L_{50}, on the other hand, represents the median levels occurring a t a site and provides an understanding of the range of sound levels at a site. From the reanalysis, L_{90} for all of the monitored sites was 33 dBA with a standard deviation of 4 dBA, while the average 24-hour L_{50} was 42 dBA with a standard deviation of 4 dBA. Quantitatively, the protected shorelines were the quietest sites and the loudest sites were the dense forests, but no statistically significant dependence of sound level on acoustical zone (i.e., type of local ecosystem) was determined. This finding suggests that single A-weighted L_{90} exceedance value can appropriately describe the natural background acoustical energy occurring in large areas of the park. The unmanned measurements, along with the reanalyzed manned measurements, demonstrate that L_{90} provides a baseline for assessing the natural soundscape on an acoustical energy basis.

L_{50}, on the other hand, represents the median levels occurring at a site and provides an understanding of the range of sound levels at a site. From the reanalysis, $L_{90}$of the subset of natural sounds was the same as that of the total data set, and it was not affected by human-caused noise. The reanalysis of the manned measurements also demonstrated that the L_{50}, although a good representative of the total noise environment, often overestimated the L_{50} of the natural sounds.

Moreover, during periods of minimal intrusion, the difference between the hourly L_{50} and the hourly L_{90} was less than 5 dBA. Thus, characterizing the natural soundscape by L_{90}, rather than L_{50},does not unreasonably bias the characterization toward lower levels.

Thus, for assessment threshold levels for defining transient and/or intruding events. This finding differs from the reported results in the Volpe report, which described the traditional ambient in terms of L_{eq} with variations based on terrain.

The monitored sound levels demonstrated a diurnal pattern with the highest natural sound levels occurring mostly at night and the lowest during the day. The average daytime L_{90} was 32 dBA, and the average nighttime L_{90} was 40 dBA with the average sunrise and sunset L_{90}s falling in between at 36 and 35 dBA, respectively. This difference probably results from more active animal sounds occurring during the night. Intruding transient sound events exhibited the opposite diurnal trend in that they increased during the day and decreased at night. This trend suggests that human-based activity generated most of the transient events.

The Wyle measurements also did not find any statistical dependence of the soundscape, as defined by the acoustical energy, on acoustical zones. This finding asserts that natural sound energy levels are fairly constant over the park areas and that levels do not appear to vary according to specific regions. This finding does not allude to any details about the sound quality throughout the park. The observed sound quality varied among the acoustical zones.

The bias in using the L_{eq} of the totality of sounds as a descriptor of the natural soundscape, as was done in the Volpe study, is significant. Typically, hourly L_{eq} values were similar to hourly L_{10} values, which biases the sound level toward that of intruding, transient events. The difference between the average L_{90} and L_{10} as a baseline for natural sound levels is not appropriate since these values represent the loudest levels occurring in the soundscape. Use of these values to assess potential intrusions could prevent the NPS from achieving its goal of preserving and restoring the natural soundscape in its parks.

5.2 Recommendations about South Florida Nature Ambient Soundscape

Park personnel can now start to establish criteria for assessing intrusions to the natural soundscape by using L_{90} as an objective basis for defining intruding event thresholds. The assessment of intruding sound events needs to include the maximum sound level of each event, the duration of each event, and the number of events occurring within a given time period.

For our analysis, thresholds were set at 10 dBA, 20 dBA, 30 dBA, and 40 dBA above the hourly L_{90}. These thresholds act as filters and provide a good description of the intruding sound events that rise above the natural background level. Exact thresholds for assessment should be formulated so that the goals of soundscape preservation and restoration can be met. Along the identification and assessment of intruding events, the exceedance metrics, e.g. L_{50} and L_{10}, should be examined to ascertain the level at which the intruding events have an impact on the natural soundscape.

Continued unmanned monitoring of the natural soundscape is recommended to build on these findings. Additional sites should include coverage of the entire parks as well as assessment of seasonal variations to test the statistical independence of A-weighted sound levels on acoustical zones at other seasons of the year than were considered here. It is recommended that at least 7 complete days of measurements be conducted at these additional sites so that the diurnal pattern can be established with more confidence.

These on-going measurements can be accomplished with a few sound level monitors that are rotated to different sites on a week by week basis. This approach will quickly build a database of sound levels that can be used to describe the character of the soundscapes in the parks. The unmanned monitor data will also highlight areas where direct observations should be undertaken.

Additional unmanned monitor data will bring the natural soundscape into focus and make direct observations efficient by assessing the need before they are conducted. Observation periods can concentrate on assessing the sound environment and the characteristics of the transient events occurring at the site. These observations will build a database of both natural and intrusive transient events for statistical discrimination of the events at other times and locations. This database will help in assessing the impact on the natural soundscape from both current and proposed noise events.

The recommended on-going monitoring should have the following objectives in order to describe the soundscape:

- Additional measurement to cover the entire park areas
- Seasonal variations in natural soundscape
- Seasonal influences on the diurnal pattern
- Seasonal variations in visitor impacts
- Observations to build a database of characteristic transient events

The observational data collected by both Volpe and SID can be used as a starting point for the development of a transient event database. The observational data along with the associated acoustic record can be analyzed to determine the characteristics of noise from intrusive sources such as aircraft and boats. With these basic characteristics defined, the transient events identified in the unmanned data can be described as natural or intrusive.

Once these objectives are met, an assessment monitoring plan can be established to evaluate the effectiveness of guidelines in preserving and restoring the natural soundscape in the parks.

5.3 Intrusive Assessment Approaches

For the south Florida National Parks, the thresholds based on the hourly L_{90} used in this analysis are recommended. The acceptable number and level of transient events will have to be determined by park personnel so that the goal of preservation and restoration of the natural soundscape can be pursued.

Several intrusive sources were identified in the course of the unmanned measurements. The generators and air conditioners at Elliot Key visitor area obscured the natural soundscape. The noise from these units was the dominant noise source in the area. The generator at Adam's key was also noticeable during our observations although boat noise was also present. At Convoy Visitor Center, the concessionaire tour boats were noisy as well as the air conditioners. Since this site serves as a focal point for visitors to Biscayne NP and as the office complex for park personnel, the natural soundscape may not be realistically restored, but the noise levels could be minimized.

At the Everglades NP, airboats could be heard in the northern Shark Valley region. Few land based noise sources were observed at the Everglades NP because the number of visitors was very low during the monitoring period. Another general noise source was aircraft which include military, commercial and regional airliners, general aviation and helicopters. Aircraft were heard in all areas of the park during the monitoring.

For assessing aircraft noise impacts, noise models such as INM and NoiseMap may be used to calculate aircraft noise intrusiveness based on the established guidelines. For INM, the Time Above calculation can be used to determine intrusiveness although some work would be required to translate the calculated data into individual transient events. Also, for a complete assessment, additional information is required on the hourly operational rates that are not included in the data bases of these aircraft models.

References

Flemming, Greg G., et al., *Ambient Sound Levels at Four Department of Interior Conservation Units, In Support of Homestead Air Base Reuse Supplement Environmental Impact Statement*, Cambridge, MA, John A. Volpe National Transportation Systems Center Acoustics Facility, DOT-VNTSC-FAA-99-3, June 1999.

Flemming, Greg G., et al., *Development of Noise Dose/Visitor Response Relationships for the National Parks Overflight Rule: Bryce Canyon National Park Study*, Cambridge, MA, John A.. Volpe National Transportation Systems Center Acoustics Facility, DOT-VNTSC-FAA-98-6, July 1998.

Foch, James, "Aircraft and Ambient Sound Levels at Devil's Tower National Monument during 1996-97", Danville, CA, July 1998.

Gdula, Eric, and Gudorf, Michelle, "Southeast Utah Group Sound Monitoring Program 1994-1996: Final Report," Southeast Utah Group, UT, February 1998.

Reddinguius, Nick H., *User's Manual for the National Park Service Overflight Decision Support System*, Canoga Park, CA, BBN Systems and Technologies, May 1994.

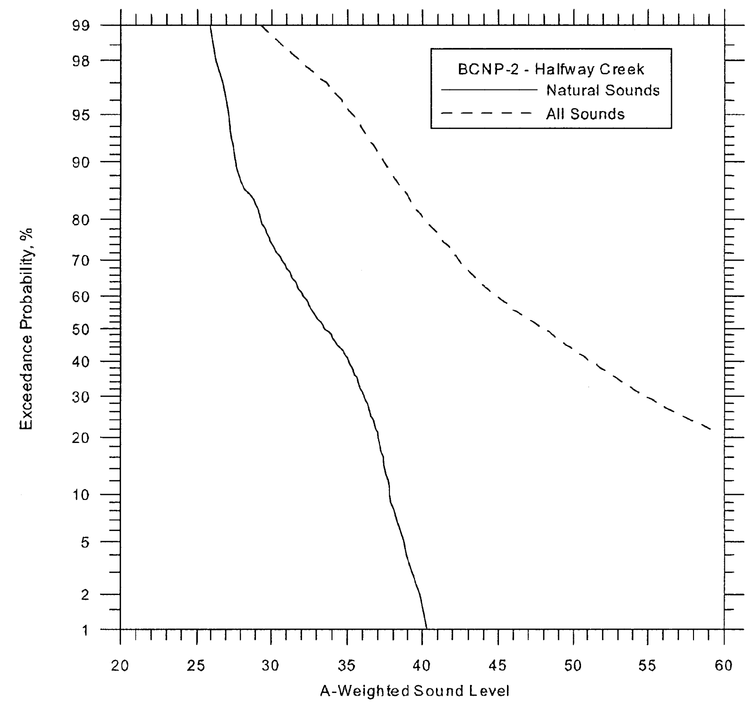
Sanchez, Gonzalo, *Acoustical Data from Biscayne National Park and Everglades National Park*, Madison, WI, Sanchez Industrial Design, September, 1998.

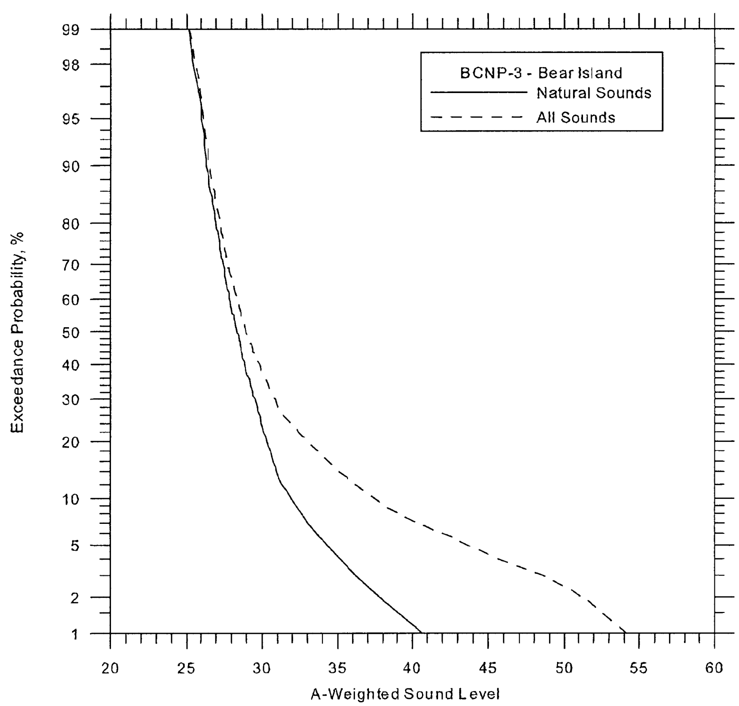
Sanchez, Gonzalo, personal communication, May, 1999.

Sneddon, Mathew, Silvati, Laura, Pearsons, Karl S., Fidell, Sanford, *Measurements and Analyses of the Indigenous Sound Environment of Coniferous Forests*, Canoga Park, CA, BBN Systems and Technologies, January 1994.

_______, Model 820 Precision Sound Level Meter: Owner's Manual, First Edition, Provo, UT, Larson•Davis, December 1991.

Appendix A
Exceedance Plots for Sanchez Industrial Design 1997 Measurements




BCNP-3 - Bear Island
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
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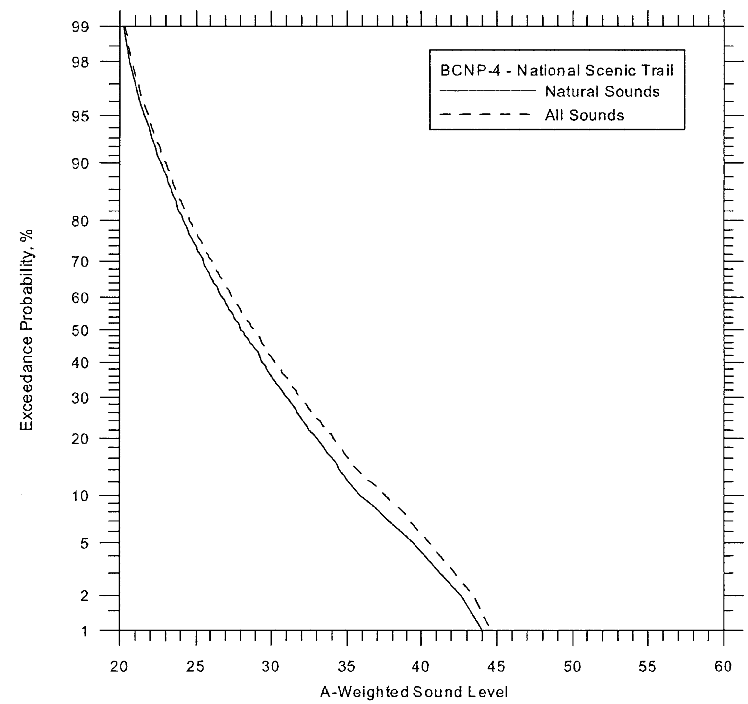
BCNP-4 - National Scenic Trail
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
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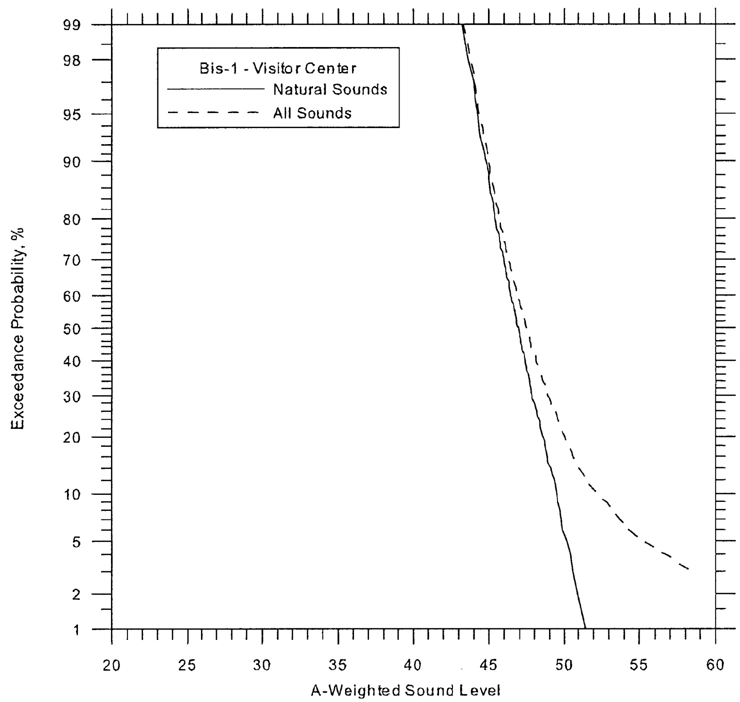
Bis-1 - Visitor Center
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
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80
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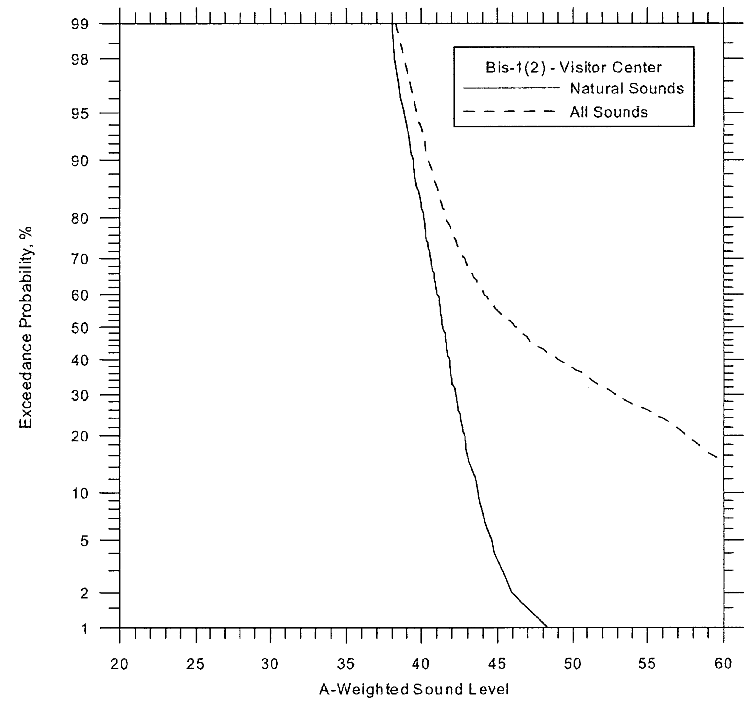
Bis-1(2) - Visitor Center
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
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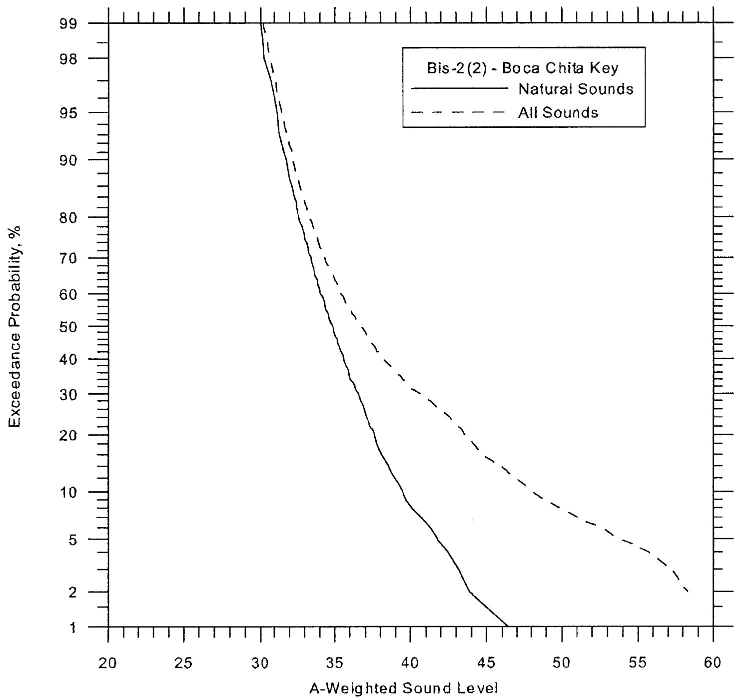
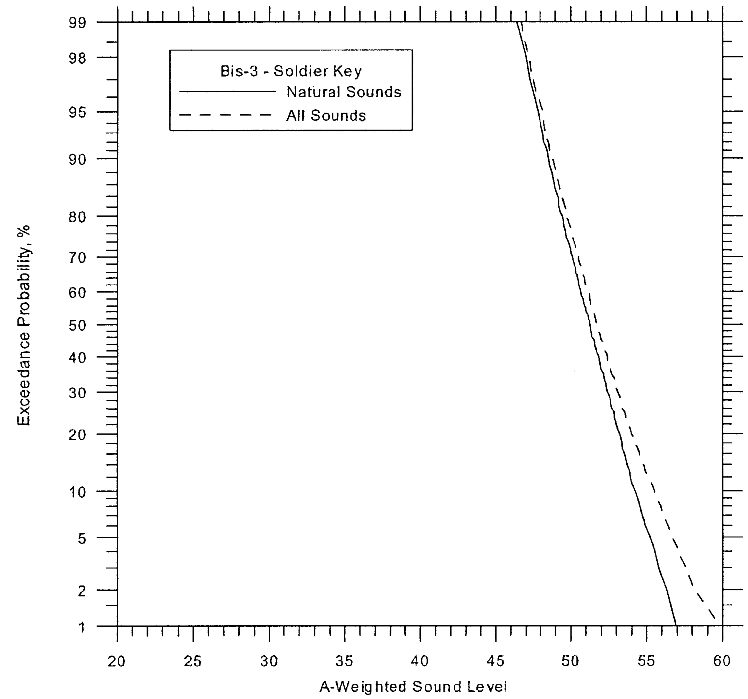
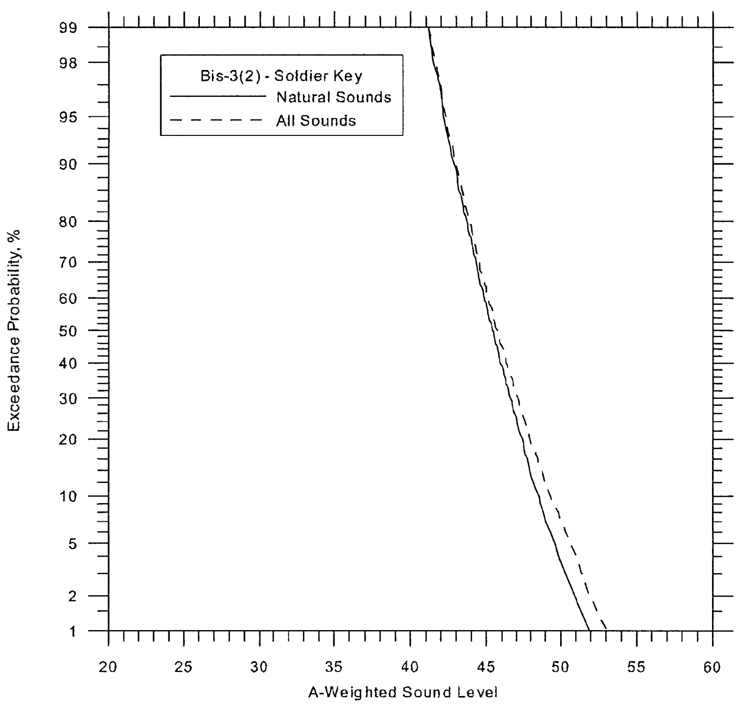

Bis-2(2) - Boca Chita Key
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level


Bis-3 - Soldier Key
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level


Bis-3(2) - Soldier Key
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
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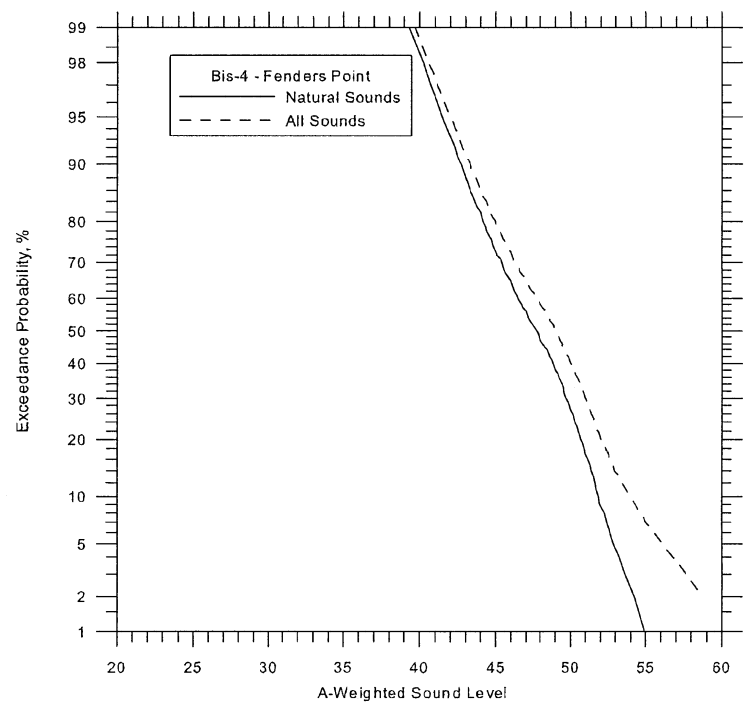
Bis-4 - Fenders Point
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
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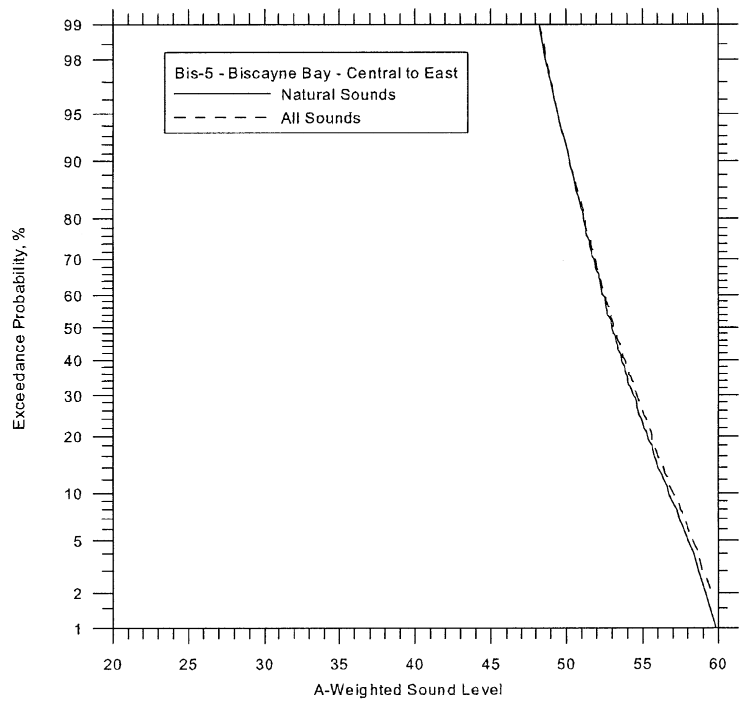
Bis-5 - Biscayne Bay - Central to East
Natural Sounds
All Sounds
Exceedance Probability, %
99
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80
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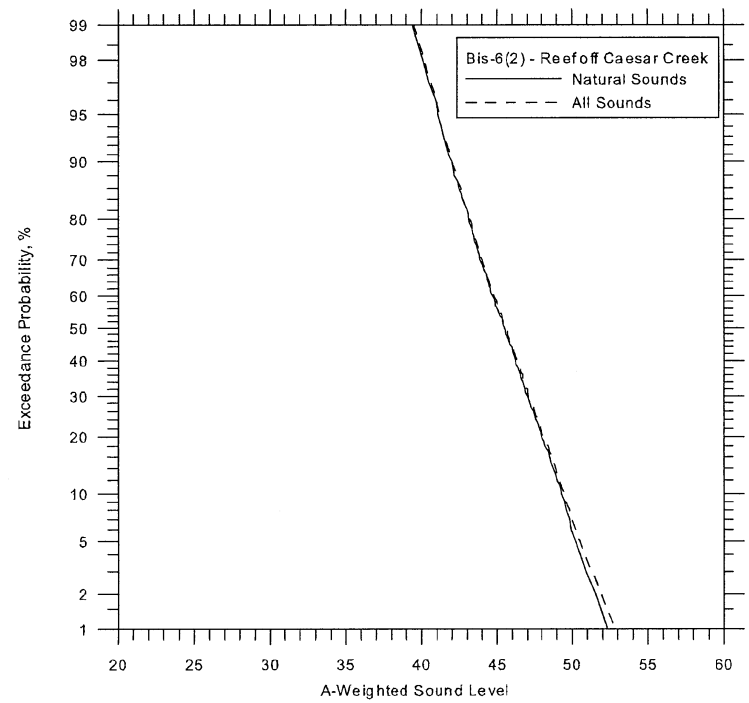
A-Weighted Sound Level


Bis-6(2) - Reef off Caesar Creek
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
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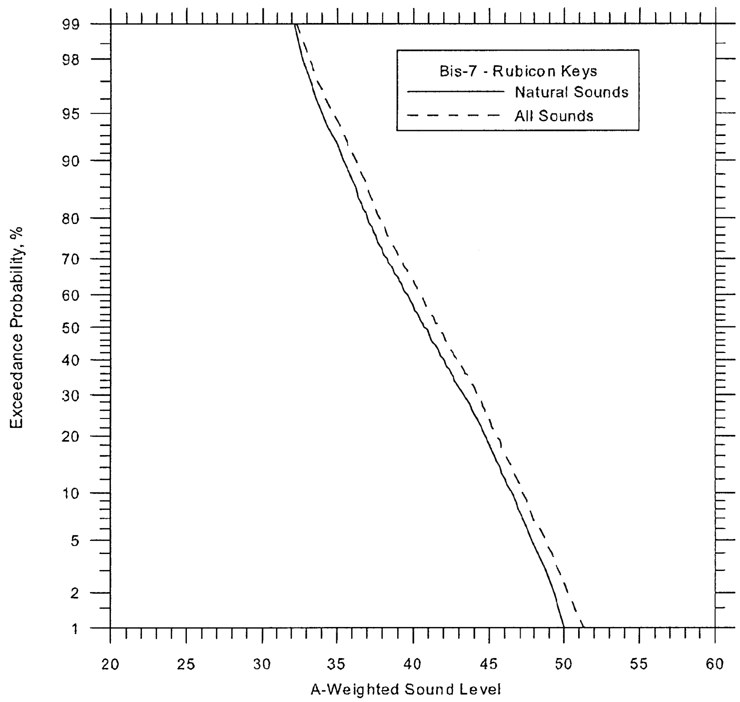
A-Weighted Sound Level


Bis-7 - Rubicon Keys
Natural Sounds
All Sounds
Exceedance Probability, %
99
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95
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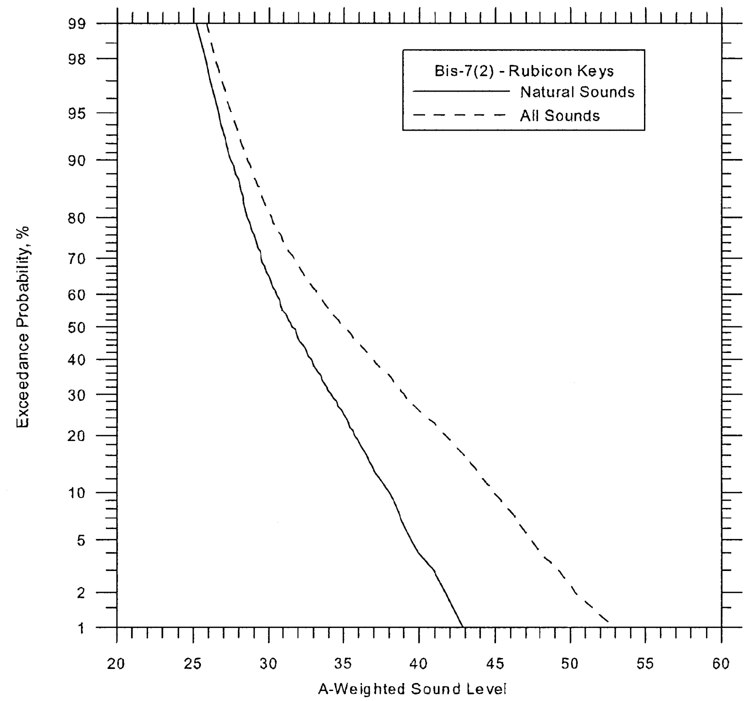
A-Weighted Sound Level


Bis-7(2) - Rubicon Keys
Natural Sounds
All Sounds
Exceedance Probability, %
99
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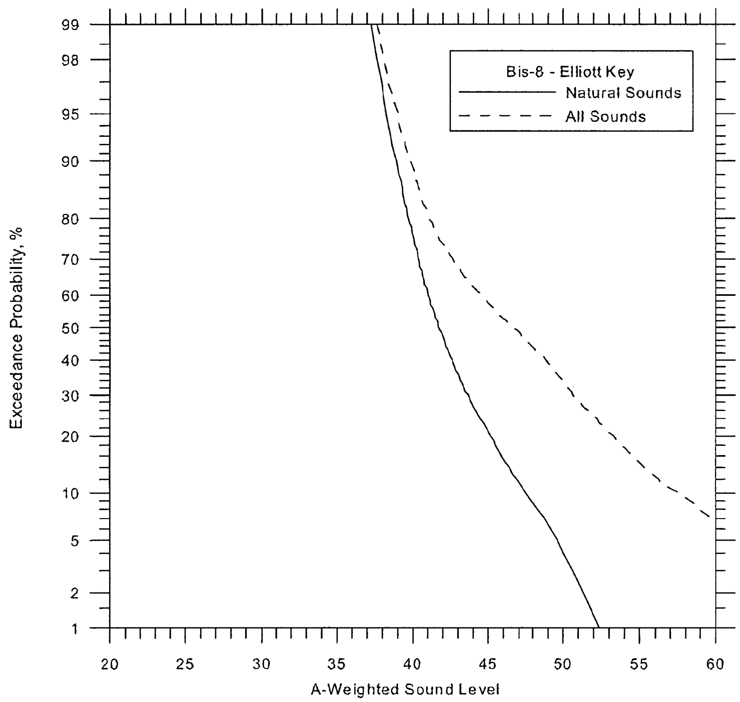
A-Weighted Sound Level


Bis-8 - Elliott Key
Natural Sounds
All Sounds
Exceedance Probability, %
99
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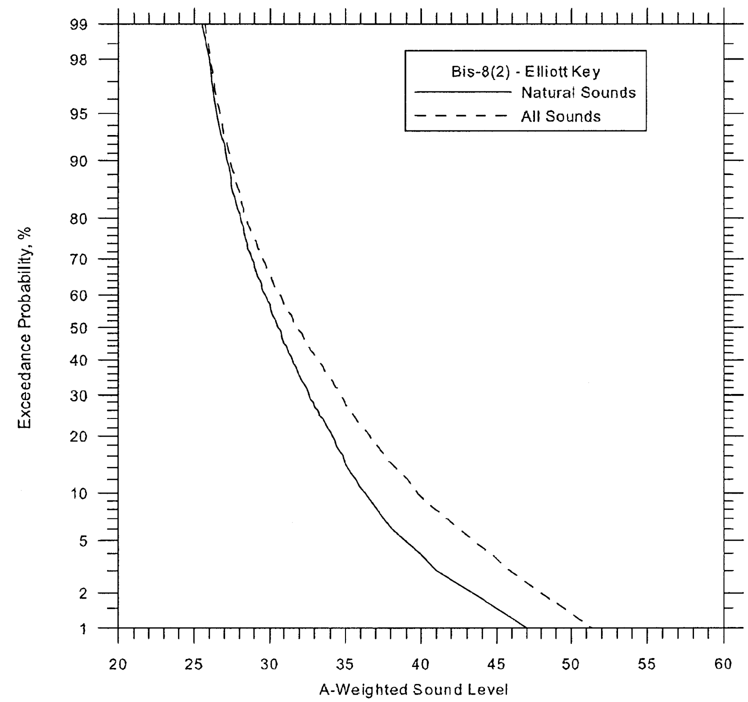
A-Weighted Sound Level


Bis-8(2) - Elliott Key
Natural Sounds
All Sounds
Exceedance Probability, %
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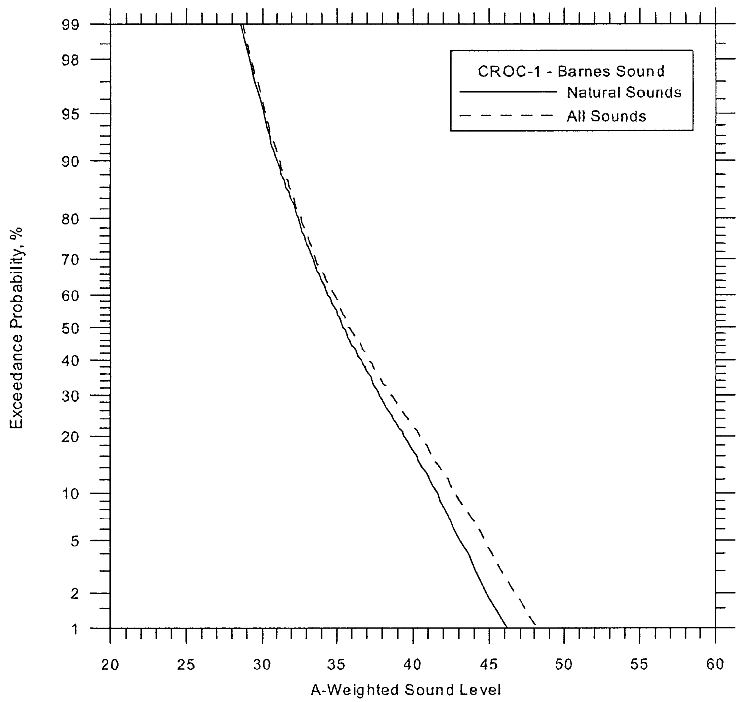
A-Weighted Sound Level


CROC-1 - Barnes Sound
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
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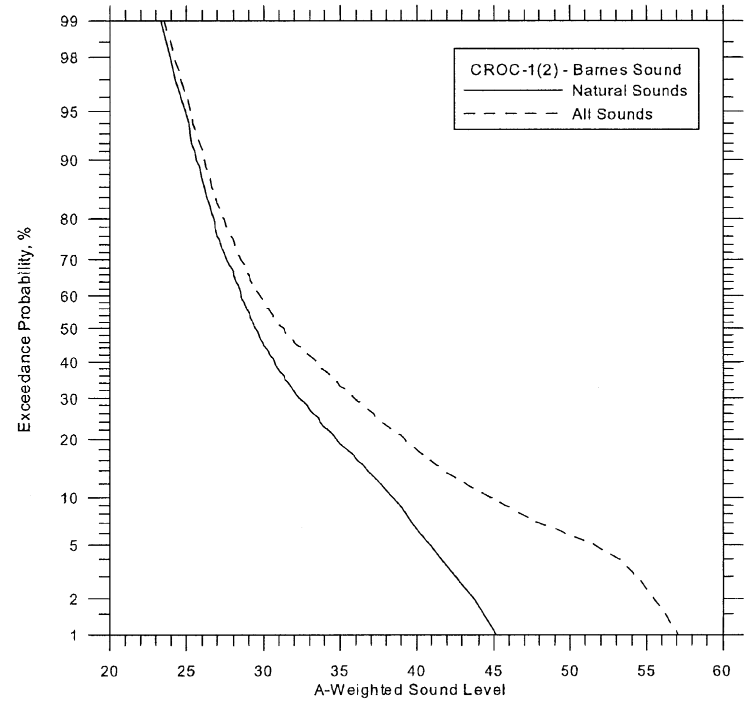
CROC-1(2) - Barnes Sound
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
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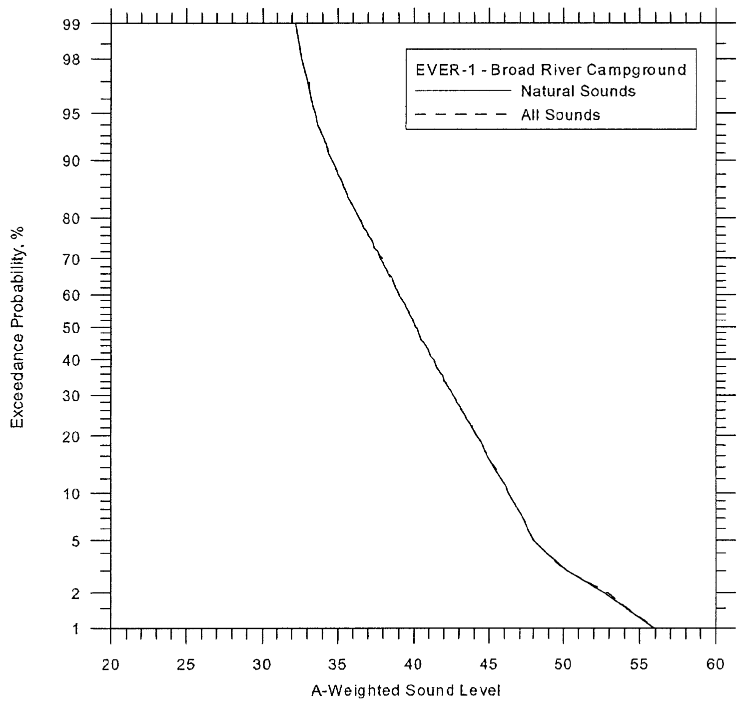
EVER-1 - Broad River Campground
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
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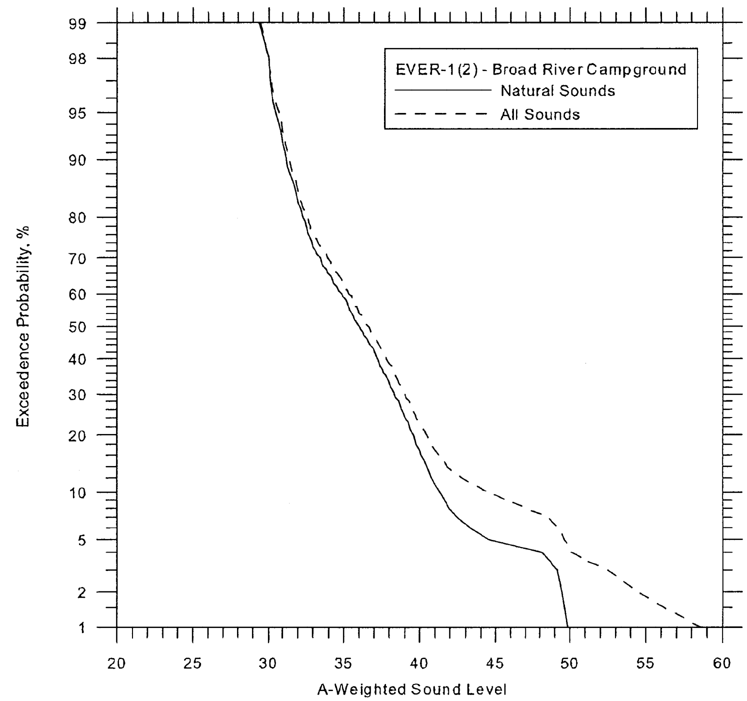
EVER-1(2) - Broad River Campground
Natural Sounds
All Sounds
Exceedence Probability, %
A-Weighted Sound Level
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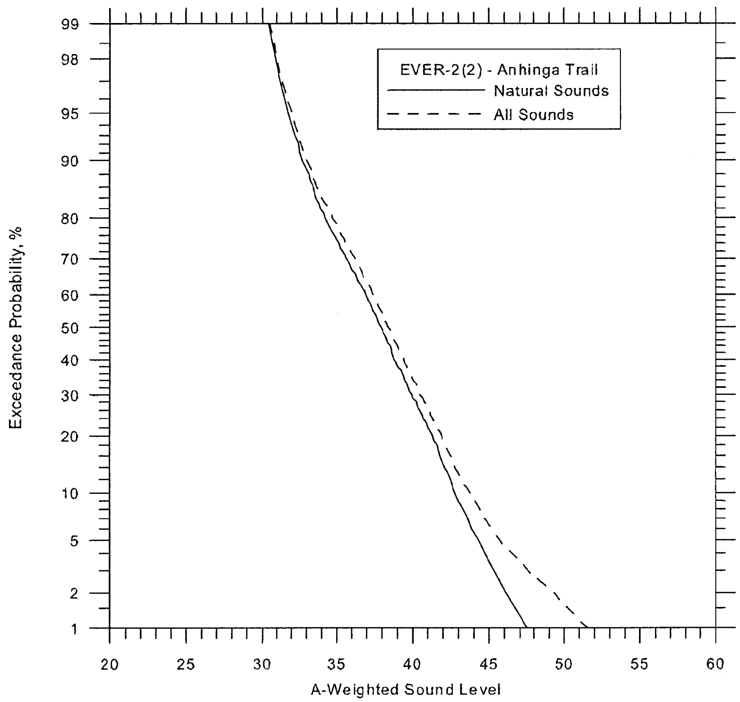
EVER-2(2) - Anhinga Trail
Natural Sounds
All Sounds
Exceedance Probability, %
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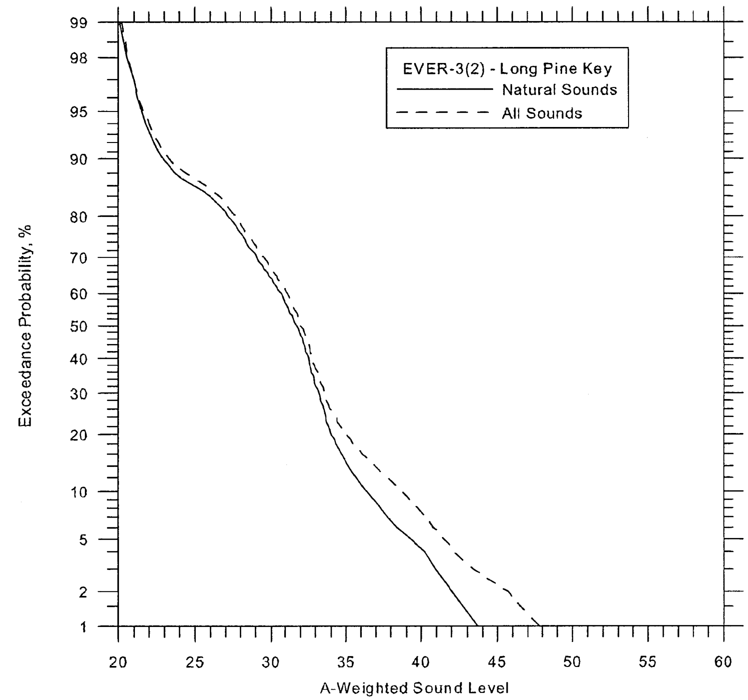
A-Weighted Sound Level


EVER-3(2) - Long Pine Key
Natural Sounds
All Sounds
Exceedance Probability, %
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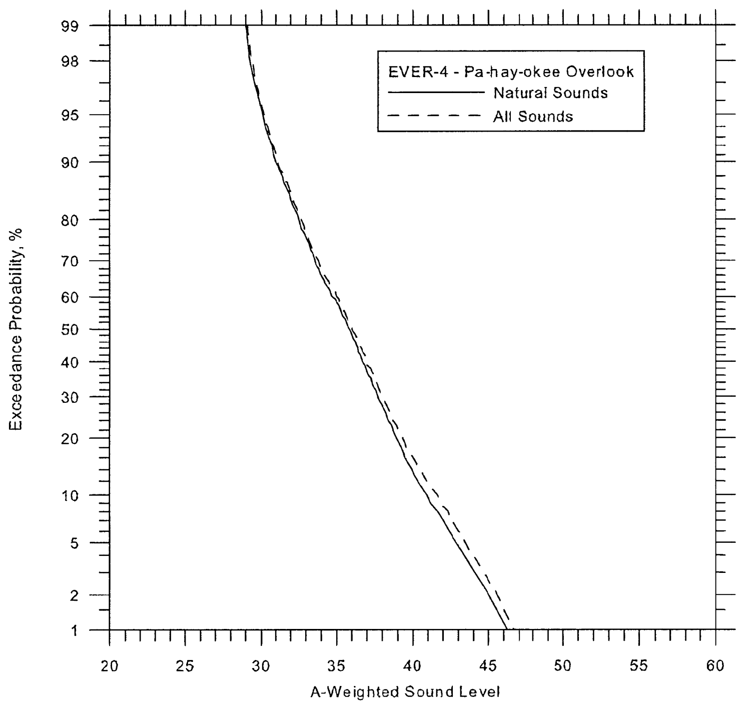
A-Weighted Sound Level


EVER-4 - Pa-hay-okee Overlook
Natural Sounds
All Sounds
Exceedance Probability, %
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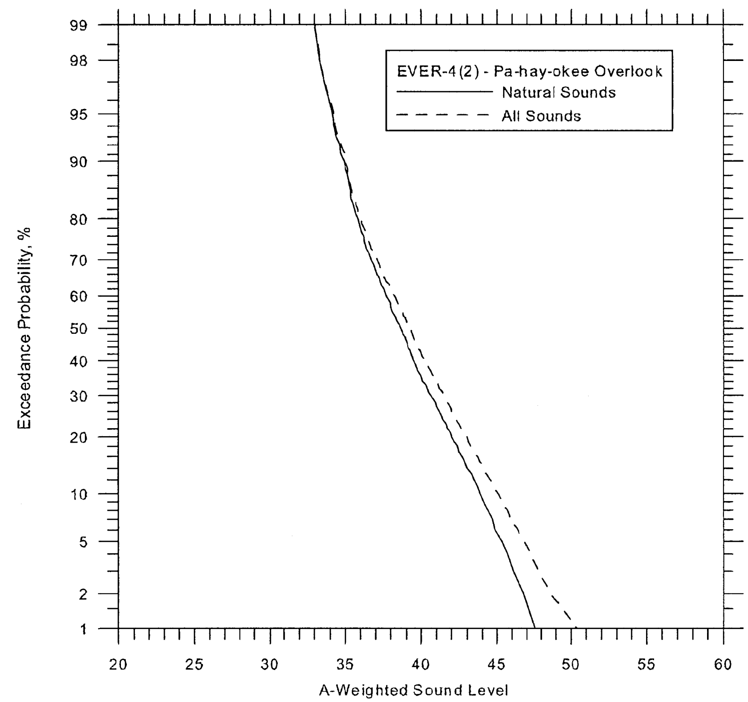
A-Weighted Sound Level


EVER-4(2) - Pa-hay-okee Overlook
Natural Sounds
All Sounds
Exceedance Probability, %
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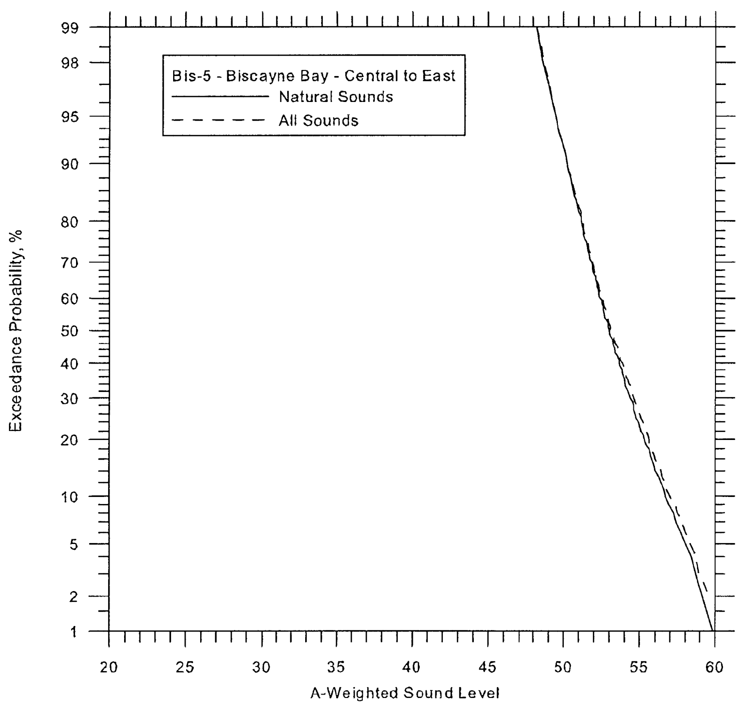
A-Weighted Sound Level


Bis-5 - Biscayne Bay - Central to East
Natural Sounds
All Sounds
Exceedance Probability, %
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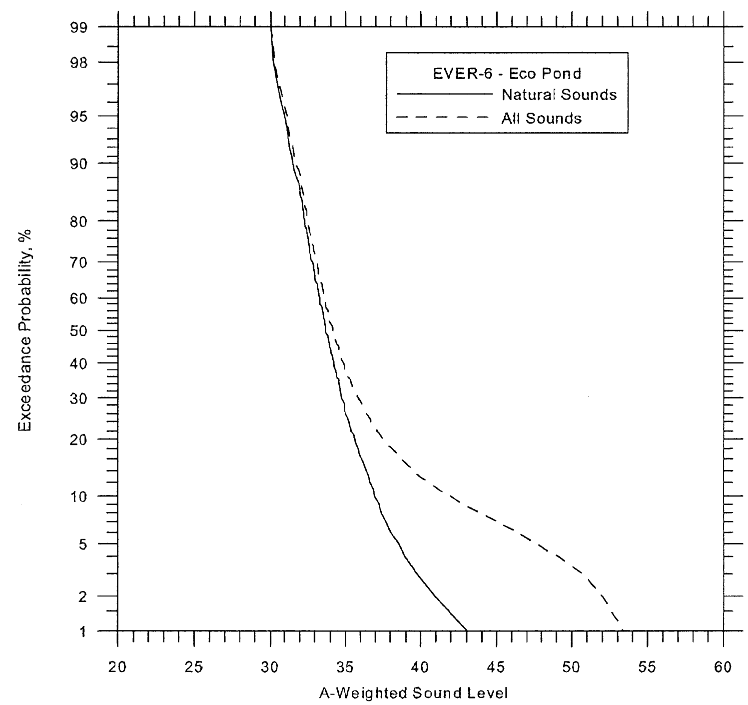
A-Weighted Sound Level


EVER-6 - Eco Pond
Natural Sounds
All Sounds
Exceedance Probability, %
99
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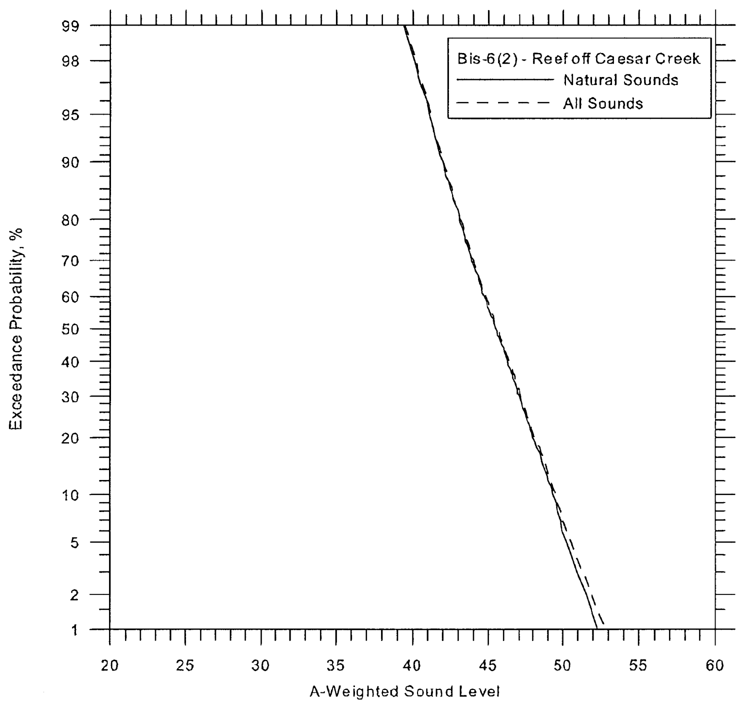
A-Weighted Sound Level


Bis-6(2) - Reef off Caesar Creek
Natural Sounds
All Sounds
Exceedance Probability, %
99
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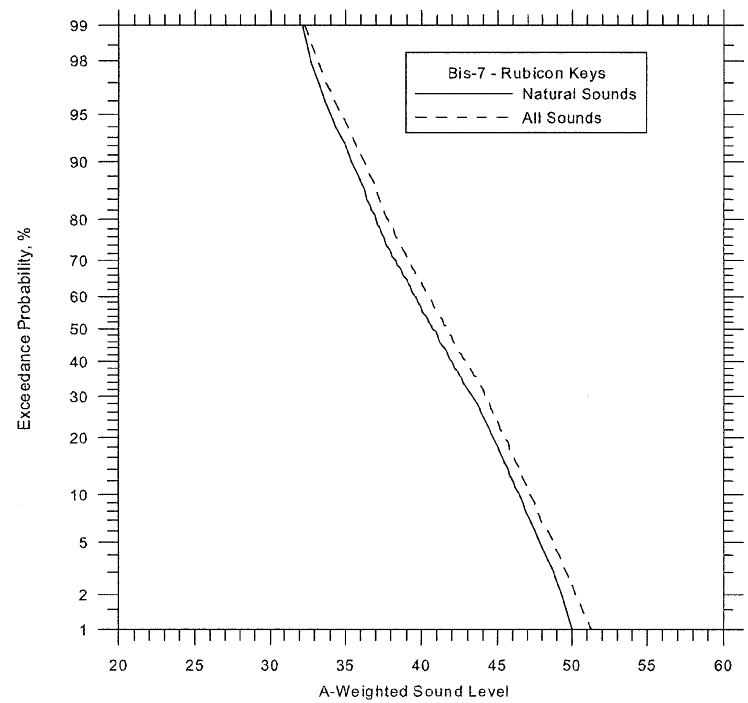
A-Weighted Sound Level


Bis-7 - Rubicon Keys
Natural Sounds
All Sounds
Exceedance Probability, %
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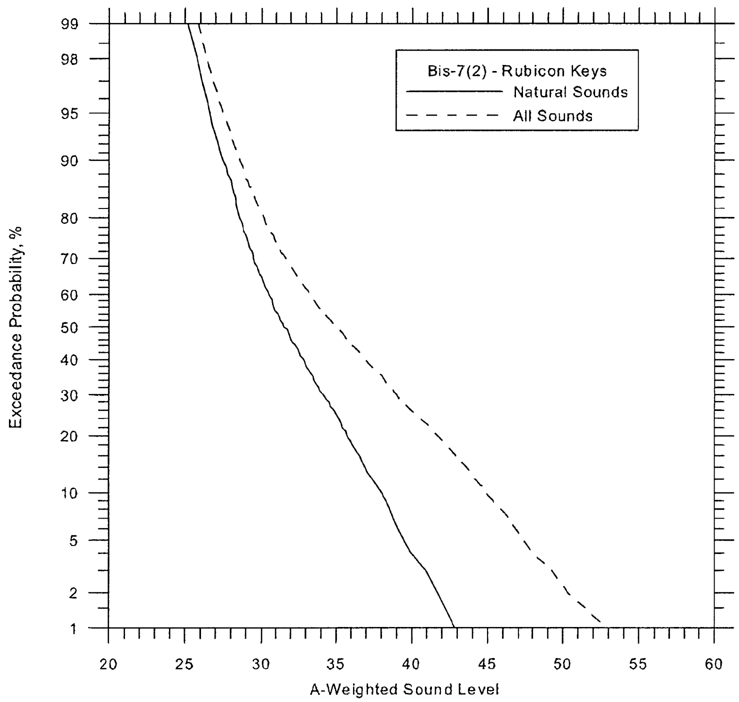
A-Weighted Sound Level


Bis-7(2) - Rubicon Keys
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
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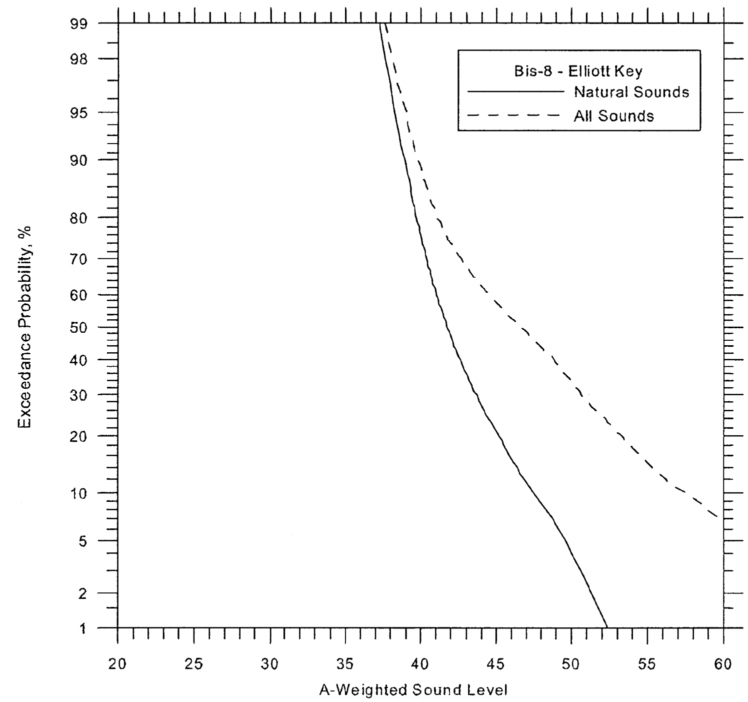
A-Weighted Sound Level


Bis-8 - Elliott Key
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
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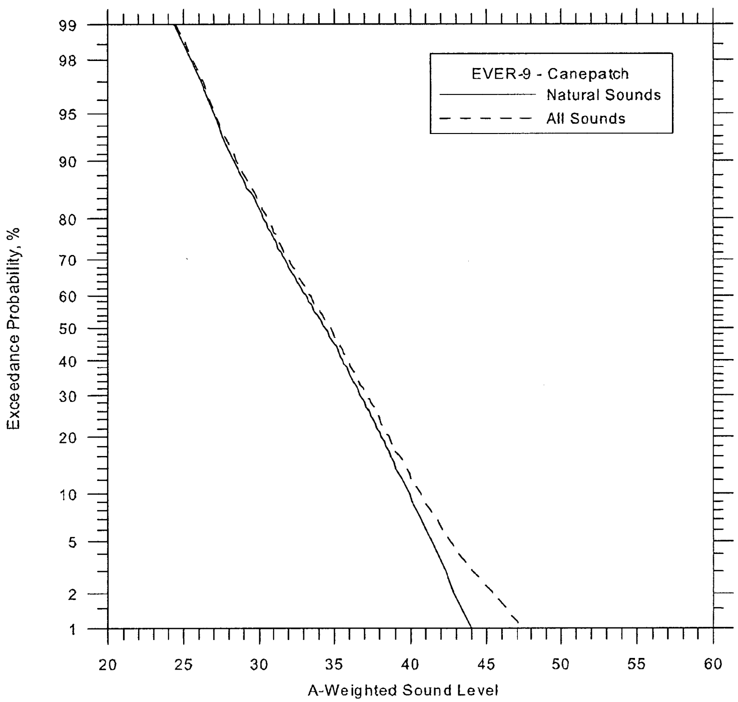
A-Weighted Sound Level


EVER-9 - Canepatch
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
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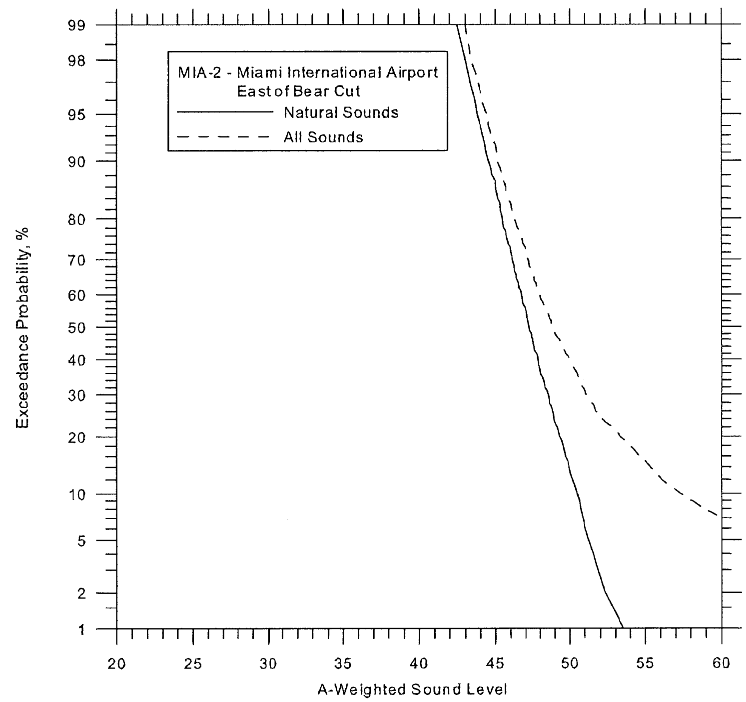
MIA-2 - Miami International Airport
East of Bear Cut
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
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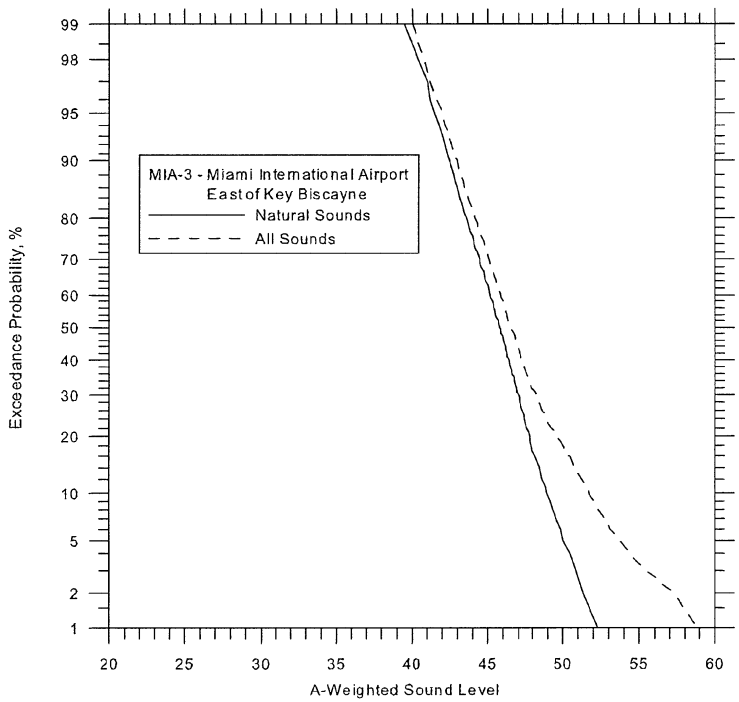
MIA-3 - Miami International Airport
East of Key Biscayne
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
95
90
80
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45
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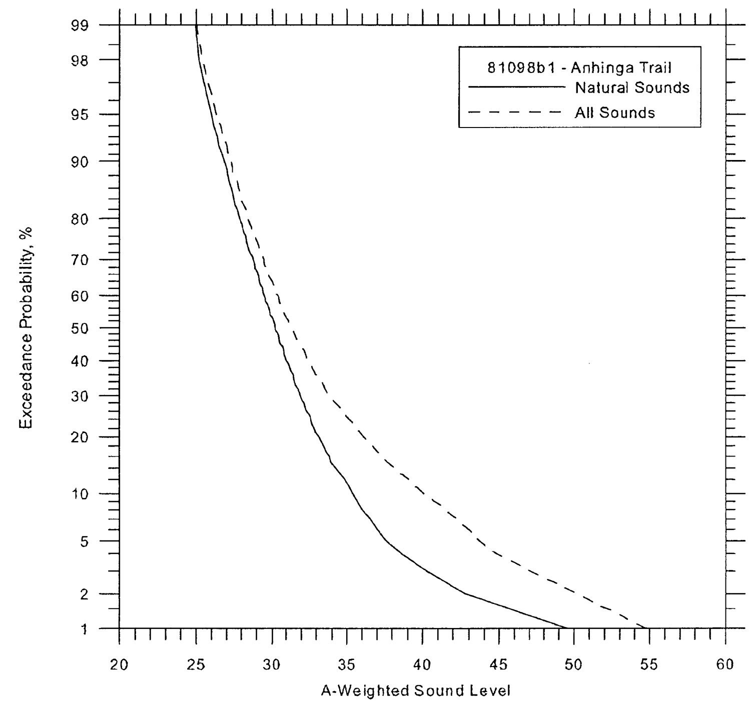
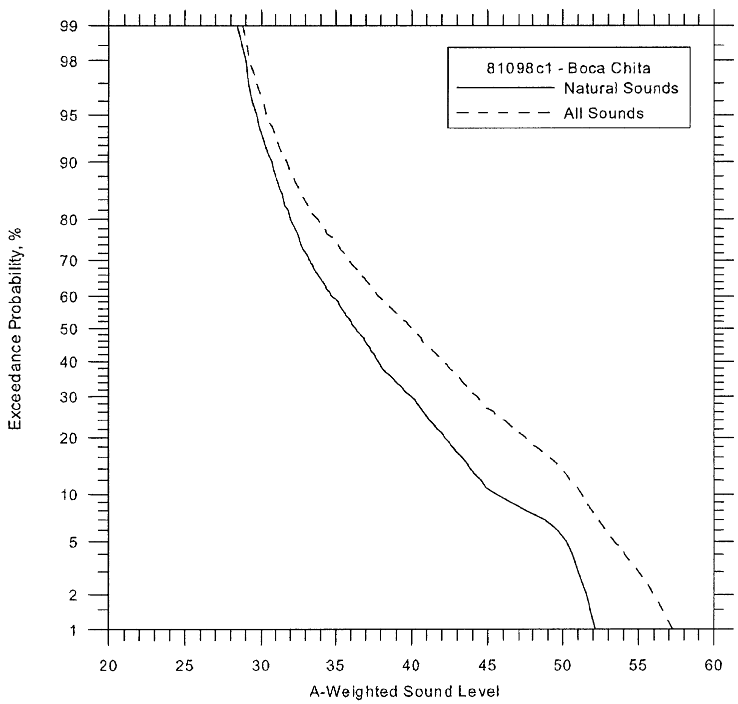
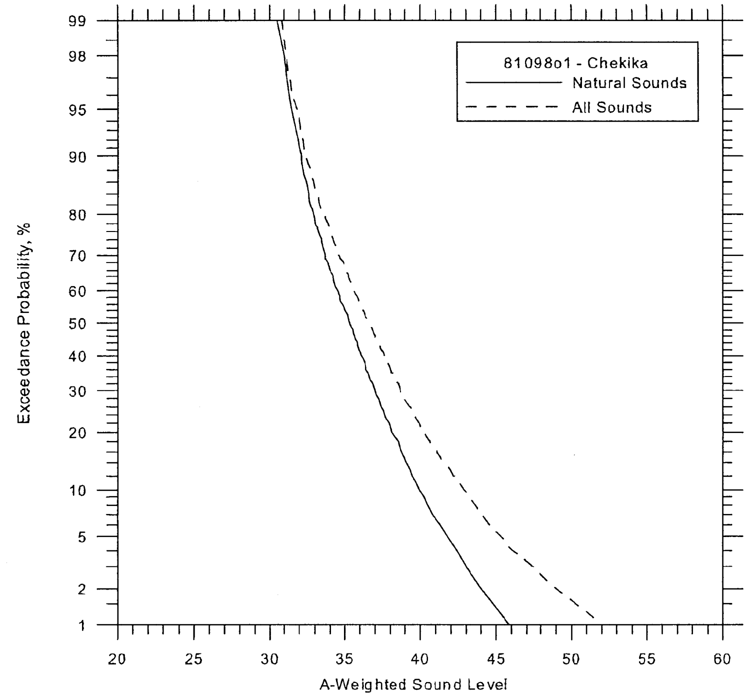
55
60
A-Weighted Sound Level

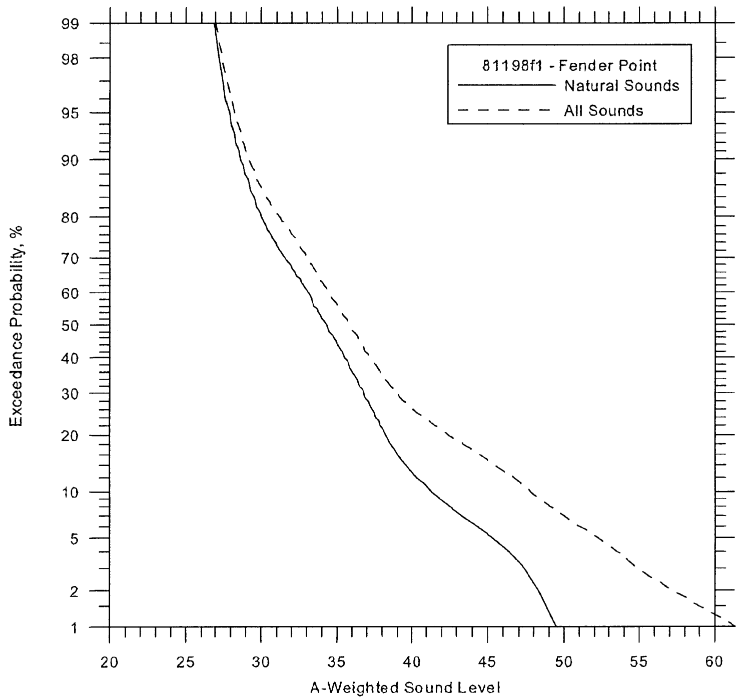
Appendix B

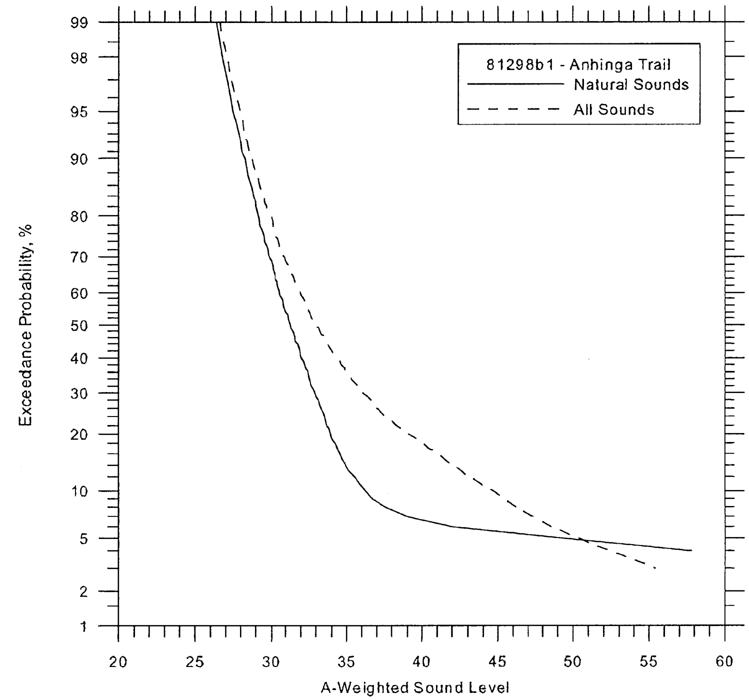
Exceedance Plots for John A. Volpe National Transportation Research Center 1998 Measurements

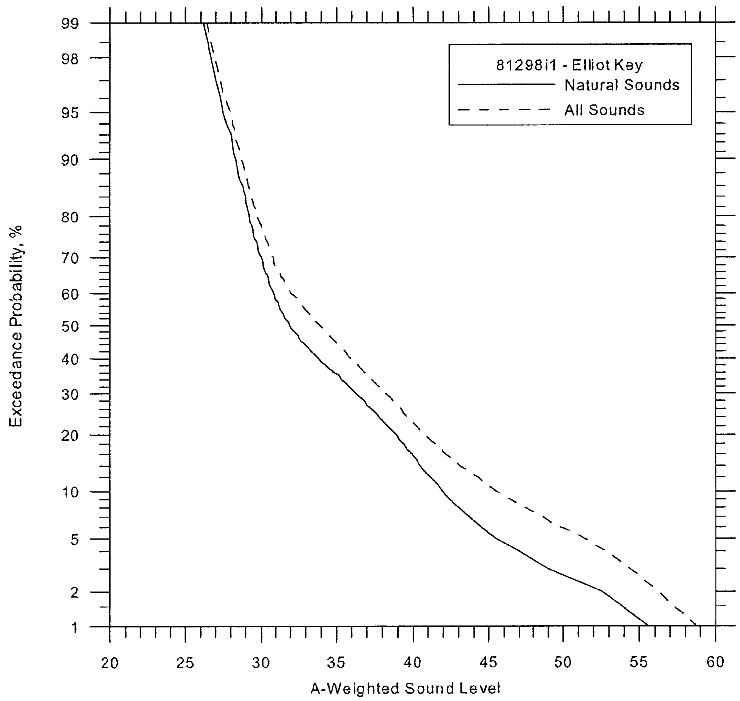


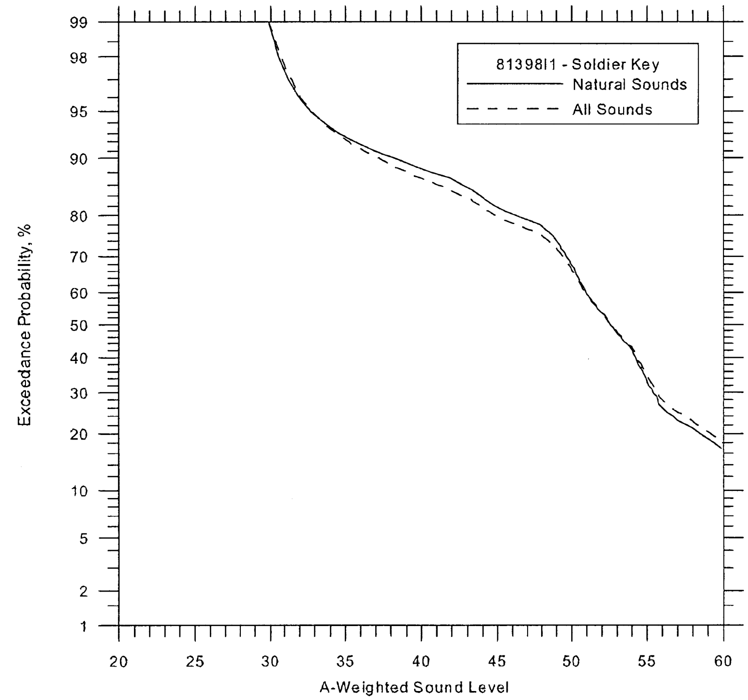

81098c1 - Boca Chita
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60

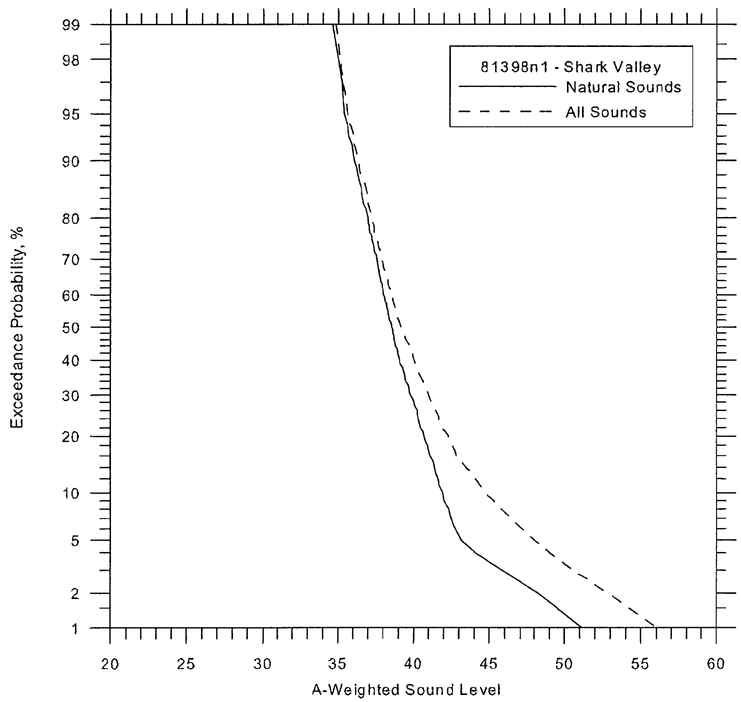

81098o1 - Chekika
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60


81198f1 - Fender Point
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60


81298b1 - Anhinga Trail
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60


81298i1 - Elliot Key
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
A-Weighted Sound Level


81398l1 - Soldier Key
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
A-Weighted Sound Level


81398n1 - Shark Valley
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
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2
1
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25
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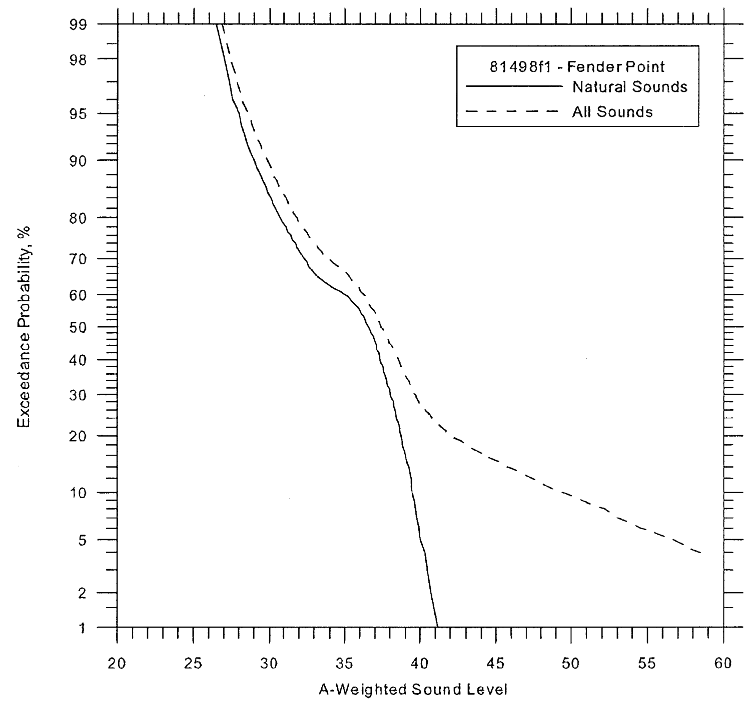
40
45
50
55
60


81498f1 - Fender Point
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
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30
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2
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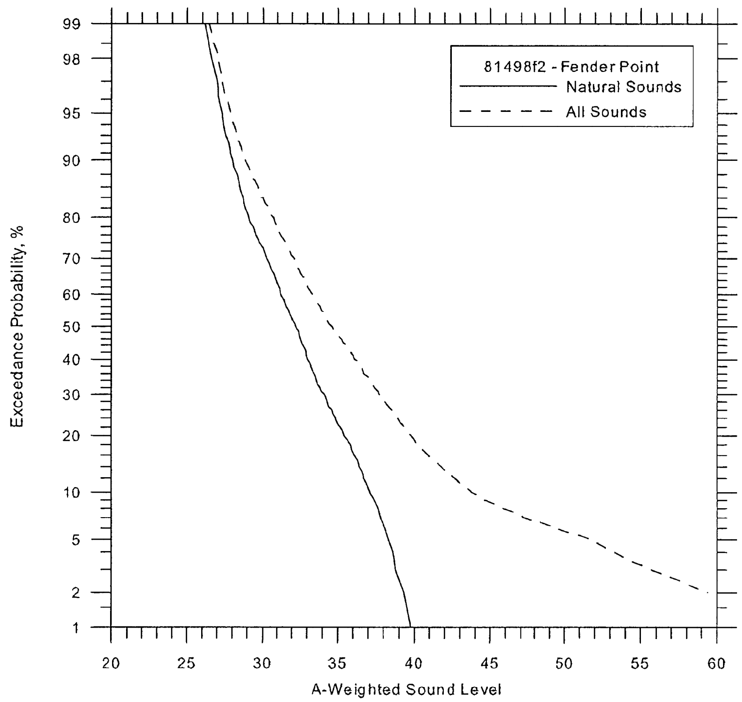
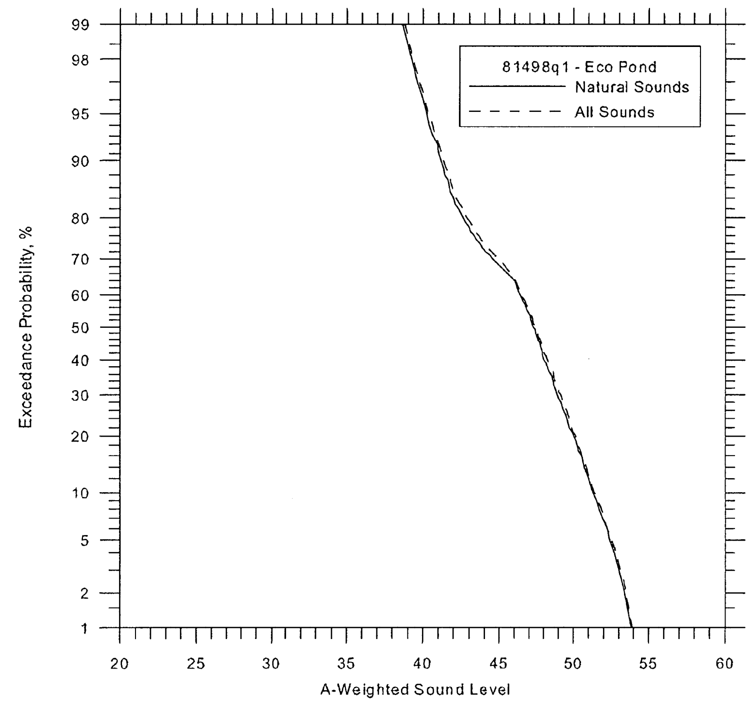
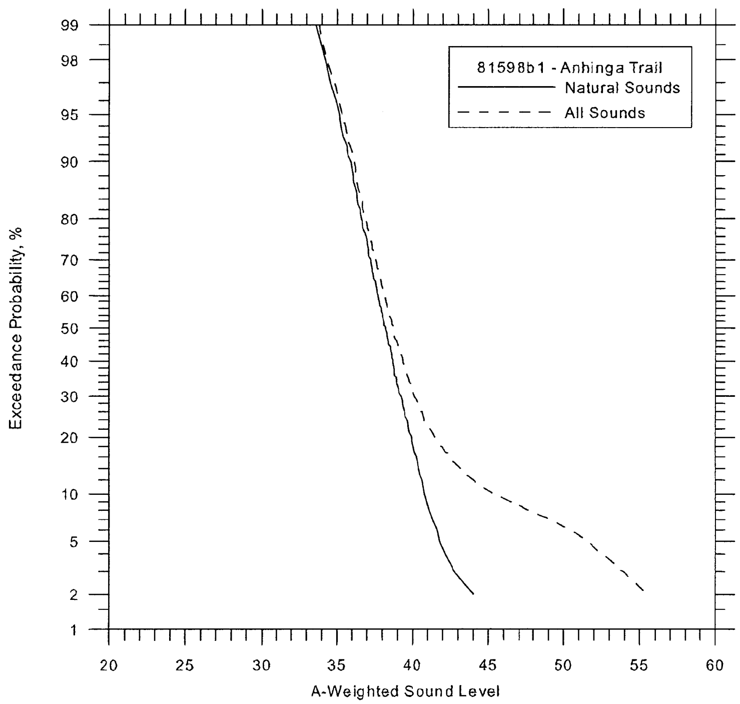
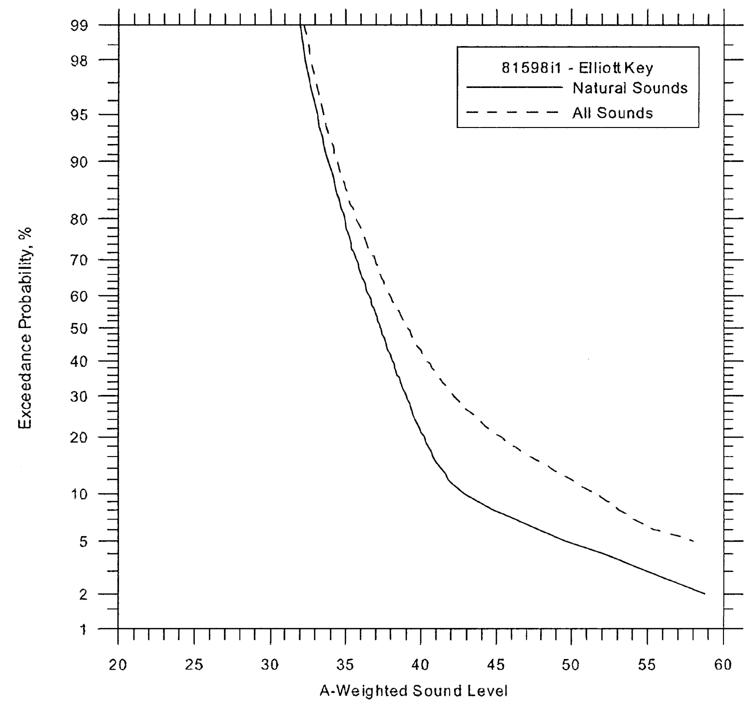
40
45
50
55
60


81498f2 - Fender Point
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level


81498q1 - Eco Pond
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level


81598b1 - Anhinga Trail
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60


81598i1 - Elliott Key
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
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30
20
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40
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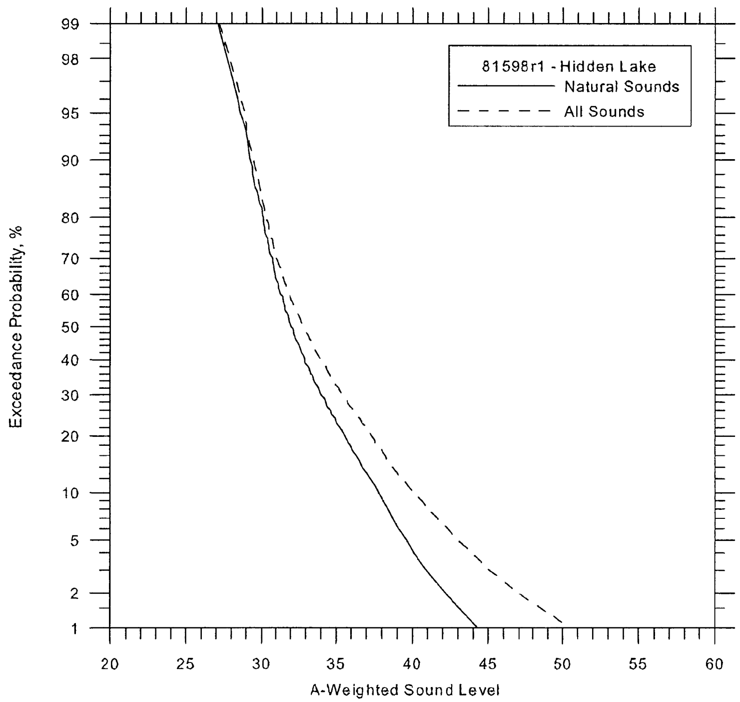
60


81598r1 - Hidden Lake
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
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40
30
20
10
5
2
1
20
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35
40
45
50
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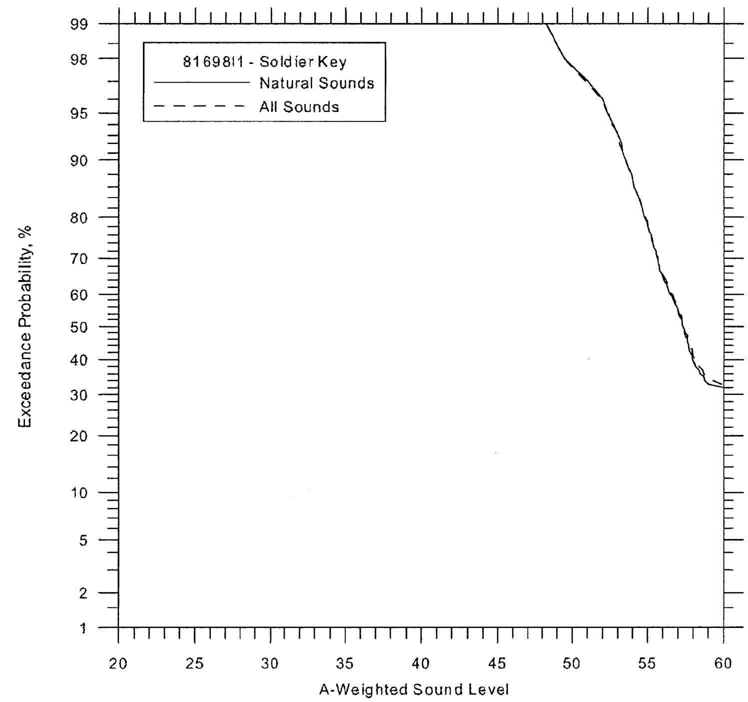
60


81698l1 - Soldier Key
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
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2
1
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25
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35
40
45
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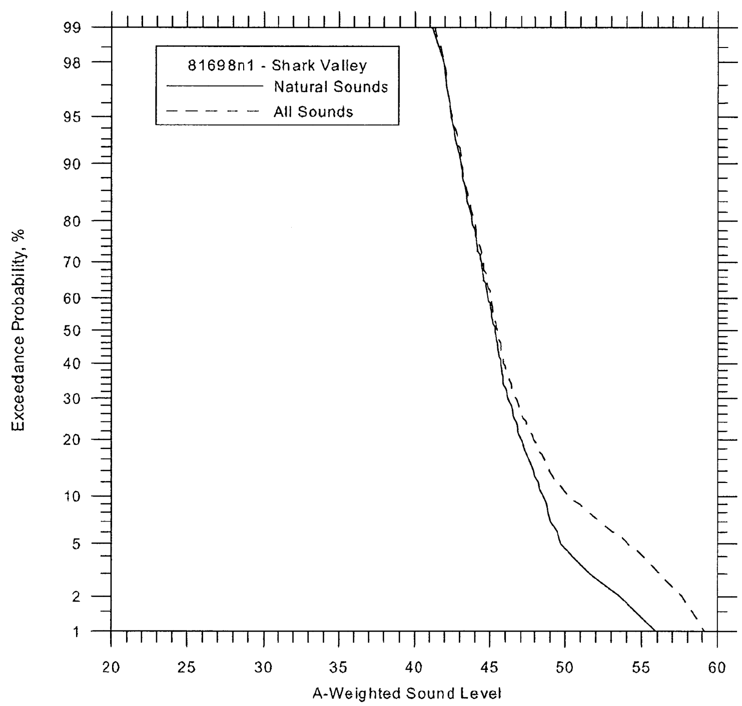
55
60


81698n1 - Shark Valley
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
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40
30
20
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2
1
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45
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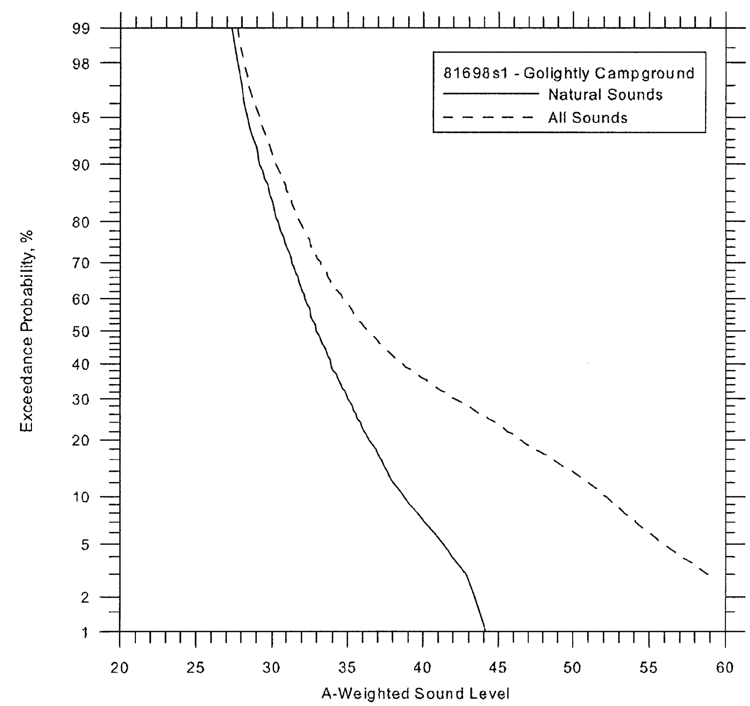
60


81698s1 - Golightly Campground
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
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30
20
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2
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45
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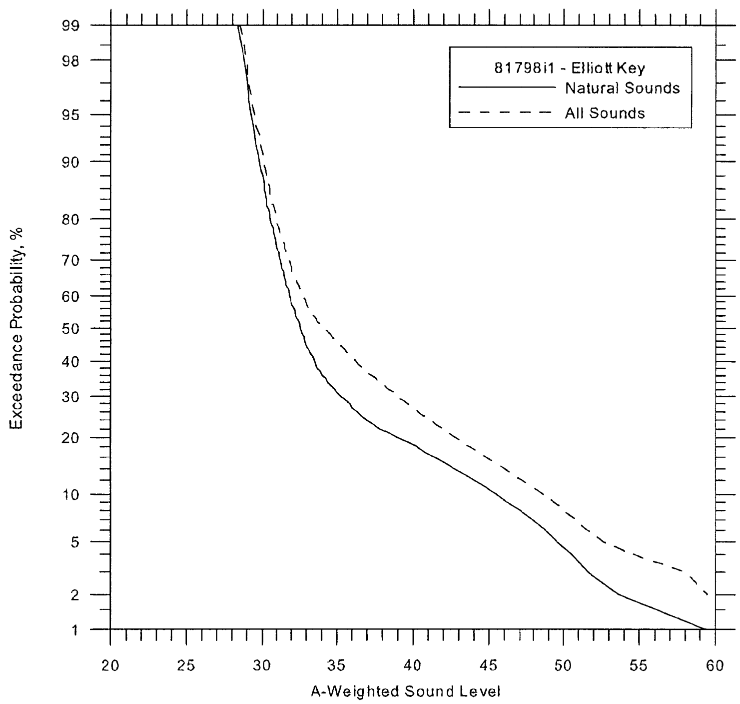
55
60


81798i1 - Elliott Key
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
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30
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40
45
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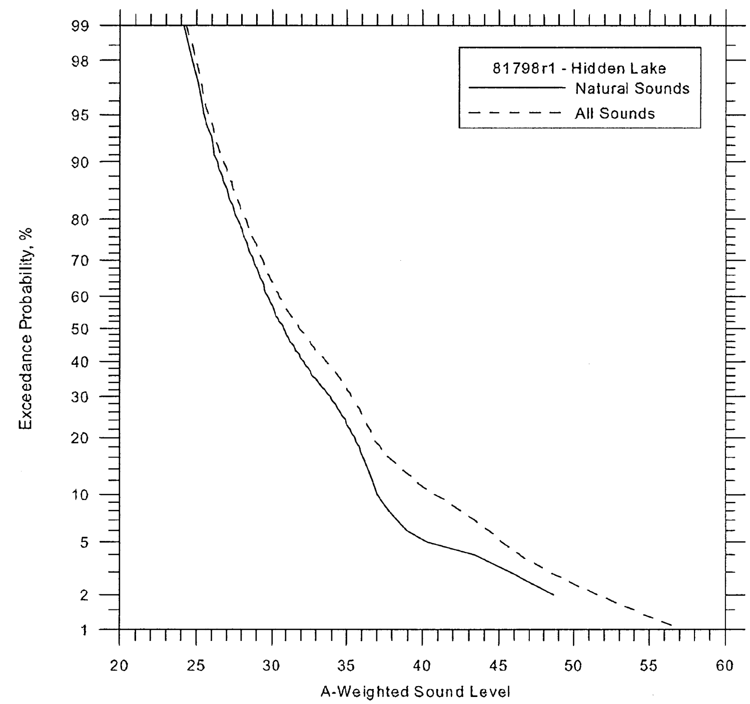
60


81798r1 - Hidden Lake
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
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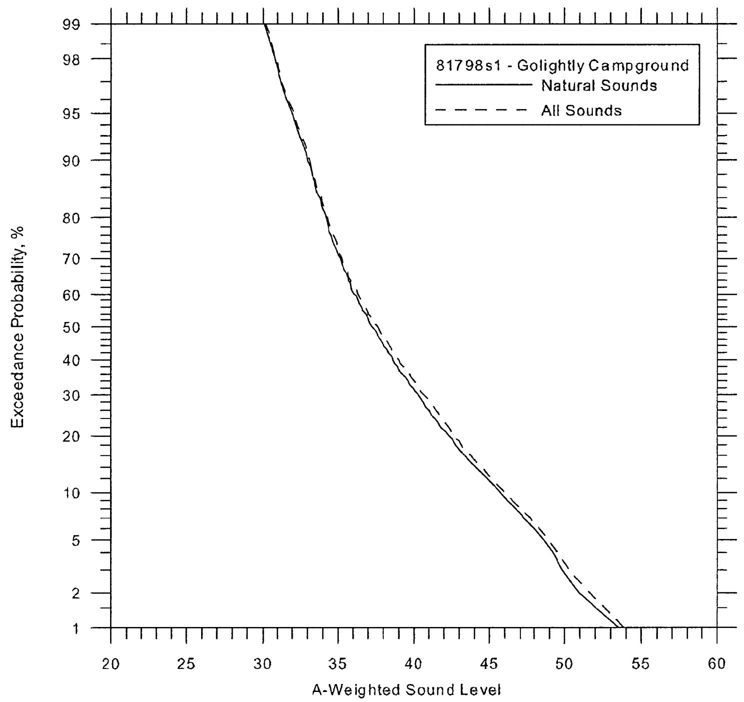
40
45
50
55
60


81798s1 - Golightly Campground
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
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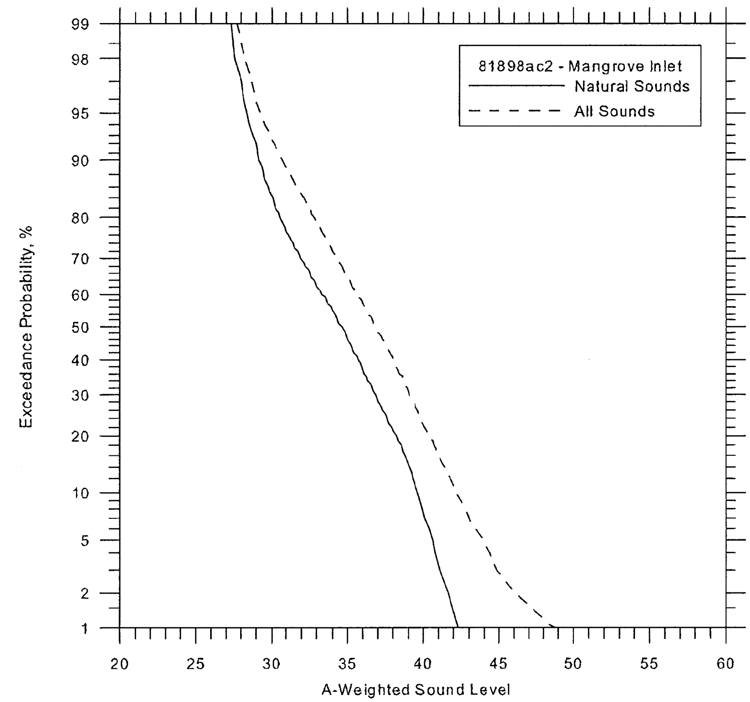
40
45
50
55
60


81898ac2 - Mangrove Inlet
Natural Sounds
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
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40
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20
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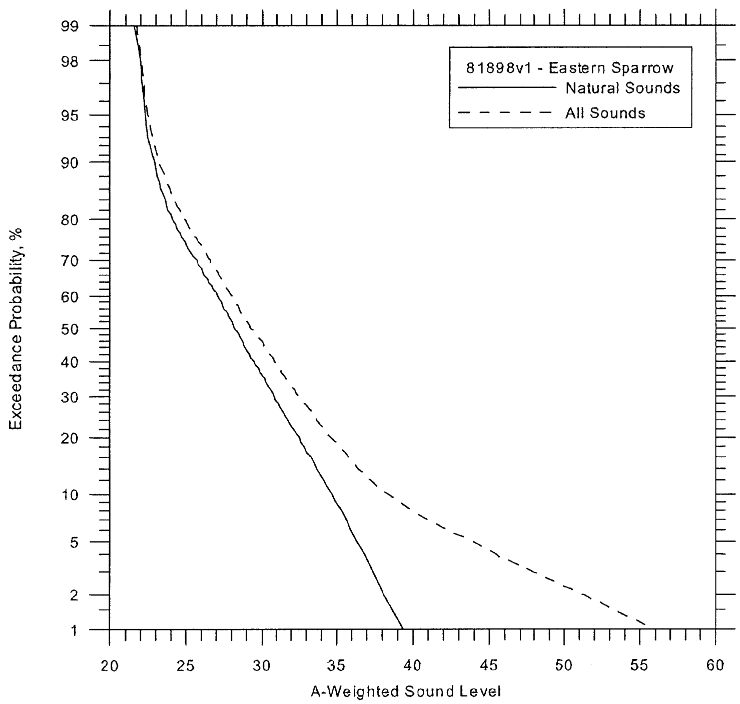
40
45
50
55
60


81898v1 - Eastern Sparrow
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
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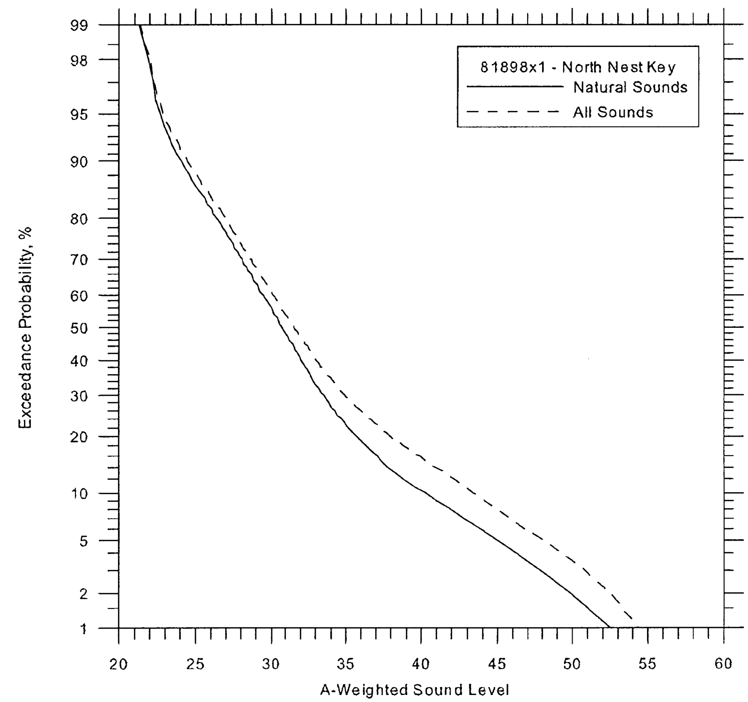
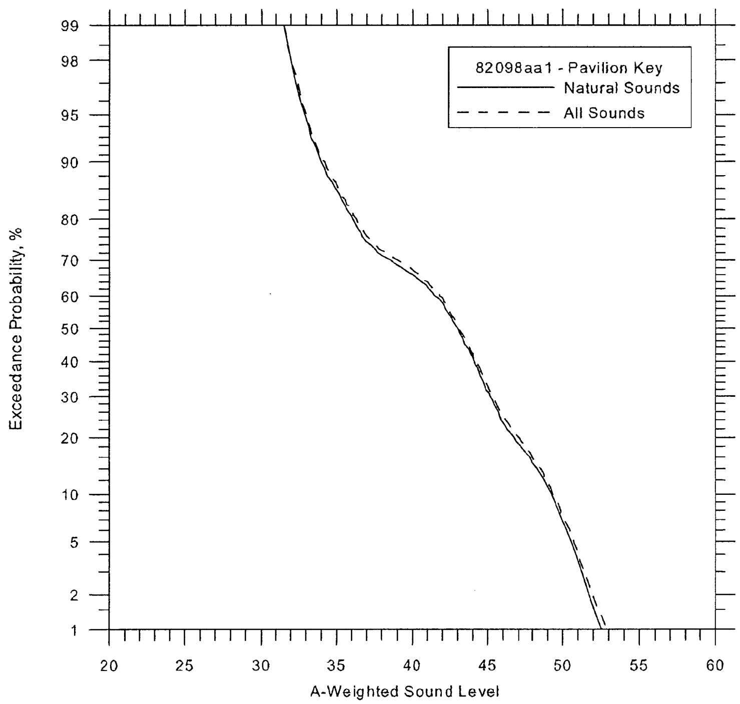
10
5
2
1
20
25
30
35
40
45
50
55
60
A-Weighted Sound Level


81898x1 - North Nest Key
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
A-Weighted Sound Level


82098aa1 - Pavilion Key
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
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1
20
25
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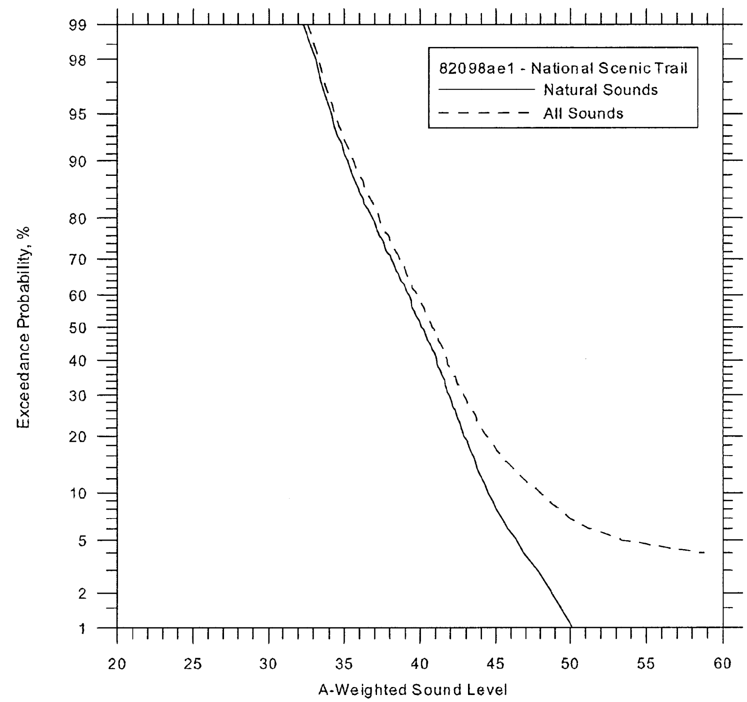
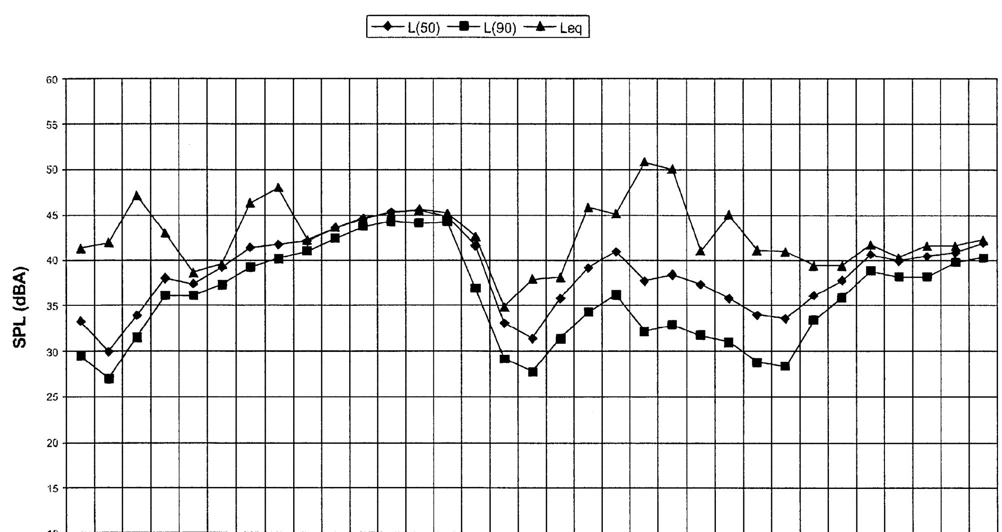
50
55
60
A-Weighted Sound Level


82098ae1 - National Scenic Trail
Natural Sounds
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
A-Weighted Sound Level

Appendix C

Hourly L50, L90, and Leq for Sanchez Industrial Design 1998 Measurements

Anhinga trail - Fri 11/20 to Sat 11/21

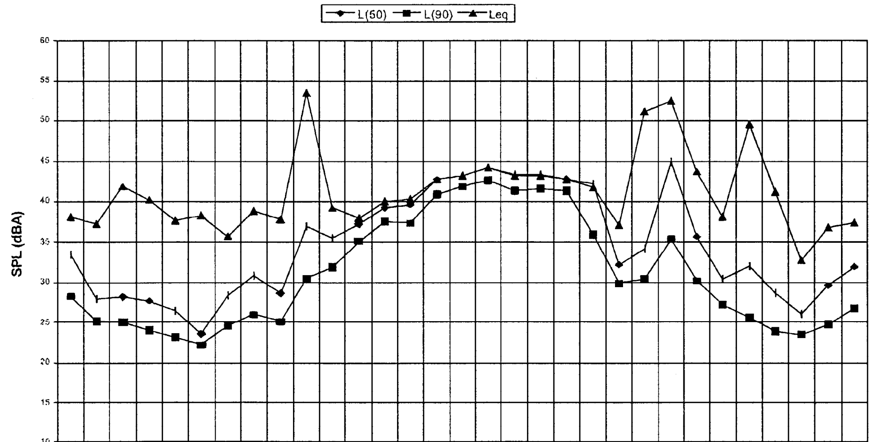


	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00
L(50)	33.3	30	33.9	38	37.4	39.2	41.4	41.7	42.1	43.6	44.6	45.3	45.5	44.9	41.6	33.1	31.4
L(90)	29.5	27	31.6	36.1	36.1	37.3	39.2	40.2	41	42.4	43.7	44.3	44.1	44.2	36.9	29.2	27.8
Leq	41.3	41.9	47.1	43	38.6	39.5	46.3	46	42.2	43.6	44.7	45.2	45.6	45.2	42.8	34.9	37.9

	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	0:00
L(50)	35.8	39.1	40.9	37.7	38.4	37.3	35.8	34	33.6	36.1	37.8	40.6	39.9	40.4	40.8	41.9
L(90)	31.4	34.3	36.2	32.2	32.9	31.7	31	28.8	28.4	33.4	35.9	38.8	38.2	38.2	39.7	40.3
Leq	38.1	45.8	45.1	50.8	50	41	45	41.1	40.9	39.4	39.4	41.7	40.3	41.5	41.6	42.2

Hour

Big Cypress - 11 mile road - Tue 11/17 to Wed 11/18

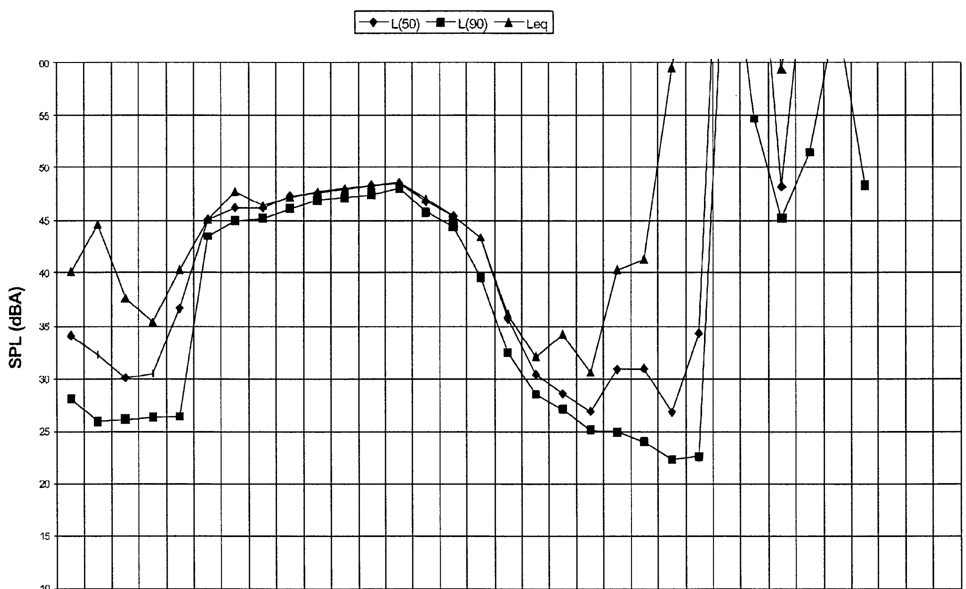


Hour	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	0:00
L(50)	33.6	27.9	28.2	27.7	26.5	23.6	28.4	30.8	28.7	36.9	35.6	37.2	39.2	39.6	42.7	43.2
L(90)	28.3	25.2	25	24	23.1	22.2	24.6	26	25.1	30.5	31.6	35.1	37.5	37.3	40.9	41.8
Leq	38.1	37.2	41.8	40.2	37.7	38.3	35.7	38.8	37.8	53.5	39.2	38	40	40.3	42.7	43.2

Hour	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00
L(50)	44.2	43.3	43.3	42.8	42.2	32.2	34.2	44.9	35.7	30.4	32	28.7	26.1	29.6	31.9
L(90)	42.6	41.3	41.6	41.2	35.9	29.9	30.4	35.4	30.2	27.2	25.6	23.9	23.5	24.7	26.6
Leq	44.2	43.2	43.2	42.7	41.7	37.1	51.2	52.5	43.7	38.1	49.6	41.2	32.7	36.8	37.4

Hour

Canepatch - Thur 11/19 to Fri 11/20

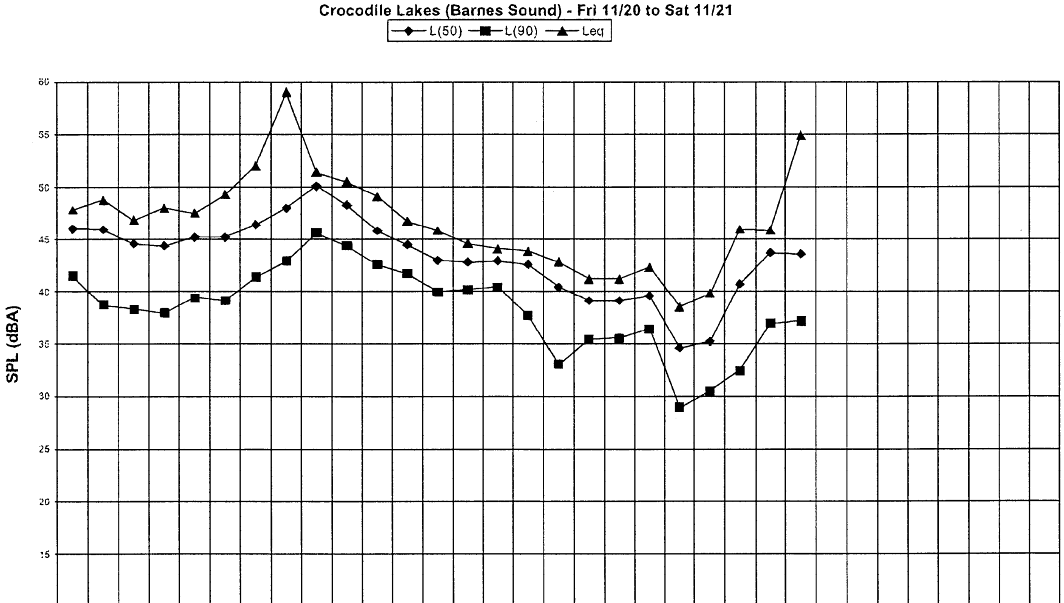


Hour	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	0:00	1:00	2:00	3:00
L(50)	34.1	32.3	30.1	30.5	36.7	45.1	46.2	46.2	47.3	47.6	47.9	48.3	48.5	46.8	45.4
L(90)	28.1	25.9	26.1	26.3	26.4	43.5	45	45.2	46.1	46.9	47.1	47.4	48	45.8	44.4
Leq	40.1	44.6	37.6	35.4	40.3	45.1	47.7	46.4	47.2	47.7	48	48.3	48.6	47	45.4

Hour	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
L(50)	43.4	35.7	30.4	28.6	26.9	30.9	31	26.8	34.3	92	79.7	48.2	72.9	72.5	66.6
L(90)	39.6	32.5	28.5	27.1	25.1	24.9	24	22.3	22.6	75	54.7	45.2	51.5	64.8	48.3
Leq	43.4	36.1	32.1	34.2	30.6	40.3	41.3	59.5	72.2	91.8	92.5	59.4	74.2	72.8	76.2

Hour

Crocodile Lakes (Barnes Sound) - Fri 11/20 to Sat 11/21

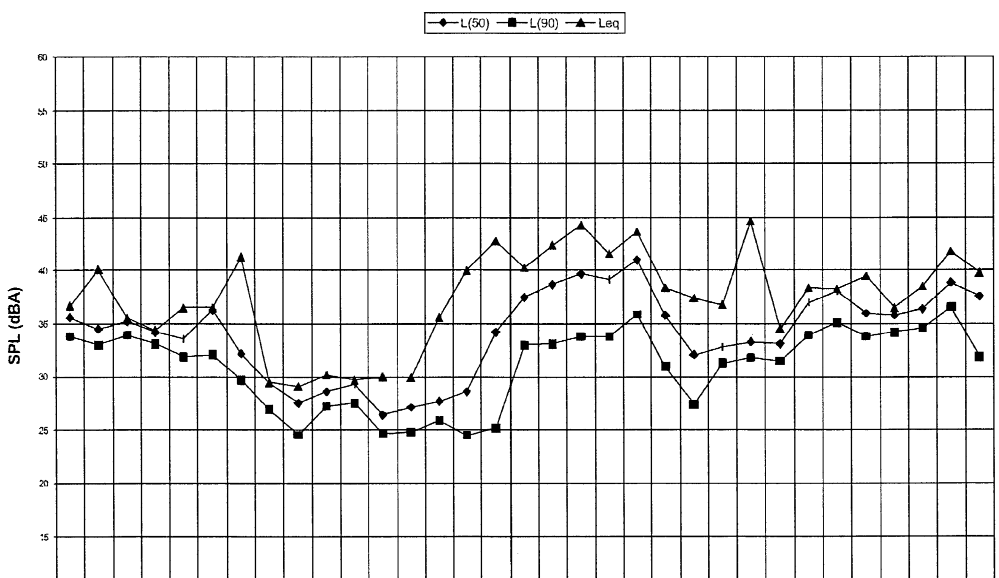


	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
L(50)	46	45.9	44.6	44.4	45.2	45.2	46.4	48	50.1	48.3	45.8	44.5	43
L(90)	41.5	38.7	38.3	37.9	39.4	39.1	41.4	42.9	45.6	44.4	42.6	41.7	40
Leq	47.6	48.8	46.8	48	47.5	49.3	52	59	51.4	50.5	49.1	46.7	45.8

	21:00	22:00	23:00	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00
L(50)	42.8	42.9	42.6	40.4	39.1	39.1	39.6	34.6	35.2	40.7	43.7	43.6
L(90)	40.2	40.4	37.7	33	35.4	35.5	36.4	28.9	30.5	32.4	36.9	37.2
Leq	44.6	44.1	43.9	42.8	41.2	41.2	42.3	38.5	39.8	45.9	45.8	54.9

Hour

Ernest Coe - Tue 11/17 to Thur 11/19

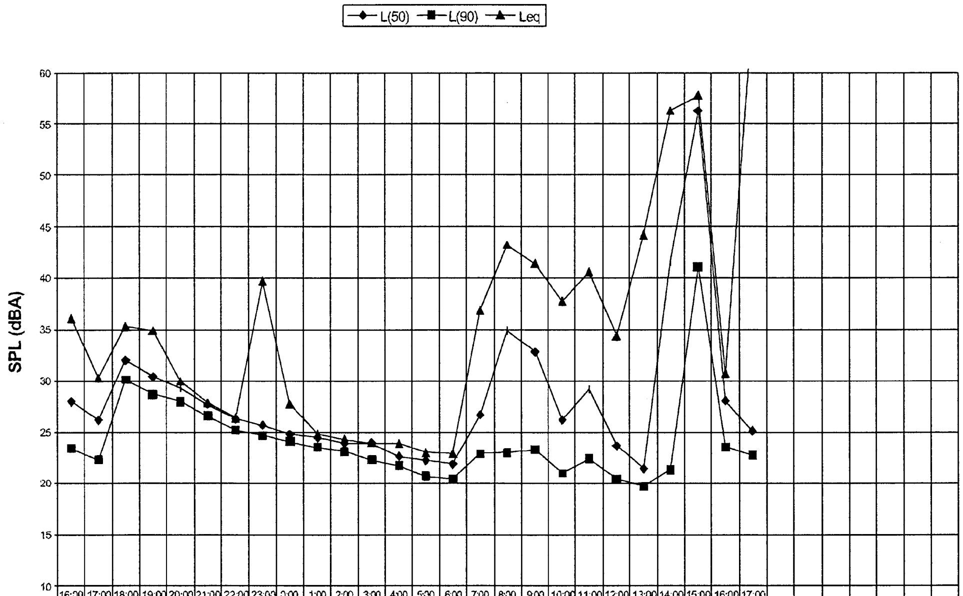


	19:00	20:00	21:00	22:00	23:00	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
L(50)	35.6	34.5	35.2	34.2	33.6	36.3	32.2	29.4	27.5	28.0	29.3	26.4	27.1	27.7	28.6	34.2	37.5
L(90)	33.8	33	33.9	33.1	31.9	32.1	29.7	26.9	24.6	27.2	27.5	24.7	24.8	25.9	24.5	25.2	33
Leq	36.7	40.1	35.5	34.4	36.5	36.5	41.3	29.5	29.1	30.2	29.7	30	29.9	35.6	40	42.6	40.3

	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	0:00	1:00	2:00	3:00
L(50)	38.7	39.7	39.2	41	35.8	32.1	32.8	33.3	33.1	37	38.1	36	35.8	36.4	38.9	37.6
L(90)	33.1	33.8	33.8	35.5	31	27.4	31.3	31.8	31.5	33.9	35.1	33.8	34.2	34.6	36.6	31.9
Leq	42.4	44.3	41.6	43.7	38.4	37.4	36.8	44.7	34.5	38.4	38.3	39.5	36.5	38.5	41.8	39.8

Hour

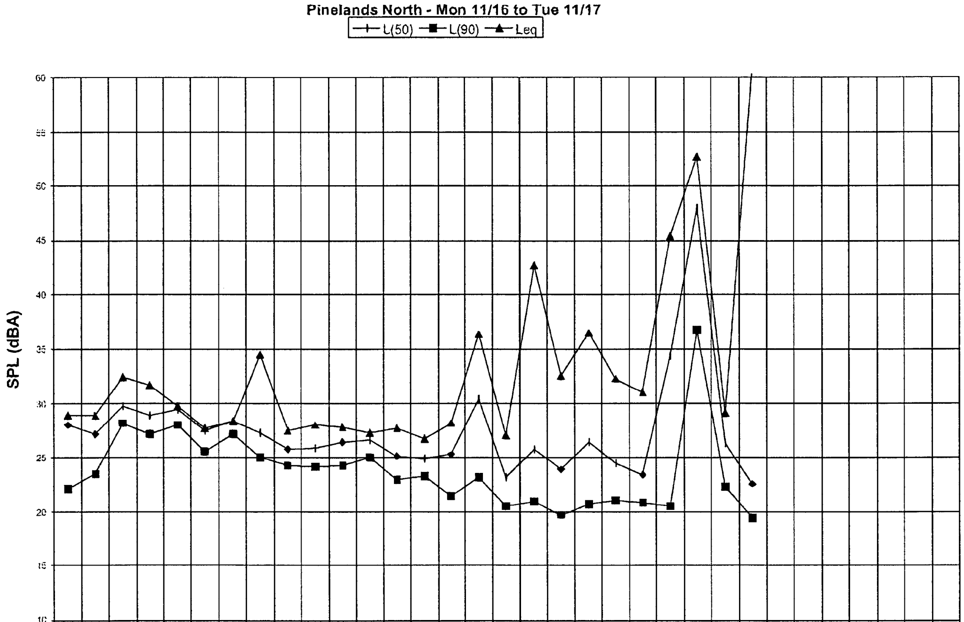
Pinelands East - Mon 11/16 to Tue 11/17



	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
L(50)	28	26.2	32	30.4	29.3	27.7	26.3	25.7	24.8	24.5	23.9	24	22.6	22.2	21.9	26.7	34.9	32.8	26.2	29.2	23.7	21.4	41.6	56.3	28.1	25.1
L(90)	23.4	22.3	30.1	28.7	28	26.6	25.2	24.7	24.1	23.5	23.1	22.3	21.7	20.7	20.4	22.9	23	23.3	21	22.4	20.4	19.7	21.3	41.1	23.6	22.7
Leq	36.1	30.3	35.3	34.9	30	27.9	26.4	39.7	27.8	24.8	24.3	24	23.9	23	22.9	36.9	43.2	41.4	37.8	40.6	34.4	44.2	56.3	57.8	30.7	65.5

Hour

Pinelands North - Mon 11/16 to Tue 11/17

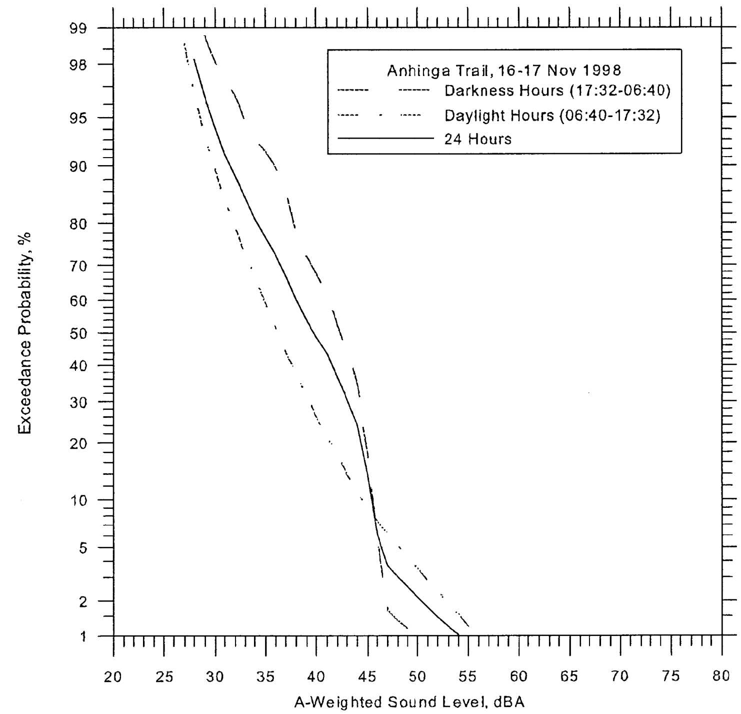


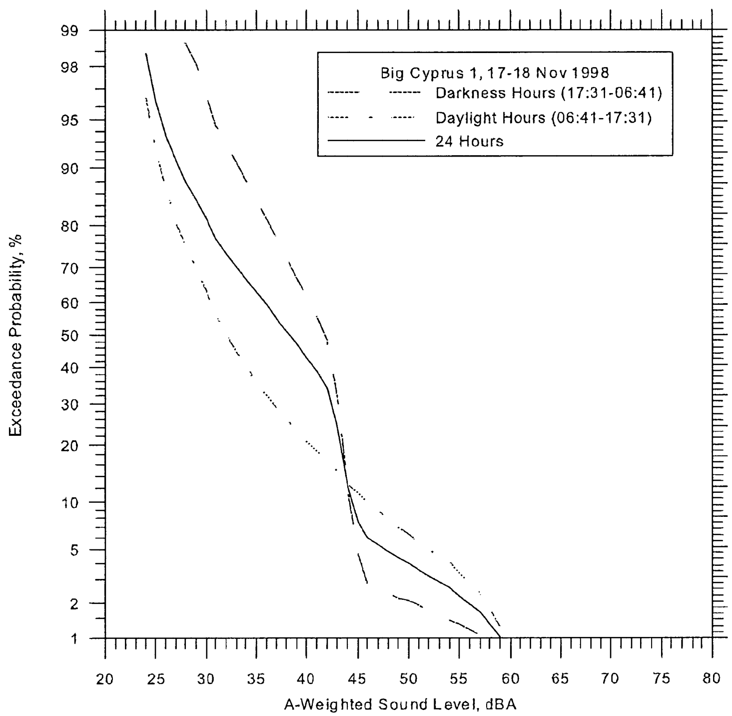
	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
L(50)	28	27.2	29.8	28.9	29.4	27.5	28.4	27.3	25.8	25.9	26.4	26.6	25.1	24.9	25.3	30.4	23.2	25.8	23.9	26.4	24.5	23.4	34.4	48	25.3	22.6
L(90)	22.1	23.5	28.2	27.2	28	25.6	27.2	25	24.3	24.2	24.3	25	23	23.3	21.5	23.2	20.5	20.9	19.7	20.7	21	20.8	20.5	36.8	22.3	19.4
Leq	28.9	28.9	32.5	31.7	29.8	27.7	28.4	34.5	27.5	28	27.8	27.3	27.7	26.8	28.2	36.4	27.1	42.7	32.6	36.5	32.3	31.1	45.4	52.7	29.1	60.7

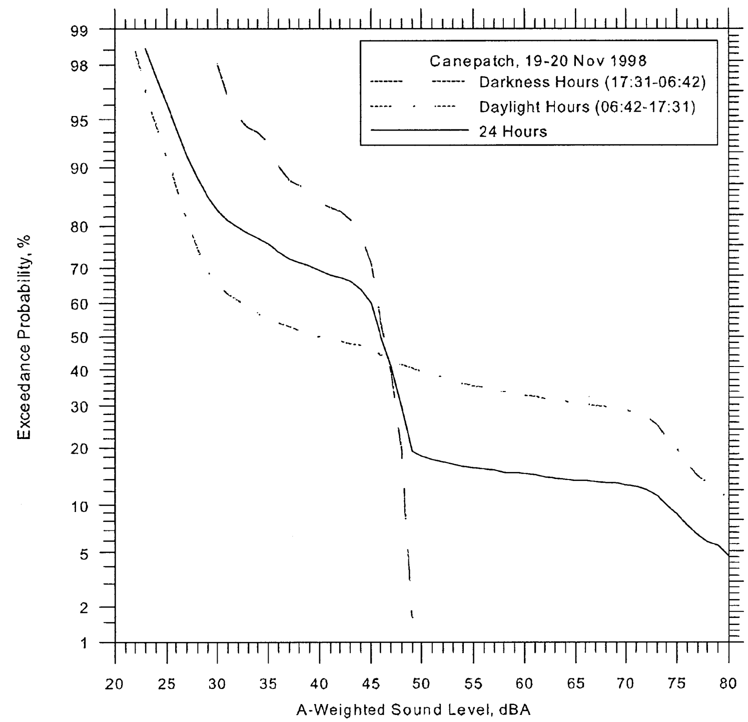
Hour

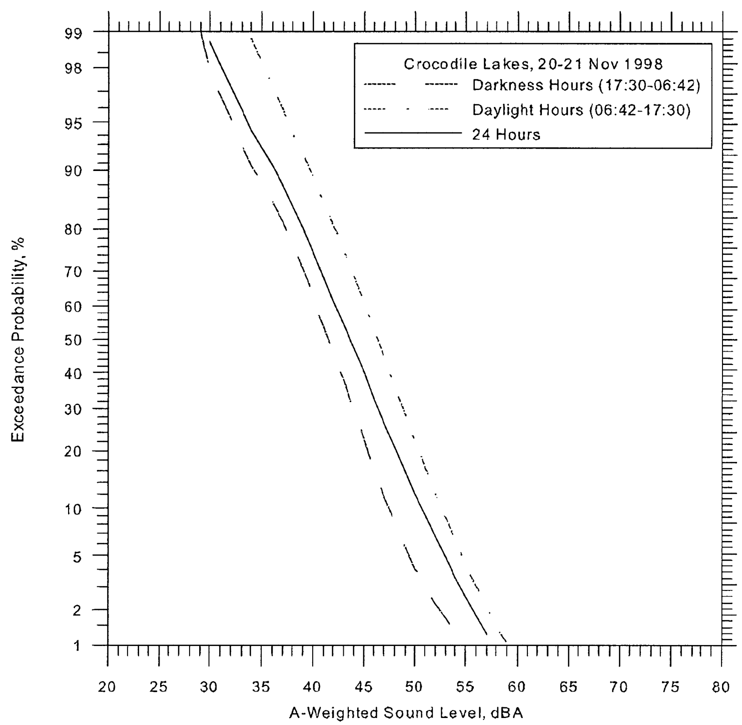
Appendix D

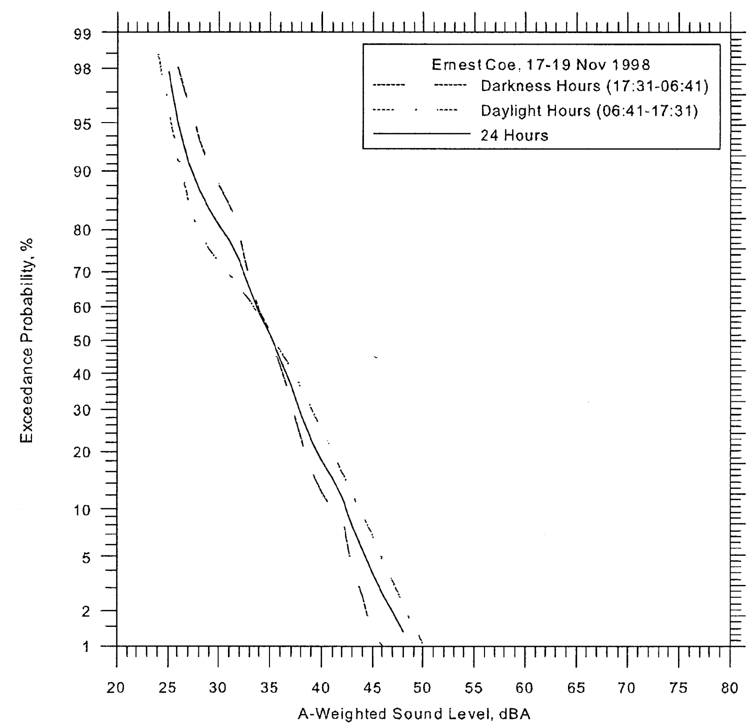
Exceedance Plots for Sanchez Industrial Design 1998 Measurements

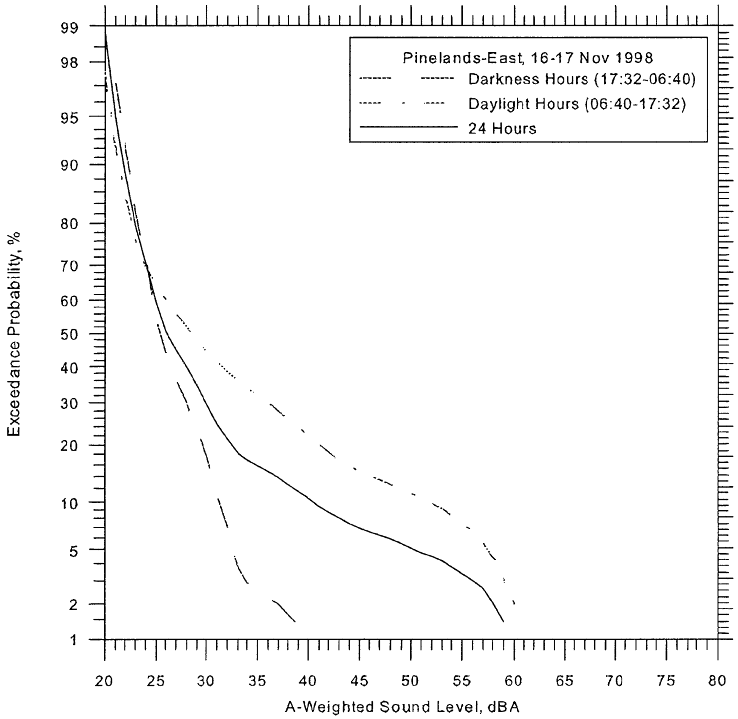


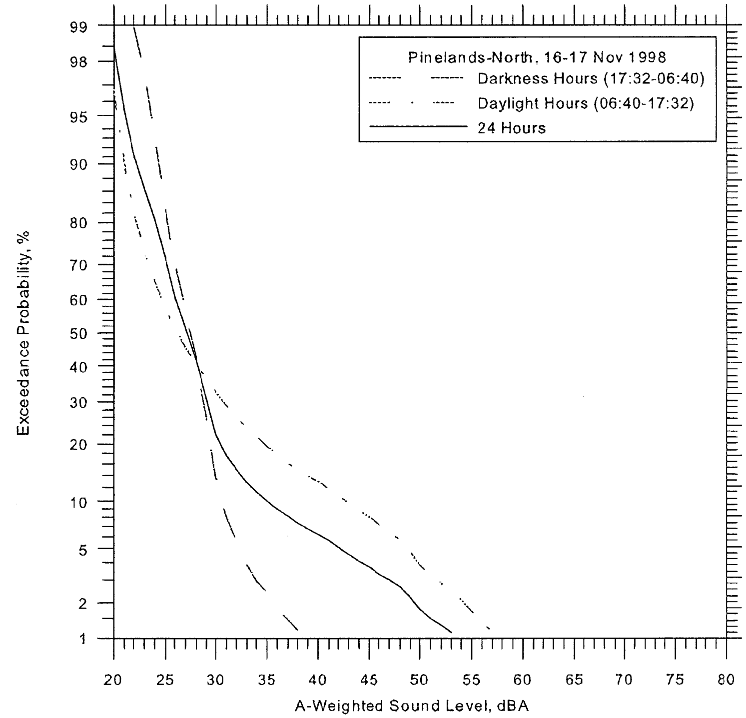

Big Cyprus 1, 17-18 Nov 1998
Darkness Hours (17:31-06:41)
Daylight Hours (06:41-17:31)
24 Hours
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level, dBA


Canepatch, 19-20 Nov 1998
Darkness Hours (17:31-06:42)
Daylight Hours (06:42-17:31)
24 Hours
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level, dBA

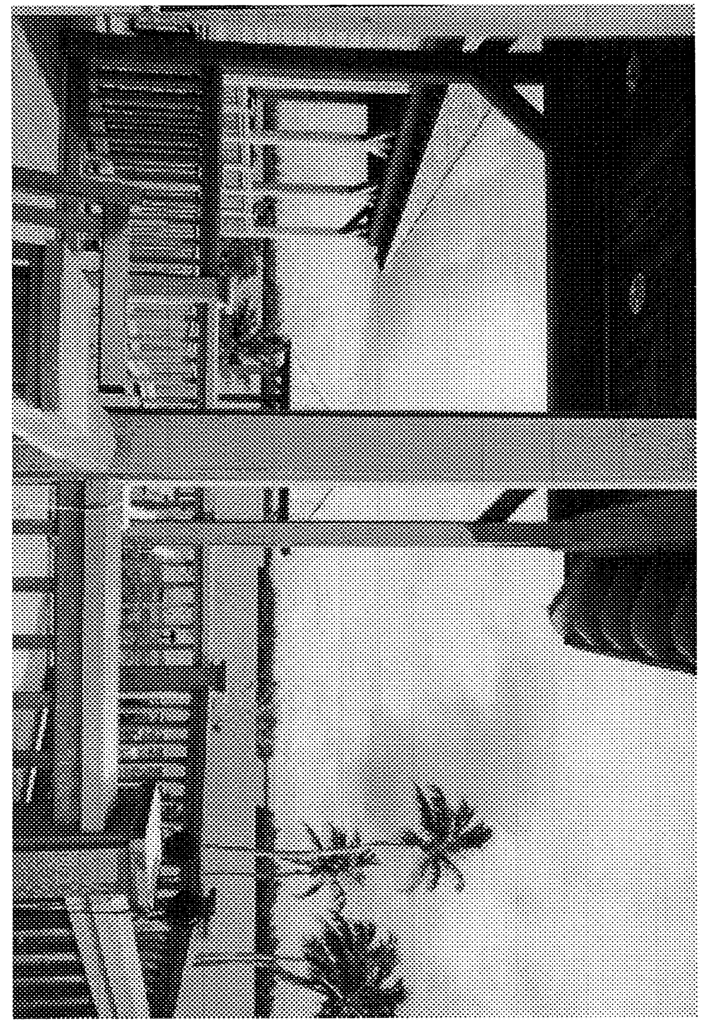

Crocodile Lakes, 20-21 Nov 1998
Darkness Hours (17:30-06:42)
Daylight Hours (06:42-17:30)
24 Hours
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level, dBA


Ernest Coe, 17-19 Nov 1998
Darkness Hours (17:31-06:41)
Daylight Hours (06:41-17:31)
24 Hours
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level, dBA

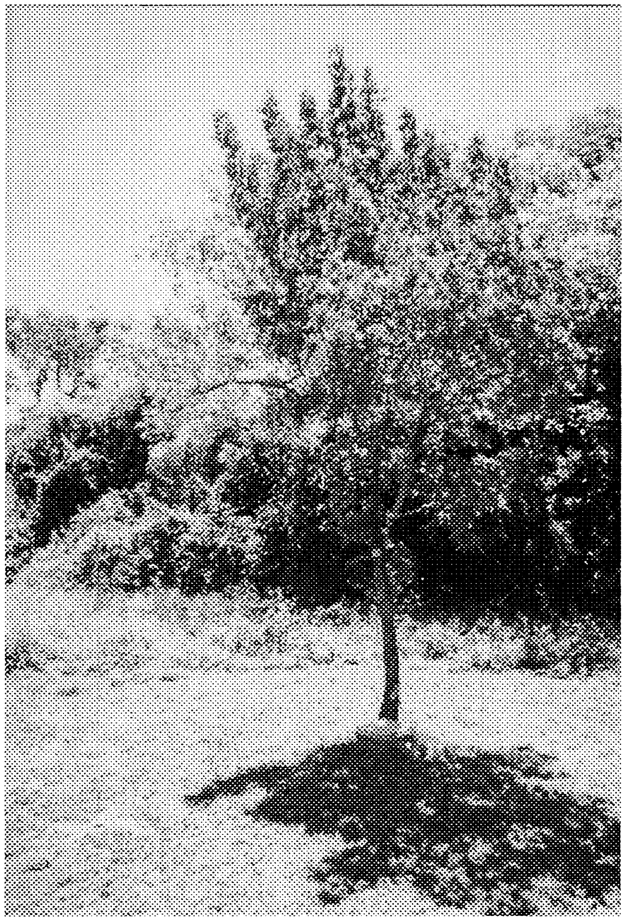

Pinelands-East, 16-17 Nov 1998
Darkness Hours (17:32-06:40)
Daylight Hours (06:40-17:32)
24 Hours
Exceedance Probability, %
A-Weighted Sound Level, dBA
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80


Pinelands-North, 16-17 Nov 1998
Darkness Hours (17:32-06:40)
Daylight Hours (06:40-17:32)
24 Hours
Exceedance Probability, %
A-Weighted Sound Level, dBA
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80

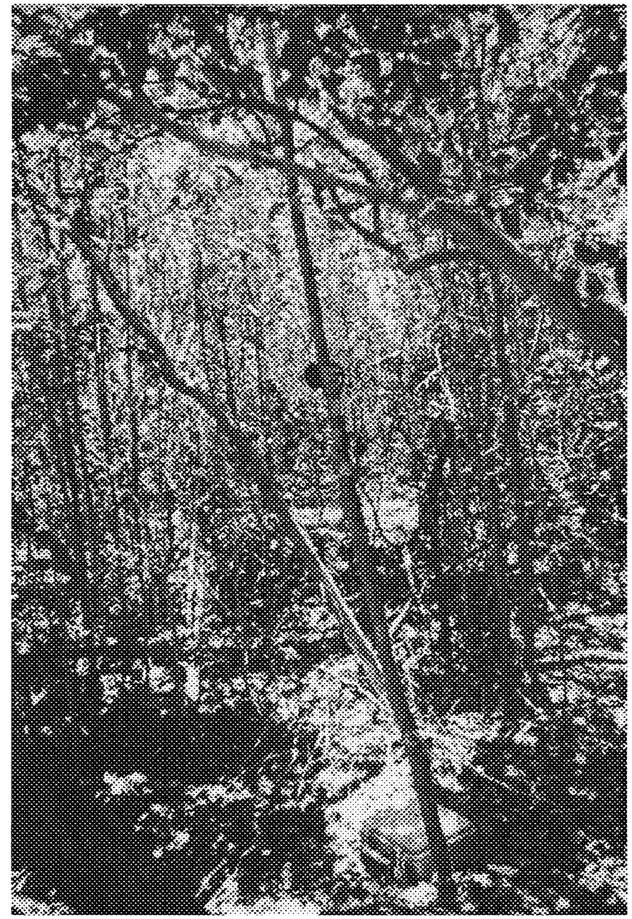
Appendix E
Pictures of Wyle 1999 Monitoring Sites



B1. Convoy Visitor Center

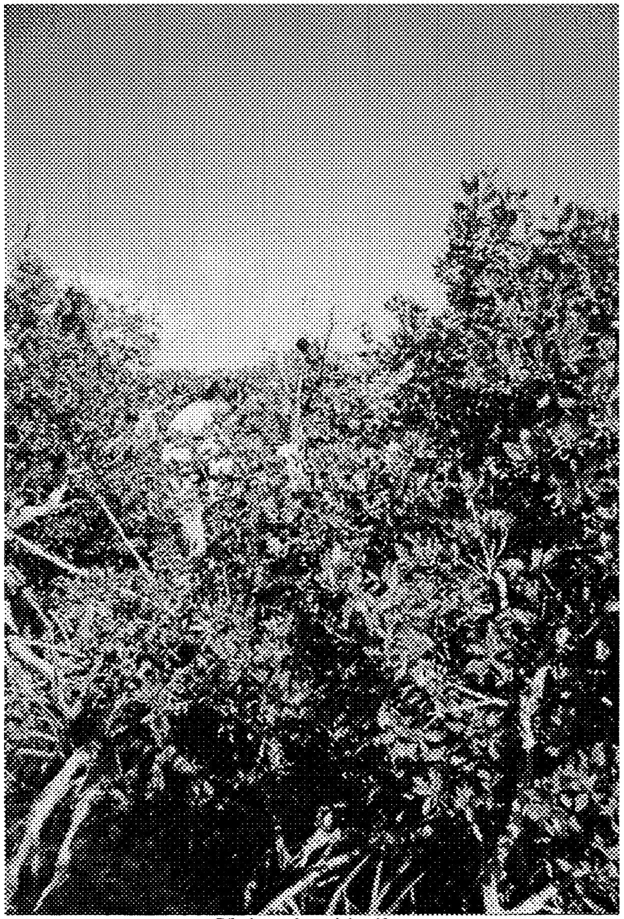


B2. Elliot Key Picnic Grounds



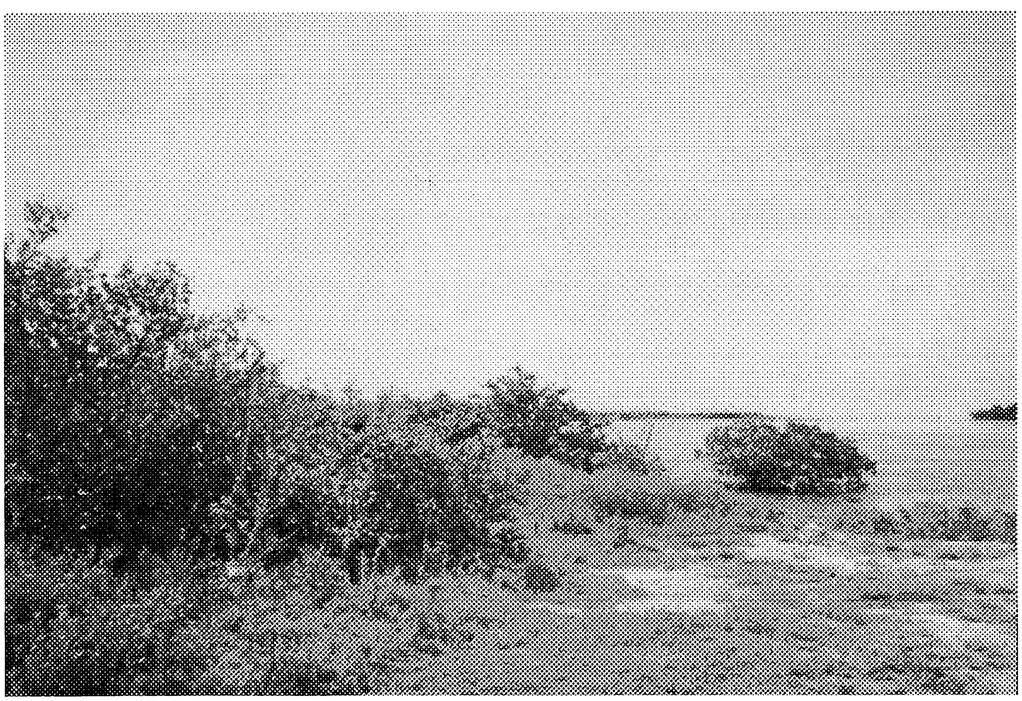
B3 Hiking Trail North of Elliot Key

B4. Hiking Trail South of Elliot Key
Missing Photo

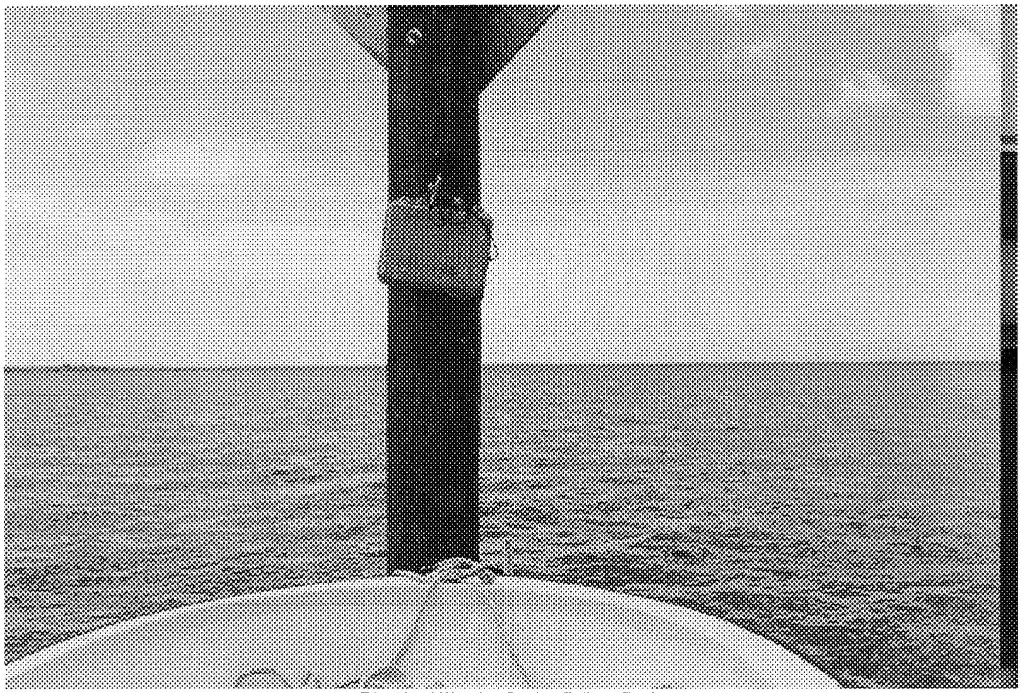


B5. Long Arsenicker Key

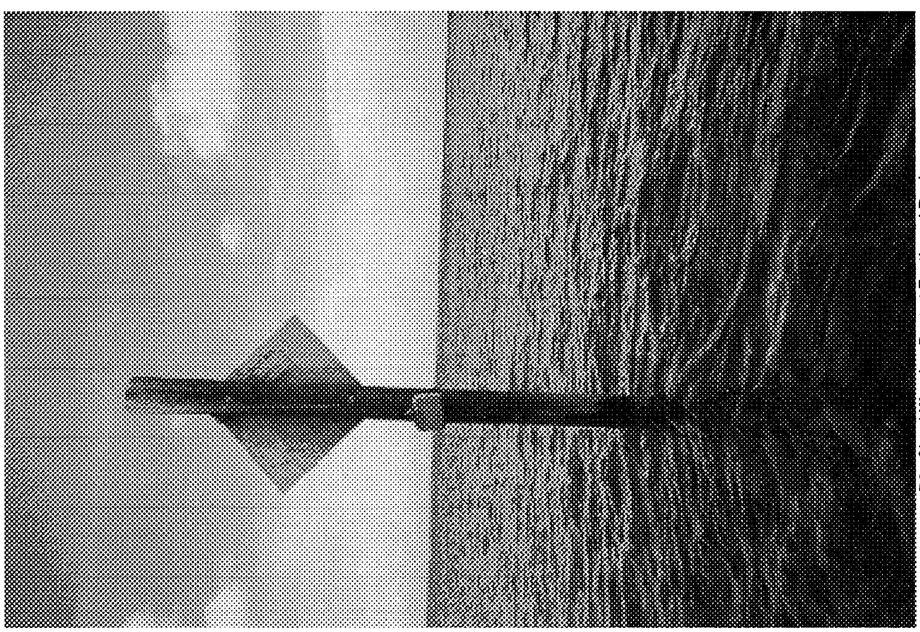
B6. Old Rhodes Key



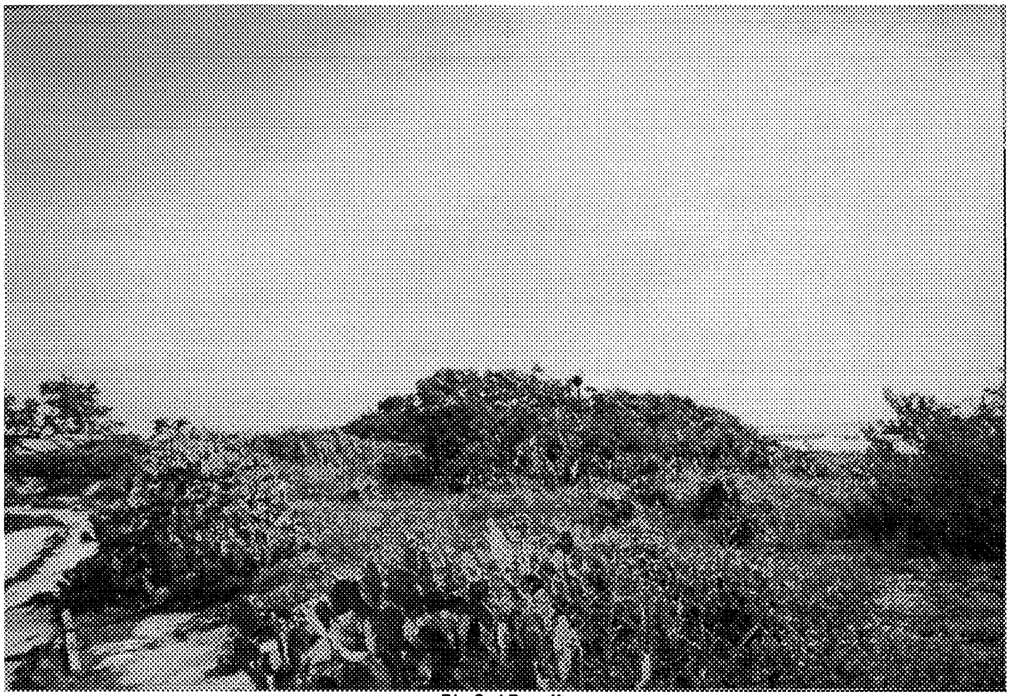
B7. Adam's Key



B9. Shoal Warning Post at Pelican Bank



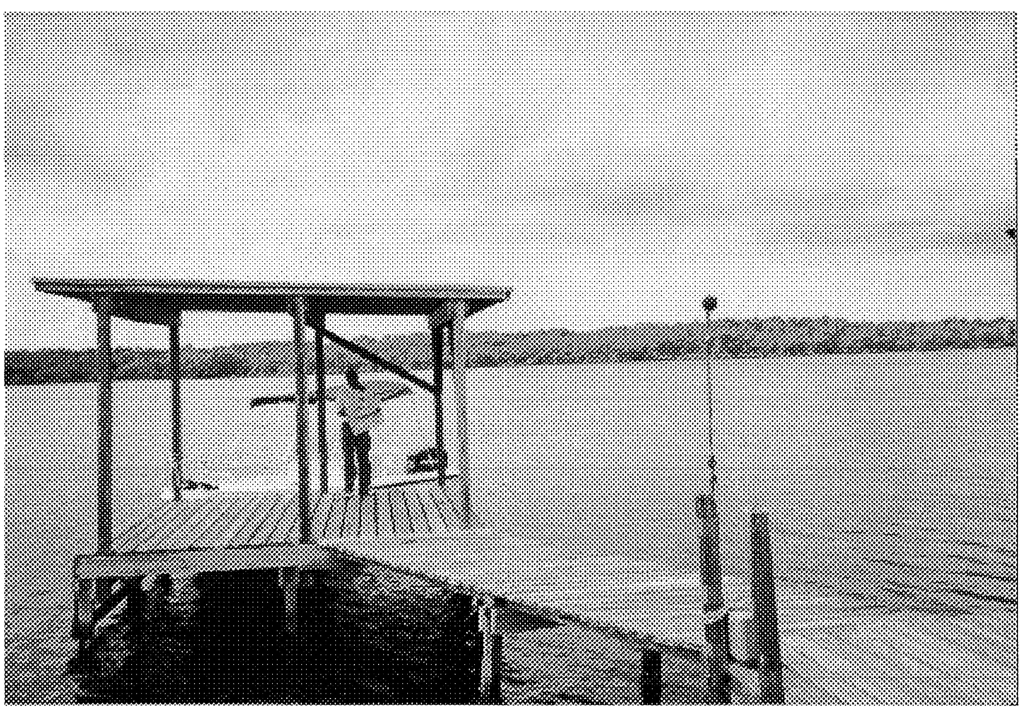
B8. Shoal Warning Post at Feathered Bank



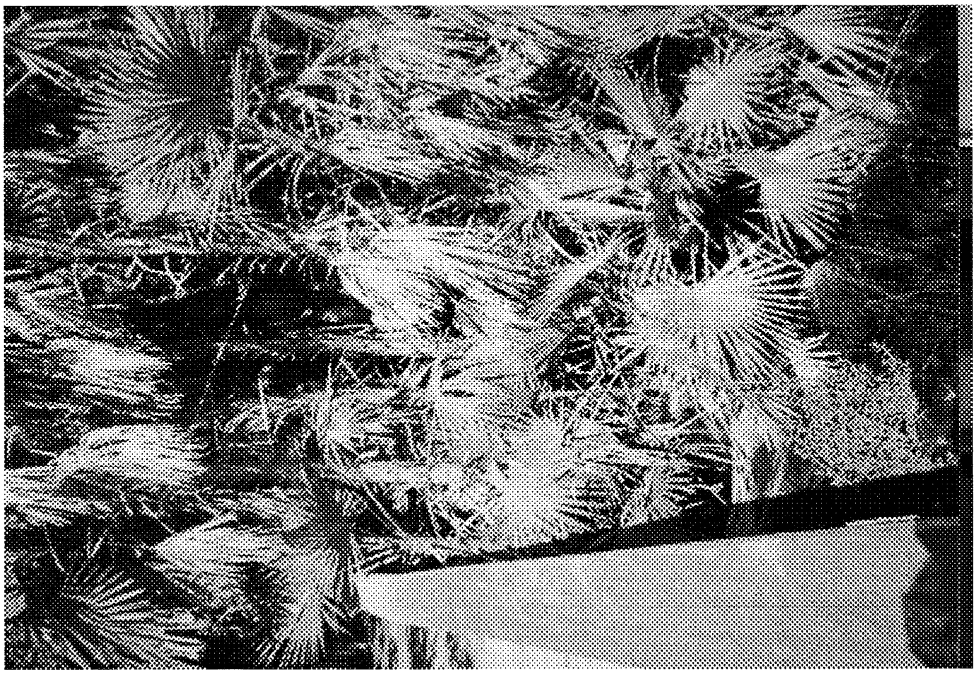
E1. Carl Ross Key

E2. Coastal Prairie Trail

E-4. North Harney River Shoreline
Photo Missing



E3. South Joe River Chickee

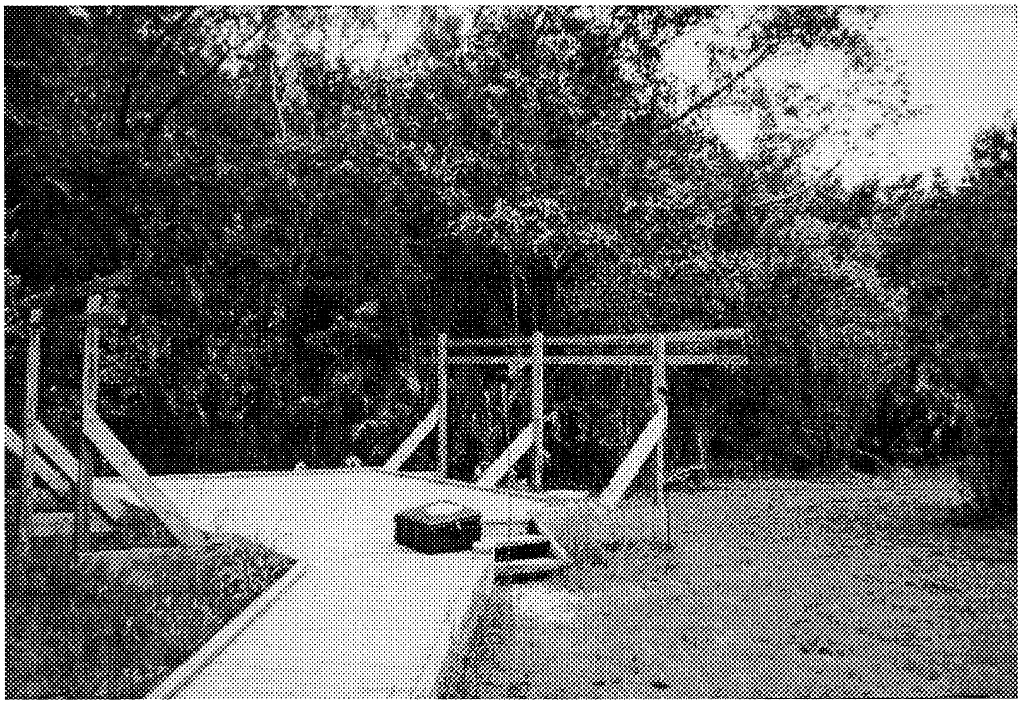


E6. Outside Mahogany Hammock

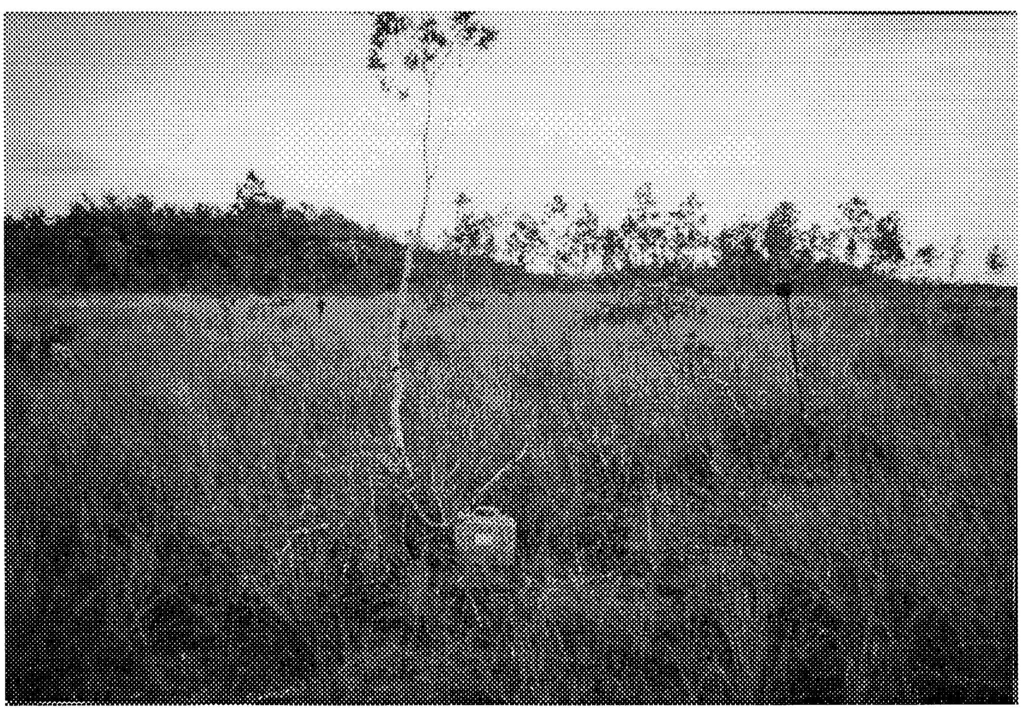
E5. Mangrove Forest along North Harney River

E8. Prairie in Taylor Slough Near Ernest Coe Campsite

E7. Inside Mahogany Hammock



E9. Hidden Lake Education Center



E10a. Transition Zone Between Marl Prairie and Pinelands

E10b. Transition Zone Between Marl Prairie and Pinelands

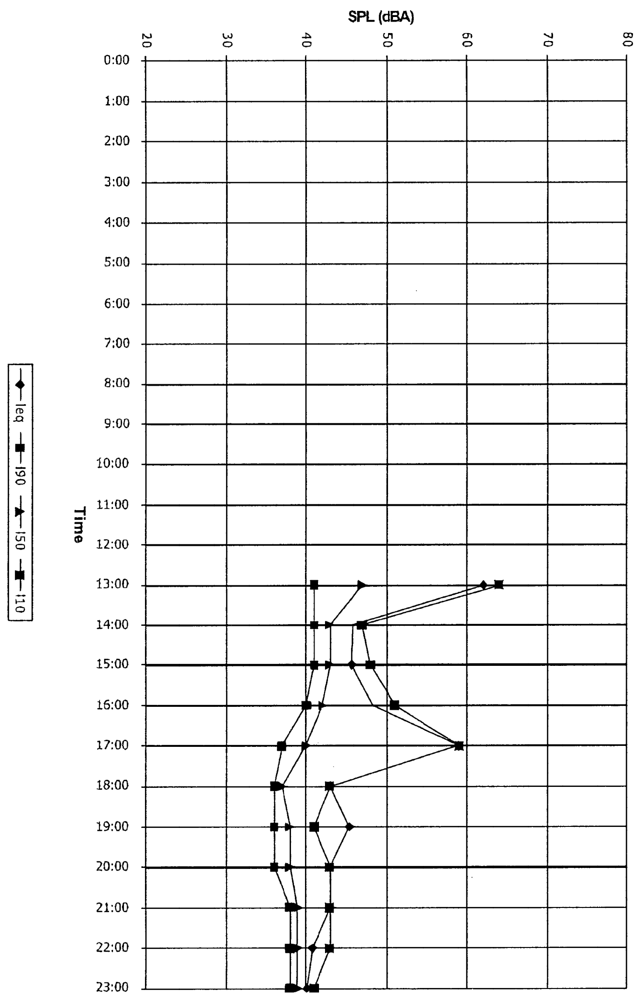
E11. Long Pine Key Campground

E12. Anhinga Trail

E14. Prairie in Shark Valley

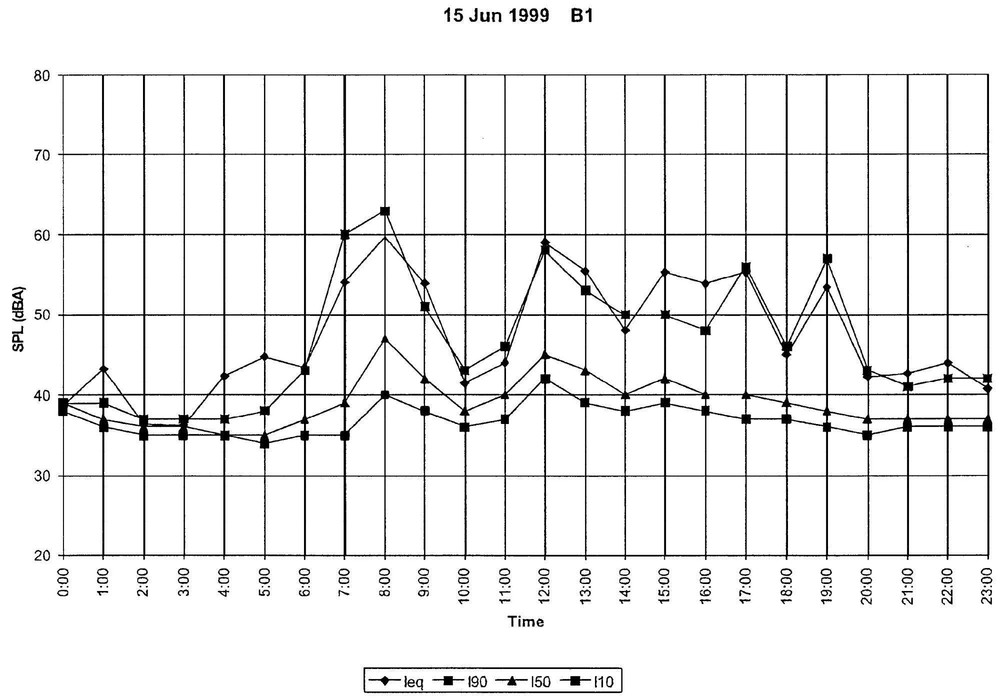
E15. Chekika

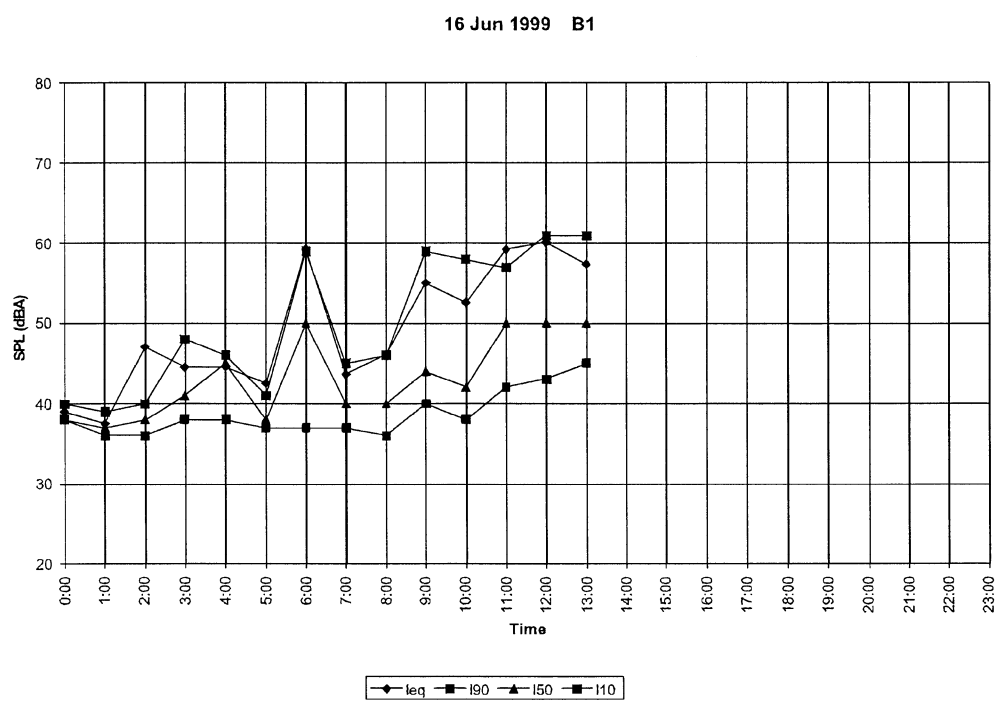
14 Jun 1999 B1



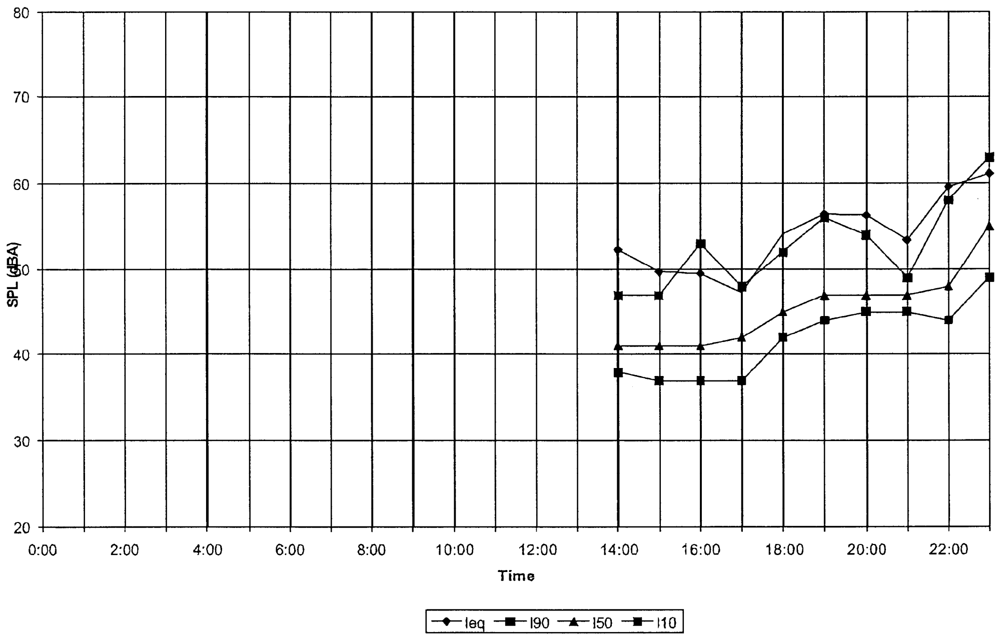
Appendix F

Hourly L90, L50, L10 and Leq Time Histories for Unmanned Measurements

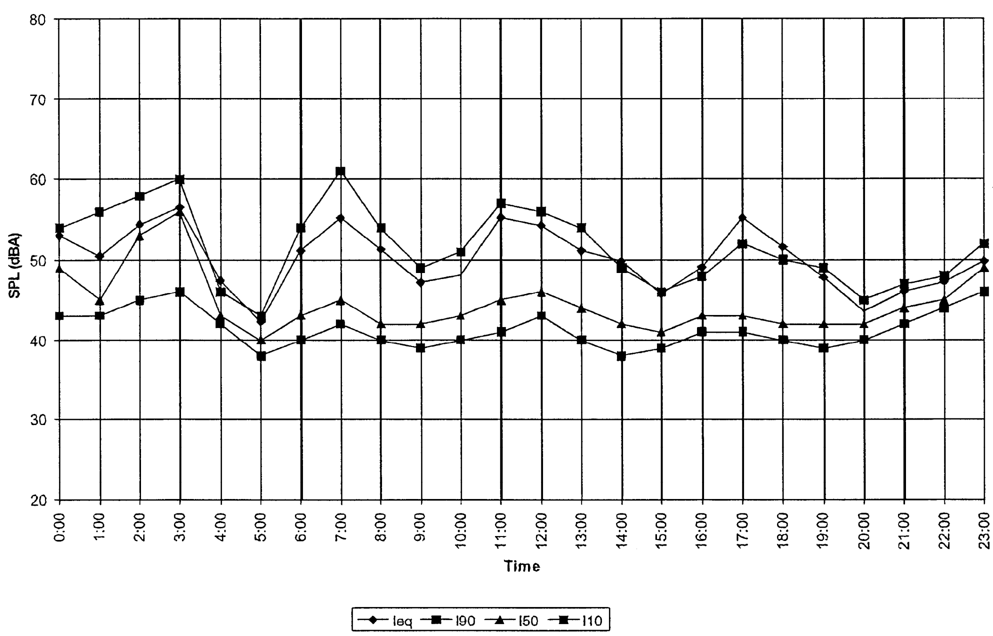

15 Jun 1999 B1
SPL (dBA)
80
70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10


16 Jun 1999 B1
SPL (dBA)
80
70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10

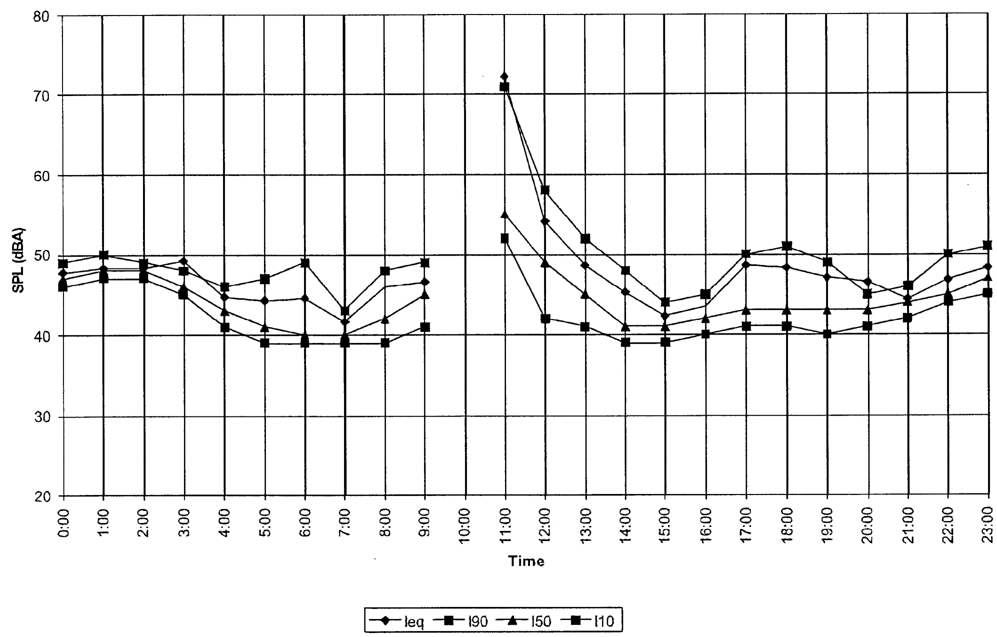
7 Jun 1999 B2



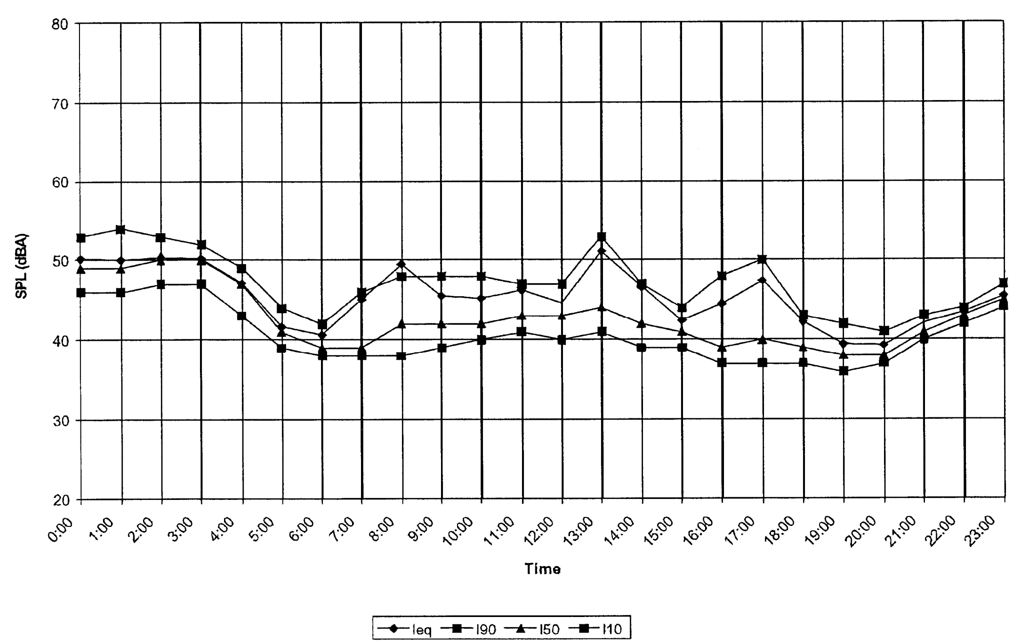
8 Jun 1999 B2

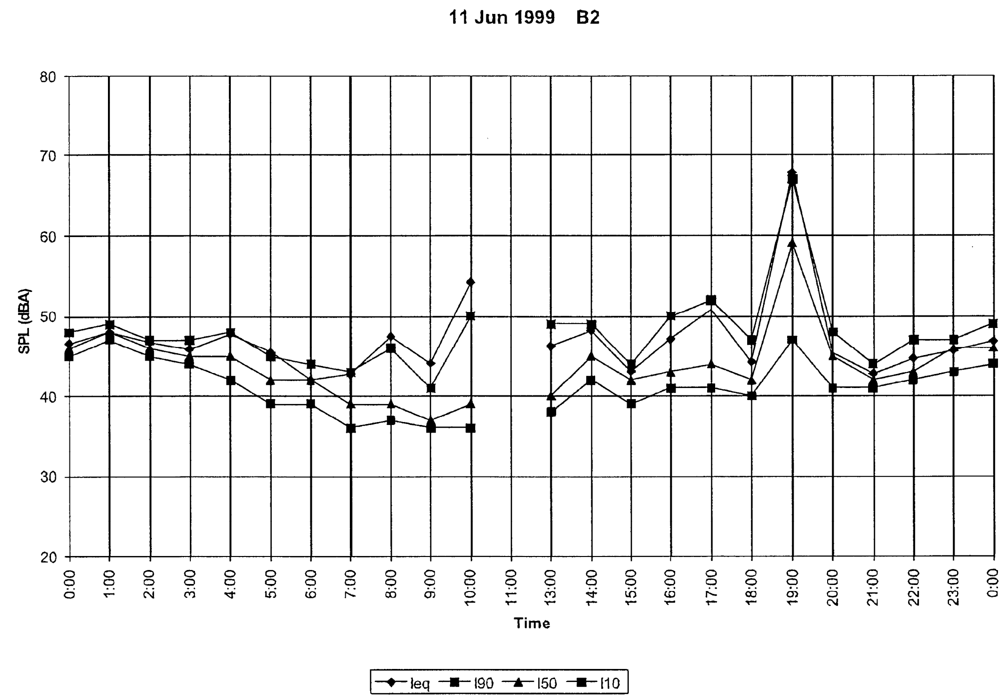


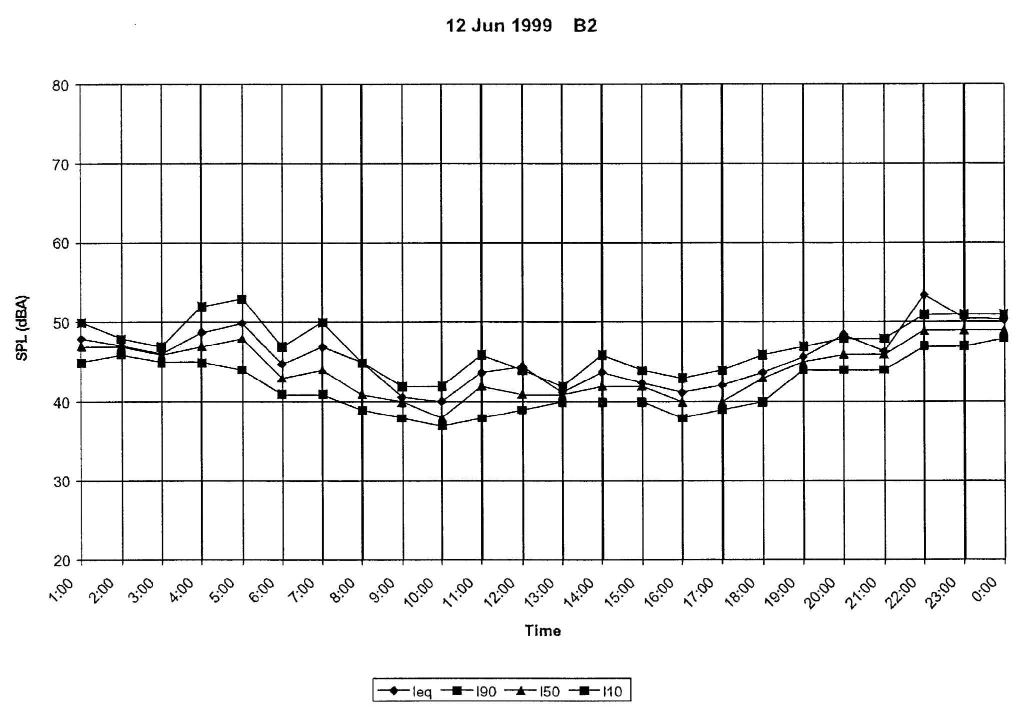
9 Jun 1999 B2

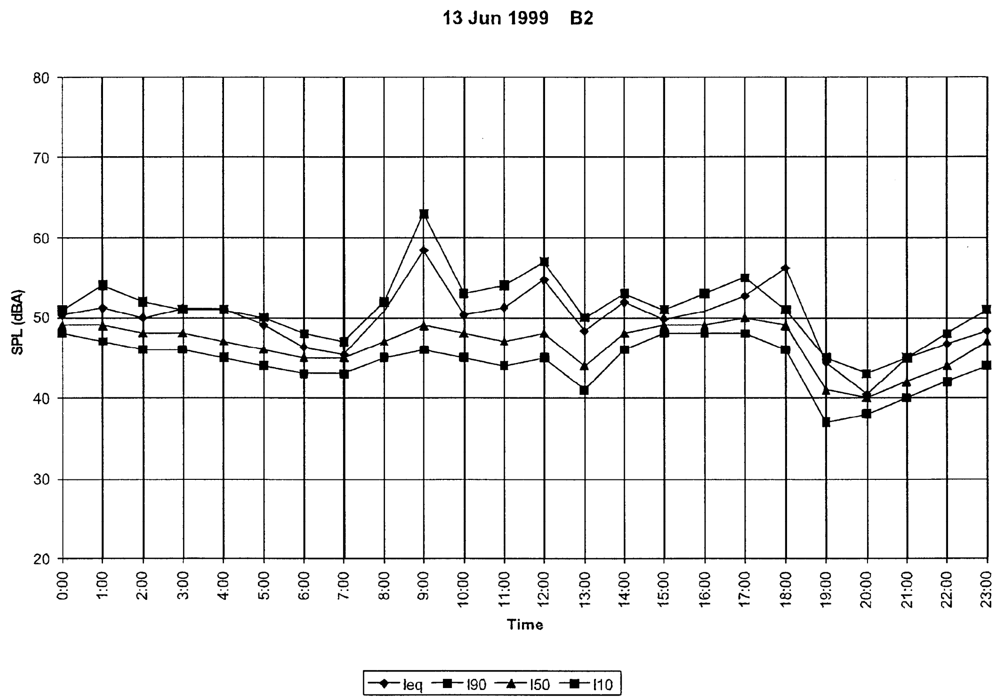


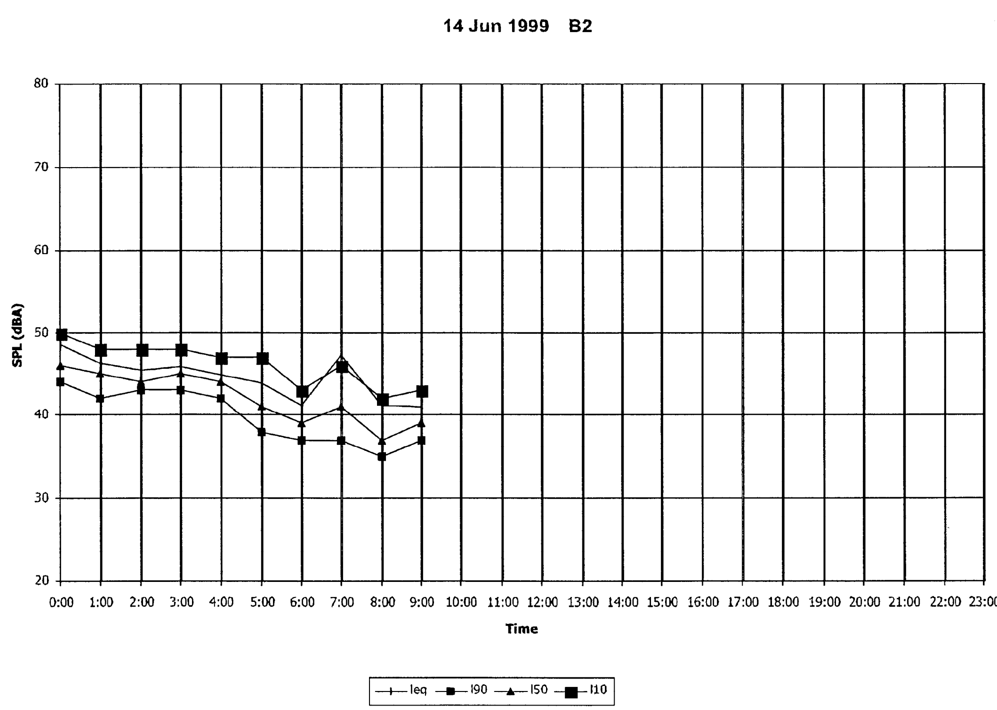
10 Jun 1999 B2



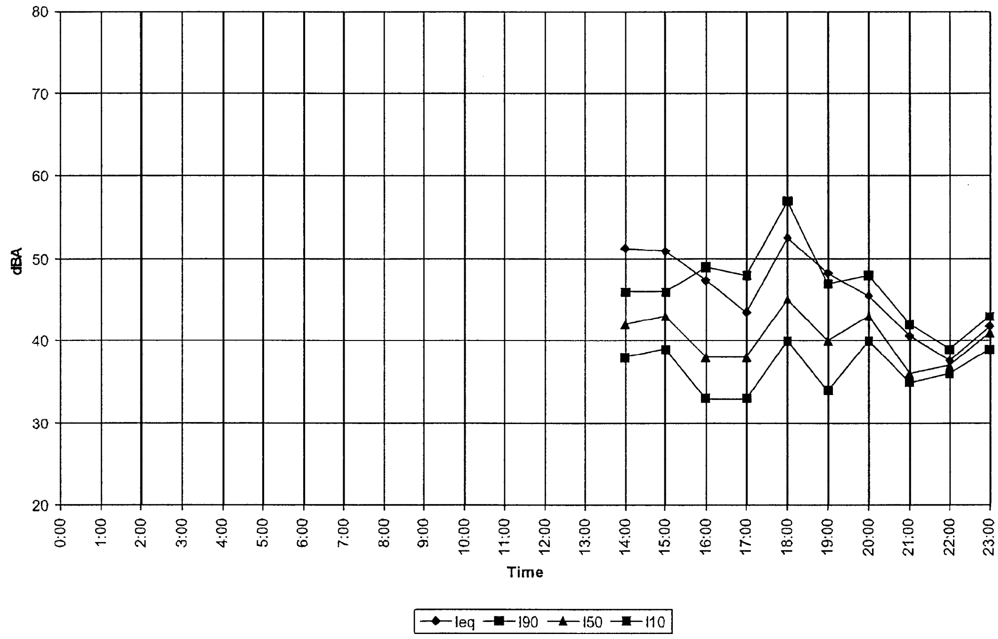

11 Jun 1999 B2
SPL (dBA)
Time
leq
l90
l50
l10


12 Jun 1999 B2
SPL (dBA)
Time
leq
l90
l50
l10

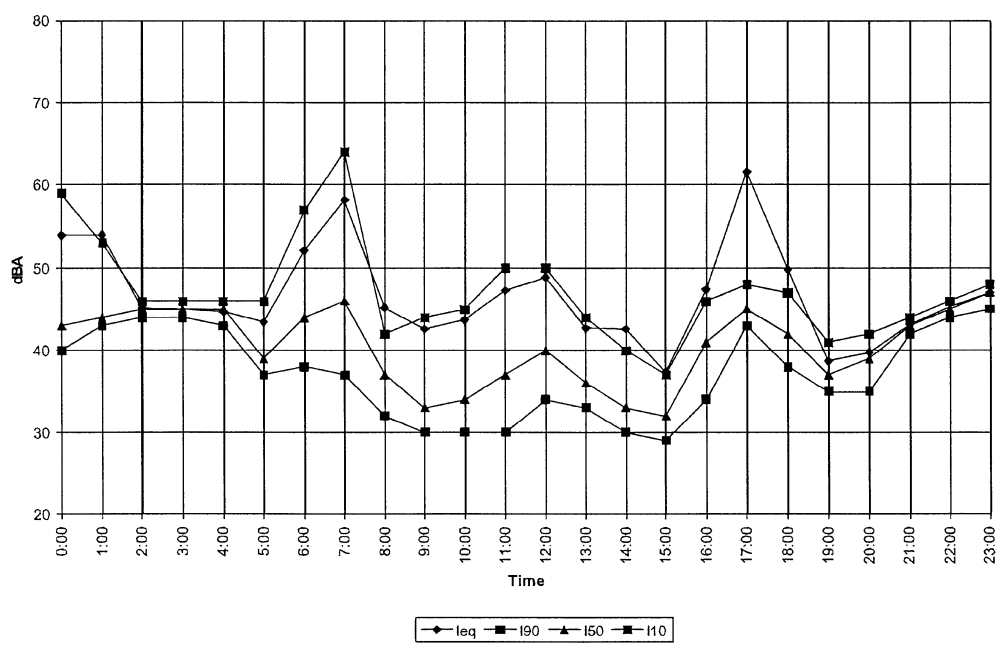

13 Jun 1999 B2
SPL (dBA)
80
70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10

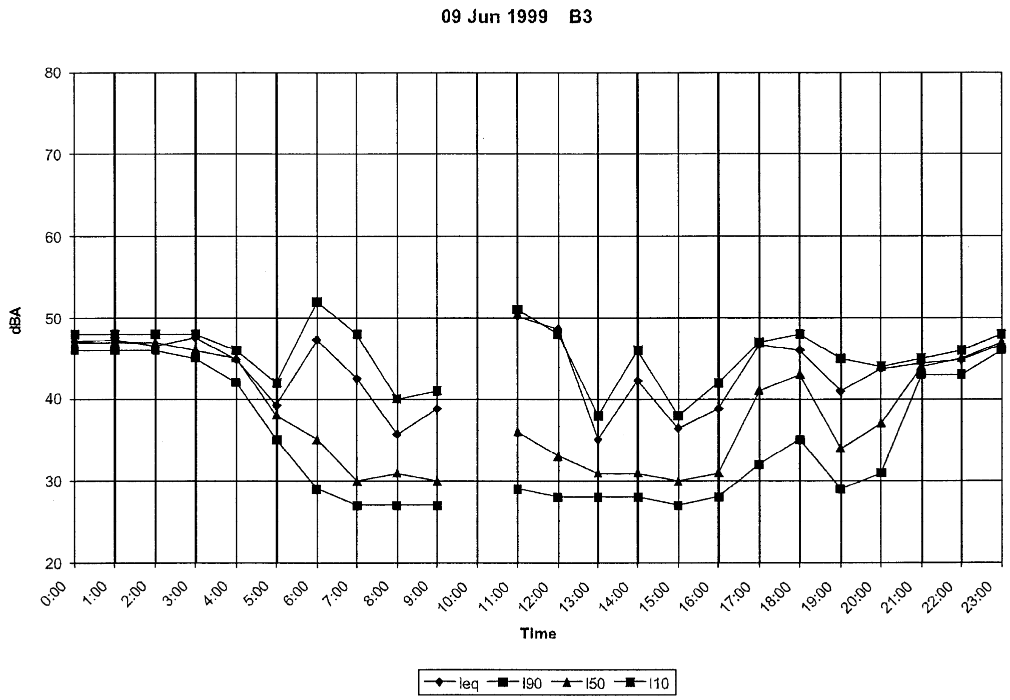

14 Jun 1999 B2
SPL (dBA)
80
70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10

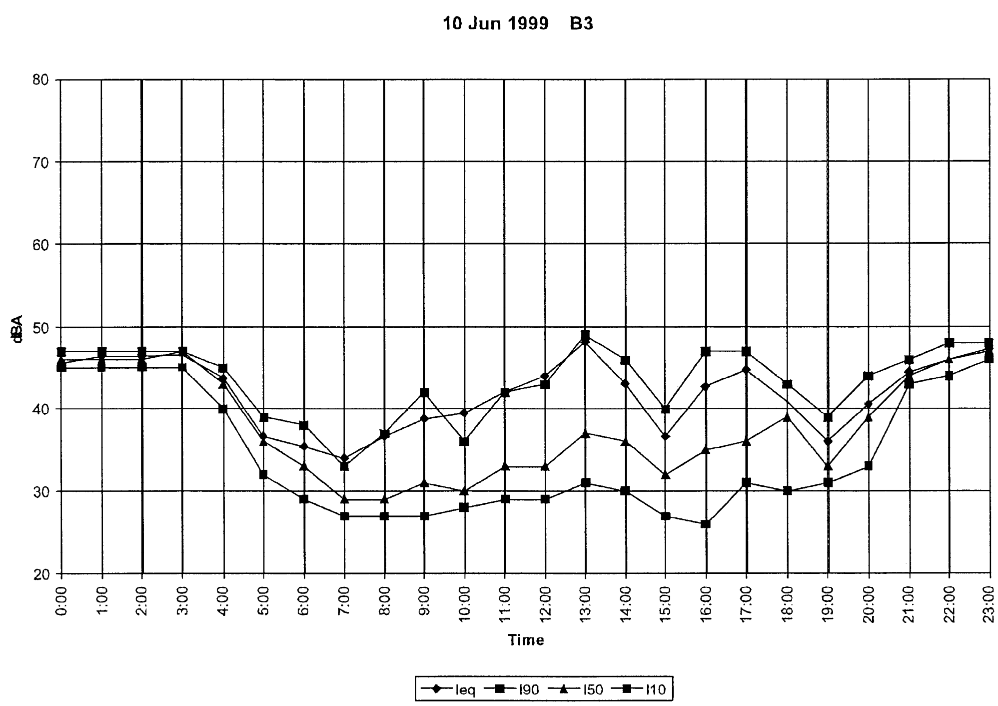
07 Jun 1999 B3



08 Jun 1999 B3




09 Jun 1999 B3
80
70
60
50
40
30
20
dBA
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10


10 Jun 1999 B3
80
70
60
50
40
30
20
dBA
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
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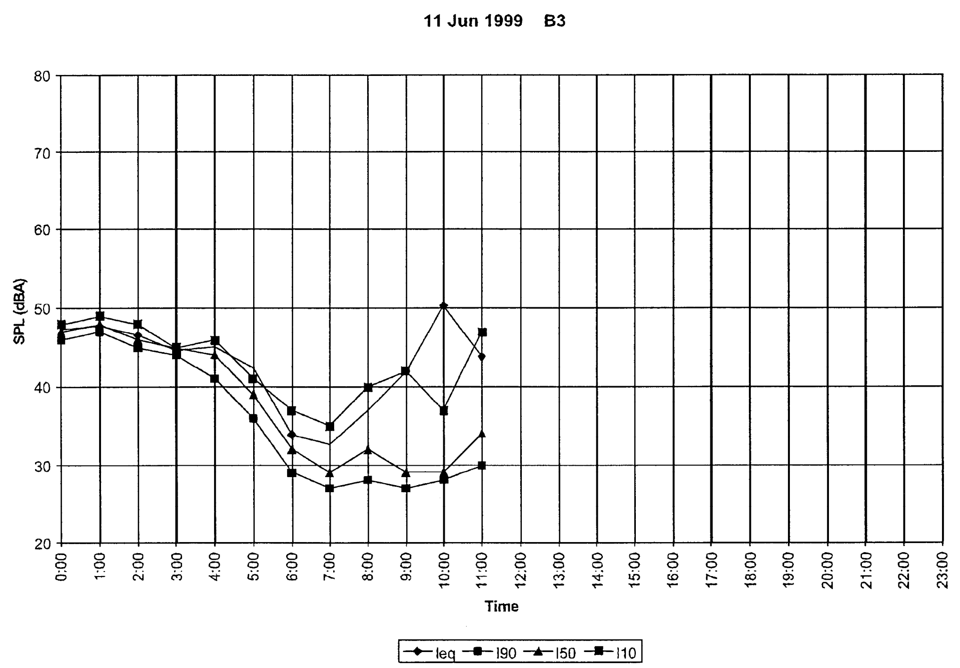
21:00
22:00
23:00
Time
leq
l90
l50
l10


11 Jun 1999 B3
SPL (dBA)
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70
60
50
40
30
20
0:00
1:00
2:00
3:00
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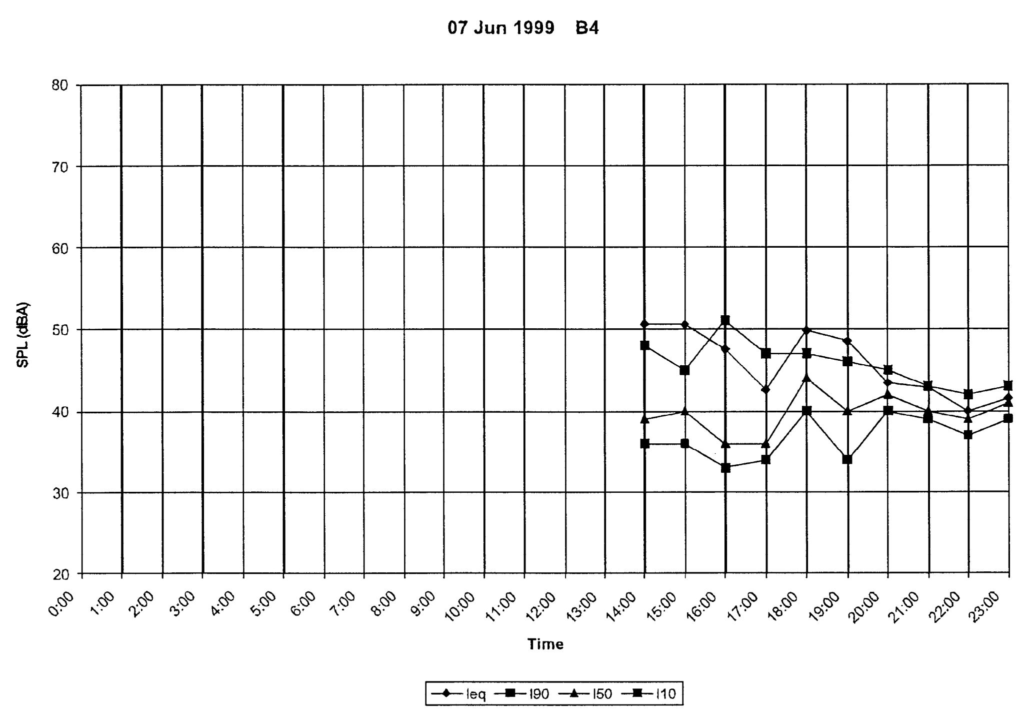
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10


07 Jun 1999 B4
SPL (dBA)
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70
60
50
40
30
20
0:00
1:00
2:00
3:00
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5:00
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8:00
9:00
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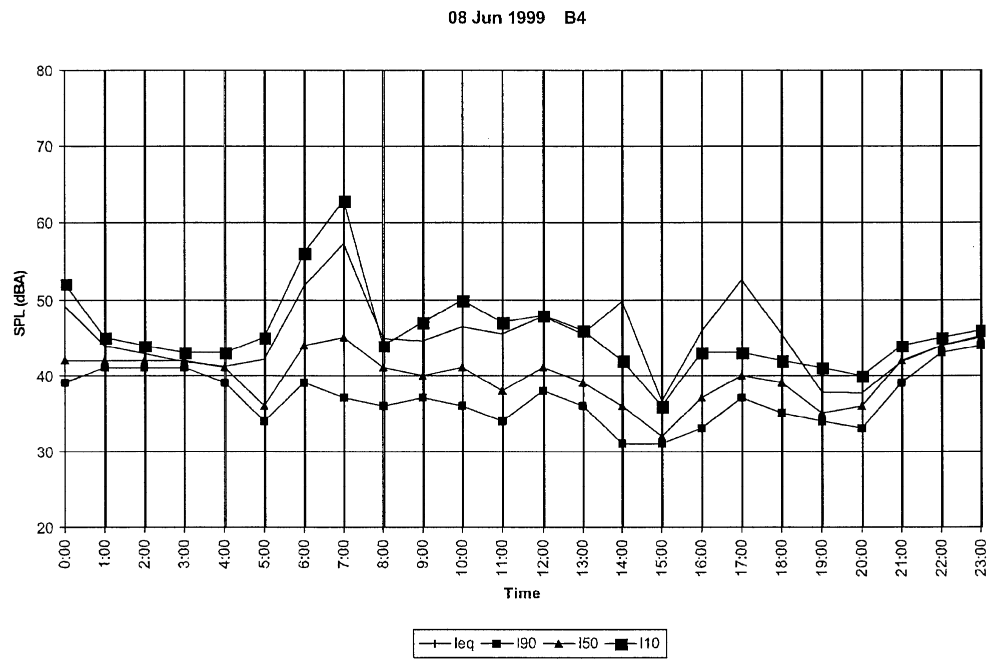
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10


08 Jun 1999 B4
SPL (dBA)
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70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
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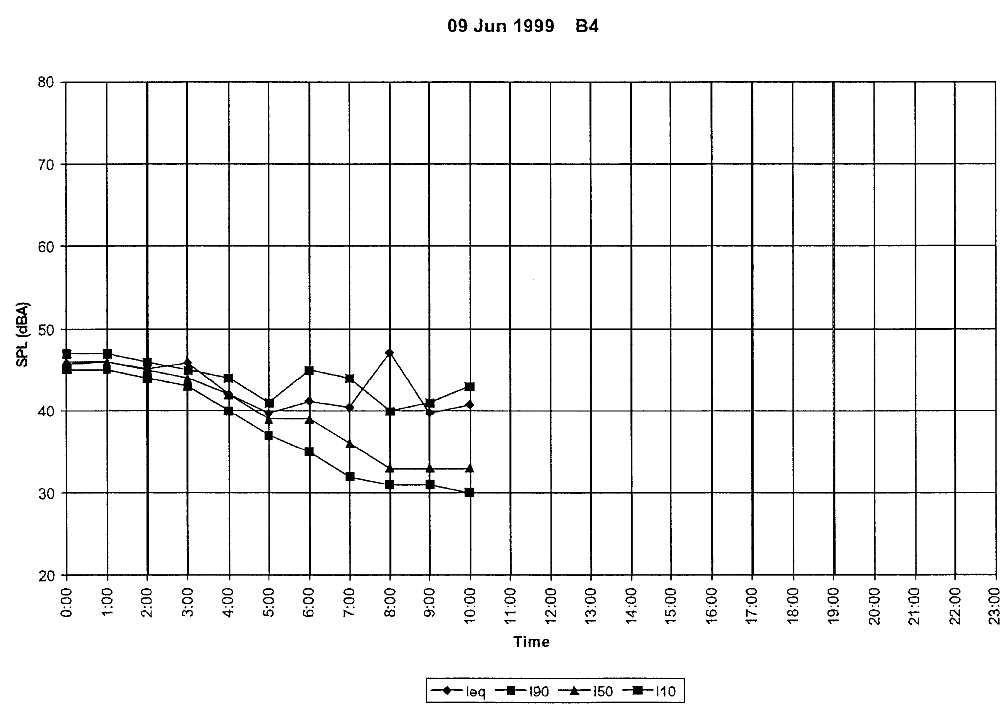
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10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SPL (dBA)
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60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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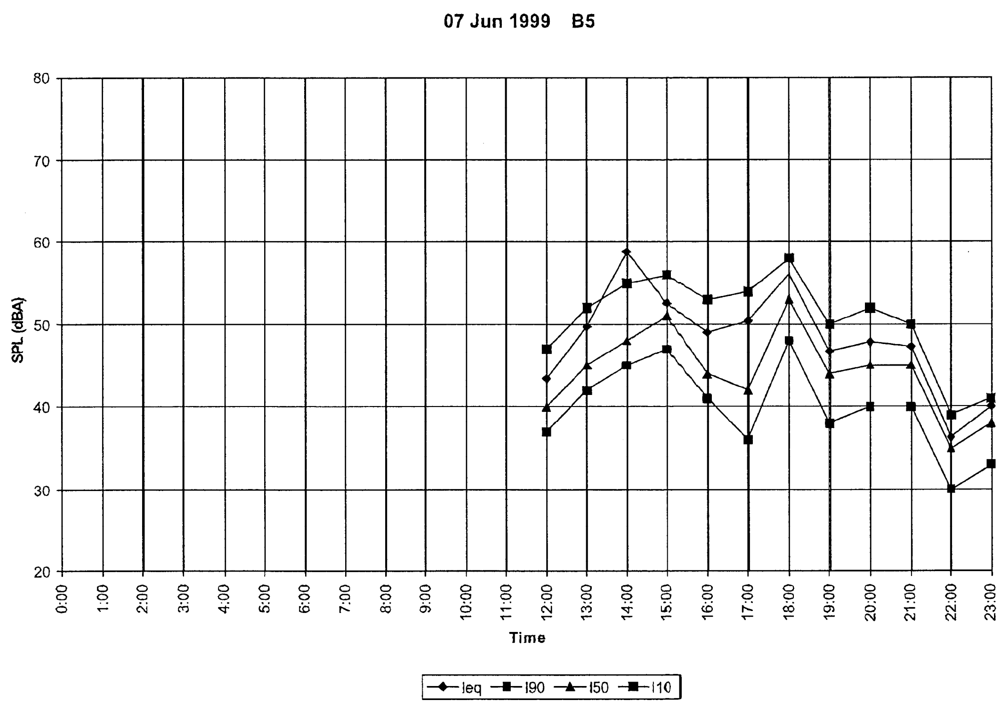
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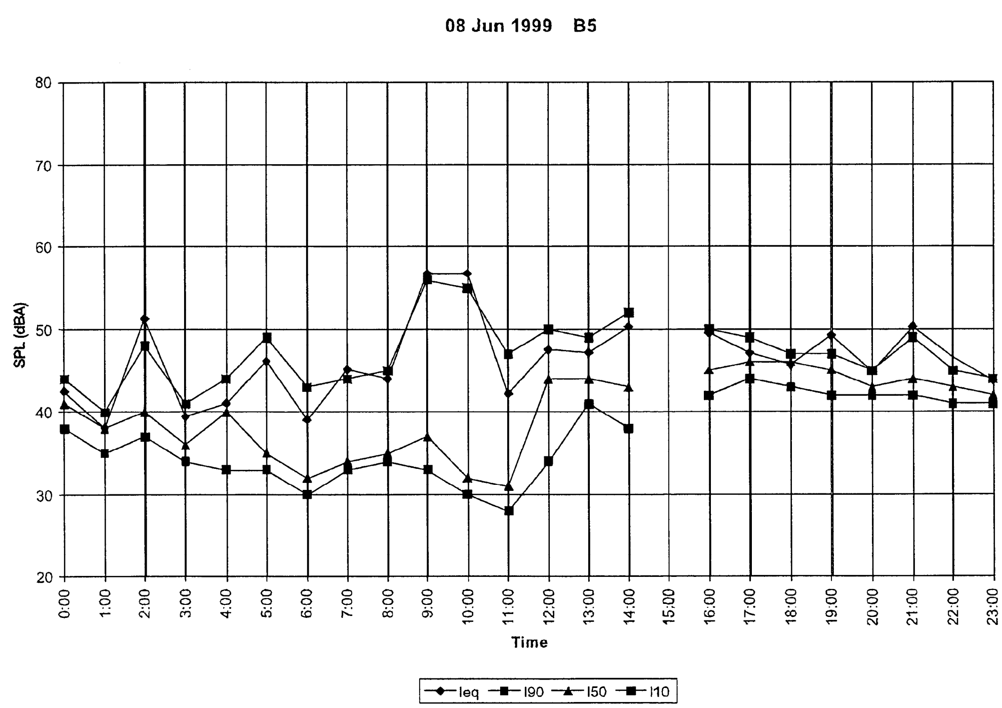
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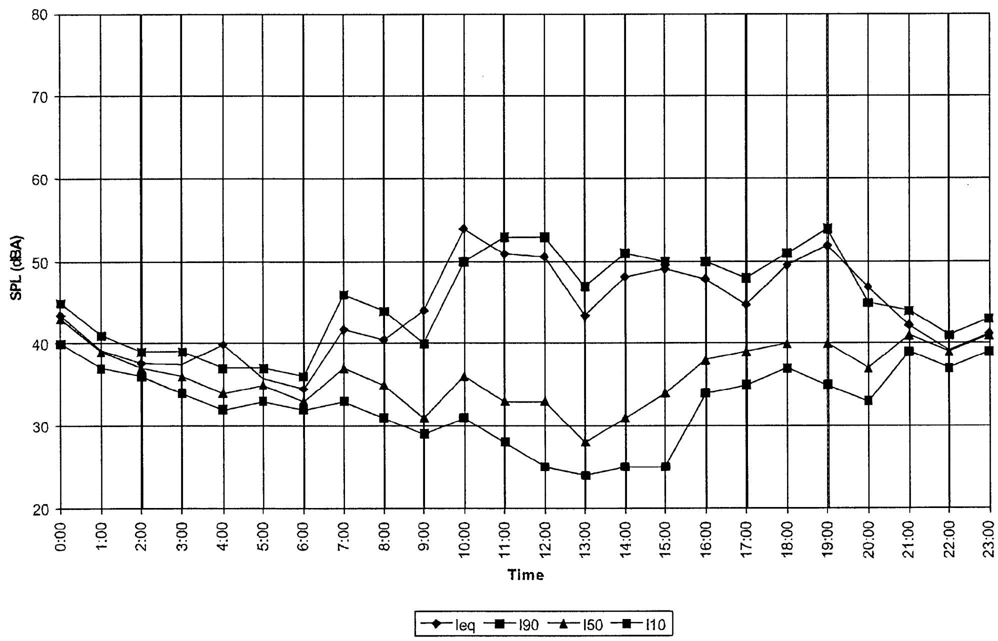
09 Jun 1999 B5



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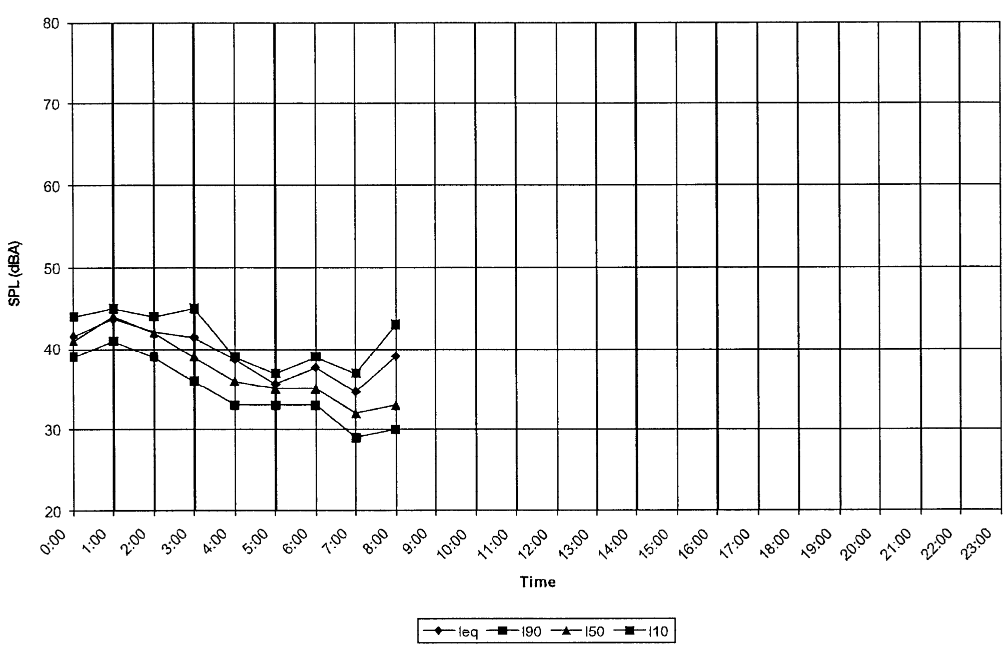

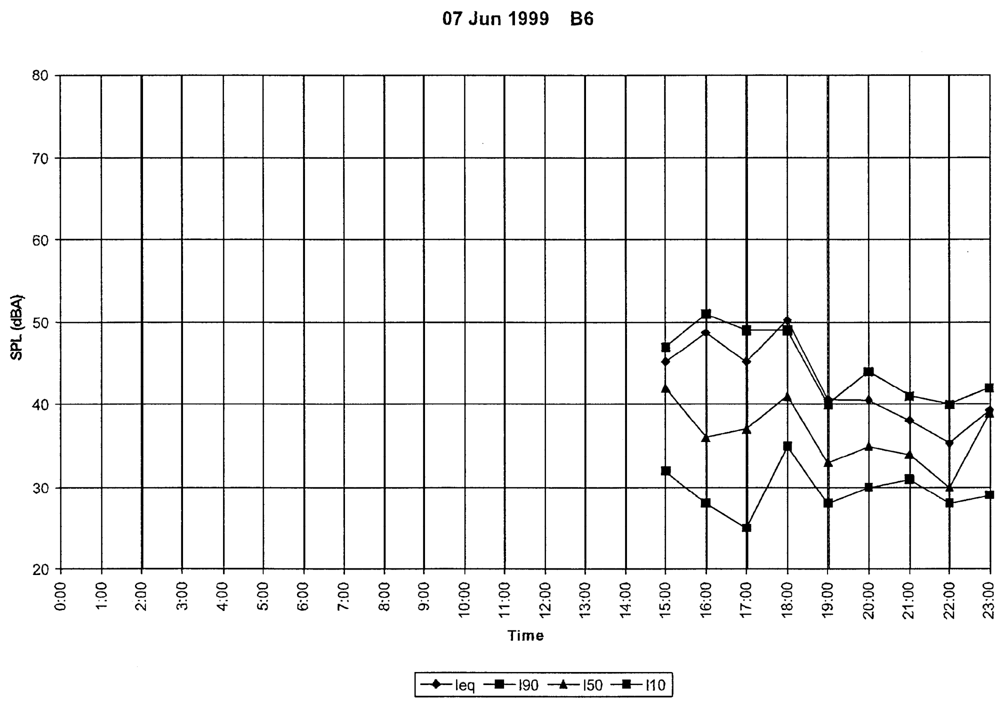
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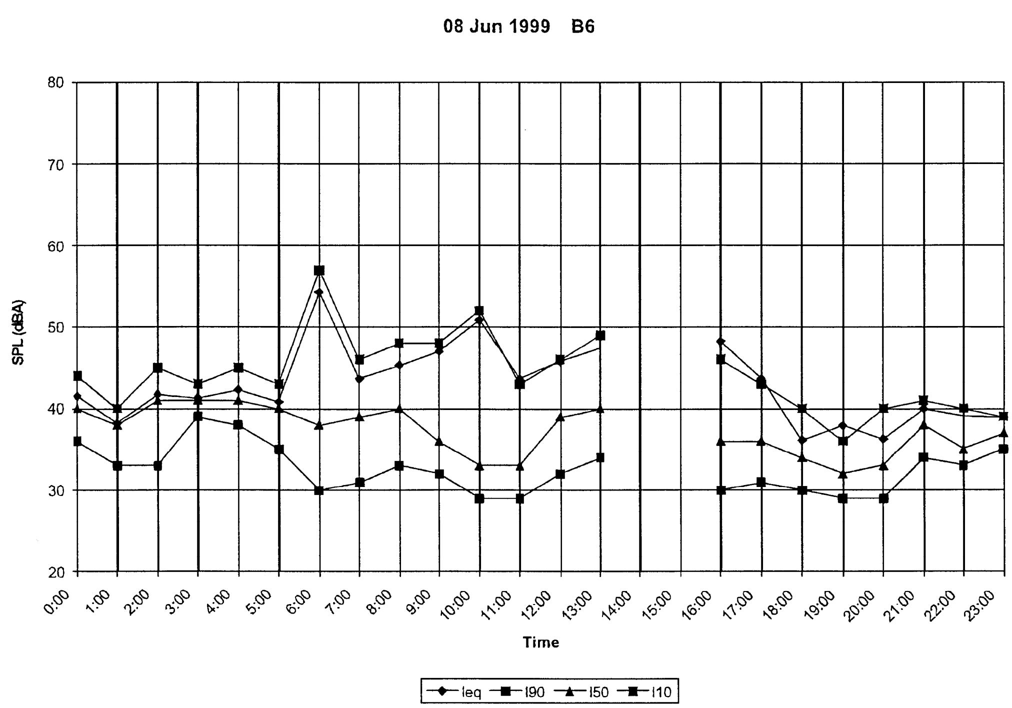
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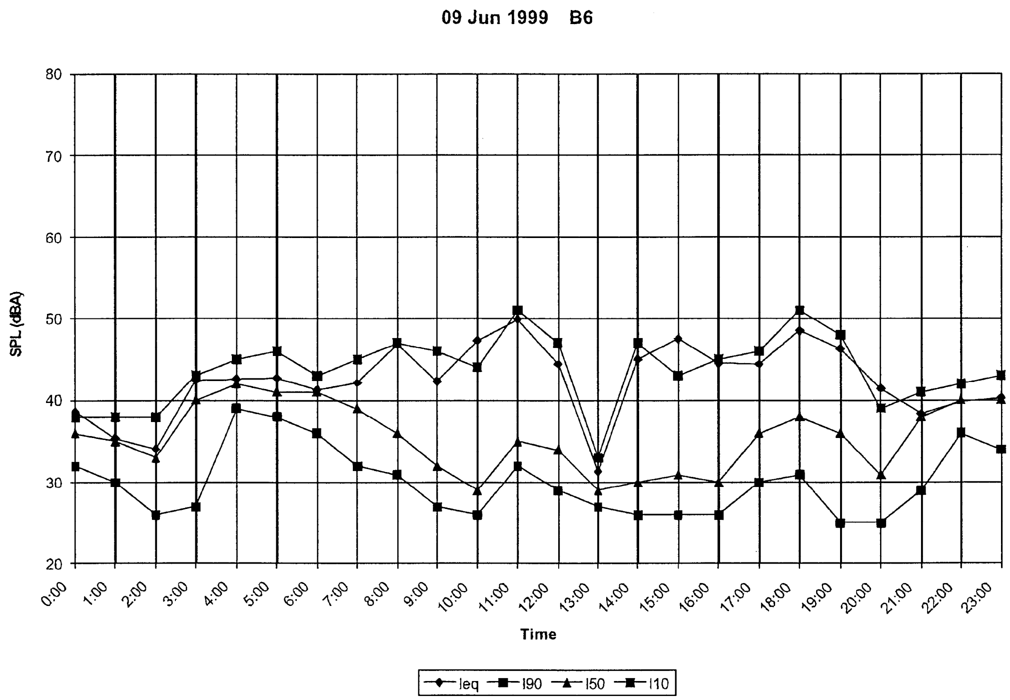
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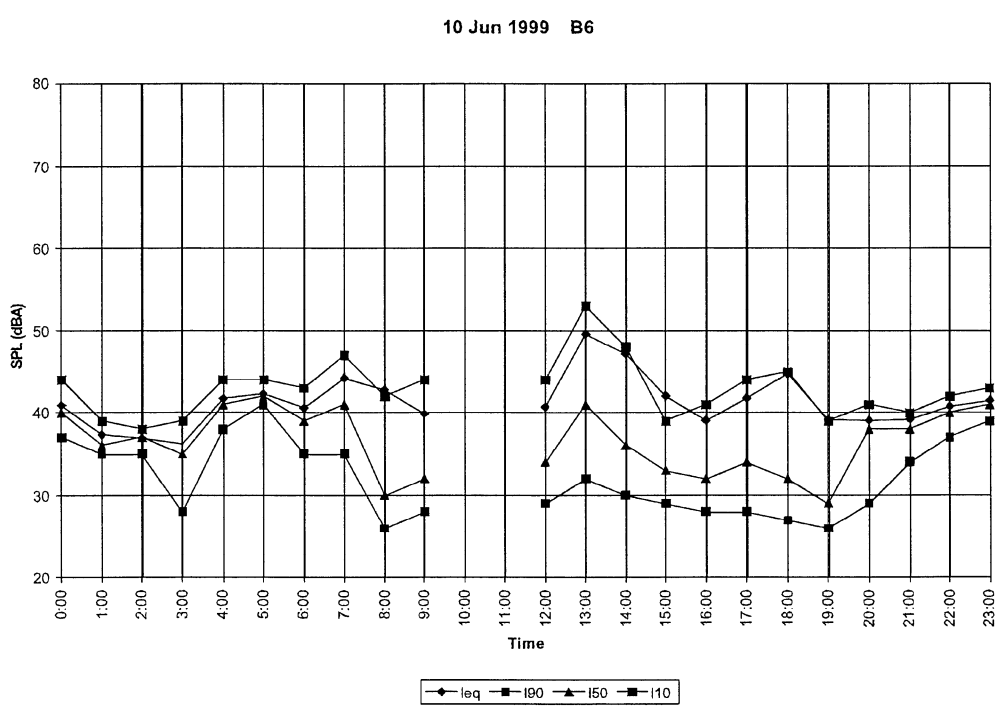
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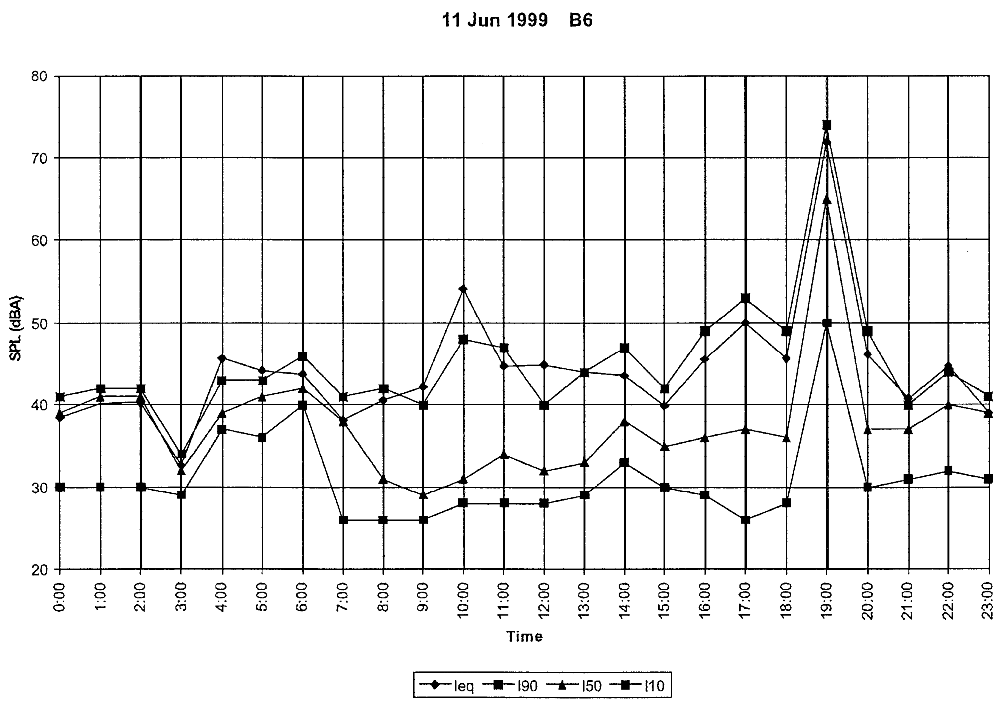
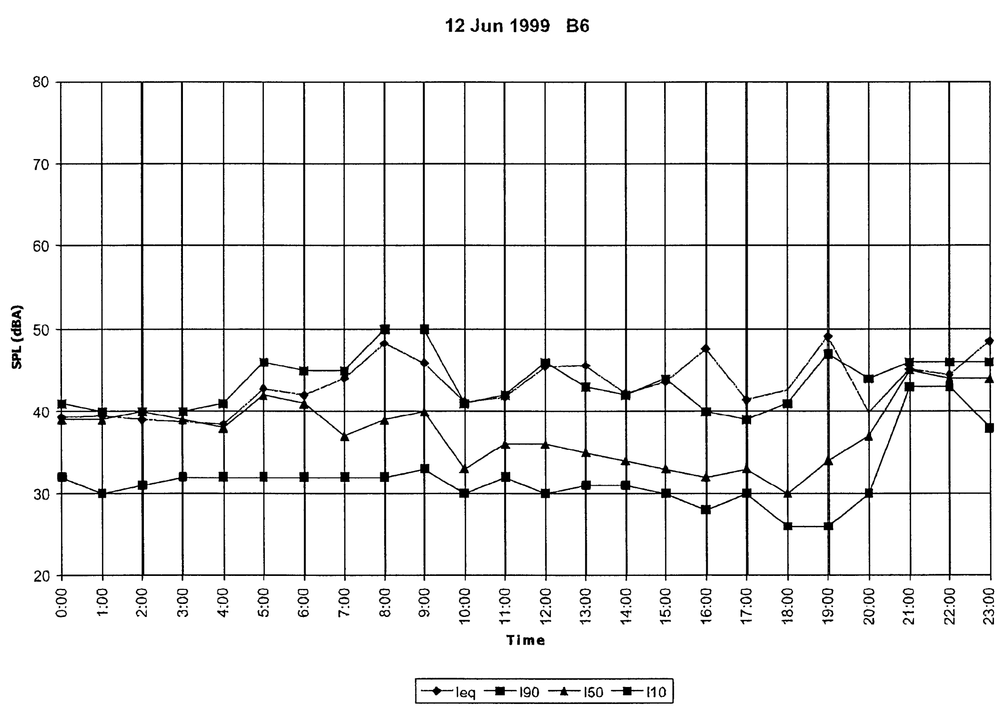


Appendix F Hourly L90, L50, L10 and Leq Time Histories for Unmanned Measurements The Soundscape in South Florida NP



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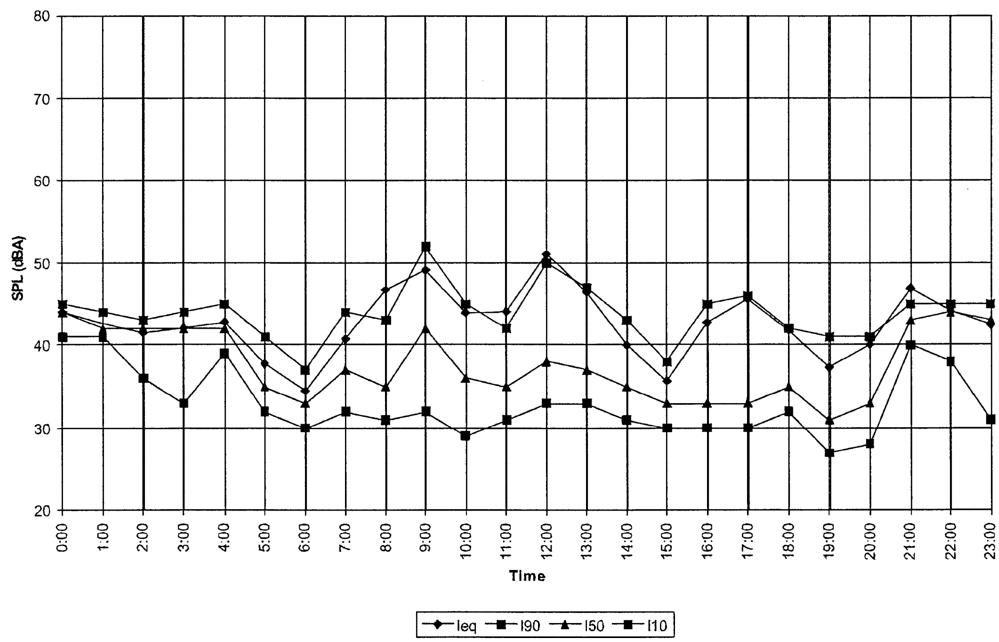

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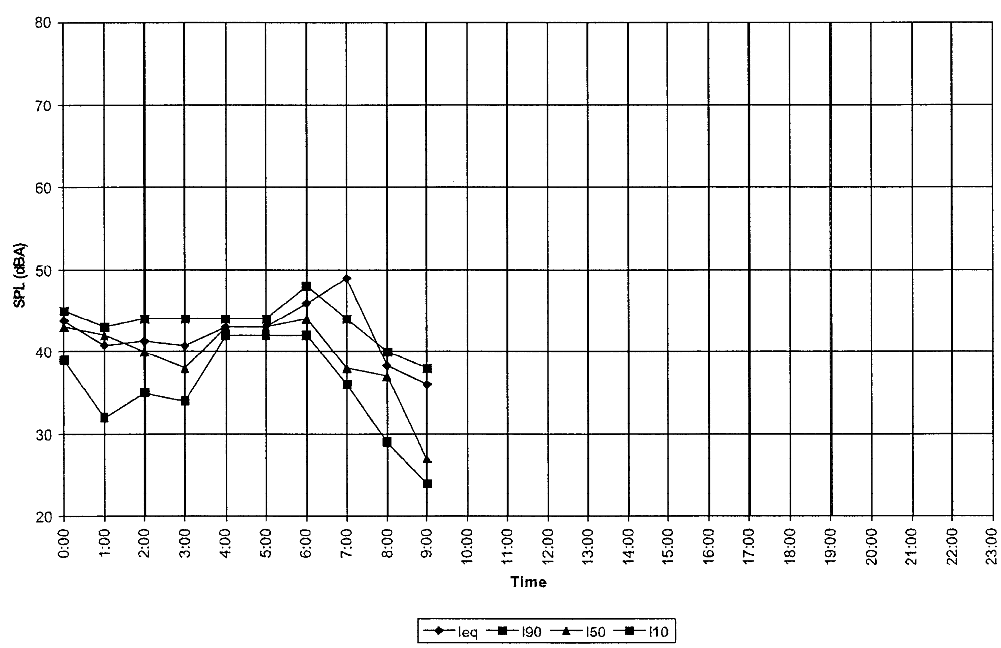

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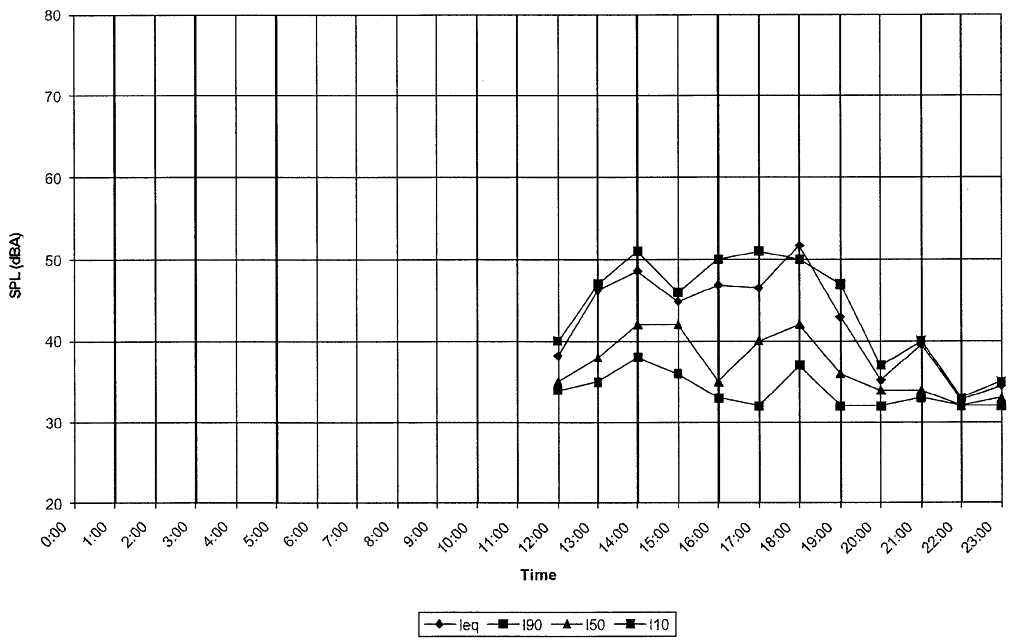

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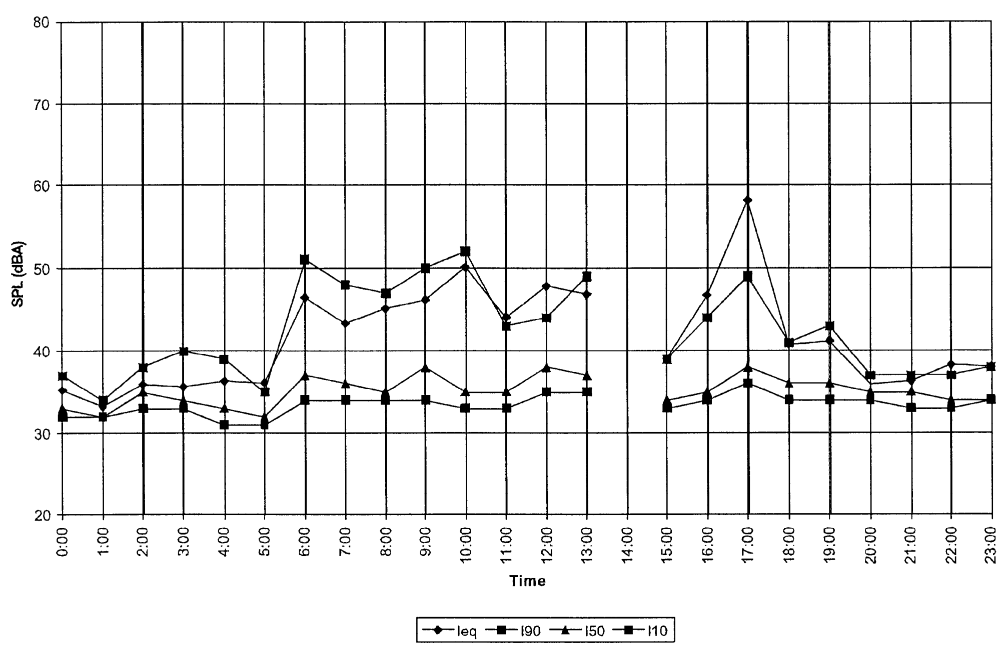

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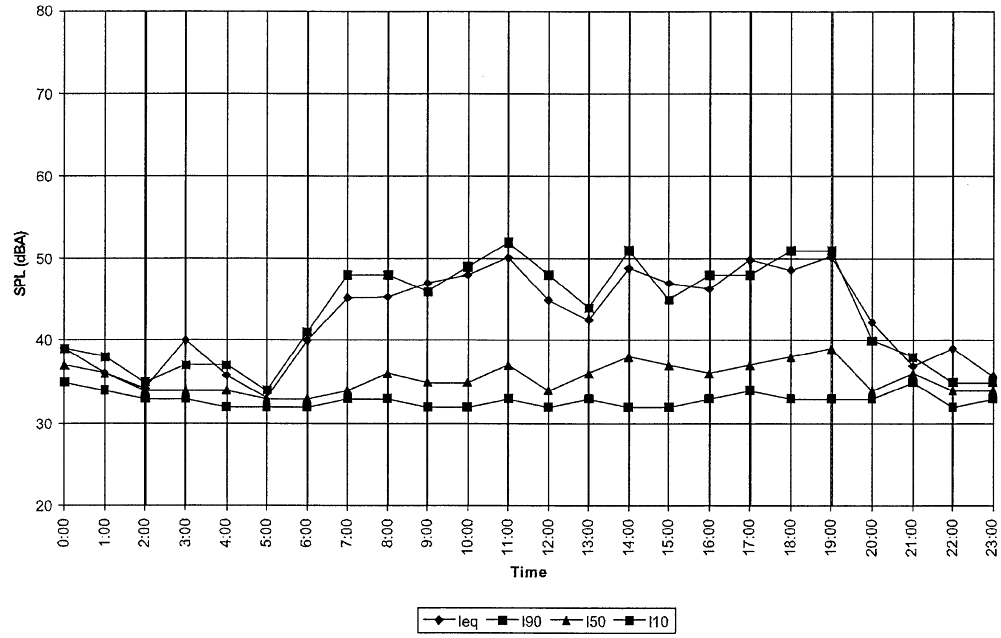

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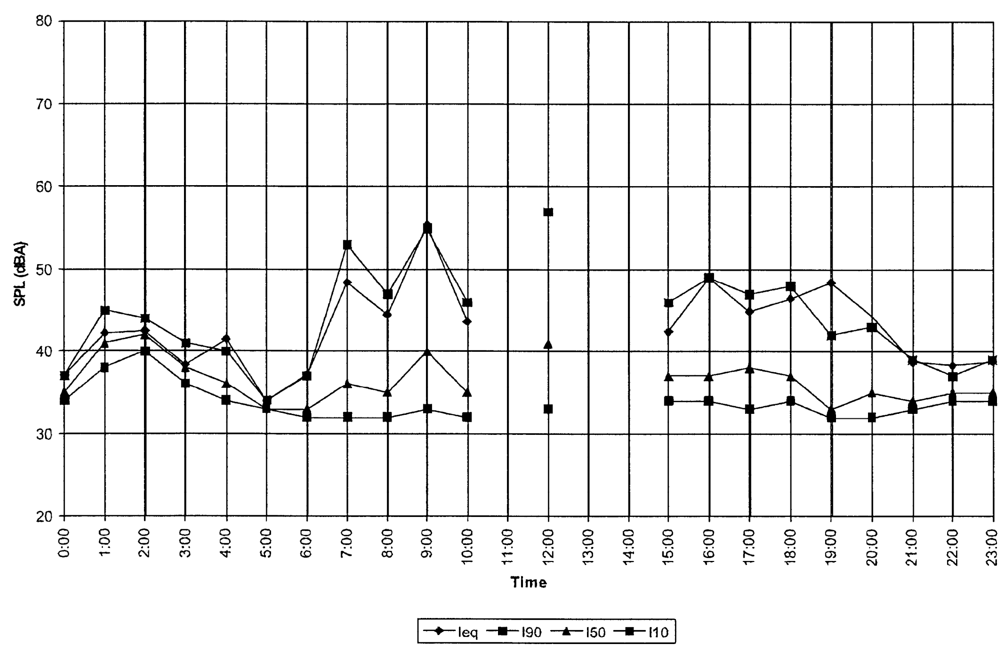

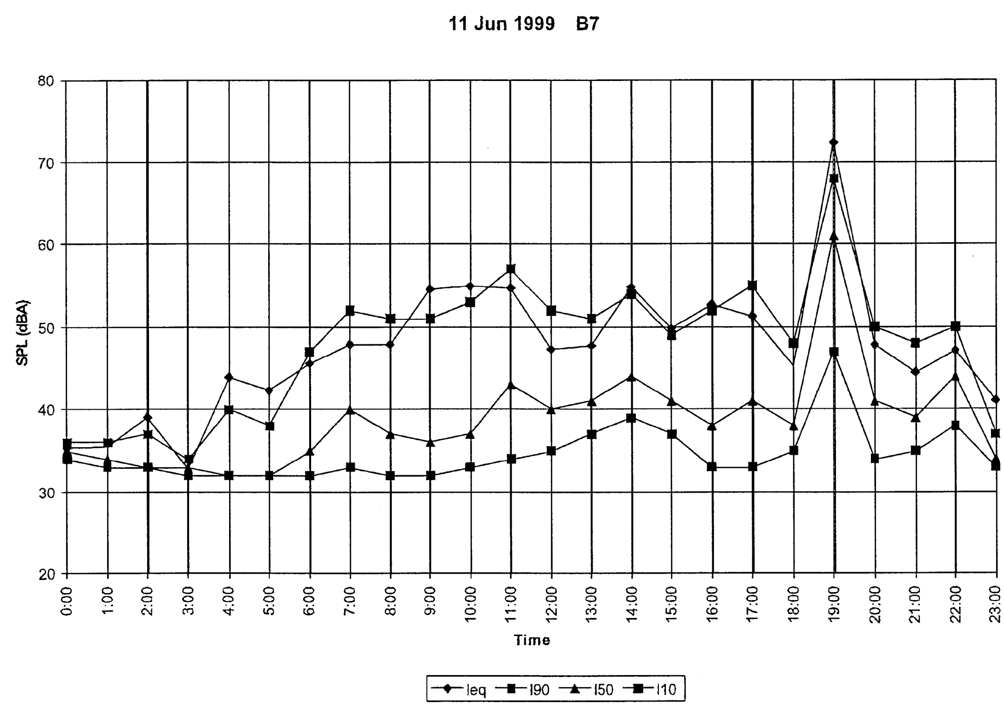
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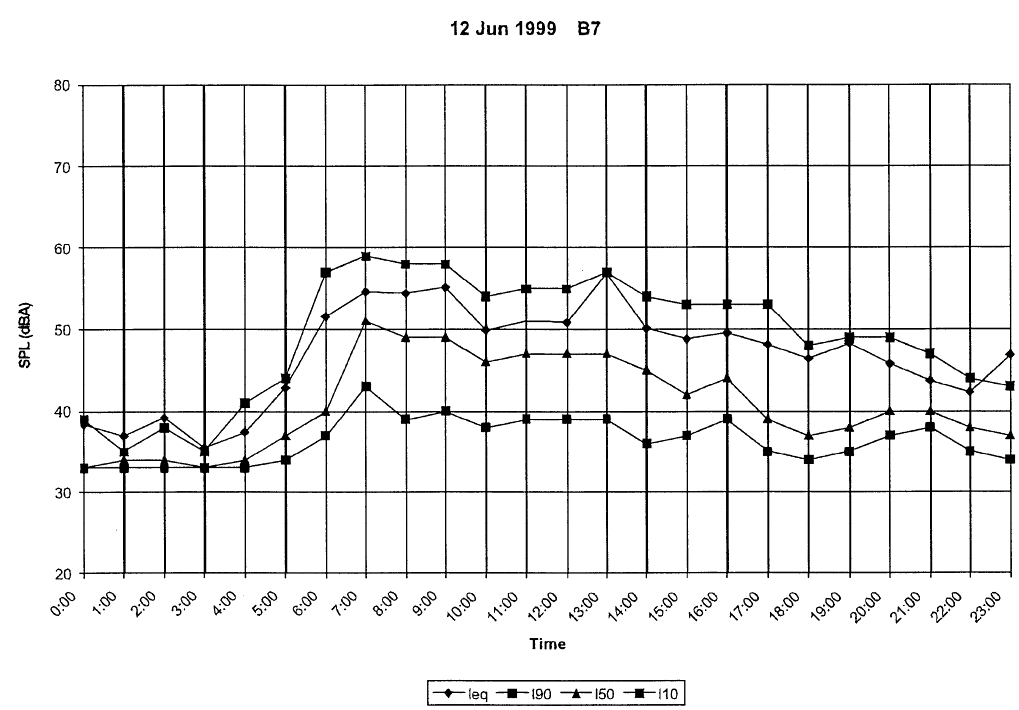
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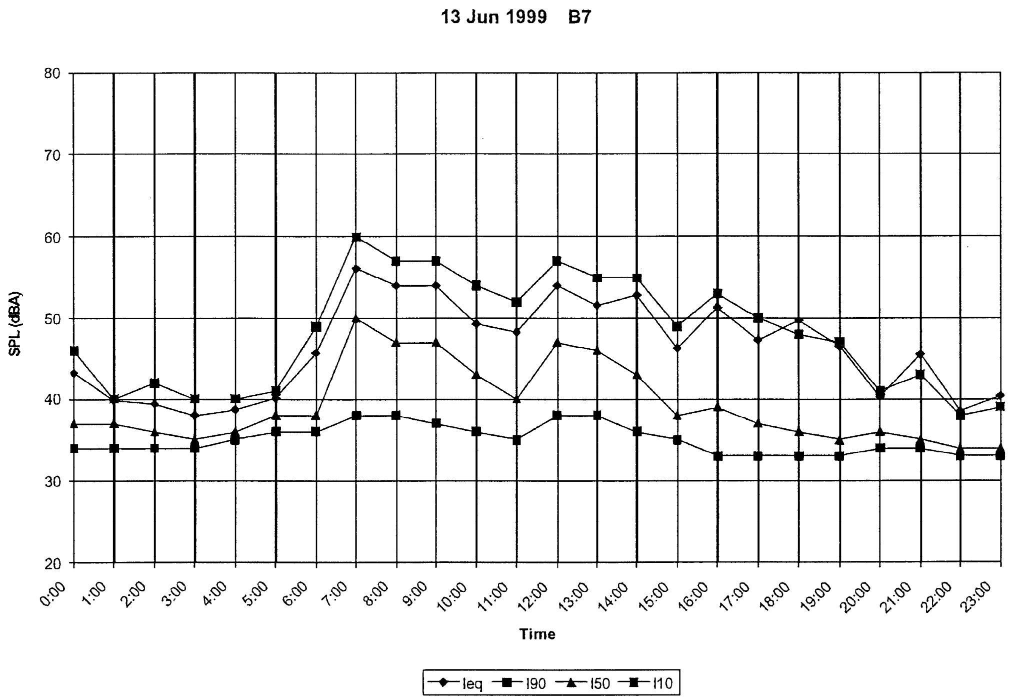
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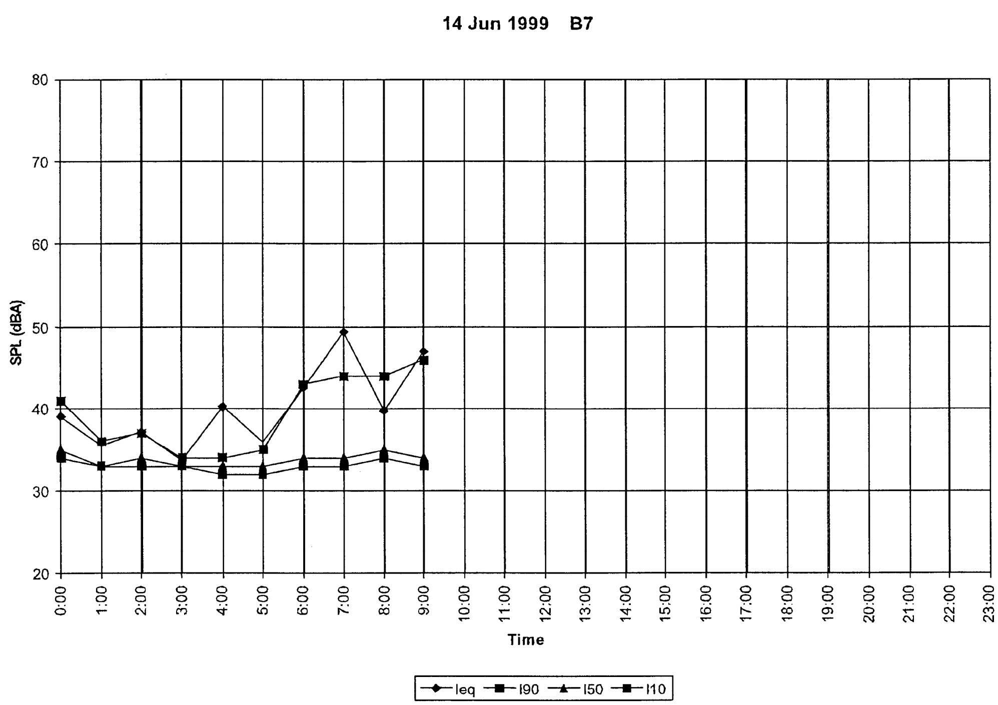
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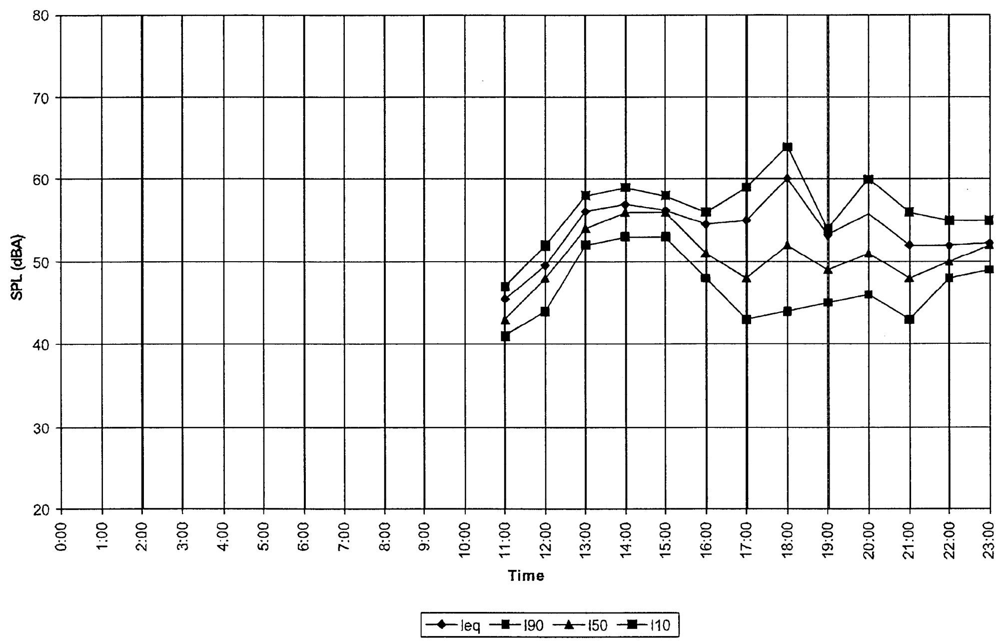

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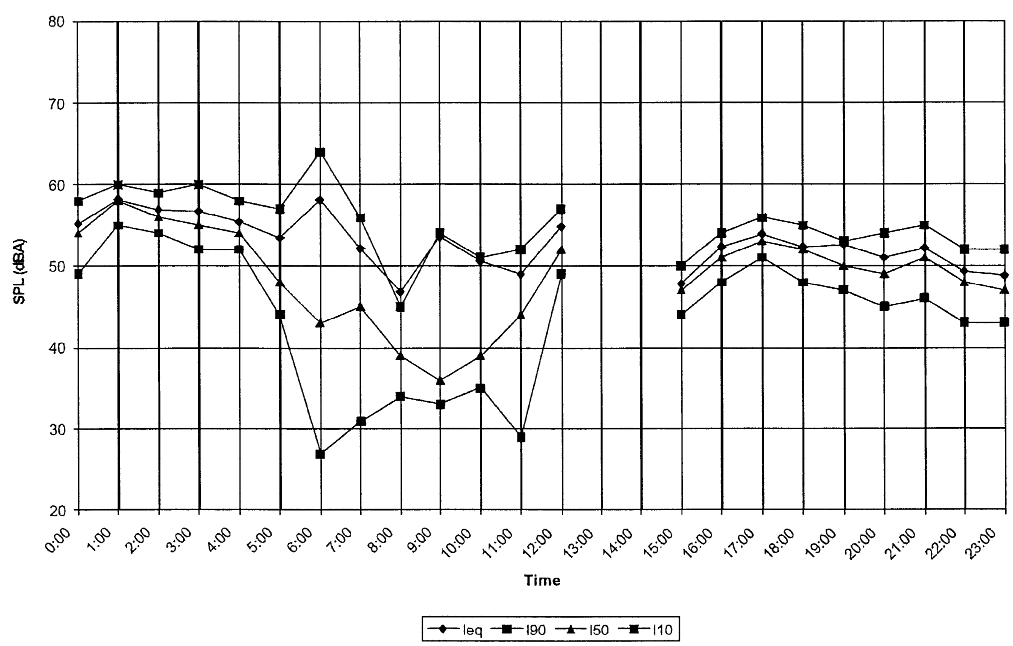

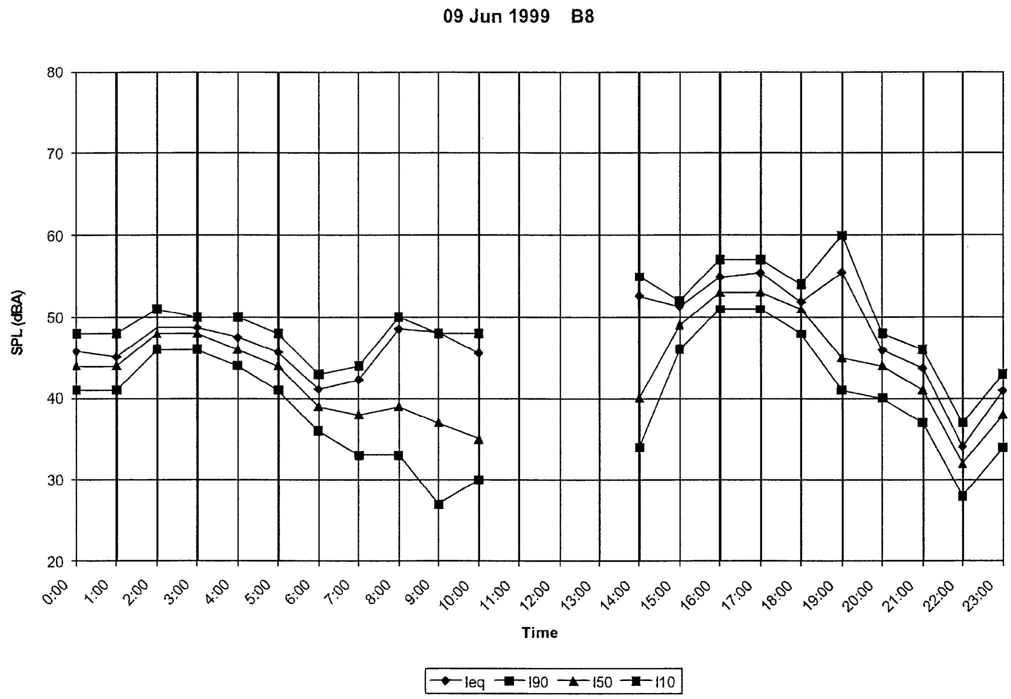
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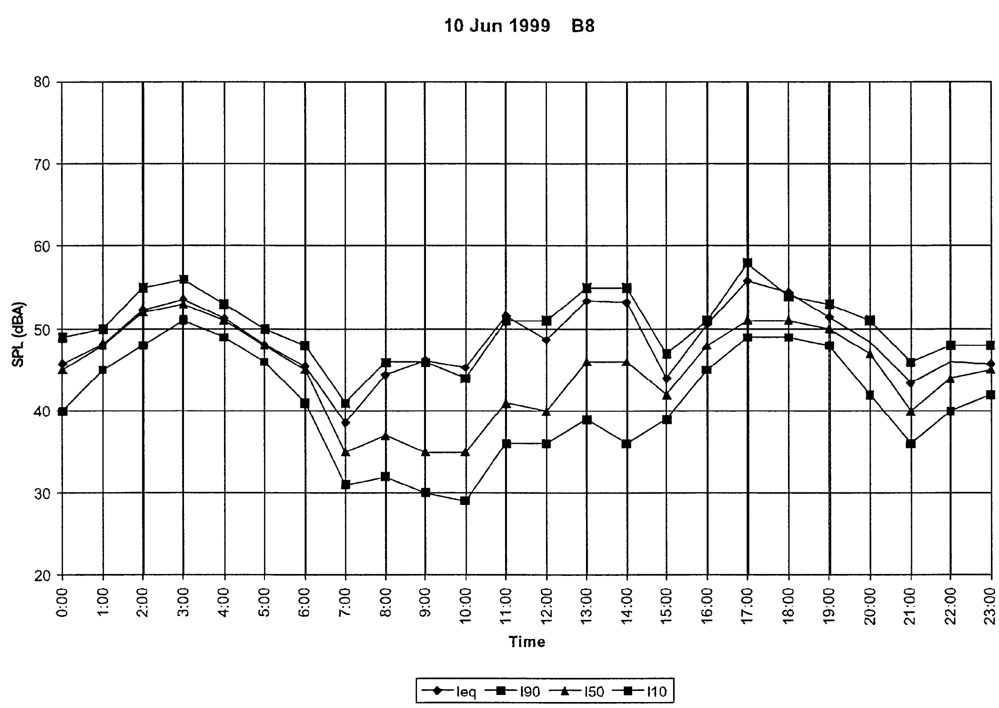
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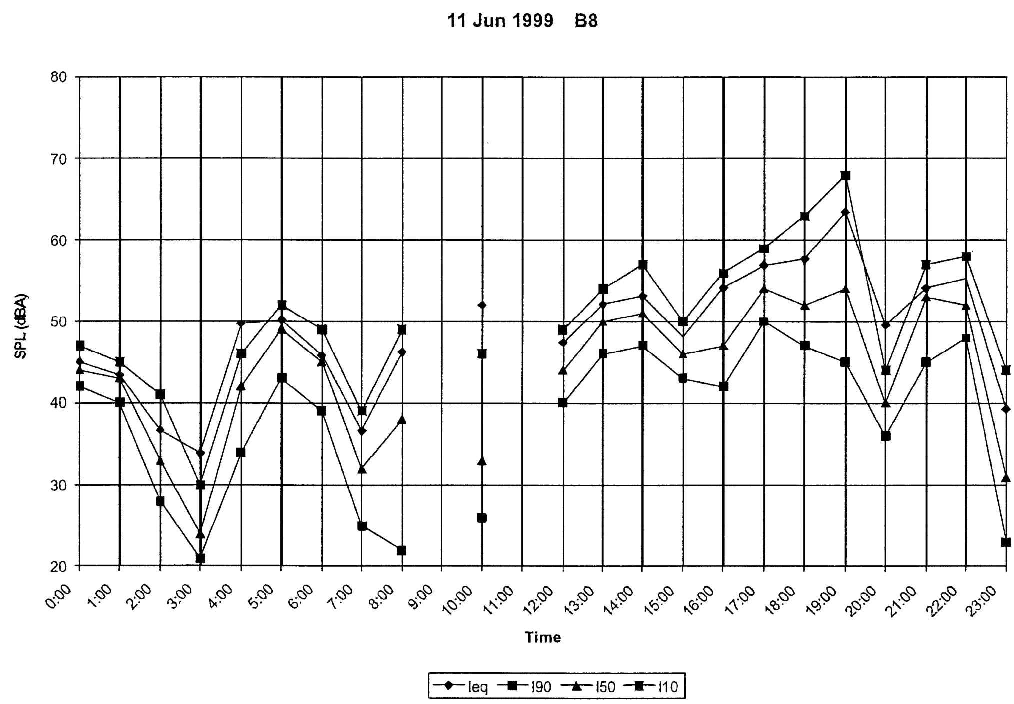
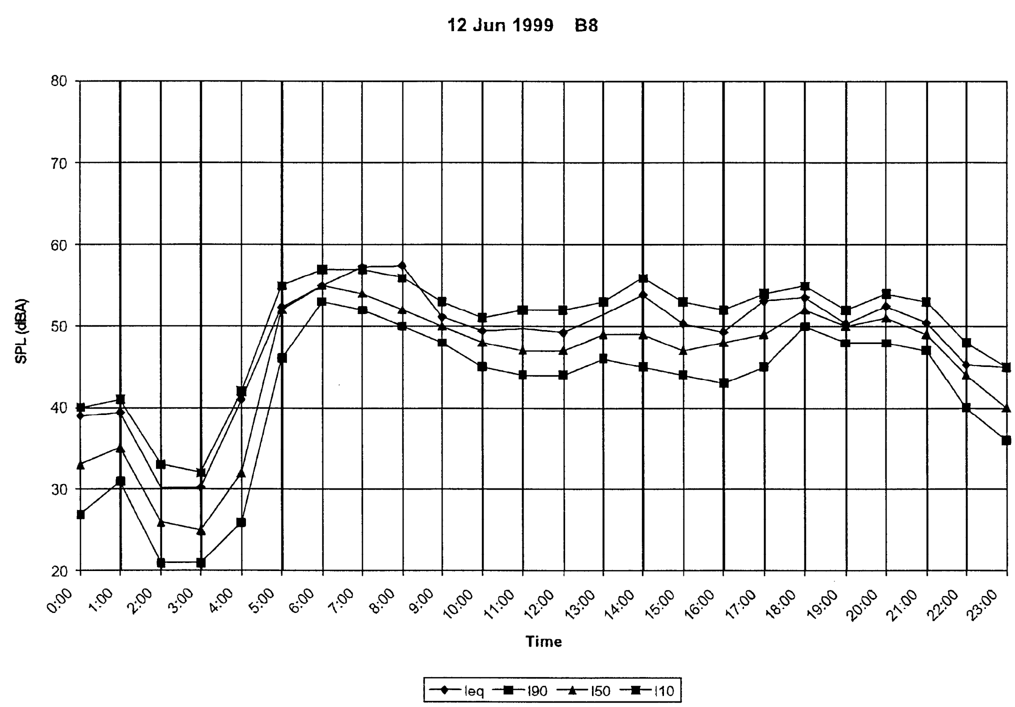
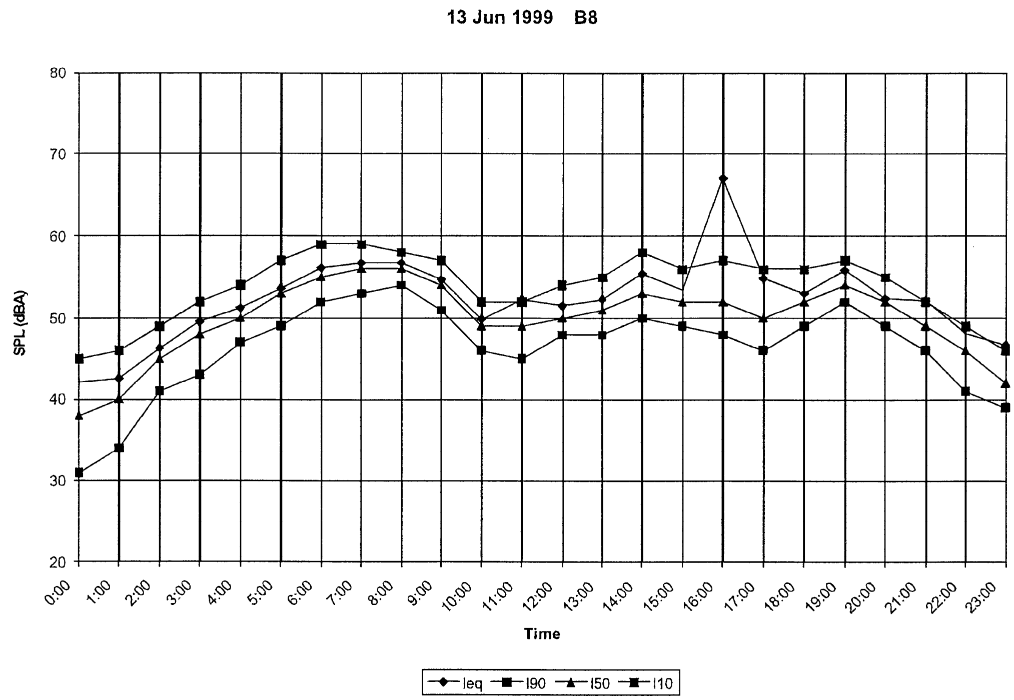


Appendix F Hourly L90, L50, L10 and Leq Time Histories for Unmanned Measurements The Soundscape in South Florida NP

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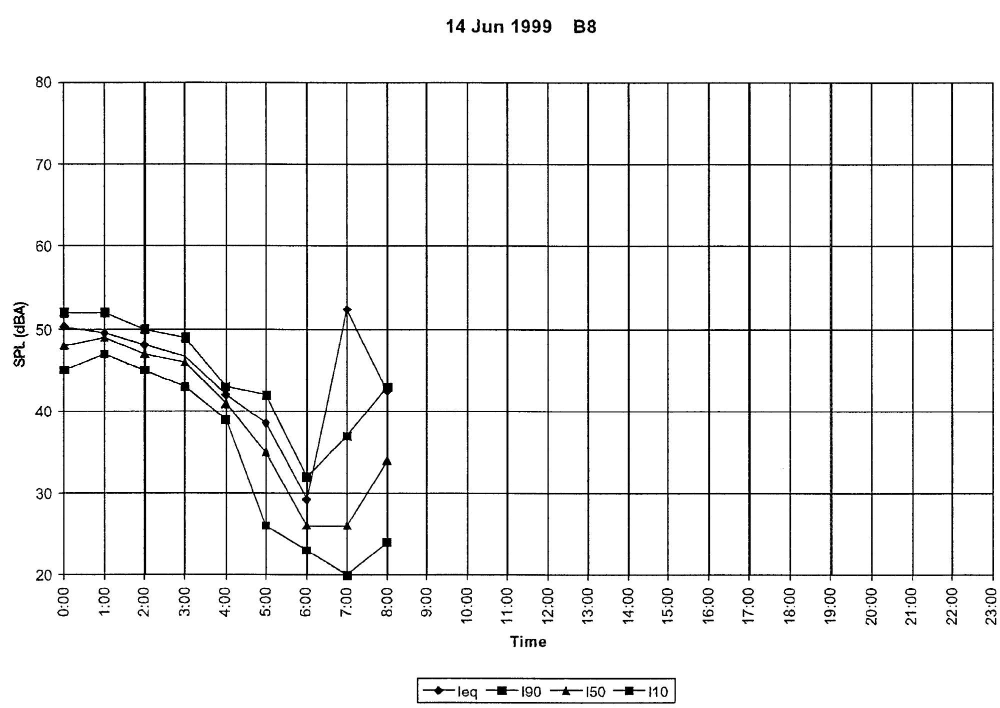
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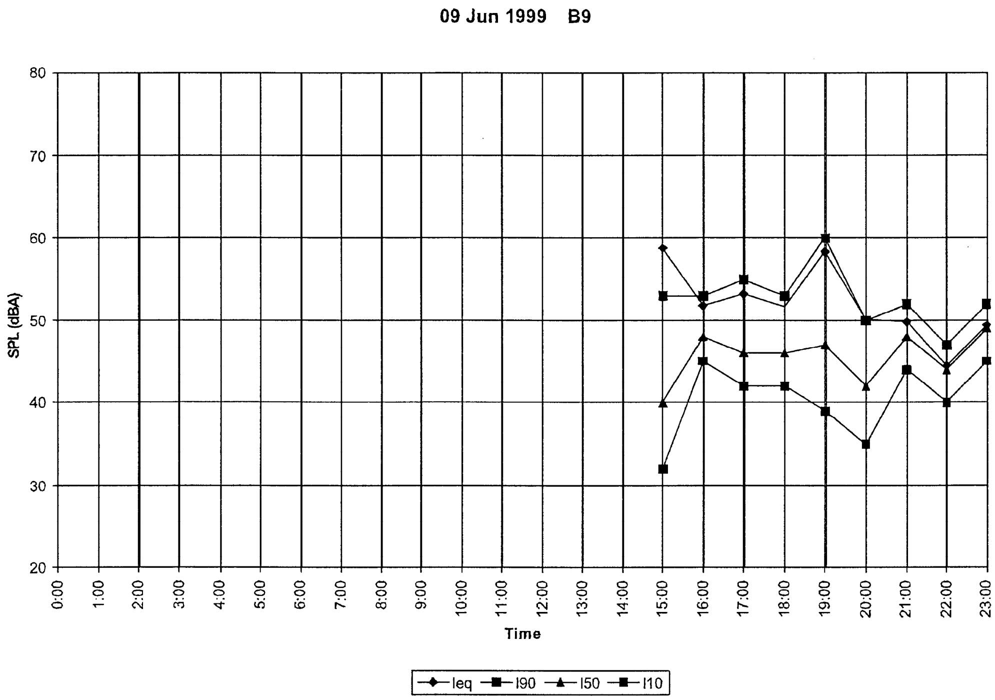
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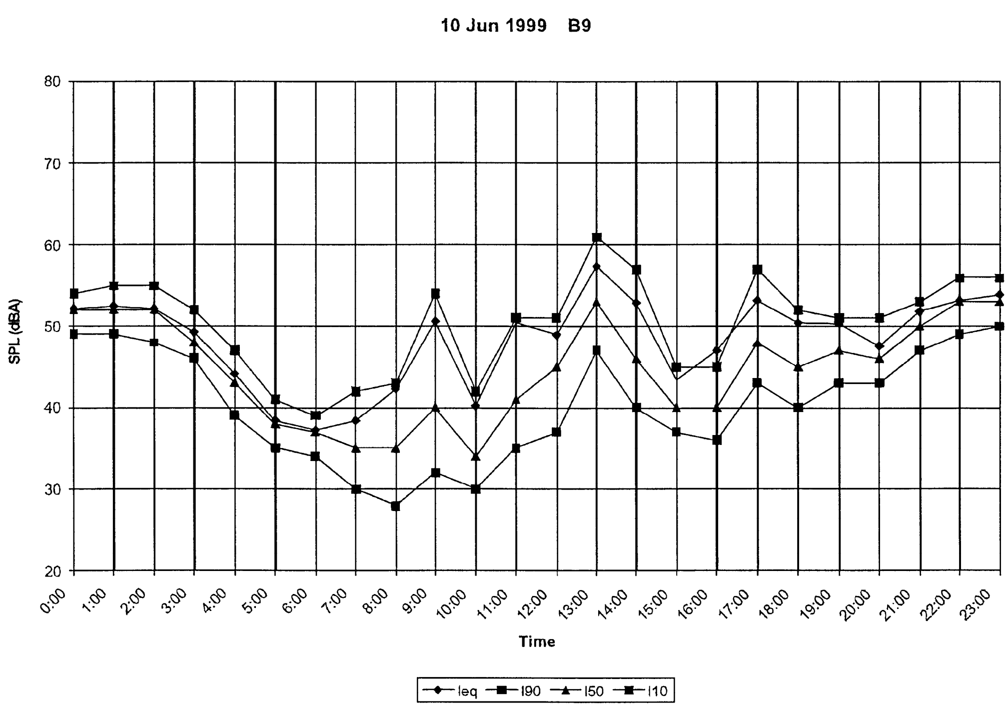
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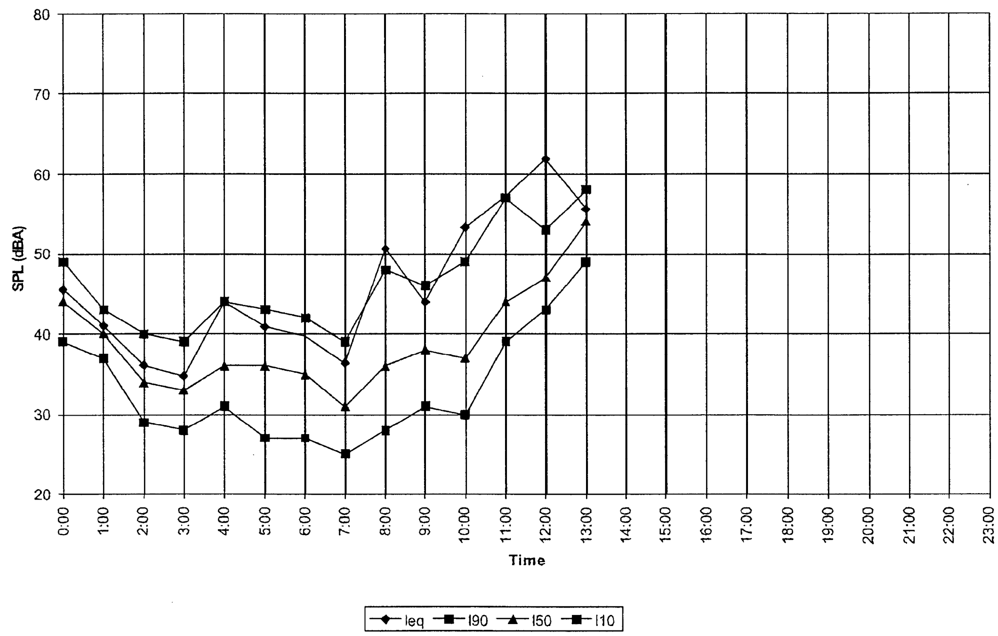
11 Jun 1999 B9



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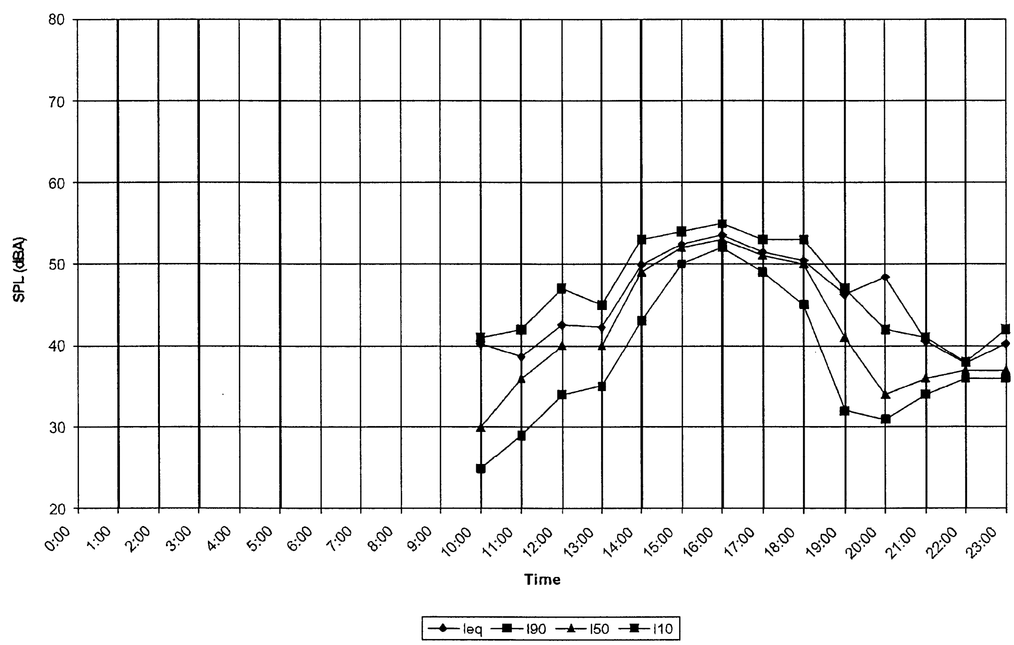

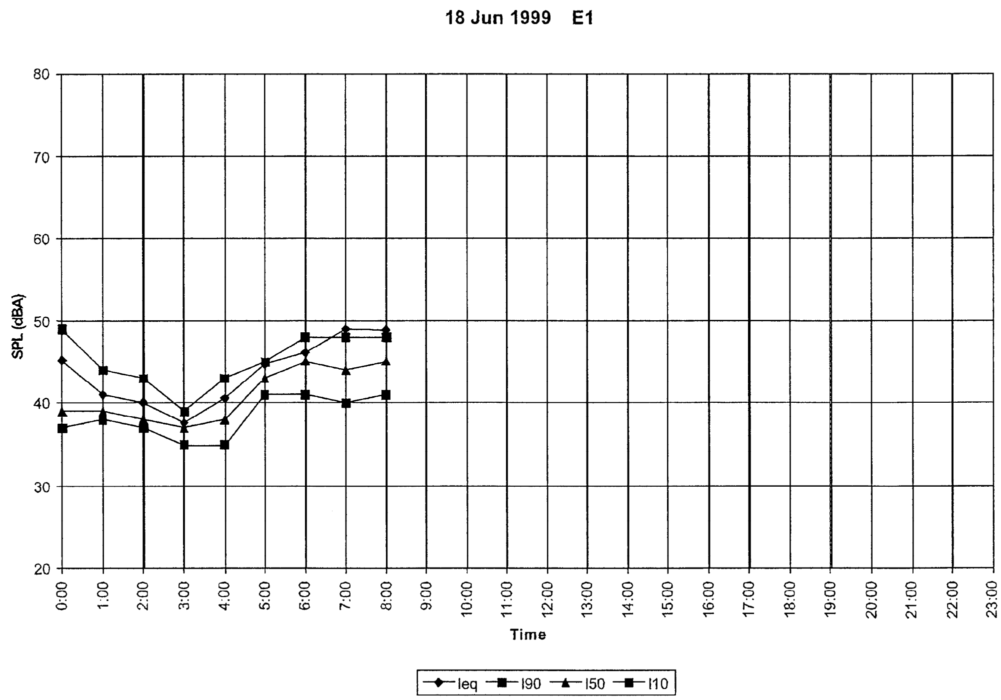
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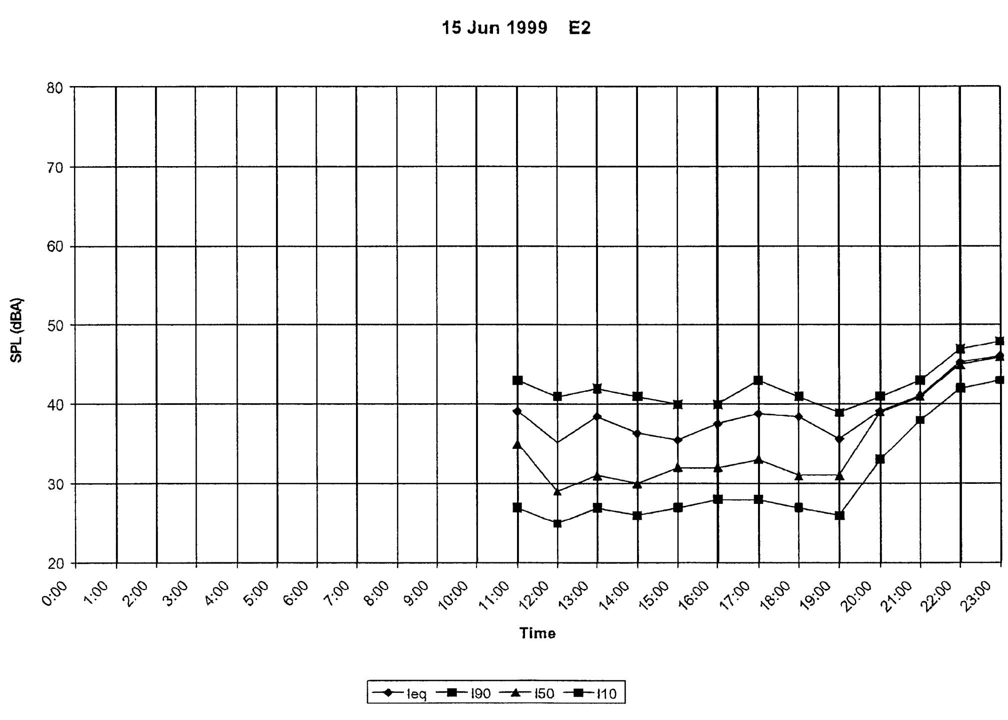
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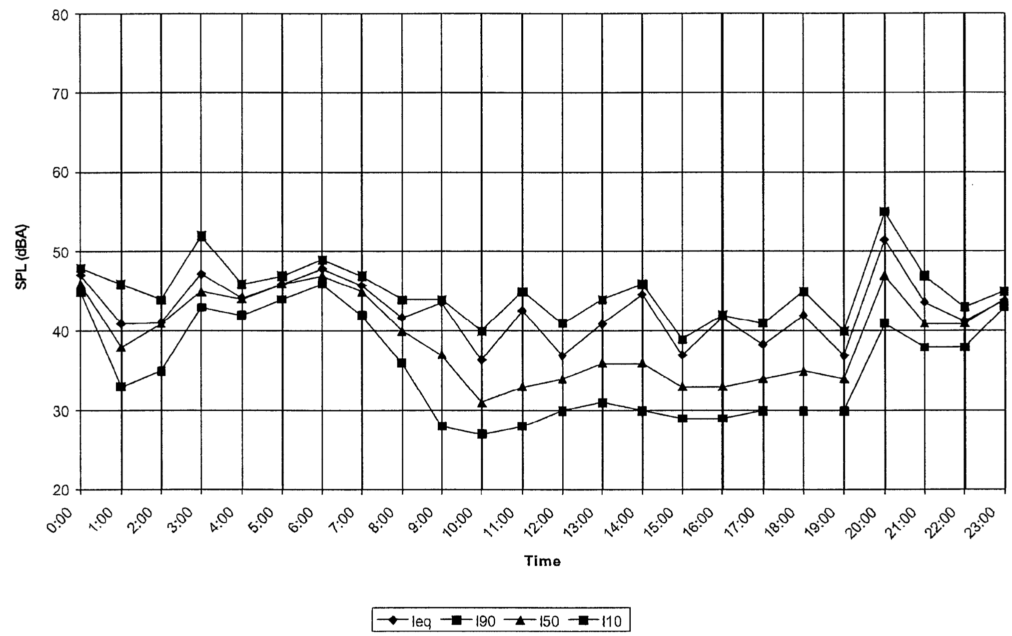

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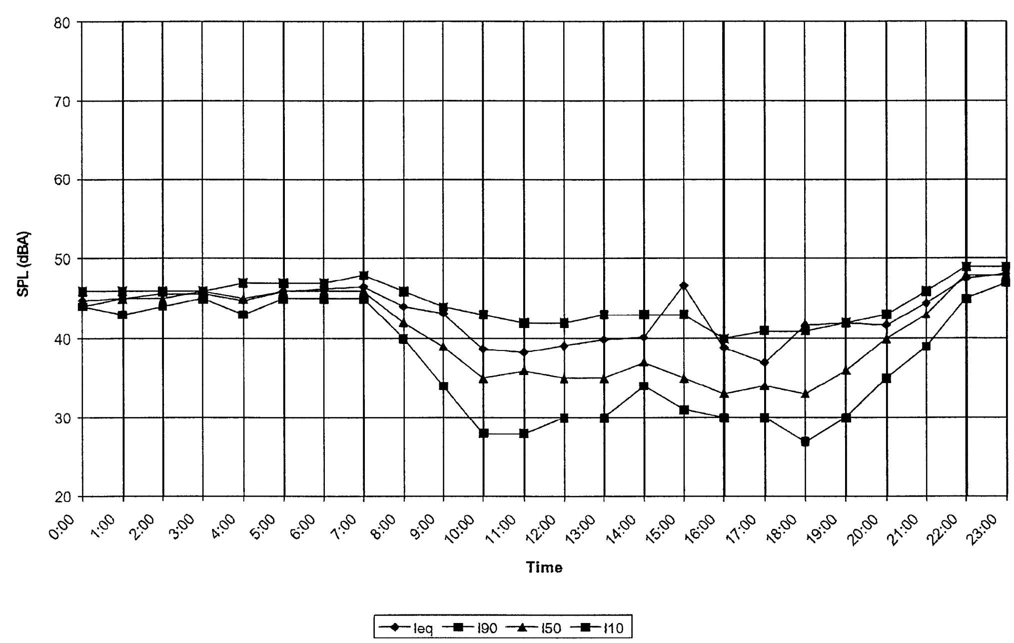

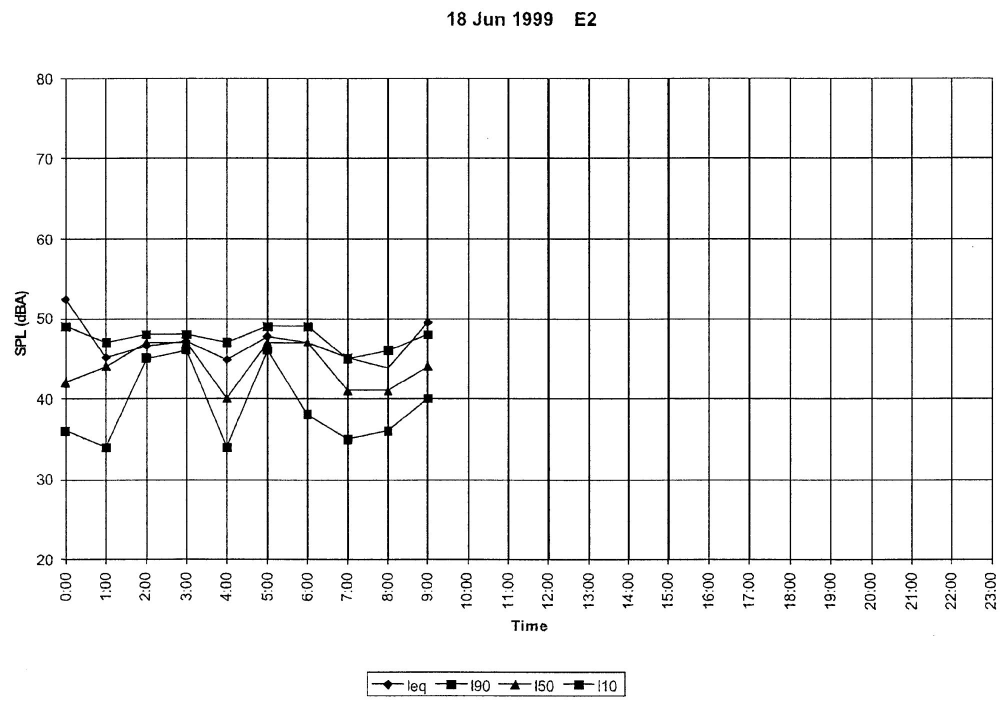
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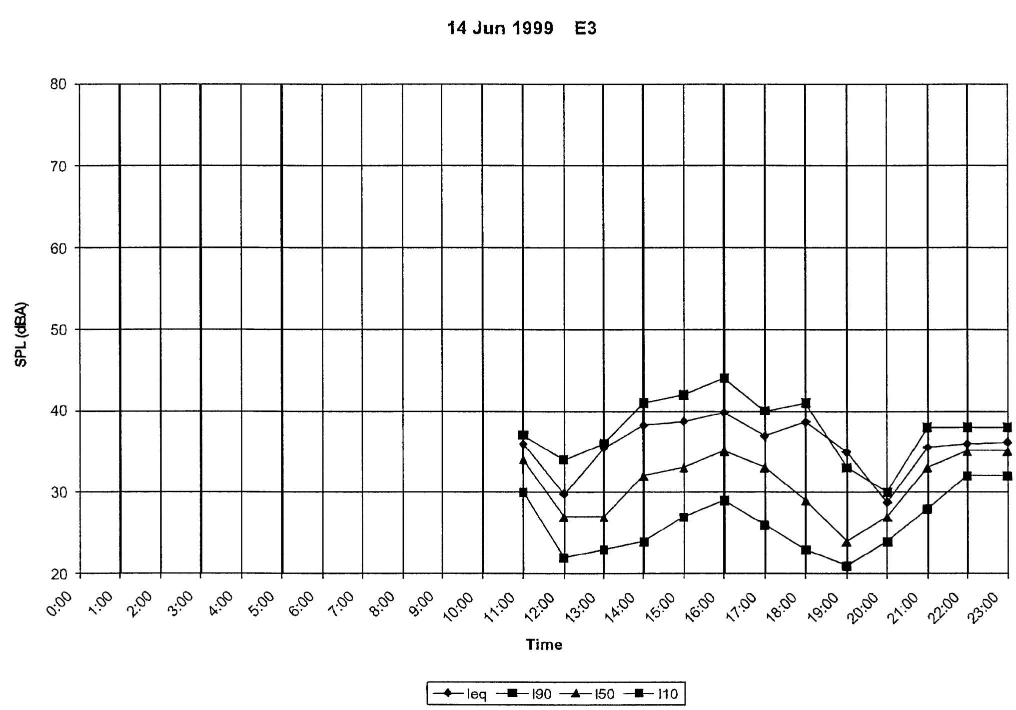
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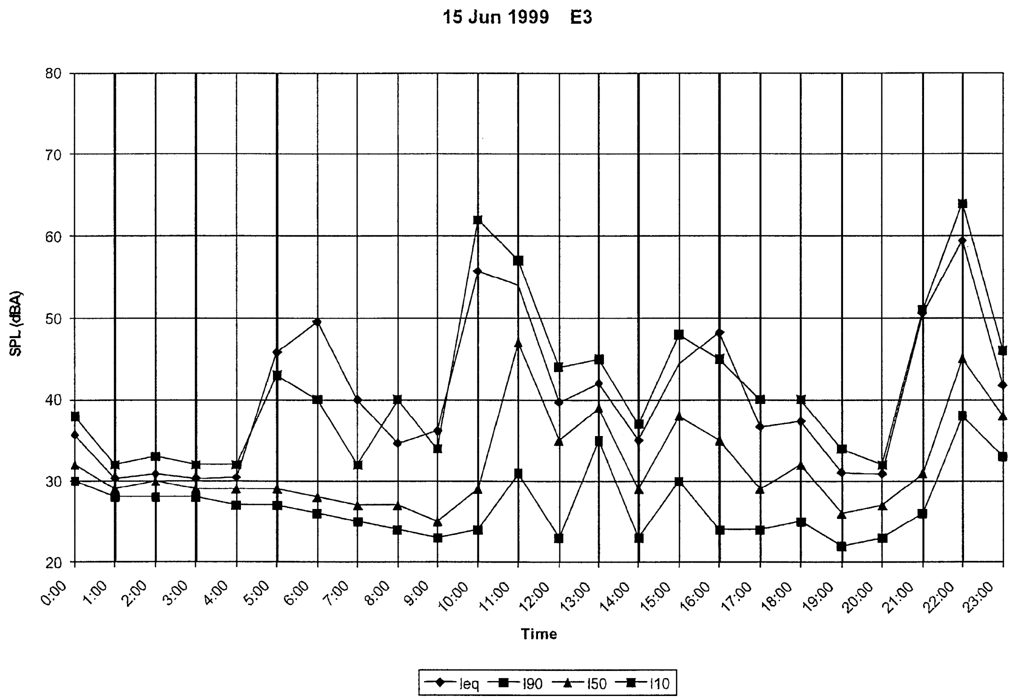
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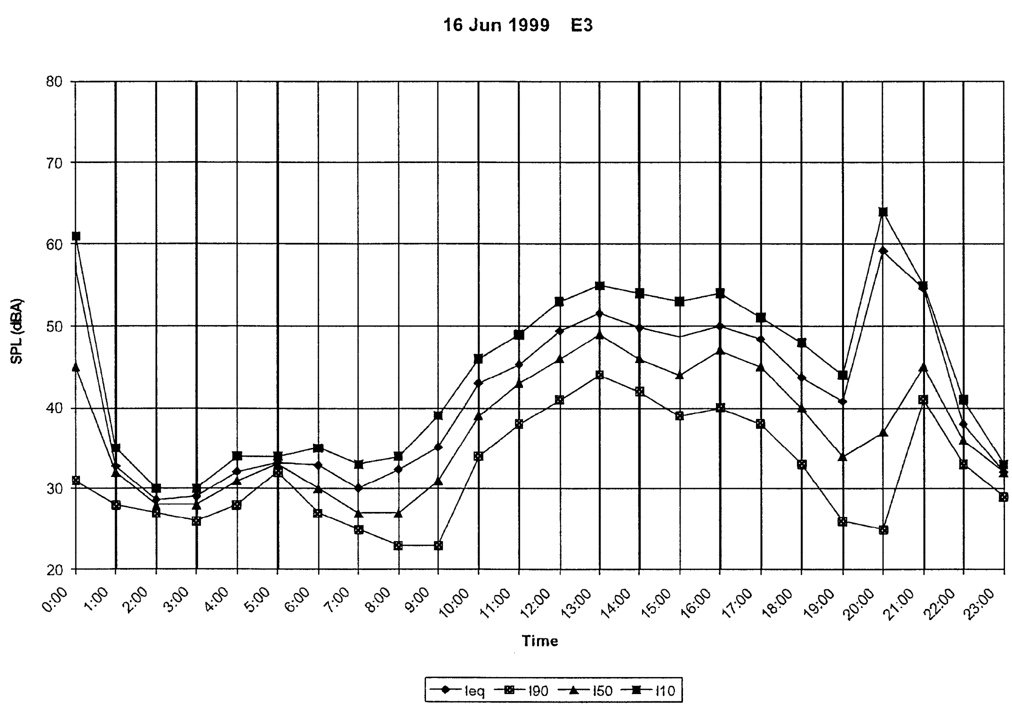
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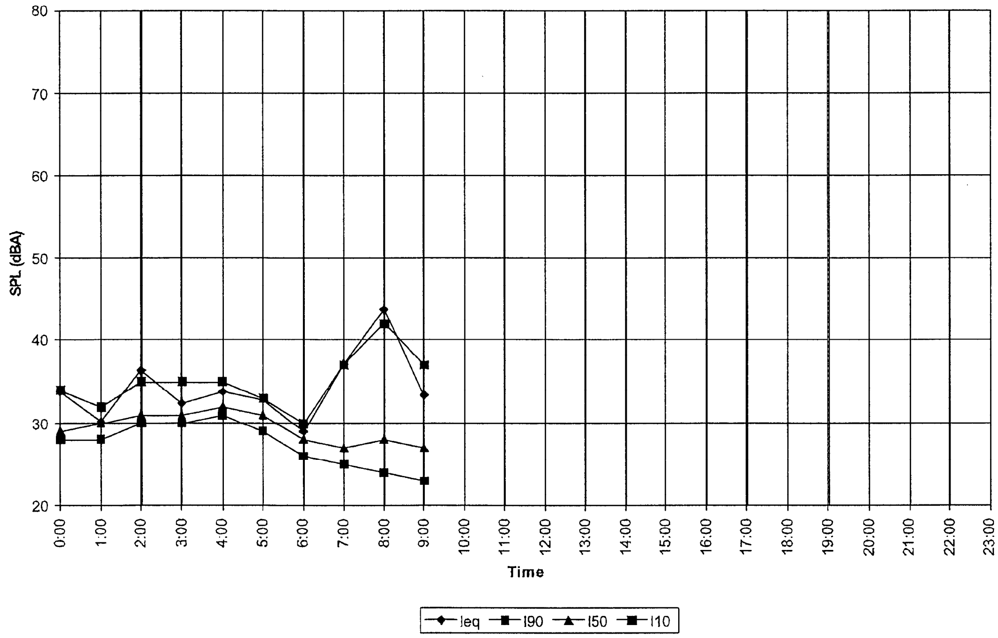
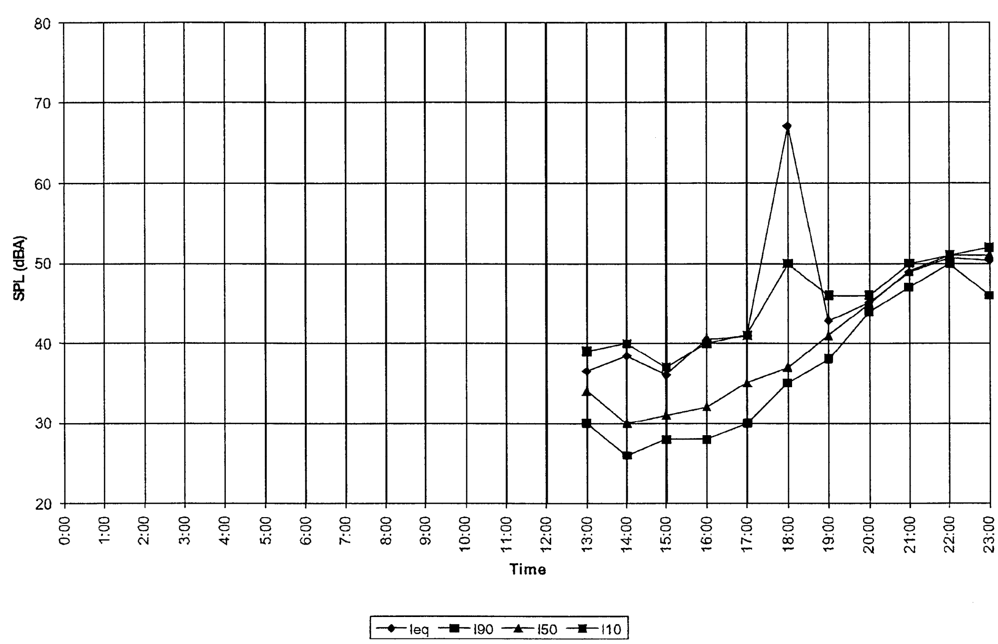
22:00
23:00
Time
leq l90 l50 l10

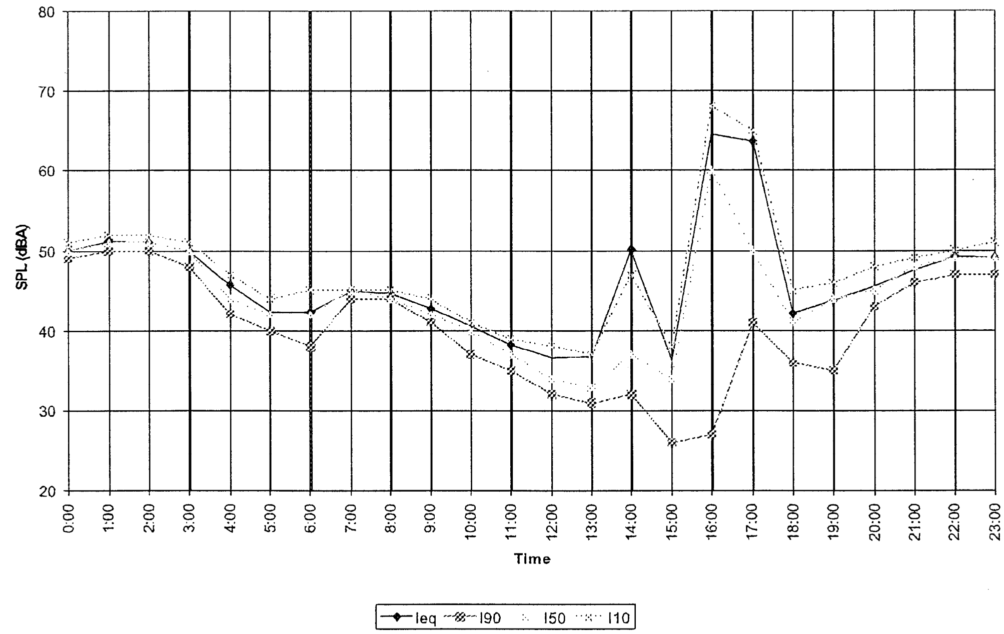
17 Jun 1999 E3



14 Jun 1999 E4

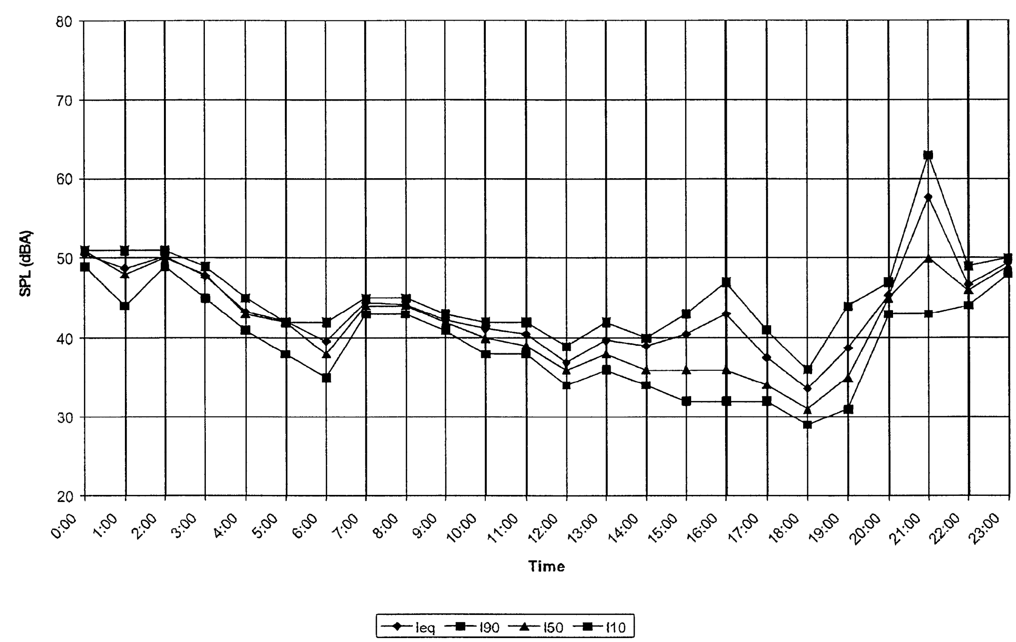


15 Jun 1999 E4

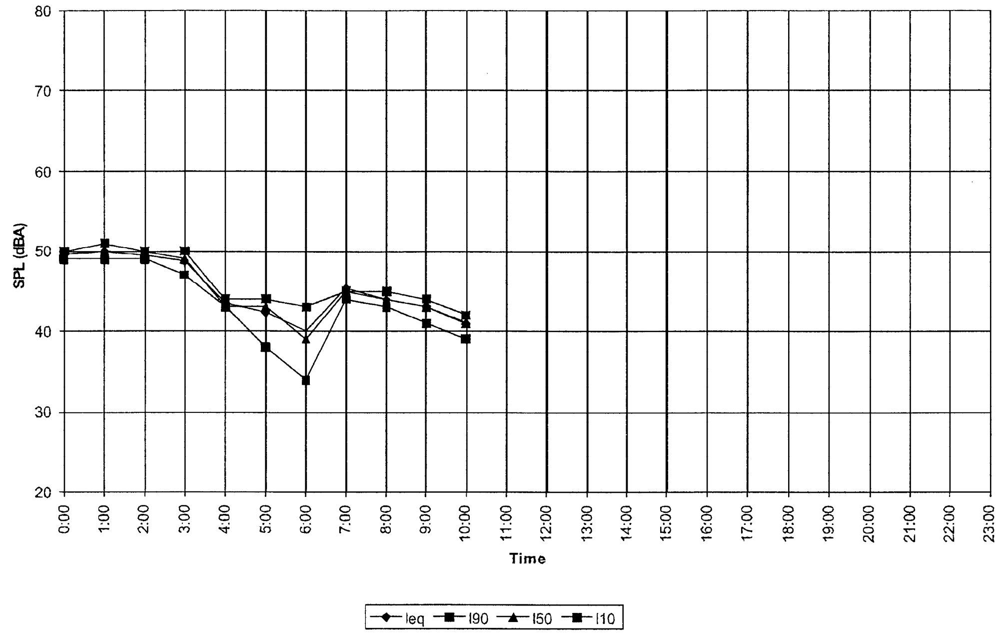


Appendix F Hourly L90, L50, L10 and Leq Time Histories for Unmanned Measurements The Soundscape in South Florida NP

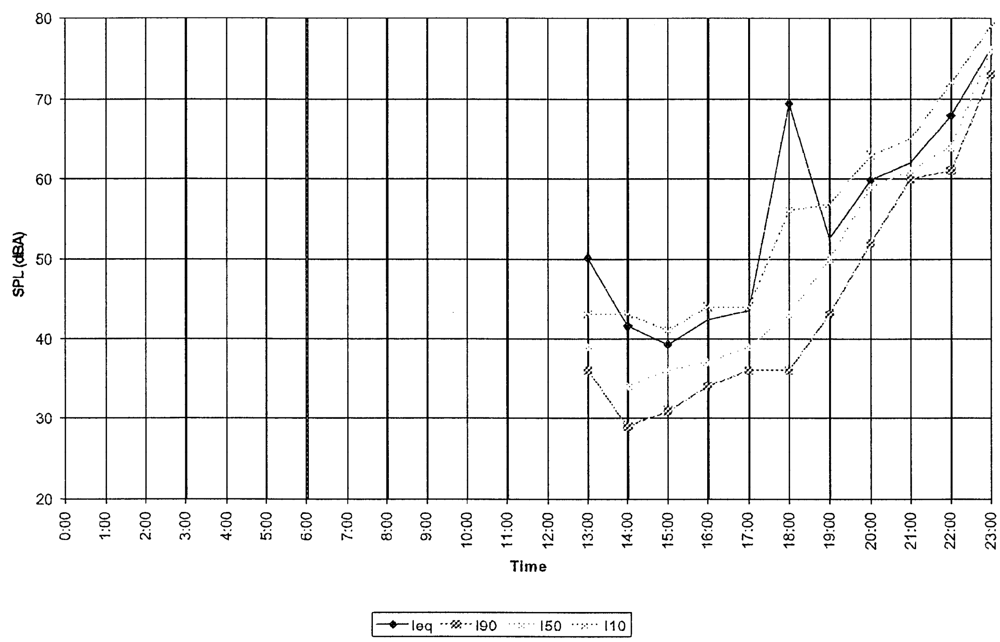
16 Jun 1999 E4

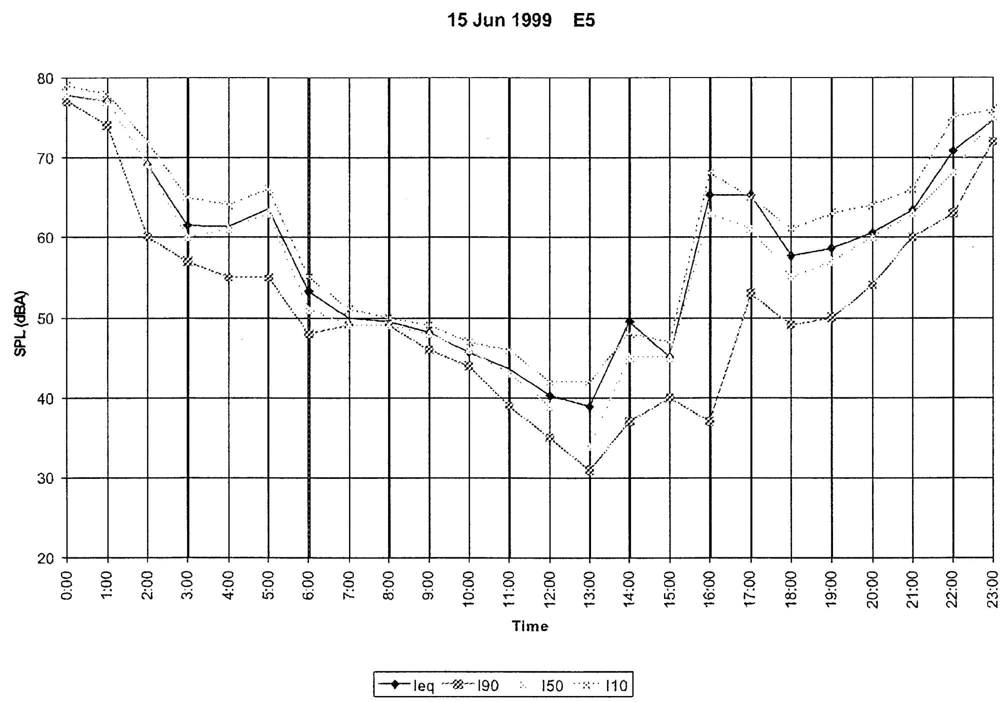


17 Jun 1999 E4



14 Jun 1999 E5

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SPL (dBA)
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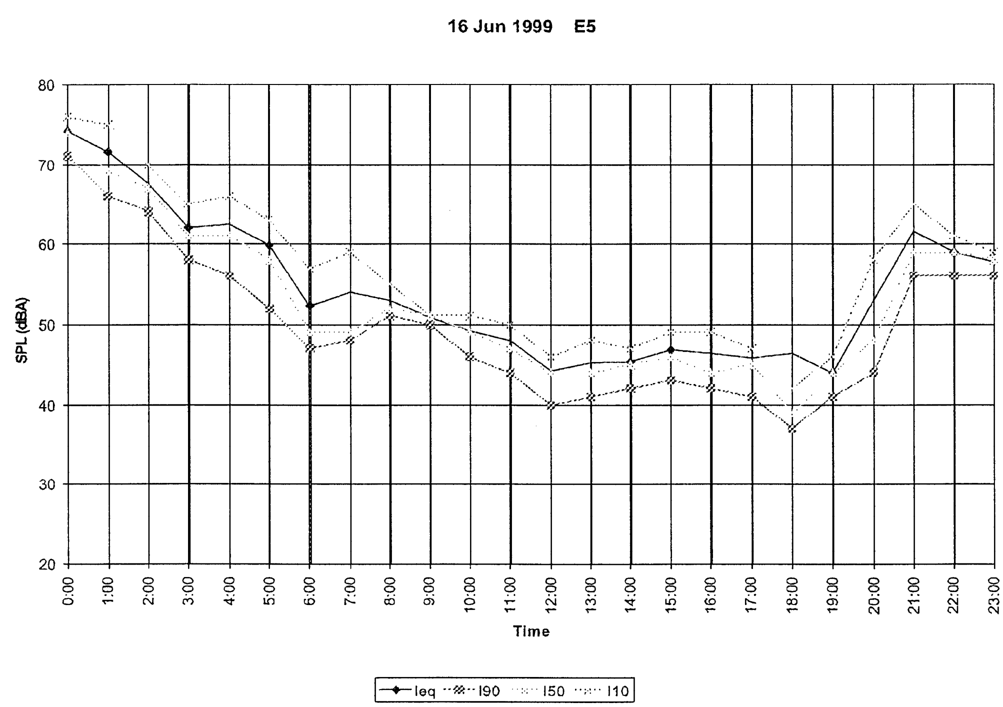
21:00
22:00
23:00
Time
leq
l90
l50
l10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SPL (dBA)
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21:00
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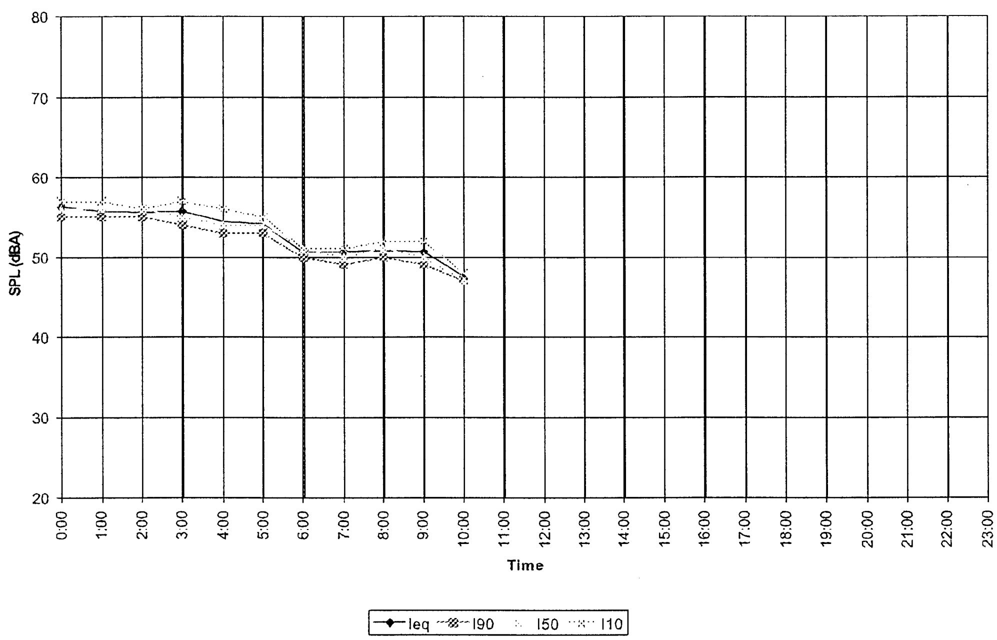
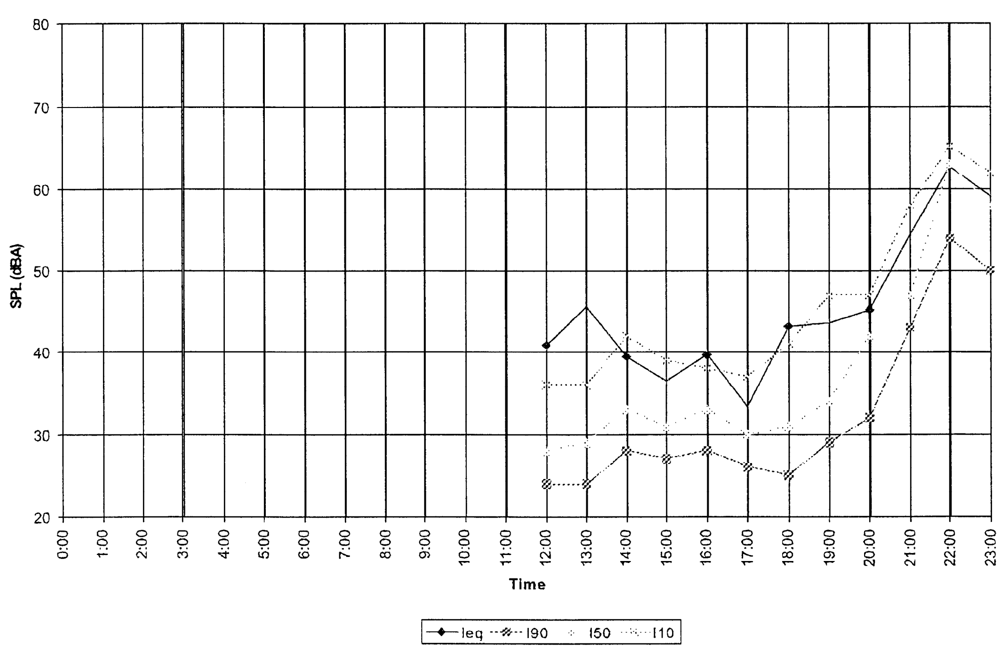
23:00
Time
leq
l90
l50
l10

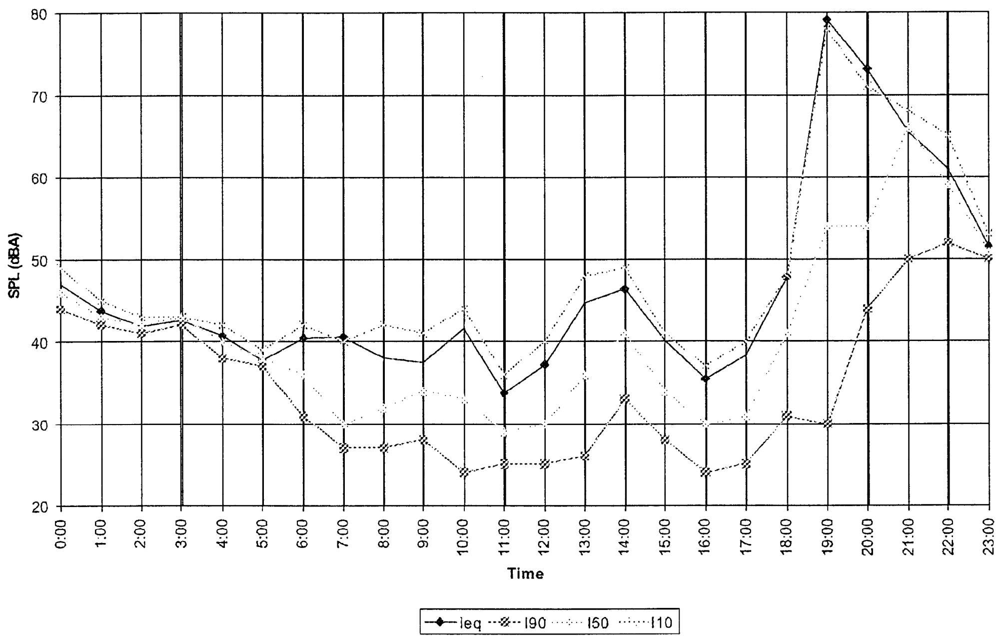
17 Jun 1999 E5



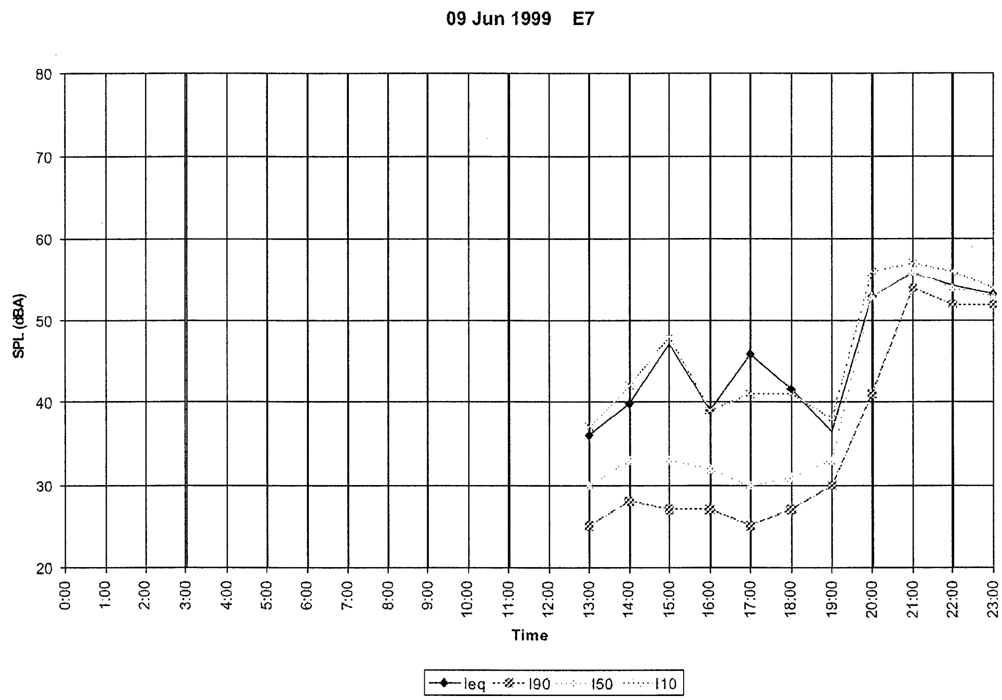
09 Jun 1999 E6



10 Jun 1999 E6



11 Jun 1999 E6


09 Jun 1999 E7
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SPL (dBA)
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18:00
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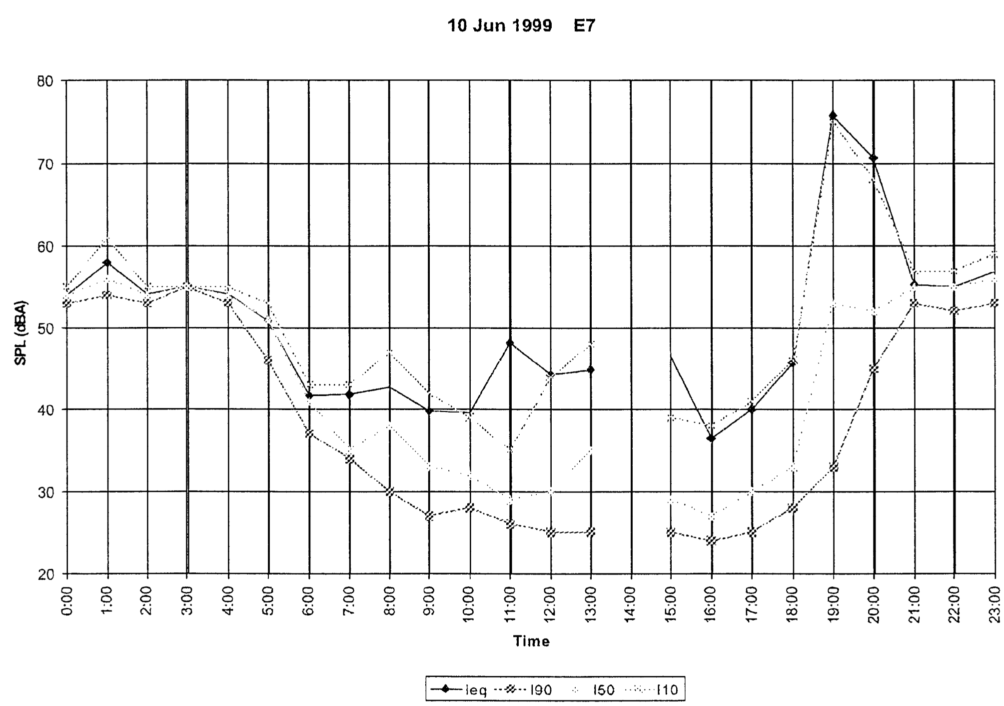
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10


10 Jun 1999 E7
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SPL (dBA)
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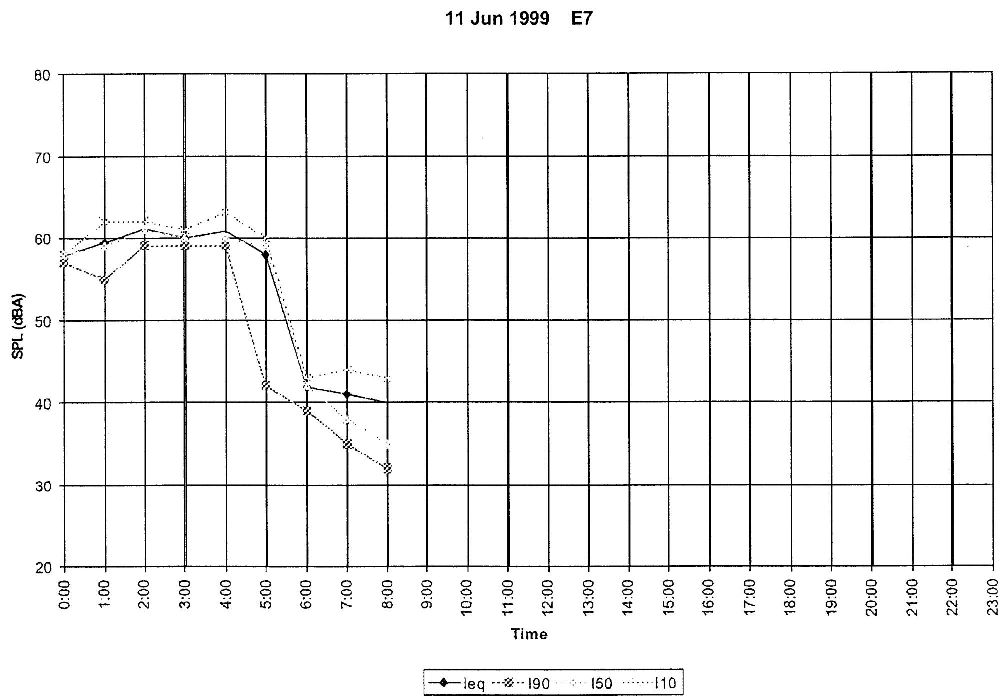
21:00
22:00
23:00
Time
leq
l90
l50
l10


11 Jun 1999 E7
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SPL (dBA)
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19:00
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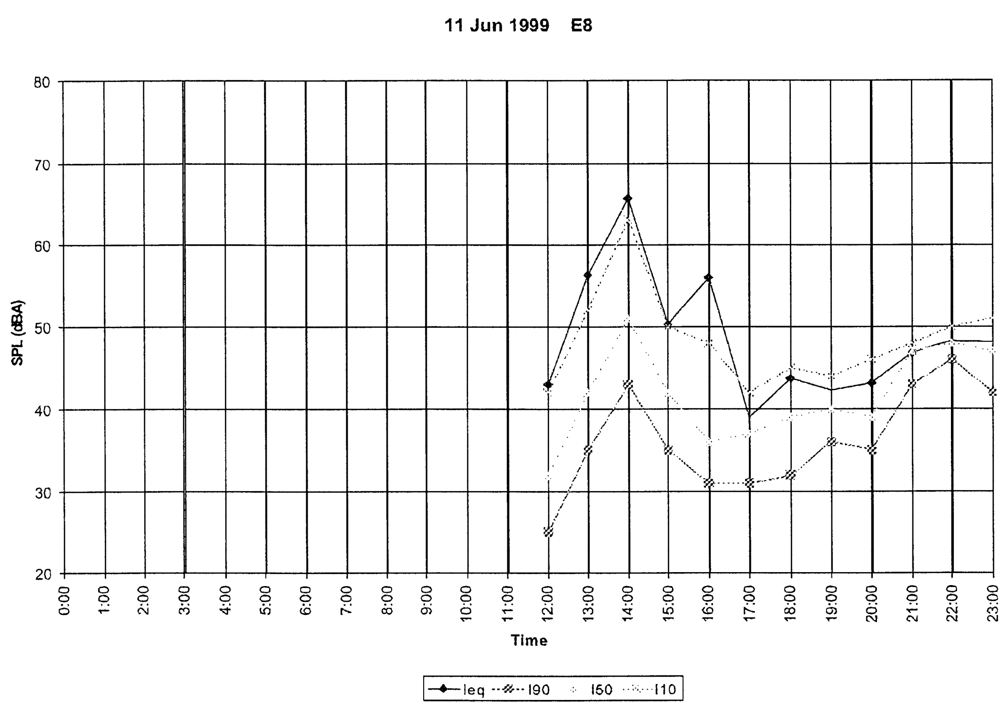
21:00
22:00
23:00
Time
leq
l90
l50
l10


11 Jun 1999 E8
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SPL (dBA)
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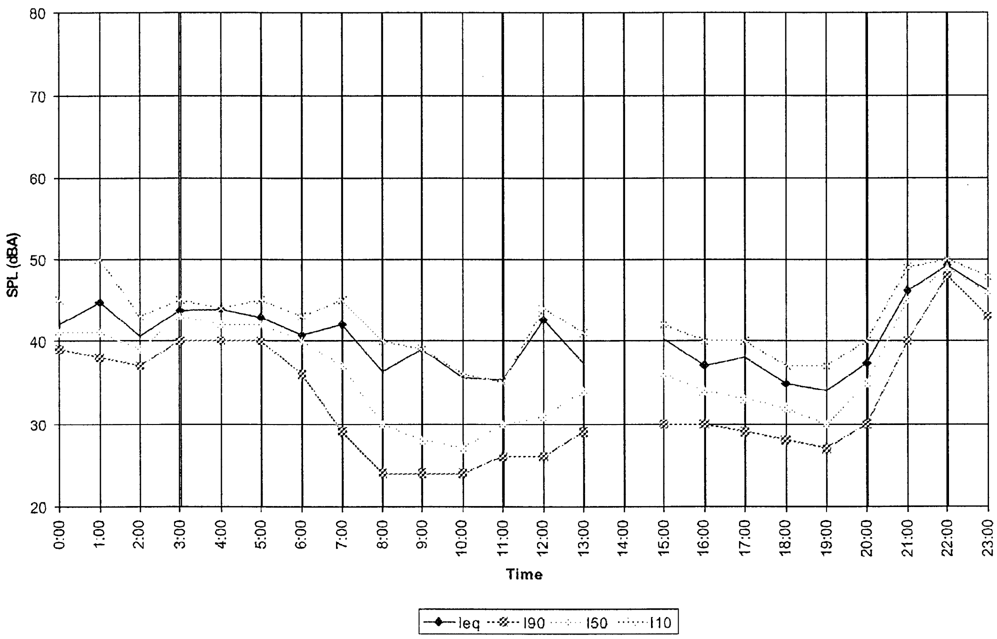
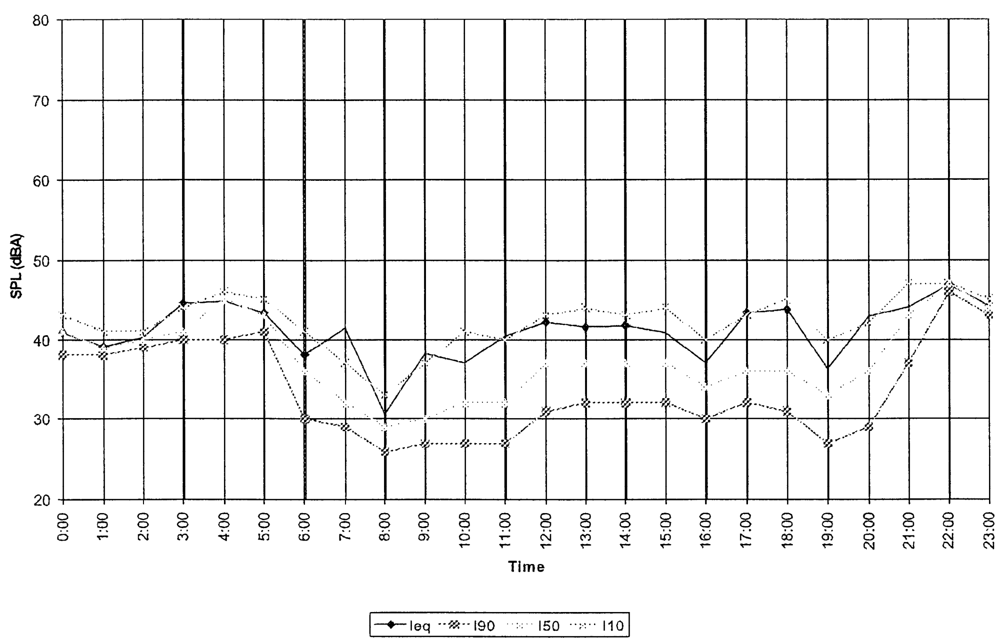
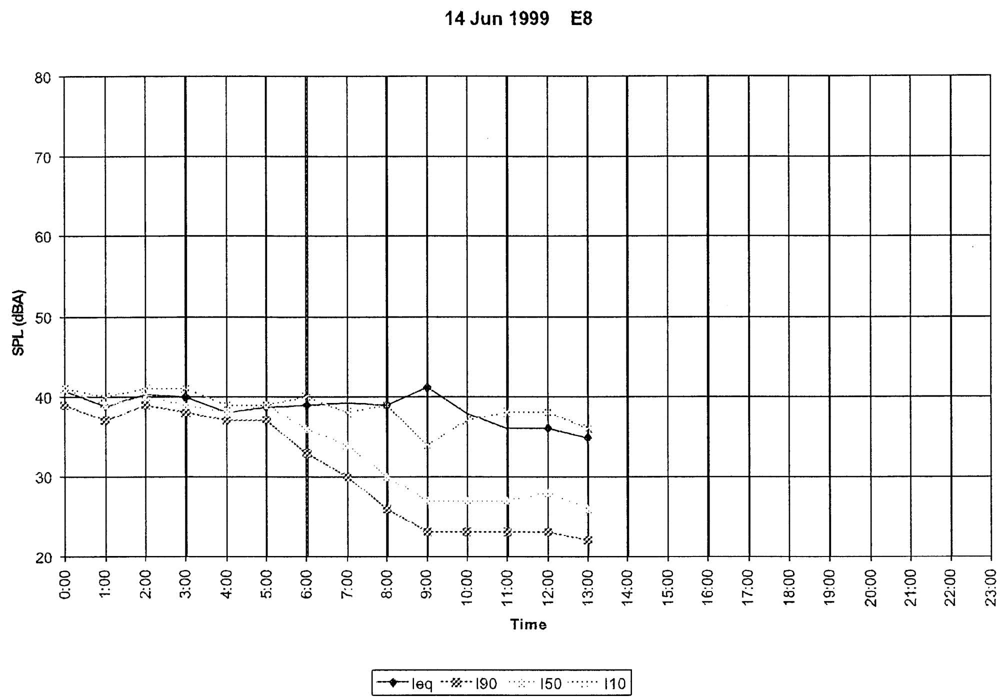
23:00
Time
leq
l90
l50
l10

12 Jun 1999 E8



13 Jun 1999 E8




14 Jun 1999 E8
SPL (dBA)
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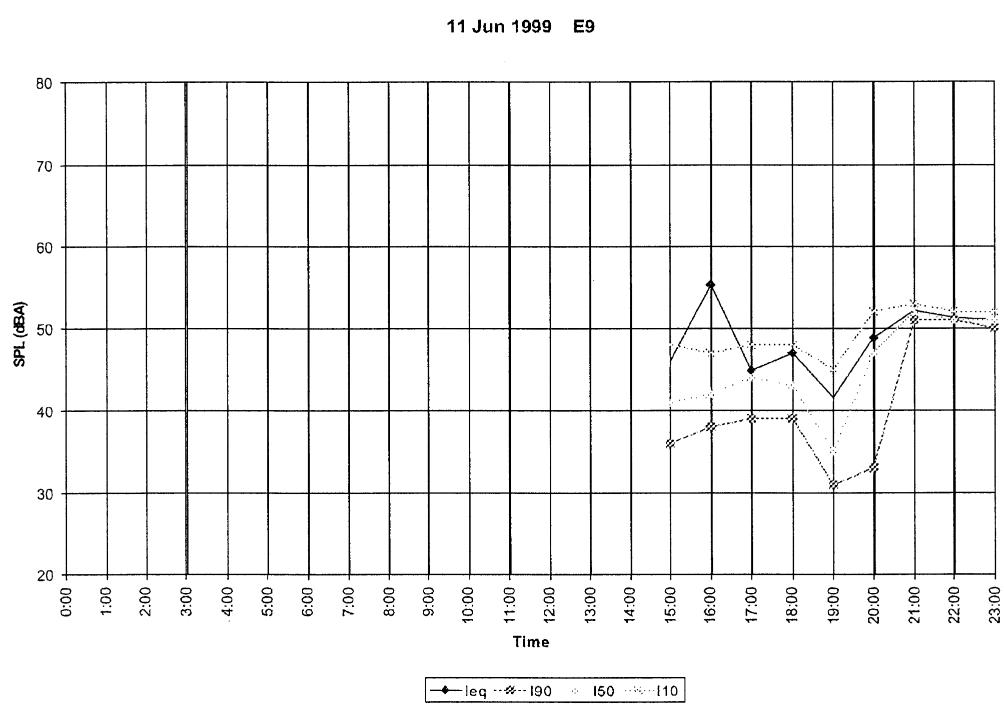
21:00
22:00
23:00
Time
leq
l90
l50
l10


11 Jun 1999 E9
SPL (dBA)
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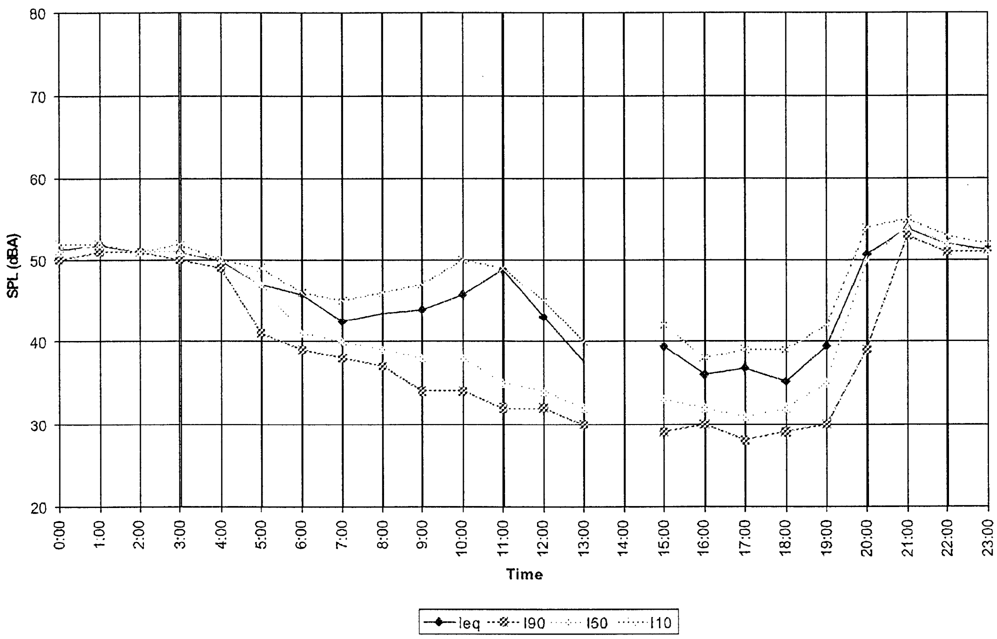
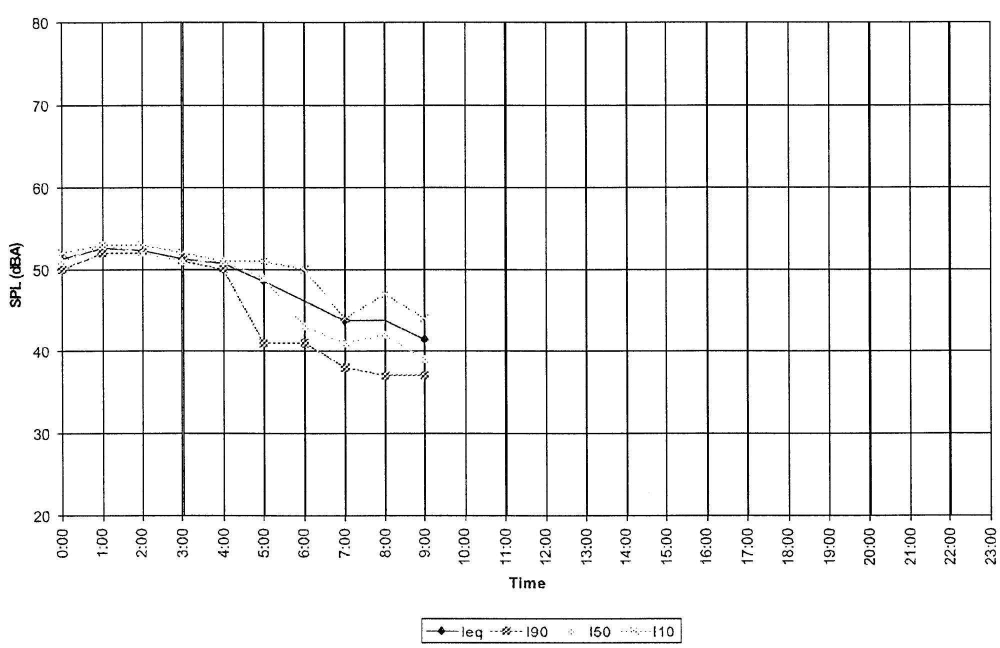
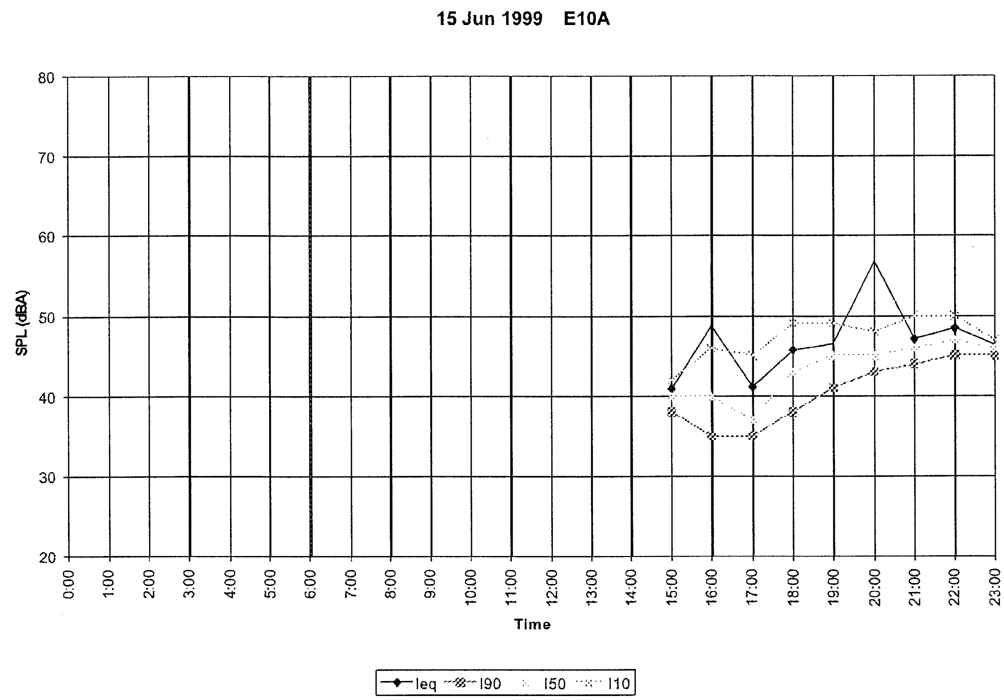
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10

12 Jun 1999 E9



13 Jun 1999 E9

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SPL (dBA)
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5:00
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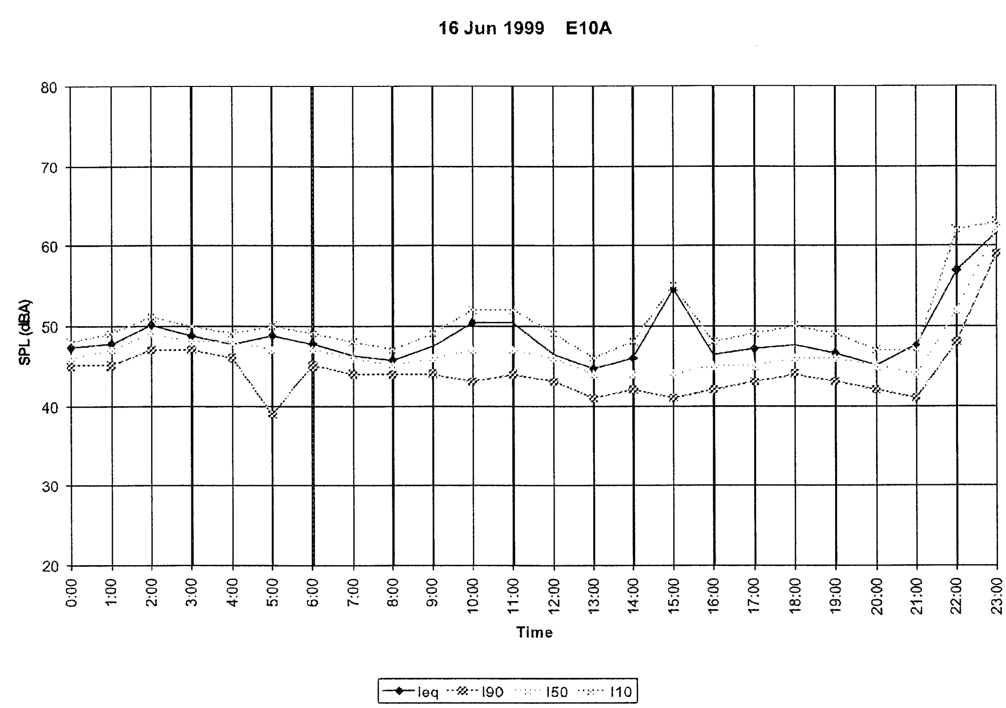
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq l90 l50 l10


16 Jun 1999 E10A
SPL (dBA)
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5:00
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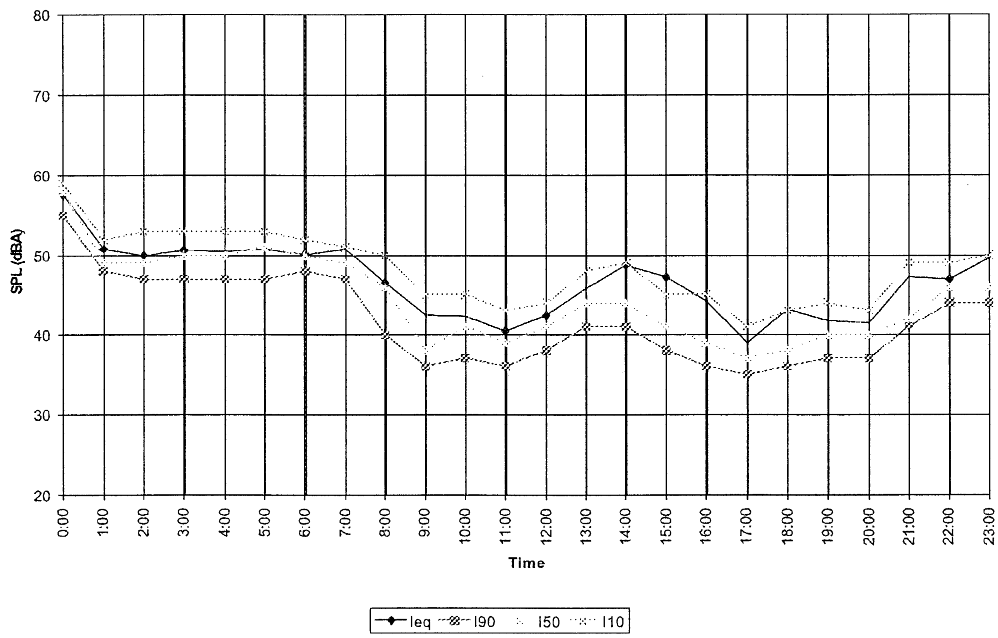
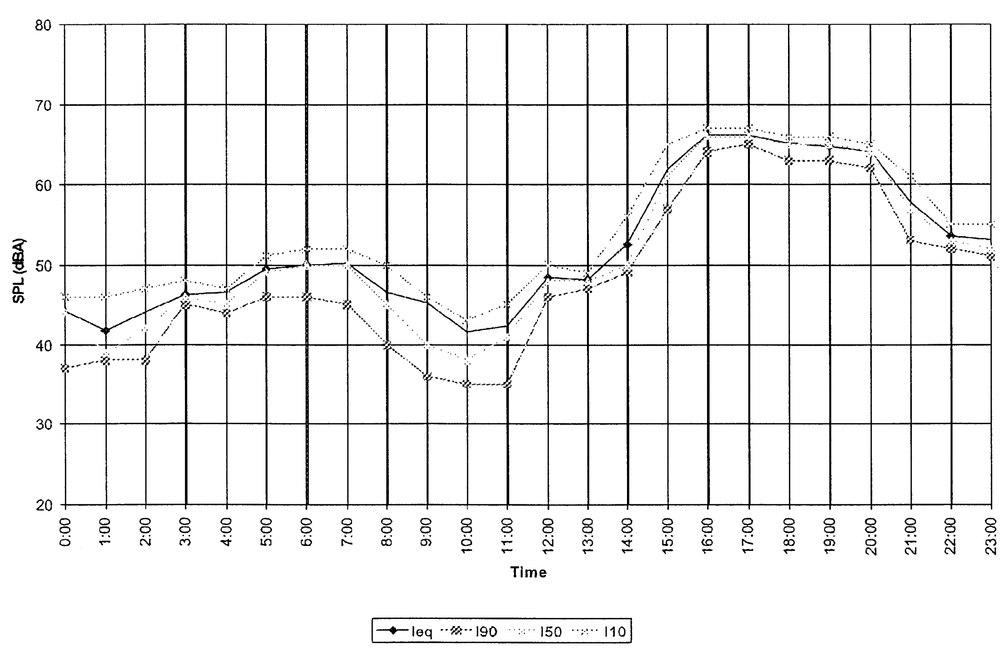
21:00
22:00
23:00
Time
leq l90 l50 l10

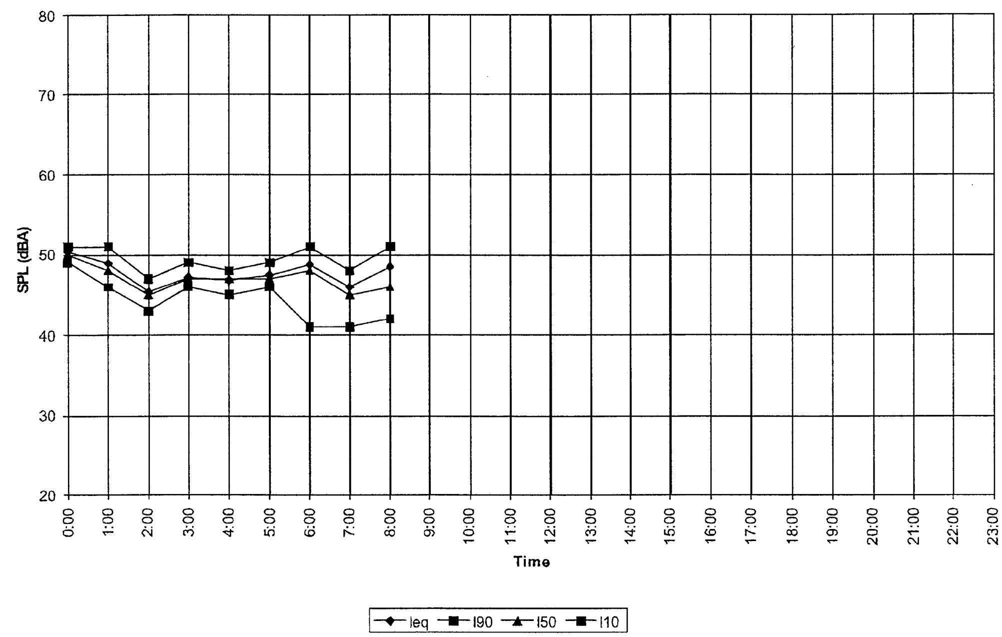
17 Jun 1999 E10A



18 Jun 1999 E10A

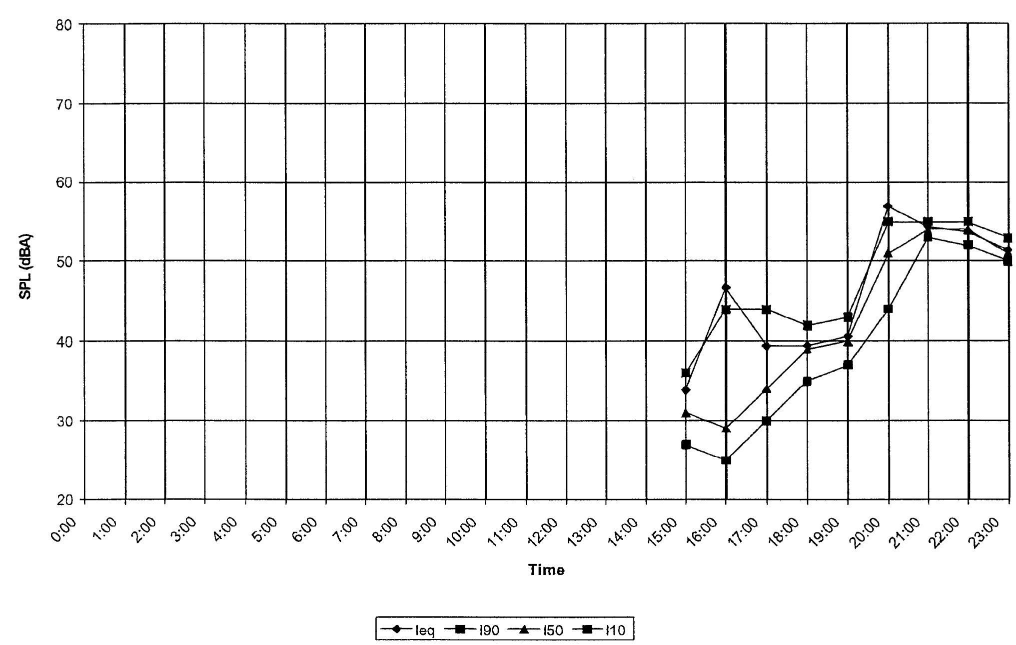


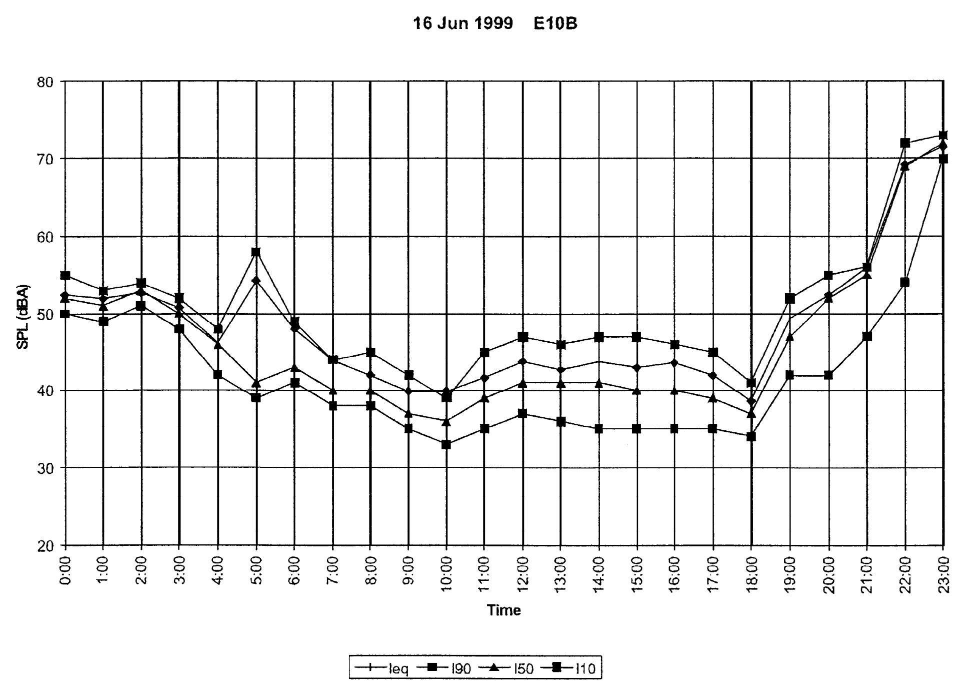
19 Jun 1999 E10A



Appendix F Hourly L90, L50, L10 and Leq Time Histories for Unmanned Measurements The Soundscape in South Florida NP

15 Jun 1999 E10B

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SPL (dBA)
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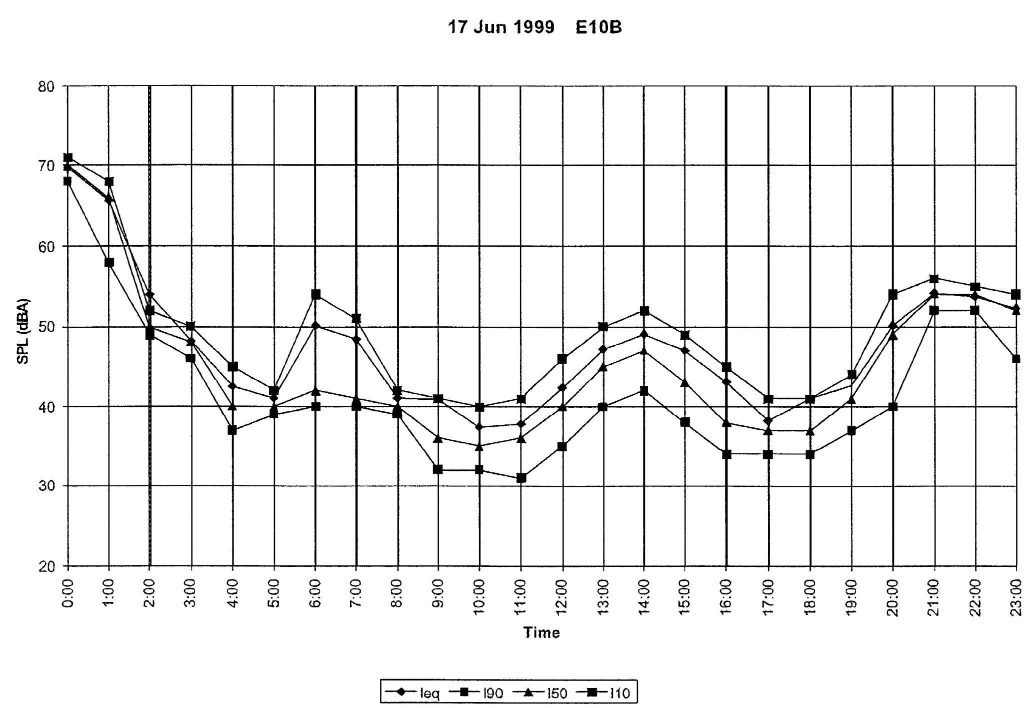
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10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SPL (dBA)
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5:00
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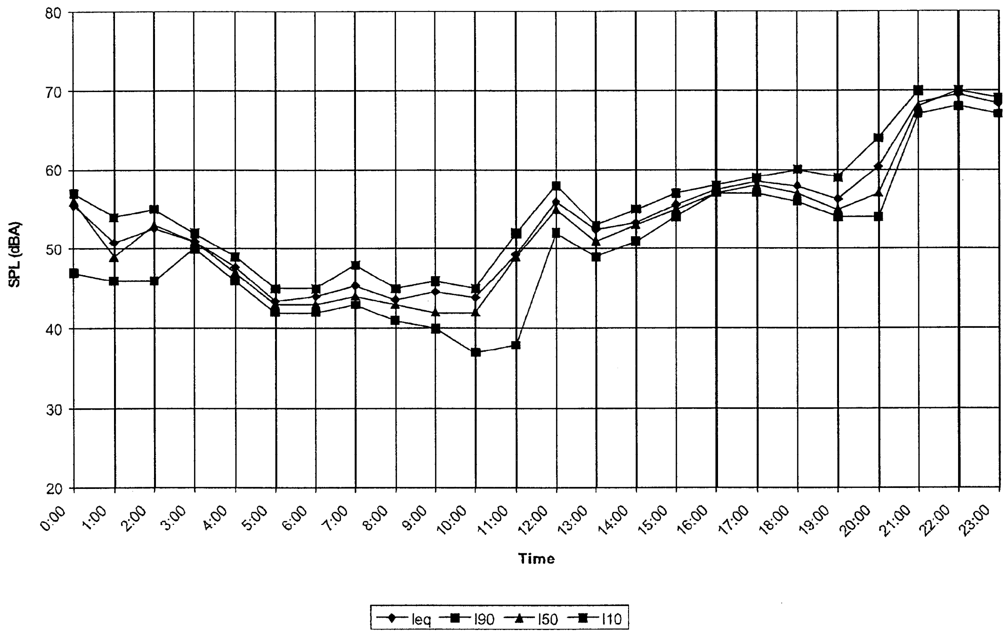
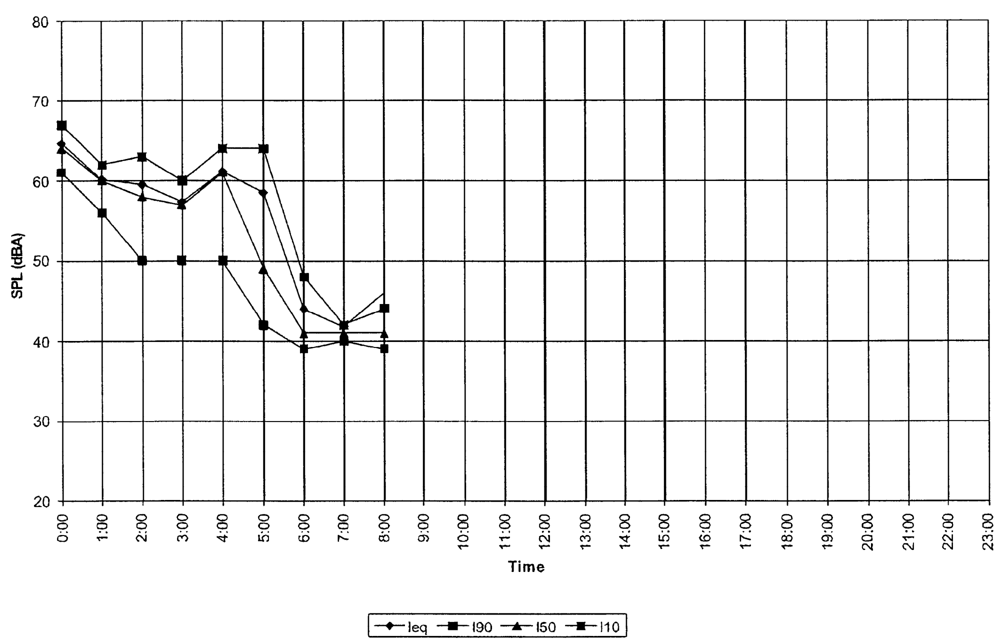
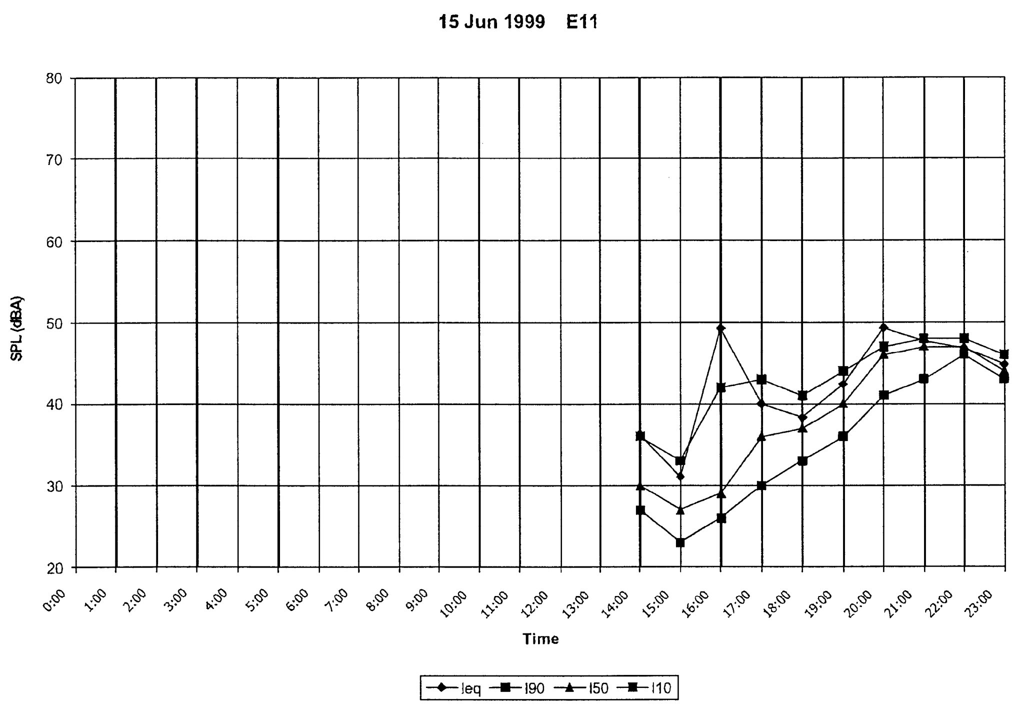
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10

18 Jun 1999 E10B



19 Jun 1999 E10B

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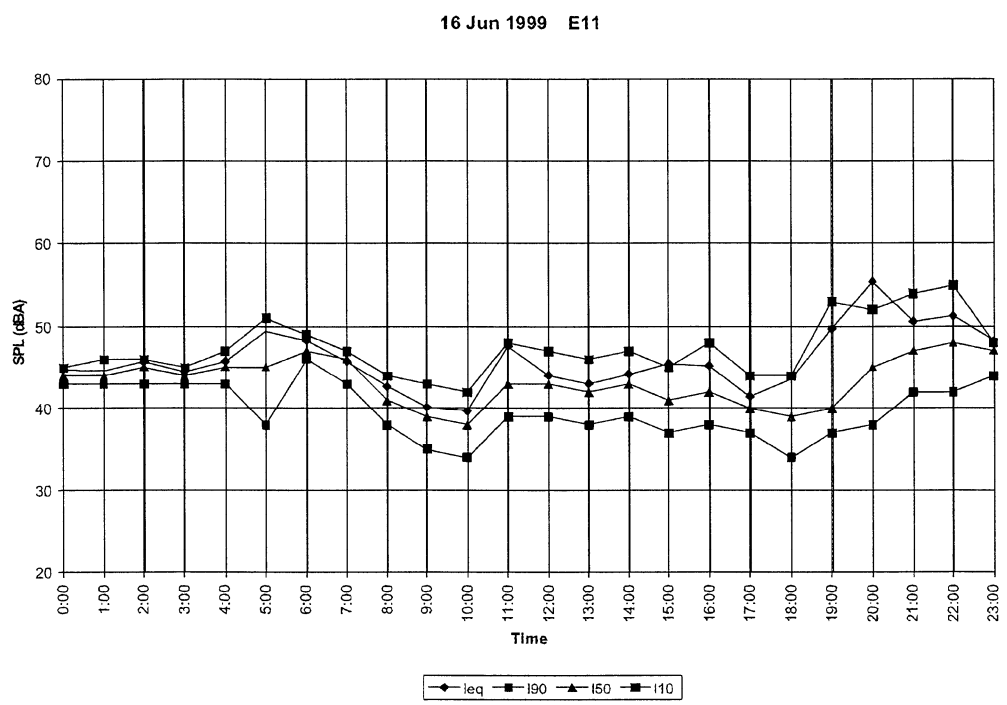
21:00
22:00
23:00
Time
leq
l90
l50
l10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SPL (dBA)
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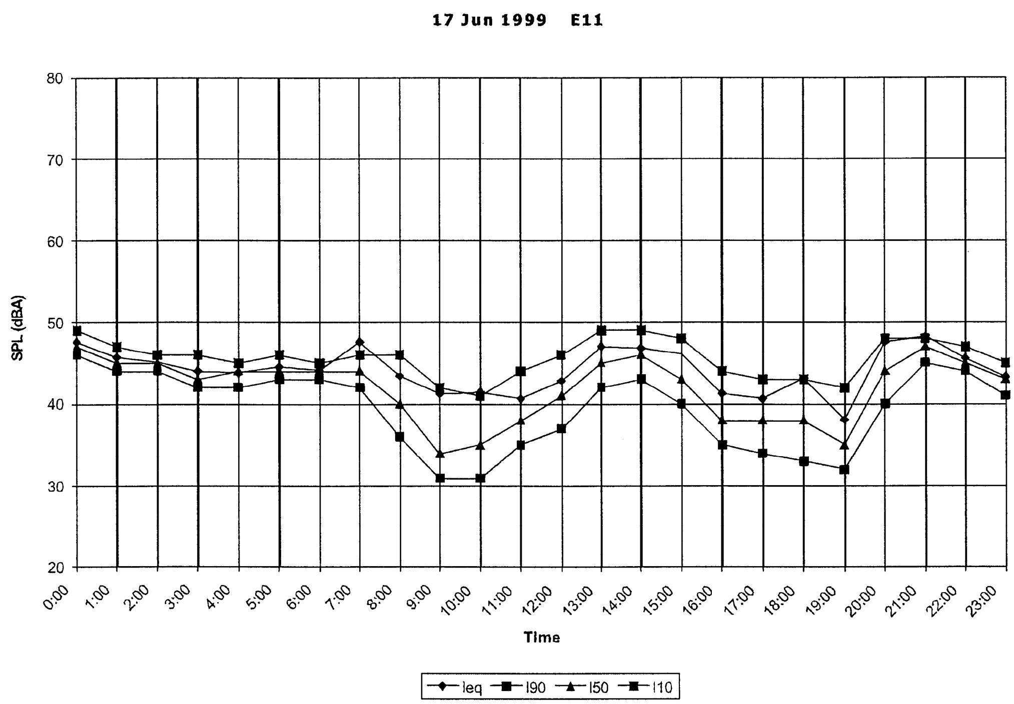
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10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SPL (dBA)
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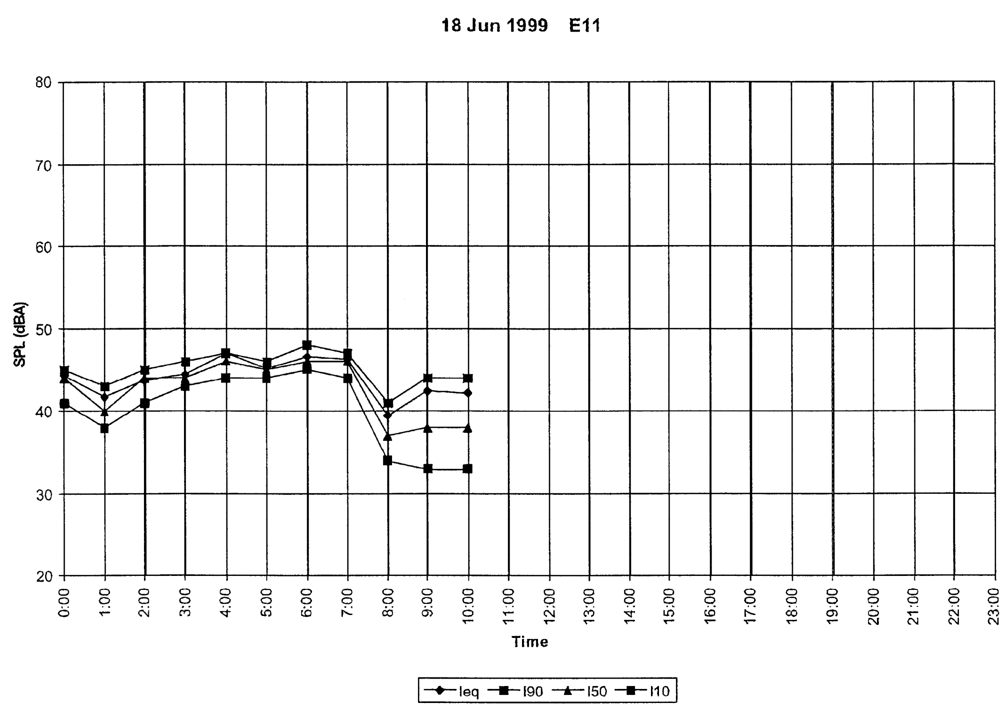
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time
leq l90 l50 l10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SPL (dBA)
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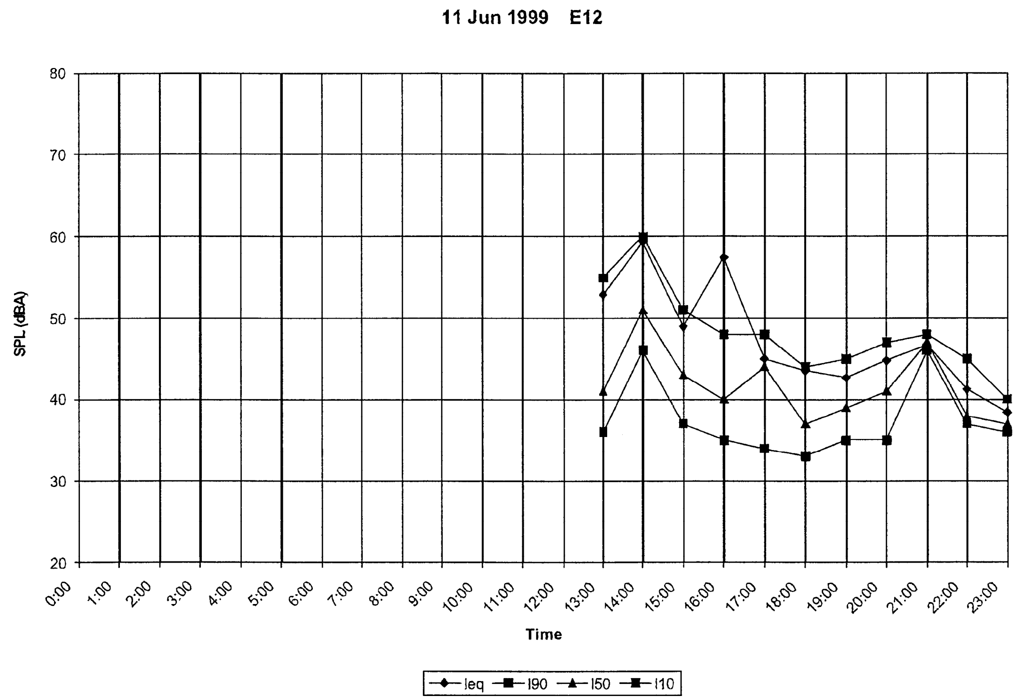
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time
leq l90 l50 l10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SPL (dBA)
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23:00
Time
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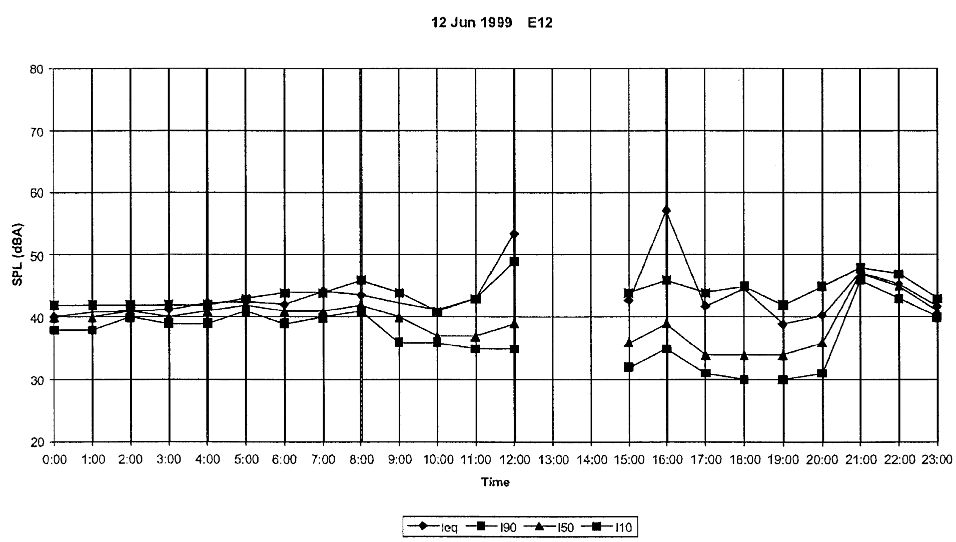
l10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SPL (dBA)
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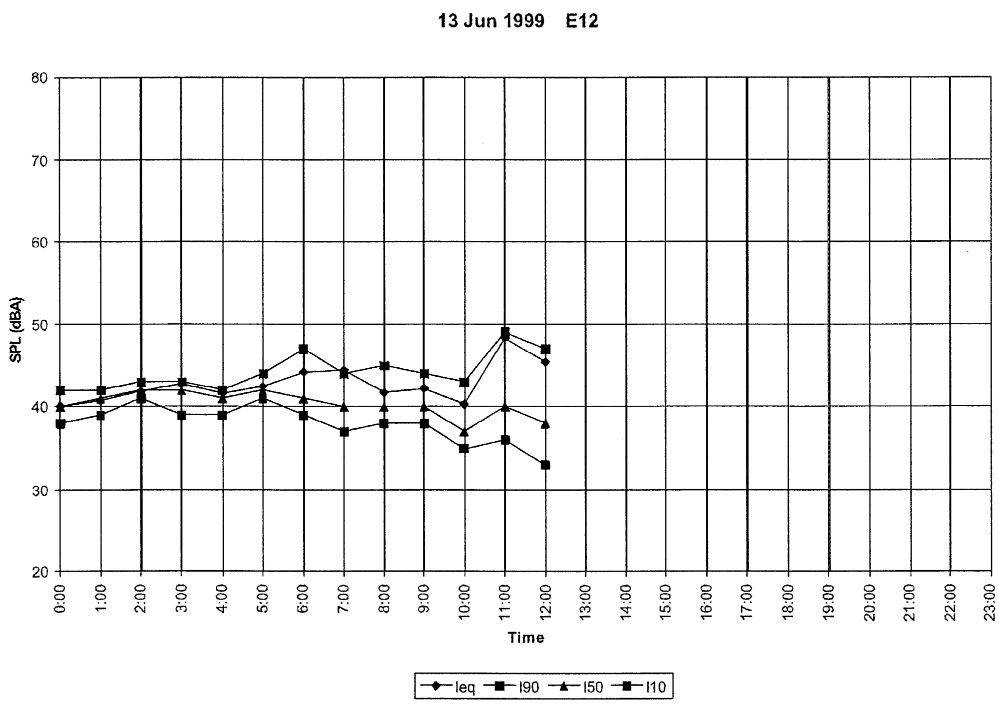
21:00
22:00
23:00
Time
leq
l90
l50
l10


13 Jun 1999 E12
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SPL (dBA)
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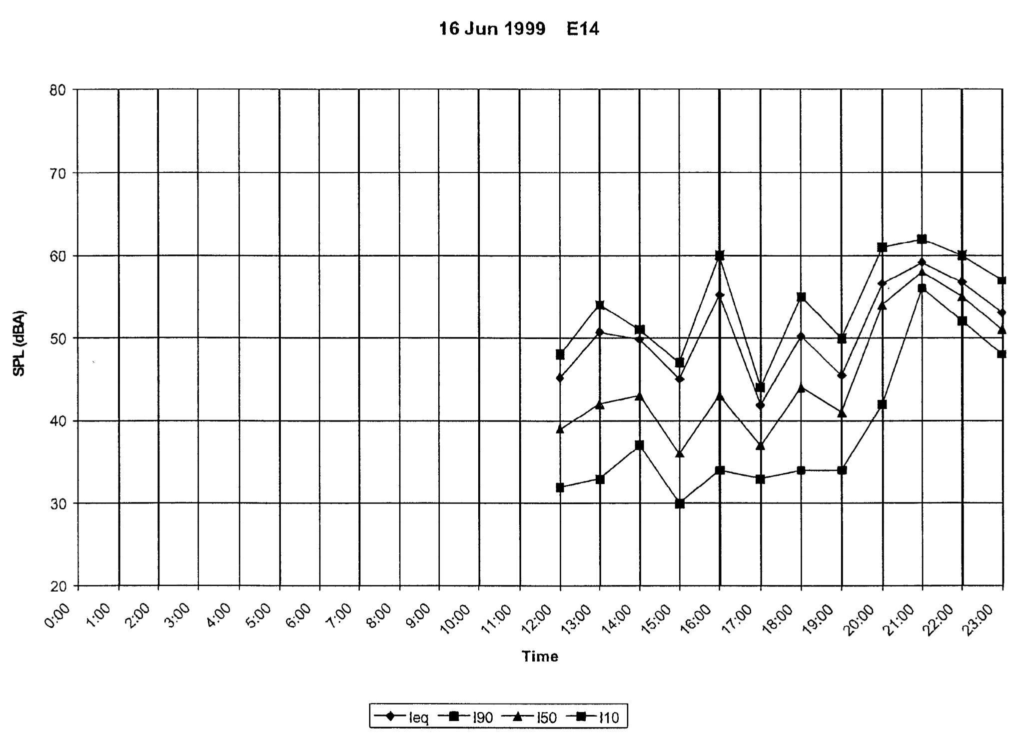
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10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SPL (dBA)
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23:00
Time
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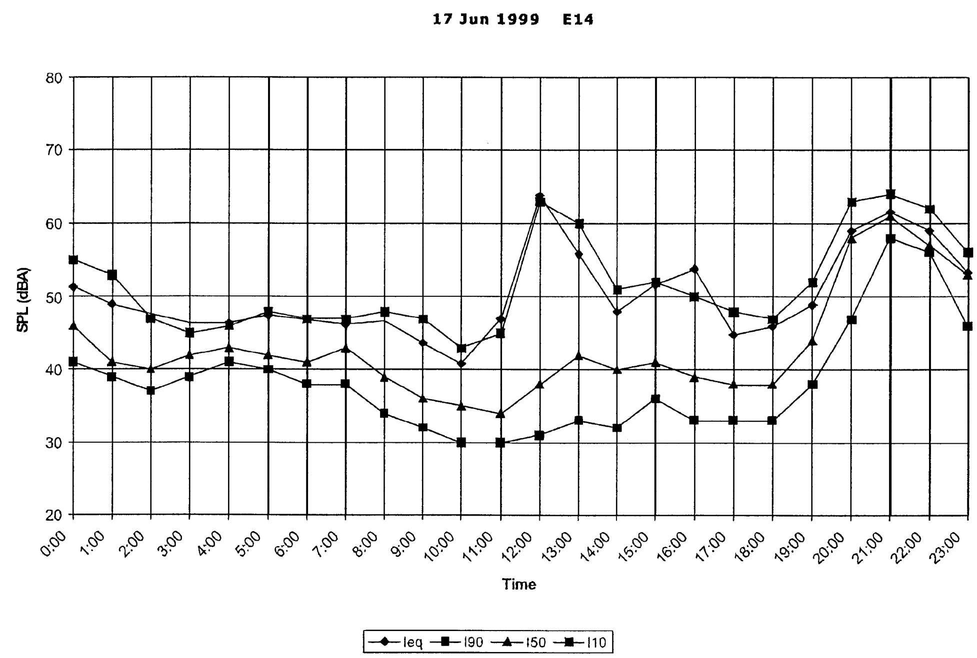
l10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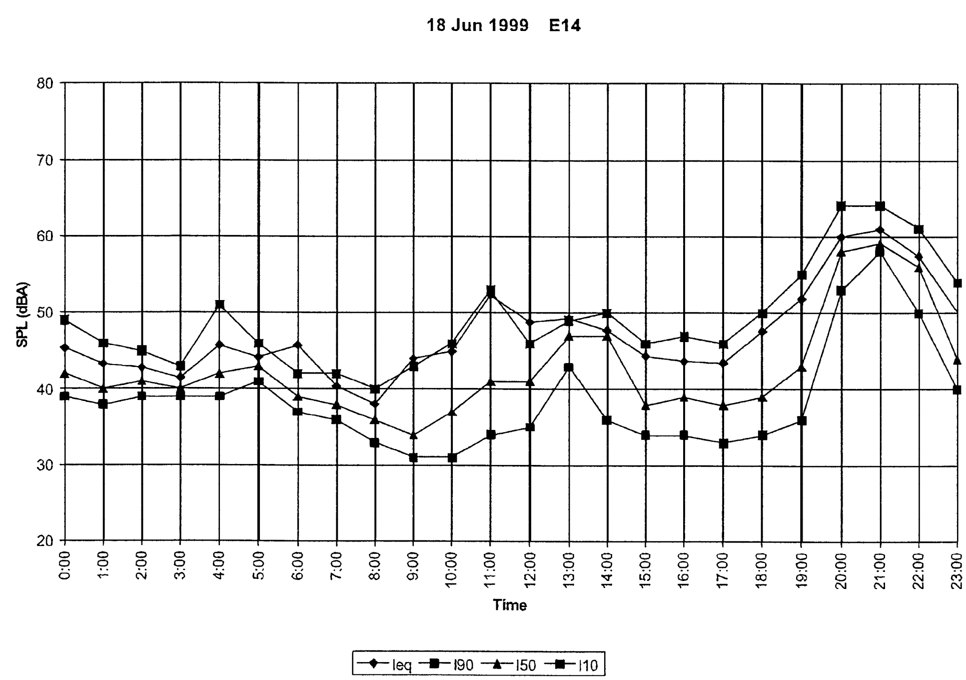
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time
leq l90 l50 l10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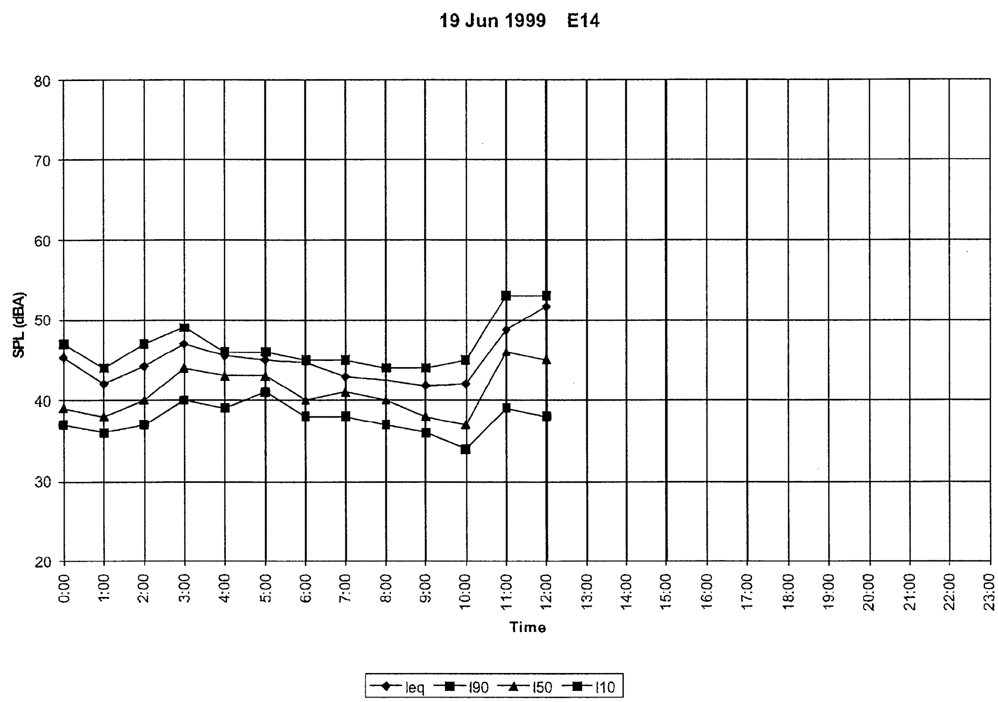
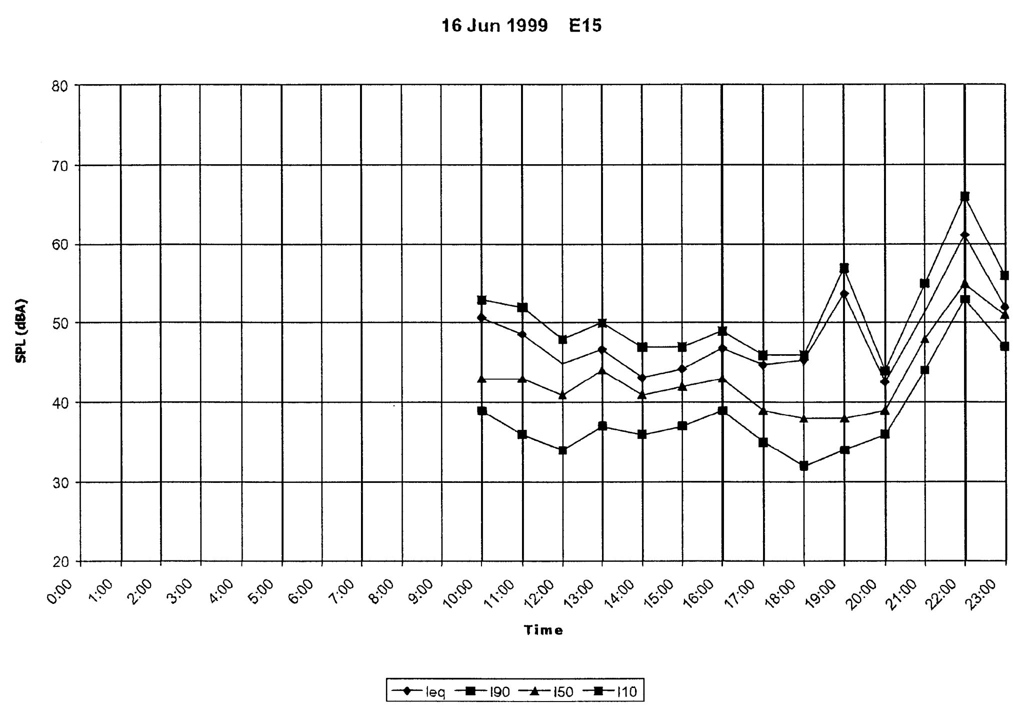
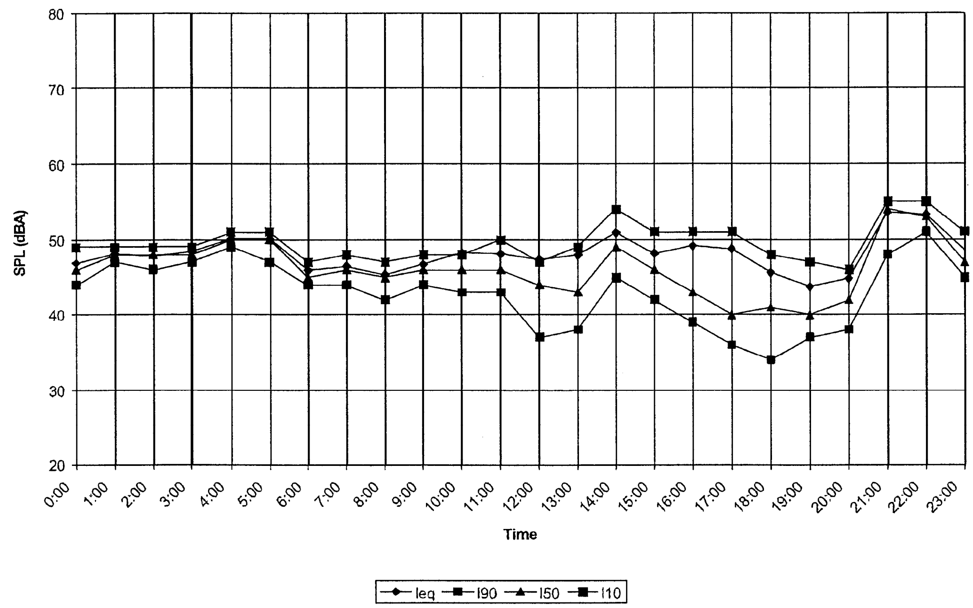
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time
leq l90 l50 l10

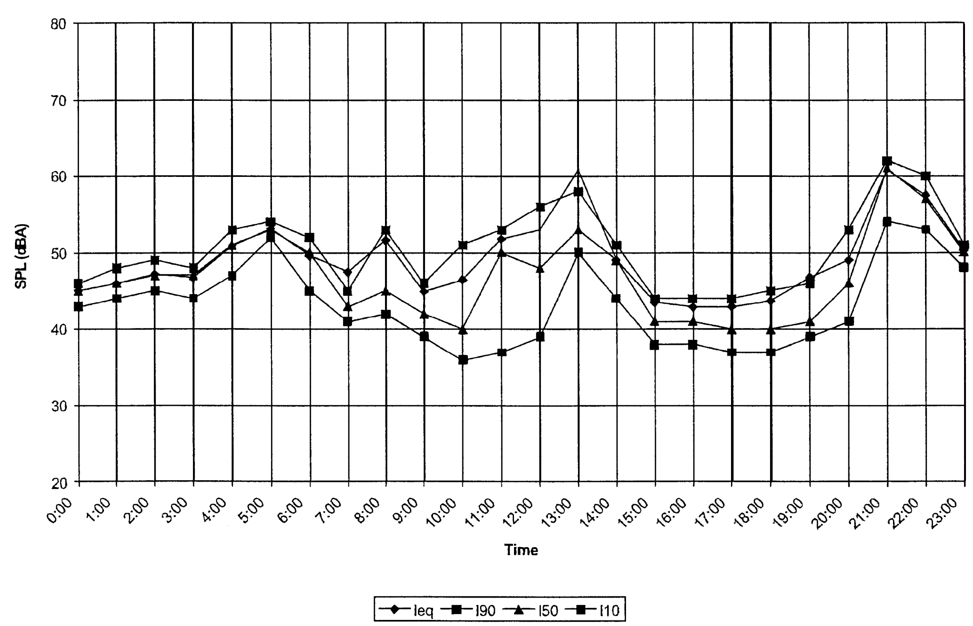

19 Jun 1999 E14
SPL (dBA)
80
70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10

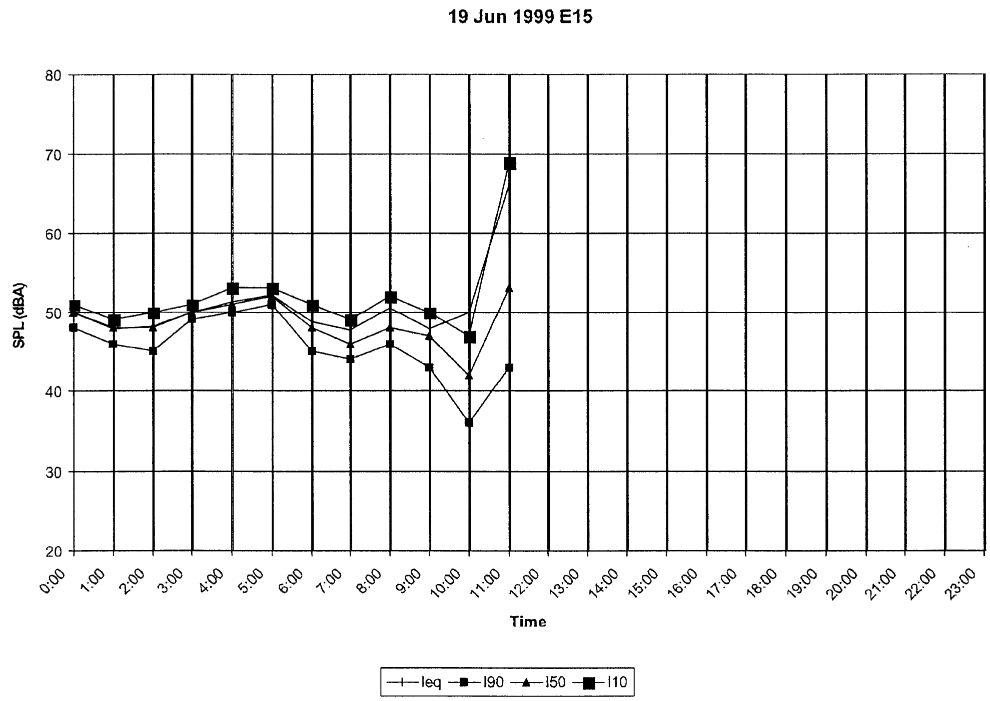

16 Jun 1999 E15
SPL (dBA)
80
70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10

17 Jun 1999 E15

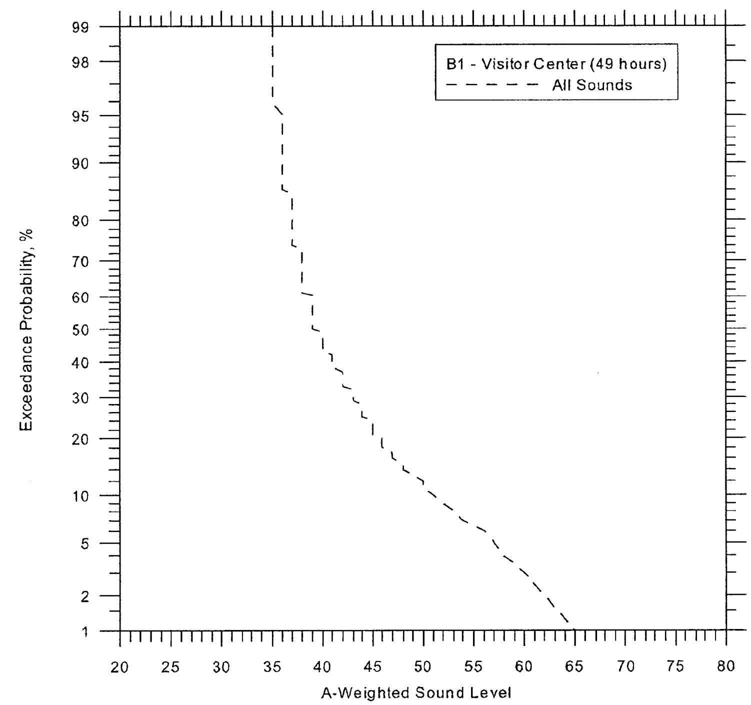


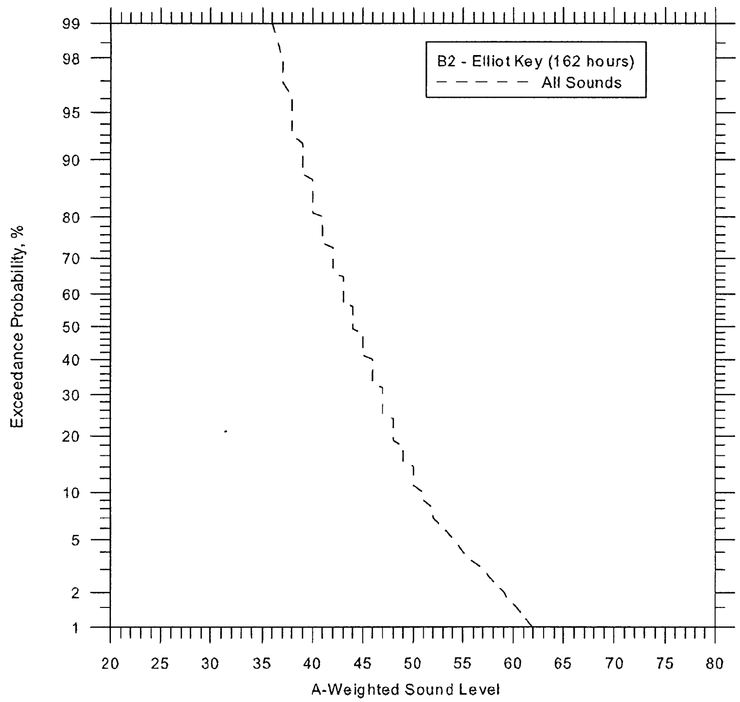
18 Jun 1999 E15

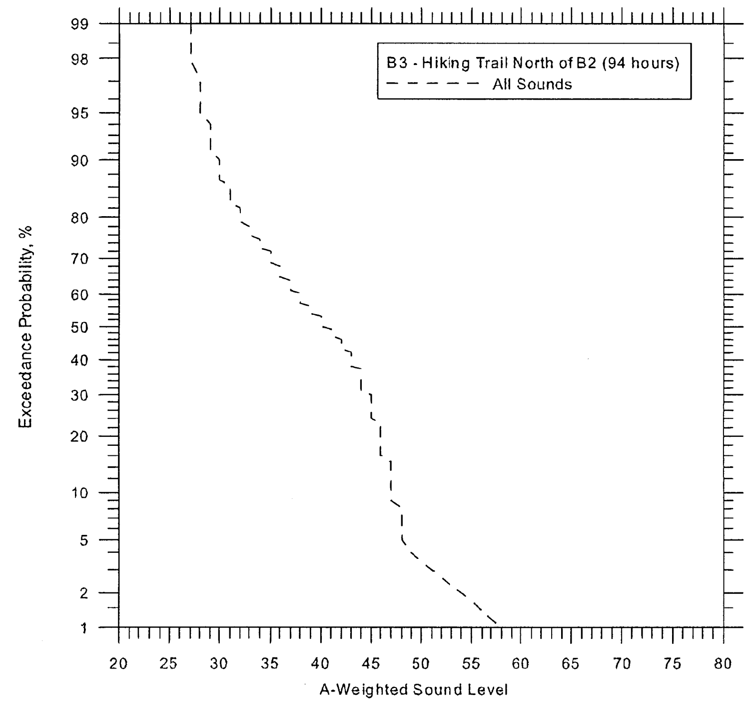


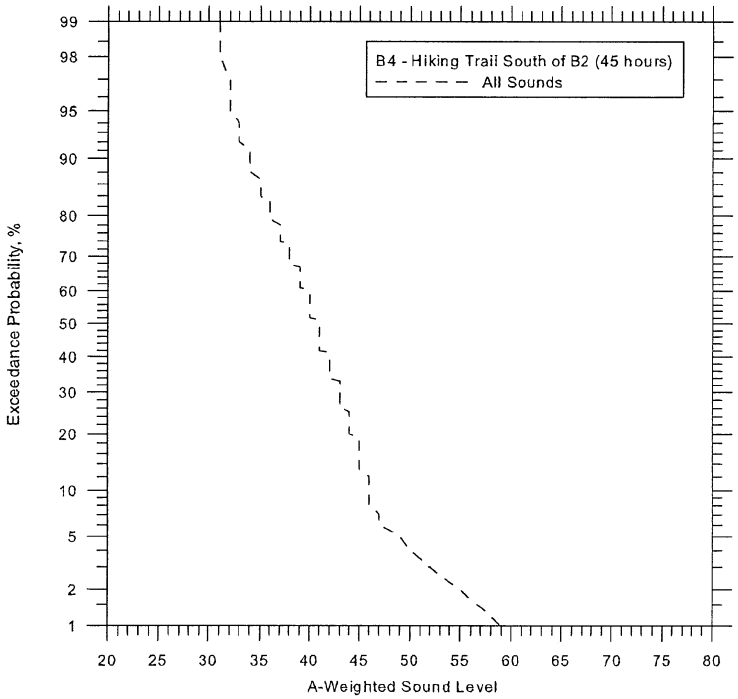

19 Jun 1999 E15
80
70
60
50
40
30
20
SPL (dBA)
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time
leq
l90
l50
l10

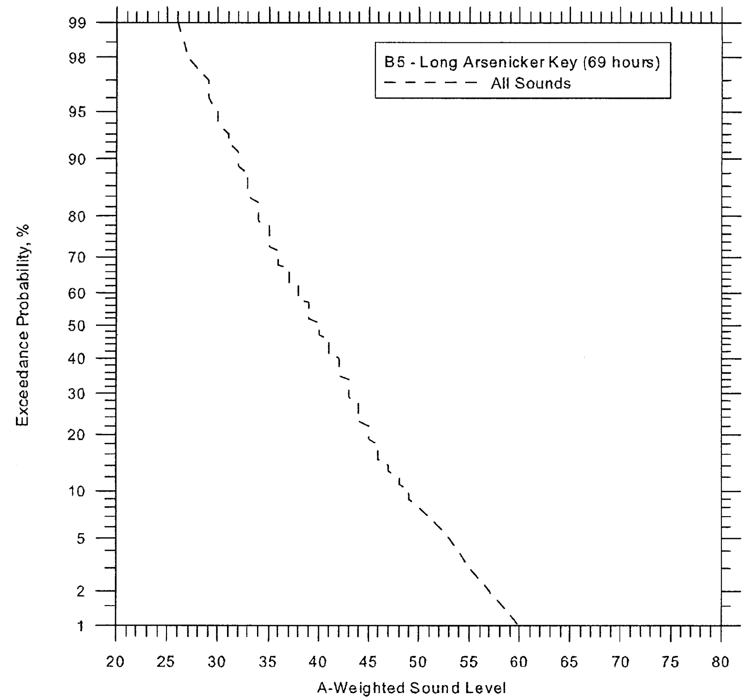
Appendix G
Exceedance Plots for Unmanned Measurements

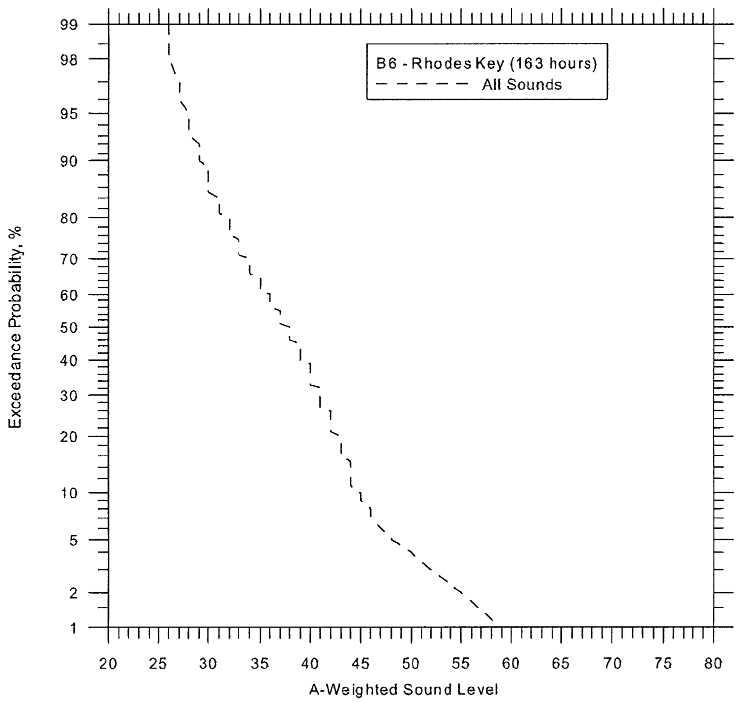


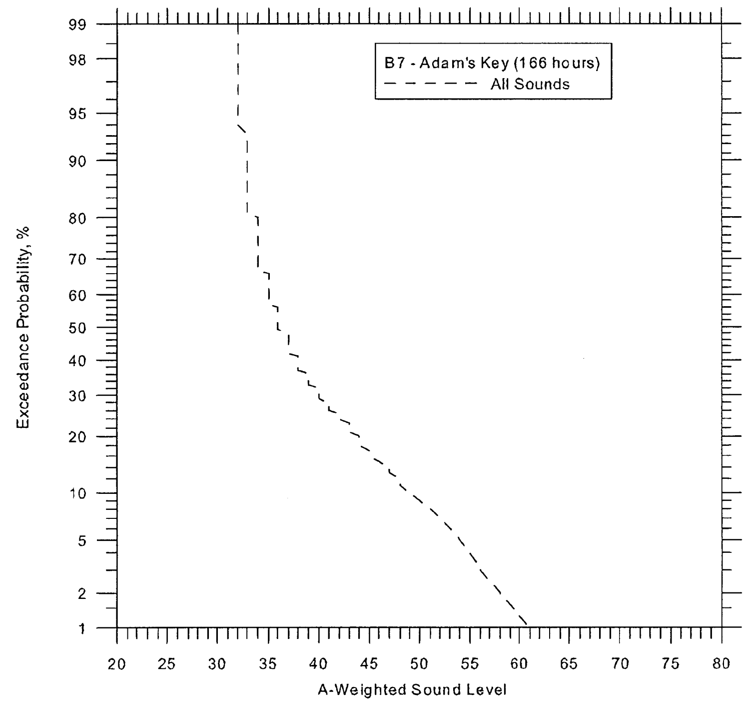

B2 - Elliot Key (162 hours)
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80

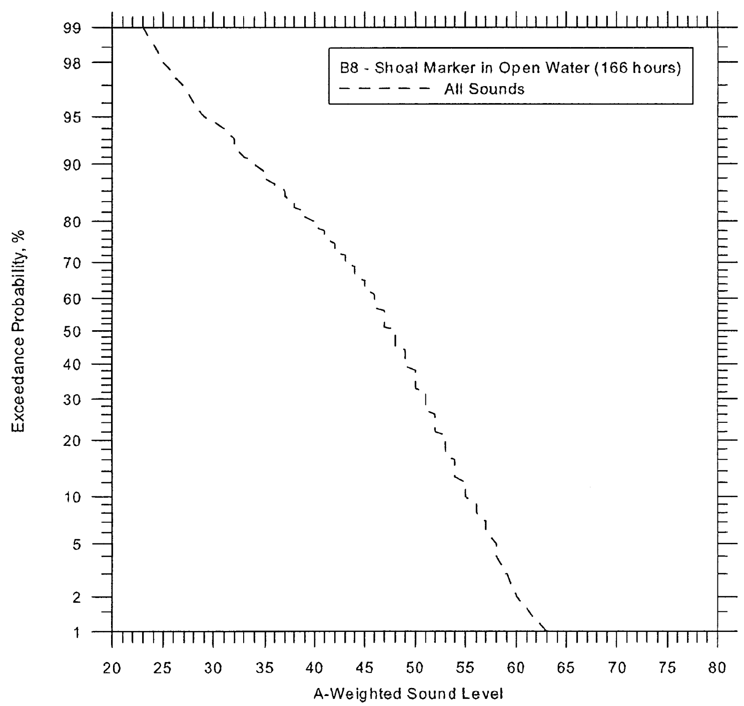

B3 - Hiking Trail North of B2 (94 hours)
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80

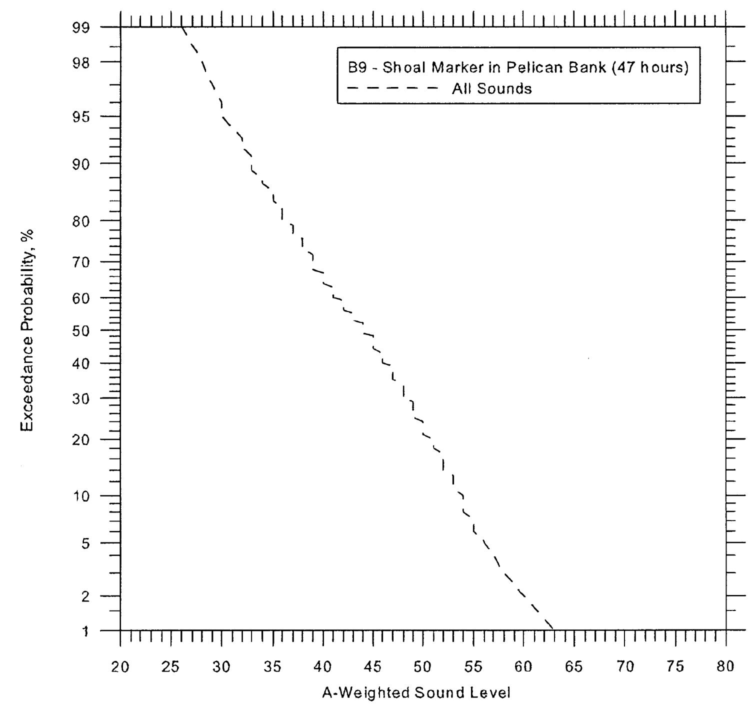

B4 - Hiking Trail South of B2 (45 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level

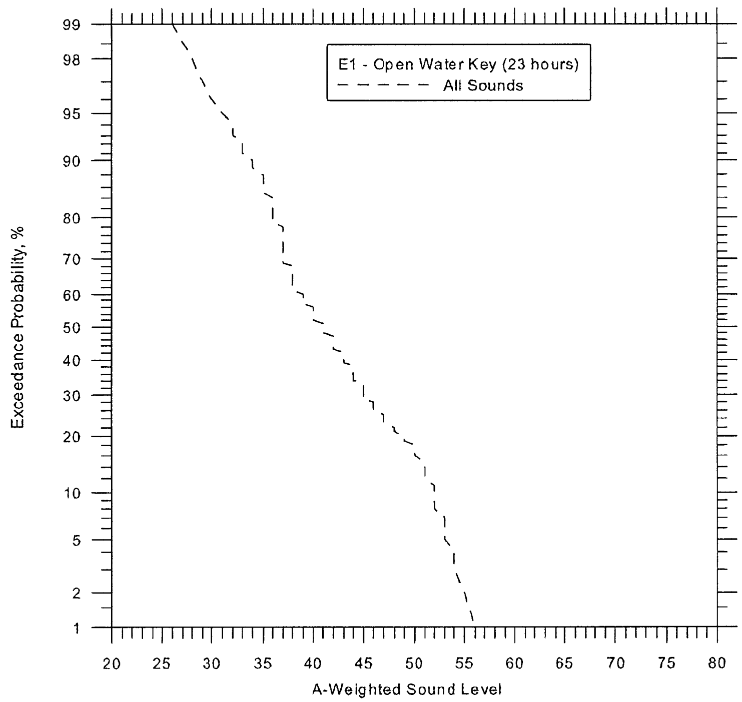

B5 - Long Arsenicker Key (69 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level

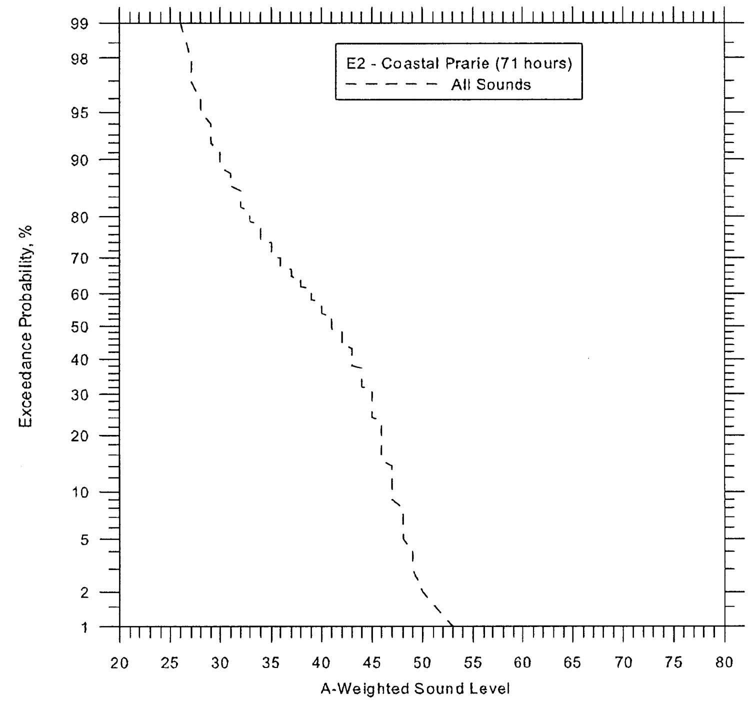

B6 - Rhodes Key (163 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level

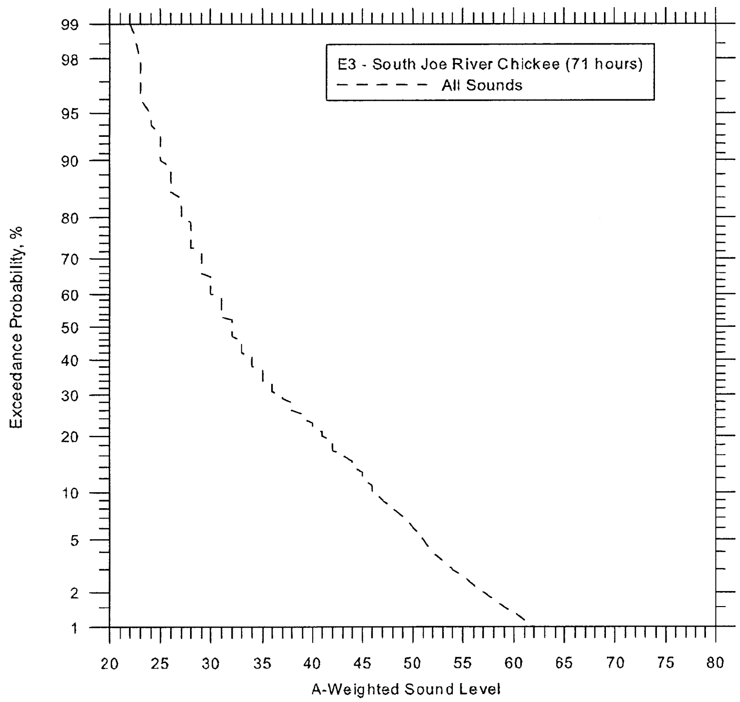

B7 - Adam's Key (166 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level

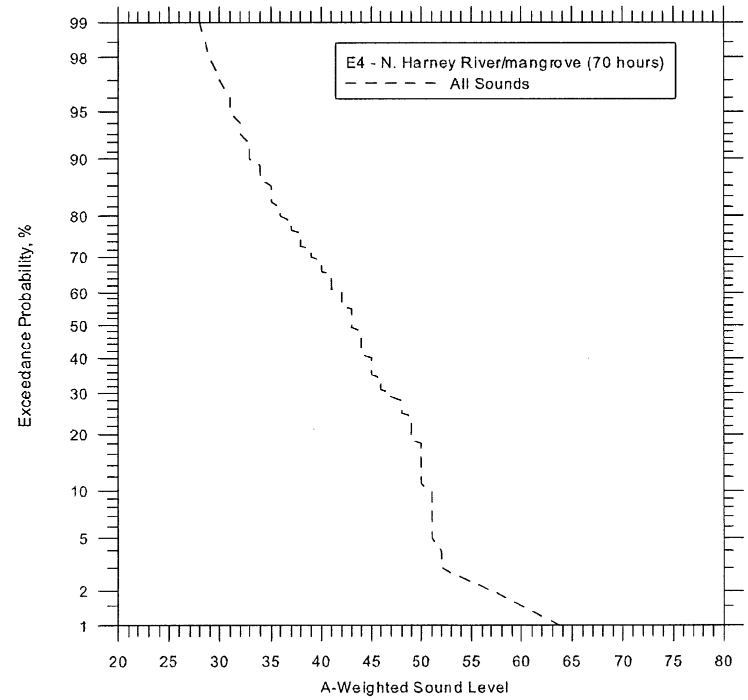

B8 - Shoal Marker in Open Water (166 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level

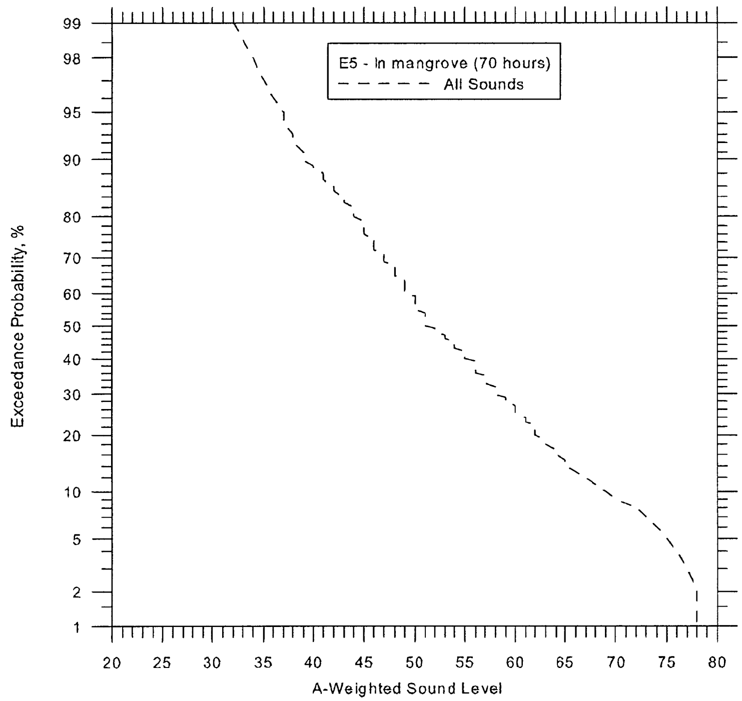

B9 - Shoal Marker in Pelican Bank (47 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level

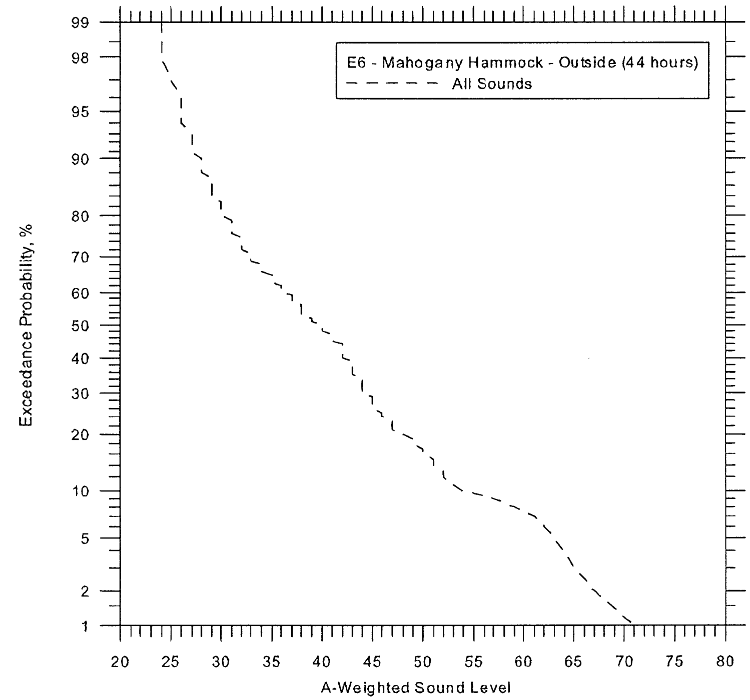

E1 - Open Water Key (23 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level

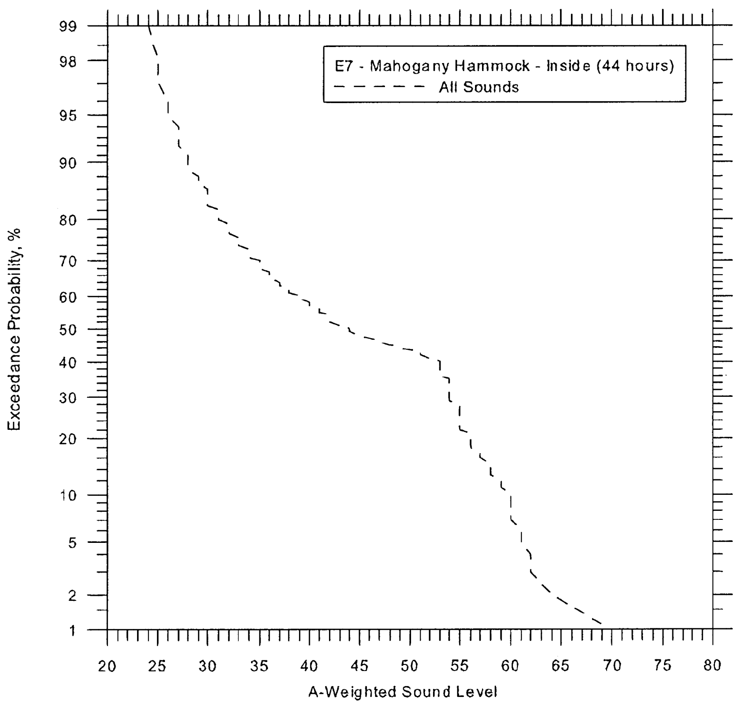

E2 - Coastal Prarie (71 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level

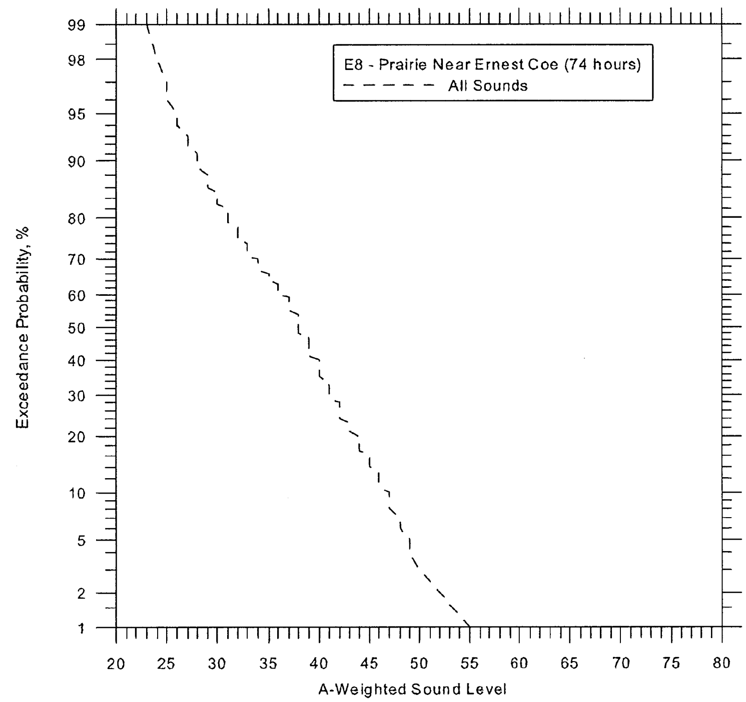

E3 - South Joe River Chickee (71 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level

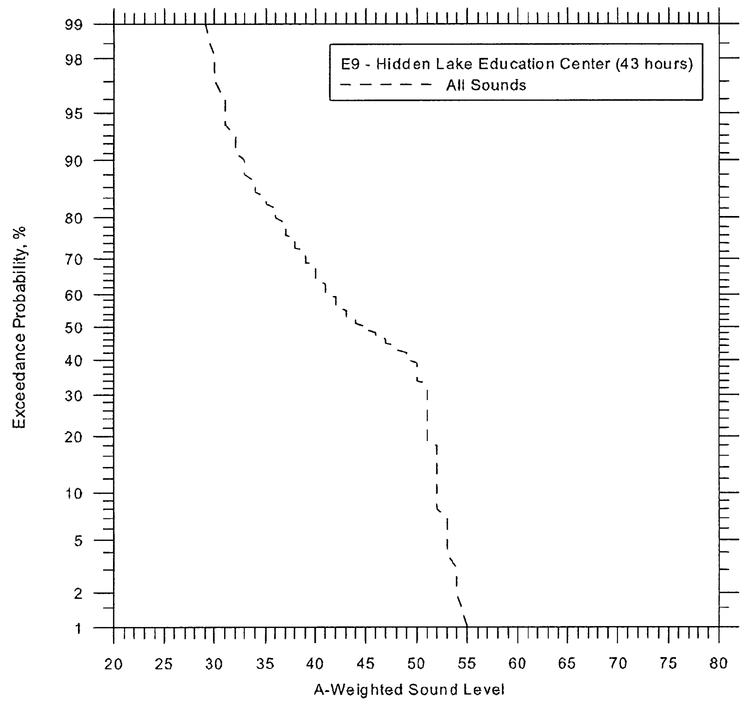

E4 - N. Harney River/mangrove (70 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level

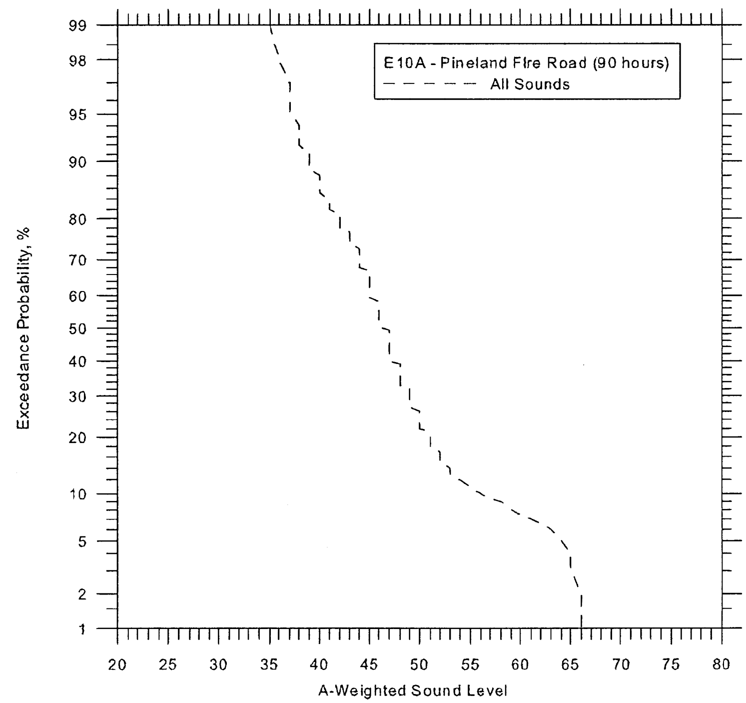

E5 - In mangrove (70 hours)
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80

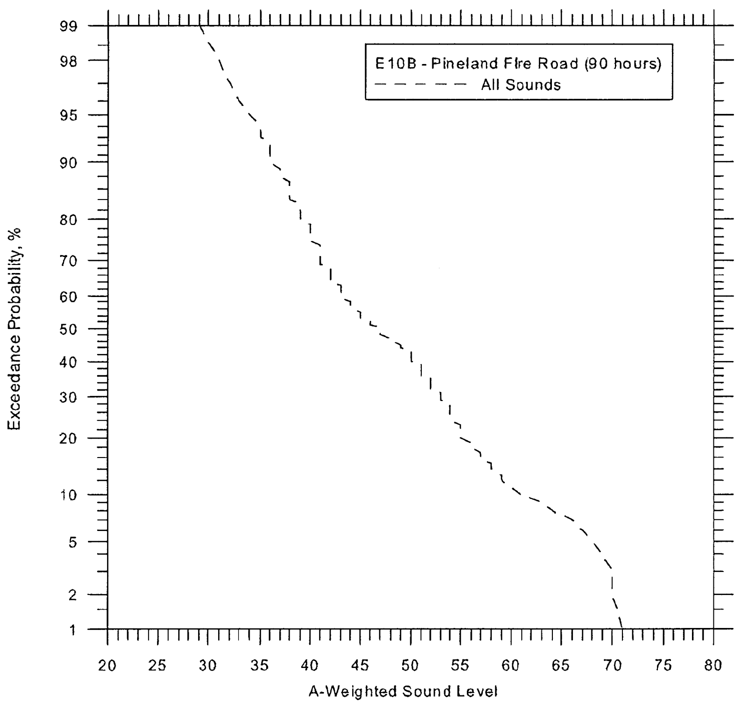

E6 - Mahogany Hammock - Outside (44 hours)
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80

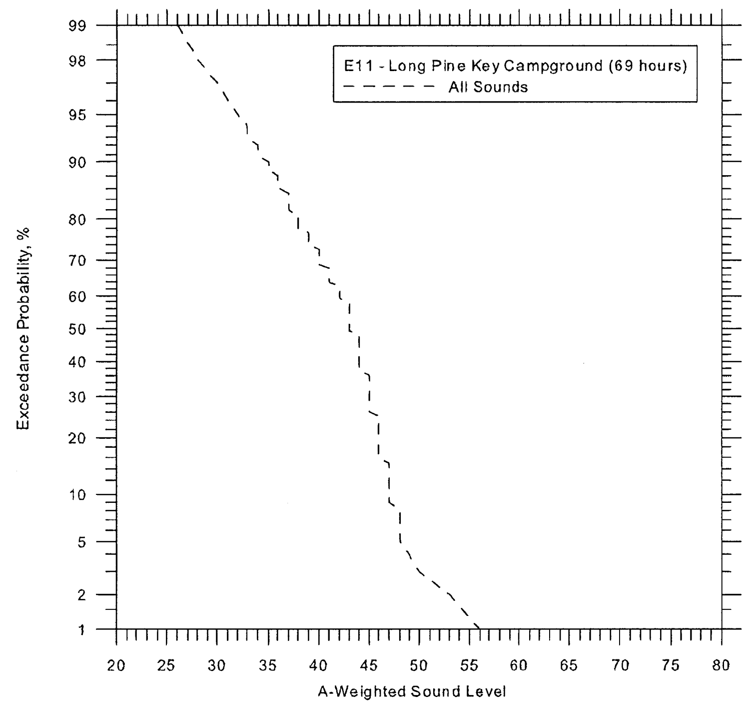

E7 - Mahogany Hammock - Inside (44 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level

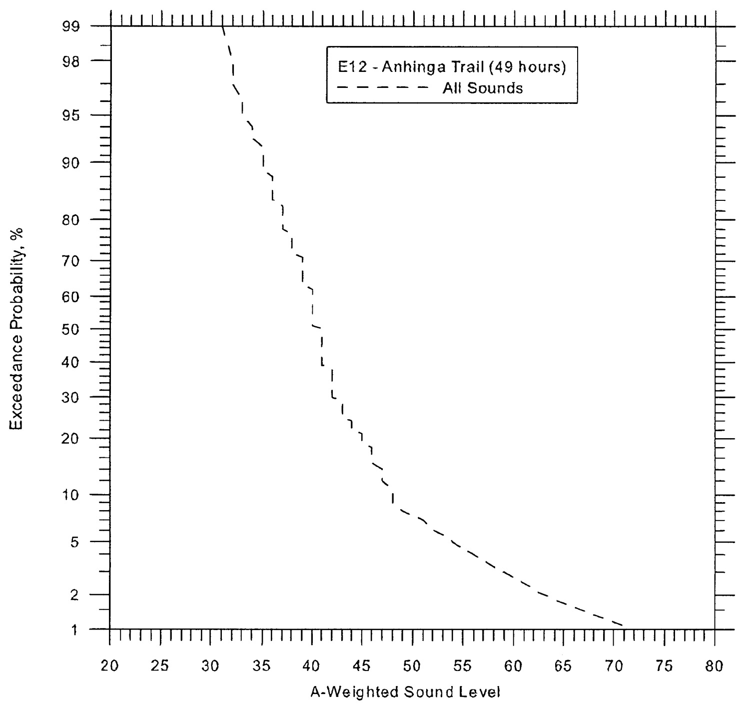

E8 - Prairie Near Ernest Coe (74 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80
A-Weighted Sound Level

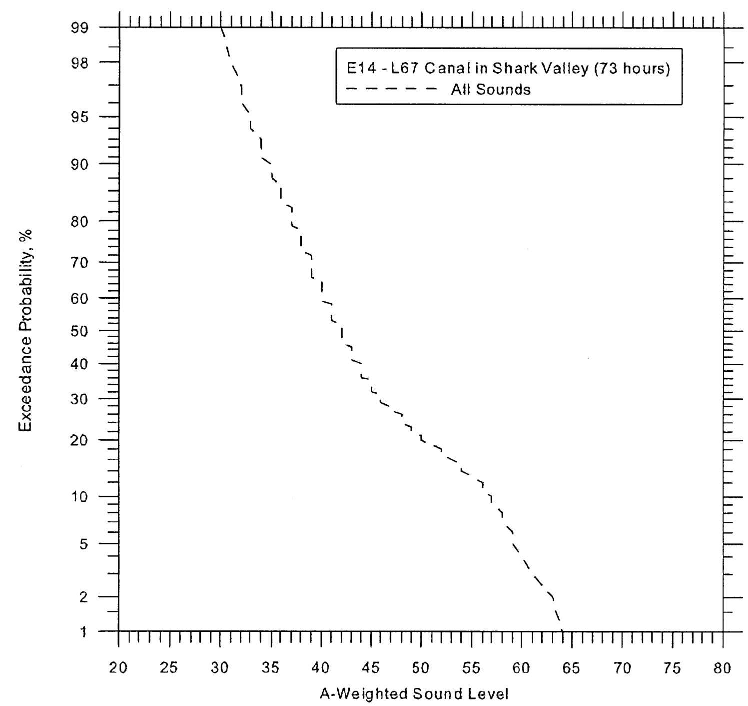

E9 - Hidden Lake Education Center (43 hours)
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80

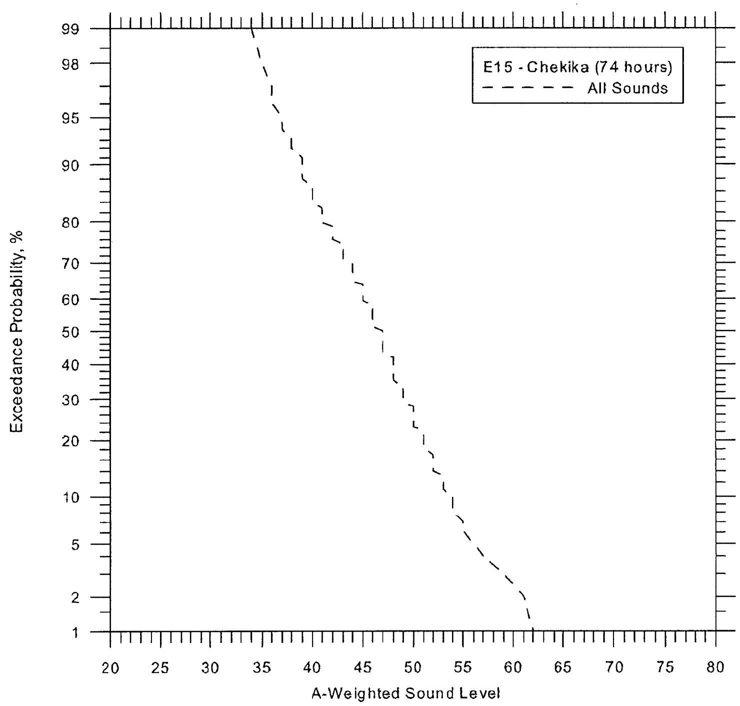

E10A - Pineland Fire Road (90 hours)
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80

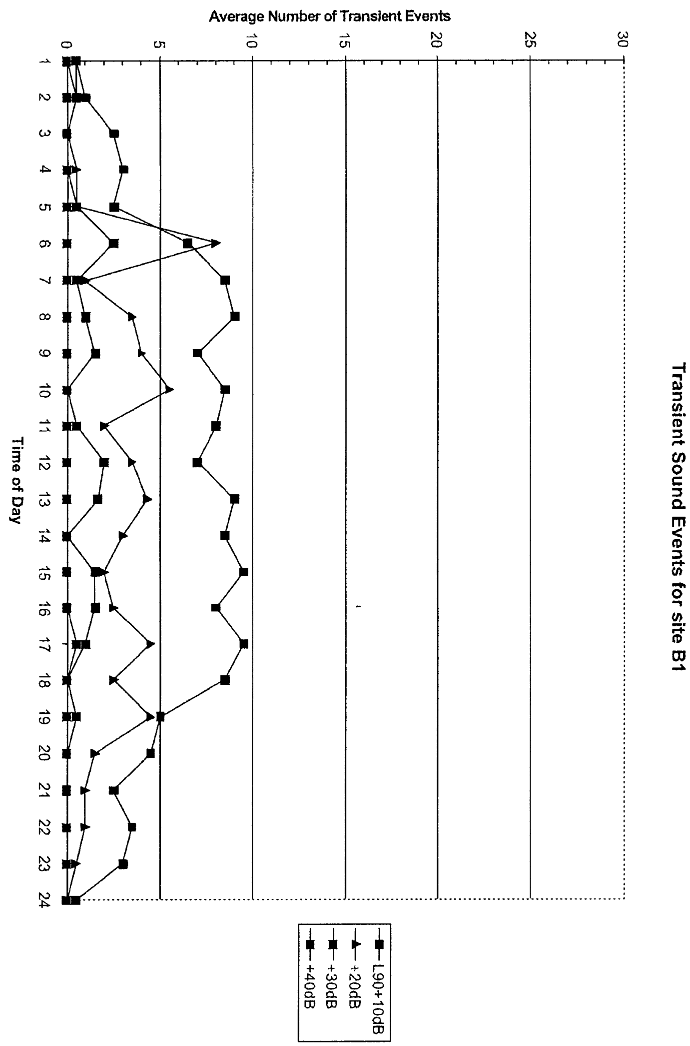

E10B - Pineland Fire Road (90 hours)
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80


E11 - Long Pine Key Campground (69 hours)
All Sounds
Exceedance Probability, %
A-Weighted Sound Level
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20
25
30
35
40
45
50
55
60
65
70
75
80


E12 - Anhinga Trail (49 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level

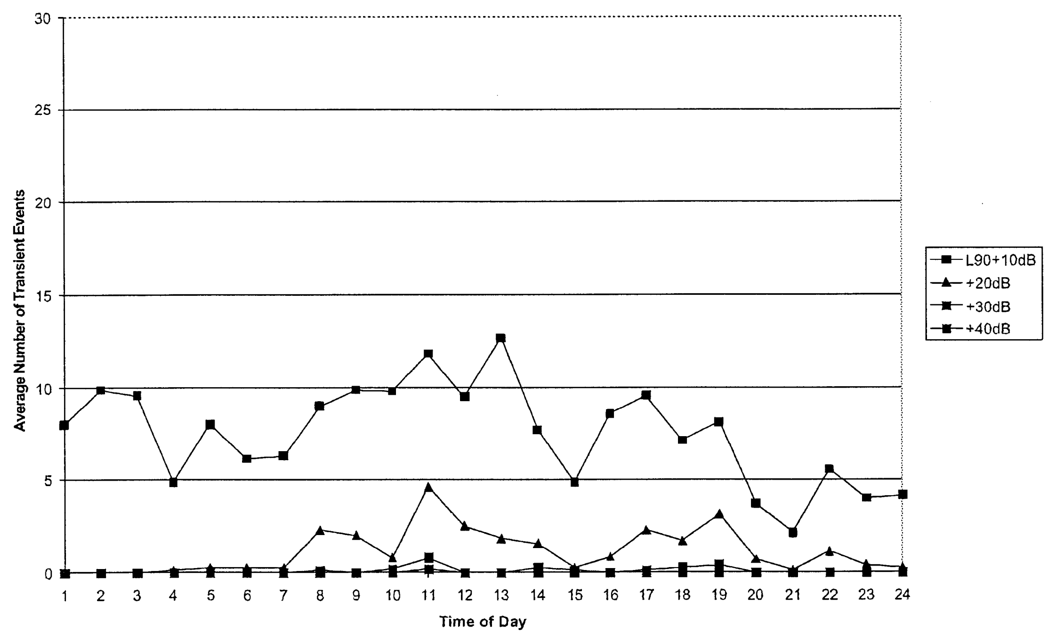

E14 - L67 Canal in Shark Valley (73 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level


E15 - Chekika (74 hours)
All Sounds
Exceedance Probability, %
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
20 25 30 35 40 45 50 55 60 65 70 75 80
A-Weighted Sound Level

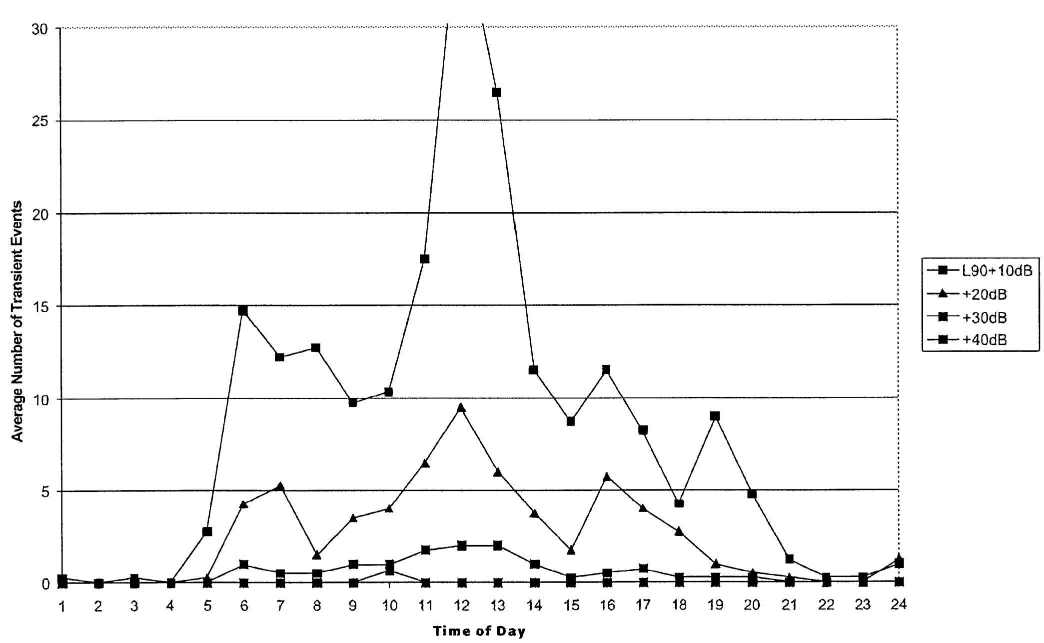


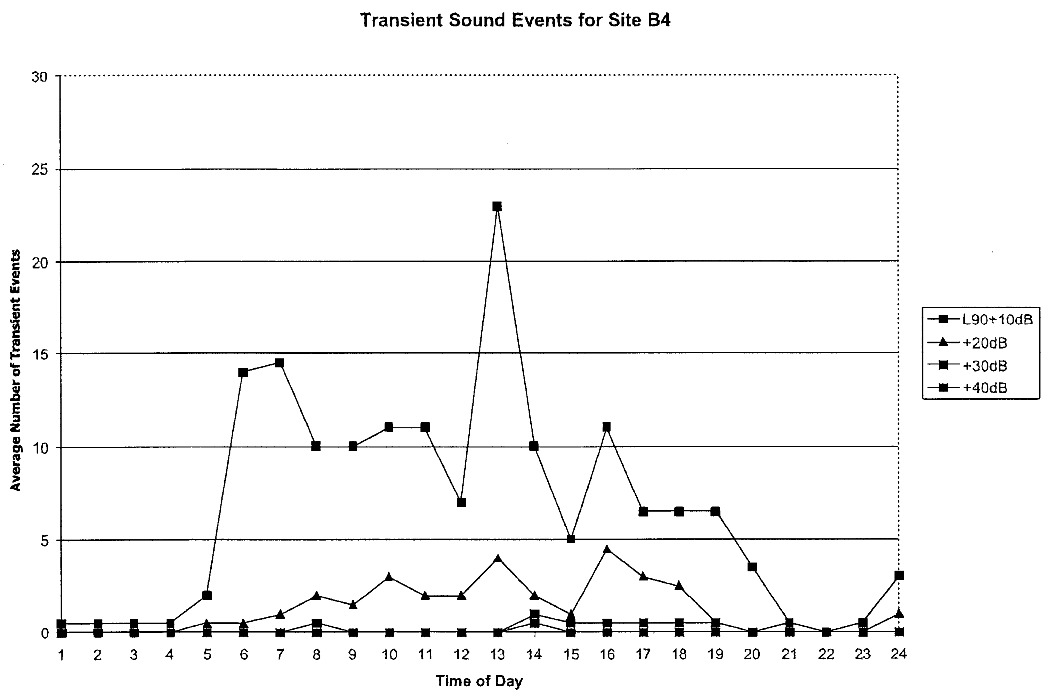
Appendix H
Transient Events Plots for Unmanned Measurements

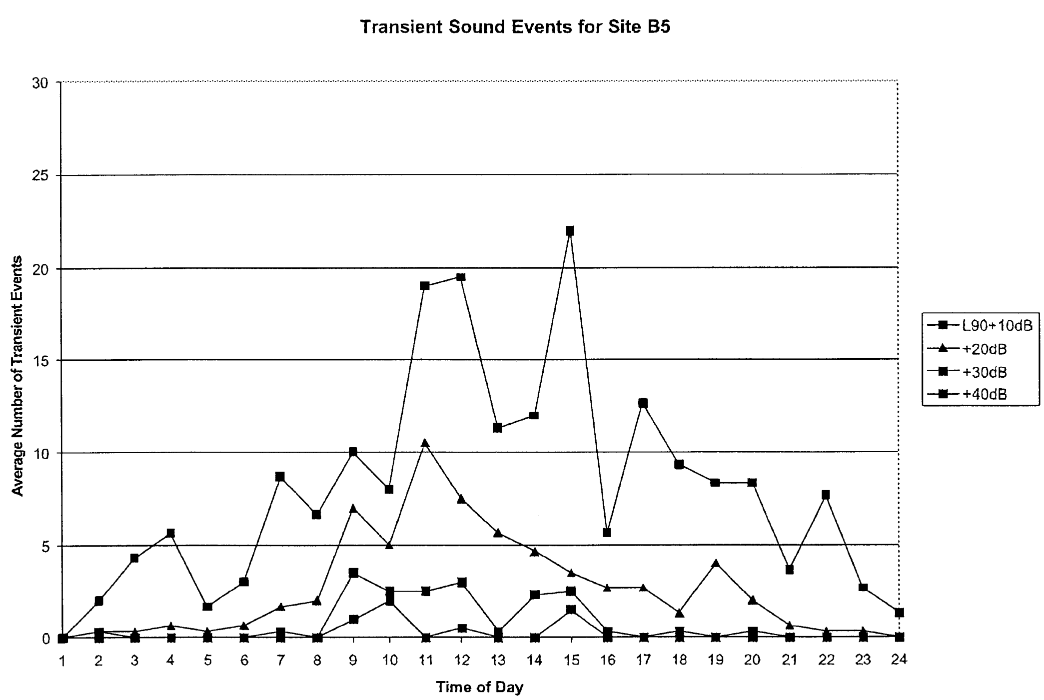
Transient Sound Events for site B2



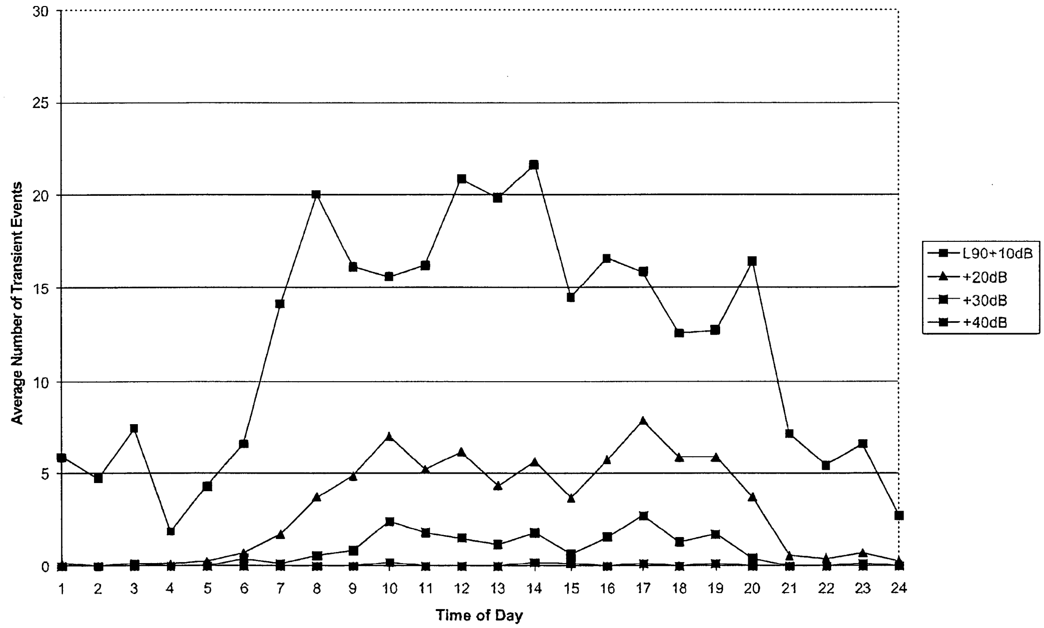
Transient Sound Events for Site B3



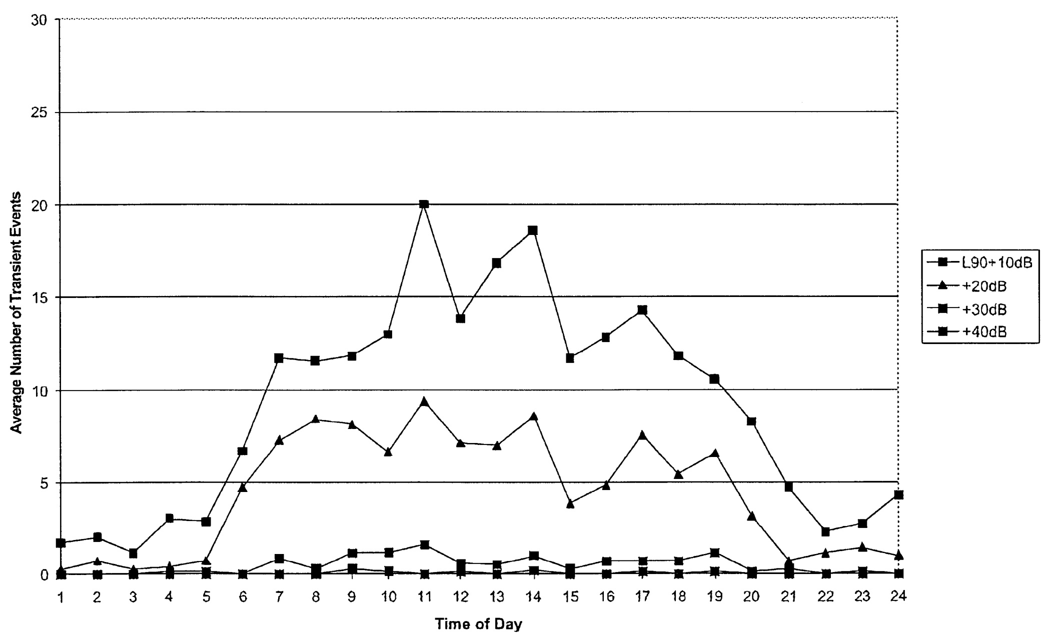

Transient Sound Events for Site B4
Average Number of Transient Events
Time of Day
L90+10dB
+20dB
+30dB
+40dB


Transient Sound Events for Site B5
Average Number of Transient Events
Time of Day
L90+10dB
+20dB
+30dB
+40dB

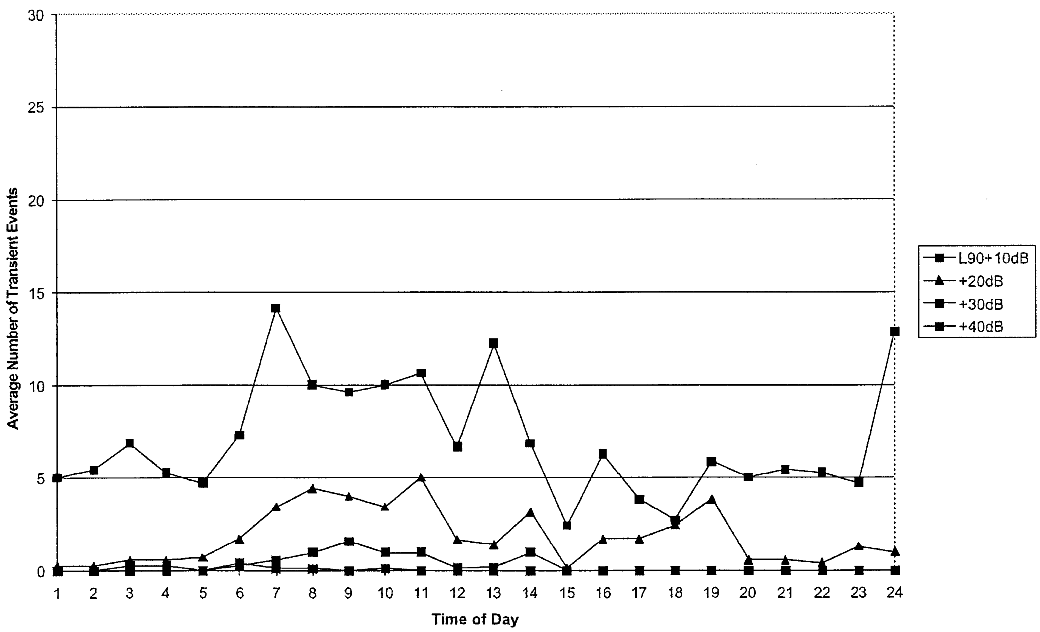
Transient Sound Events for Site B6



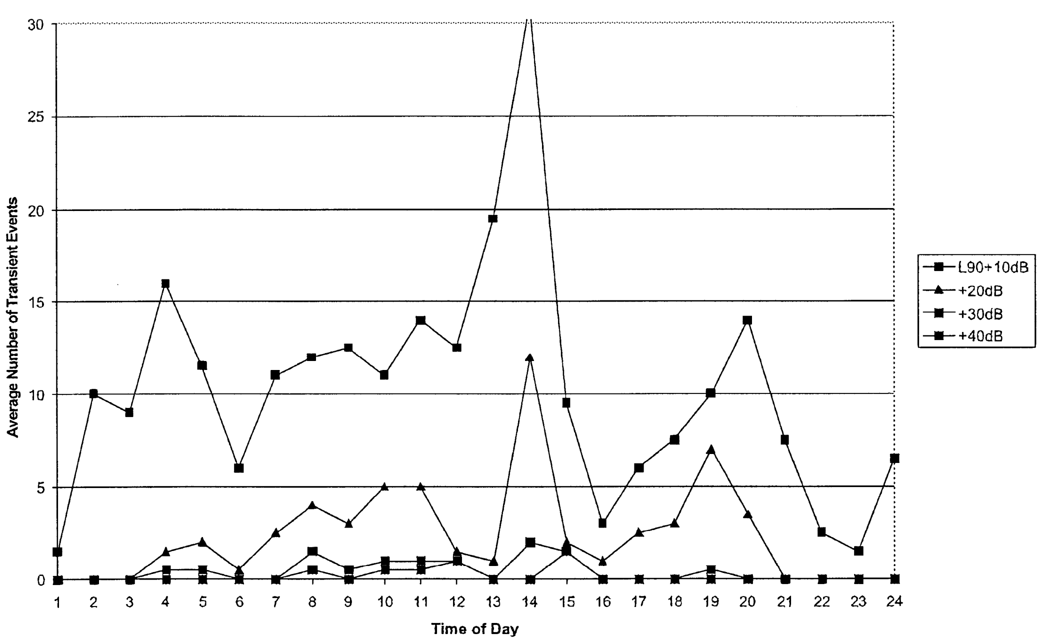
Transient Sound Events for Site B7

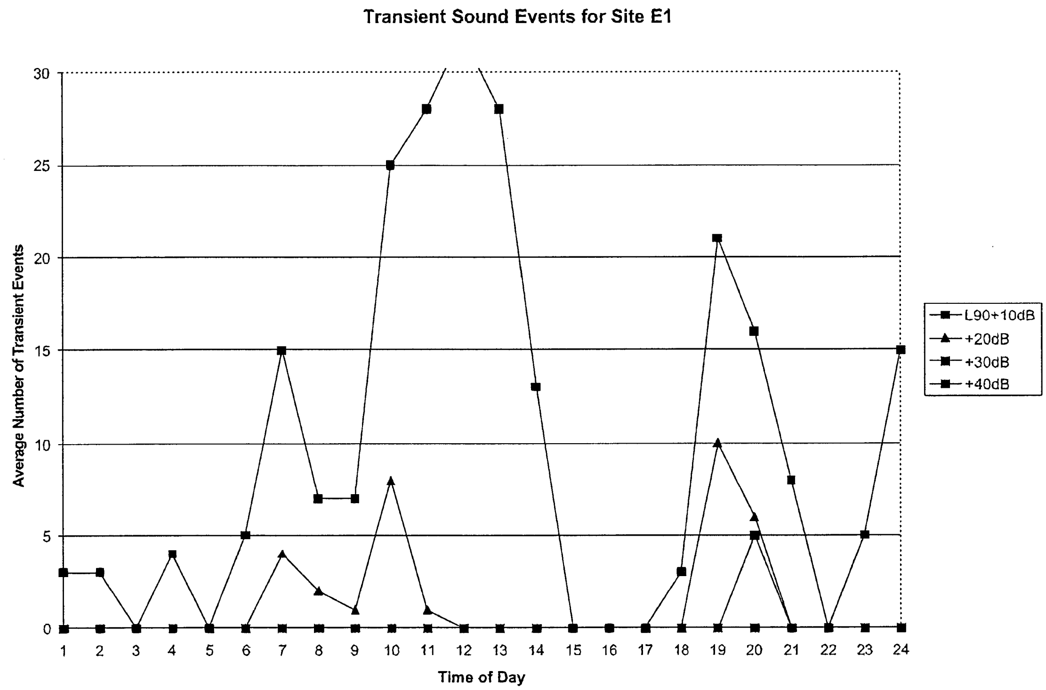


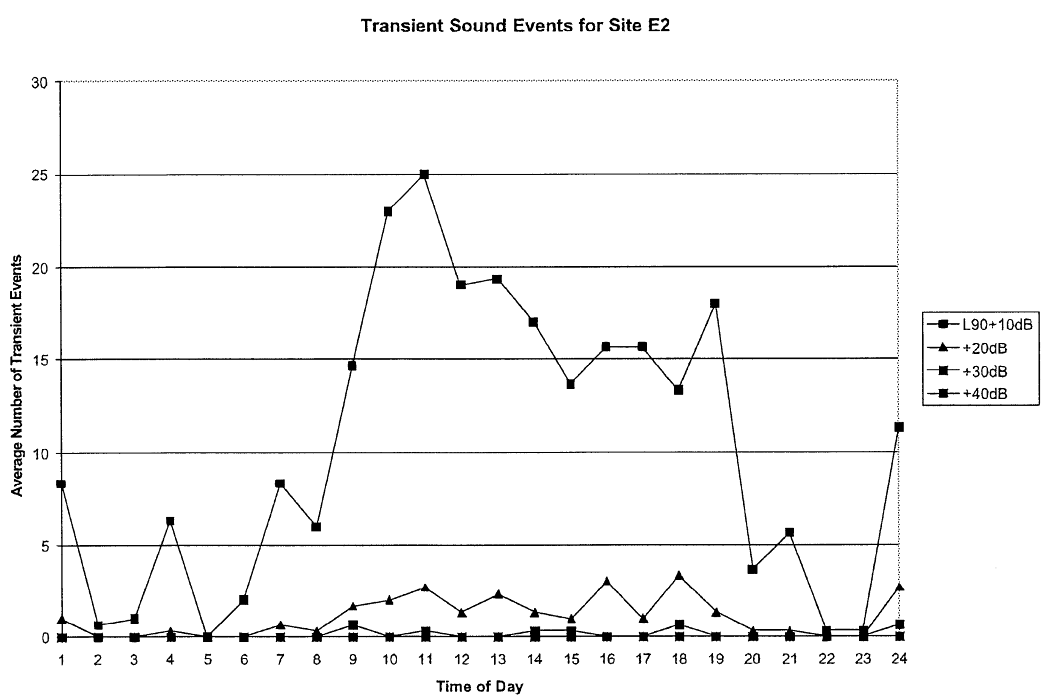
Transient Sound Events for Site B8

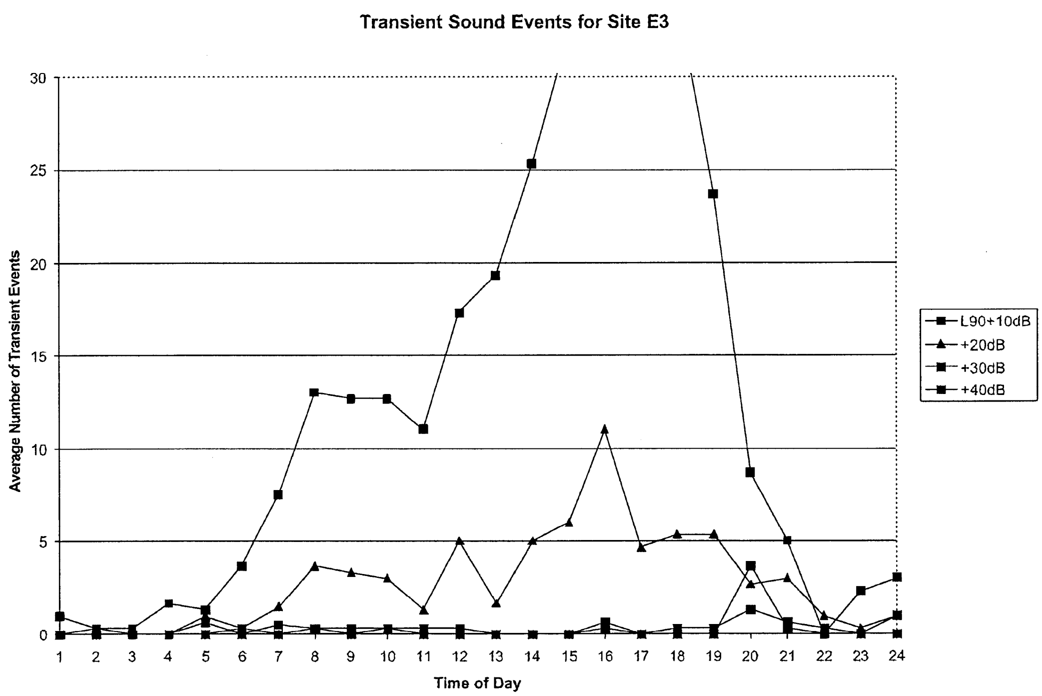


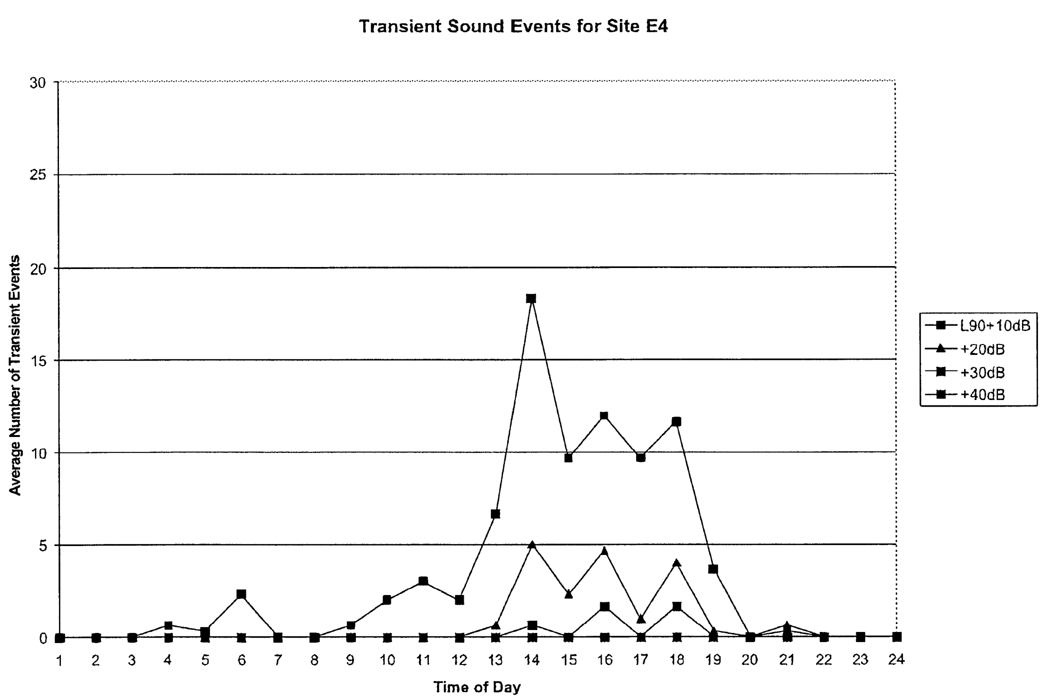
Transient Sound Events for Site B9

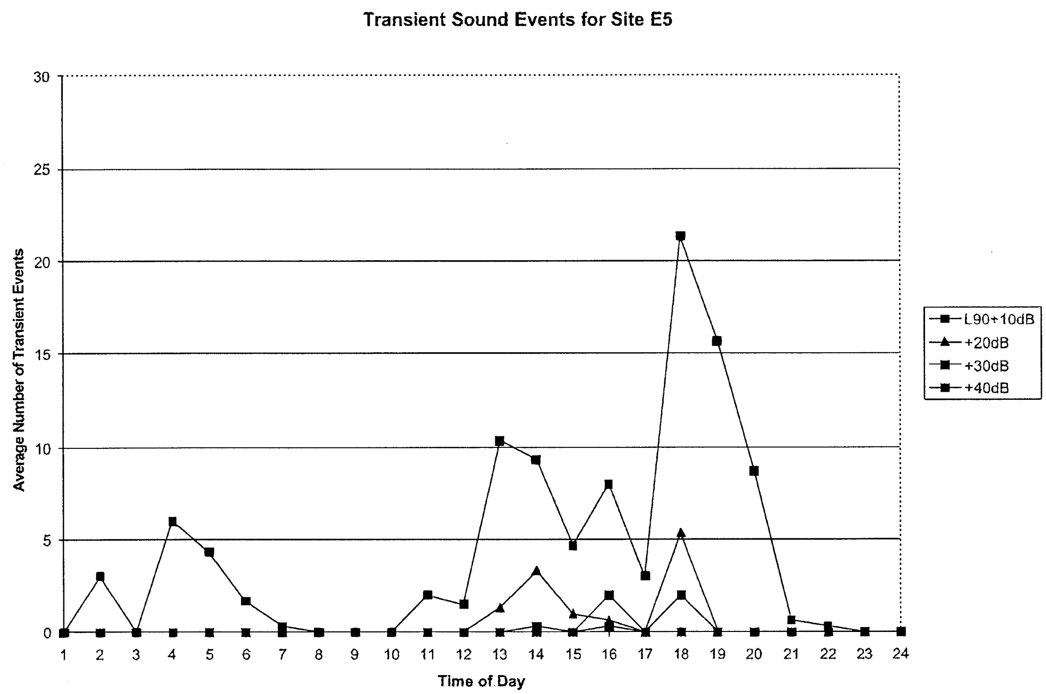



Transient Sound Events for Site E1
Average Number of Transient Events
Time of Day
L90+10dB
+20dB
+30dB
+40dB

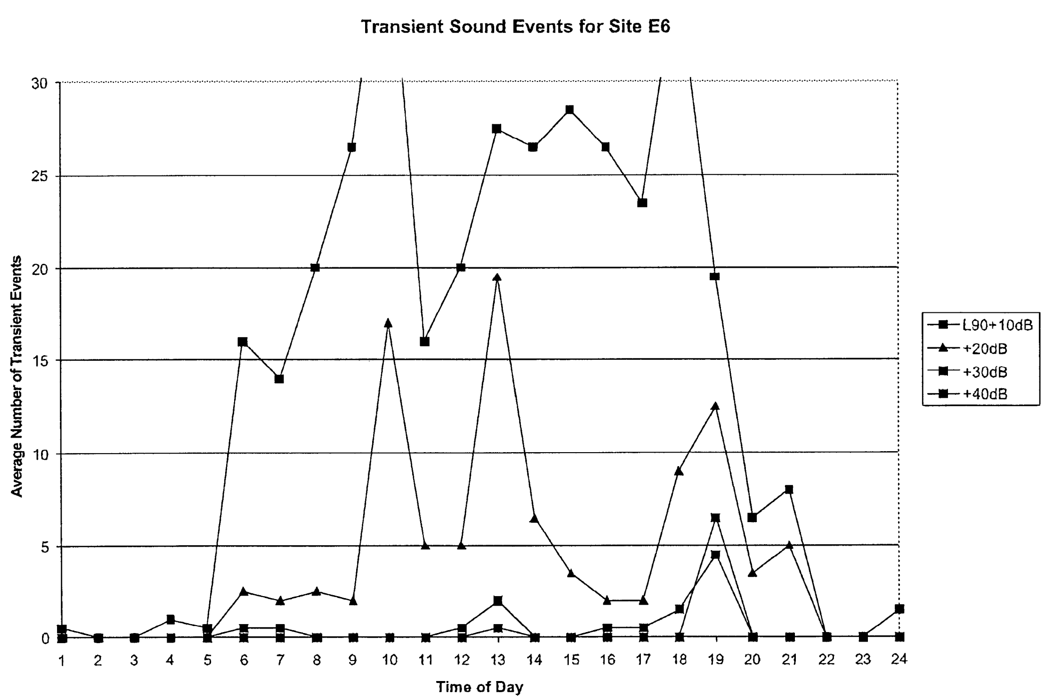

Transient Sound Events for Site E2
Average Number of Transient Events
Time of Day
L90+10dB
+20dB
+30dB
+40dB


Transient Sound Events for Site E3
Average Number of Transient Events
Time of Day
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
L90+10dB
+20dB
+30dB
+40dB

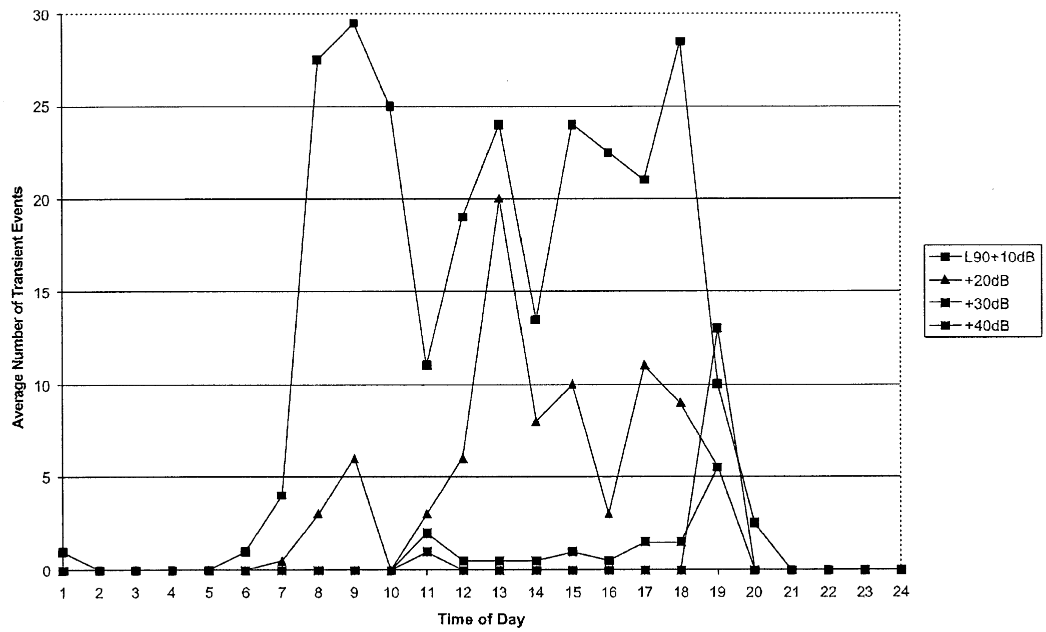

Transient Sound Events for Site E4
Average Number of Transient Events
Time of Day
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
L90+10dB
+20dB
+30dB
+40dB



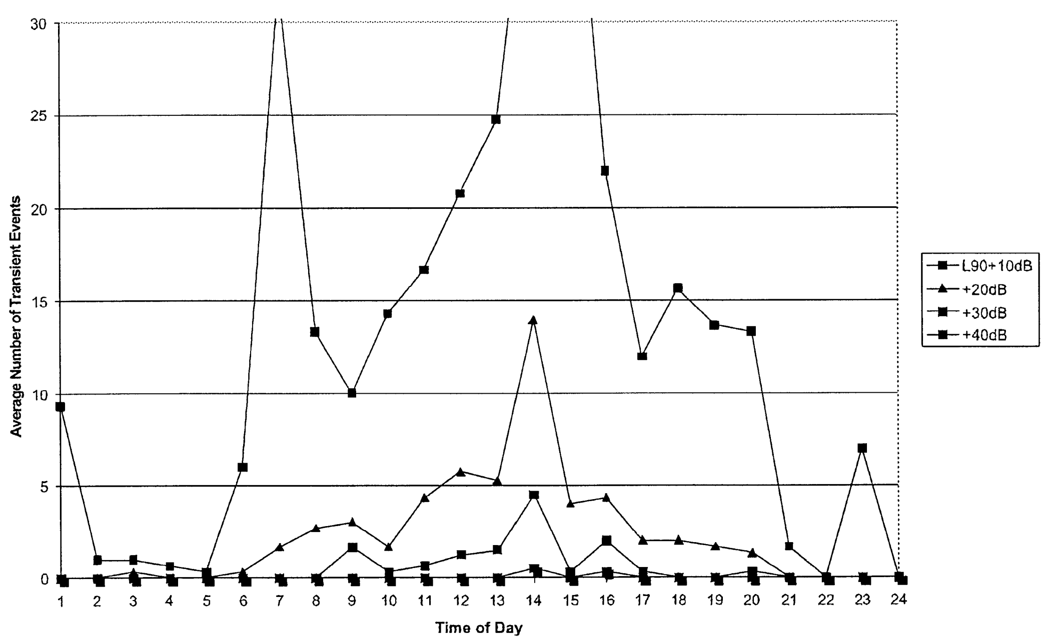
Appendix H Transient Events Plots for Unmanned Measurements The Soundscape in South Florida NP

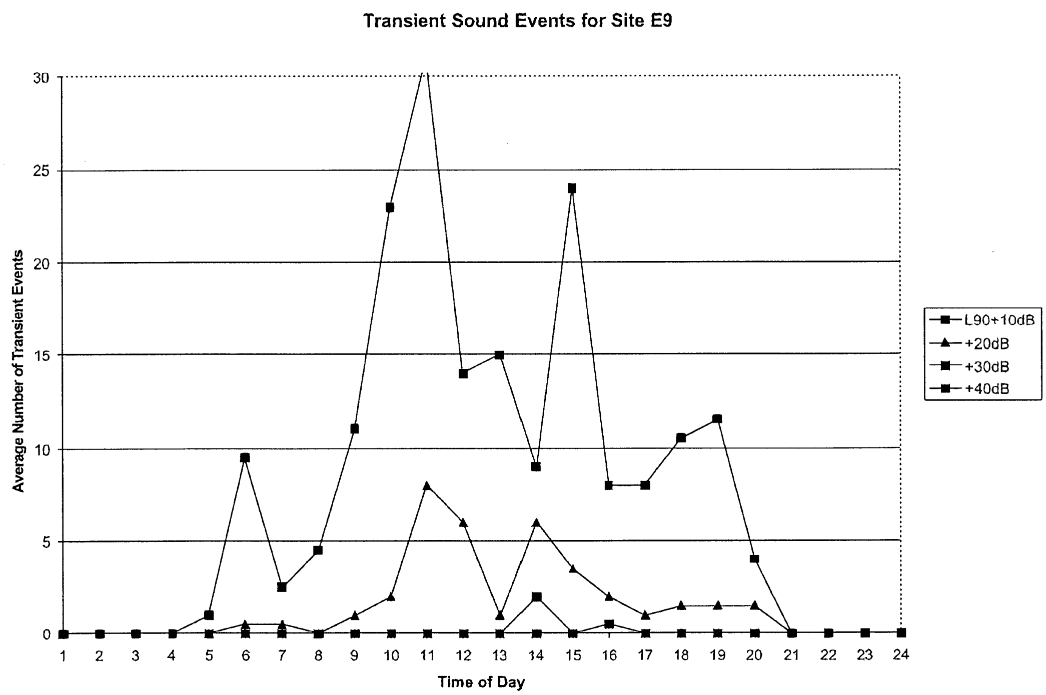


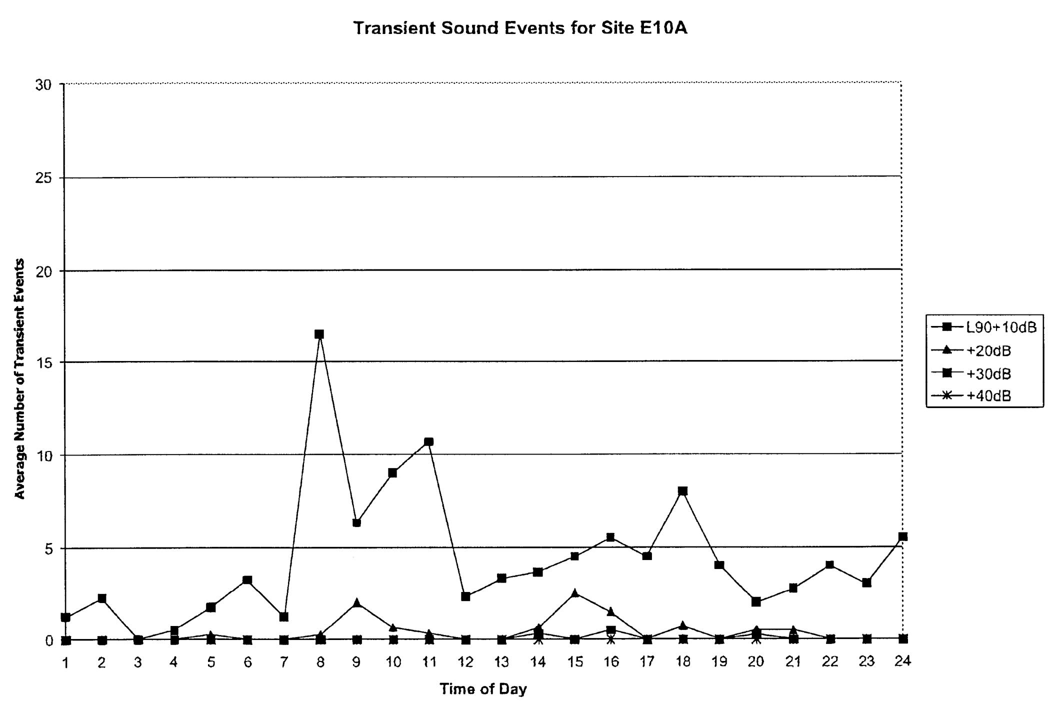
Transient Sound Events for Site E7



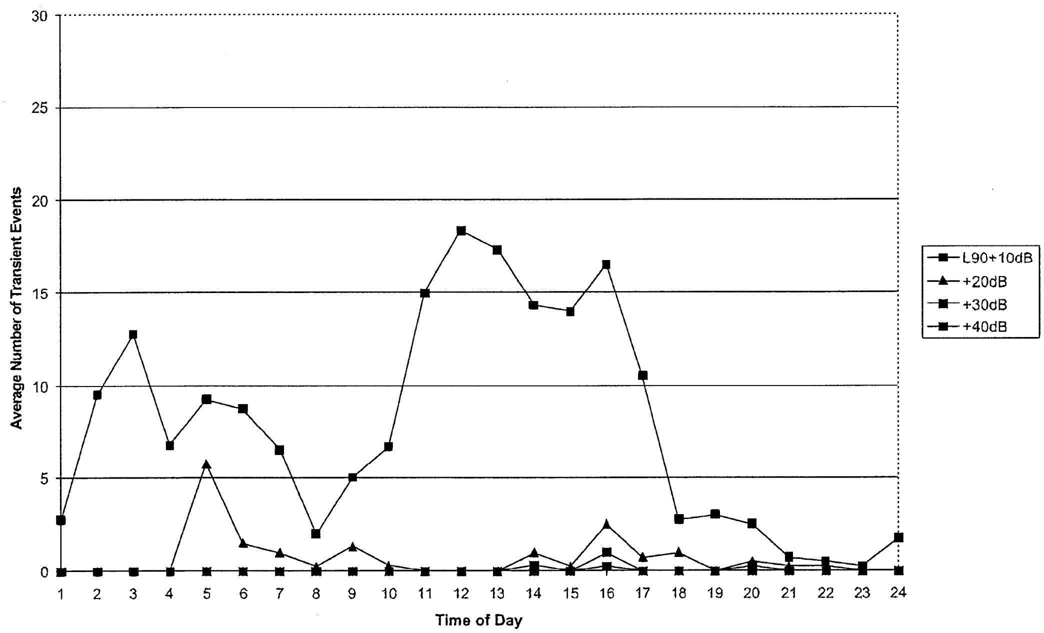
Transient Sound Events for Site E8



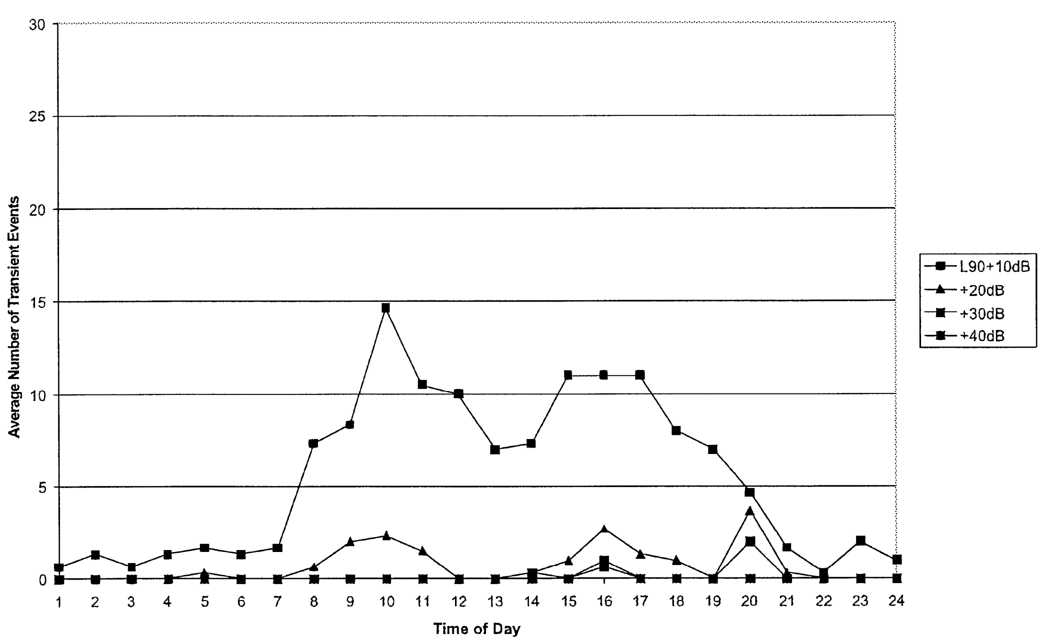

Transient Sound Events for Site E9
Average Number of Transient Events
0
5
10
15
20
25
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
L90+10dB
+20dB
+30dB
+40dB


Transient Sound Events for Site E10A
Average Number of Transient Events
0
5
10
15
20
25
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
L90+10dB
+20dB
+30dB
+40dB

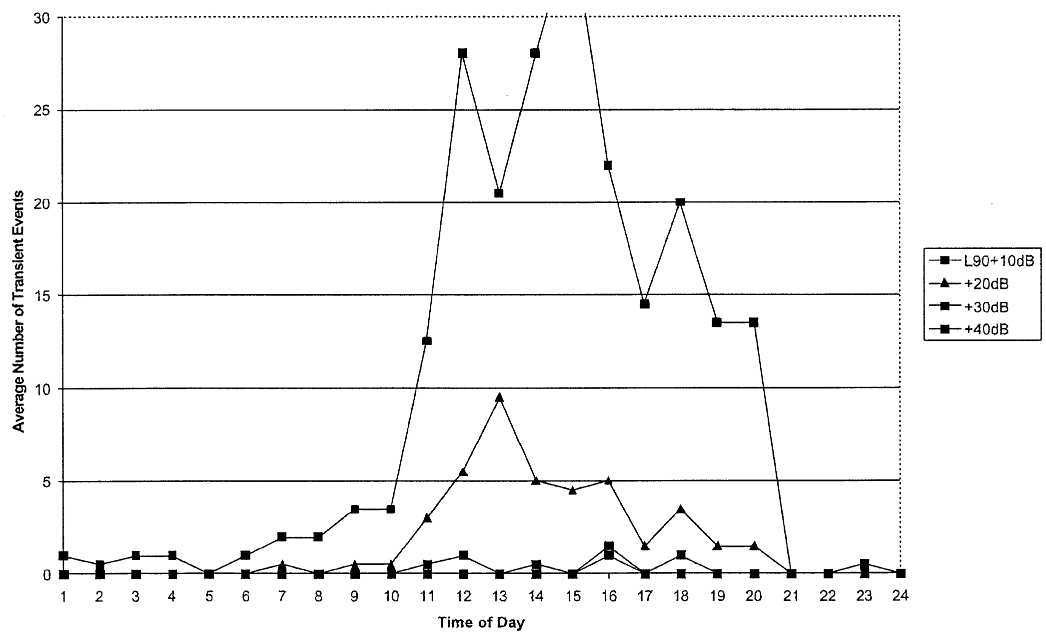
Transient Sound Events for Site E10B



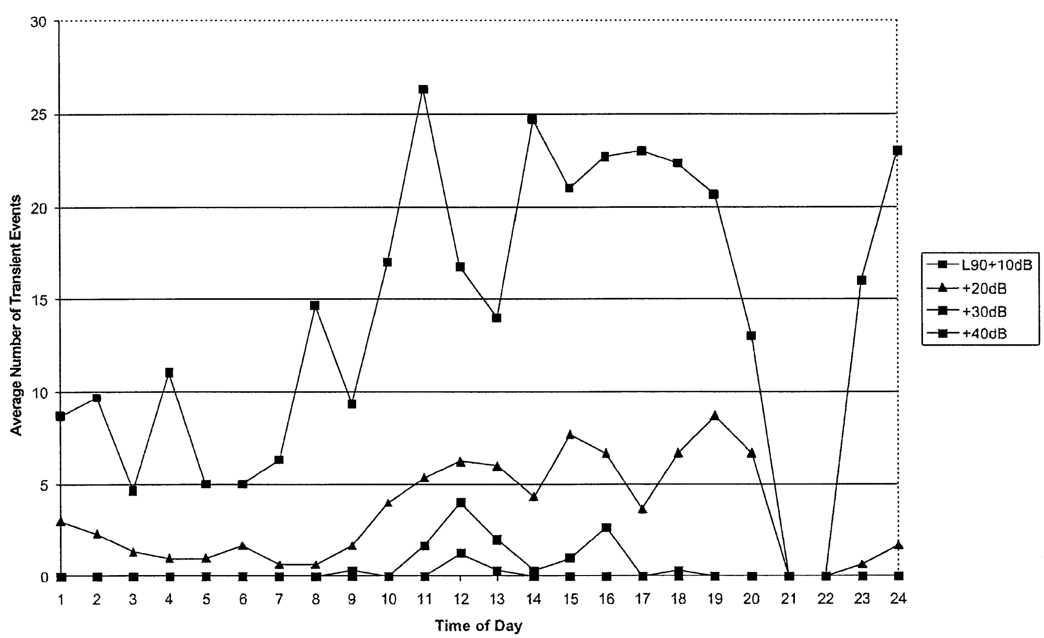
Transient Sound Events for Site E11

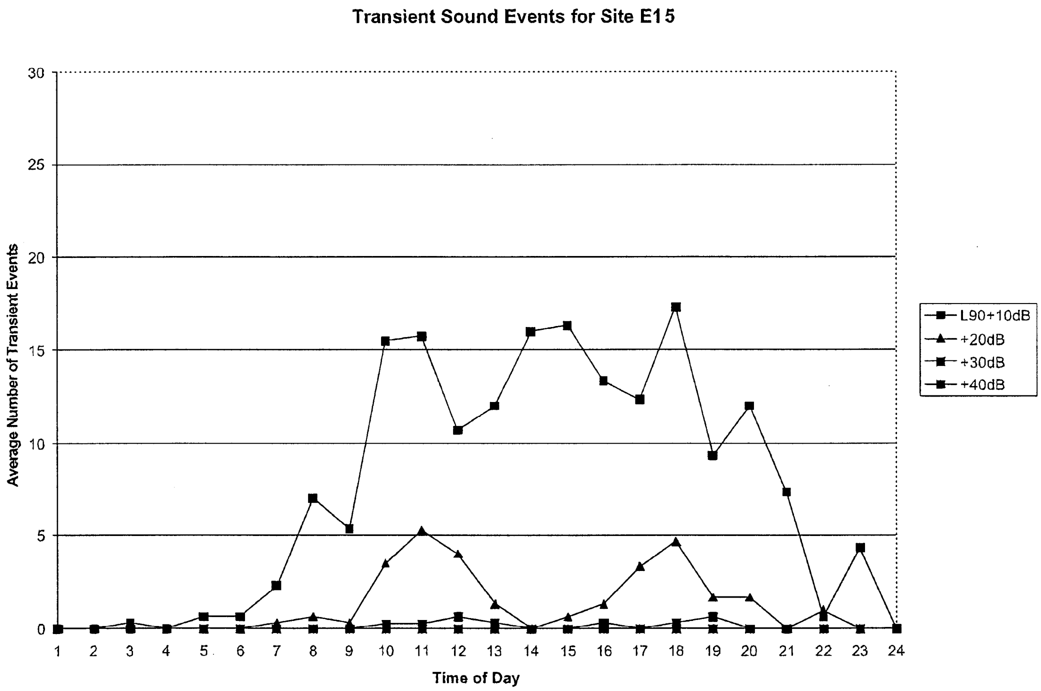


Transient Sound Events for Site E12



Transient Sound Events for Site E14




Transient Sound Events for Site E15
Average Number of Transient Events
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
L90+10dB
+20dB
+30dB
+40dB