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Interim Report – 2006 Testing

TIRE/PAVEMENT AND ENVIRONMENTAL TRAFFIC NOISE RESEARCH STUDY

Robert Otto Rasmussen

July 2008

COLORADO DEPARTMENT OF TRANSPORTATION
DTD APPLIED RESEARCH AND INNOVATION BRANCH

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16. Abstract

This research study on tire-pavement noise is being conducted in response to CDOT's interest in traffic noise in general, and the tire/pavement interaction in particular. Following a rigid set of testing protocols, data is being collected on highway traffic noise characteristics along with safety and durability aspects of the associated pavements. The overall goal of this research project is to develop and execute a comprehensive, long-term study to determine if a particular pavement surface type and/or texture can be successfully used in Colorado to help satisfy FHWA noise mitigation requirements. The study is needed to accomplish the following:

- Determine the noise generation/reduction characteristics of pavements as functions of pavement type, pavement texture, age, time, traffic loading, and distance away from the pavement;
- Determine a correlation between source measurements including close-proximity (CPX) and on-board sound intensity (OBSI), and statistical pass-by (SPB) and time-averaged wayside measurements; and
- Accumulate information that can be used for validation and verification of the accuracy of the FHWA Traffic Noise Model (TNM) to use on future Colorado highway projects.

Implementation:

The information included in this report represents the first in a series of four measurements to be collected over a five-year period. While some of this information can be used immediately for decisions related to pavement design and specification, it is recommended that caution be exercised as the results from future testing will help assess the long-term acoustical durability of these pavement surfaces.

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by

Robert Otto Rasmussen, Ph.D., P.E. (TX)
Vice President & Chief Engineer
The Transtec Group, Inc.

Report No.
CDOT-2008-2

Prepared by
The Transtec Group, Inc.
6111 Balcones Drive
Austin, Texas 78731

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4201 E Arkansas Ave., Shumate Bldg.
Denver, CO 80222

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The authors would also like to recognize others that have contributed to this effort. These include Dr. Bob Bernhard, Notre Dame University and Purdue University Institute for Safe, Quiet and Durable Highways; Dr. Ulf Sandberg of the Swedish National Road and Transport Research Institute (VTI); Eric Mun, Robert Whirledge, and Robert Light of Transtec; and Ted Ferragut of TDC Partners. Others on the Transtec team that have assisted include Jason Dick, Matt Pittman, Yadhira Resendez, and Sabrina Garber. Finally, the team would like to thank Dr. Judy Rochat of the US DOT Volpe Center for her guidance and leadership.

EXECUTIVE SUMMARY

This report summarizes the results of a field testing program to evaluate tire-pavement and environmental noise of representative pavements throughout the State of Colorado. Tire-pavement noise has been measured using two unique technologies: close-proximity (CPX) and on-board sound intensity (OBSI). Environmental noise was measured using wayside (roadside) microphones that capture traffic noise in a manner that is more relevant to the potential impacts to highway abutters. The test results provided in this interim report are only from testing in 2006 – the first year of testing under a multi-year effort. Additional test results from years 2007, 2009, and 2011 will be needed in order to assess the long-term acoustical durability of the various pavements being evaluated.

Implementation Statement

The information included in this report represents the first in a series of four measurements to be collected over a five-year period. While some of this information can be used immediately for decisions related to pavement design and specification, it is recommended that caution be exercised as the results from future testing will help assess the long-term acoustical durability of these pavement surfaces, which is sometimes (often unintentionally) overlooked as an important variable.

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INTRODUCTION

Background

Traffic noise pollution has become a growing concern to residents worldwide. This is particularly true in urban areas where the population density near major thoroughfares is much higher, and there is a greater volume of commuter traffic. To mitigate the noise – at least for residences directly adjacent to the highway – engineers at the Colorado Department of Transportation (CDOT) and elsewhere commonly resort to costly noise barriers. Although arguably the psychology of a noise wall is a factor, noise barriers including walls have not been shown to be an ideal solution for minimizing noise pollution in all cases. Sound tends to diffract over the top and around the ends of barriers, thus proving ineffective on arterial streets since the openings in the barrier required for side streets and driveways effectively defeat the benefits provided by the barrier. Furthermore, the mountainous terrain commonly found in Colorado can further challenge the effectiveness of barriers.

In recent years, alternative solutions to noise barriers have been advanced – ones that may be able to mitigate noise for drivers, adjacent residences, and even for citizens farther from the highway. Driven in large part by public outcry, national policy, and eventually directives to reduce noise, engineers in the European Union and elsewhere have developed alternative pavement types and surfaces that reduce noise generated at the tire-pavement interface.

The noise produced from tire-pavement interaction is just one of several types of traffic noise. However, for many roads with low truck volumes, it becomes the primary source of traffic noise for vehicular speeds over 35 mph. While not a cure-all, certain pavement type and texture options have led to improvements in noise levels; in some cases, reducing the need for or height of noise walls and improving the quality of life.

For a more thorough discussion on these topics, one of the better sources is the FHWA *Little Book of Quieter Pavements*.

As a matter of federal policy (23 CFR 772), pavement type or texture cannot be considered as traffic noise abatement in projects receiving federal funding. For pavement effects to be considered in determining impacts or as a mitigation technique, a so-called Quiet Pavement Pilot Program (QPPP) must be approved and in place. Under a QPPP, a commitment must be made by the Department to guarantee, in perpetuity, noise mitigation through use of a specified pavement type and/or texture. To date, Arizona is the only state that has accepted this challenge, opting for an asphalt-rubber friction course (ARFC) as the "pavement" of choice. A lot has been learned since 2003 when ARFC resurfacing began under the QPPP. However, any state that is interested in asphalt-rubber or any specific pavement type should first evaluate its noise reducing capabilities under local conditions.

Every state has unique conditions, with differences in characteristics and issues such as climate, traffic, materials availability, and maintenance. Choosing a "quiet pavement" alternative that is best for any state must account for all of these factors along with durability, cost, and safety. Currently, the factors that CDOT considers in pavement selection emphasize safety and durability; life cycle cost analyses are performed to determine the most appropriate pavement type and/or rehabilitation technique for a given project. While noise is not currently a factor that is considered in CDOT pavement type selection process, it may eventually be used as a secondary consideration in environmentally sensitive areas and in cases where no significant differences in cost among alternatives have been determined.

Given the inherent issues with a QPPP, most states have instead opted to conduct Quiet Pavement Research (QPR). While the data that is collected under a QPPP and QPR is the same, no policy changes are made that would allow for a mitigation contribution from the pavements under investigation. Instead, if research is being conducted on a project that requires abatement, conventional means will need to be used until a QPPP is in place.

To meet the requirements of a Federal Highway Administration (FHWA) QPR program, the research should have an intended purpose, include a Data Acquisition Plan (DAP), and possess a reporting schedule frequent enough to demonstrate the various changes in the properties of the pavements under study over time. Within this research project, CDOT has drafted a DAP, which

contains the various data collection, analysis, and reporting elements described in the FHWA model which, in turn, is based on that developed and implemented by the State of Arizona under their QPPP.

Within the current DAP, data are be collected on tire-pavement and wayside noise, along with pavement, traffic, safety, and meteorological data. These data will be analyzed and reported in a fashion suitable to derive acoustic properties of various pavement types – by season, over time (and cumulative traffic), and correlated to the physical characteristics of the pavement and texture. Additionally, the data will be used to relate various noise measures to one another, particularly as standardization of these measures – at least, in the US – is an ongoing task within the industry.

Scope

This project is about examining current pavements in Colorado to determine their tire-pavement noise characteristics over a long period of time. In recent years, the FHWA has supported this through establishment of both a QPPP and guidelines for a QPR. For now, CDOT's emphasis will be on the latter, but the intent is to prepare for the possibility of entering the QPPP, depending on the results of the project.

The scope of this project is to assist CDOT with the collection of tire-pavement surface and environmental (wayside) noise data. This data is then organized and reported in such a manner to help fulfill the Department's mission of conducting a proper Quiet Pavement Research program.

Project Objectives

The primary objective of this study is to provide CDOT with tire-pavement and environmental traffic data that are reliable, accurate, and representative given the sheer variety of conditions within the State of Colorado – from both traffic and climatic perspectives. Supporting data on traffic and climate are collected simultaneously with noise measurements. Ultimately, these will be compiled along with numerous other data being collected by CDOT, and interpreted and

reported accordingly. The goal is to fulfill the overall QPR requirements as well as the desire of CDOT to learn what various pavement types and/or textures might do to address or supplement overall noise mitigation requirements.

To meet this objective, a specialized database has been developed. It has been initially populated by data collected from 31 select pavement sections, as described in a QPPP/QPR Data Acquisition Plan (DAP). Along with noise (and related) data collected by Transtec, a variety of other information about the pavement sections will eventually populate this database, including items related to design, materials construction, climate, traffic, and maintenance.

As additional data are collected in subsequent years, the database will be used to fulfill at least three specific objectives, as follows:

1. To establish relationships between the various noise measures, their change over time, and the variables that may be contributors to both.

2. To establish relationships between and within the various noise measurement techniques – near-field (e.g., close-proximity (CPX) and on-board sound intensity (OBSI), wayside (e.g., statistical pass-by index (SPBI), and environmental (e.g., "SPBI+").

3. To assist in providing information suitable for validating and verifying the accuracy of the FHWA Traffic Noise Model (TNM) based on the pavements and other conditions unique to the State of Colorado.

DATA COLLECTION

Data collection under this project, as reported herein, was conducted between September and November 2006. Repeat measurements are planned to for three additional times in the late summer or early fall of the years 2007, 2009, and 2011. Thirty-one unique pavement sections were evaluated during this effort, representing the vast array of pavement types and surface treatment textures that are currently used by CDOT. These are listed in Table 1 along with some additional identifying information.

In April 2006, a kick-off meeting was held with CDOT, which was immediately followed by a reconnaissance trip of the majority of the sites. The trip was attended by Dr. Rasmussen and Mr. Mun of Transtec, Dr. Ulf Sandberg of VTI (Sweden), and Dr. Judith Rochat (Volpe Center, US DOT). Tim Aschenbrener, Roberto de Dios, and Gary DeWitt of CDOT also participated. During this trip, confirmation was made of the noted site characteristics. Candidate locations for wayside noise measurements were also noted.

Table 1. Site Location Information.

Site ID	Road	Direction	Location	Nearest City	Zip Code
1	SH 83	NB	Between. CR-14 & Hess Rd.	Parker	80134
2	I-70	EB	Between Evergreen Pkwy. & CR-65	Golden	80439
3	I-70	WB	Between Federal Blvd. & Pecos St.	Denver	80221
4	US 50	WB	Between 35 6/10 Rd. and Bridgeport Rd.	Grand Junction	81527
5	SH 74	EB	Between Bergen Pkwy. & Lewis Ridge Rd.	Evergreen	80439
6	US 50	EB	Between 35 6/10 Rd. and Bridgeport Rd.	Grand Junction	81527
7	US 85	SB	Between Daniels Park Rd. & Happy Canyon Rd.	Sedalia	80135
8	I-70	EB	Between US 6 & Herman Gulch Rd.	Bakerville (E.Dillon)	80444
9	C-470	WB (N)	Between US 285 & Morrison Rd.	Morrison	80465
10	US 287	SB	Between Bonner Spring Ranch Rd. & SH 14	Laporte	80535
11	SH 82	EB	Between Hunter Logan & Lower River Rd.	Basalt	81654
12	SH 58	WB	Between McIntyre St. & 44th Ave.	Golden	80403
13	I-25	SB	Between CR-12 and CR-10	Erie	80516
14	US 285	NB	Between Surrey Dr. & Goddard Ranch Ct.	Indian Hills	80465
15	I-25	NB	Between Fontanero St. & Fillmore St.	Colorado Springs	80907
16	SH 121	NB	Between Chatfield Ave. & Ken Caryl Ave.	Littleton	80128
17	I-70	WB	Between SH 13 and US 6/24	Rifle	81650
18	US 285	NB	BetweenTurkey Creek Rd. & Chamberlain Rd.	Indian Hills	80465
19	I-70	WB	Between Camino Dorado Rd. & Trail Gulch Rd.	Gypsum	81637
20	US 40	WB	Between CR-8 & SH 94	Kit Carson	80862
21	US 285	SB	Between Kipling Pkwy. & C-470	Morrison	80227
22	US 160	WB	Between CR-103 & Threemile Rd.	Alamosa	81101
23	I-70	EB	Between 23 Rd. & 24 Rd.	Grand Junction	81505
24	I-76	WB	Between CR-49 & SH 52	Hudson	80642
25	I-76	EB	Between 88th Ave. & 96th Ave.	Henderson	80640
26	I-25	SB	Between SH 105 & Higby Rd.	Monument	80132
27	C-470	WB (N)	Between Morrison Rd.& Alameda Pkwy.	Morrison	80228
28	Powers Blvd.	NB (W)	Between Union Blvd. & Old Ranch Rd.	Colorado Springs	80908
29	Powers Blvd.	SB (E)	Btw. Old Ranch Rd. & Union Blvd.	Colorado Springs	80908
30	US 85	NB	Btw. Daniels Park Rd. & SH 67	Sedalia	80135
31	I-70	EB	Btw. 15th St. & US 40	Georgetown	80444

In September 2006, the testing began, conducted by Eric Mun and Robert Light of Transtec. Prior to each of the field visits, Transtec coordinated with relevant CDOT central and/or regional offices. Depending on the type of site, the following measurements were made:

1. **Close-Proximity (CPX) –** a type of near-field testing with the intent to measure tire-pavement noise near the source. The procedures employed in this project were based on the draft ISO 11819-2 standard. Dr. Ulf Sandberg of our team is currently the chair of the technical committee that is developing this standard, and has worked to ensure that the equipment in use by Transtec meets the intent of the standard to the greatest extent possible. It should be noted that some adaptation to the draft standard was required as tire availability, and other factors preclude full compliance. The test tires used in this project include both the Goodyear Aquatred III (P205/70R15) and the new ASTM F 2493 Standard Reference Test Tire (SRTT) (P225/60R16). Furthermore, a standard test speed of 60 mph was selected (although two of the 31 test sections were tested at 55 mph due to safety concerns).

2. **On-Board Sound Intensity (OBSI)** – a second near-field technique that employs a different type of measurement approach. Instead of measuring levels via sound pressure from a single microphone (as the CPX method does), OBSI measures tire-pavement noise using a phase-matched pair of microphones that are positioned in such a way to isolate sound generated near the tire-pavement contact patch. The OBSI technique in use today was originally developed by Dr. Paul Donavan of Illingworth & Rodkin (while employed by General Motors). The technique has recently been adopted by Caltrans and numerous other states, and is continuing to be standardized by AASHTO with the assistance of an FHWA Expert Task Group. Both ASTM and SAE also have standards for OBSI under development. The current standard tire for OBSI measurements is the ASTM F 2493 SRTT tire. The Aquatred III tire was used on some sections, but only for informational purposes. The test speeds used in OBSI measurements are the same as those for CPX testing.

3. **Statistical Pass-By (SPB) and Time-Averaged (TA) Wayside** – these measurements are made using a tripod-mounted microphone located at a fixed position (50 ft. from and 5 ft. higher than the center of the outside lane). In order to normalize for the traffic present during the measurements, there is a simultaneous collection of vehicle counts, classifications, and speeds. The SPB measurements collected in this effort have been made by adopting components of the ISO 11819-1 standard, again developed in large part by Dr. Sandberg. To assist in developing Reference Energy Mean Emission Level (REMEL) type data for the various pavements under study, provisions of the FHWA "Measurement of Highway-Related Noise" have also been adopted, particularly those related to site selection, microphone positioning, data processing, and reporting (e.g., third-octave). Dr. Judith Rochat of the US DOT Volpe Center – architects of the REMEL database and Traffic Noise Model (TNM) software – joined the project team during the site reconnaissance and offered invaluable guidance in this aspect of the measurements.

4. **Environmental Wayside** – these measurements are intended to be collected in the same manner as SPB/TA wayside measurements. They have been referred to as "SPBI+" by CDOT. The intent is to set up and measure from additional microphone positions at 100, 200, 400, and 800 ft. from the center of the outside lane. The reason that this information is desired is to attempt to characterize if the noise characteristics of different pavement types are significant at these distances, which would correspond to the locations of residences in these areas. Conducting these tests during the 2006 testing was not possible due to the inability to obtain the proper clearances for adjacent land access. Furthermore, there was some concern expressed by Drs. Sandberg and Rochat during the reconnaissance visit about the accuracy and usefulness of such measurements (at least, those 200 ft. and greater). However, further attempts will be made in the remaining years to collect these measurements even if on a limited basis.

5. **Supporting Data** – this includes climatic data via an on-site weather station, photographs and digital video, and site surveys to benchmark the begin/end points for each section along with the location of any wayside microphone positions.

Photographs of some of the test equipment can be found in Appendix A. Additional details for each site, along with the types of measurements collected in 2006 are listed in Table 2.

RESULTS OF 2006 EVALUATION

The testing conducted under this project resulted in a large database of information. To begin, the database has been populated with various site reference information, such as that contained in Tables 1 and 2. Additional information has also been organized by the project team for future use. This includes items such as-built plans and construction records for many of the 31 sites.

The noise data collected thus far has also been organized into the database and classified in a hierarchical folder structure for ready access as more sophisticated analyses are anticipated in the coming years.

Appendix B contains a detailed summary of the data collected thus far from each of the sites. General information on the sites is followed by details of both the environmental and tire-pavement noise measurements.

A summary of the source data can also be found in Tables 3 and 4. Table 3 summarizes the CPX data (A-weighted Sound Pressure Level (SPL) in dB ref 20 µPa), and Table 4, the OBSI data (A-weighted Sound Intensity Level (SIL) in dB ref 1 pW/m^2). It should be noted again that the standard tire for the OBSI testing is the SRTT; however, some testing using the Aquatred III tire was conducted for informational purposes. Table 5 contains a summary of the SPB wayside testing.

Figure 1 includes a chart of estimated OBSI levels using the Aquatred III tire. While this tire is no longer considered the "standard," it does allow for a comparison to large databases of existing tire-pavement noise information. This includes data collected for Caltrans, Arizona DOT, and numerous other states.

Table 2. Additional Site Information.

Site ID	Surface Type	Construction Accepted	CPX	OBSI	SPB	TA	Approx. Lat.	Approx. Lon.	Approx. Elev. (ft.)	Section Length (ft.)	Wayside Mic Pos. From Begin (ft.)
1	SMA (3/4")	2004	✓	✓		✓	39.4883	104.7591	5960	1558	769
2	SMA (3/4")	1/2004	✓	✓		✓	39.7084	105.3511	7490	5308	4116
3	SMA (3/4")	10/2003	✓	✓			39.7841	105.0186	5330	3575	n/a
4	SMA (1/2")	8/2002	✓	✓	✓		38.8147	108.3385	5110	4847	1422
5	SMA (3/8")	7/2004	✓	✓			39.2861	107.1376	7680	3488	n/a
6	Asphalt (SX, 1/2")	8/2002	✓	✓	✓		38.8994	108.3666	5010	5333	1048
7	Asphalt (SX, 1/2")	2006	✓**	✓**	✓		39.4288	104.9111	6000	2686	1864
8	Asphalt (SX, 1/2")	2005 *(to be confirmed)*	✓	✓			39.6976	105.8703	10470	3535	n/a
9	SMA (1/2")	6/2006	✓	✓		✓	39.6410	105.1723	5760	3033	2460
10	Asphalt (S, 3/4")	10/2003	✓	✓	✓		40.7113	105.1730	5470	3380	2649
11	NovaChip	10/2000	✓	✓			39.3389	106.9989	6880	3228	n/a
12	NovaChip	6/2003	✓	✓		✓	39.7706	105.1895	5600	3082	653
13	Concrete (Long. Tining)	10/2005	✓	✓		✓	40.0667	104.9809	5060	3389	1054
14	Concrete (Long. Tining)	10/1999	✓	✓			39.5838	105.2258	7130	1613	n/a
15	Concrete (Long. Grooving)	11/2001	✓	✓			38.8672	104.8340	6130	4485	n/a
16	Concrete (Carpet Drag)	8/2001	✓	✓		✓	39.5741	105.0837	5580	2422	1323
17	Concrete (Diamond Grinding)	11/2005	✓	✓		✓	39.5205	107.8229	5290	6368	1177
18	Concrete (Diamond Grinding)	10/1999	✓	✓			39.5980	105.2255	7050	2069	n/a
19	SMA	8/1996	✓	✓	✓		39.6528	106.8823	6630	3122	443
20	Concrete	4/2002	✓	✓	✓		38.8328	103.0540	4520	5241	2668
21	Asphalt (S, 3/4")	11/2003	✓	✓		✓	39.6438	105.1318	5700	3599	1451
22	Asphalt	10/1999	✓	✓	✓		37.5177	105.9948	7610	2930	796
23	Asphalt	10/2004	✓	✓			39.1138	108.6193	4560	3623	n/a
24	Concrete	3/2001	✓	✓			40.0942	104.6143	4940	3345	n/a
25	Concrete	11/2002	✓	✓			39.8655	104.9059	5120	2495	n/a
26	Concrete	10/1996	✓	✓			39.0862	104.8614	7010	1493	n/a
27	Concrete	1/2001	✓	✓			39.6759	105.1869	5890	7873	n/a
28	Concrete (Drag)	12/2004	✓	✓			38.9796	104.7574	7010	1804	n/a
29	SMA	9/2005	✓	✓			38.9790	104.7575	7010	1724	n/a
30	Concrete (Burlap Drag)	2003 *(to be confirmed)*	✓**	✓**			39.4365	104.9514	5870	3019	n/a
31	SMA (3/4")	10/2006	✓				39.7286	105.6919	8560	5529	n/a

** Note: OBSI/CPX testing conducted at 55 mph; all other sites at 60 mph

Table 3. CPX Test Summary A-weighted SPL (dB ref 20 µPa).

Site	CPX – SRTT			CPX – Aquatred III			Average Both Tires
	Leading Edge	Trailing Edge	Average	Leading Edge	Trailing Edge	Average	
1	99.6	100.9	100.3	100.8	102.0	101.4	100.8
2	101.7	101.7	101.7	103.1	103.2	103.1	102.4
3	101.4	102.2	101.8	102.3	103.0	102.6	102.2
4	99.6	99.8	99.7	100.7	101.0	100.8	100.2
5	100.4	100.7	100.6	101.7	101.8	101.8	101.2
6	99.9	100.5	100.2	101.1	101.6	101.4	100.8
7**	102.4	103.0	102.7	103.2	104.0	103.6	103.1
8	103.0	102.7	102.8	104.5	104.3	104.4	103.6
9	98.1	98.7	98.4	99.2	99.8	99.5	99.0
10	99.4	100.3	99.9	100.3	100.9	100.6	100.2
11	101.8	101.7	101.7	102.7	102.8	102.7	102.2
12	99.8	100.1	99.9	100.6	100.6	100.6	100.3
13	99.4	100.6	100.0	100.9	102.1	101.5	100.7
14	102.1	102.2	102.1	102.9	103.2	103.0	102.6
15	99.4	100.5	99.9	100.8	101.8	101.3	100.6
16	101.4	101.4	101.4	102.3	102.6	102.5	101.9
17	99.5	99.8	99.6	100.7	101.1	100.9	100.3
18	102.1	102.4	102.3	103.2	103.5	103.3	102.8
19	100.5	102.8	101.6	103.4	104.0	103.7	102.7
20	98.8	99.9	99.3	100.0	101.3	100.7	100.0
21	102.4	102.6	102.5	103.2	103.4	103.3	102.9
22	100.2	102.3	101.3	101.3	103.2	102.2	101.8
23	99.7	100.0	99.9	100.8	101.3	101.0	100.4
24	99.5	100.6	100.0	100.6	102.0	101.3	100.7
25	100.0	100.7	100.3	101.2	101.9	101.5	100.9
26	99.0	100.3	99.6	99.9	101.2	100.6	100.1
27	99.9	100.4	100.2	101.0	101.7	101.4	100.8
28	99.8	100.2	100.0	100.5	100.6	100.5	100.3
29	99.1	99.8	99.5	100.1	100.3	100.2	99.8
30**	100.0	101.0	100.5	101.0	102.0	101.5	101.0
31	98.6	99.0	98.8	100.0	100.4	100.2	99.5

** Note: Results normalized to standard test speed of 60 mph.

Table 4. OBSI Test Summary A-weighted SIL (dB ref 1pW/m²).

Site	OBSI – SRTT			OBSI – Aquatred III		
	Leading Edge	Trailing Edge	Average	Leading Edge	Trailing Edge	Average
1	102.5	102.9	102.7			
2	102.4	103.3	102.9			
3	103.9	104.1	104.0			
4	101.2	101.6	101.4			
5	102.4	102.3	102.3			
6	101.3	101.8	101.6			
7**	104.7	104.9	104.8			
8	103.6	104.3	104.0			
9	100.2	100.8	100.6			
10	102.3	102.7	102.5			
11	104.0	104.5	104.3			
12	101.8	101.8	101.8			
13	101.5	102.1	101.8	102.9	104.2	103.6
14	104.1	104.4	104.3	105.1	105.8	105.5
15	102.2	102.6	102.4			
16	102.7	102.9	102.8	104.3	105.3	104.8
17	101.5	101.7	101.6	101.8	103.0	102.5
18	104.5	104.6	104.5	105.7	106.3	106.0
19	104.7	104.8	104.7			
20	101.9	101.9	101.9	102.3	103.5	103.0
21	104.6	104.8	104.7			
22	103.1	103.8	103.4			
23	101.4	101.8	101.6			
24	102.2	102.3	102.2			
25	102.5	101.9	102.2			
26	102.0	102.2	102.1			
27	102.3	102.5	102.4			
28	101.3	101.5	101.4	102.2	103.3	102.8
29	101.2	101.6	101.4	102.3	103.1	102.7
30**	102.2	102.6	102.4			

** Note: Results normalized to standard test speed of 60 mph.

Table 5. SPB Test Summary A-weighted SPL (dB ref 20 µPa).

Site	SPB		
	Car	Med. Truck	Hvy. Truck
4	74.1	79.9	80.8
6	74.4	80.1	83.0
7	74.5	78.8	83.5
10	74.8	80.7	83.7
19	76.0	79.3	83.0
20	73.8	78.4	82.8
22	74.5	77.5	81.9

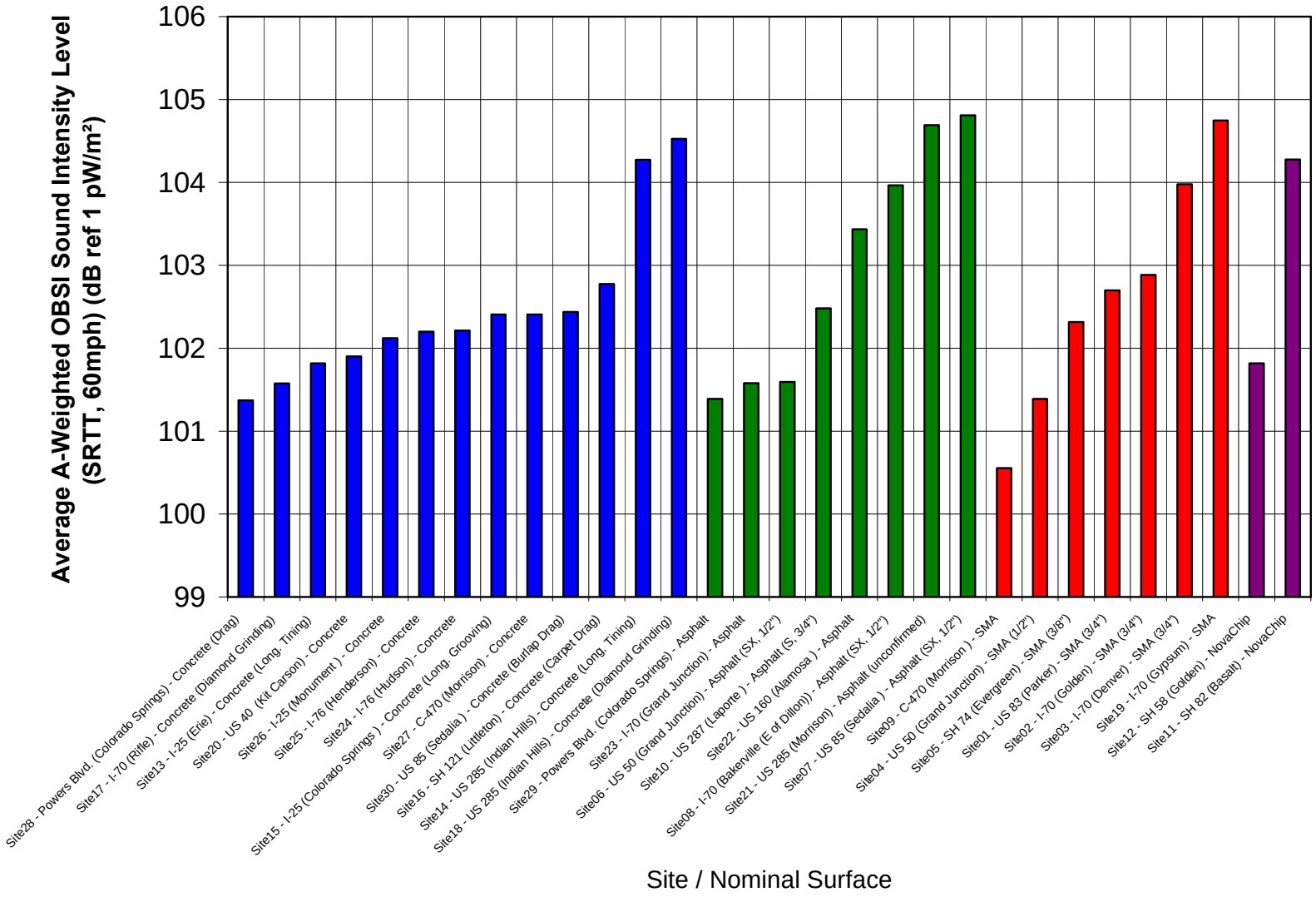


Figure 1. Summary of Estimated OBSI A-weighted SILUsing Aquatred III Tire (dB ref 1pW/m²).

Relationship between Test Tires

Using the information that has been collected to date, a comparison can be made of the average sound levels of the various test sections using the Aquatred III and SRTT tires. Figure 2 includes the trend that emerges. Two trend lines are drawn that separate this relationship between the CPX and OBSI techniques. In both cases, it can be noted that when the Aquatred III tire is used, the resulting sound level is approximately 1.1 to 1.4 dB higher than when the SRTT tire is used. The trends are also very strong, indicating a high correlation between these two tires.

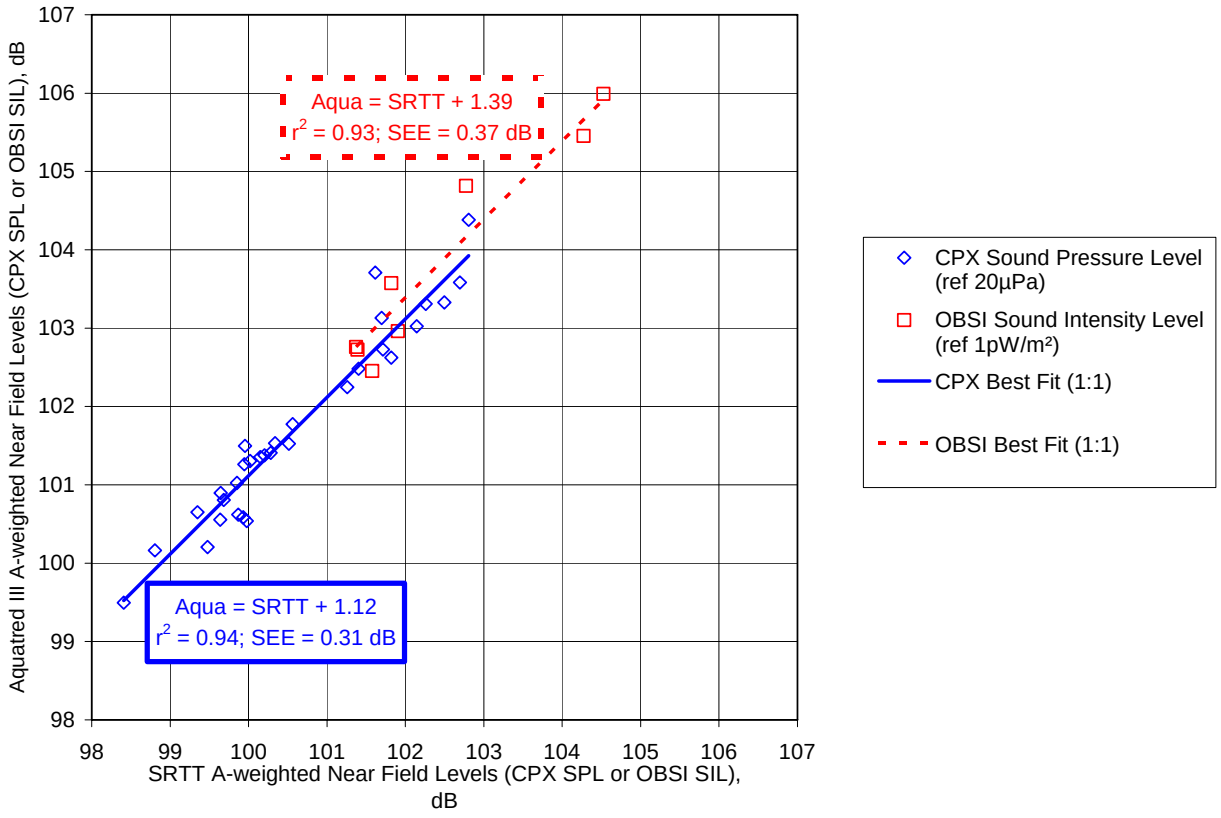


Figure 2. Comparison of Sound Levels Using Aquatred III vs. SRTT Test Tires.

Relationship between Source Tests

A second comparison could be made using the data to compare the average sound levels of each of the pavements as measured using the two source techniques: CPX and OBSI. In both cases, this comparison is separated by tire type; the resulting trends can be seen in Figure 3. Here as

well, a strong relationship can be noted, indicating a correlation between these two measurement techniques, as expected.

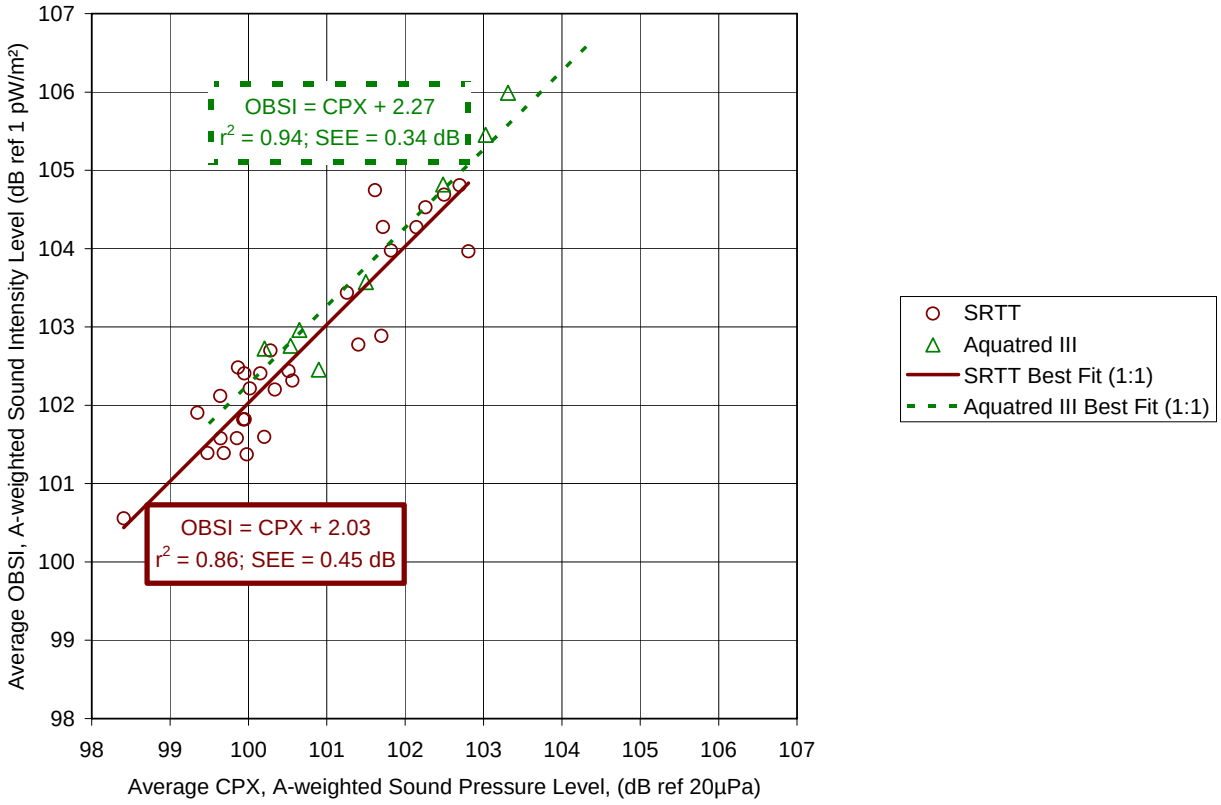


Figure 3. Comparison of Sound Levels from the OBSI and CPX MeasurementTechniques.

Relationship between Source and Wayside Tests

On seven of the sites, SPB data was collected, which permits the estimate of an "average" car at 60 mph. This average is reported as an index level, as summarized in Table 5.

A comparison can be made of the SPBI levels for cars and the corresponding estimated average OBSI levels using an Aquatred III tire at 60 mph. This is shown in Figure 4. At first glance from this plot, the relationship is rather weak. However, when forcing a best-fit 1:1 slope, the offset is 29.6 dBA, which is comparable to reported offsets of controlled pass-by (CPB) data compared to corresponding OBSI data. Dr. Paul Donavan of Illingworth & Rodkin has reported that offset to be 30.4 dBA. Iowa State University has calculated an offset of 29.5 dBA based on its database.

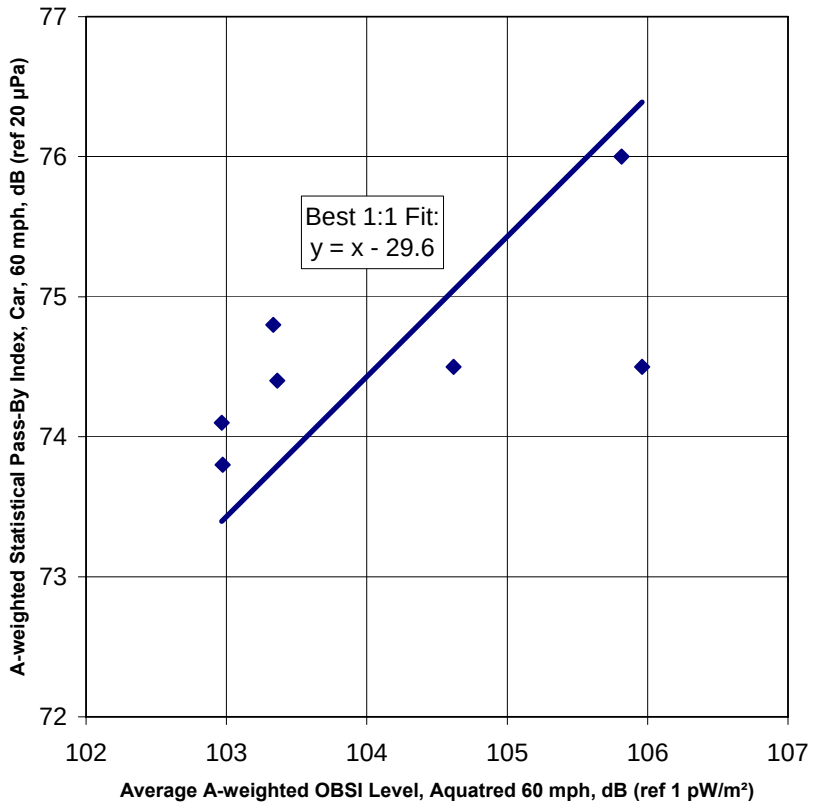


Figure 4. Comparison of OBSI and SPBI Levels.

CONCLUSIONS AND RECOMMENDATIONS

To date, a wealth of information has been collected concerning the tire-pavement noise and environmental noise on various pavements in the State of Colorado. Thirty-one unique pavement surfaces have been evaluated, and the information reported herein as the first step in constructing acoustical durability relationships. Additional testing is currently scheduled to occur in Years 2007, 2009, and 2011.

From the measurements, it can be concluded that no single pavement type can be considered definitively quieter; each has demonstrated that a range of noise levels is possible. Furthermore, it is anticipated that as additional measurements are made in subsequent years, these levels will change by different amounts, making the conclusion of a single quieter pavement type even less likely.

Based on the testing conducted to date, it is recommended that the SRTT test tire serve as the standard for all subsequent testing in Colorado under this study. The Goodyear Aquatred III is no longer in production, and while care is taken to protect the remaining test tires, changes in their properties are inevitable.

It is also recommended that all future source testing be conducted using OBSI. This will allow more robust analyses to be conducted in future years due to the increased testing efficiency. It also appears now that the OBSI technique will become the standard for tire-pavement noise testing in the USA.

Finally, it is recommended that all subsequent testing continue to be conducted at both the source and wayside. The relationship between these measurements is simply too weak to rely on one to correlate to the other. This recommendation is in line with recommendations made by experts both in the USA and abroad. In addition, every effort will be made to conduct the environmental wayside measurements in the subsequent testing periods.

REFERENCES

- R. Rasmussen, et. al., FHWA Little Book of Quieter Pavements, Report FHWA-IF-08-004, USDOT Federal Highway Administration (2007).
- R. Rasmussen, R. Bernhard, Y. Resendez, and U. Sandberg, Tire Pavement Noise 101: An FHWA Workshop, USDOT Federal Highway Administration (2007).
- U. Sandberg and J. Ejsmont, Tyre/Road Noise Reference Book (Informex, Handelsbolag, Sweden, 2002).
- R. Rasmussen, E. Mun, T. Ferragut, and P. Wiegand, "A Comprehensive Field Study on Concrete Pavement Solutions for Reducing Tire-Pavement Noise," Proceedings of Inter-Noise 2006, Honolulu, Hawaii (2006).
- P. Donavan and B. Rymer, "Quantification of Tire/Pavement Noise: Application of the Sound Intensity Method," Proceedings of Inter-Noise 2004, Prague, the Czech Republic (2004).
- C. Lee and G. Fleming,, Measurement of Highway-Related Noise, Report FHWA-PD-96-046, USDOT Research and Special Programs Administration (1996).
- General Motors, "Road Tire Noise Evaluation Procedure," test Procedure GMN7079TP (2004).
- ISO, "Acoustics – Measurement of the influence of road surfaces on traffic noise – Part 1: Statistical Pass-By method," ISO 11819-1 (1997).
- ISO, "Acoustics – Measurement of the influence of road surfaces on traffic noise – Part 2: The close-proximity method," ISO TC 43 / SC 1 N, ISO/CD 11819-2 (2000).
- F. Fahy, Sound Intensity (E & FN Spon, London, 1995).
- Guidance manual for the implementation of low-noise road surfaces, FEHRL Report 2006/02, Ed. by Phil Morgan, TRL (2006).

APPENDIX A – PHOTOGRAPHS

Figure A.1. CPX Measurement Bracket Configuration.

Figure A.2. OBSI Measurement Bracket Configuration.

Figure A.3. Test Tires – ASTM F 2493 SRTT and Goodyear Aquatred III.

Figure A.4. Wayside Measurement Configuration.

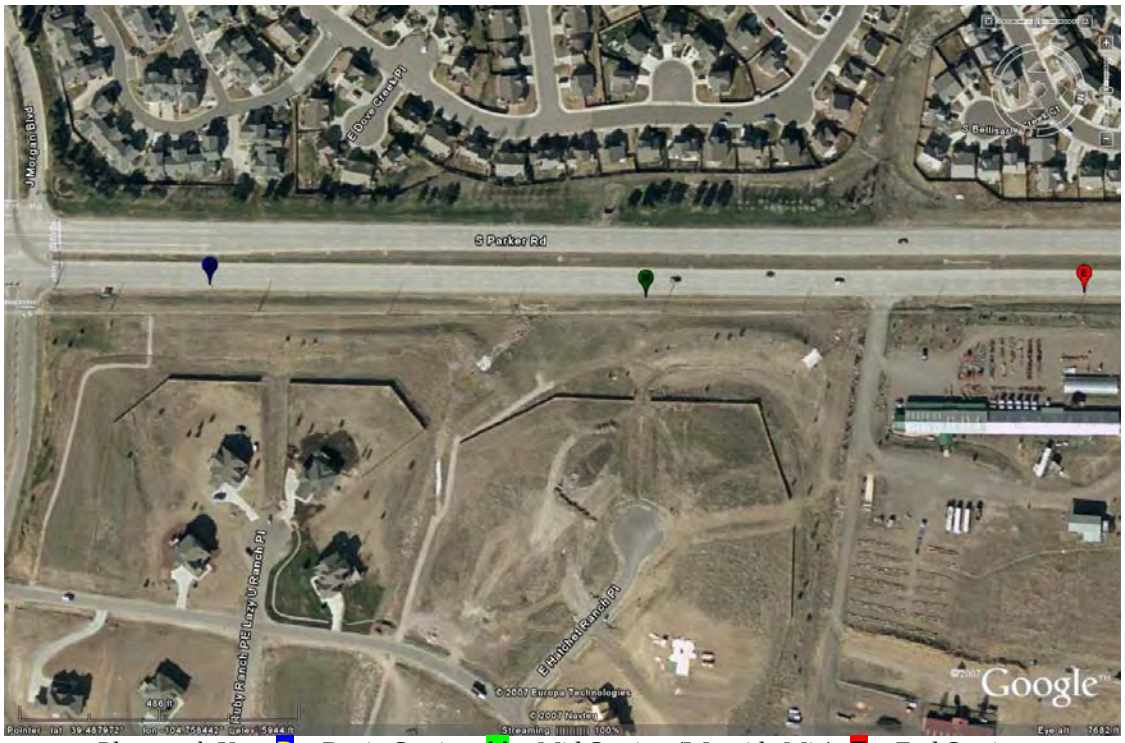
APPENDIX B – DETAILED SITE DATA

Site: 01
General Information

Highway: US Highway 83, Northbound
Location: Between CR-14 & Hess Rd., Parker (80134)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.4883 / 104.7591 / 5960

Nominal Surface: SMA (3/4”) **Construction Accepted:** 2004

CPX?: Yes (10/31/06) **OBSI?:** Yes (10/31/06) **SPB?:** No **TA?:** Yes (10/30/06)
Total Section Length: 1558 ft.
Distance from Begin to Wayside Microphone: 769 ft.



Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 01
Time-Averaged Wayside Test Information

Sampling Periods: 2

Sample Period 1 – 4 Blocks @ 15 min ea. = 60 min. (9:20 am to 10:20 am, 10/30/06)

Traffic Volumes and Speeds during Sample Period

	NB Lane 3 (Outside)	NB Lane 2	NB Lane 1 (Inside)	SB Lane 1 (Inside)	SB Lane 2	SB Lane 3 (Outside)
Distance from Mic (ft.)	50	62	74	121	133	145
Average Speed (mph)	n/a **			66		
Automobile	98	425	535	831**		
Heavy Truck	3	19	3	38**		
Medium Truck	8	19	18	43**		
Bus	0	3	0	1**		
Motorcycle	0	1	0	3**		
Auto + 1-Axle Trlr.	1	1	2	6**		
Auto + 2-Axle Trlr.	0	5	3	6**		
M.Trk. + 1-Axle Trlr.	0	1	1	2**		
M.Trk. + 2-Axle Trlr.	0	3	1	6**		

** Combined SB data and no NB speed due to camera malfunction

Block 1	Block 2	Block 3	Block 4	Average
71.0 dBA	70.6 dBA	70.6 dBA	70.1 dBA	**70.6 dBA**

Site: 01
Time-Averaged Wayside Test Information

Sample Period 2 – 5 Blocks @ 15 min ea. = 75 min. (10:55 am to 12:10 pm, 10/30/06)

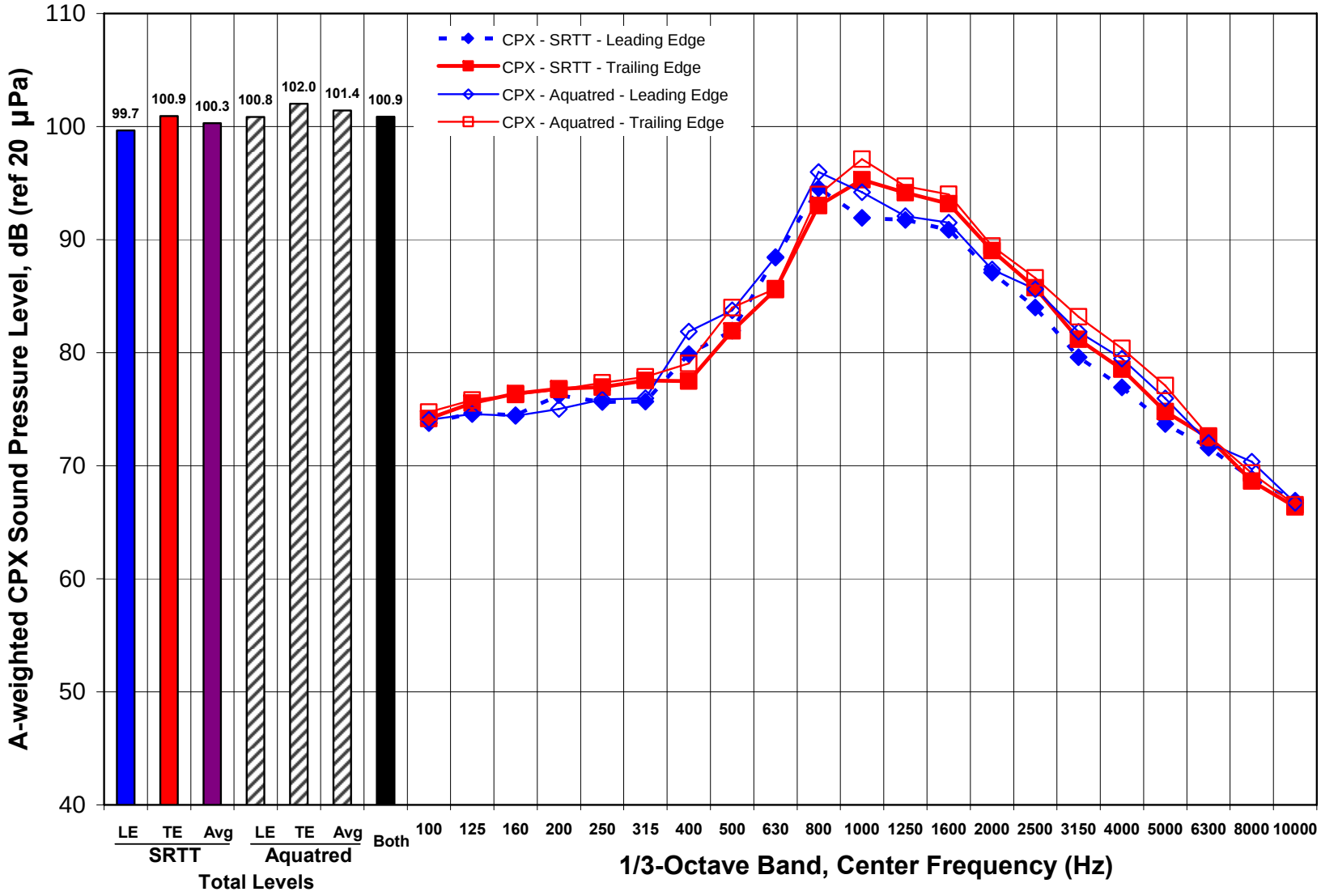
Traffic Volumes and Speeds during Sample Period

	NB Lane 3 (Outside)	NB Lane 2	NB Lane 1 (Inside)	SB Lane 1 (Inside)	SB Lane 2	SB Lane 3 (Outside)
Distance from Mic (ft.)	50	62	74	121	133	145
Average Speed (mph)	65			62		
Automobile	131	505	624	469	605	80
Heavy Truck	3	22	3	3	25	1
Medium Truck	10	23	22	19	24	0
Bus	0	2	0	0	0	0
Motorcycle	0	1	3	3	1	0
Auto + 1-Axle Trlr.	1	4	3	1	7	0
Auto + 2-Axle Trlr.	1	5	1	0	7	0
M.Trk. + 1-Axle Trlr.	0	0	1	1	3	0
M. Trk. + 2-Axle Trlr.	1	2	1	2	1	0
H.Trk. + 2-Axle Trlr.	0	2	1	0	1	0

Block 1	Block 2	Block 3	Block 4	Block 5	Average
69.8 dBA	69.9 dBA	69.9 dBA	69.3 dBA	69.1 dBA	**69.6 dBA**

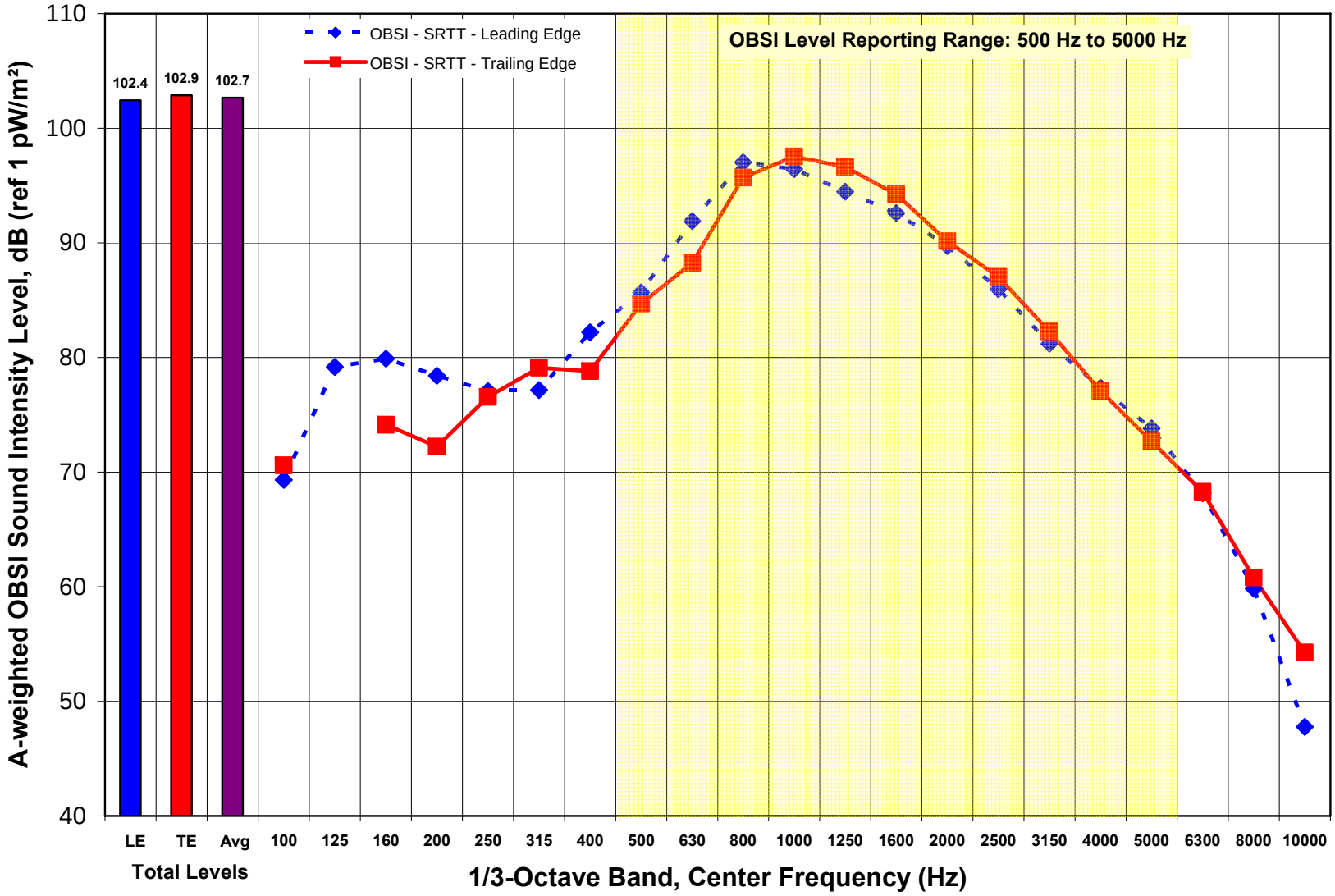
Site: 01

CPX Test Information



Site: 01

OBSI Test Information



Site: 02
General Information

Highway: Interstate 70, Eastbound
Location: Between Evergreen Pkwy. & CR-65, Golden (80439)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.7084 / 105.3511 / 7490

Nominal Surface: SMA (3/4") **Construction Accepted:** 2004

CPX?: Yes (9/25/06) **OBSI?:** Yes (9/25/06) **SPB?:** No **TA?:** Yes (10/4/06)
Total Section Length: 5308 ft.
Distance from Begin to Wayside Microphone: 4116 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 02
Time-Averaged Wayside Test Information

Sampling Periods: 3

Sample Period 1 – 5 Blocks @ 15 min ea. = 75 min. (10:25 am to 11:40 am, 10/4/06)

Traffic Volumes and Speeds during Sample Period

	EB Lane 3 (Outside)	**EB Lane 2**	**EB Lane 1 (Inside)**	**WB Lane 1 (Inside)**	**WB Lane 2**	**WB Lane 3 (Outside)**
Distance from Mic (ft.)	50	62	74	131	143	155
Average Speed (mph)	67			69		
Automobile	267	528	162	304	772	268
Heavy Truck	100	27	0	4	47	116
Medium Truck	30	19	1	3	27	39
Bus	0	1	0	0	1	1
Motorcycle	3	1	0	1	0	0
Auto + 1-Axle Trlr.	4	4	1	–	–	–
Auto + 2-Axle Trlr.	8	1	0	–	–	–
M.Trk. + 1-Axle Trlr.	0	0	0	–	–	–
M. Trk. + 2-Axle Trlr.	3	1	0	–	–	–

– = Not observed

Block 1	**Block 2**	**Block 3**	**Block 4**	**Block 5**	**Average**
75.4 dBA	75.1 dBA	75.3 dBA	74.9 dBA	75.2 dBA	**75.2 dBA**

Site: 02
Time-Averaged Wayside Test Information

Sample Period 2 – 4 Blocks @ 15 min ea. = 60 min. (12:00 pm to 1:00 pm, 10/4/06)

Traffic Volumes and Speeds during Sample Period

	EB Lane 3 (Outside)	EB Lane 2	EB Lane 1 (Inside)	WB Lane 1 (Inside)	WB Lane 2	WB Lane 3 (Outside)
Distance from Mic (ft.)	50	62	74	131	143	155
Average Speed (mph)	66			68		
Automobile	203	452	144	201	584	206
Heavy Truck	89	32	2	5	30	90
Medium Truck	20	11	2	2	12	27
Bus	1	0	0	0	0	0
Motorcycle	1	0	2	0	1	2
Auto + 1-Axle Trlr.	8	5	3	–	–	–
Auto + 2-Axle Trlr.	10	2	2	–	–	–
M.Trk. + 1-Axle Trlr.	2	1	0	–	–	–
M. Trk. + 2-Axle Trlr.	3	2	0	–	–	–

– = Not observed

Block 1	Block 2	Block 3	Block 4	Average
75.5 dBA	75.7 dBA	75.8 dBA	75.2 dBA	**75.6 dBA**

Site: 02
Time-Averaged Wayside Test Information

Sample Period 3 – 3 Blocks @ 15 min ea. = 45 min. (1:30 pm to 2:15 pm, 10/4/06)

Traffic Volumes and Speeds during Sample Period

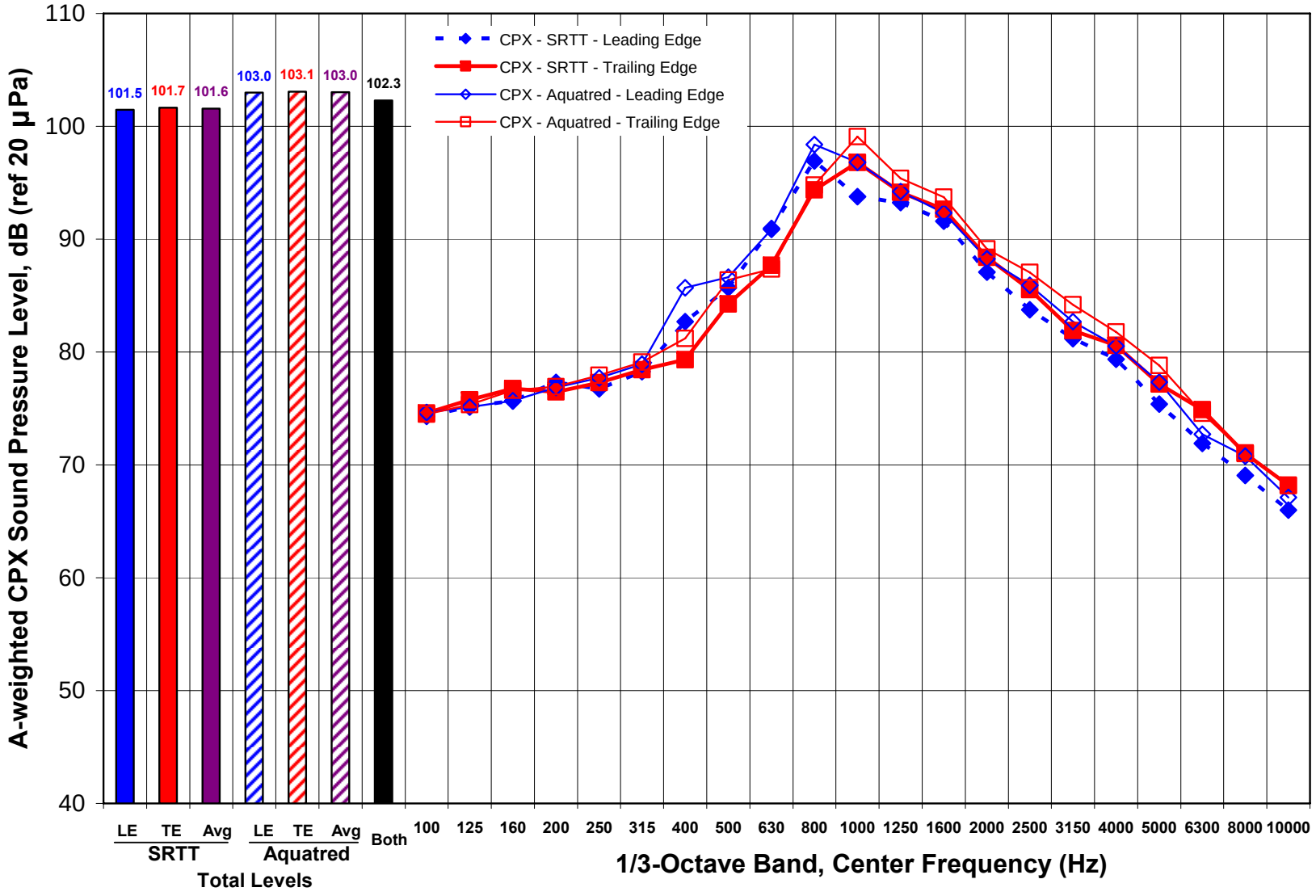
	EB Lane 3 (Outside)	EB Lane 2	EB Lane 1 (Inside)	WB Lane 1 (Inside)	WB Lane 2	WB Lane 3 (Outside)
Distance from Mic (ft.)	50	62	74	131	143	155
Average Speed (mph)		**			**	
Automobile	**	**	**	183	505	168
Heavy Truck	**	**	**	2	24	78
Medium Truck	**	**	**	2	11	19
Bus	**	**	**	0	1	2
Motorcycle	**	**	**	2	1	1
Auto + 1-Axle Trlr.	**	**	**	–	–	–
Auto + 2-Axle Trlr.	**	**	**	–	–	–
M.Trk. + 1-Axle Trlr.	**	**	**	–	–	–
M. Trk. + 2-Axle Trlr.	**	**	**	–	–	–

– = Not observed
** = Traffic volumes and speeds recorded, but not reduced due to consistency in results.

Block 1	Block 2	Block 3	Average
75.9 dBA	75.8 dBA	76.1 dBA	**75.9 dBA**

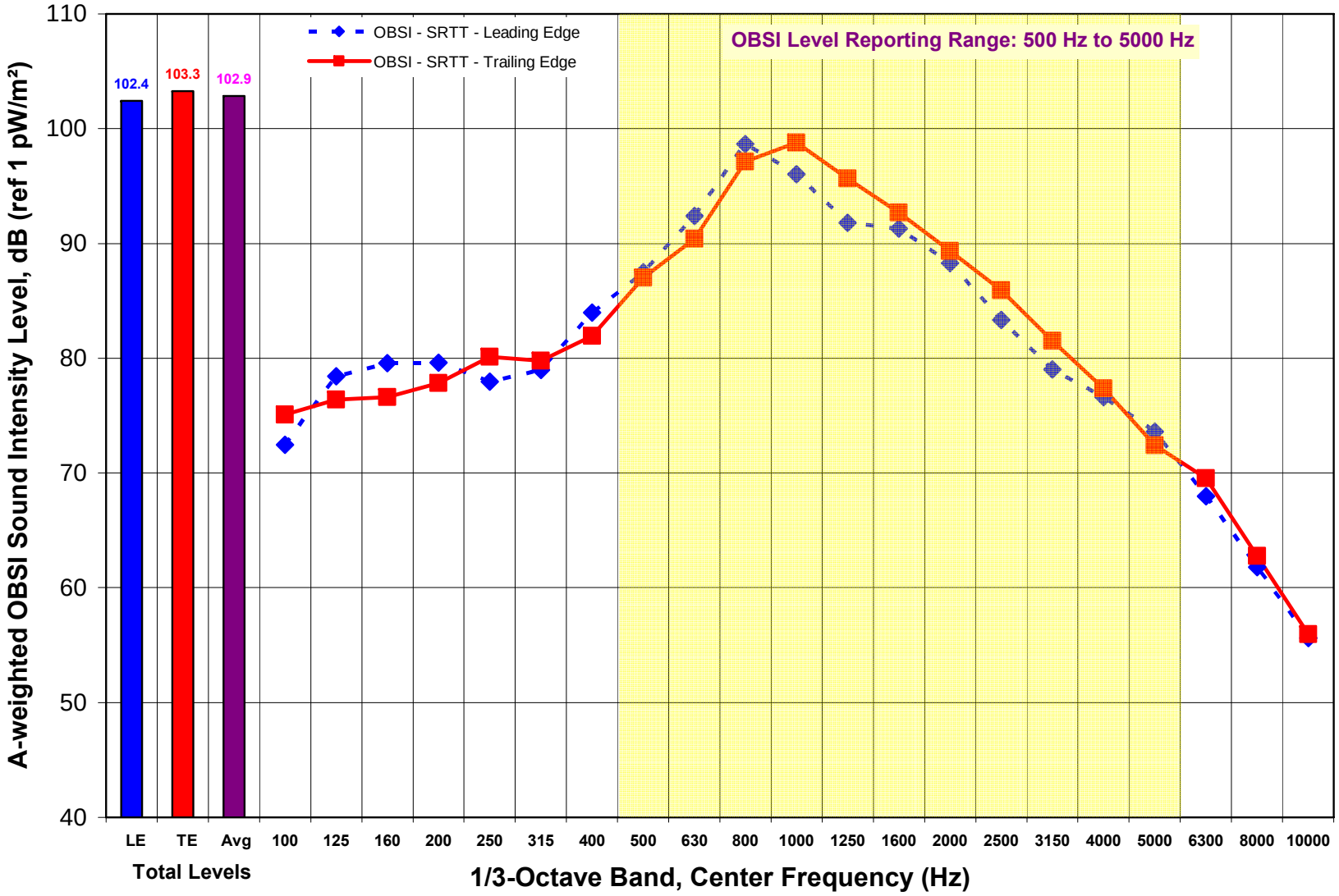
Site: 02

CPX Test Information



Site: 02

OBSI Test Information

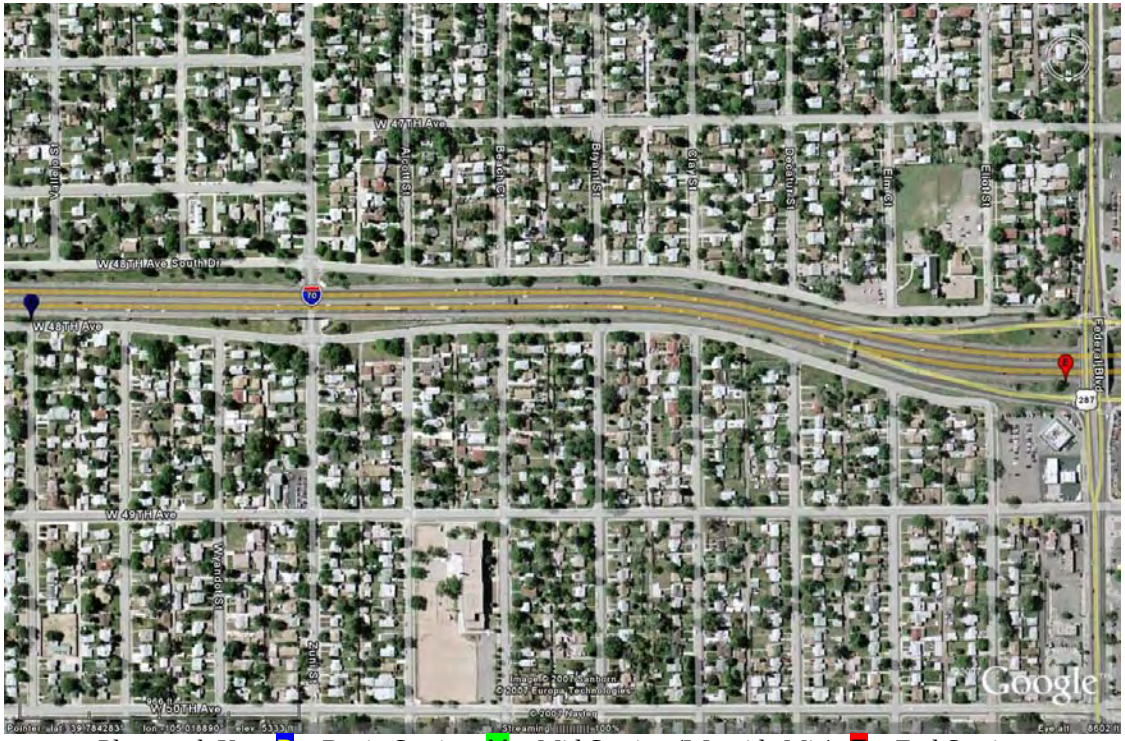


Site: 03
General Information

Highway: Interstate 70, Westbound
Location: Between Federal Blvd. & Pecos St., Denver (80221)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.7841 / 105.0186 / 5330

Nominal Surface: SMA (3/4") **Construction Accepted:** 2003

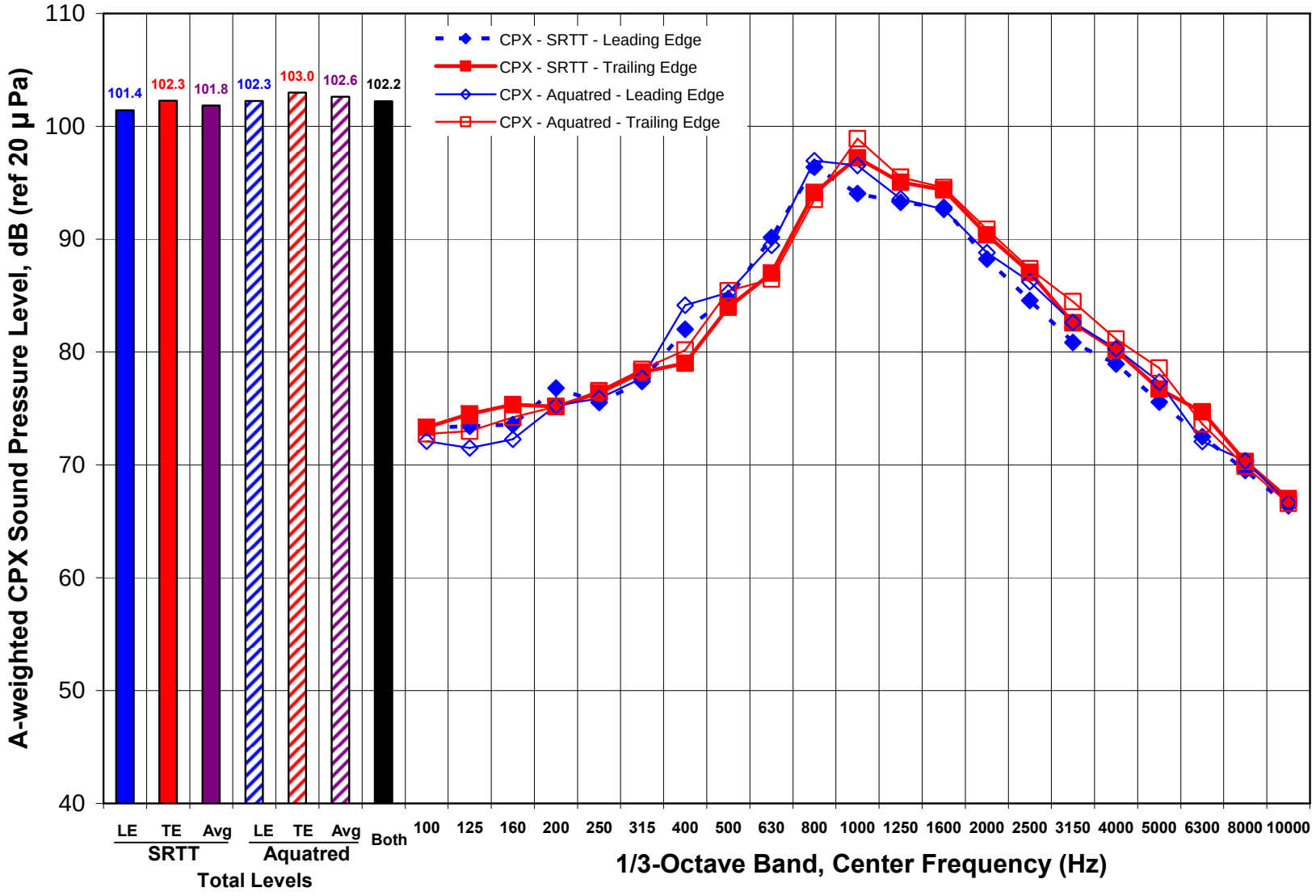
CPX?: Yes (10/29/06) **OBSI?:** Yes (10/29/06) **SPB?:** No **TA?:** No
Total Section Length: 3575 ft.
Distance from Begin to Wayside Microphone: n/a



Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 03

CPX Test Information



Site: 03

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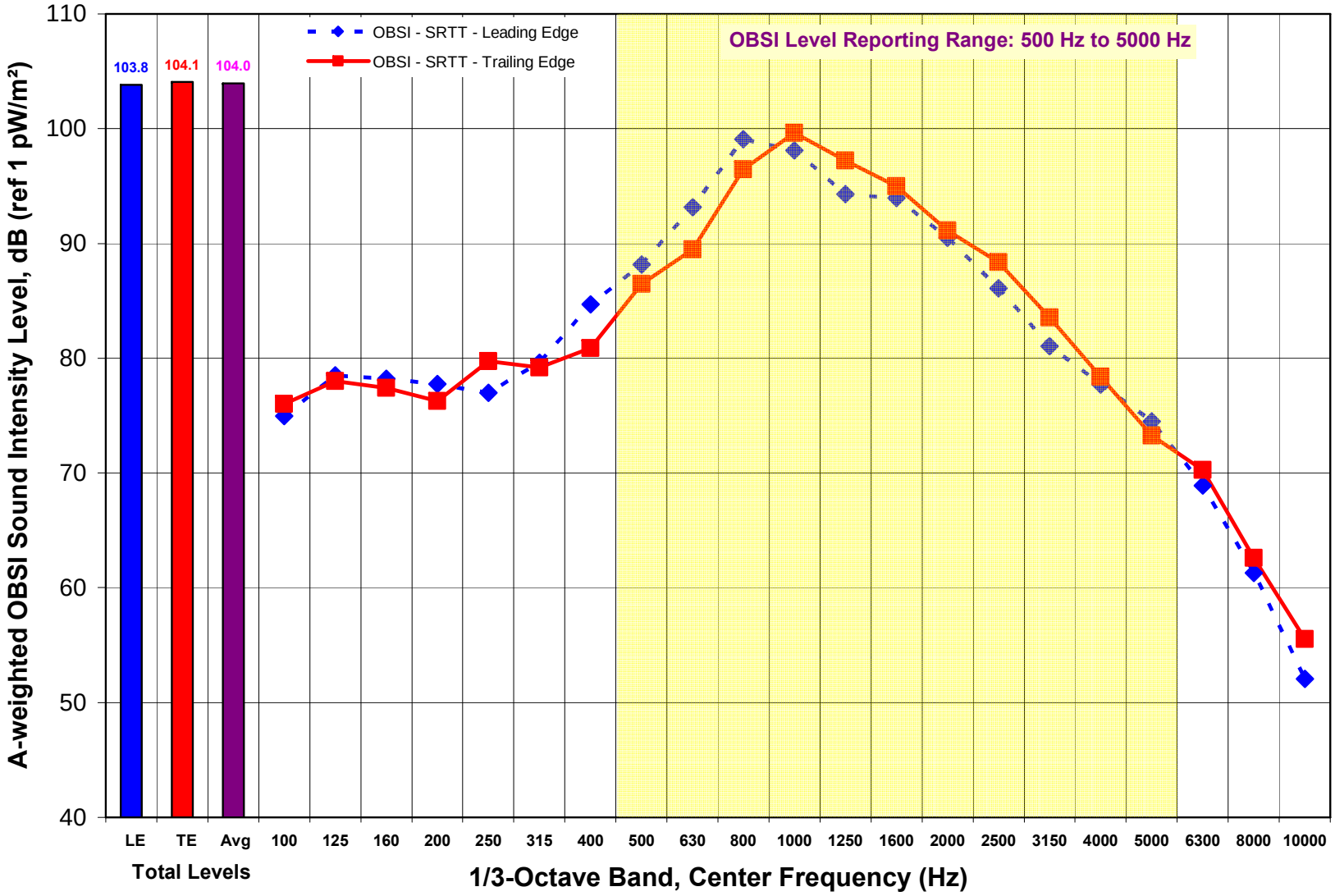


Site: 04
General Information

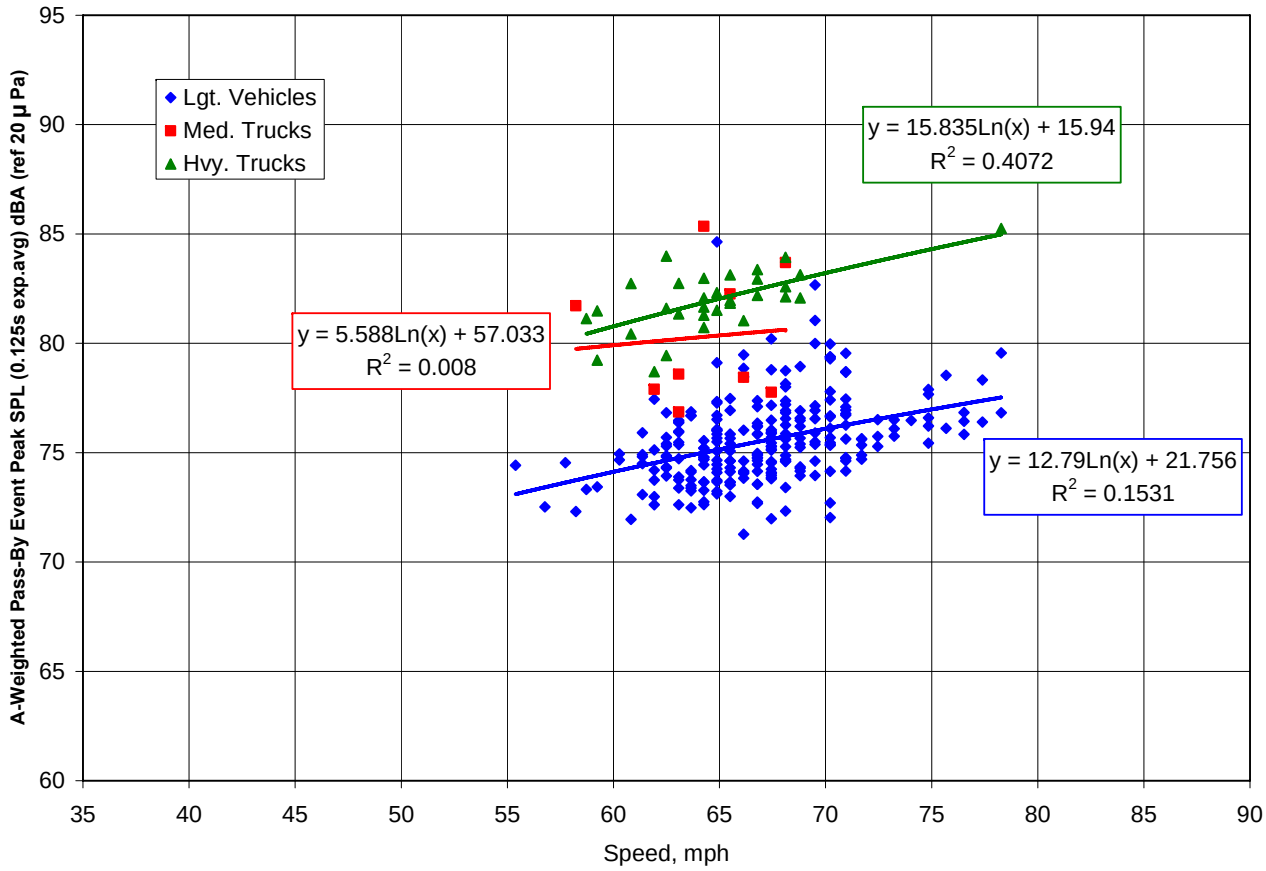
Highway: US Highway 50, Westbound
Location: Between 35 6/10 Rd. & Bridgeport Rd., Grand Junction (81527)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 38.8147 / 108.3385 / 5110

Nominal Surface: SMA (1/2") **Construction Accepted:** 2002

CPX?: Yes (10/2/06) **OBSI?:** Yes (10/2/06) **SPB?:** Yes (10/27/06) **TA?:** No
Total Section Length: 4847 ft.
Distance from Begin to Wayside Microphone: 1422 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

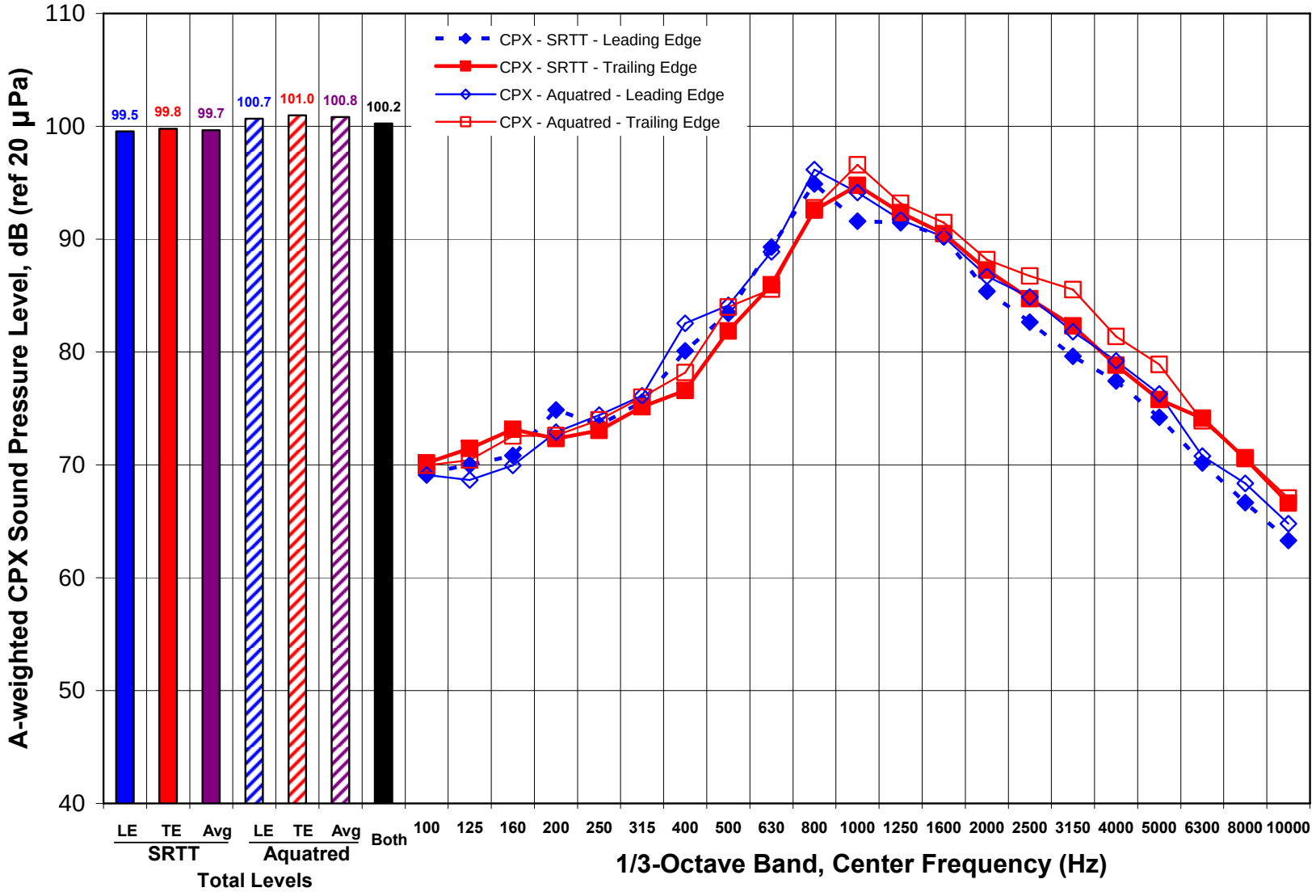
Site: 04
SPB Wayside Test Information



SPBI (Car, 60mph): 74.1 dBA
SPBI (M. Truck, 60mph): 79.9 dBA
SPBI (H. Truck, 60mph): 80.8 dBA

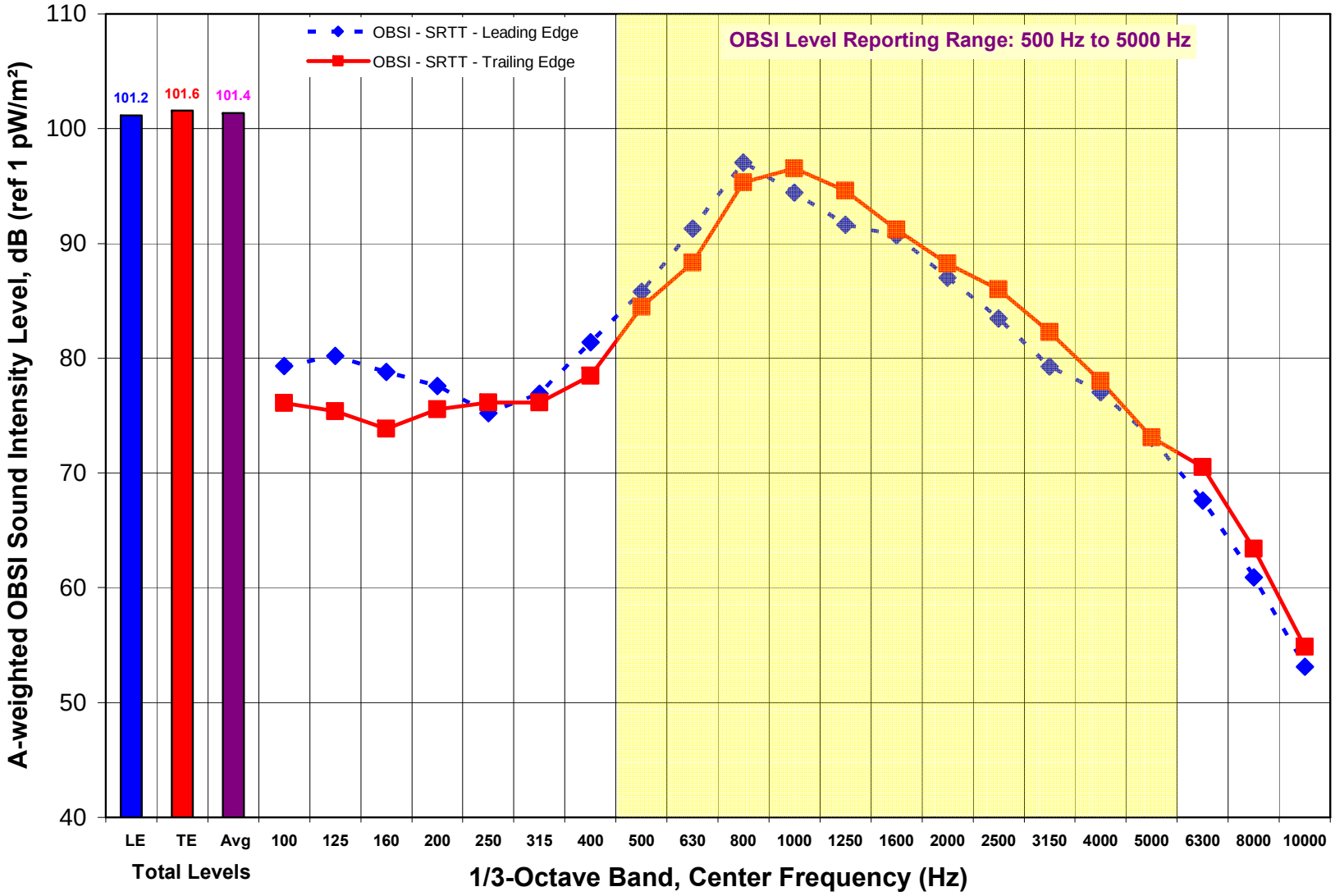
Site: 04

CPX Test Information



Site: 04

OBSI Test Information

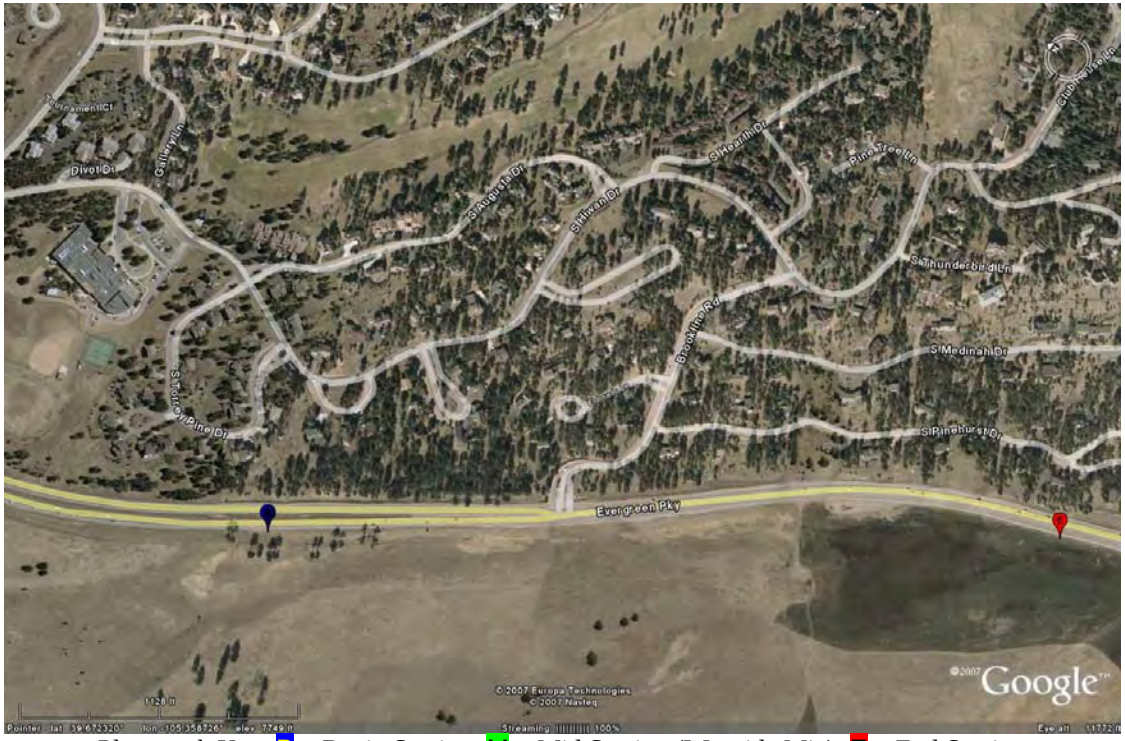


Site: 05
General Information

Highway: State Highway 74, Eastbound
Location: Between Bergen Pkwy. & Lewis Ridge Rd., Evergreen (80439)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.2861 / 107.1376 / 7680

Nominal Surface: SMA (3/8") **Construction Accepted:** 2004

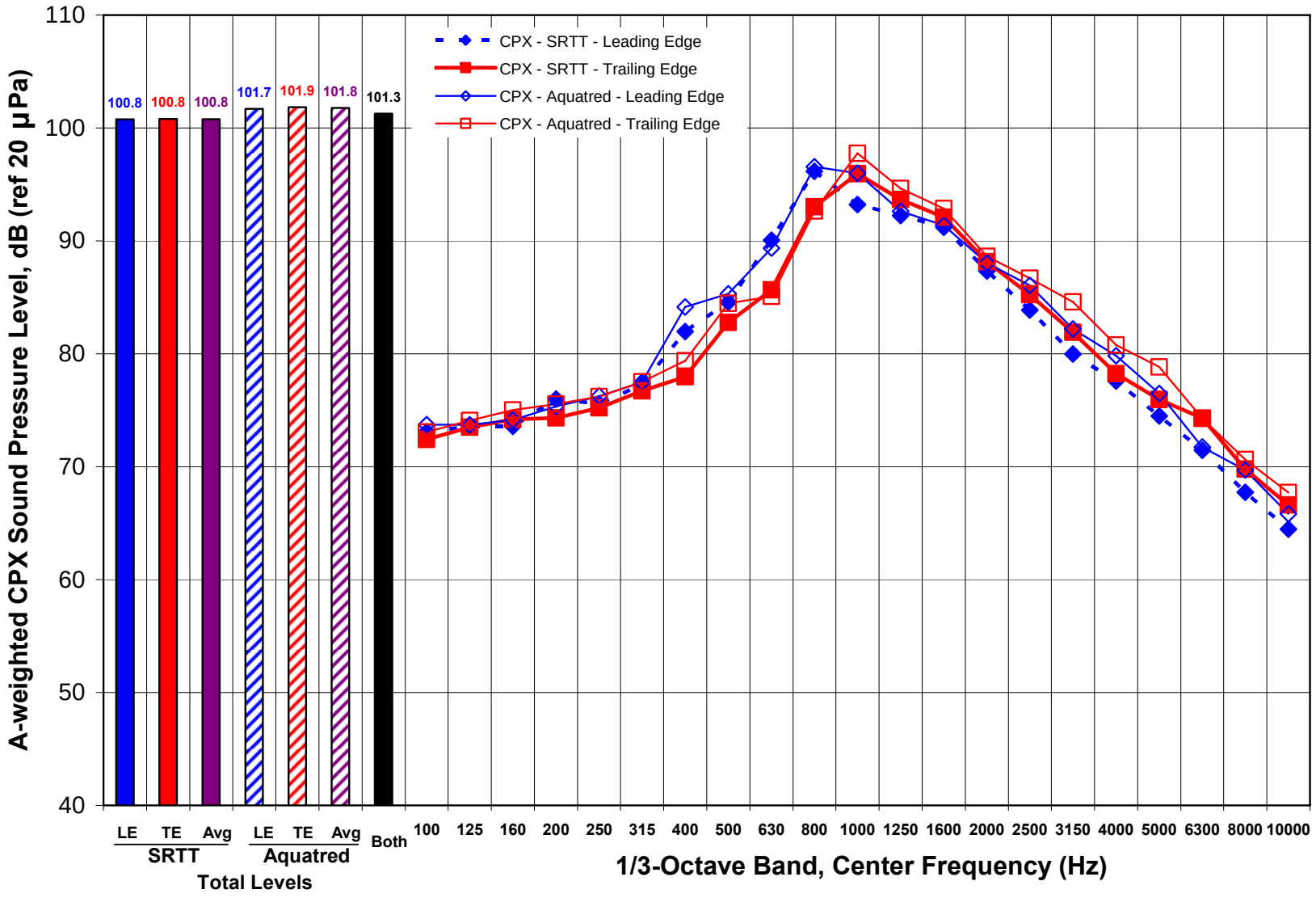
CPX?: Yes (10/11/06) **OBSI?:** Yes (10/11/06) **SPB?:** No **TA?:** No
Total Section Length: 3488 ft.
Distance from Begin to Wayside Microphone: n/a



Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

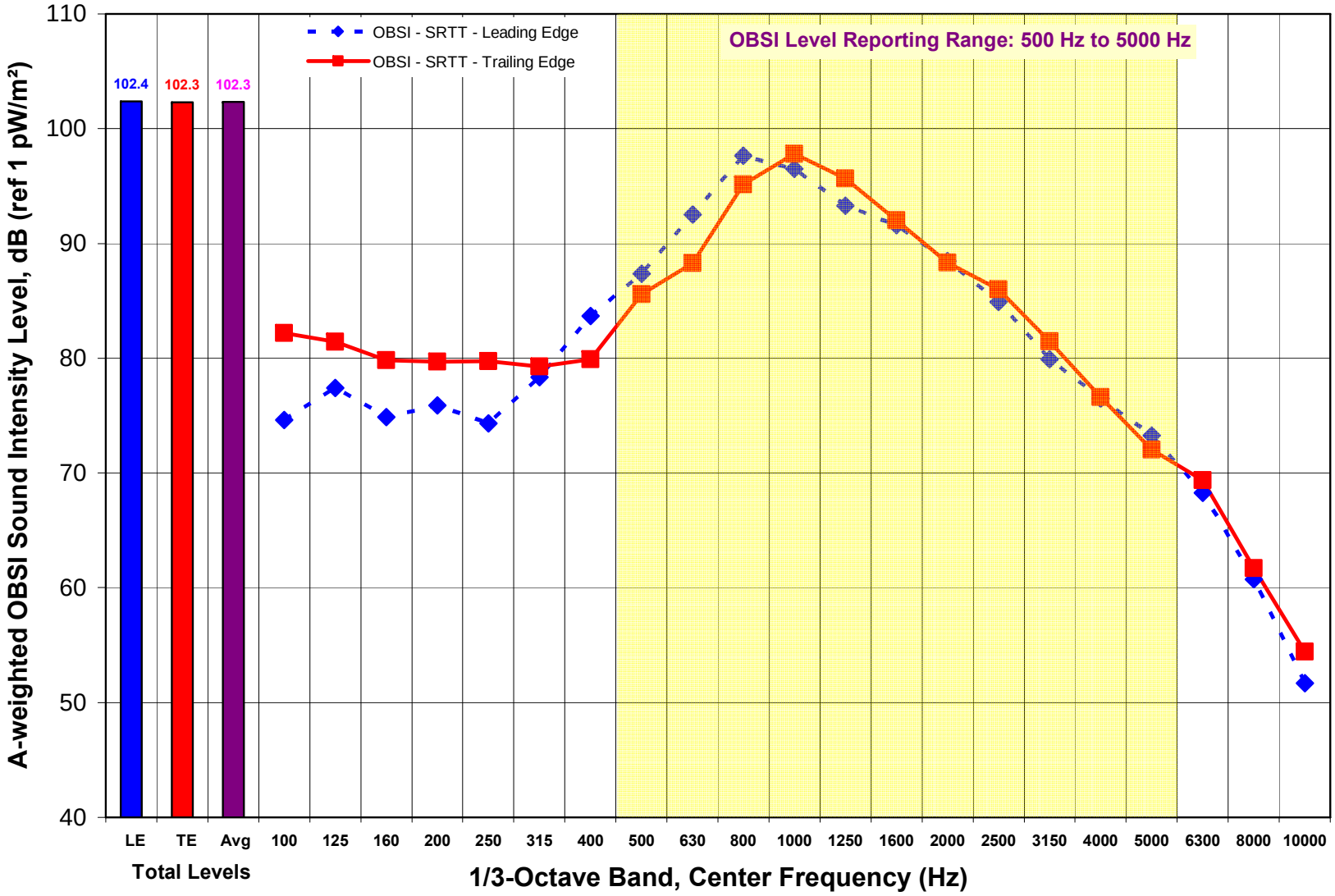
Site: 05

CPX Test Information



Site: 05

OBSI Test Information

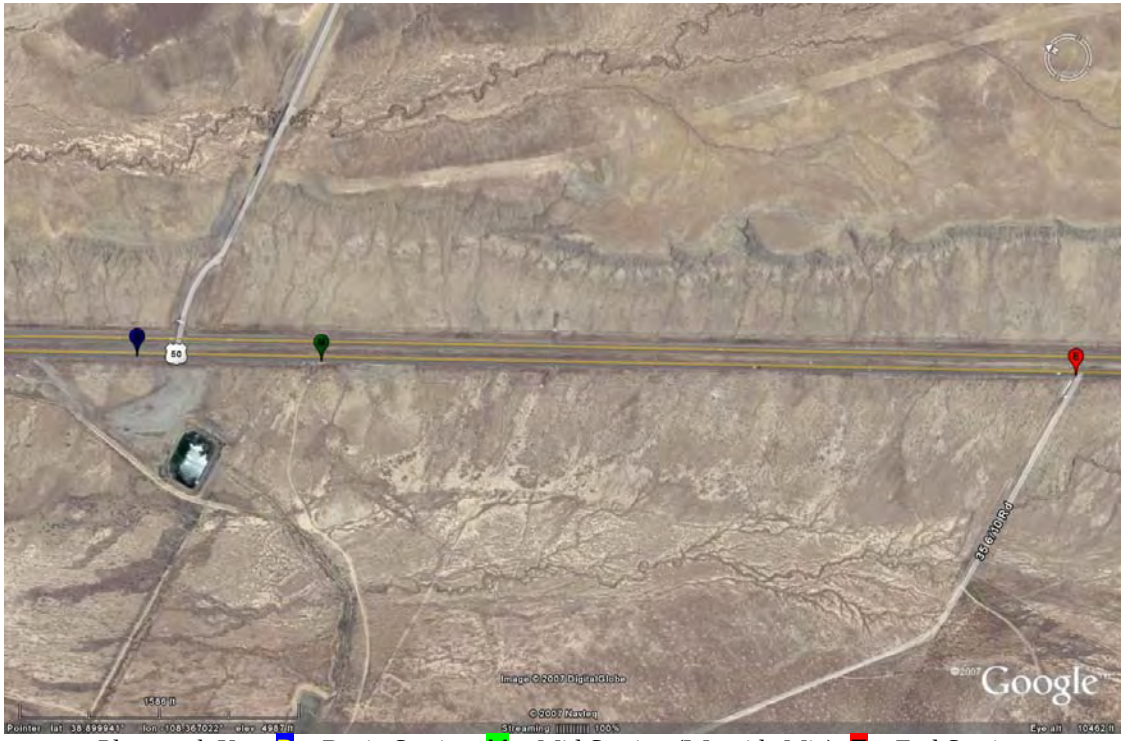


Site: 06
General Information

Highway: US Highway 50, Eastbound
Location: Between 35 6/10 Rd. & Bridgeport Rd., Grand Junction (81527)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 38.8994 / 108.3666 / 5010

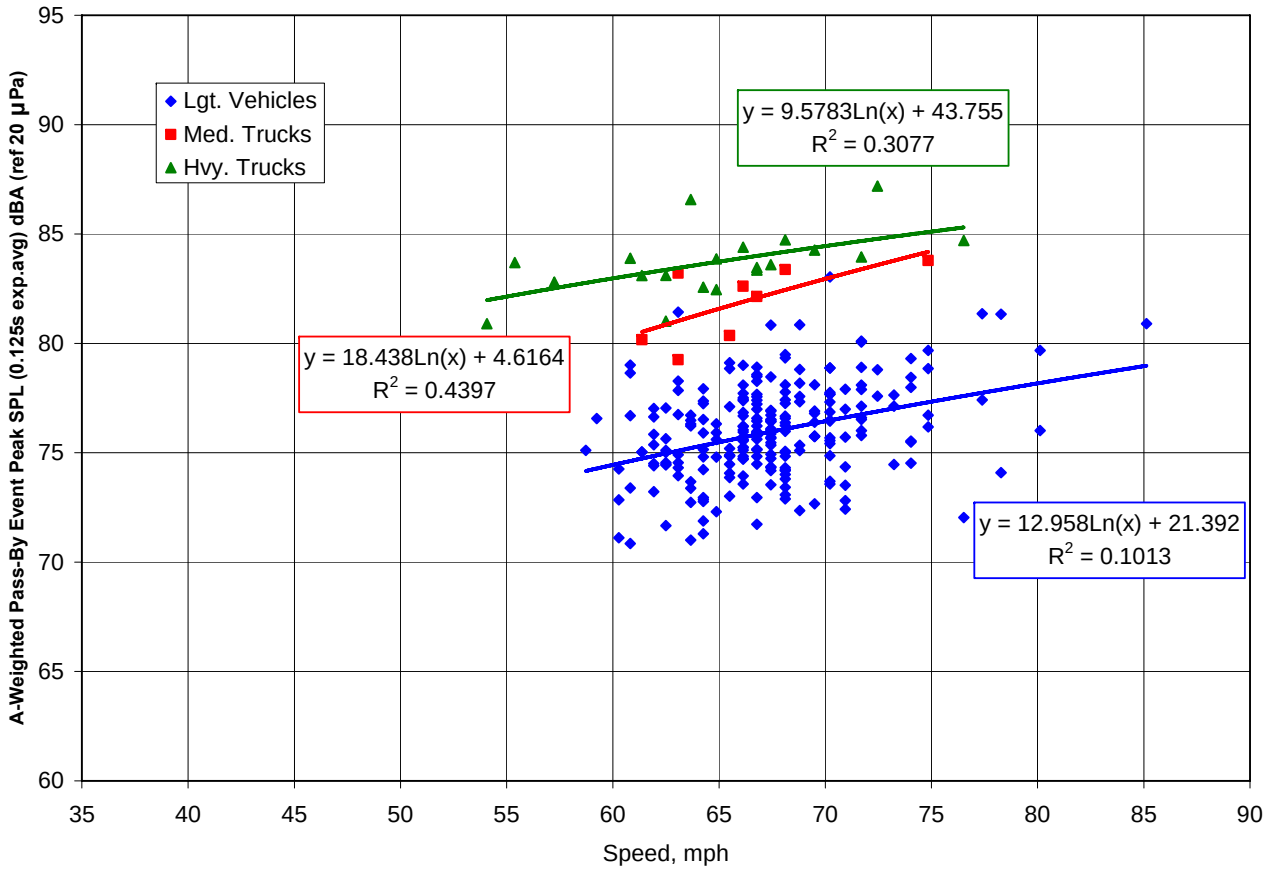
Nominal Surface: Asphalt (SX, 1/2") **Construction Accepted:** 2002

CPX?: Yes (10/2/06) **OBSI?:** Yes (10/2/06) **SPB?:** Yes (10/28/06) **TA?:** No
Total Section Length: 5333 ft.
Distance from Begin to Wayside Microphone: 1048 ft.



Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

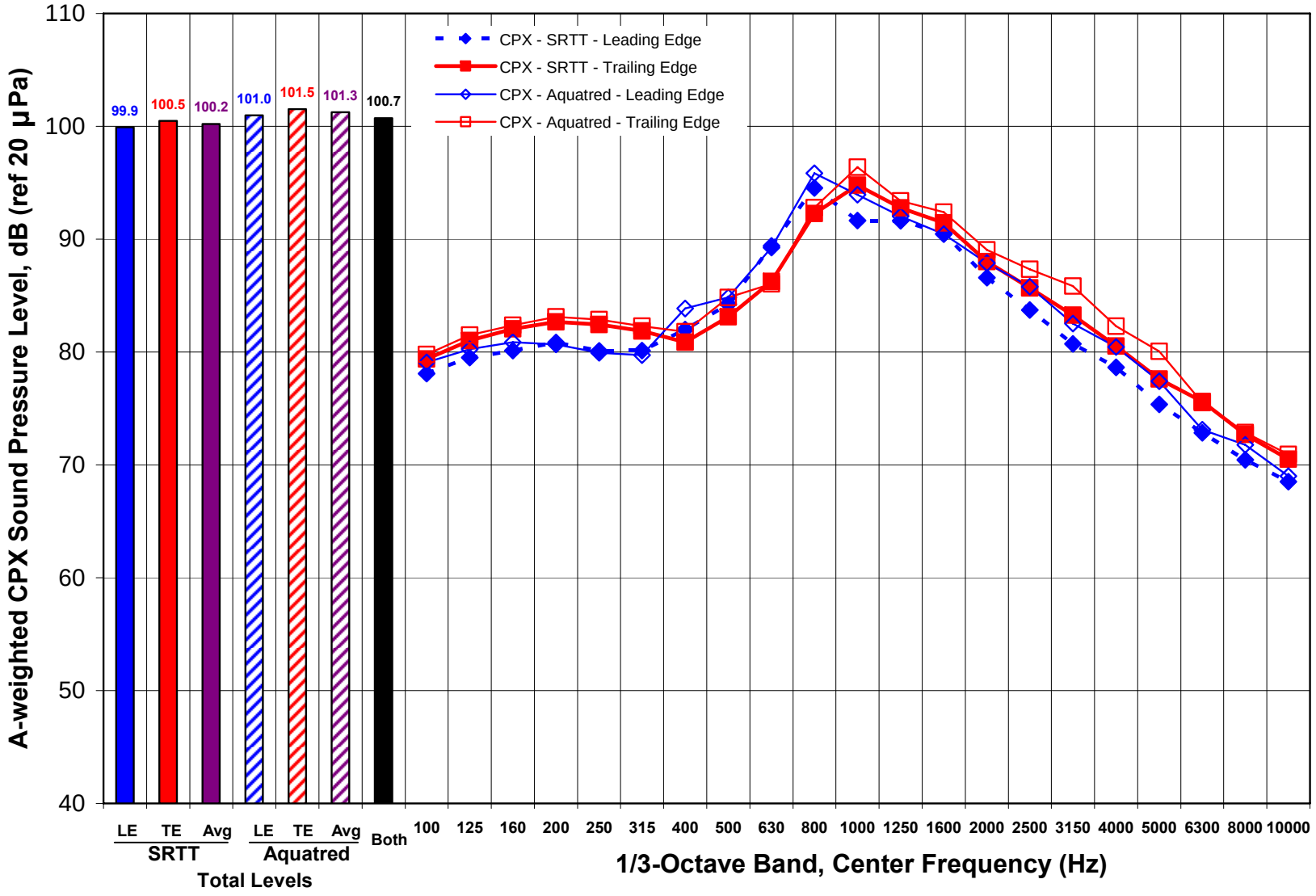
Site: 06
SPB Wayside Test Information



SPBI (Car, 60mph): 74.4 dBA
SPBI (M. Truck, 60mph): 80.1 dBA
SPBI (H. Truck, 60mph): 83.0 dBA

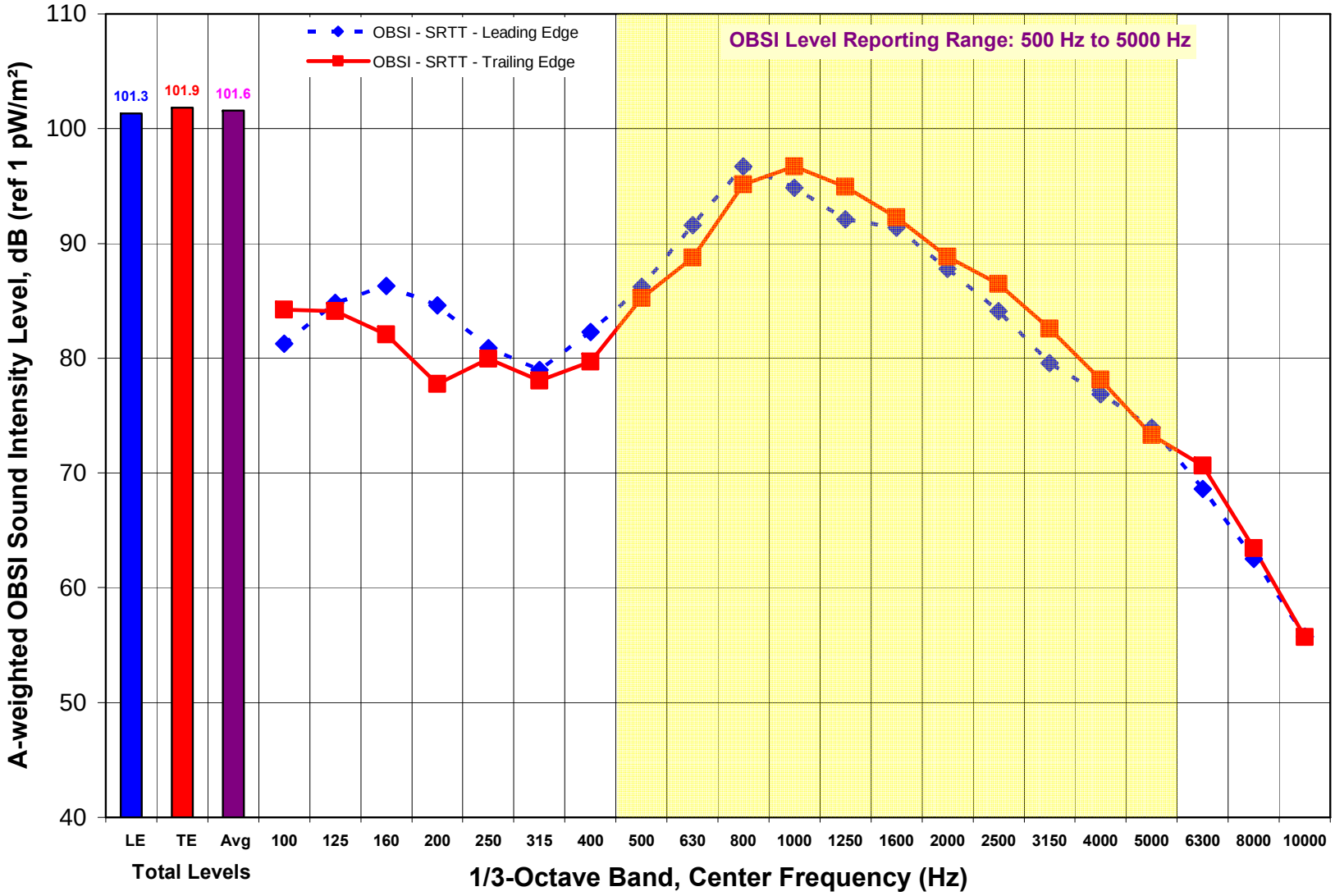
Site: 06

CPX Test Information



Site: 06

OBSI Test Information



Site: 07
General Information

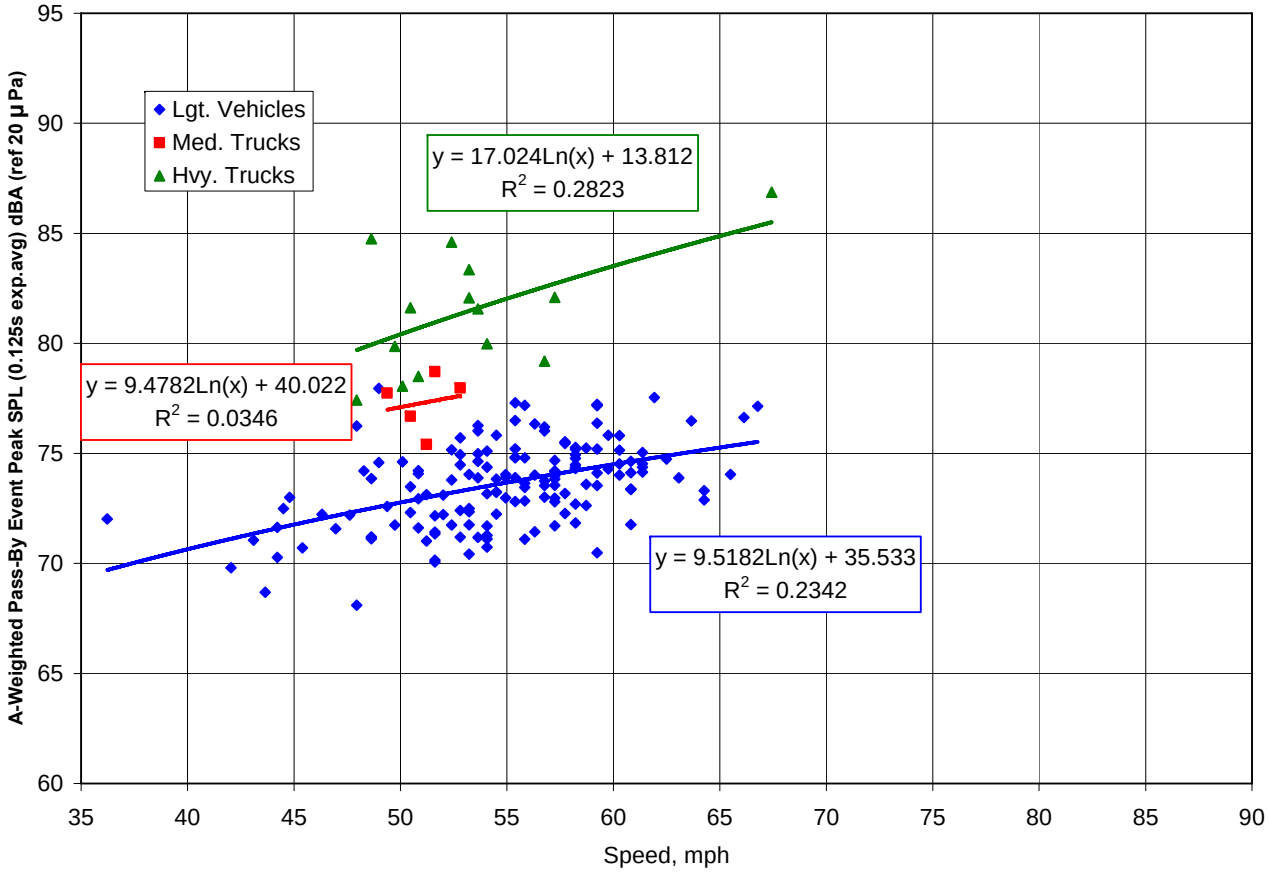
Highway: US Highway 85, Southbound
Location: Between Daniels Park Rd. & Happy Canyon Rd., Sedalia (80135)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.4288 / 104.9111 / 6000

Nominal Surface: Asphalt (SX, 1/2") **Construction Accepted:** 2006

CPX?: Yes (10/31/06) **OBSI?:** Yes (10/31/06) **SPB?:** Yes (11/1/06) **TA?:** No
Total Section Length: 2686 ft.
Distance from Begin to Wayside Microphone: 1864 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

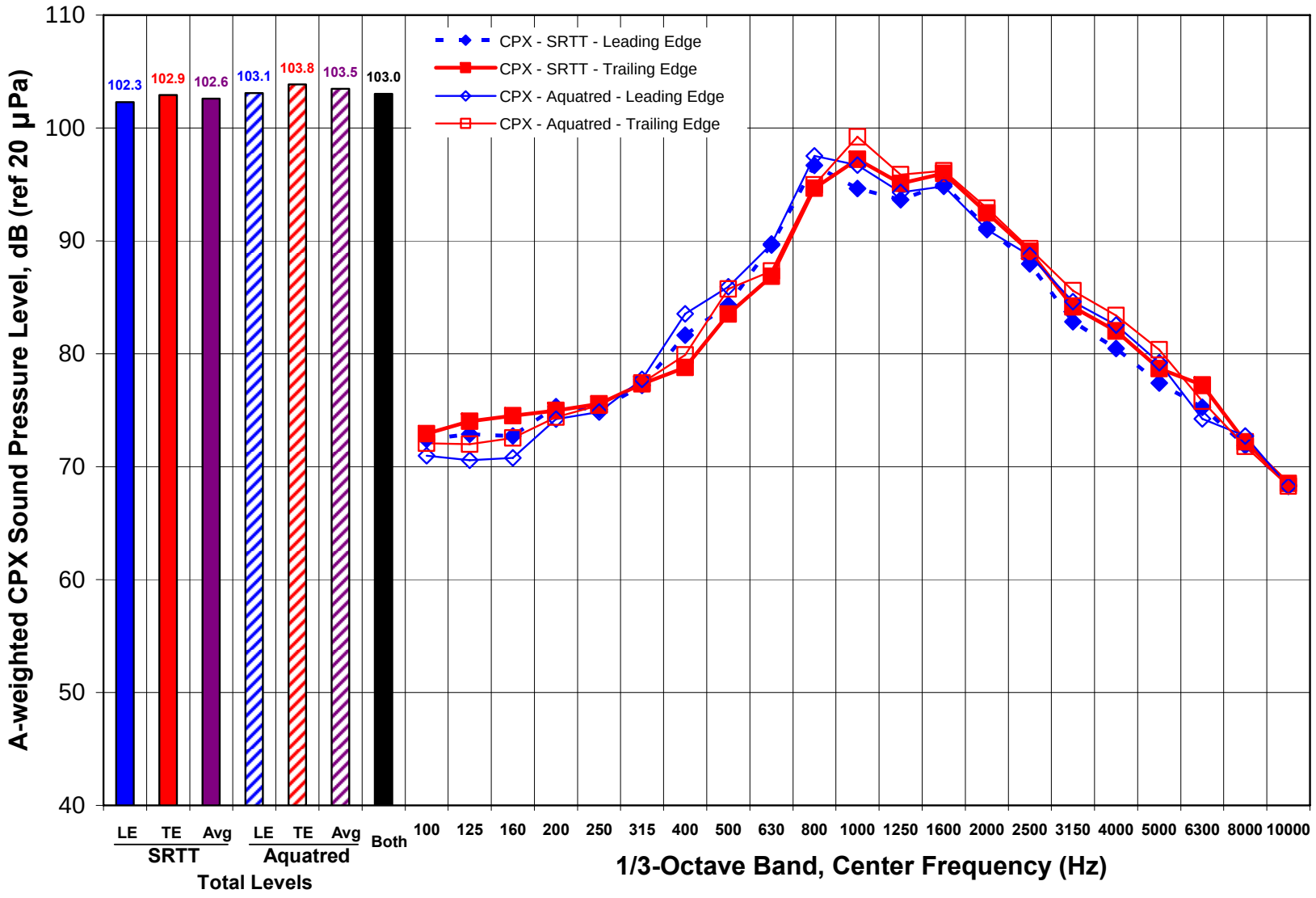
Site: 07
SPB Wayside Test Information



SPBI (Car, 60mph): 74.5 dBA
SPBI (M. Truck, 60mph): 78.8 dBA
SPBI (H. Truck, 60mph): 83.5 dBA

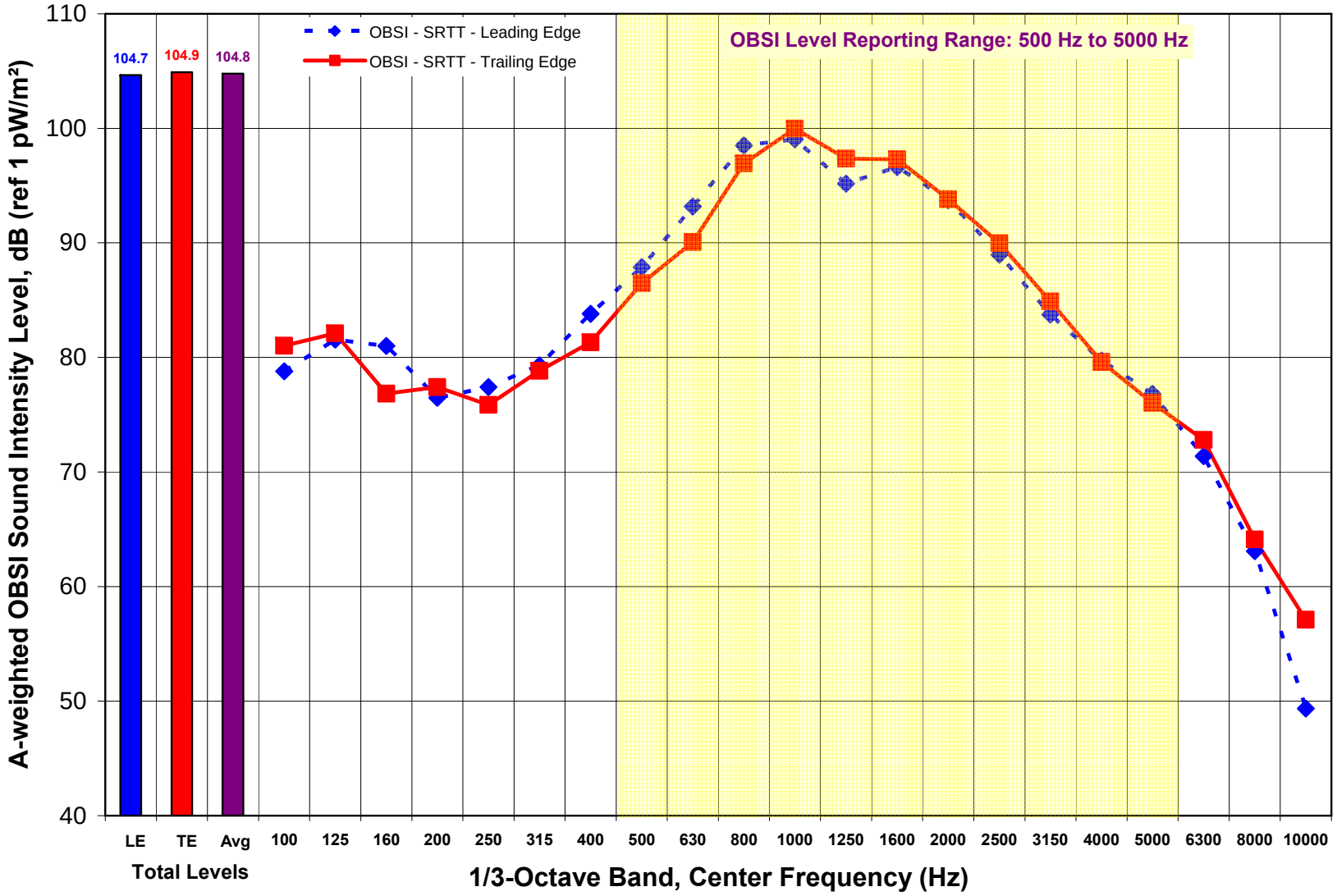
Site: 07

CPX Test Information



Site: 07

OBSI Test Information



Site: 08
General Information

Highway: Interstate 70, Eastbound
Location: Between US 6 & Herman Gulch Rd., Bakerville (E of Dillon) (80444)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.6976 / 105.8703 / 10470

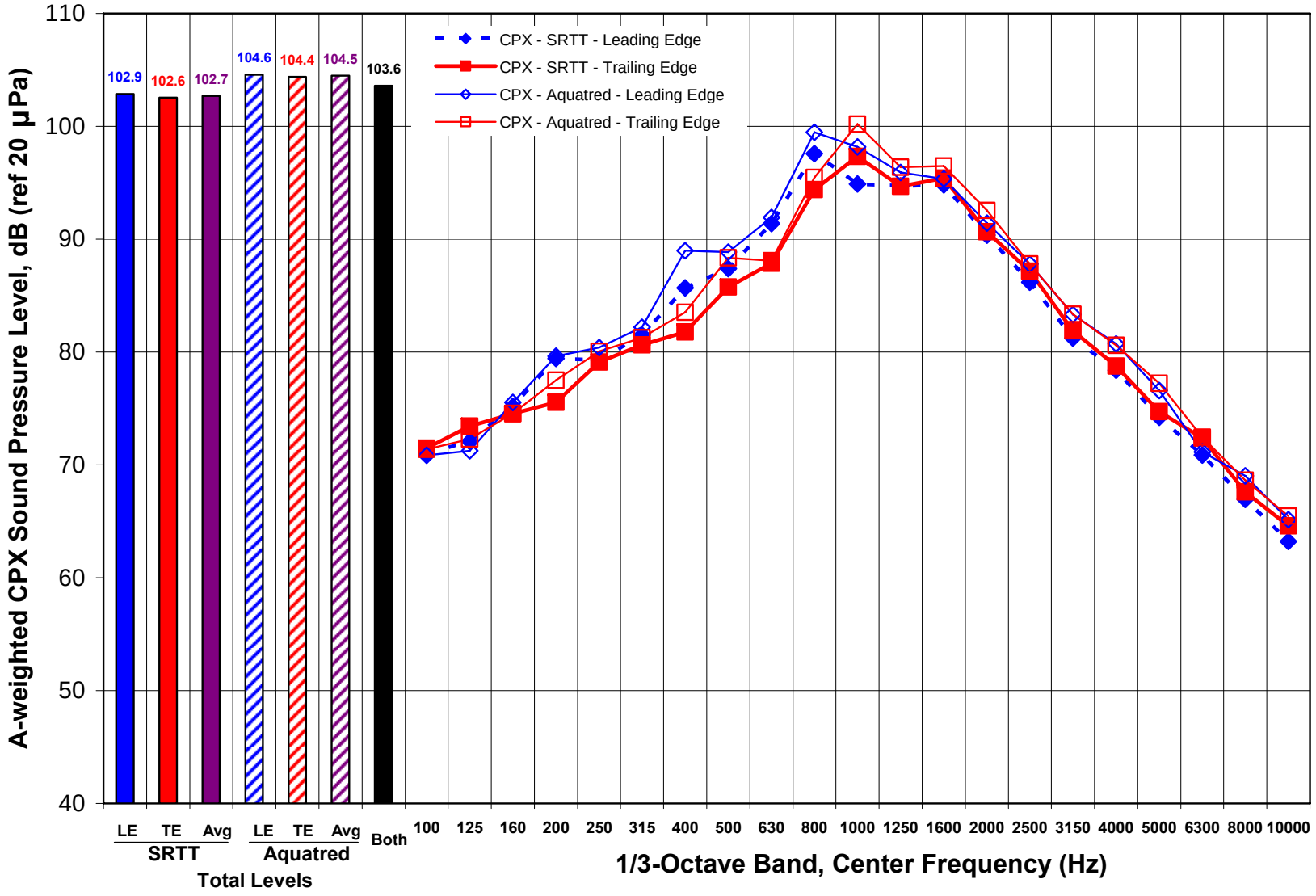
Nominal Surface: Asphalt (SX, 1/2") **Construction Accepted:** 2005

CPX?: Yes (9/26/06) **OBSI?:** Yes (9/26/06) **SPB?:** No **TA?:** No
Total Section Length: 3535 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

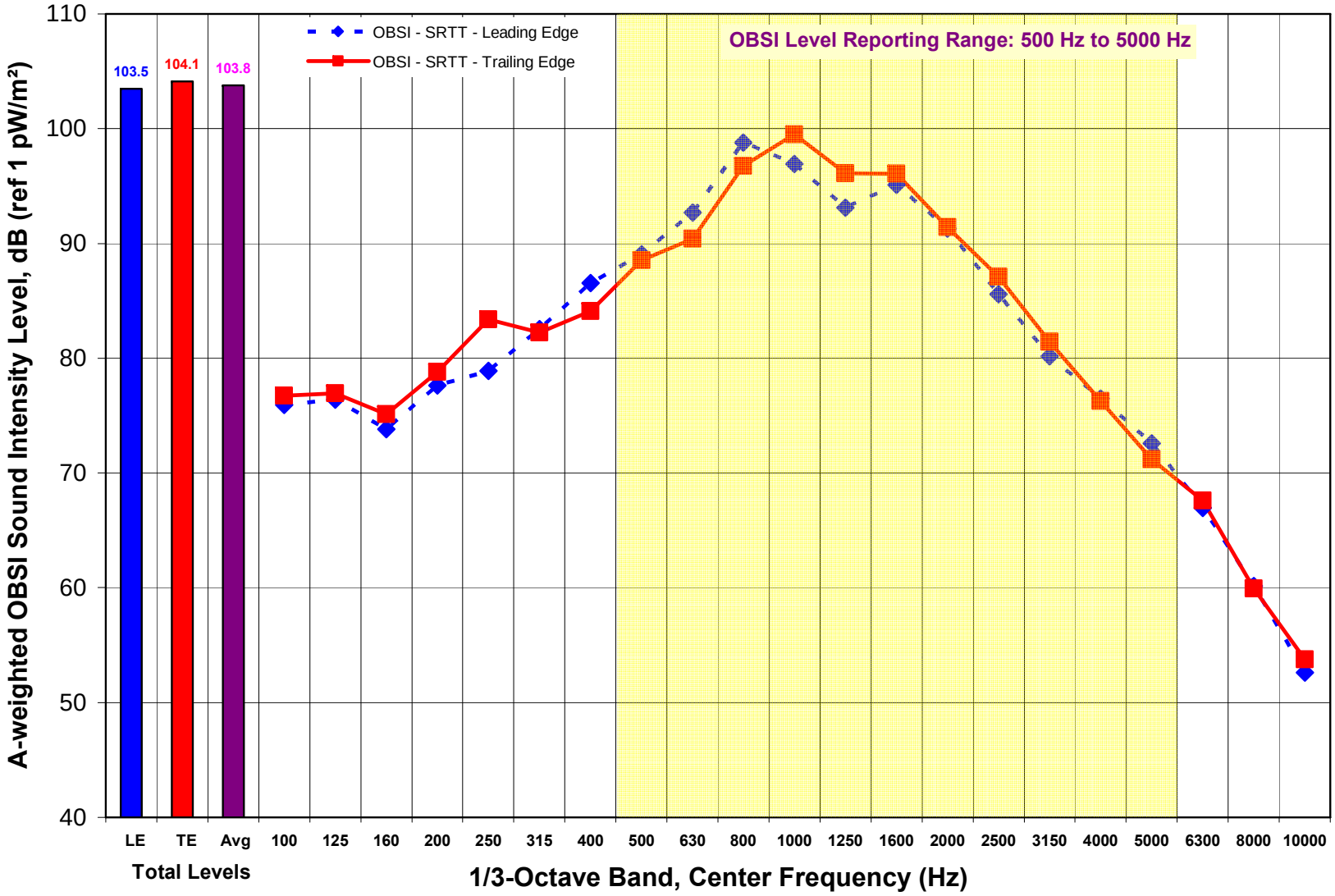
Site: 08

CPX Test Information



Site: 08

OBSI Test Information



Site: 09
General Information

Highway: Highway C-470, Westbound (Northbound)
Location: Between US 285 & Morrison Rd., Morrison (80465)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.641 / 105.1723 / 5760

Nominal Surface: SMA (1/2”) **Construction Accepted:** 2006

CPX?: Yes (10/6/06) **OBSI?:** Yes (10/6/06) **SPB?:** No **TA?:** Yes (10/7/06)
Total Section Length: 3033 ft.
Distance from Begin to Wayside Microphone: 2460 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 09
Time-Averaged Wayside Test Information

Sampling Periods: 2

Sample Period 1 – 5 Blocks @ 15 min ea. = 75 min. (9:30 am to 10:45 am, 10/7/06)

Traffic Volumes and Speeds during Sample Period

	WB Lane 3 (Outside)	WB Lane 2	WB Lane 1 (Inside)	EB Lane 1 (Inside)	EB Lane 2	EB Lane 3 (Outside)
Distance from Mic (ft.)	50	62	74	121	133	145
Average Speed (mph)	71			73		
Automobile	554	1569	1413	789	1200	379
Heavy Truck	2	59	19	6	45	5
Medium Truck	5	23	2	6	15	6
Bus	0	8	2	0	1	0
Motorcycle	25	25	16	60	99	8
Auto + 1-Axle Trlr.	5	23	8	4	10	9
Auto + 2-Axle Trlr.	7	15	7	1	9	3
M.Trk. + 1-Axle Trlr.	0	0	0	1	0	1
M. Trk. + 2-Axle Trlr.	6	8	0	1	8	1

– = Not observed

Block 1	Block 2	Block 3	Block 4	Block 5	Average
75.9 dBA	75.8 dBA	75.6 dBA	75.7 dBA	75.3 dBA	**75.7 dBA**

Site: 09
Time-Averaged Wayside Test Information

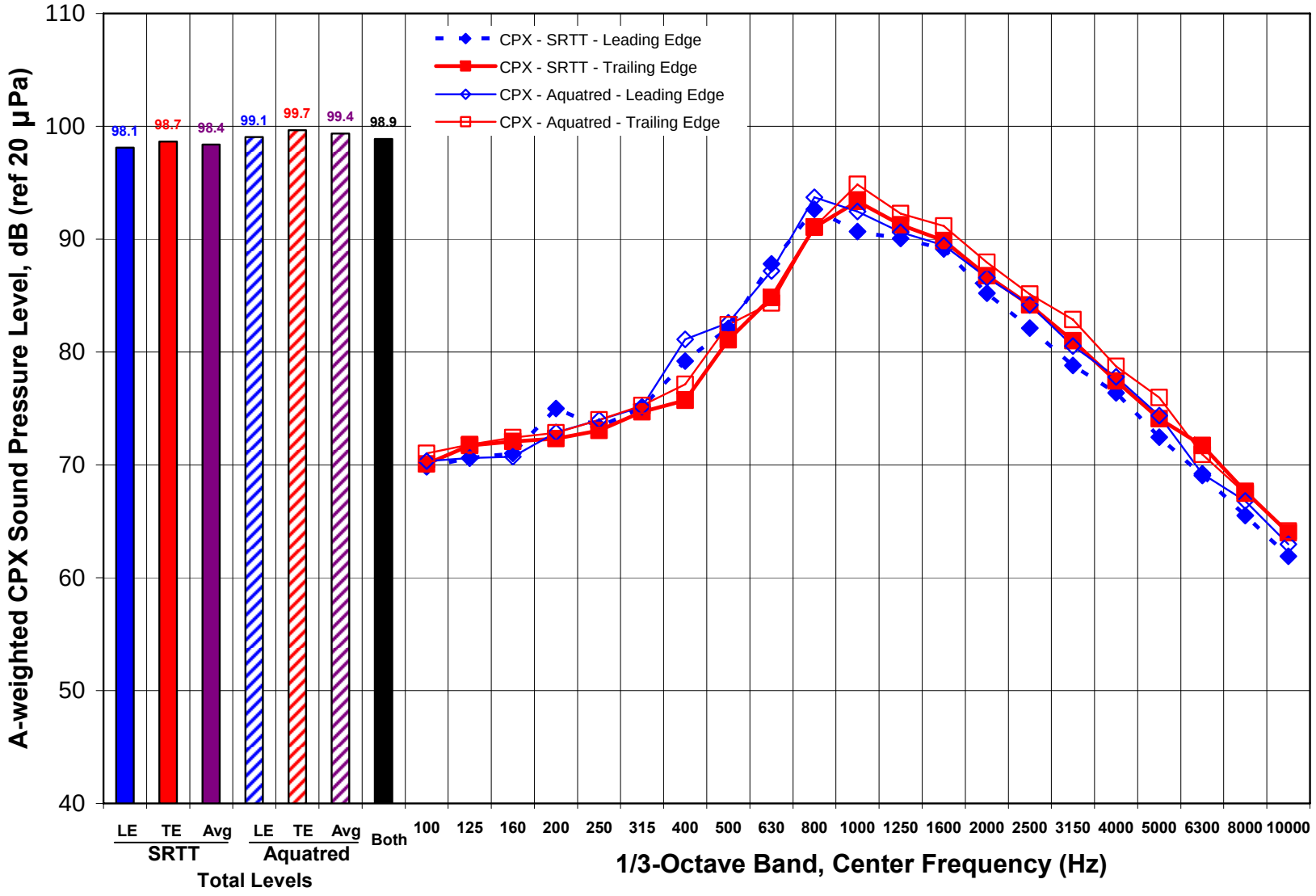
Sample Period 2 – 5 Blocks @ 15 min ea. = 75 min. (11:15 am to 12:30 pm, 10/7/06)

Traffic volumes and speeds recorded, but not reduced.

Block 1	Block 2	Block 3	Block 4	Block 5	Average
75.8 dBA	75.5 dBA	74.9 dBA	74.1 dBA	73.4 dBA	**74.7 dBA**

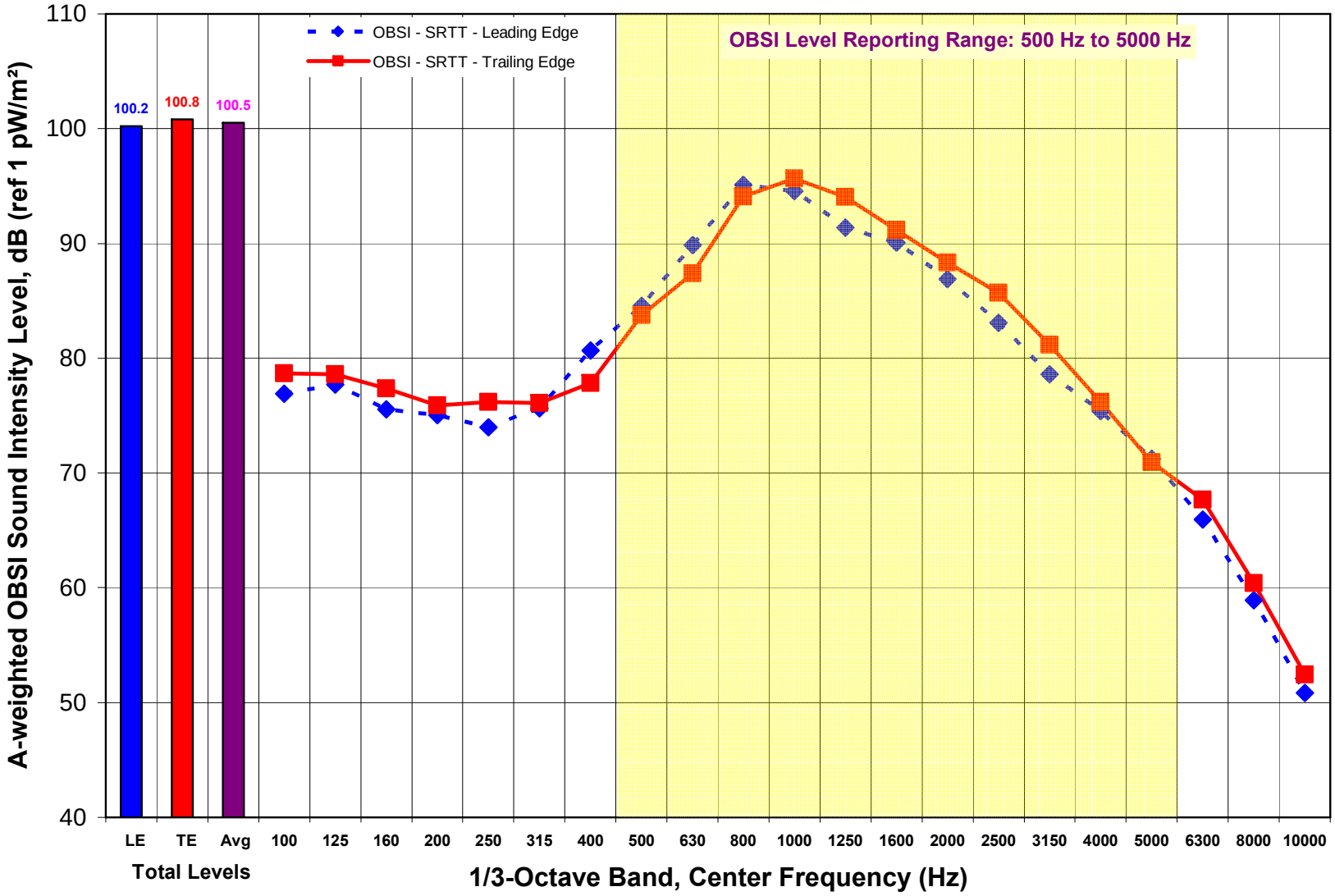
Site: 09

CPX Test Information



Site: 09

OBSI Test Information



Site: 10
General Information

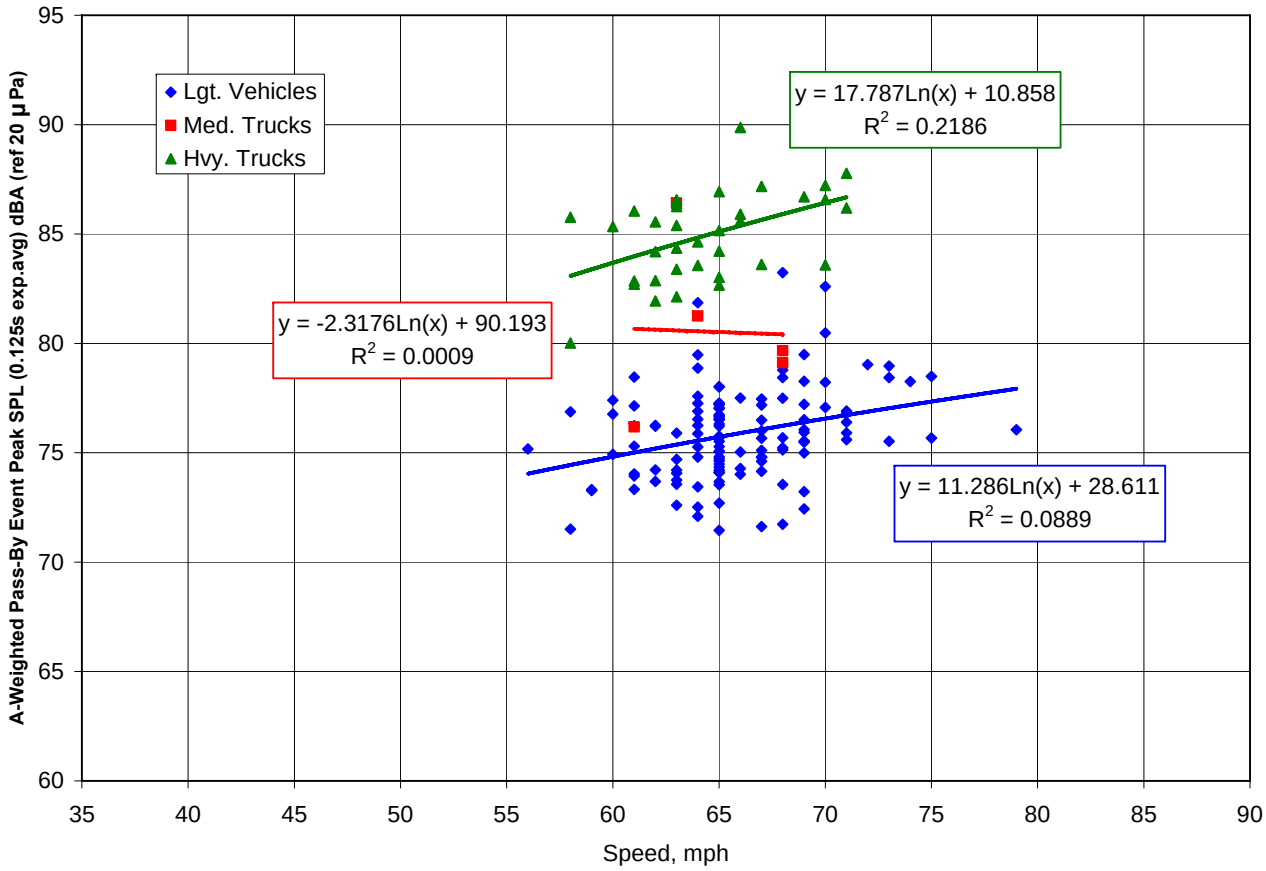
Highway: US Highway 287, Southbound
Location: Between Bonner Spring Ranch Rd. & SH 14, Laporte (80535)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 40.7113 / 105.173 / 5470

Nominal Surface: Asphalt (S, 3/4") **Construction Accepted:** 2003

CPX?: Yes (11/8/06) **OBSI?:** Yes (11/8/06) **SPB?:** Yes (11/7-8/06) **TA?:** No
Total Section Length: 3380 ft.
Distance from Begin to Wayside Microphone: 2649 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

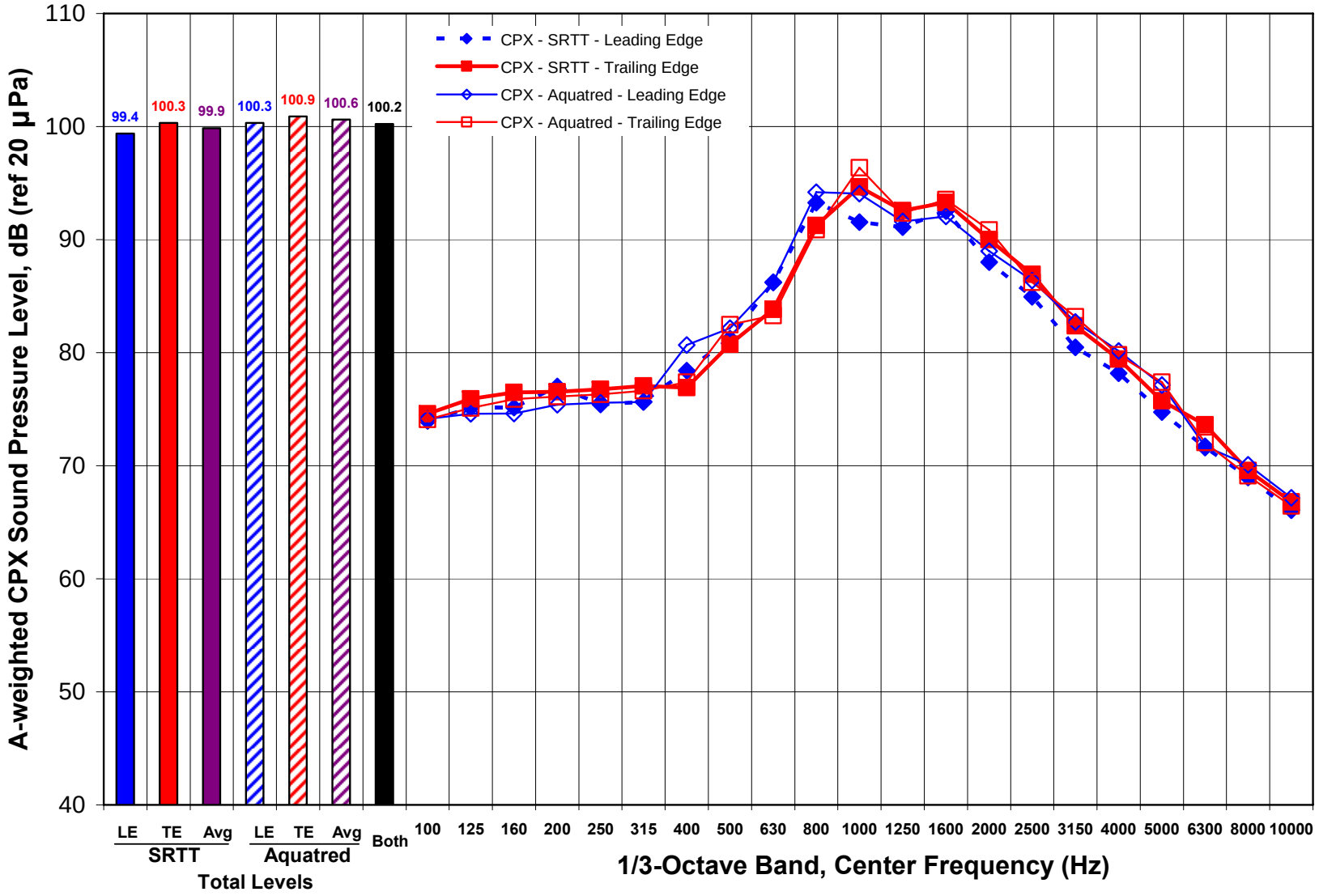
Site: 10
SPB Wayside Test Information



SPBI (Car, 60mph): 74.8 dBA
SPBI (M. Truck, 60mph): 80.7 dBA
SPBI (H. Truck, 60mph): 83.7 dBA

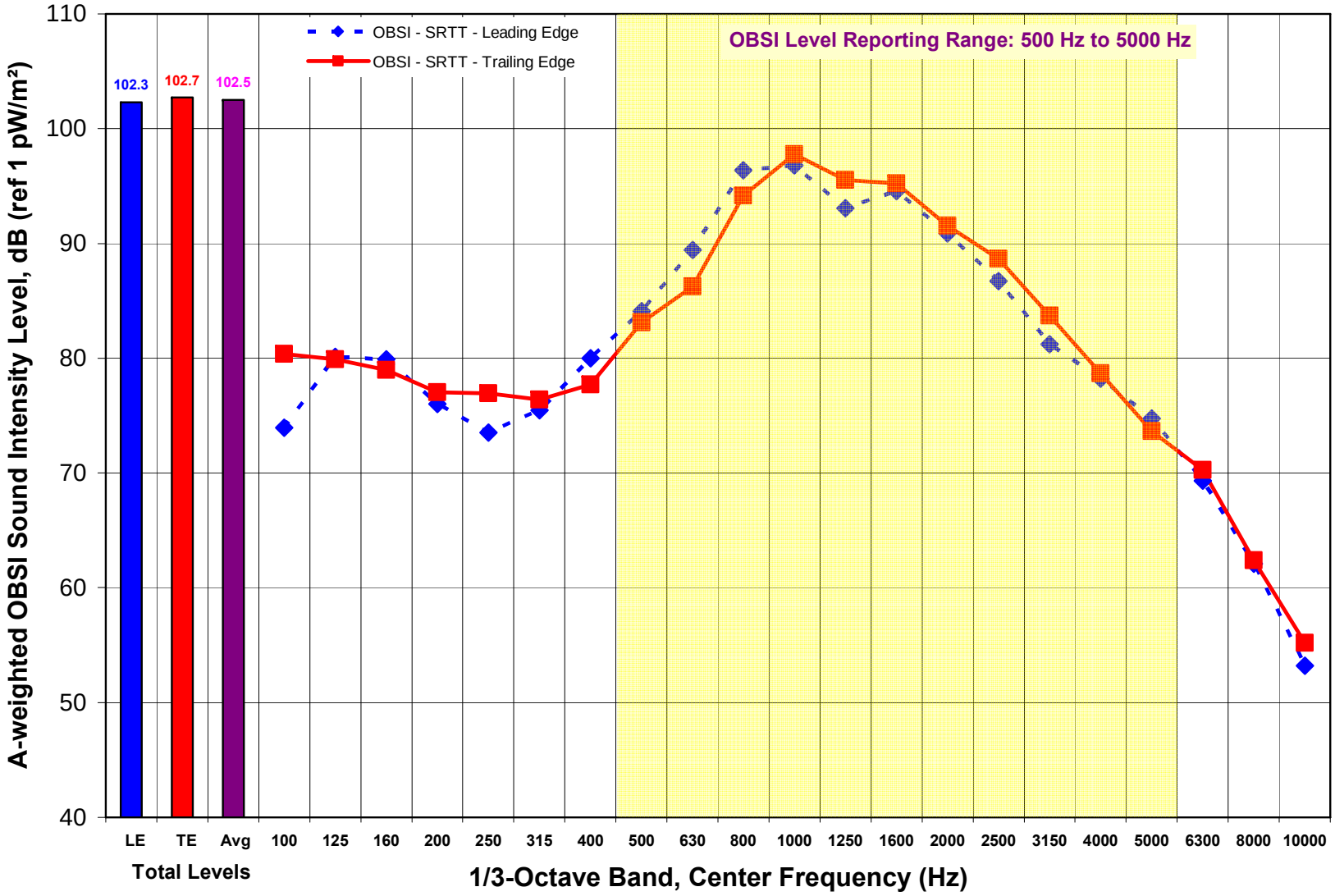
Site: 10

CPX Test Information



Site: 10

OBSI Test Information



Site: 11
General Information

Highway: State Highway 82, Eastbound
Location: Between Hunter Logan & Lower River Rd., Basalt (81654)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.3389 / 106.9989 / 6880

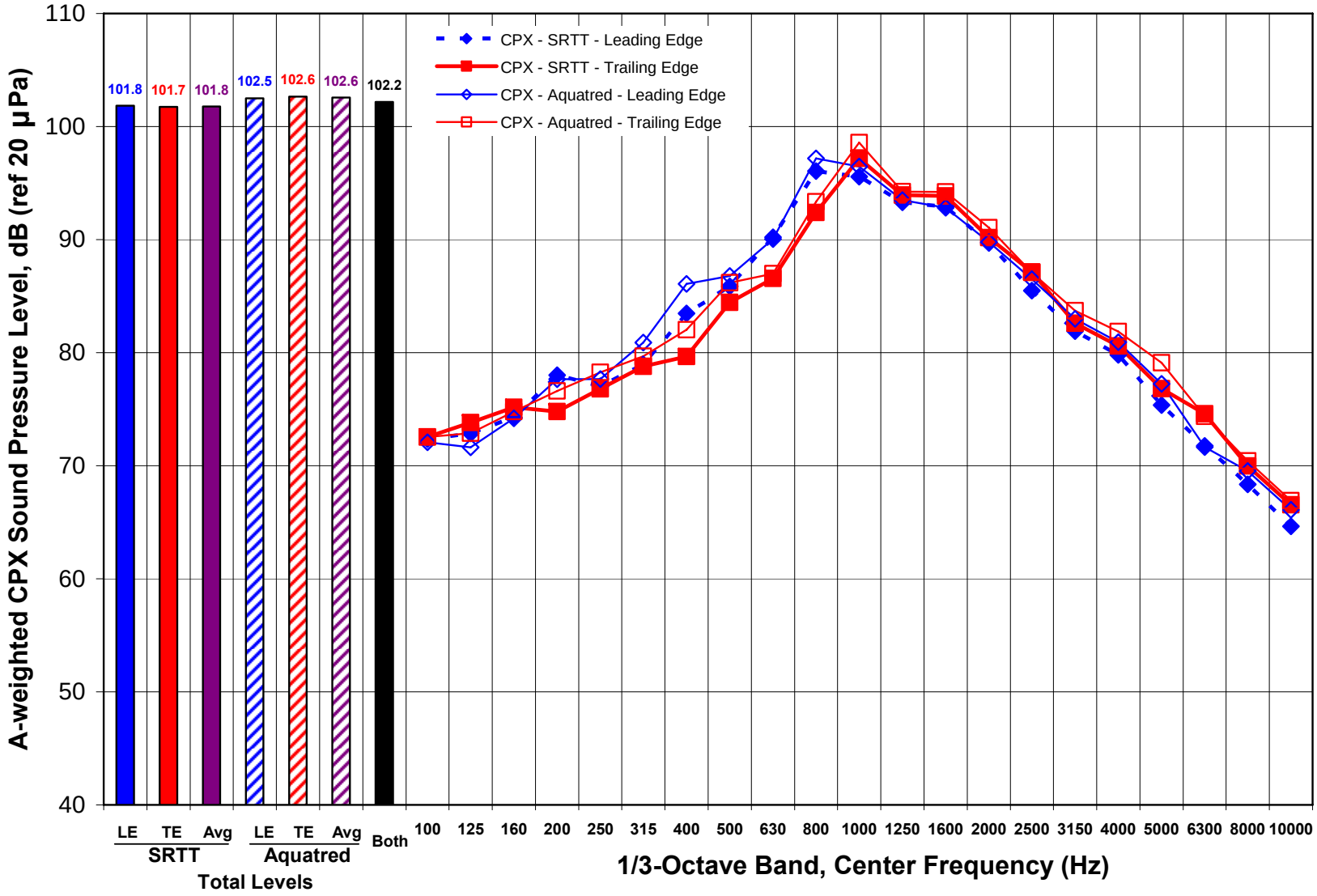
Nominal Surface: NovaChip **Construction Accepted:** to be confirmed

CPX?: Yes (9/27/06) **OBSI?:** Yes (9/27/06) **SPB?:** No **TA?:** No
Total Section Length: 3228 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

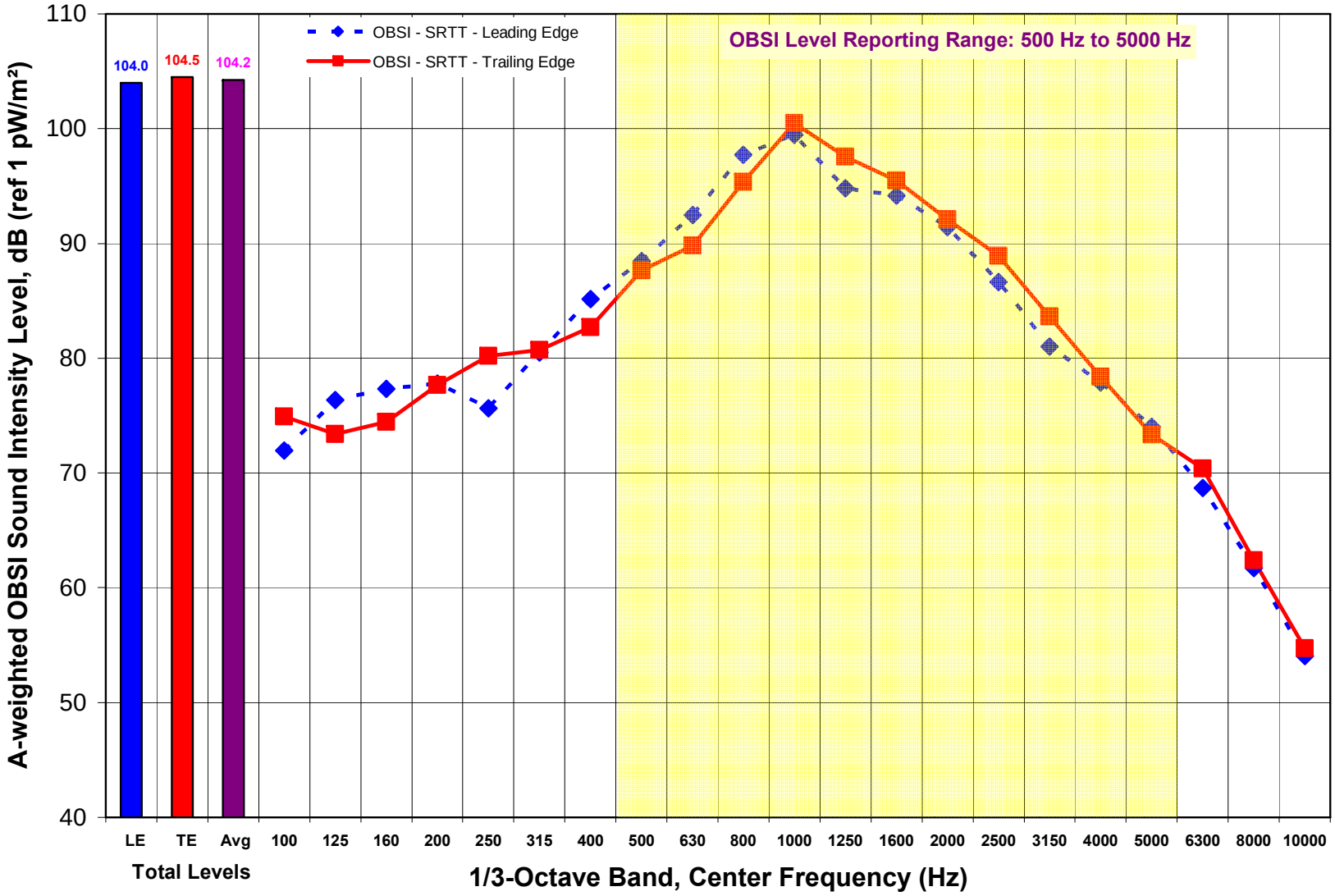
Site: 11

CPX Test Information



Site: 11

OBSI Test Information



Site: 12
General Information

Highway: State Highway 58, Westbound
Location: Between McIntyre St. & 44th Ave., Golden (80403)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.7706 / 105.1895 / 5600

Nominal Surface: NovaChip **Construction Accepted:** 2003

CPX?: Yes (10/11/06) **OBSI?:** Yes (10/11/06) **SPB?:** No **TA?:** Yes (10/13/06)
Total Section Length: 3082 ft.
Distance from Begin to Wayside Microphone: 653 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 12
Time-Averaged Wayside Test Information

Sampling Periods: 3

Sample Period 1 – 4 Blocks @ 15 min ea. = 60 min. (10:10 am to 11:10 am, 10/13/06)

Traffic Volumes and Speeds during Sample Period

	WB Lane 2 (Outside)	**WB Lane 1 (Inside)**	**EB Lane 1 (Inside)**	**EB Lane 2 (Outside)**
Distance from Mic (ft.)	50	62	111	123
Average Speed (mph)	64		69	
Automobile	385	121	91	317
Heavy Truck	19	2	10	55
Medium Truck	23	2	6	21
Bus	2	3	2	2
Motorcycle	0	1	0	2
Auto + 1-Axle Trlr.	3	2	–	–
Auto + 2-Axle Trlr.	1	0	–	–
M.Trk. + 1-Axle Trlr.	0	0	–	–
M. Trk. + 2-Axle Trlr.	3	1	–	–

– = Not observed

Block 1	**Block 2**	**Block 3**	**Block 4**	**Average**
70.3 dBA	69.9 dBA	70.8 dBA	69.6 dBA	**70.2 dBA**

Site: 12
Time-Averaged Wayside Test Information

Sample Period 2 – 4 Blocks @ 15 min ea. = 60 min. (11:30 am to 12:30 pm, 10/13/06)

Traffic Volumes and Speeds during Sample Period

	WB Lane 2 (Outside)	WB Lane 1 (Inside)	EB Lane 1 (Inside)	EB Lane 2 (Outside)
Distance from Mic (ft.)	50	62	111	123
Average Speed (mph)	67		67	
Automobile	396	158	99	365
Heavy Truck	31	2	14	43
Medium Truck	17	2	2	25
Bus	5	1	2	2
Motorcycle	2	1	0	1
Auto + 1-Axle Trlr.	3	1	–	–
Auto + 2-Axle Trlr.	6	2	–	–
M.Trk. + 1-Axle Trlr.	0	0	–	–
M. Trk. + 2-Axle Trlr.	0	0	–	–

– = Not observed

Block 1	Block 2	Block 3	Block 4	Average
70.7 dBA	72.0 dBA	70.2 dBA	70.6 dBA	**70.9 dBA**

Site: 12
Time-Averaged Wayside Test Information

Sample Period 3 – 4 Blocks @ 15 min ea. = 60 min. (2:35 pm to 3:35 pm, 10/13/06)

Traffic Volumes and Speeds during Sample Period

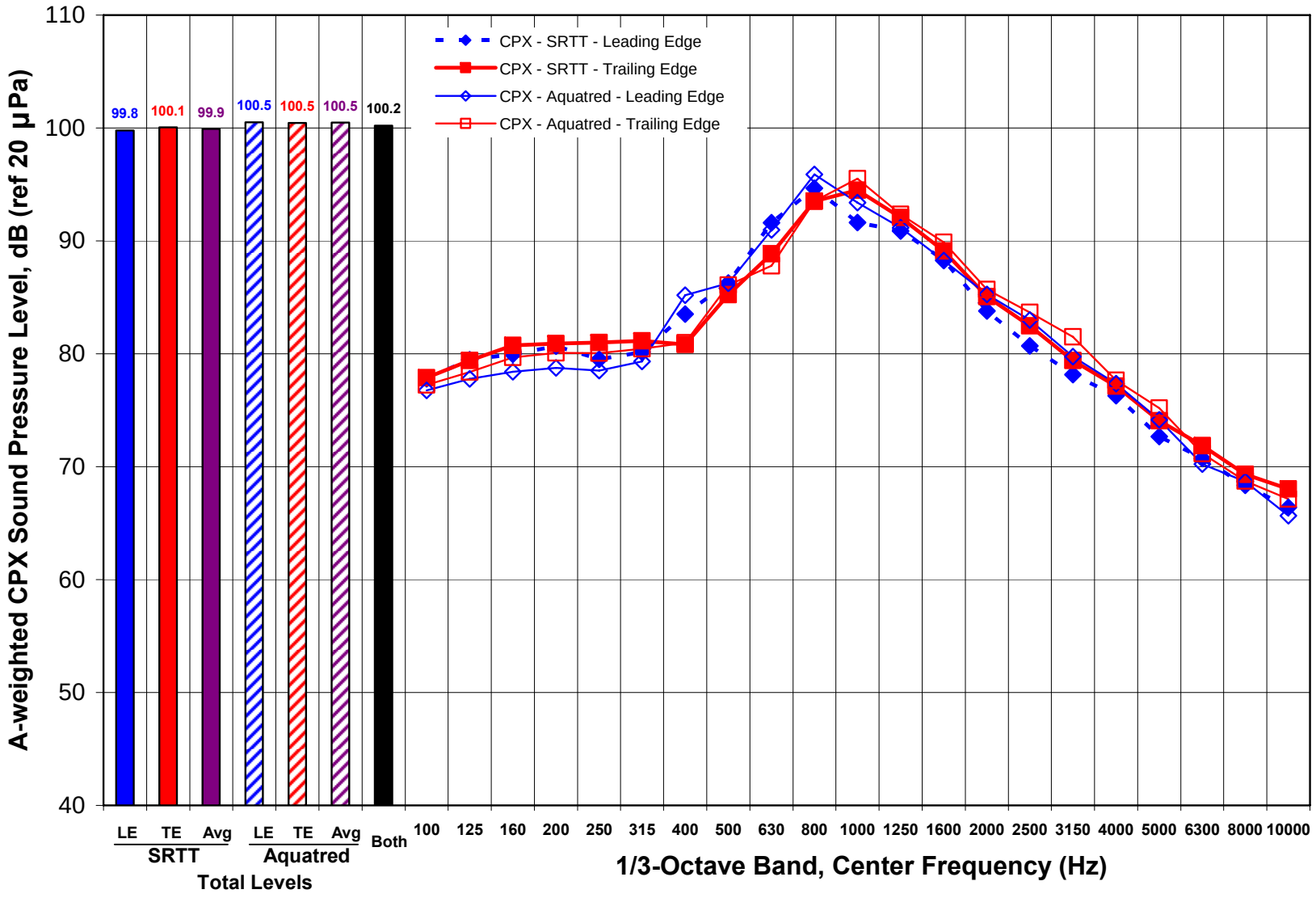
	WB Lane 2 (Outside)	WB Lane 1 (Inside)	EB Lane 1 (Inside)	EB Lane 2 (Outside)
Distance from Mic (ft.)	50	62	111	123
Average Speed (mph)	69		70	
Automobile	510	207	260	592
Heavy Truck	11	0	11	36
Medium Truck	12	0	4	21
Bus	8	2	3	7
Motorcycle	6	3	0	4
Auto + 1-Axle Trlr.	3	0	–	–
Auto + 2-Axle Trlr.	2	0	–	–
M.Trk. + 1-Axle Trlr.	0	0	–	–
M. Trk. + 2-Axle Trlr.	2	0	–	–

– = Not observed

Block 1	Block 2	Block 3	Block 4	Average
71.4 dBA	69.9 dBA	71.7 dBA	71.2 dBA	**71.0 dBA**

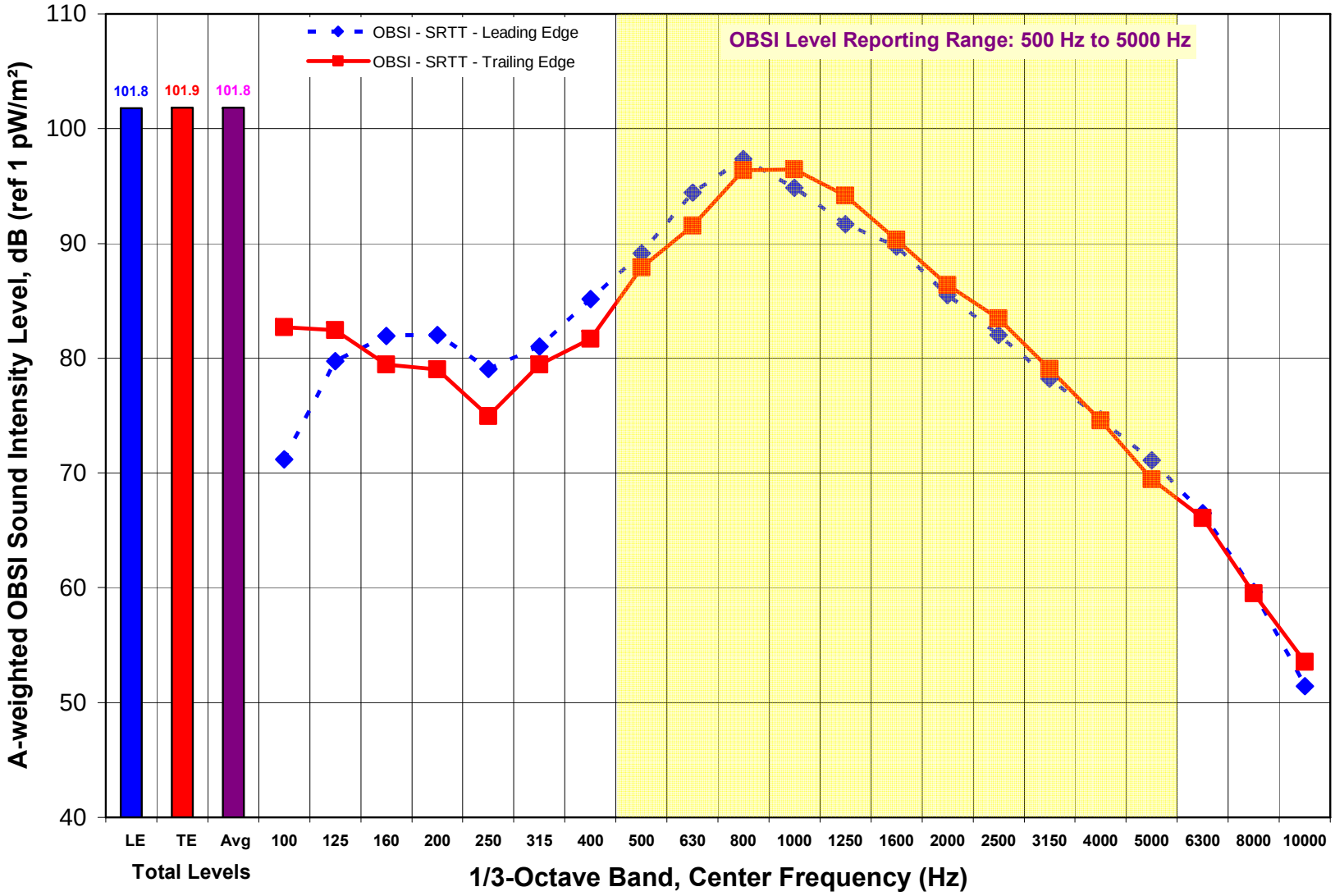
Site: 12

CPX Test Information



Site: 12

OBSI Test Information



Site: 13
General Information

Highway: Interstate 25, Southbound
Location: Between CR-12 & CR-10, Erie (80516)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 40.0667 / 104.9809 / 5060

Nominal Surface: Concrete (Long. Tining) **Construction Accepted:** 2003

CPX?: Yes (11/5/06) **OBSI?:** Yes (11/5/06) **SPB?:** No **TA?:** Yes (11/6/06)
Total Section Length: 3389 ft.
Distance from Begin to Wayside Microphone: 1054 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 13
Time-Averaged Wayside Test Information

Sampling Periods: 2

Sample Period 1 – 4 Blocks @ 15 min ea. = 60 min. (9:30 am to 10:30 am, 11/6/06)

Traffic Volumes and Speeds during Sample Period

	SB Lane 3 (Outside)	SB Lane 2	SB Lane 1 (Inside)	NB Lane 1 (Inside)	NB Lane 2	NB Lane 3 (Outside)
Distance from Mic (ft.)	50	62	74	145	157	169
Average Speed (mph)	75			74		
Automobile	315	809	794	572	771	316
Heavy Truck	128	136	19	19	161	228
Medium Truck	41	61	7	24	57	47
Bus	2	4	0	0	3	2
Motorcycle	0	2	1	0	2	3
Auto + 1-Axle Trlr.	5	7	1	3	7	3
Auto + 2-Axle Trlr.	2	4	1	3	4	8
M.Trk. + 1-Axle Trlr.	3	3	0	1	0	1
M. Trk. + 2-Axle Trlr.	3	3	0	1	7	5

Block 1	Block 2	Block 3	Block 4	Average
79.9 dBA	80.4 dBA	79.3 dBA	79.3 dBA	**79.8 dBA**

Site: 13
Time-Averaged Wayside Test Information

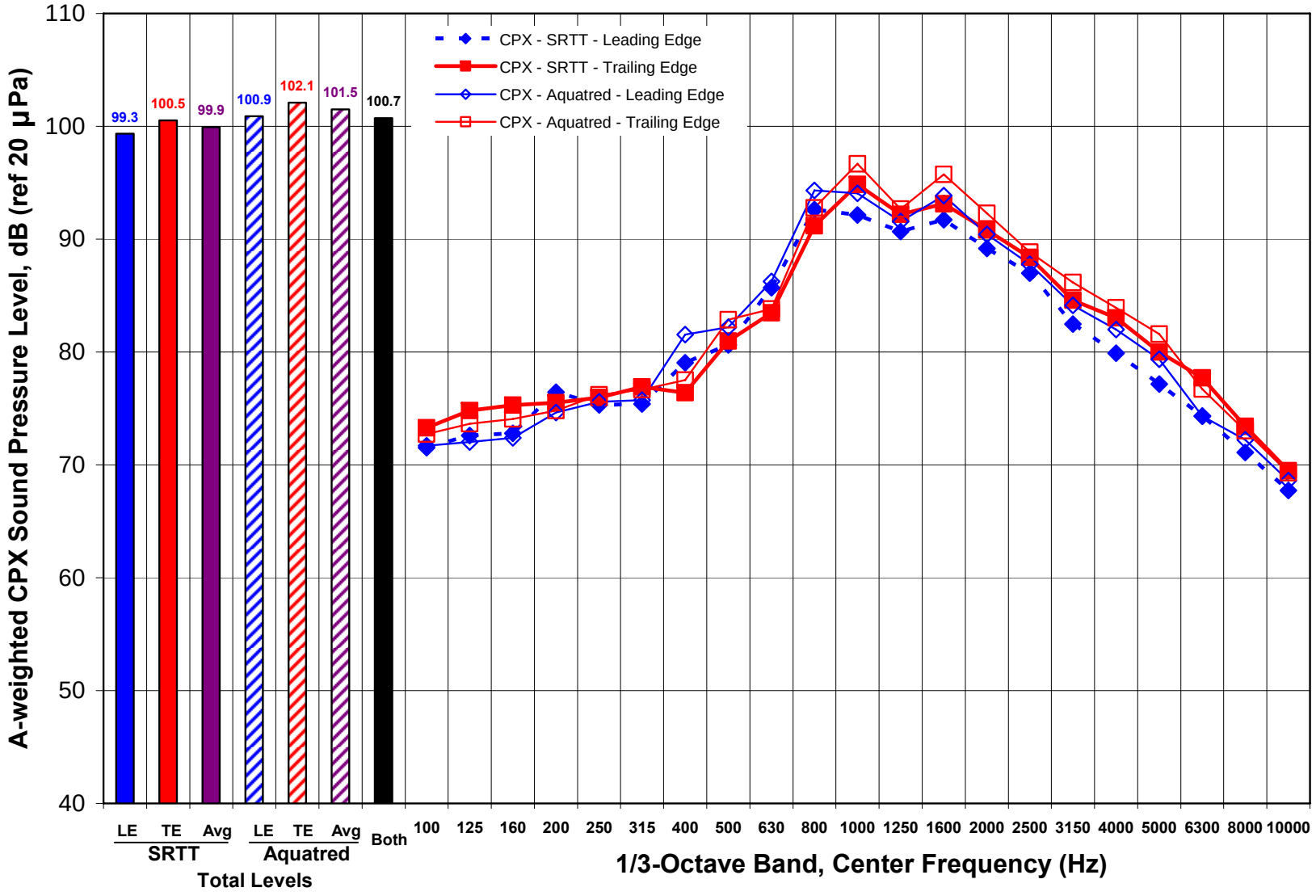
Sample Period 2 – 4 Blocks @ 15 min ea. = 60 min. (10:55 am to 11:55 am, 11/6/06)

Traffic volumes and speeds recorded, but not reduced.

Block 1	Block 2	Block 3	Block 4	Average
79.3 dBA	79.3 dBA	79.3 dBA	79.4 dBA	**79.3 dBA**

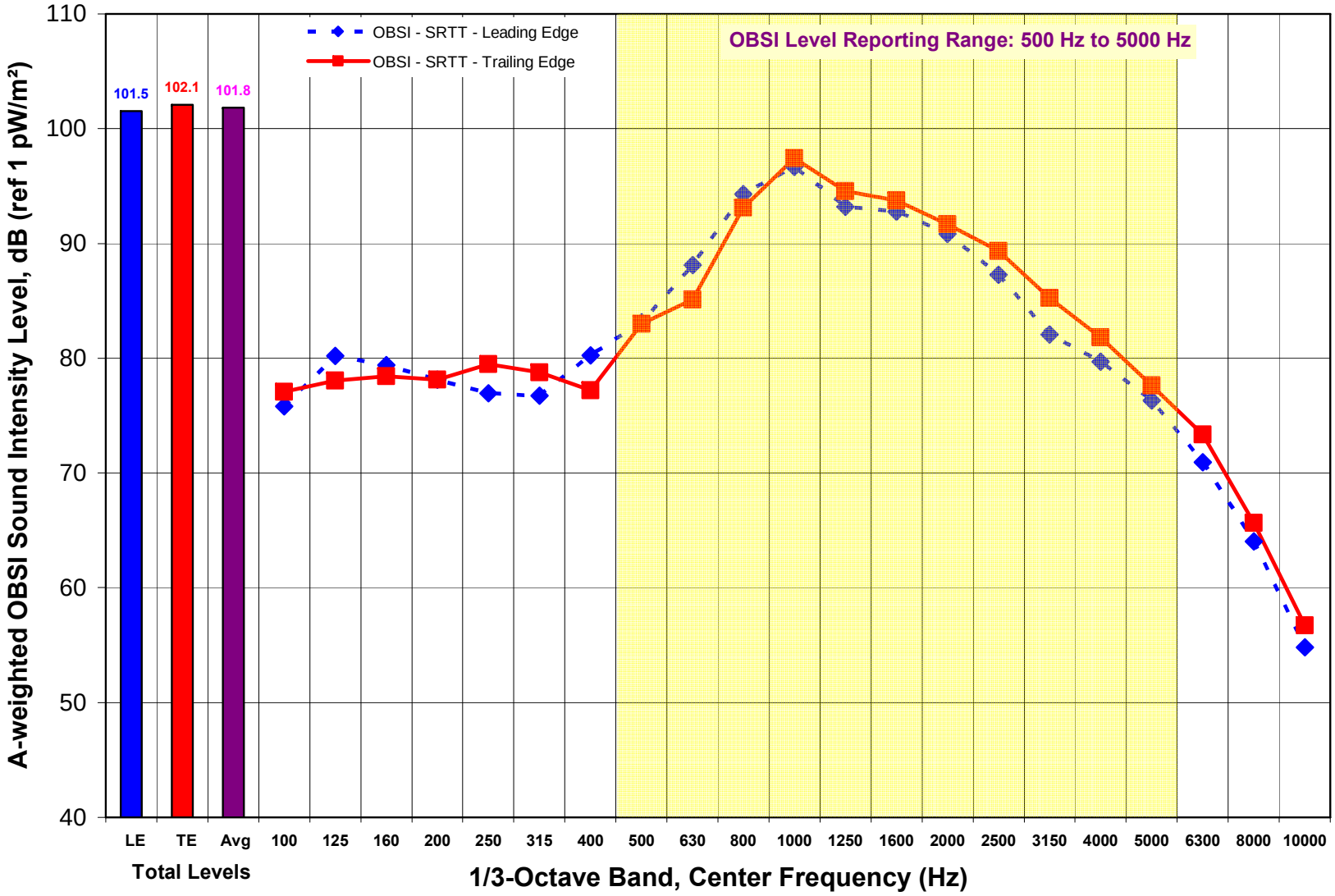
Site: 13

CPX Test Information



Site: 13

OBSI Test Information



Site: 14
General Information

Highway: US Highway 285, Northbound
Location: Between Surrey Dr. & Goddard Ranch Ct., Indian Hills (80465)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.5838 / 105.2258 / 7130

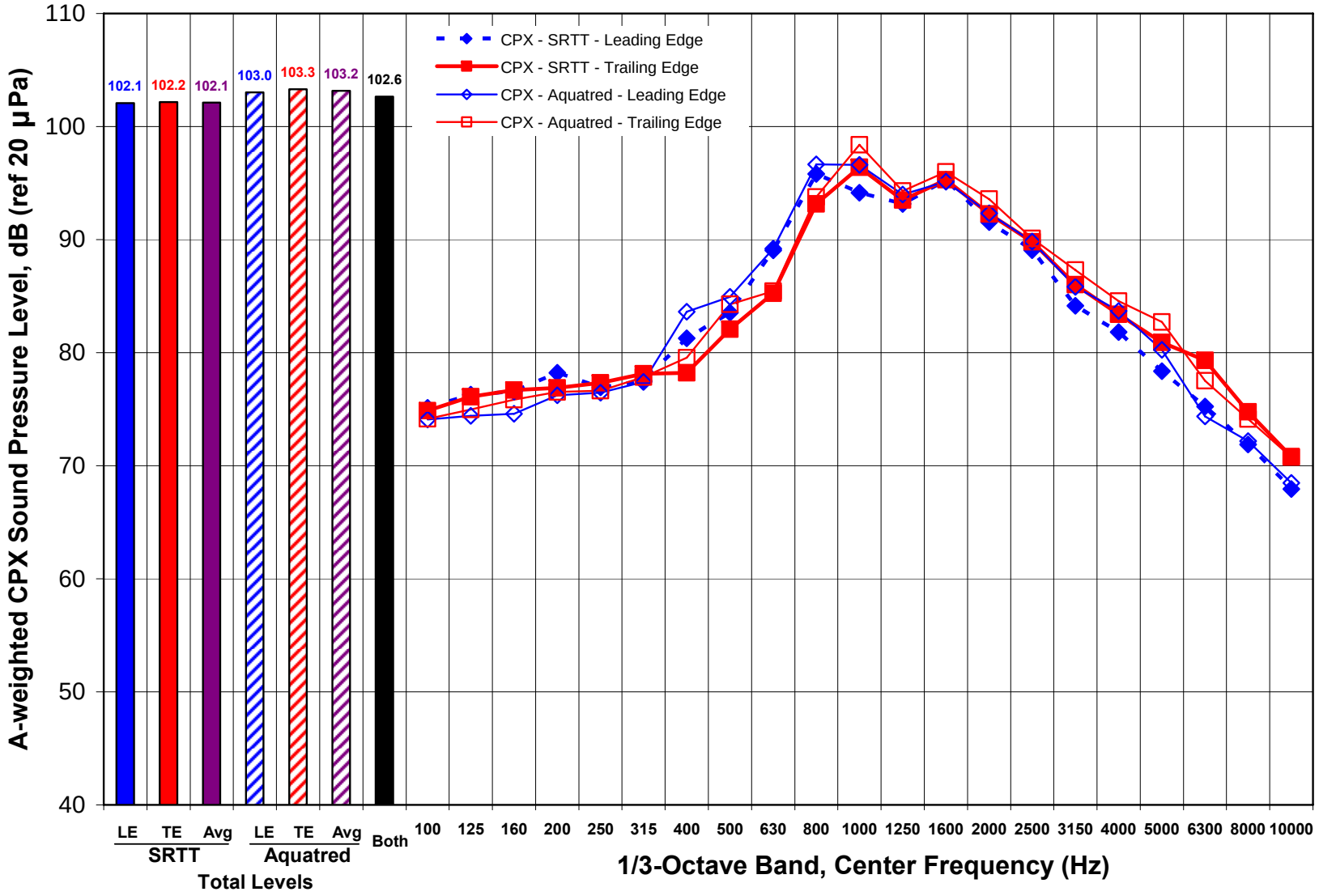
Nominal Surface: Concrete (Long. Tining) **Construction Accepted:** 1999

CPX?: Yes (10/10/06) **OBSI?:** Yes (10/10/06) **SPB?:** No **TA?:** No
Total Section Length: 1613 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

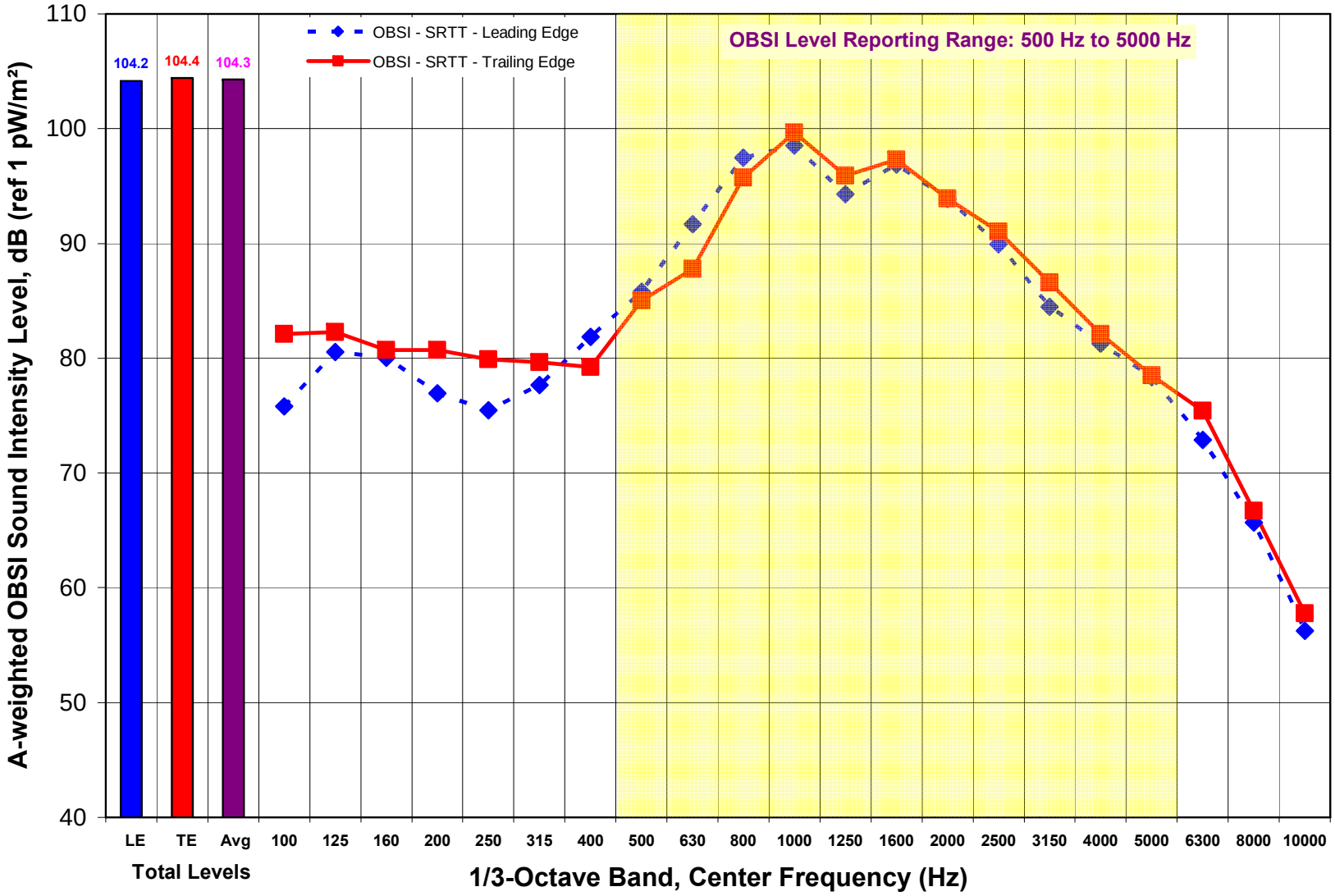
Site: 14

CPX Test Information



Site: 14

OBSI Test Information



Site: 15
General Information

Highway: Interstate 25, Northbound
Location: Between Fontanero St. & Fillmore St., Colorado Springs (80907)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 38.8672 / 104.834 / 6130

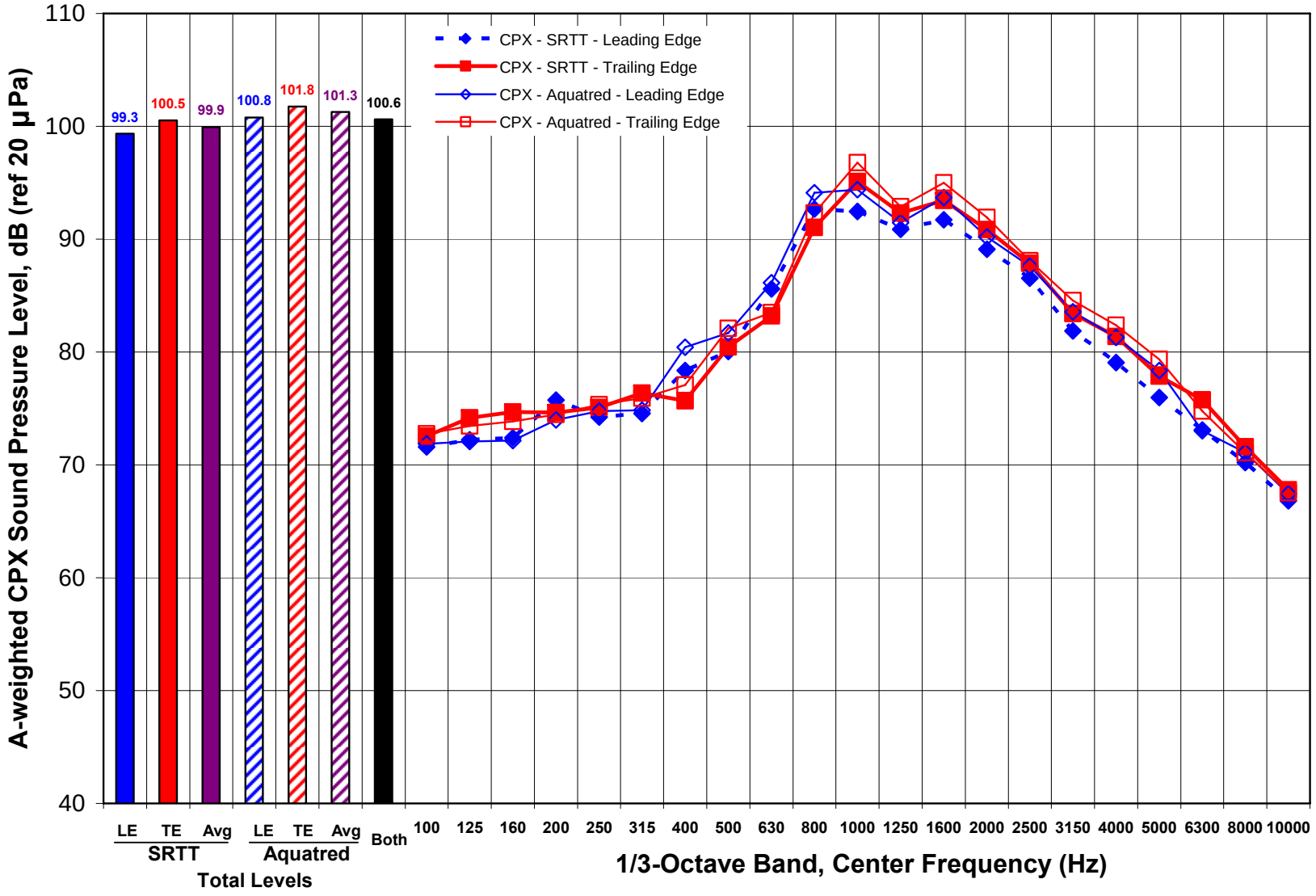
Nominal Surface: Concrete (Long. Grooving) **Construction Accepted:** 2000

CPX?: Yes (11/4/06) **OBSI?:** Yes (11/4/06) **SPB?:** No **TA?:** No
Total Section Length: 4485 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

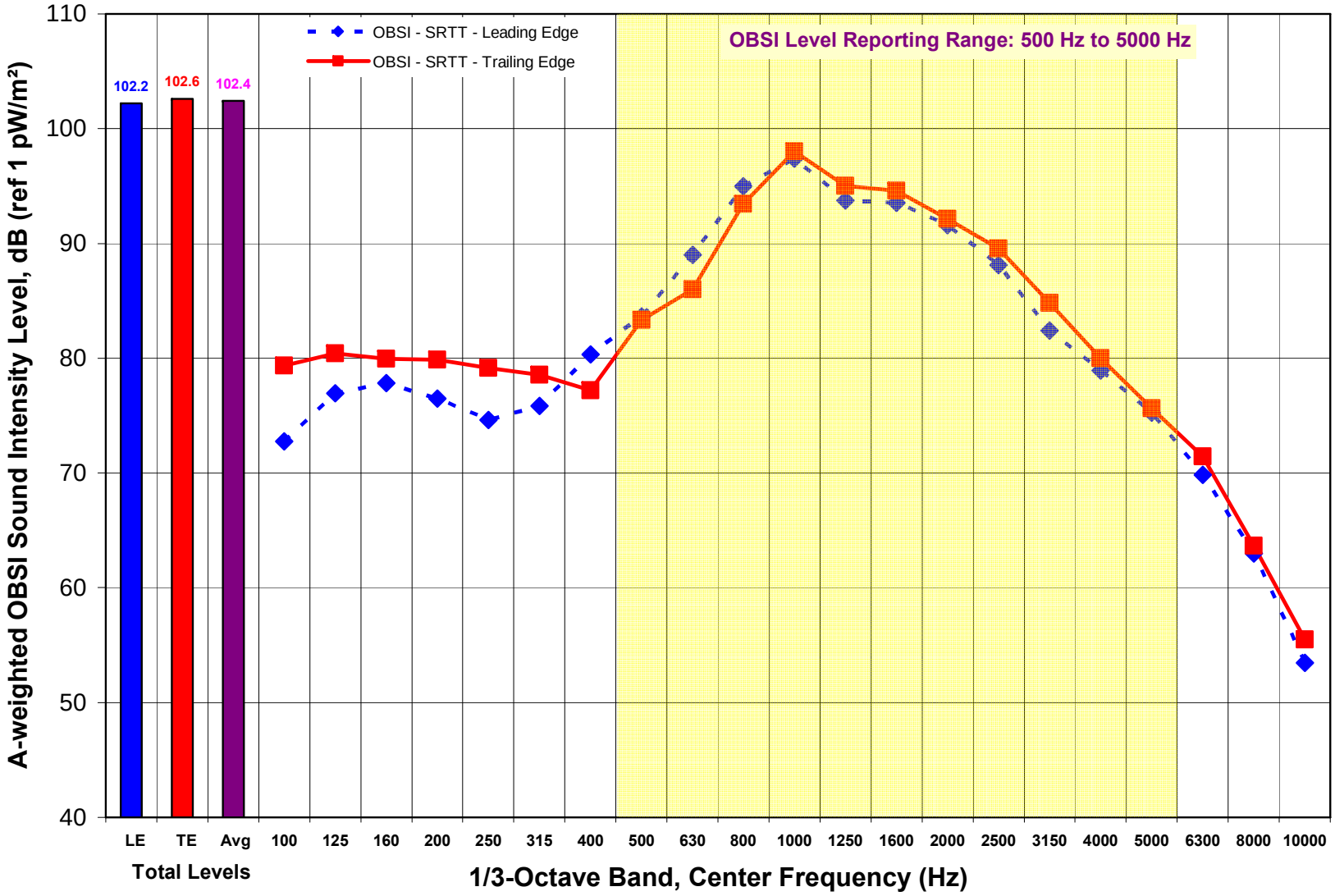
Site: 15

CPX Test Information



Site: 15

OBSI Test Information

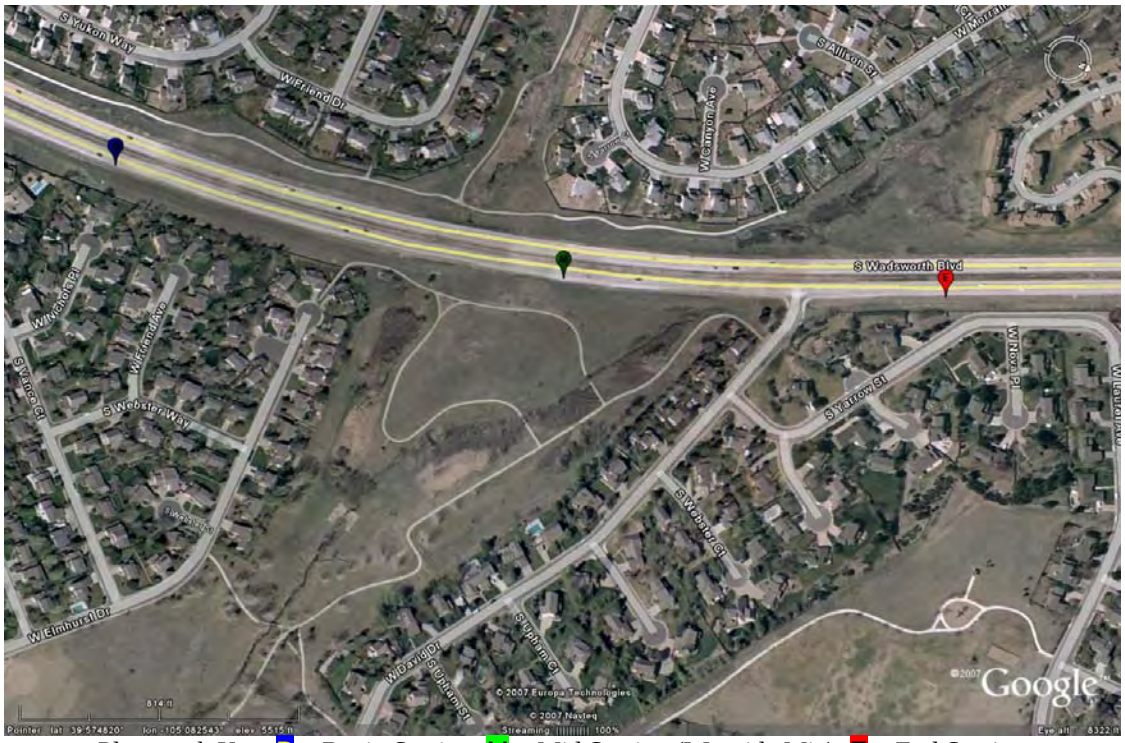


Site: 16
General Information

Highway: State Highway 121, Northbound
Location: Between Chatfield Ave. & Ken Caryl Ave., Littleton (80128)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.5741 / 105.0837 / 5580

Nominal Surface: Concrete (Carpet Drag) **Construction Accepted:** 2001

CPX?: Yes (10/12/06) **OBSI?:** Yes (10/12/06) **SPB?:** No **TA?:** Yes (10/12/06)
Total Section Length: 2422 ft.
Distance from Begin to Wayside Microphone: 1323 ft.



Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 16
Time-Averaged Wayside Test Information

Sampling Periods: 3

Sample Period 1 – 4 Blocks @ 15 min ea. = 60 min. (10:00 am to 11:00 am, 10/12/06)

Traffic Volumes and Speeds during Sample Period

	NB Lane 2 (Outside)	NB Lane 1 (Inside)	SB Lane 1 (Inside)	SB Lane 2 (Outside)
Distance from Mic (ft.)	50	62	104	116
Average Speed (mph)	56		53	
Automobile	369	312	337	264
Heavy Truck	9	3	2	3
Medium Truck	15	5	15	11
Bus	1	0	0	1
Motorcycle	2	0	0	0
Auto + 1-Axle Trlr.	1	0	–	–
Auto + 2-Axle Trlr.	3	1	–	–
M.Trk. + 1-Axle Trlr.	1	0	–	–
M. Trk. + 2-Axle Trlr.	2	0	–	–

– = Not observed

Block 1	Block 2	Block 3	Block 4	Average
70.7 dBA	69.7 dBA	70.3 dBA	70.1 dBA	**70.2 dBA**

Site: 16
Time-Averaged Wayside Test Information

Sample Period 2 – 4 Blocks @ 15 min ea. = 60 min. (11:20 am to 12:20 pm, 10/12/06)

Traffic Volumes and Speeds during Sample Period

	NB Lane 2 (Outside)	NB Lane 1 (Inside)	SB Lane 1 (Inside)	SB Lane 2 (Outside)
Distance from Mic (ft.)	50	62	104	116
Average Speed (mph)	53		56	
Automobile	350	309	387	312
Heavy Truck	7	1	3	0
Medium Truck	12	4	8	7
Bus	1	0	0	0
Motorcycle	1	1	0	2
Auto + 1-Axle Trlr.	1	2	–	–
Auto + 2-Axle Trlr.	1	3	–	–
M.Trk. + 1-Axle Trlr.	0	1	–	–
M. Trk. + 2-Axle Trlr.	0	1	–	–

– = Not observed

Block 1	Block 2	Block 3	Block 4	Average
70.5 dBA	69.6 dBA	69.9 dBA	68.6 dBA	**69.6 dBA**

Site: 16
Time-Averaged Wayside Test Information

Sample Period 3 – 4 Blocks @ 15 min ea. = 60 min. (12:40 pm to 1:40 pm, 10/12/06)

Traffic Volumes and Speeds during Sample Period

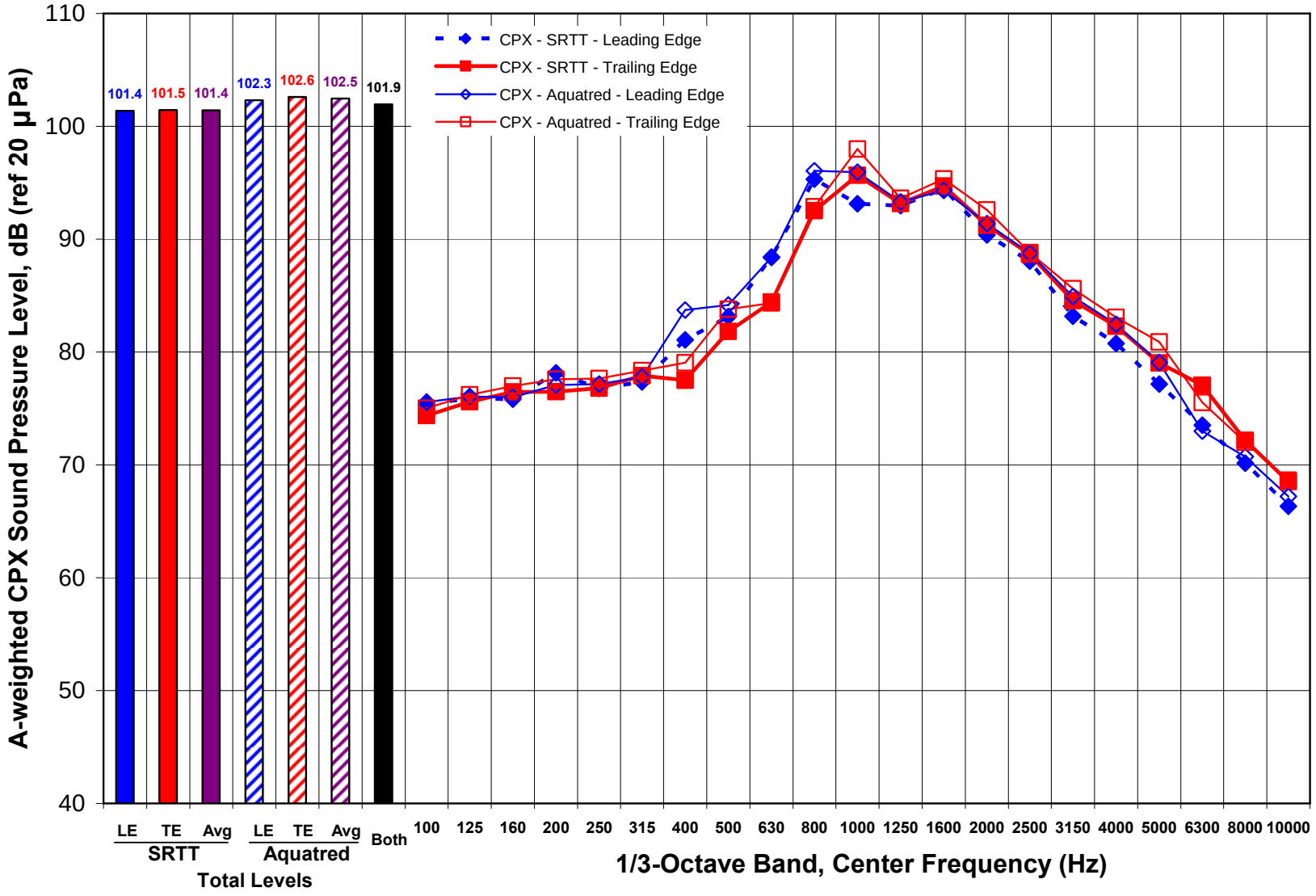
	NB Lane 2 (Outside)	NB Lane 1 (Inside)	SB Lane 1 (Inside)	SB Lane 2 (Outside)
Distance from Mic (ft.)	50	62	104	116
Average Speed (mph)	**		**	
Automobile	**	**	416	338
Heavy Truck	**	**	3	4
Medium Truck	**	**	8	9
Bus	**	**	0	0
Motorcycle	**	**	2	2
Auto + 1-Axle Trlr.	**	**	**	**
Auto + 2-Axle Trlr.	**	**	**	**
M.Trk. + 1-Axle Trlr.	**	**	**	**
M. Trk. + 2-Axle Trlr.	**	**	**	**

– = Not observed
** = Traffic volumes and speeds recorded, but not reduced due to consistency in results.

Block 1	Block 2	Block 3	Block 4	Average
69.6 dBA	69.7 dBA	69.3 dBA	69.6 dBA	**69.5 dBA**

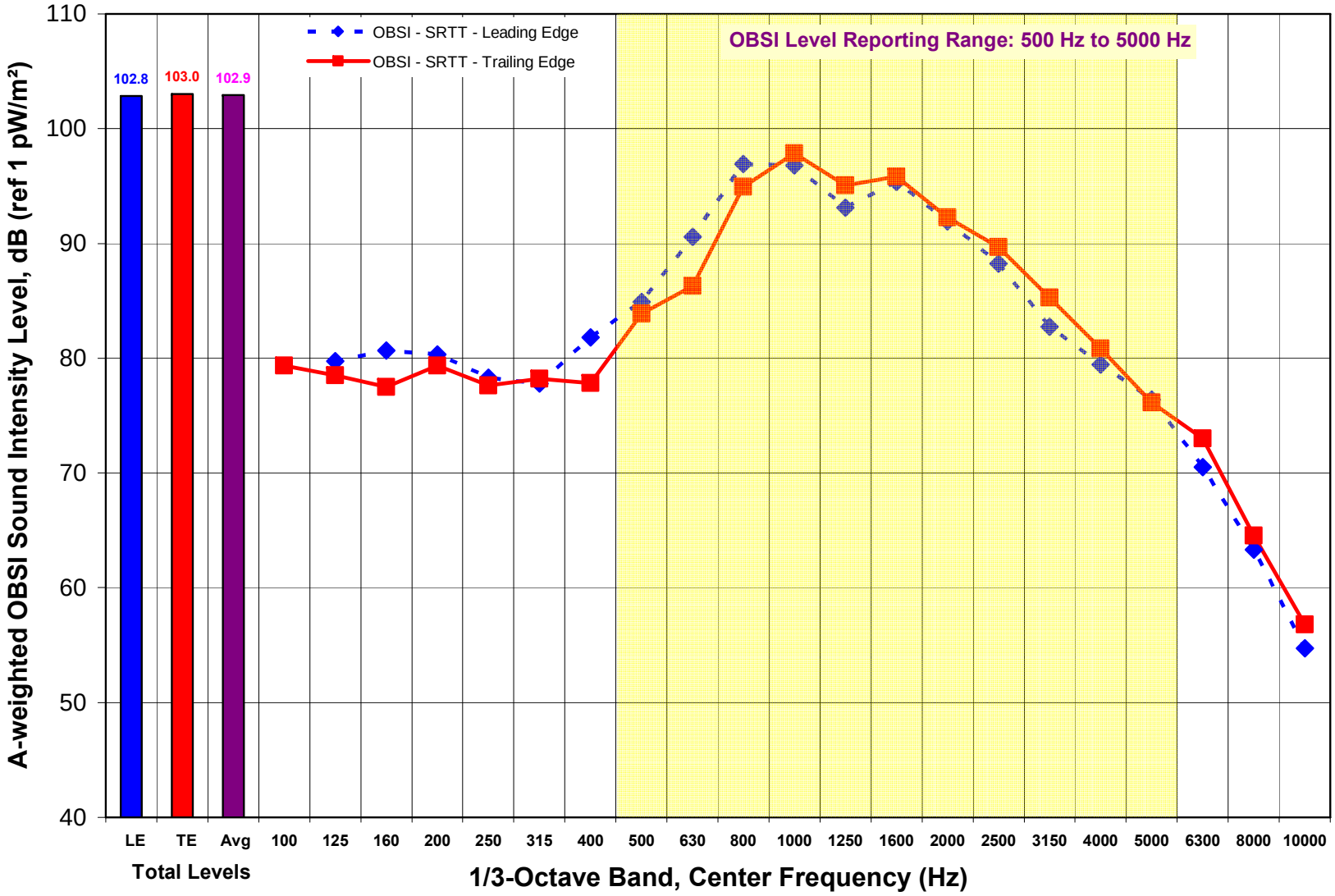
Site: 16

CPX Test Information



Site: 16

OBSI Test Information



Site: 17
General Information

Highway: Interstate 70, Westbound
Location: Between SH 13 & US 6/24, Rifle (81650)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.5205 / 107.8229 / 5290

Nominal Surface: Concrete (Diamond Grinding) **Construction Accepted:** 2005

CPX?: Yes (9/28/06) **OBSI?:** Yes (9/28/06) **SPB?:** No **TA?:** Yes (9/30/06)
Total Section Length: 6368 ft.
Distance from Begin to Wayside Microphone: 1177 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 17
Time-Averaged Wayside Test Information

Sampling Periods: 3

Sample Period 1 – 4 Blocks @ 15 min ea. = 60 min. (10:35 am to 11:35 am, 9/30/06)

Traffic Volumes and Speeds during Sample Period

	WB Lane 2 (Outside)	**WB Lane 1 (Inside)**	**EB Lane 1 (Inside)**	**EB Lane2 (Outside)**
Distance from Mic (ft.)	50	62	174	186
Average Speed (mph)	76		67	
Automobile	363	123	119	287
Heavy Truck	39	3	6	42
Medium Truck	19	2	3	15
Bus	1	0	0	1
Motorcycle	3	1	1	7
Auto + 1-Axle Trlr.	4	0	0	15
Auto + 2-Axle Trlr.	16	4	2	12
M.Trk. + 1-Axle Trlr.	2	0	0	0
M. Trk. + 2-Axle Trlr.	4	2	0	8

Block 1	**Block 2**	**Block 3**	**Block 4**	**Average**
73.6 dBA	71.8 dBA	72.3 dBA	73.6 dBA	**72.8 dBA**

Site: 17
Time-Averaged Wayside Test Information

Sample Period 2 – 5 Blocks @ 15 min ea. = 75 min. (12:45 pm to 2:00 pm, 9/30/06)

Traffic volumes and speeds recorded, but not reduced.

Block 1	Block 2	Block 3	Block 4	Block 5	Average
72.7 dBA	72.3 dBA	73.4 dBA	72.7 dBA	72.9 dBA	**72.8 dBA**

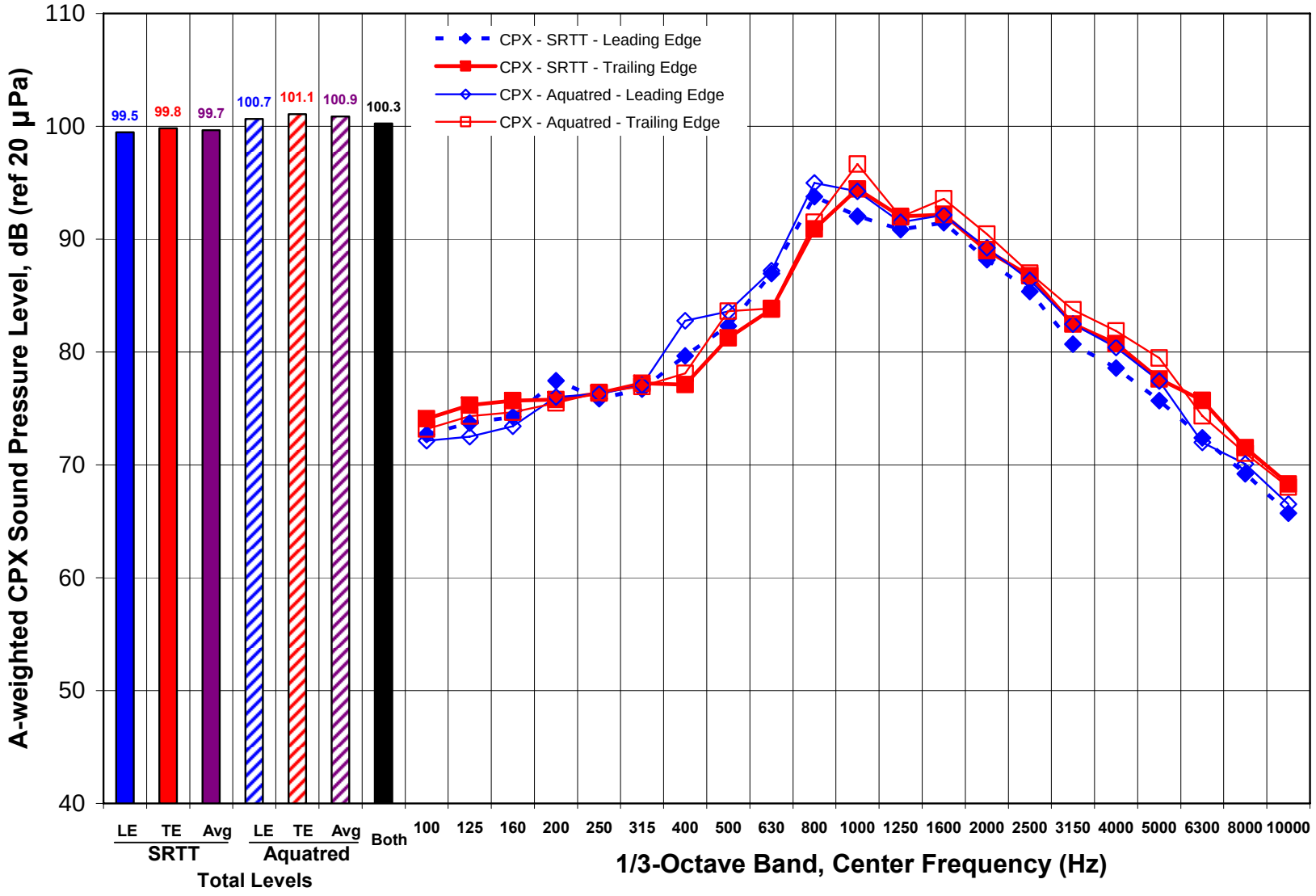
Sample Period 3 – 5 Blocks @ 15 min ea. = 75 min. (2:30 pm to 3:45 pm, 9/30/06)

Traffic volumes and speeds recorded, but not reduced.

Block 1	Block 2	Block 3	Block 4	Block 5	Average
72.4 dBA	70.8 dBA	71.5 dBA	71.1 dBA	72.4 dBA	**71.6 dBA**

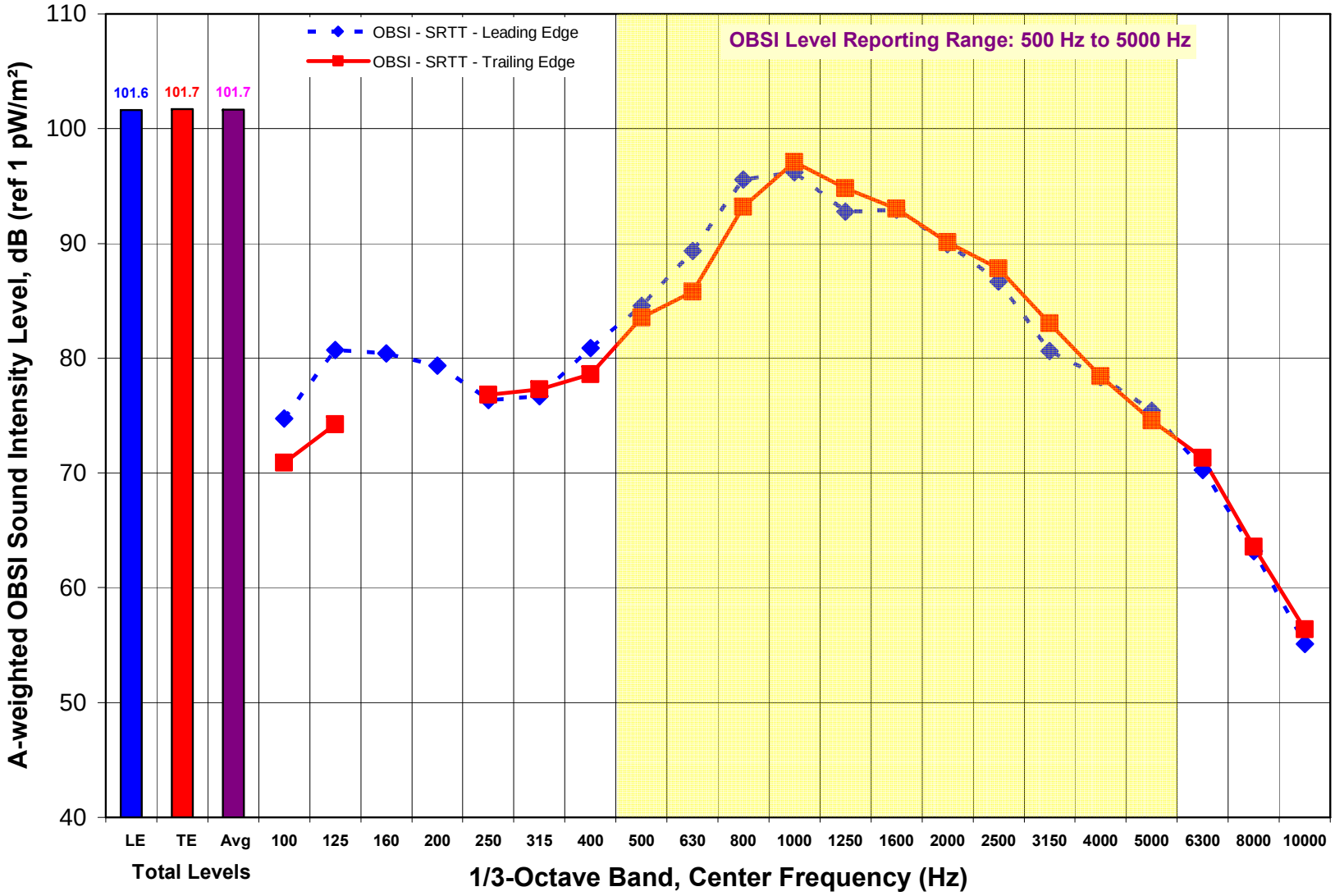
Site: 17

CPX Test Information



Site: 17

OBSI Test Information



Site: 18
General Information

Highway: US Highway 285, Northbound
Location: Between Turkey Creek Rd. & Chamberlain Rd., Indian Hills (80465)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.598 / 105.2255 / 7050

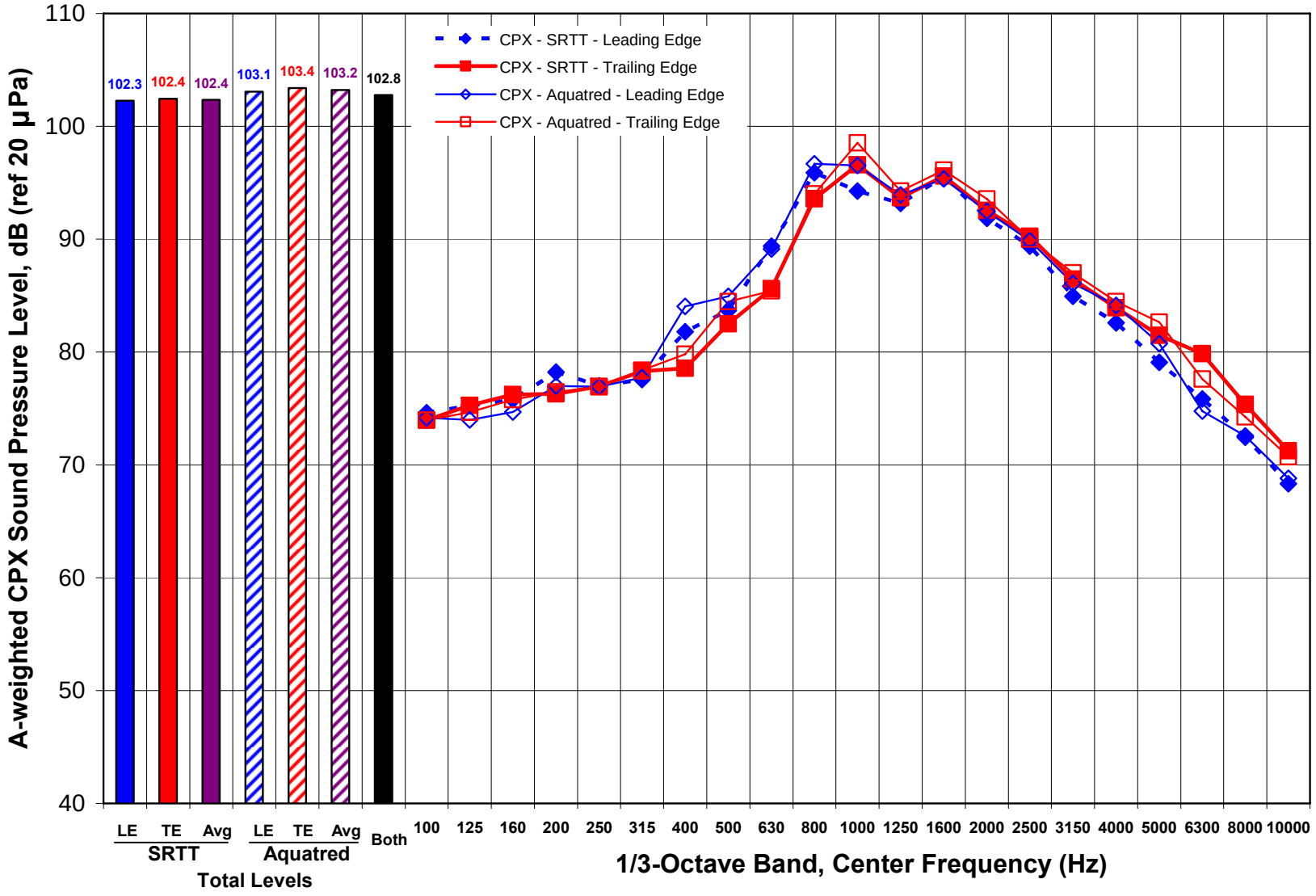
Nominal Surface: Concrete (Diamond Grinding) **Construction Accepted:** 1999

CPX?: Yes (10/10/06) **OBSI?:** Yes (10/10/06) **SPB?:** No **TA?:** No
Total Section Length: 2069 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

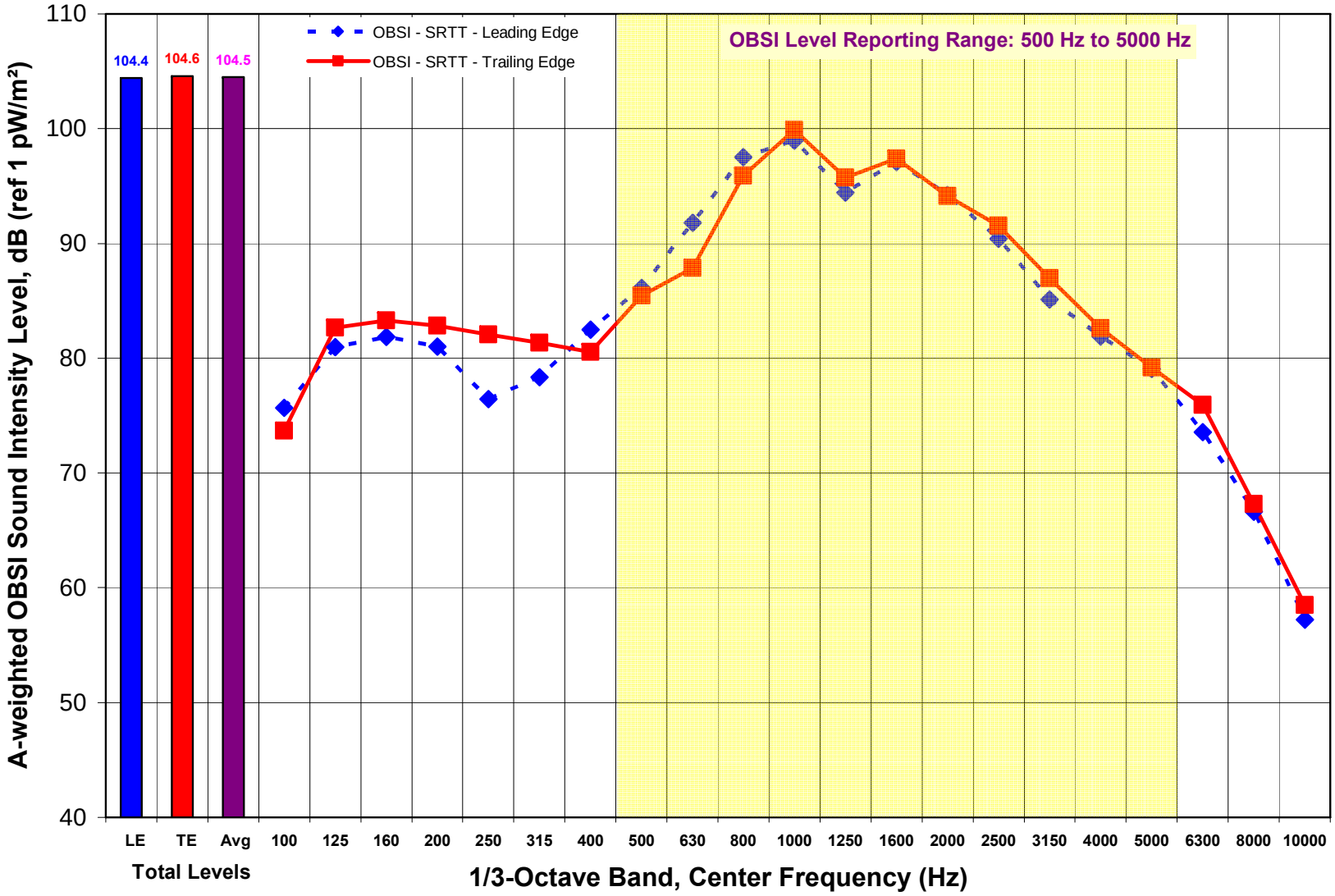
Site: 18

CPX Test Information



Site: 18

OBSI Test Information



Site: 19
General Information

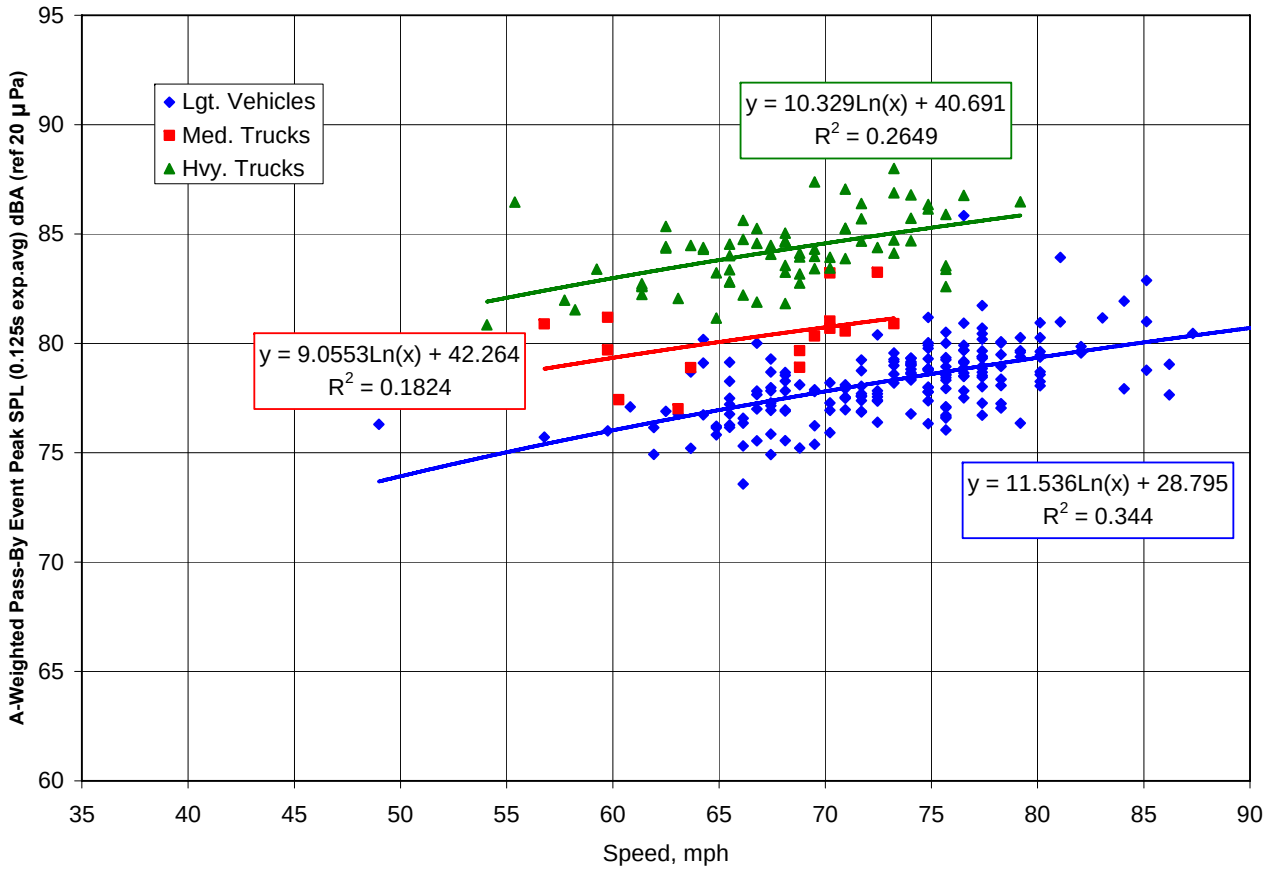
Highway: Interstate 70, Westbound
Location: Between Camino Dorado Rd. & Trail Gulch Rd., Gypsum (81637)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.6528 / 106.8823 / 6630

Nominal Surface: SMA **Construction Accepted:** 1996

CPX?: Yes (10/23/06) **OBSI?:** Yes (10/23/06) **SPB?:** Yes (10/24/06) **TA?:** No
Total Section Length: 3122 ft.
Distance from Begin to Wayside Microphone: 443 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

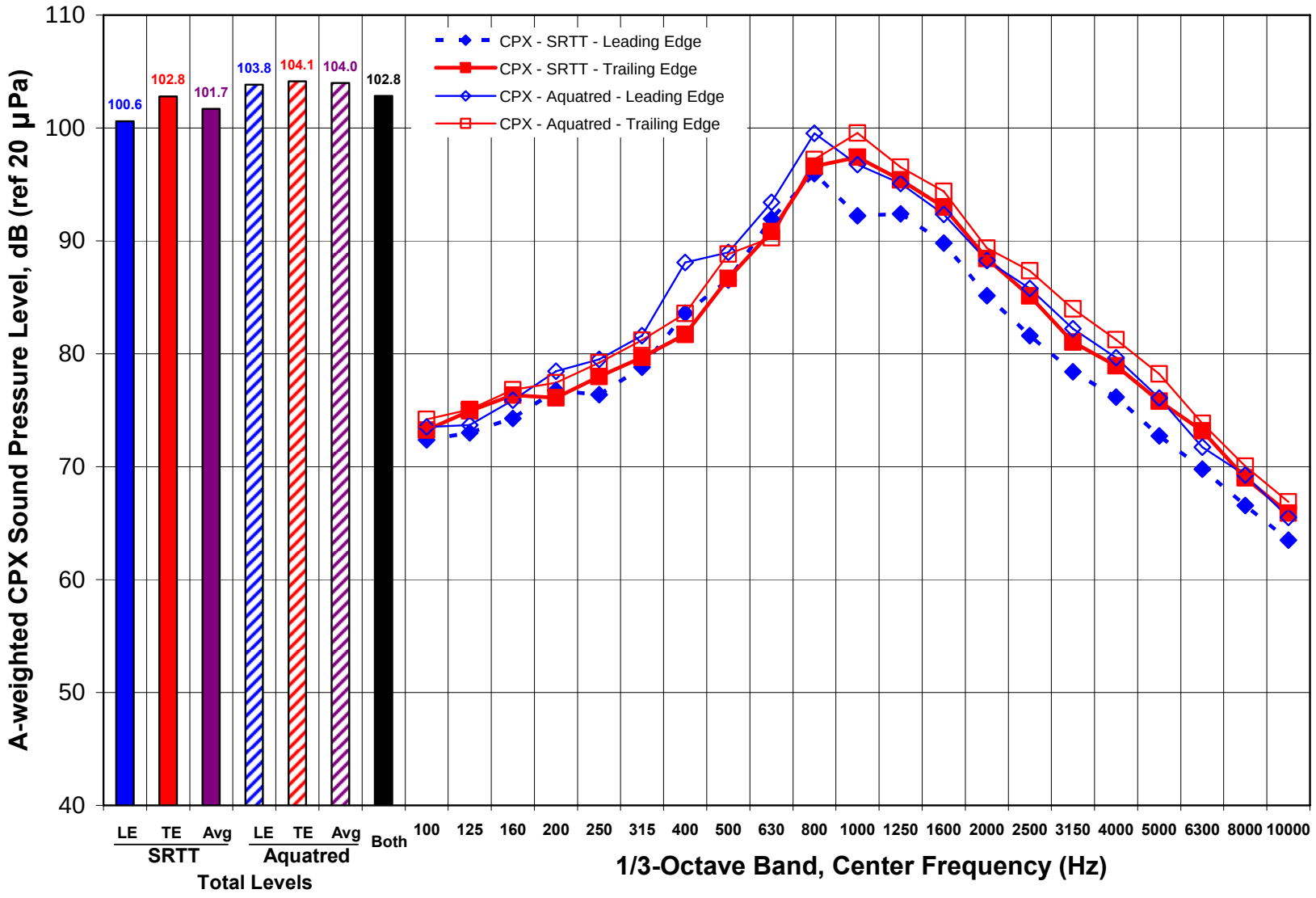
Site: 19
SPB Wayside Test Information



SPBI (Car, 60mph): 76.0 dBA
SPBI (M. Truck, 60mph): 79.3 dBA
SPBI (H. Truck, 60mph): 83.0 dBA

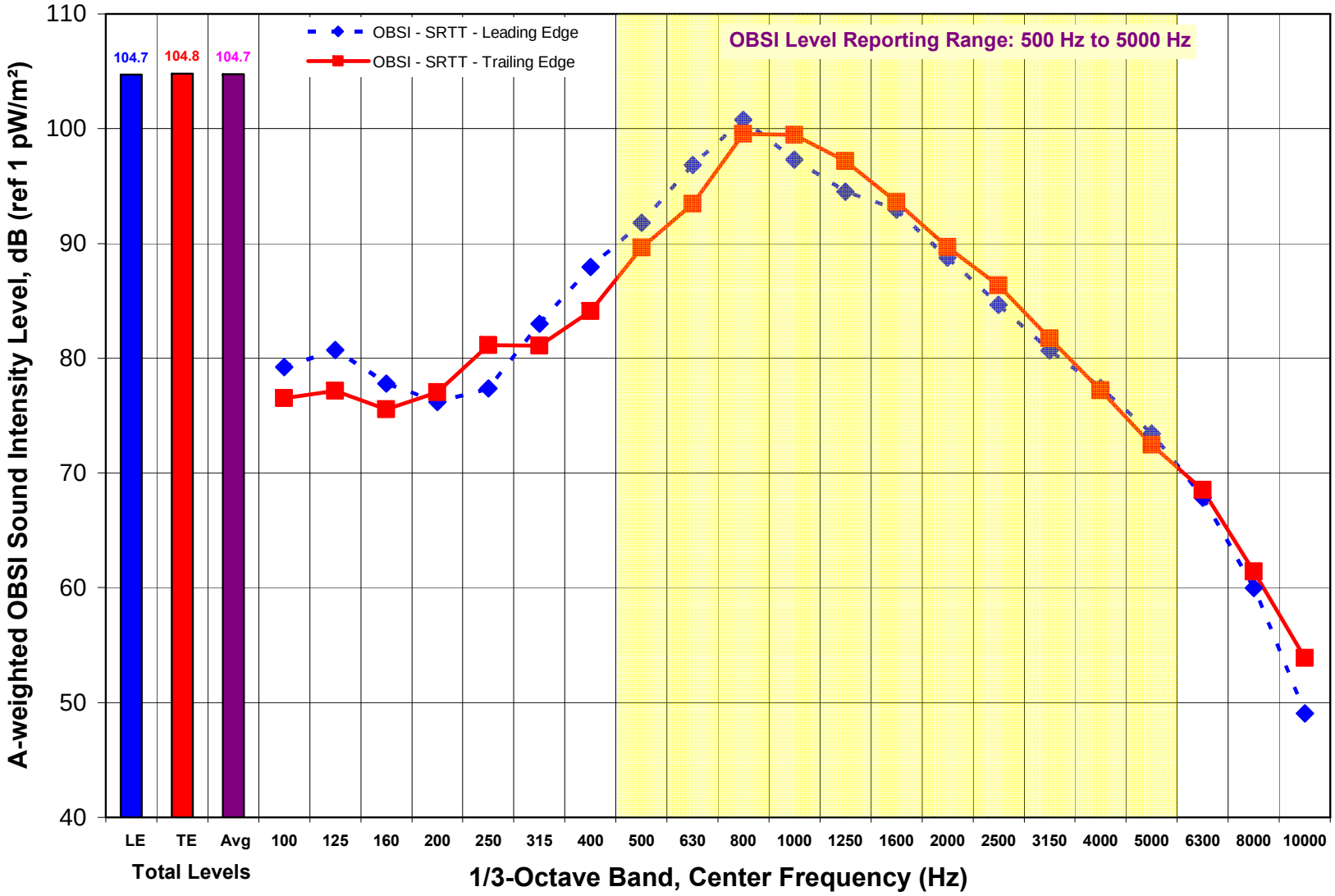
Site: 19

CPX Test Information



Site: 19

OBSI Test Information



Site: 20
General Information

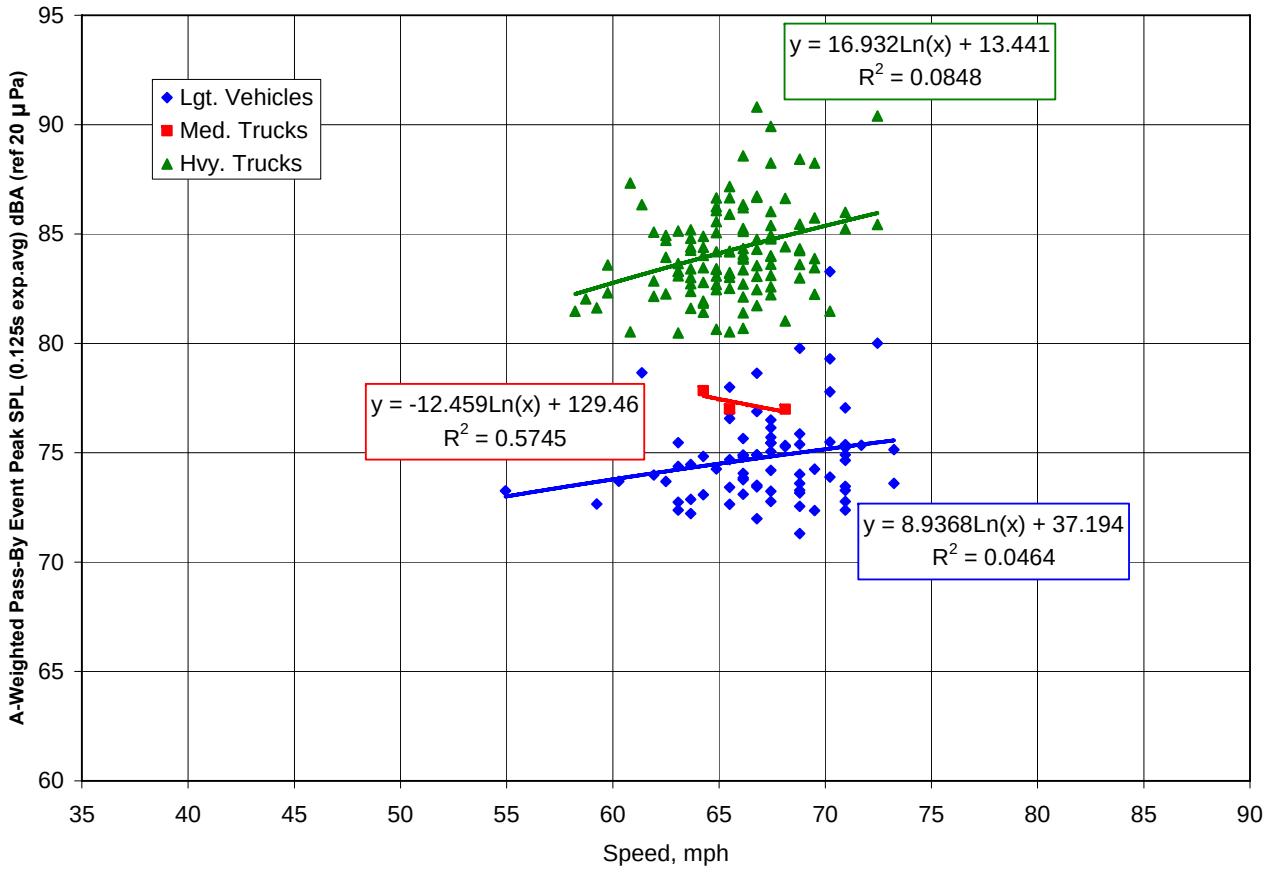
Highway: US Highway 40, Westbound
Location: Between CR-8 & SH 94, Kit Carson (80862)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 38.8328 / 103.054 / 4520

Nominal Surface: Concrete **Construction Accepted:** 2001

CPX?: Yes (11/3/06) **OBSI?:** Yes (11/3/06) **SPB?:** Yes (11/2/06) **TA?:** No
Total Section Length: 5241 ft.
Distance from Begin to Wayside Microphone: 2668 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

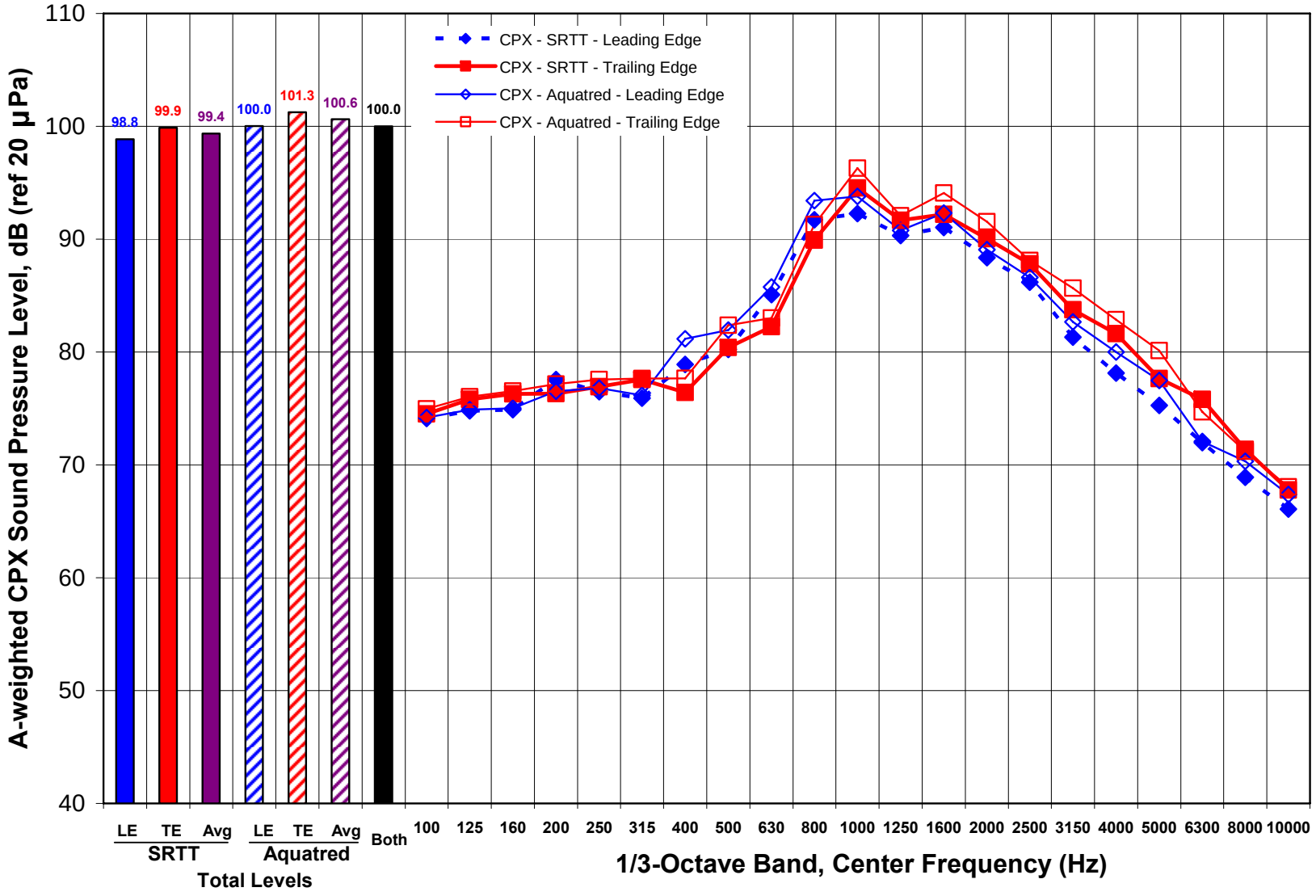
Site: 20
SPB Wayside Test Information



SPBI (Car, 60mph): 73.8 dBA
SPBI (M. Truck, 60mph): 78.4 dBA
SPBI (H. Truck, 60mph): 82.8 dBA

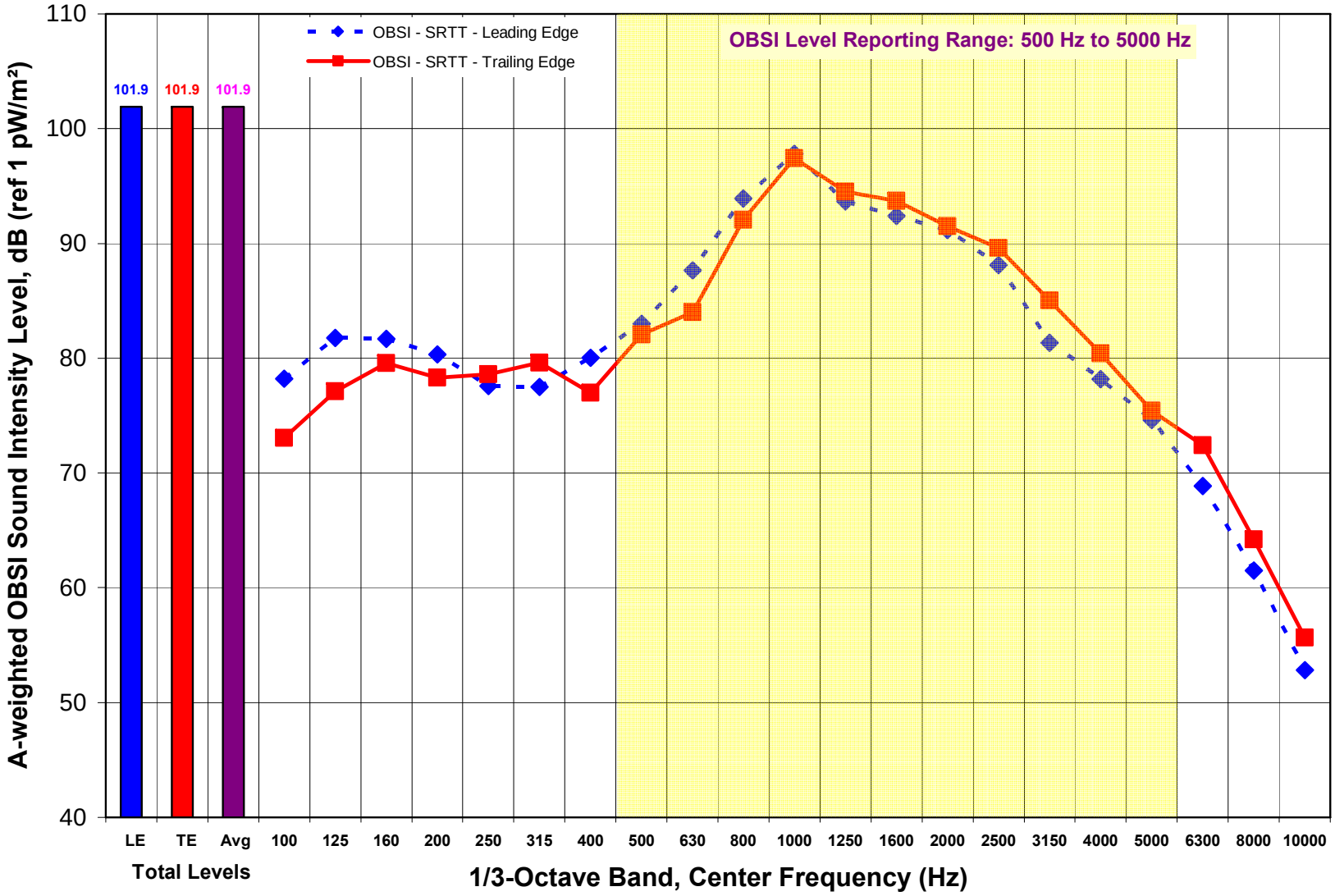
Site: 20

CPX Test Information



Site: 20

OBSI Test Information



Site: 21
General Information

Highway: US Highway 285, Southbound
Location: Between Kipling Pkwy. & C-470, Morrison (80227)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.6438 / 105.1318 / 5700

Nominal Surface: Asphalt (S, 3/4") **Construction Accepted:** 2003

CPX?: Yes (10/7/06) **OBSI?:** Yes (10/8/06) **SPB?:** No **TA?:** Yes (10/5/06)
Total Section Length: 3599 ft.
Distance from Begin to Wayside Microphone: 1451 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 21
Time-Averaged Wayside Test Information

Sampling Periods: 3

Sample Period 1 – 4 Blocks @ 15 min ea. = 60 min. (10:15 am to 11:15 am, 10/5/06)

Traffic Volumes and Speeds during Sample Period

	SB Lane 3 (Acceleration)	SB Lane 2 (Test Lane)	SB Lane 1 (Inside)	NB Lane 1 (Inside)	NB Lane 2	NB Lane 3 (Deceleration)
Distance from Mic (ft.)	38	50	62	110	122	134
Average Speed (mph)	69			66		
Automobile	2	460	158	135	434	64
Heavy Truck	0	40	2	2	26	2
Medium Truck	0	20	2	2	17	3
Bus	0	2	0	1	3	0
Motorcycle	0	4	1	0	1	1
Auto + 1-Axle Trlr.	0	3	1	0	5	0
Auto + 2-Axle Trlr.	0	3	2	0	1	0
M.Trk. + 1-Axle Trlr.	0	0	0	0	1	0
M. Trk. + 2-Axle Trlr.	0	0	0	0	2	0

Block 1	Block 2	Block 3	Block 4	Average
74.4 dBA	73.9 dBA	74.5 dBA	73.2 dBA	**74.0 dBA**

Site: 21
Time-Averaged Wayside Test Information

Sample Period 2 – 5 Blocks @ 15 min ea. = 75 min. (11:45 am to 1:00 pm, 10/5/06)

Traffic volumes and speeds recorded, but not reduced.

Block 1	Block 2	Block 3	Block 4	Block 5	Average
74.2 dBA	73.9 dBA	73.6 dBA	73.4 dBA	74.3 dBA	**73.9 dBA**

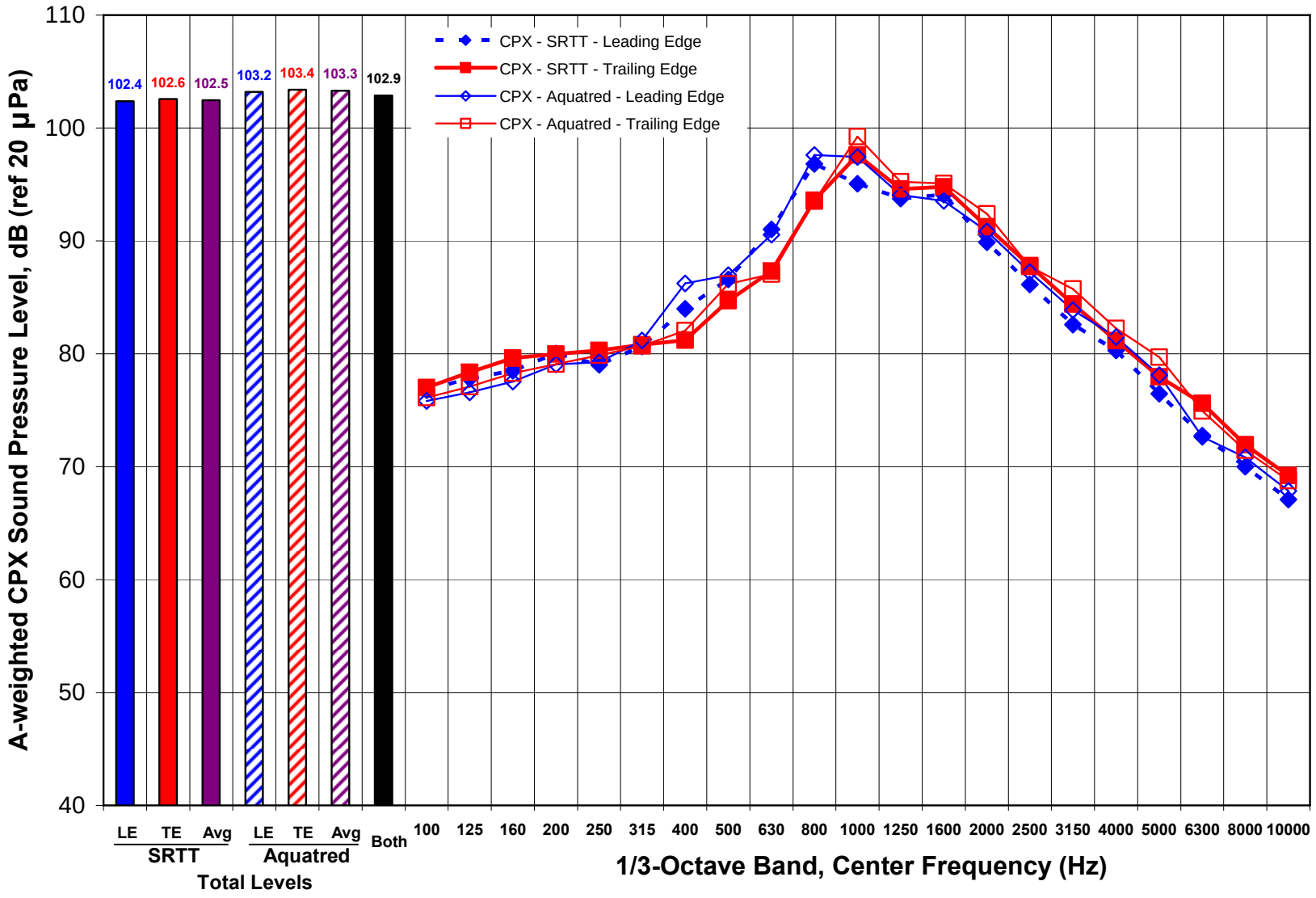
Sample Period 3 – 5 Blocks @ 15 min ea. = 75 min. (1:15 pm to 2:30 pm, 10/5/06)

Traffic volumes and speeds recorded, but not reduced.

Block 1	Block 2	Block 3	Block 4	Block 5	Average
73.8 dBA	74.0 dBA	73.5 dBA	73.9 dBA	74.0 dBA	**73.9 dBA**

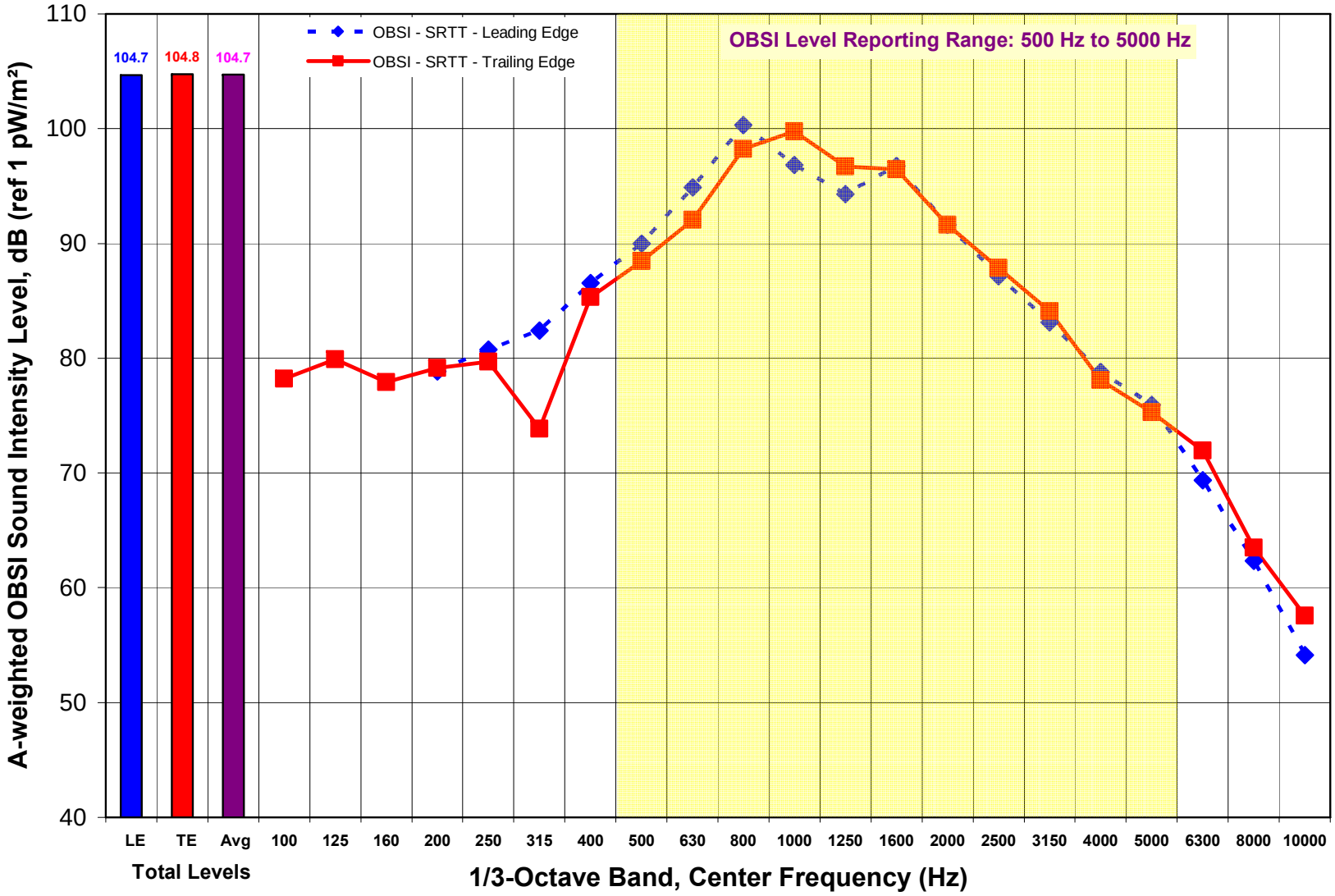
Site: 21

CPX Test Information



Site: 21

OBSI Test Information



Site: 22
General Information

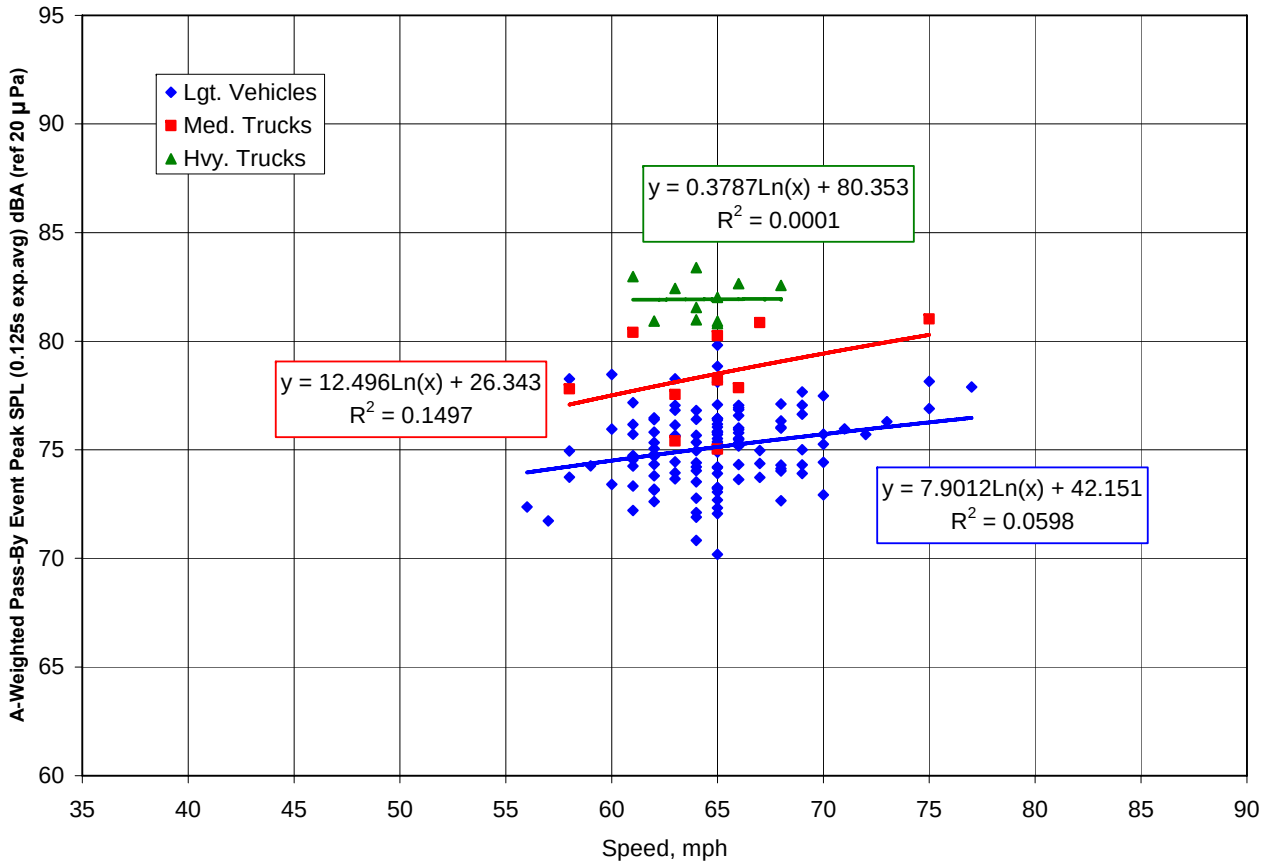
Highway: US Highway 160, Westbound
Location: Between CR-103 & Threemile Rd., Alamosa (81101)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 37.5177 / 105.9948 / 7610

Nominal Surface: Asphalt **Construction Accepted:** 1999

CPX?: Yes (11/10/06) **OBSI?:** Yes (11/10/06) **SPB?:** Yes (11/9/06) **TA?:** No
Total Section Length: 2930 ft.
Distance from Begin to Wayside Microphone: 796 ft.

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

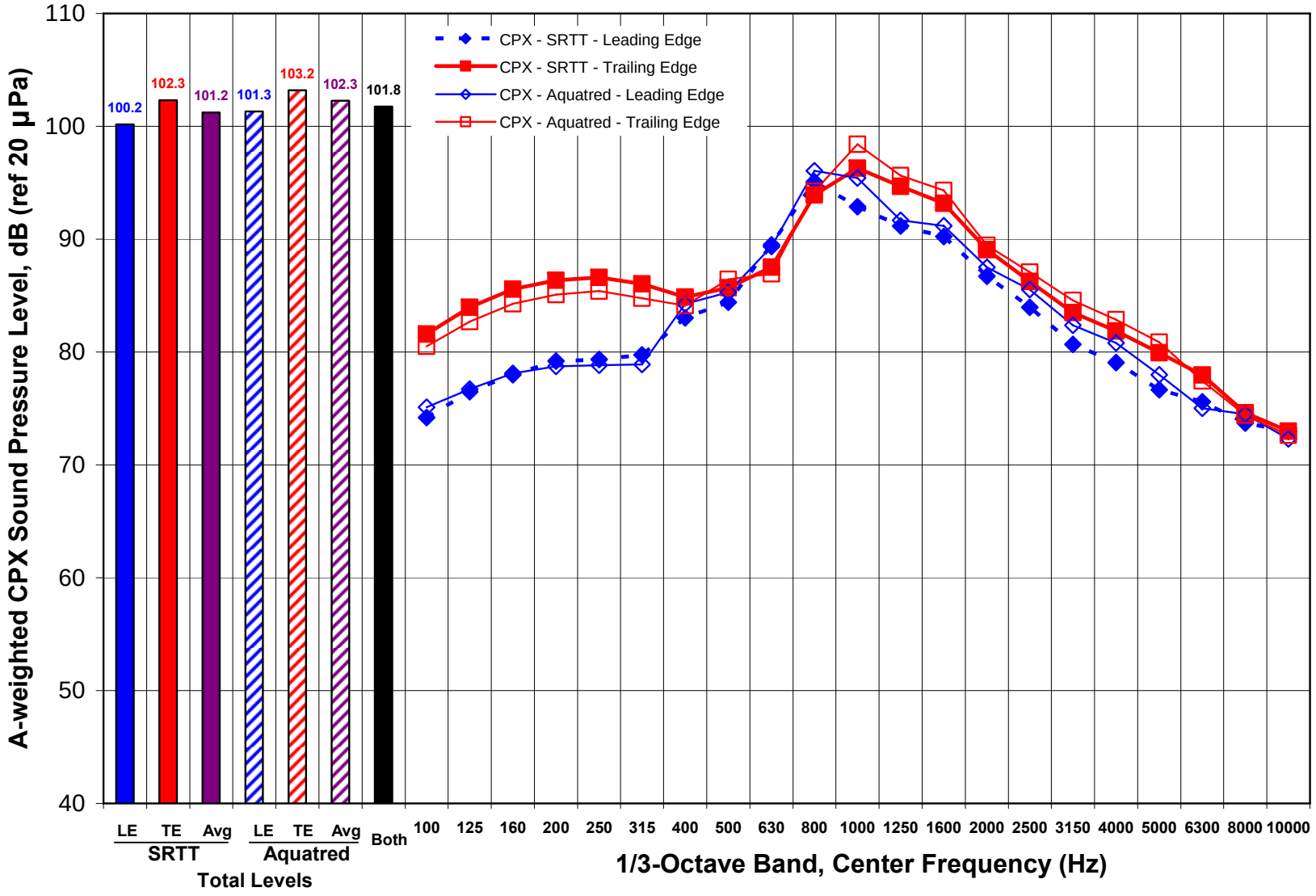
Site: 22
SPB Wayside Test Information



SPBI (Car, 60mph): 74.5 dBA
SPBI (M. Truck, 60mph): 77.5 dBA
SPBI (H. Truck, 60mph): 81.9 dBA

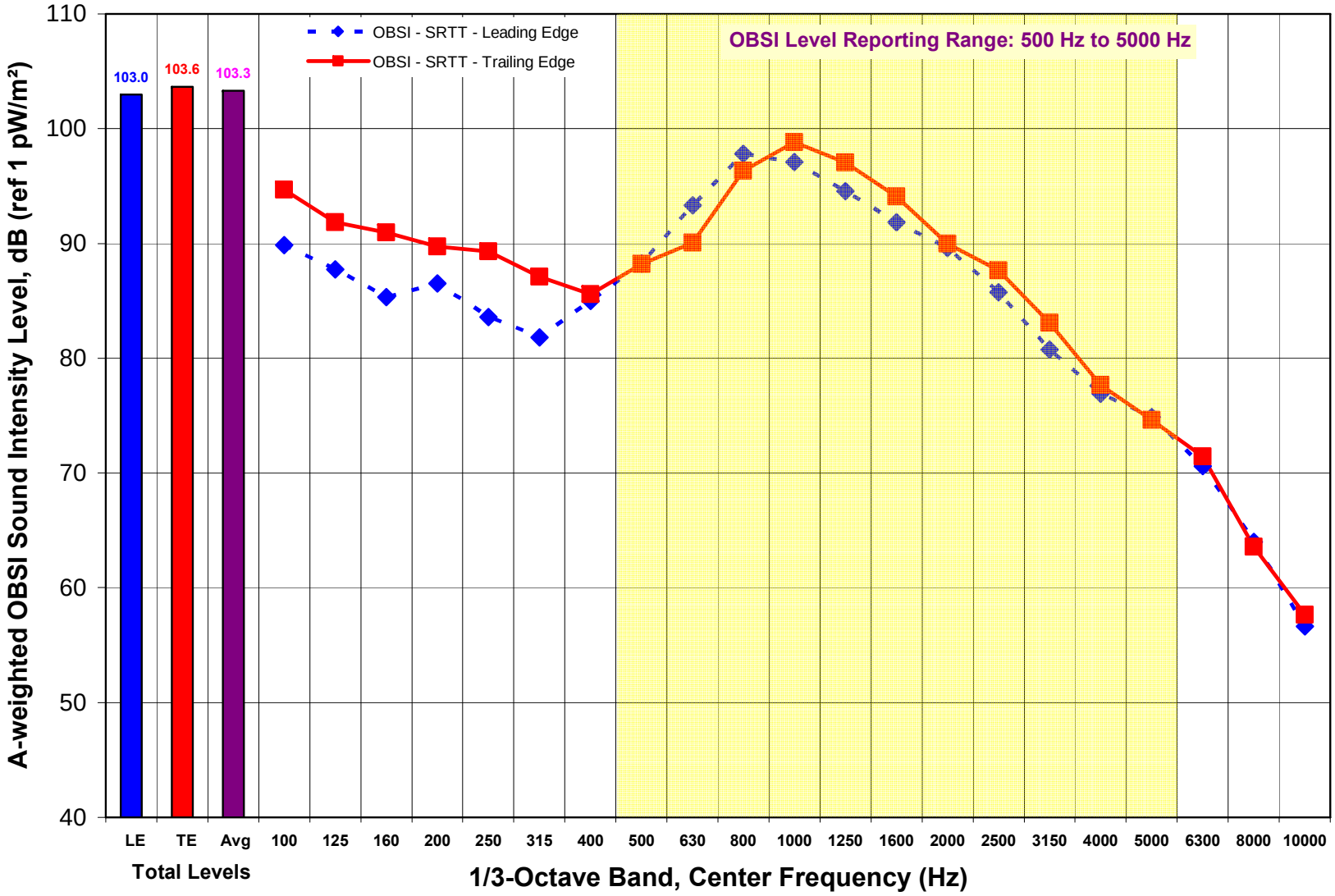
Site: 22

CPX Test Information



Site: 22

OBSI Test Information



Site: 23
General Information

Highway: Interstate 70, Eastbound
Location: Between 23 Rd. & 24 Rd., Grand Junction (81505)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.1138 / 108.6193 / 4560

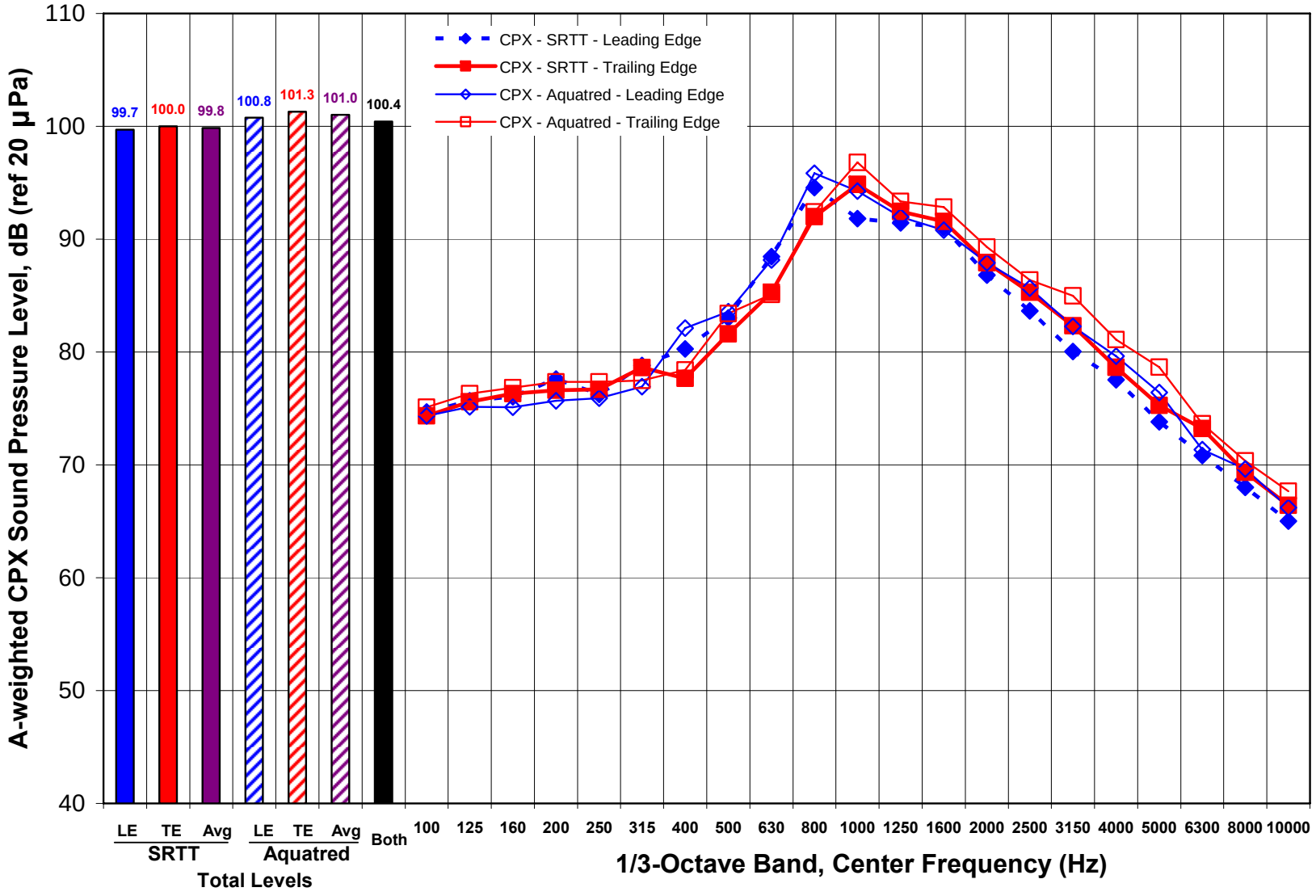
Nominal Surface: Asphalt **Construction Accepted:** 2004

CPX?: Yes (10/1/06) **OBSI?:** Yes (10/1/06) **SPB?:** No **TA?:** No
Total Section Length: 3623 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

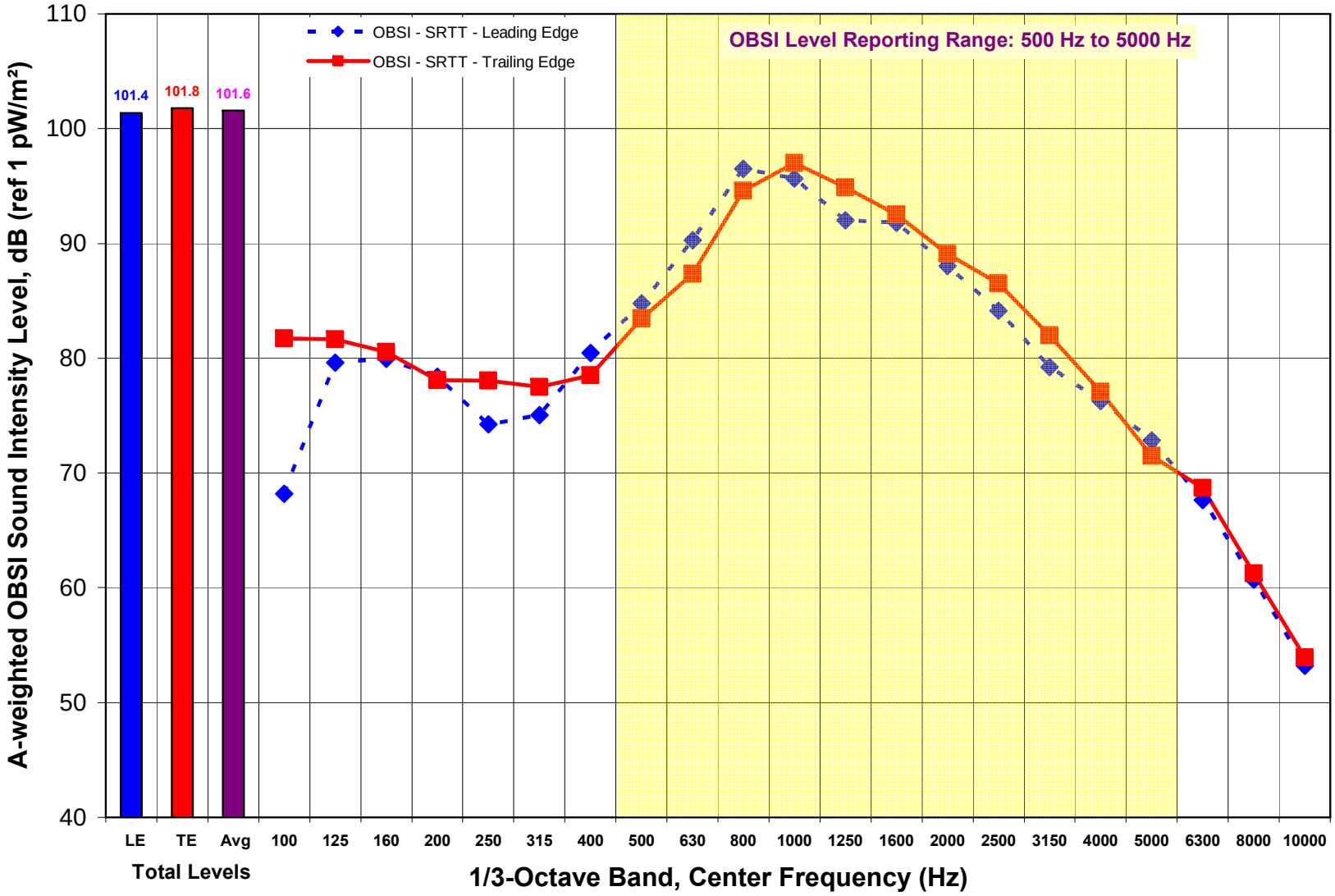
Site: 23

CPX Test Information



Site: 23

OBSI Test Information



Site: 24
General Information

Highway: Interstate 76, Westbound
Location: Between CR-49 & SH 52, Hudson (80642)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 40.0942 / 104.6143 / 4940

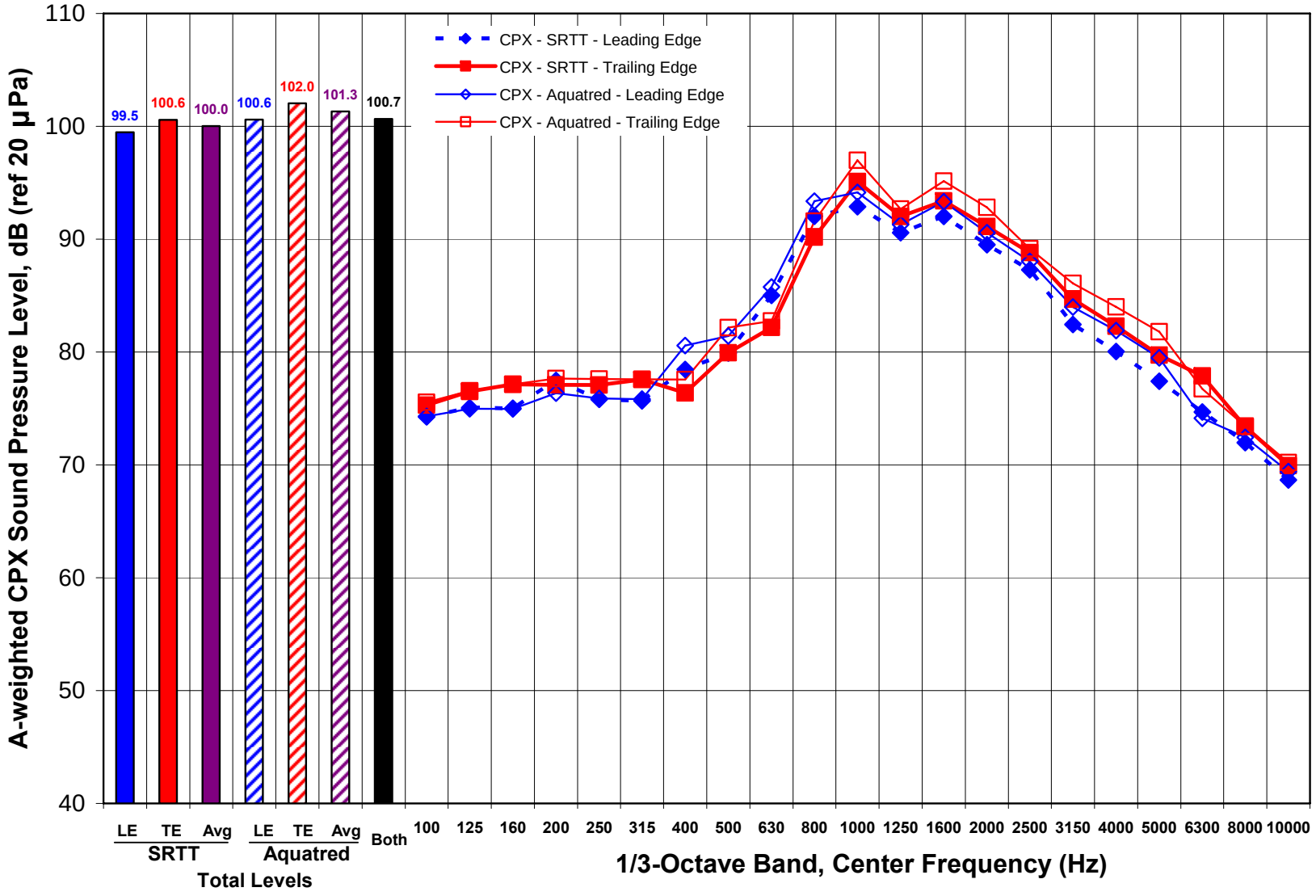
Nominal Surface: Concrete **Construction Accepted:** 2001

CPX?: Yes (11/5/06) **OBSI?:** Yes (11/5/06) **SPB?:** No **TA?:** No
Total Section Length: 3345 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

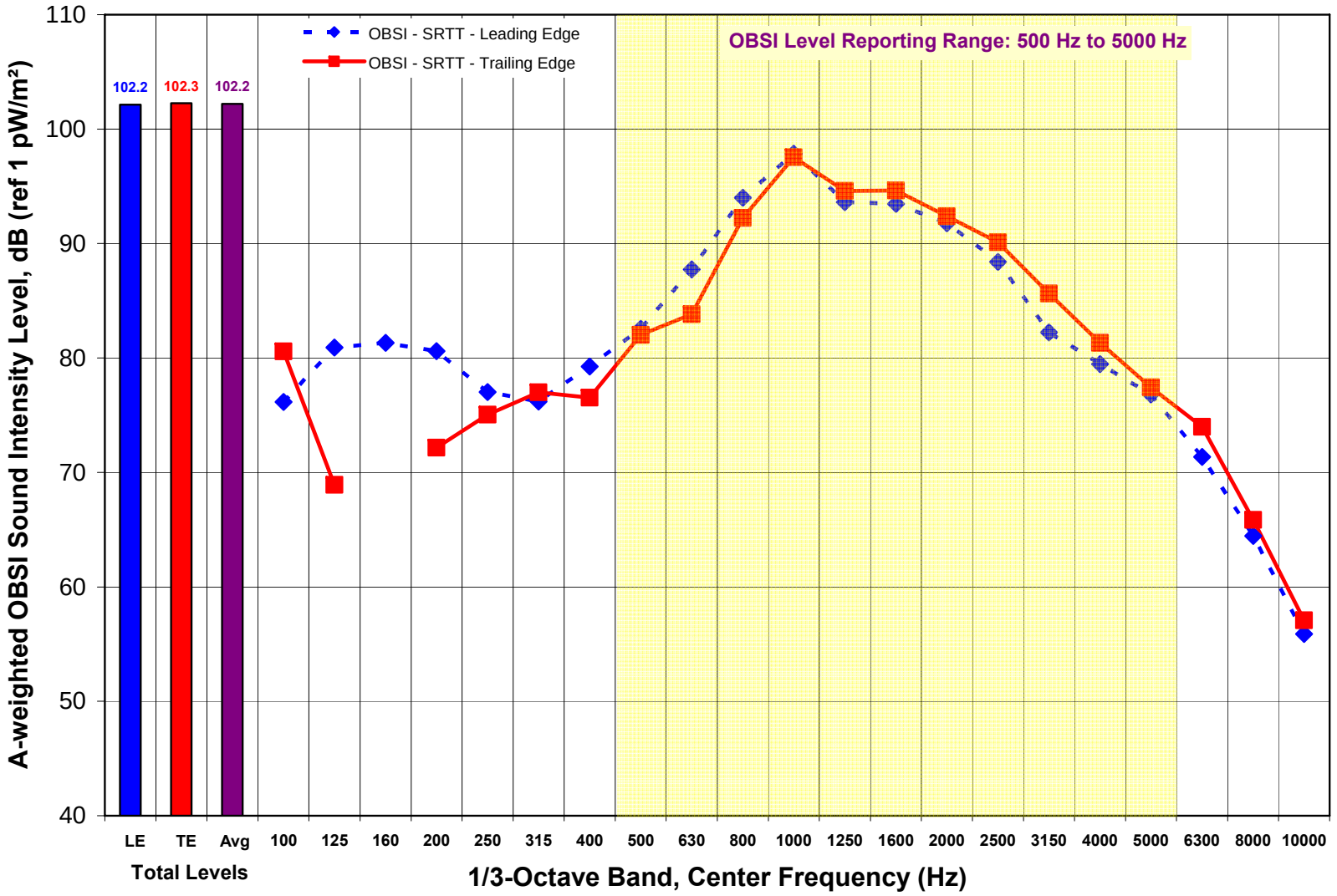
Site: 24

CPX Test Information



Site: 24

OBSI Test Information



Note: Break in data for OBSI trailing edge is the result of negative intensity calculation at this frequency.

Site: 25
General Information

Highway: Interstate 76, Eastbound
Location: Between 88th Ave. & 96th Ave., Henderson (80640)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.8655 / 104.9059 / 5120

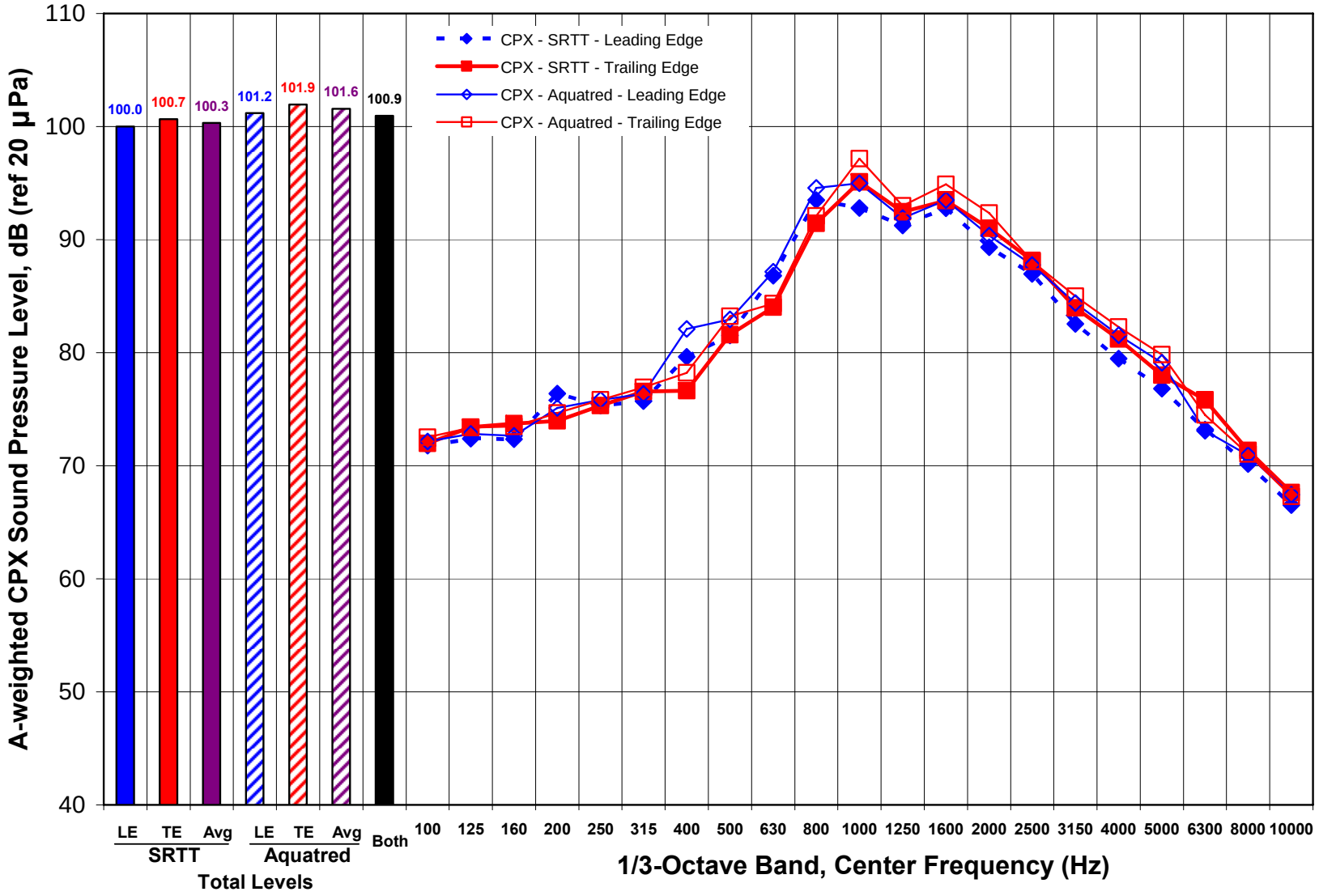
Nominal Surface: Concrete **Construction Accepted:** 2002

CPX?: Yes (11/6/06) **OBSI?:** Yes (11/6/06) **SPB?:** No **TA?:** No
Total Section Length: 2495 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

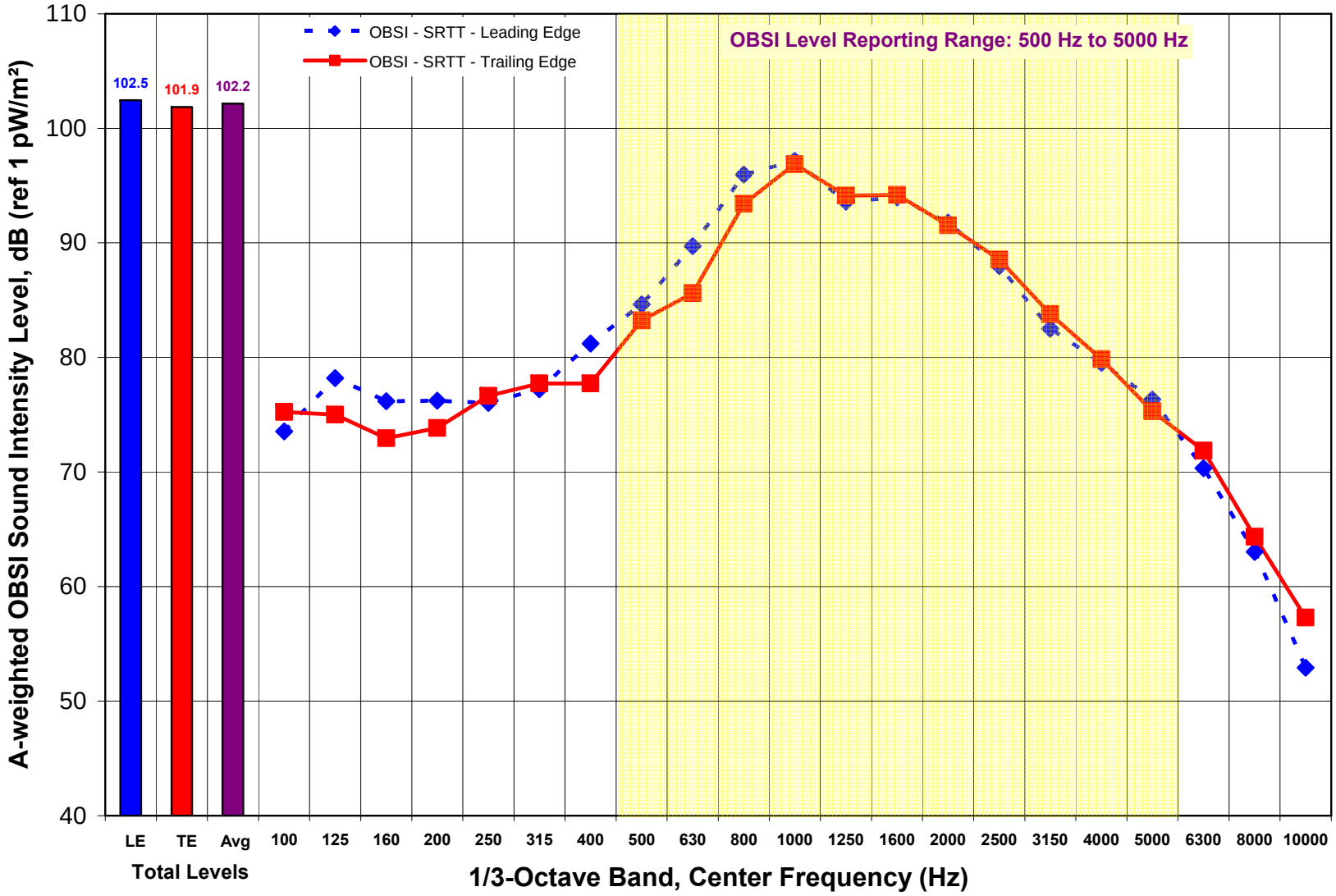
Site: 25

CPX Test Information



Site: 25

OBSI Test Information



Site: 26
General Information

Highway: Interstate 25, Southbound
Location: Between SH 105 & Higby Rd., Monument (80132)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.0862 / 104.8614 / 7010

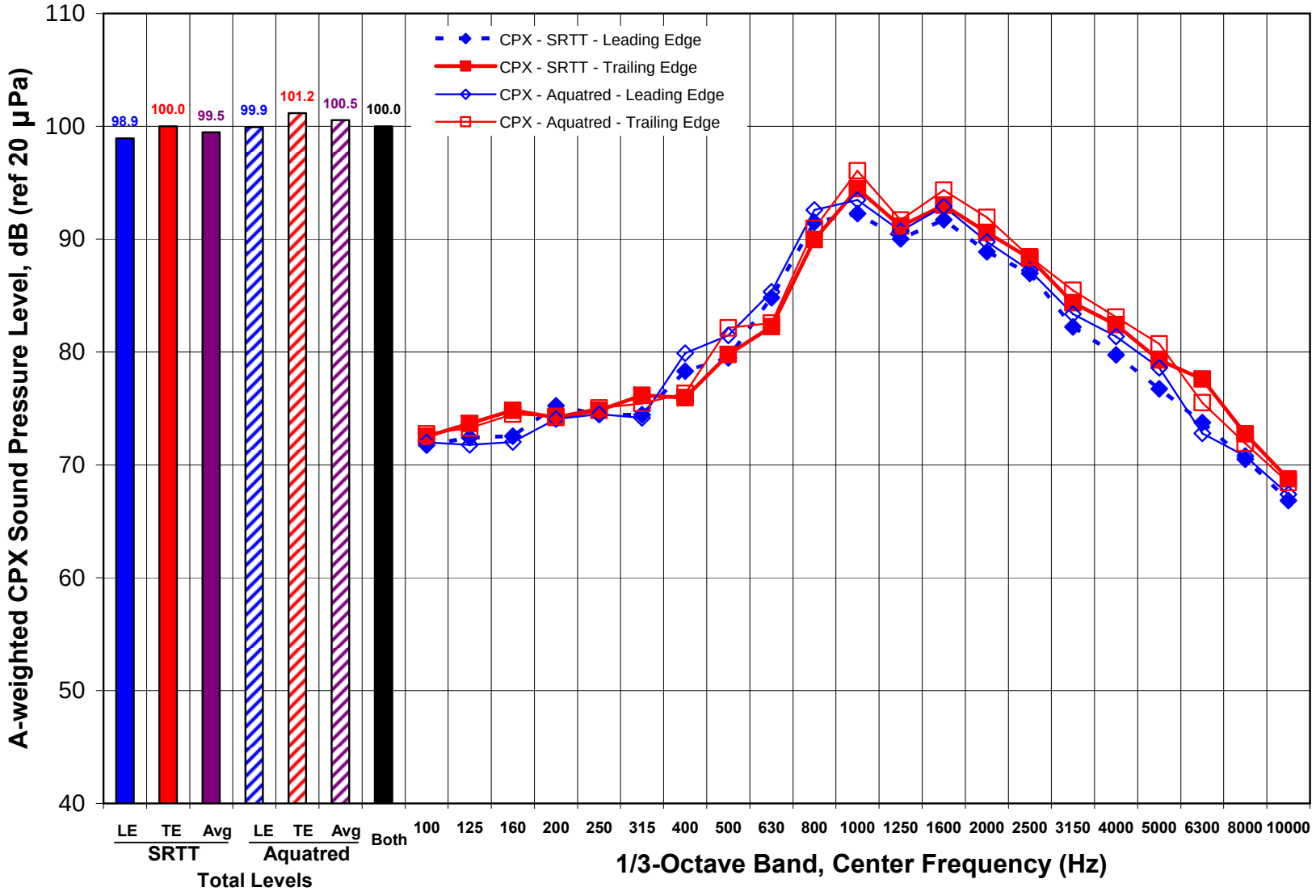
Nominal Surface: Concrete **Construction Accepted:** 1996

CPX?: Yes (11/4/06) **OBSI?:** Yes (11/4/06) **SPB?:** No **TA?:** No
Total Section Length: 1493 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

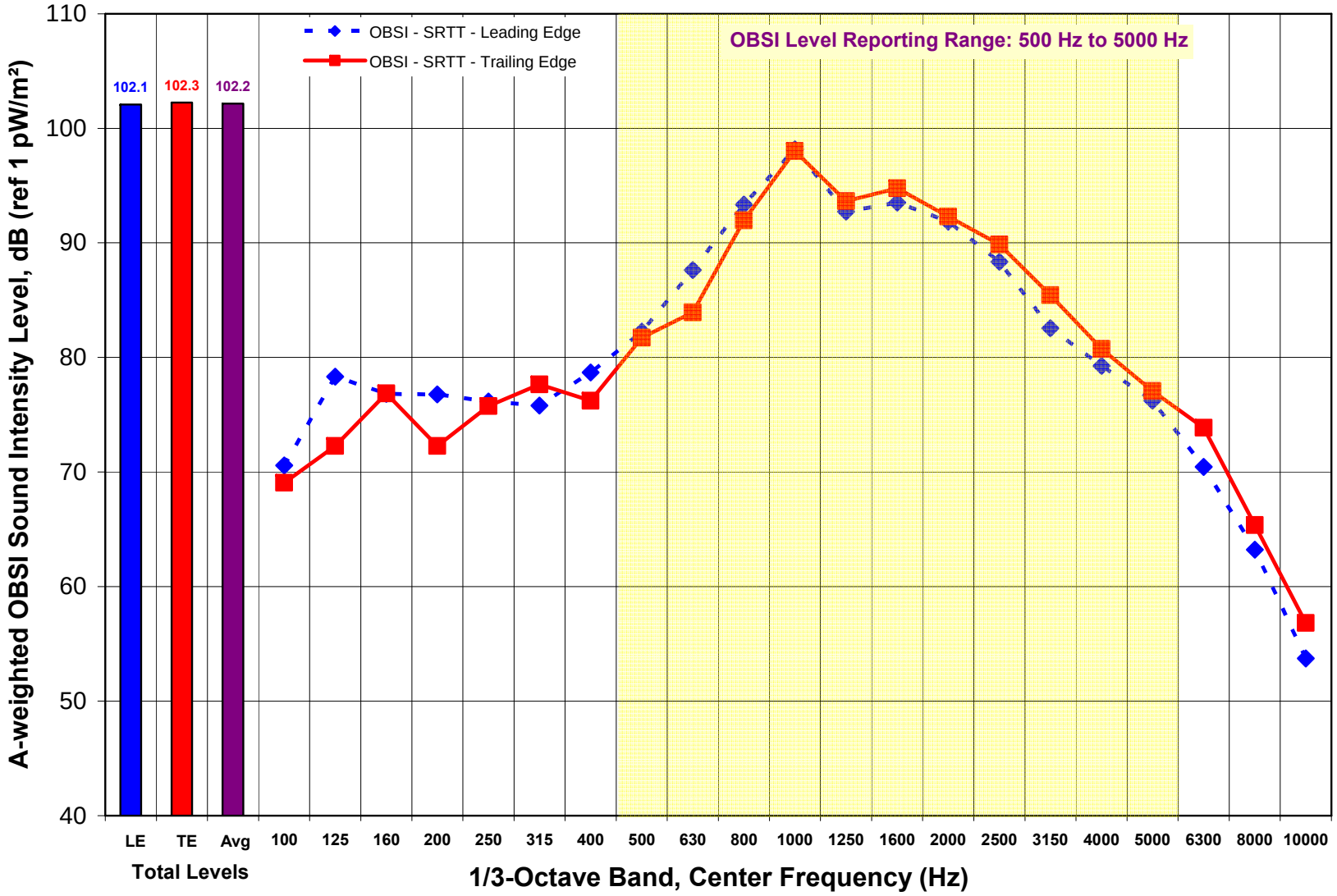
Site: 26

CPX Test Information



Site: 26

OBSI Test Information



Site: 27
General Information

Highway: Highway C-470, Westbound (Northbound)
Location: Between Morrison Rd.& Alameda Pkwy., Morrison (80228)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.6759 / 105.1869 / 5890

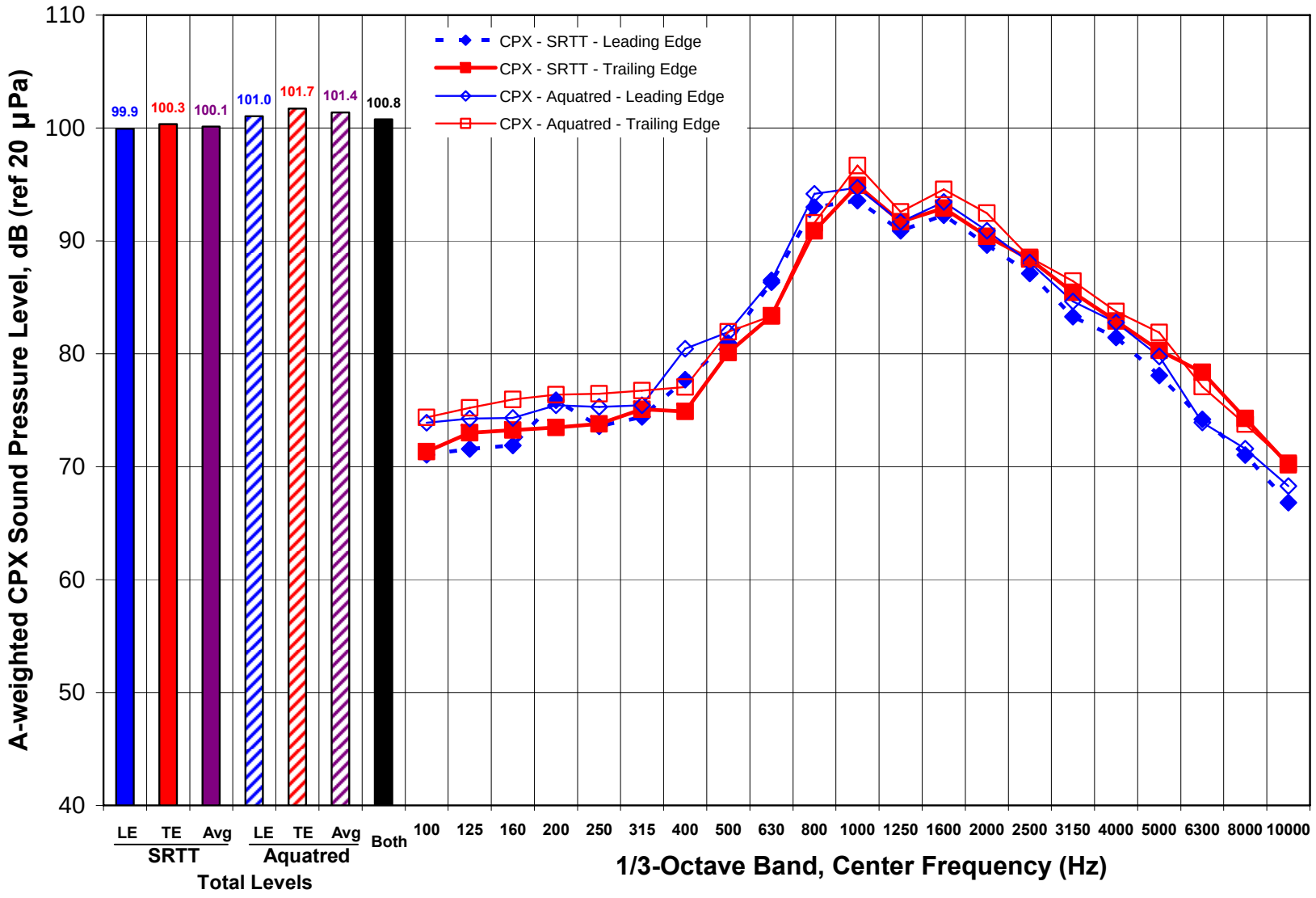
Nominal Surface: Concrete **Construction Accepted:** 2001

CPX?: Yes (10/6/06) **OBSI?:** Yes (10/6/06) **SPB?:** No **TA?:** No
Total Section Length: 7873 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

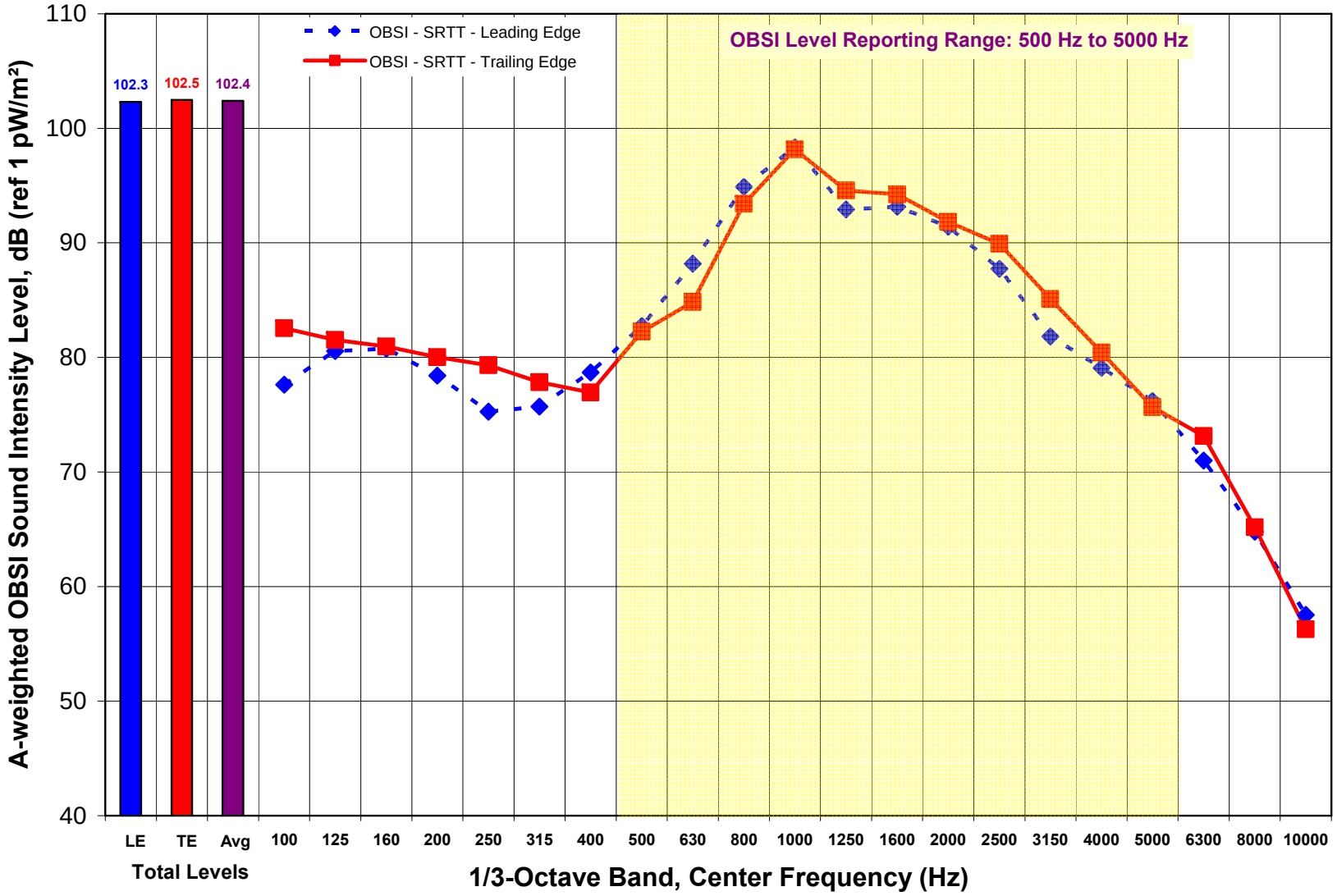
Site: 27

CPX Test Information



Site: 27

OBSI Test Information



Site: 28
General Information

Highway: Powers Blvd., Northbound (Westbound)
Location: Between Union Blvd. & Old Ranch Rd., Colorado Springs (80908)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 38.9796 / 104.7574 / 7030

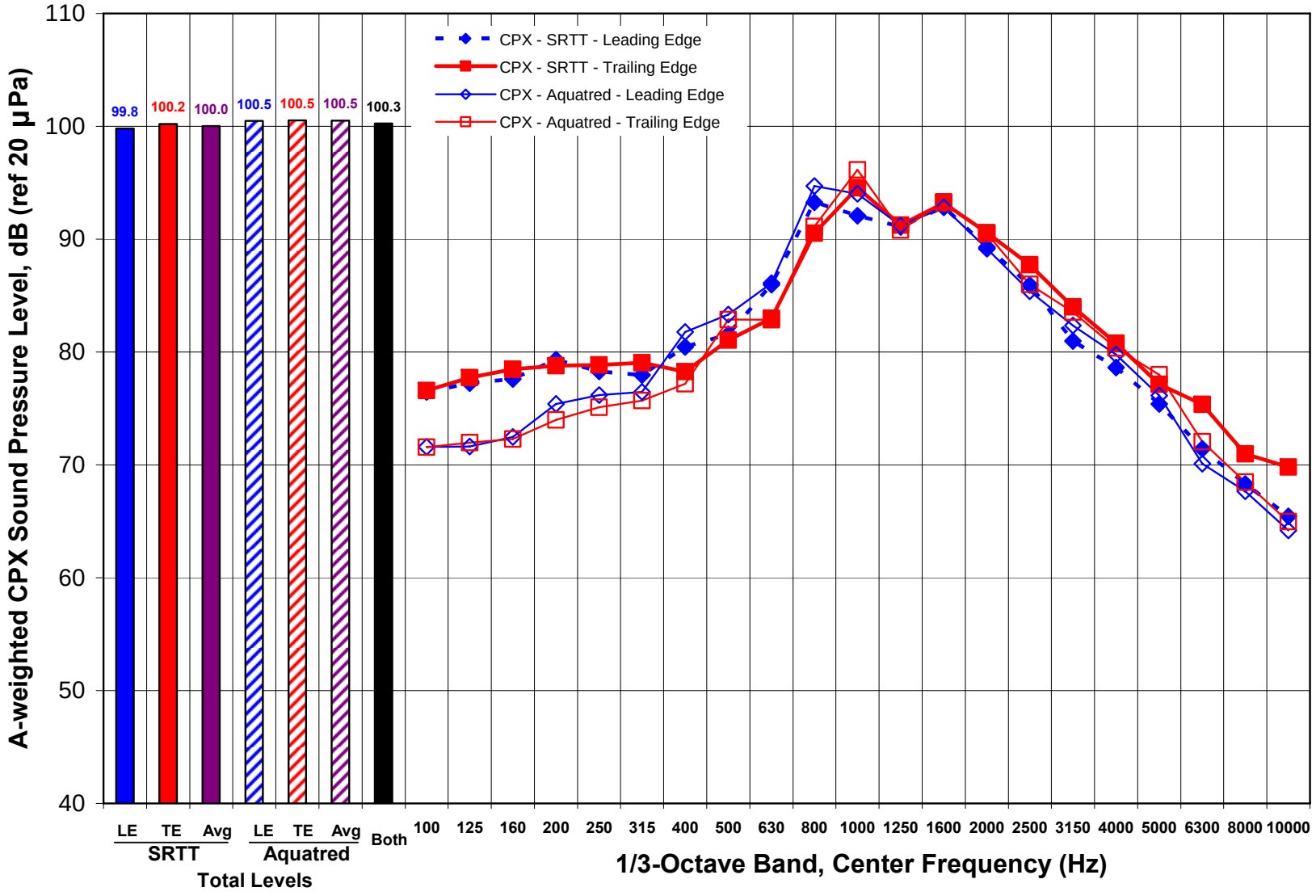
Nominal Surface: Concrete (Drag) **Construction Accepted:** 2004

CPX?: Yes (9/14-15/06) **OBSI?:** Yes (9/15/06) **SPB?:** No **TA?:** No
Total Section Length: 1804 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

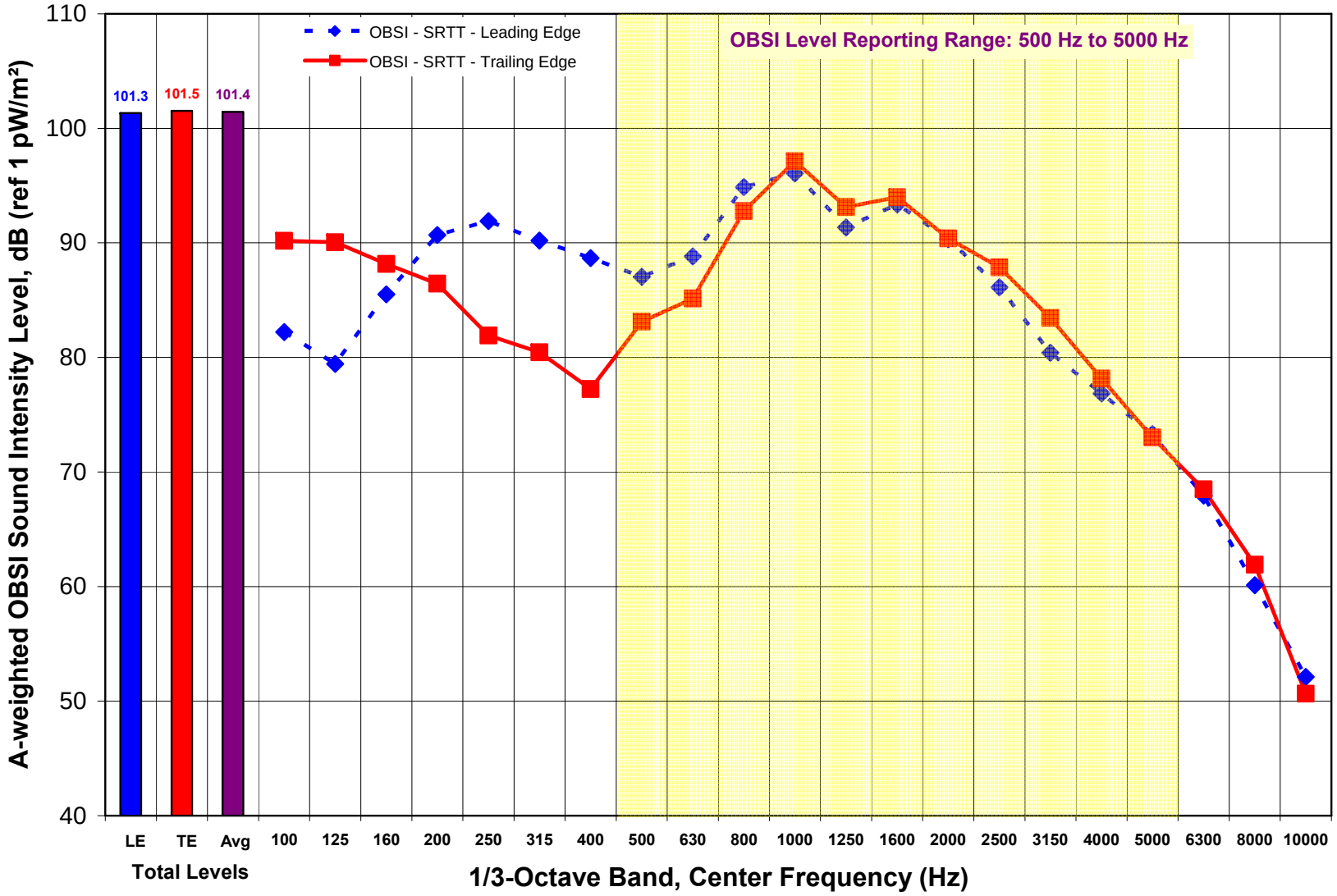
Site: 28

CPX Test Information



Site: 28

OBSI Test Information



Site: 29
General Information

Highway: Powers Blvd., Southbound (Eastbound)
Location: Between Old Ranch Rd. & Union Blvd., Colorado Springs (80920)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 38.979 / 104.7575 / 6990

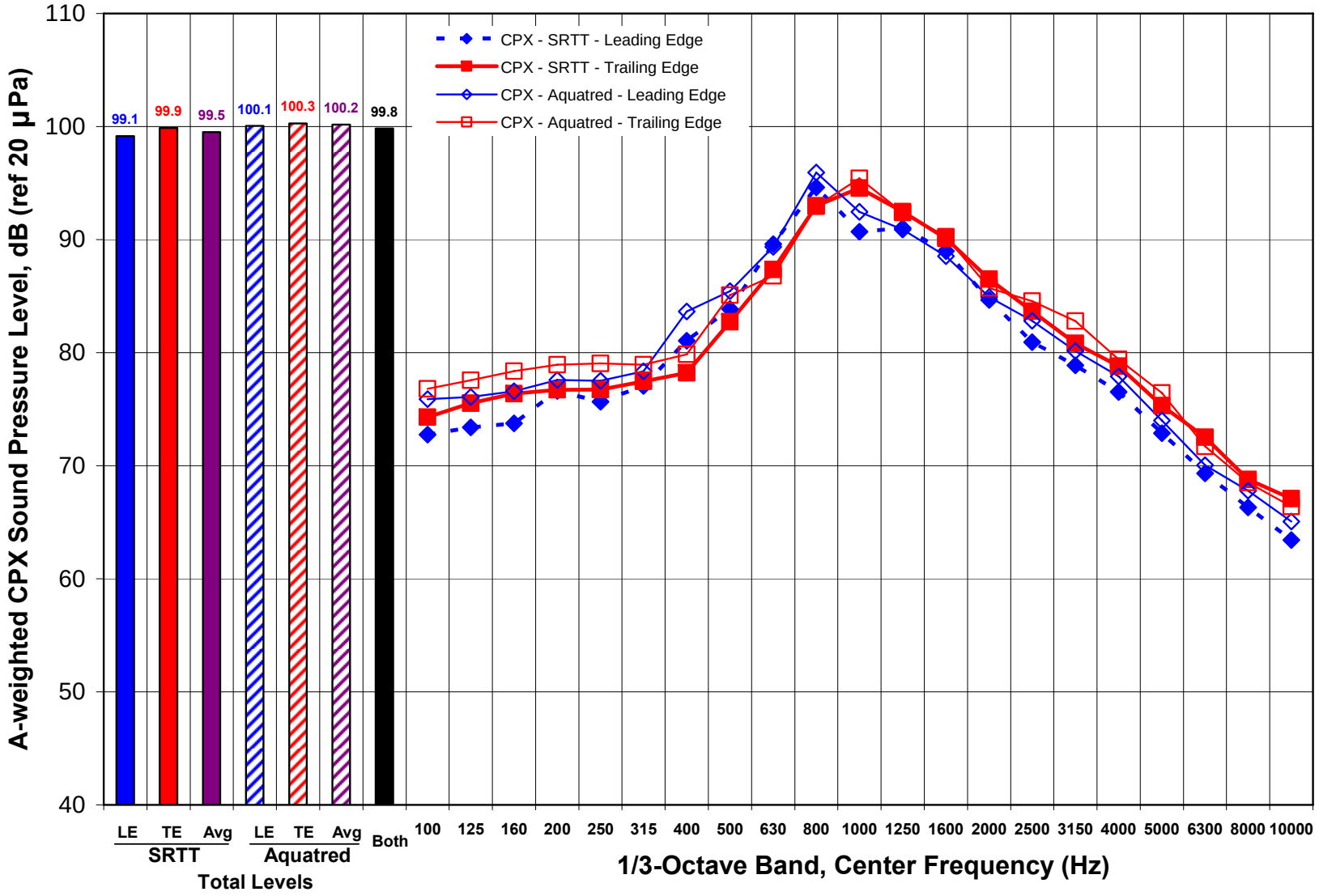
Nominal Surface: Asphalt **Construction Accepted:** 2005

CPX?: Yes (9/14-15/06) **OBSI?:** Yes (9/15/06) **SPB?:** No **TA?:** No
Total Section Length: 1724 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

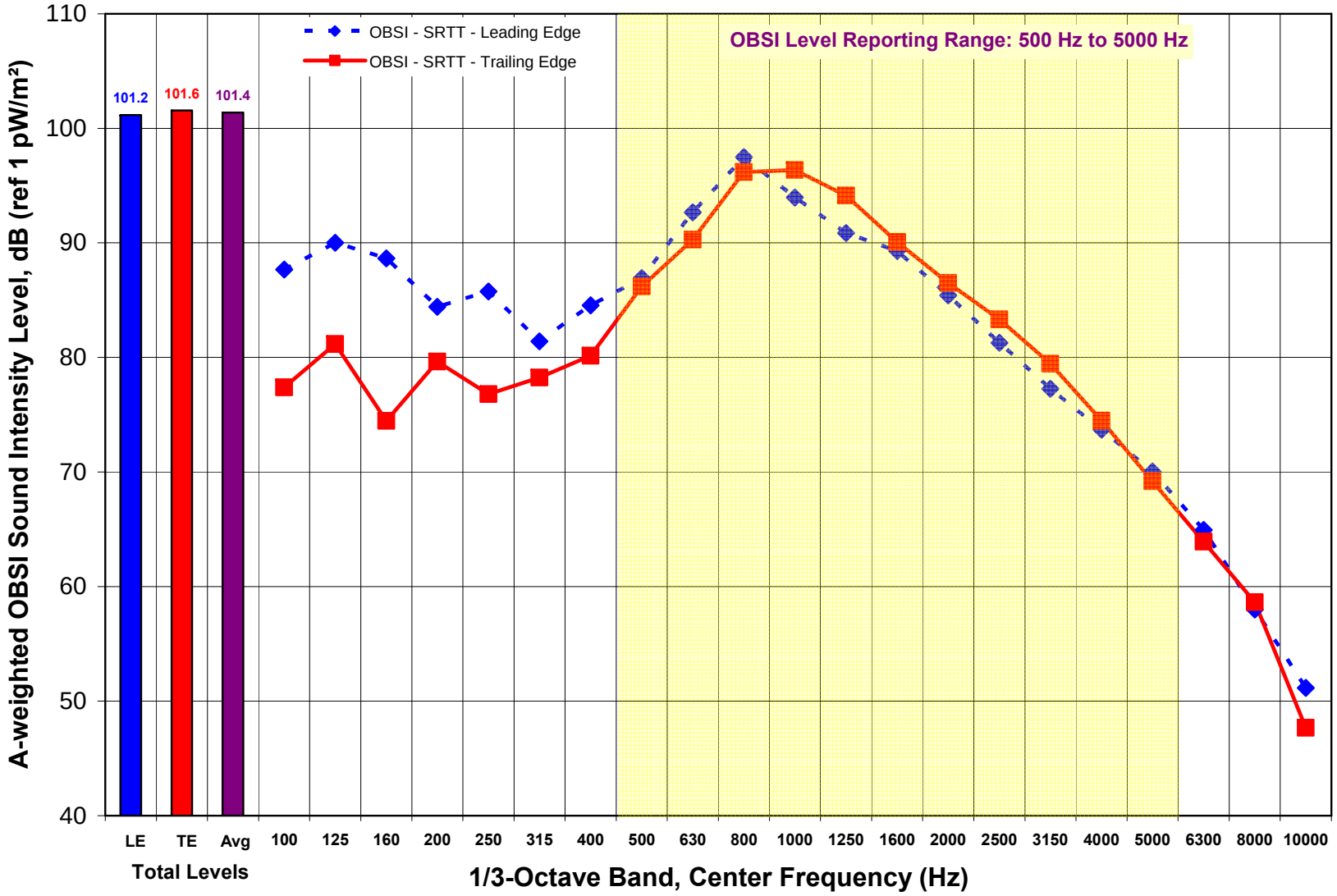
Site: 29

CPX Test Information



Site: 29

OBSI Test Information



Site: 30
General Information

Highway: US Highway 85, Northbound
Location: Between Daniels Park Rd. & SH 67, Sedalia (80135)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.4365 / 104.9514 / 5870

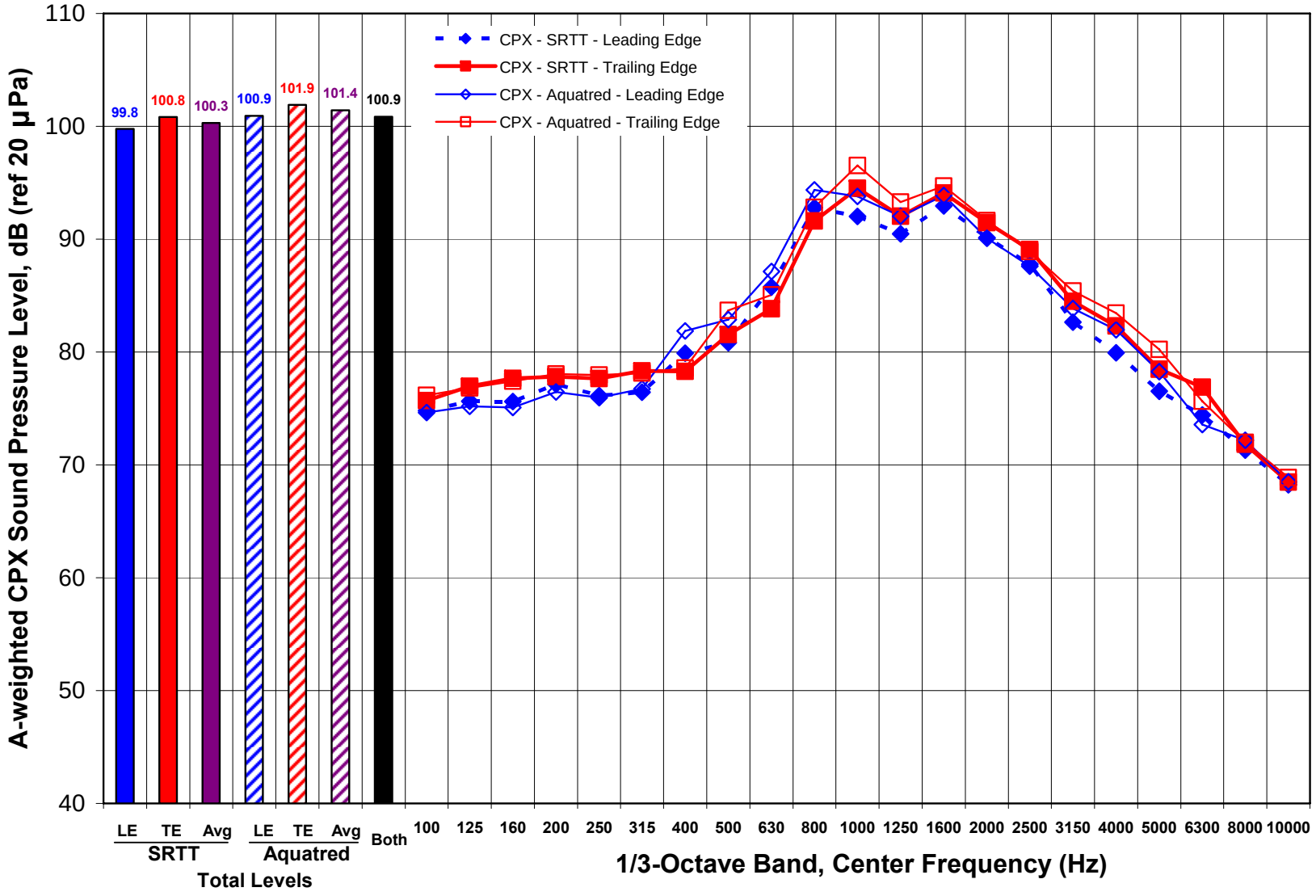
Nominal Surface: Concrete (Burlap Drag) **Construction Accepted:** to be confirmed

CPX?: Yes (10/31/06) **OBSI?:** Yes (10/31/06) **SPB?:** No **TA?:** No
Total Section Length: 3019 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

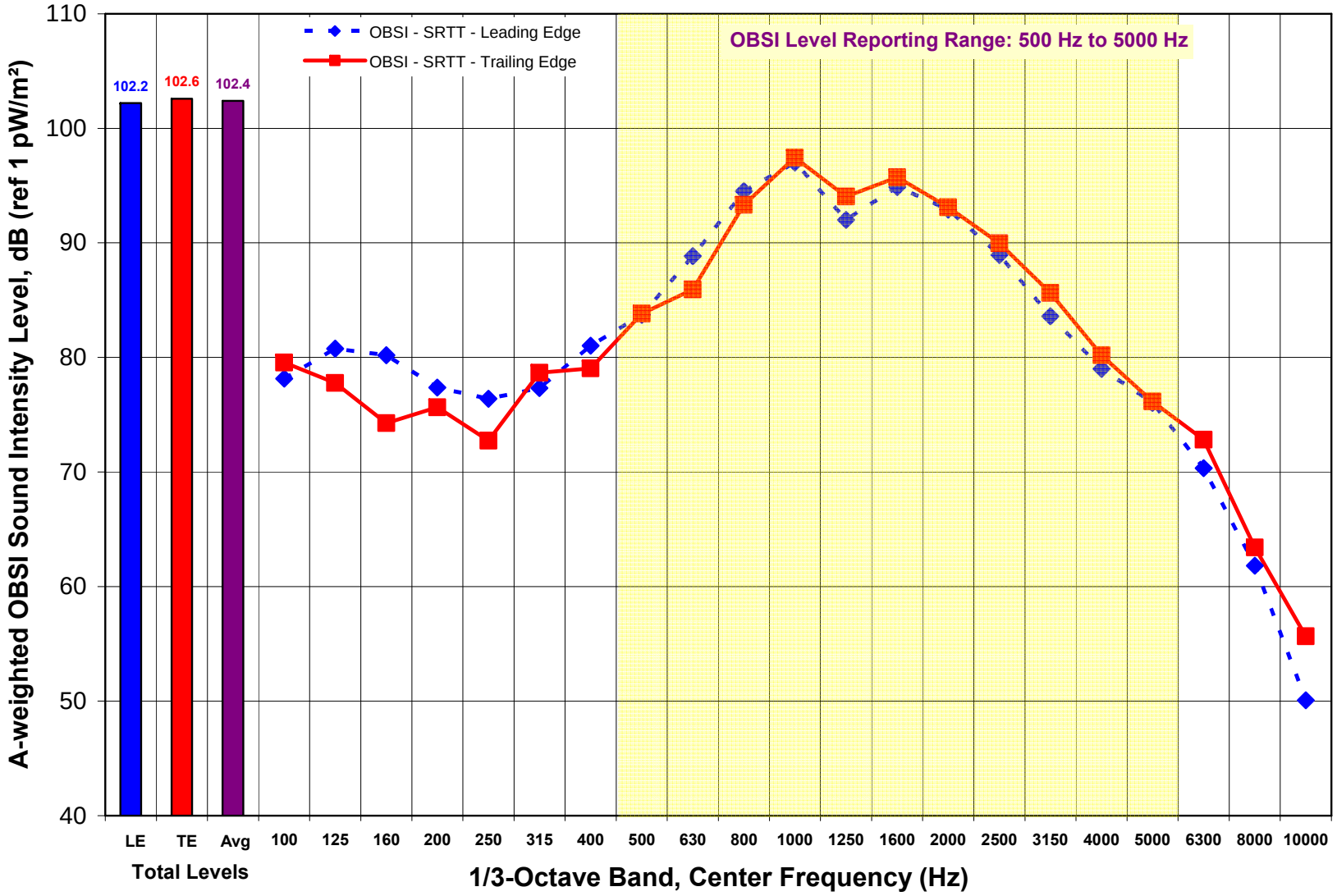
Site: 30

CPX Test Information



Site: 30

OBSI Test Information



Site: 31
General Information

Highway: Interstate 70, Eastbound
Location: Between 15th St. & US 40, Georgetown (80444)
Approx. Latitude (°N) / Longitude (°W) / Elevation (ft.): 39.7286 / 105.6919 / 8560

Nominal Surface: SMA (3/4") **Construction Accepted:** 2006

CPX?: Yes (9/26/06) **OBSI?:** No **SPB?:** No **TA?:** No
Total Section Length: 5529 ft.
Distance from Begin to Wayside Microphone: n/a

Placemark Key: B = Begin Section; M = Mid Section (Wayside Mic); E = End Section

Site: 31

CPX Test Information