WIDE-AREA AUGMENTATION SYSTEM PERFORMANCE ANALYSIS REPORT

Report #18

Reporting Period: July 1 to September 30, 2006

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NSTB/WAAS T&E Team
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Changes:

List of Figures
Figure 5-1 SV Daily Alert Trends
Table 10-1 CNMP Bounding Statistics (changes to column label only)

Executive Summary

Since 1999 the WAAS Group at the William J. Hughes Technical Center has reported GPS performance as measured against the GPS Standard Positioning Service (SPS) Signal Specification. These quarterly reports are known as the PAN (Performance Analysis Network) Report. In addition to that report, the WAAS/NSTB Team reports on the performance of the Wide-Area Augmentation System (WAAS). This report is the eighteenth such WAAS quarterly report. This report covers WAAS performance during the period from July 1, 2006 to September 30 2006.

The following table shows observations for accuracy and availability made during the reporting period. See the body of the report for additional results in accuracy, availability, safety index, range accuracy, WAAS broadcast message rates and GEO ranging availability. Please note that the results in the below table are valid when the Localizer Approach with Vertical Guidance (LPV) service is available. LPV service is available when the calculated Horizontal Protection Level (HPL) is less than 40 meters and the Vertical Protection Level (VPL) is less than 50 meters.

Parameter	Site/Maximum	Site/Minimum
95% Horizontal Accuracy	Seattle 0.935 meters	Memphis 0.579 meters
95% Vertical Accuracy	Greenwood 1.289 meters	Salt Lake City 0.907 meters
LPV Availability (HPL < 40 meters & VPL < 50 meters)	Washington DC 99.99%	Los Angeles 95.73%
95% HPL	Los Angeles 29.689 meters	Atlanta 18.297 meters
95% VPL	Los Angeles 47.16 meters	Atlanta 29.532 meters

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1.0 INTRODUCTION

The FAA began monitoring GPS SPS performance in order to ensure the safe and effective use of the satellite navigation system in the National Airspace System (NAS). The Wide Area Augmentation System (WAAS) adds more timely integrity monitoring of GPS and improves position accuracy and availability of GPS within the WAAS coverage area.

Objectives of this report are:

a. To evaluate and monitor the ability of WAAS to augment GPS by characterizing important performance parameters.
b. To analyze the effects of GPS satellite operation and maintenance, and ionospheric activity on the WAAS performance.
c. To investigate any GPS and WAAS anomalies and determine their impact on potential users.
d. To archive performance of GPS and WAAS for future evaluations.

The WAAS data transmitted from GEO satellite PRN#122 (AORW) and PRN#134 (POR) were used in the evaluation. Table 1.1 and Table 1.2 list NSTB and WAAS reference station receivers used in Precision Approach (PA) and Non-Precision Approach (NPA) evaluation process, respectively. This report presents results from three months of data, collected from July 1, 2006 to September 30, 2006.

Table 1-1 PA Sites

	Number of Days Evaluated	Number of Samples
NSTB:		
Atlantic City	90	7769343
Greenwood	92	7906413
San Angelo	89	7661176
WAAS:		
Albuquerque	90	7807328
Atlanta	91	7898140
Billings	81	6974699
Boston	91	7879021
Chicago	91	7901726
Cleveland	91	7870758
Dallas	91	7893609
Denver	91	7873815
Houston	71	6159062
Jacksonville	91	7882827
Kansas City	82	7114513
Los Angeles	91	7884991
Memphis	86	7459509
Miami	91	7894387
Minneapolis	91	7877282
New York	90	7793816
Oakland	91	7898780
Salt Lake City	91	7894502
Seattle	83	7159396
Washington DC	84	7299785

Table 1-2 NPA Sites

Location	Number of Days Evaluated	Number of Samples
Albuquerque	91	7887281
Anchorage	91	7910759
Atlanta	91	7912640
Bethel	88	7681390
Billings	75	6482123
Boston	91	7890965
Cleveland	91	7883403
Cold Bay	91	7885952
Fairbanks	90	7827844
Honolulu	91	7882600
Houston	74	6465937
Juneau	91	7912739
Kansas City	85	7377813
Kotzebue	90	7808798
Los Angeles	91	7907490
Miami	91	7914612
Minneapolis	91	7896251
Oakland	91	7920753
Salt Lake City	91	7919188
San Juan	91	7917721
Seattle	91	7872755
Washington DC	84	7334481

The report is divided in the performance categories listed below. This report also includes WAAS LPV Service Availability at Selected Airports, and WAAS Deterministic Code Noise and Multipath (CNMP) Bounding Analysis.

1. WAAS Position Accuracy
2. WAAS Operational Service Availability
3. Coverage
4. Integrity
5. WAAS Range Domain Accuracy
6. GEO Ranging Performance

Table 1.3 lists the performance parameters evaluated for the WAAS in this report. Please note that these are the performance parameters associated with the WAAS IOC system. These requirements are extracted from the FAA Specification FAA-E-2892B Change 1. In future reports the performance parameters will be derived from FAA Specification FAA-E-2976, as applicable.

Table 1-3 WAAS Performance Parameters

Performance Parameter	Expected WAAS Performance
PA Accuracy Horizontal	≤ 7.6m error 95% of the time
PA Accuracy Vertical	≤ 7.6m error 95% of the time
NPA Accuracy Horizontal	≤ 100m error 95% of the time ≤ 556m error 99.999% of the time
Availability LPV*	Not Defined for Current WAAS phase
Availability LNAV/VNAV*	Not Defined for Current WAAS phase
LPV and LNAV/VNAV Outages and outage rate	Not Defined for Current WAAS phase
LNAV Outages and outage rates	Not Defined for Current WAAS phase
Coverage LPV	Not Defined for Current WAAS phase For this report - 95% availability of 75% of CONUS
Coverage LNAV/VNAV	95% availability of 75% of CONUS
Coverage NPA	99.9% availability of 75% of service volume
LPV Availability	≥ 95% of the time within the service volume
LNAV/VNAV Availability	≥ 95% of the time within the service volume
Integrity	≤ 4 X 10e-8 HMI's per approach

* Instantaneous availability (i.e. Availability is calculated every second.)

1.1 Event Summary

Table 1.4 lists test events that occurred during the reporting period that affected WAAS performance or the ability to determine the WAAS performance. These events include GPS or WAAS anomalies, relevant receiver malfunctions, and receiver maintenance conducted. Detailed analyses of particular events are documented in the Discrepancy Reports (DR). The DRs are posted on the website under 'WAAS Technical Reports' and can be accessed by via hyperlink from the Table 1.4.

There are no DRs for this quarter.

Table 1-4 Test Events

GPS Week	Date	Sites	Events
1383 day 0	7/9/06	All Sites	WAAS Release 4 deployed.
1384 day 1	7/17/06	Sites connected to Atlanta and LA TCS Comm Nodes	ZTL (Atlanta) TCS Communications Node outage (281 sec). ZLA TCS Communications Node outages (14 & 18 sec).
1384 day 3	7/19/06	Sites connected to LA TCS Comm Node	ZLA TCS Communications Node outages (705 & 265 sec).
1385 day 3 to 1386 day 2	7/26/06 to 8/1/06	Kansas City	Kansas City outage.
1385 day 3 to 1386 day 4; 1387 day 0	7/26/06 to 8/3/06; 8/6/06	Houston	Houston outage.
1385 day 5	7/28/06	All WAAS Sites	2 WEI outages.
1386 day 5	8/4/06	All WAAS Sites	WEI outage.
1388 day 0	8/13/06	All WAAS Sites	WEI outage.
1386 day 6 to 1387 day 3	8/5/06 to 8/9/06	Memphis	Memphis outage.
1387 day 4 to 1388 day 5	8/10/06 to 8/18/06	Houston	Houston outage.
1388 day 1 to 1389 day 5	8/14/06 to 8/25/06	Billings	Billings outage.
1388 day 3	8/16/06	All WAAS Sites	2 WEI outages.
1389 day 0	8/20/06	North-Central CONUS Sites	IGP Warning for 40N 95W.
1389 day 2	8/22/06	All WAAS Sites	WEI outage.
1390 day 6	9/2/06	All WAAS Sites	WEI outage.
1391 day 6	9/9/06	Denver, Dallas, KC, LA, Oakland, Seattle; Alaska Sites	ZLA TCS Communication Node outage (78 sec).
1392 day 2 to 1393 day 1	9/12/06 to 9/18/06	DC	DC outage.
1394 day 1	9/25/06	None	Manual POR GUS switchover to resolve G2 firmware problem.

1.2 Report Overview

Section 2 provides the vertical and horizontal position accuracies from data collected, on a daily basis, at one-second intervals. The 95% accuracy index and the maximum accuracy for the reporting period are tabulated. The daily 95% accuracy index is plotted graphically for each receiver. Histograms of the vertical and horizontal error distribution are provided for three receivers within the WAAS service area.

Section 3 summarizes the WAAS instantaneous availability performance, at each receiver, for three operational service levels during the reporting period. Daily availability is also plotted for each receiver evaluated. The number of outages and outage rate for each site is reported.

Section 4 provides the percent of coverage provided by WAAS on a daily basis. Monthly roll-up graphs presented indicate the portions of service volume covered, and the percentage of time that WAAS was available.

Section 5 summarizes the number of HMI's detected during the reporting period and presents a safety margin index for each receiver. The safety index reflects the amount of over bounding of position error by WAAS protection levels. This section also includes update rates of WAAS messages transmitted from AORW and POR.

Section 6 provides the UDRE and GIVE bounding percentage and the 95% index of the range and ionospheric accuracy for each satellite tracked by the WAAS receiver in Houston.

Section 7 provides the GEO ranging performance for AORW and POR.

Section 8 summarizes WAAS anomalies and problems identified during the reporting period, which adversely affect WAAS performance described in Table 1.3.

Section 9 provides WAAS LPV availability and outages at selected airports.

Section 10 provides the assessment of WAAS CNMP bounding for 75 WAAS receivers.

2.0 WAAS POSITION ACCURACY

Navigation error data, collected from WAAS and NSTB reference stations, was processed to determine position accuracy at each location. This was accomplished by utilizing the GPS/WAAS position solution tool to compute a MOPS-weighted least squares user navigation solution, and WAAS horizontal and vertical protection levels (HPL & VPL), once every second. The user position calculated for each receiver was compared to the surveyed position of the antenna to assess position error associated with the WAAS SIS over time. The position errors were analyzed and statistics were generated for two operational service levels: WAAS LPV, and WAAS LNAV/VNAV, as shown in Table 2.1. For this evaluation, the WAAS operational service level is considered available at a given time and location, if the computed WAAS HPL and VPL are within the horizontal and vertical alarm limits (HAL & VAL) specified in Table 2.1.

Table 2-1 Operational Service Levels

WAAS Operational Service Levels	Horizontal Alert Limit HAL (meters)	Vertical Alert Limit VAL (meters)
LPV (LOC/VNAV)	40	50
LNAV/VNAV	556	50

Table 2.2 shows PA horizontal and vertical position accuracy maintained for 95% of the time at LPV and LNAV/VNAV operational service levels for the quarter. The table also includes 95% SPS accuracy for certain locations. Figures 2.1 to 2.4 show the daily horizontal and vertical 95% accuracy for LNAV/VNAV operational service level for the period. Note that WAAS accuracy statistics presented are compiled only when all WAAS corrections (fast, long term, and ionospheric) for at least 4 satellites are available. This is referred to as PA navigation mode. The percentage of time that PA navigation mode was supported by WAAS at each receiver is also shown in Table 2.2. A user is considered to be in NPA navigation mode if only WAAS fast and long term corrections are available to a user (i.e. no ionospheric corrections). Table 2.3 shows NPA horizontal position accuracy for 95% and 99.999% of the time. This table also shows the maximum NPA horizontal position error for the quarter. Figures 2.5 shows the daily horizontal 95% accuracy for NPA.

During the evaluated period, the 95% horizontal and vertical accuracy at all evaluated sites were less than 2 meters for both WAAS operational service levels. The maximum 95% horizontal and vertical LPV errors are 0.935meters at Seattle and 1.289 at Greenwood, respectively. The minimum 95% horizontal and vertical LPV errors are 0.579 meters at Memphis and 0.907 meters at Salt Lake City, respectively. The maximum 95% and 99.999% NPA horizontal errors are 2.572 meters and 6.636 meters both at Honolulu, respectively. The minimum 95% and 99.999% horizontal errors are 1.012 meters at Atlanta and 2.213 meters at Billings, respectively. For this quarter, San Juan was not able to track the AOR-W GEO at its new location and therefore was not evaluated.

The AOR-W GEO was unavailable for PA ranging this quarter as expected. The reason is the AOR-W GEO was repositioning to its new location and was not available during the transitional period.

Table 2.4 shows the maximum horizontal and vertical position errors while the calculated HPL and VPL met the LPV service levels. The column marked ‘Horizontal (or Vertical) Error/HPL (or VPL)’ is the ratio of position error to protection level at the time the maximum error occurred. The column marked 'Horizontal (or Vertical) Maximum Ratio' is the maximum position error to protection level ratio for the quarter.

Figures 2.6 to 2.15 show the distributions of the vertical and horizontal errors in triangle charts and 2-D histogram plots for the quarter at three locations, Kansas City, Washington DC and Seattle. The triangle charts show the distributions of vertical position errors (VPE) versus vertical protection levels (VPL) and horizontal position errors (HPE) versus horizontal protection levels (HPL). The horizontal axis is the position error and the vertical axis is the WAAS protection levels. Lower protection levels equate to better availability. The diagonal line shows the point where error equals protection level. Above and to the left of the diagonal line in the chart, errors are bounded (WAAS is providing integrity in the position domain); below and to the right, errors are not bounded (HMI could be present). The horizontal lines at various protection levels represent the various operational service levels as defined in Table 2.1. The 2-D histogram plots contain four histograms showing the distributions of vertical and horizontal position errors and normalized position errors. The left top and bottom histograms show the distributions of the actual vertical and horizontal errors. The horizontal axis is the position errors and the vertical axis is the total count of data samples (log scale) in each 0.1-meter bin. The right top and bottom histograms show the distributions of the actual vertical and horizontal errors normalized by one-sigma value of the protection level; vertical - (VPL/5.33) and horizontal - (HPL/6.0). The horizontal axis is the standard units and vertical axis is the observed distribution of normalized errors data samples in each 0.1-sigma bin. Narrowness of the normalized error distributions shows very good observed safety performance.

Table 2-2 PA 95% Horizontal and Vertical Accuracy

Location	Horizontal GLS/APV2/LPV (HAL=40m) (Meters)	Horizontal APV-1(LNAV) (HAL=556m) (Meters)	Vertical LPV/VNAV (VAL=50m) (Meters)	Percentage in PA mode (%)	SPS Accuracy	
					95% Horizontal (Meters)	95% Vertical (Meters)
Atlantic City	0.727	0.727	1.271	99.99305	*	*
Greenwood	0.641	0.641	1.289	99.99416	*	*
San Angelo	0.655	0.656	1.008	99.99128	*	*
Albuquerque	0.658	0.658	1.213	99.99088	2.461	4.005
Atlanta	0.617	0.617	1.098	99.99376	2.489	4.284
Billings	0.773	0.773	0.969	99.98847	2.341	4.045
Boston	0.807	0.807	1.217	99.99306	2.466	4.237
Chicago	0.718	0.718	1.122	99.99378	*	*
Cleveland	0.706	0.706	1.267	99.99361	2.549	4.435
Dallas	0.825	0.825	1.210	99.99371	*	*
Denver	0.682	0.682	1.164	99.99106	*	*
Houston	0.700	0.700	1.130	99.99285	2.582	4.471
Jacksonville	0.626	0.626	1.125	99.99365	*	*
Kansas City	0.782	0.783	1.148	99.99329	2.518	4.527
Los Angeles	0.827	0.827	1.200	99.99998	2.530	4.310
Memphis	0.579	0.580	1.213	99.99461	*	*
Miami	0.806	0.806	1.388	99.99364	2.740	4.602
Minneapolis	0.783	0.784	1.202	99.99381	2.443	4.245
New York	0.737	0.737	1.127	99.99386	*	*
Oakland	0.817	0.817	1.228	99.99919	2.521	4.491
Salt Lake City	0.741	0.741	0.907	99.99991	2.466	4.266
Seattle	0.935	0.935	0.993	100	2.525	4.237
Washington DC	0.644	0.644	1.100	99.99500	2.540	4.577

* SPS accuracy not computed for this location.

Table 2-3 NPA 95% and 99.999% Horizontal Accuracy

Location	95% Horizontal (meters)	99.999% Horizontal (meters)	Percentage in NPA mode (%)	Maximum Horizontal Error
Albuquerque	1.130	3.381	99.9942	6.154
Anchorage	1.385	3.847	99.9999	4.046
Atlanta	1.012	2.935	99.9946	4.219
Bethel	1.309	3.058	100	3.387
Billings	1.114	2.213	99.9950	5.513
Boston	1.160	4.697	99.9943	5.792
Cleveland	1.082	3.477	99.9944	5.953
Cold Bay	1.403	3.903	99.9998	4.642
Fairbanks	1.305	3.781	100	4.812
Honolulu	2.572	6.636	99.9956	7.179
Houston	1.241	4.043	99.9940	6.481
Juneau	1.263	3.048	100	3.534
Kansas City	1.170	4.142	99.9941	13.606
Kotzebue	1.706	3.869	99.9999	4.476
Los Angeles	1.332	4.130	99.9999	11.427
Miami	1.421	5.073	99.9945	8.116
Minneapolis	1.155	3.705	99.9943	6.424
Oakland	1.203	3.065	99.9999	3.122
Salt Lake City	1.226	2.935	99.9999	3.301
San Juan	2.905	11.226	0	11.365
Seattle	1.253	4.570	99.9996	12.281
Washington DC	1.044	2.730	99.9950	4.373

Table 2-4 Maximum Position Errors and Position Error/Protection Level Ratio

Location	Horizontal Error (m)	Horizontal Error/HPL	Horizontal Maximum Ratio	Vertical Error (m)	Vertical Error/VPL	Vertical Maximum Ratio
Atlantic City	2.523	0.084	0.116	4.413	0.125	0.139
Greenwood	2.312	0.123	0.115	5.246	0.136	0.196
San Angelo	1.836	0.088	0.110	3.084	0.092	0.111
Albuquerque	1.956	0.073	0.100	3.512	0.100	0.129
Atlanta	1.764	0.082	0.120	5.607	0.192	0.192
Billings	1.852	0.062	0.106	4.131	0.090	0.130
Boston	3.553	0.168	0.168	4.462	0.132	0.152
Chicago	2.272	0.145	0.145	3.505	0.097	0.132
Cleveland	2.199	0.135	0.141	4.967	0.115	0.195
Dallas	3.072	0.143	0.195	6.888	0.184	0.214
Denver	2.061	0.082	0.120	5.195	0.104	0.153
Houston	1.926	0.065	0.109	4.115	0.101	0.125
Jacksonville	2.091	0.085	0.113	4.209	0.143	0.143
Kansas City	2.381	0.070	0.128	4.300	0.167	0.182
Los Angeles	2.151	0.057	0.111	5.323	0.112	0.112
Memphis	1.718	0.046	0.105	3.241	0.089	0.127
Miami	2.199	0.118	0.122	5.136	0.108	0.129
Minneapolis	2.541	0.188	0.188	4.005	0.165	0.166
New York	2.059	0.062	0.128	3.746	0.095	0.119
Oakland	2.375	0.068	0.122	7.296	0.156	0.156
Salt Lake City	2.213	0.082	0.121	5.116	0.129	0.134
Seattle	2.840	0.103	0.138	4.332	0.087	0.149
Washington DC	2.063	0.075	0.106	3.092	0.079	0.114

Figure 2-1 95% Horizontal Accuracy at LNAV/VNAV

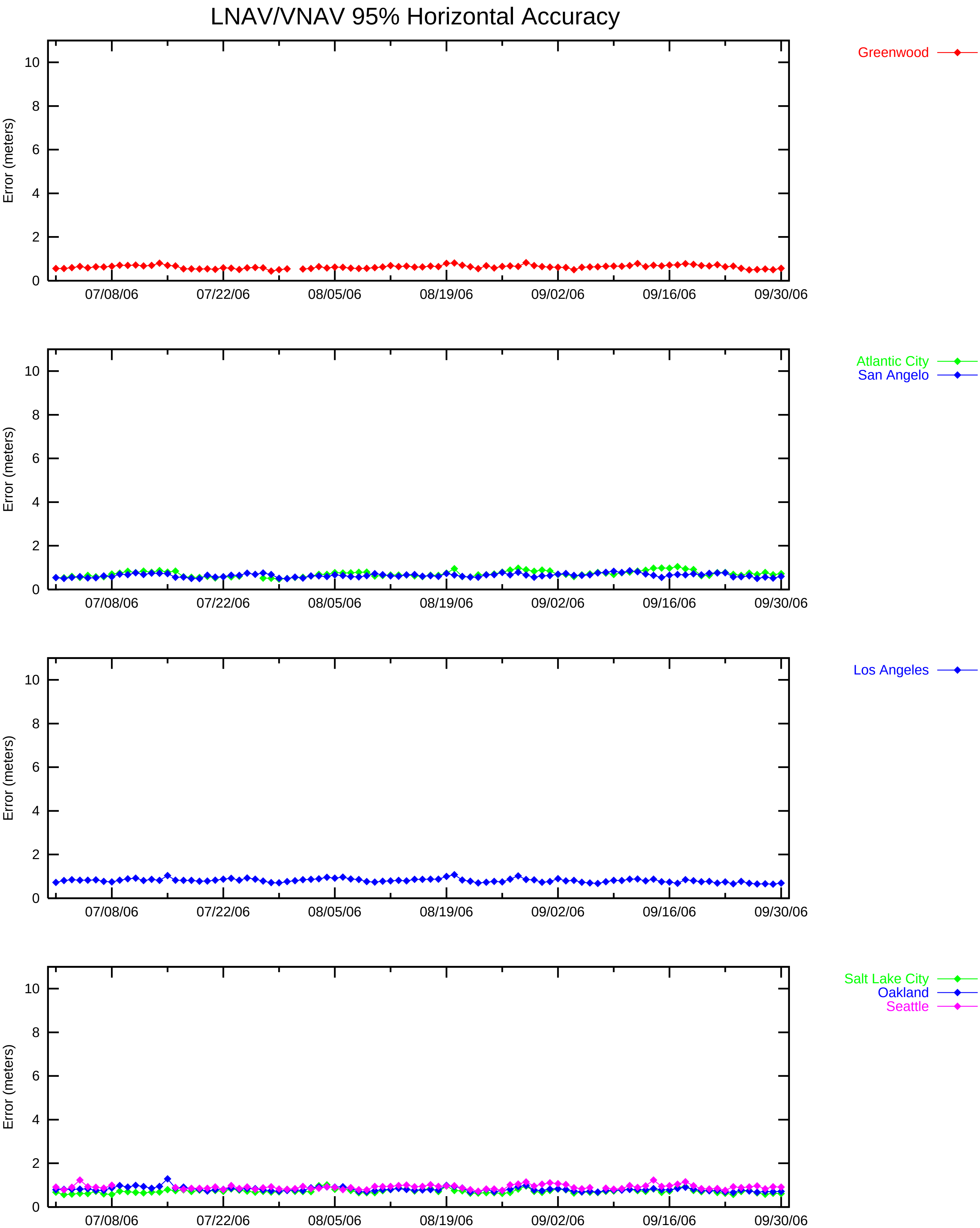


Figure 2-2 95% Horizontal Accuracy at LNAV/VNAV

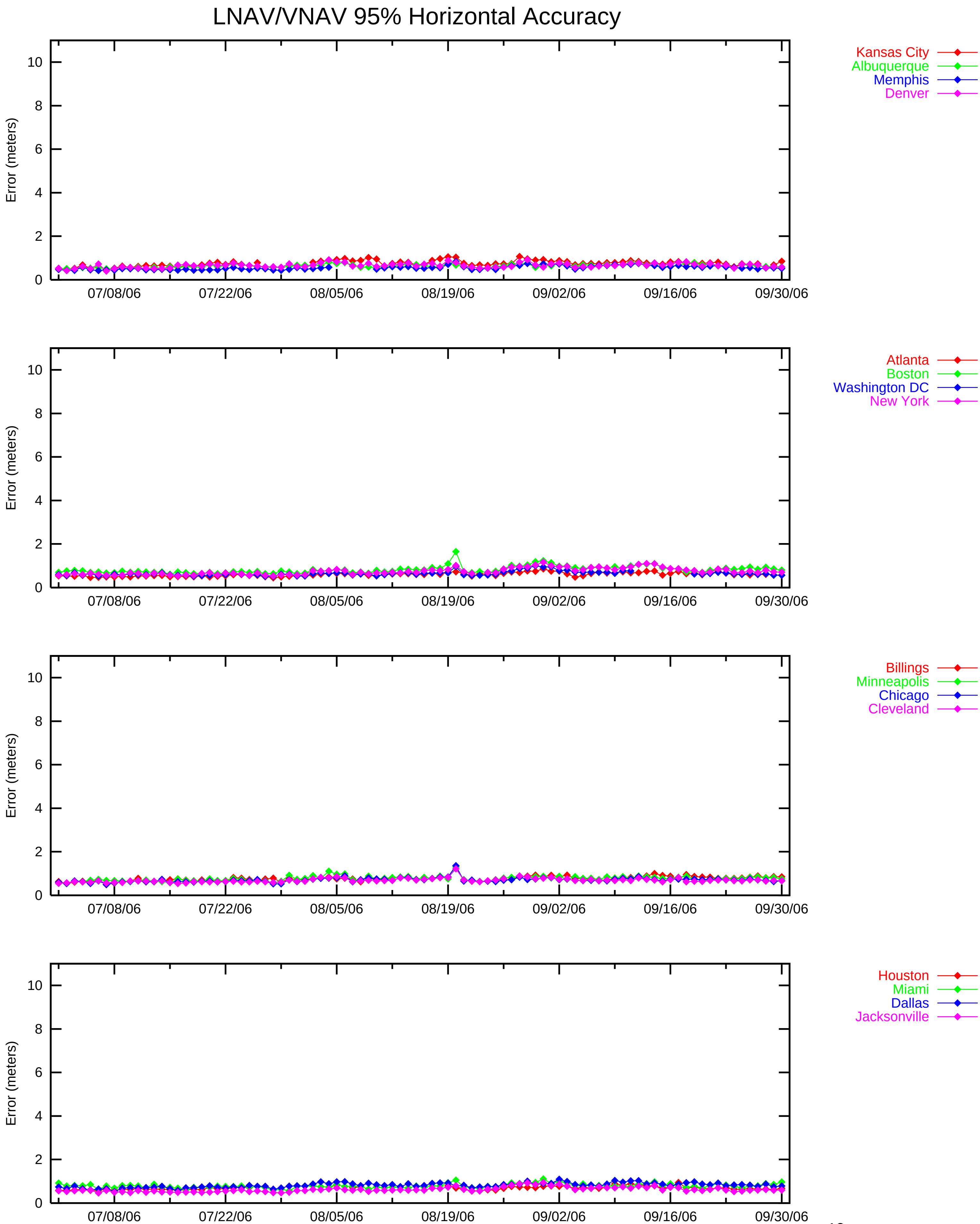


Figure 2-3 95% Vertical Accuracy at LNAV/VNAV

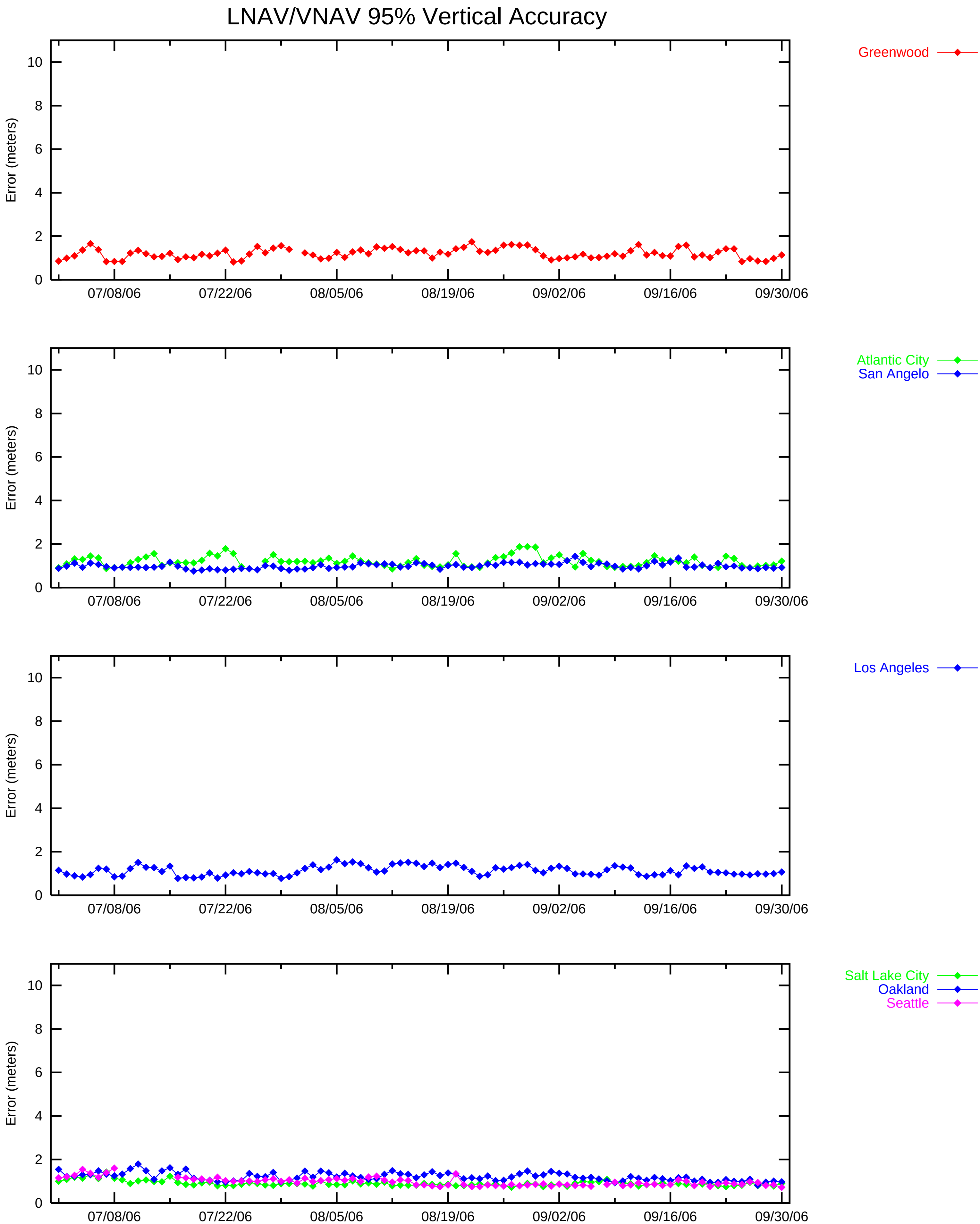


Figure 2-4 95% Vertical Accuracy at LNAV/VNAV

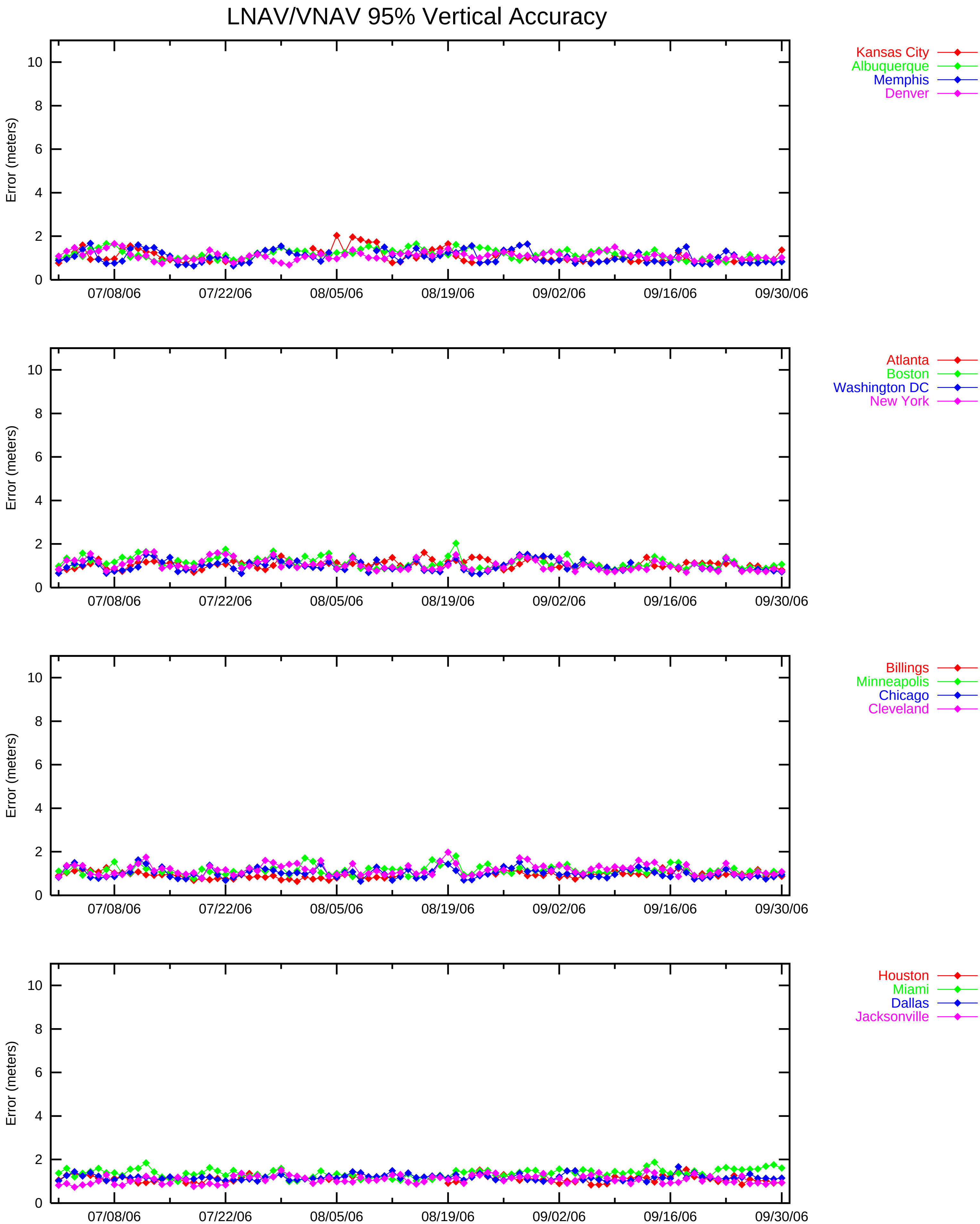


Figure 2-5 NPA 95% Horizontal Accuracy

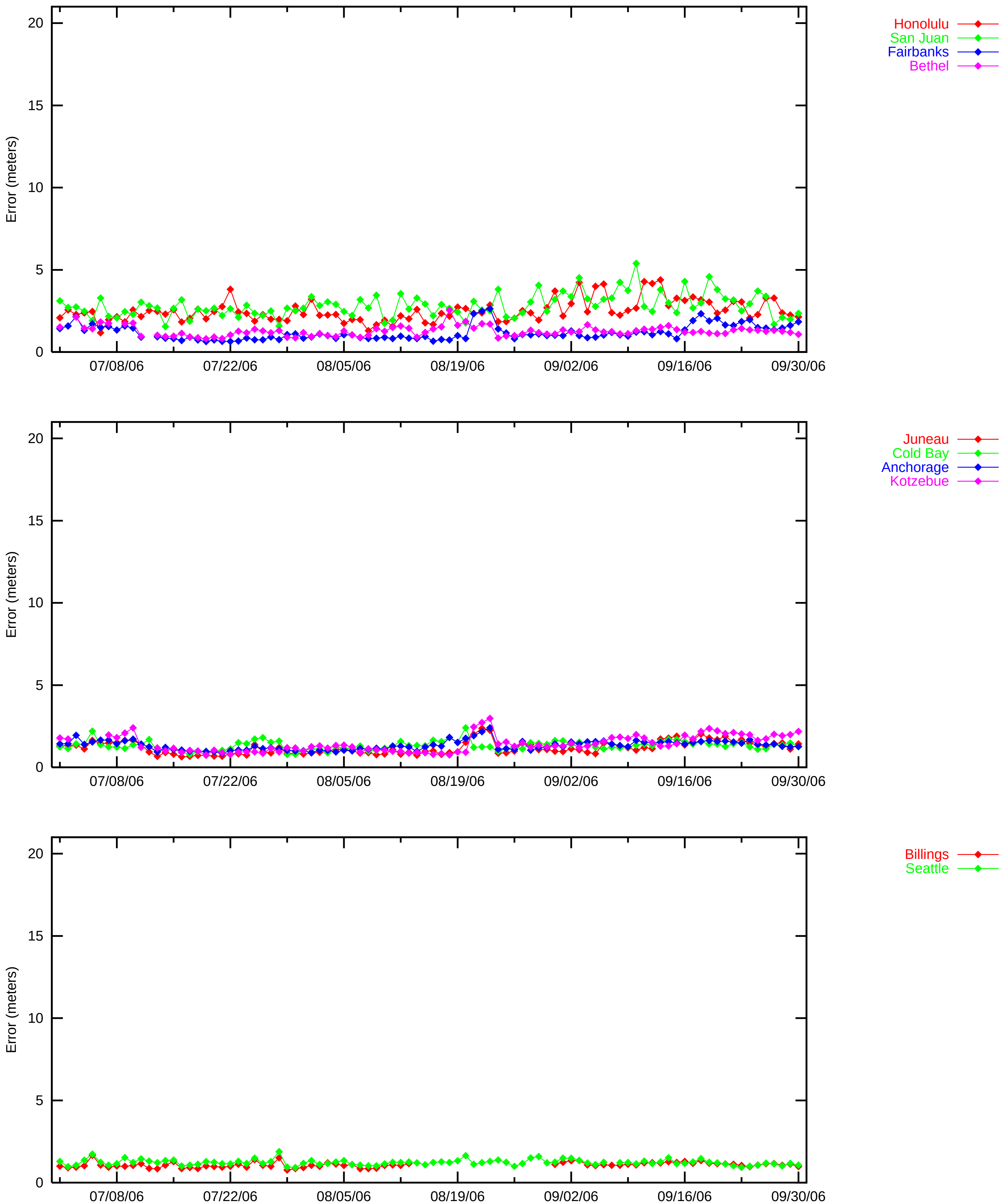


Figure 2-6 NPA 95% Horizontal Accuracy

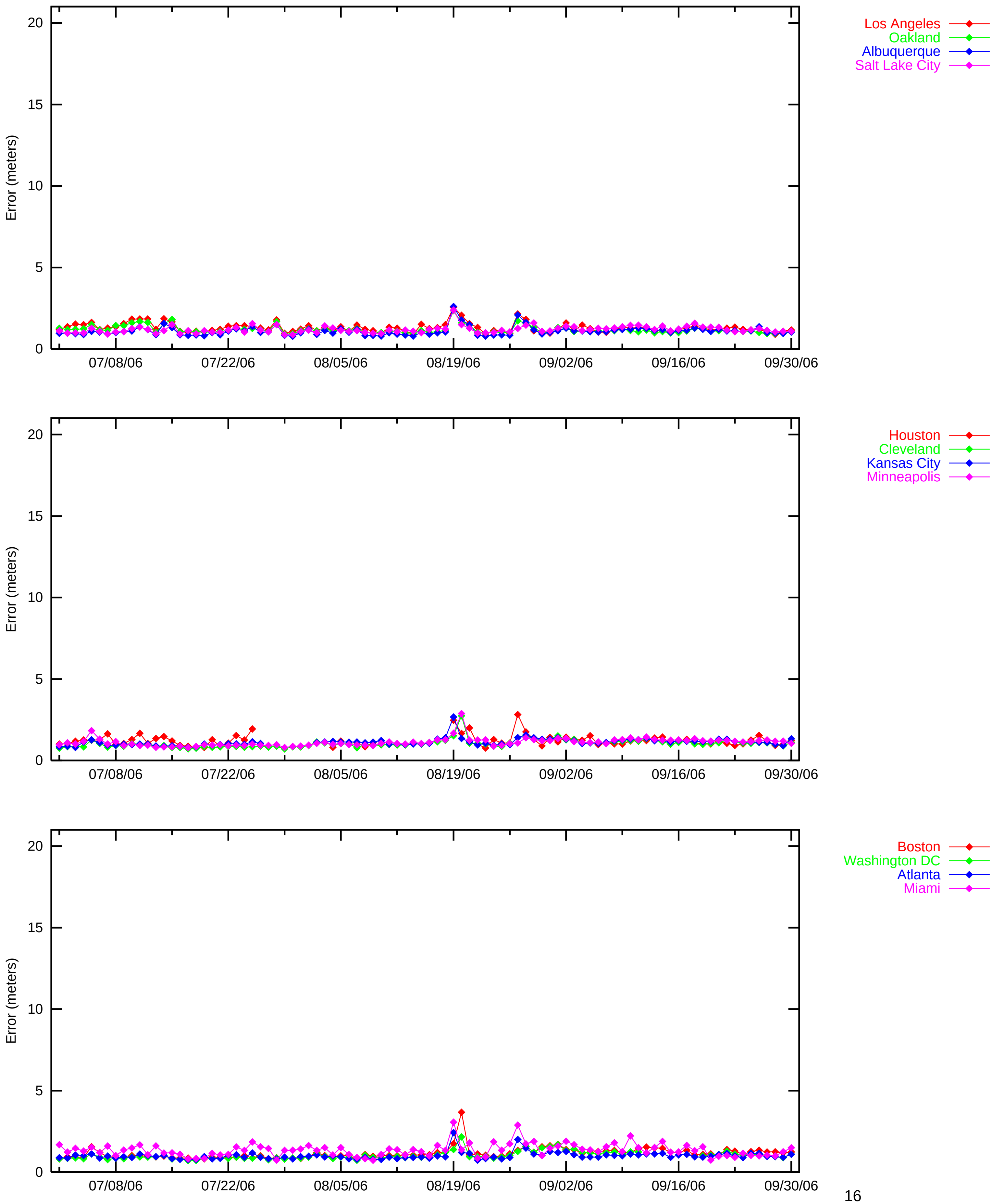


Figure 2-7 Horizontal Triangle Chart forKansas City

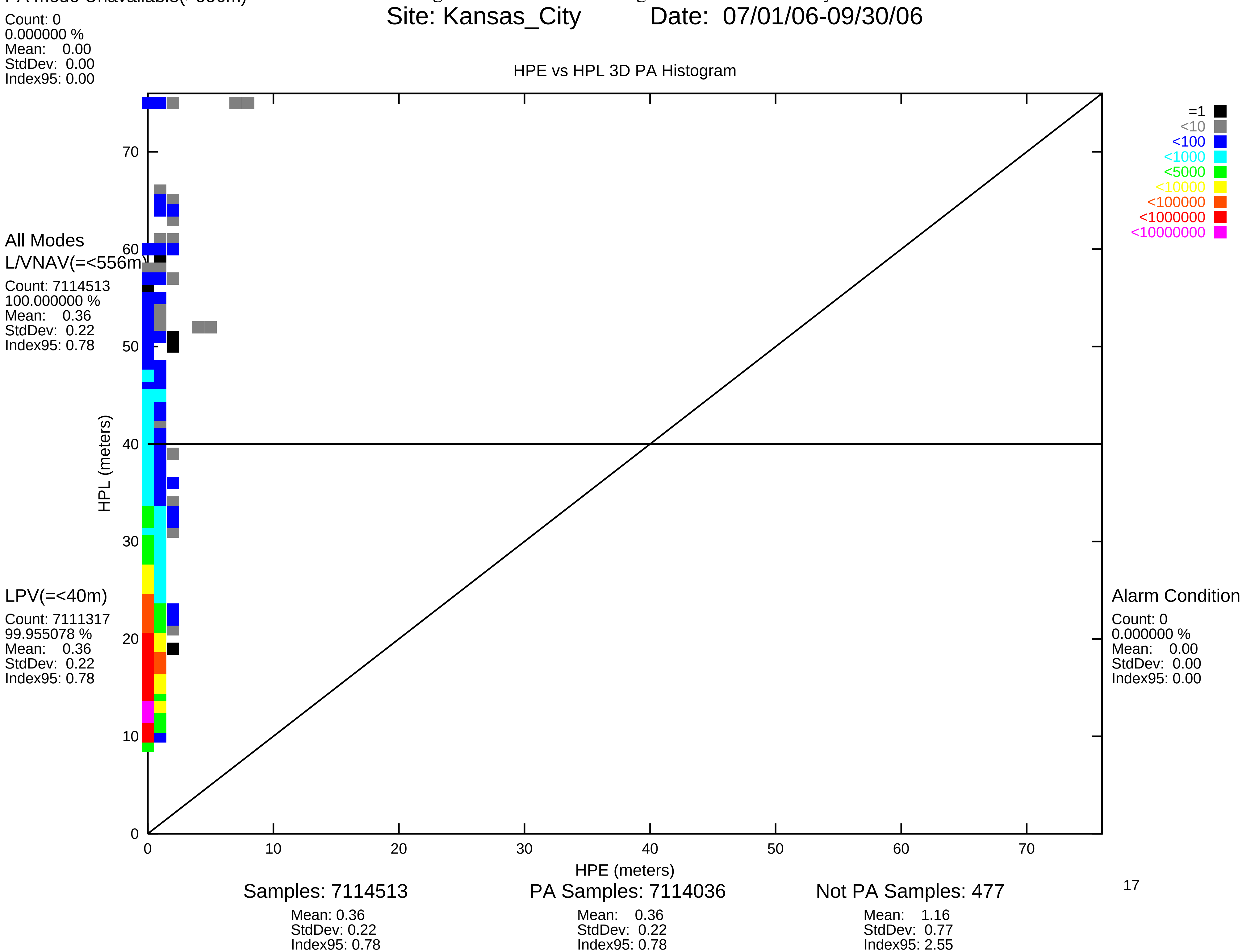


Figure 2-8 Vertical Triangle Chart for Kansas City

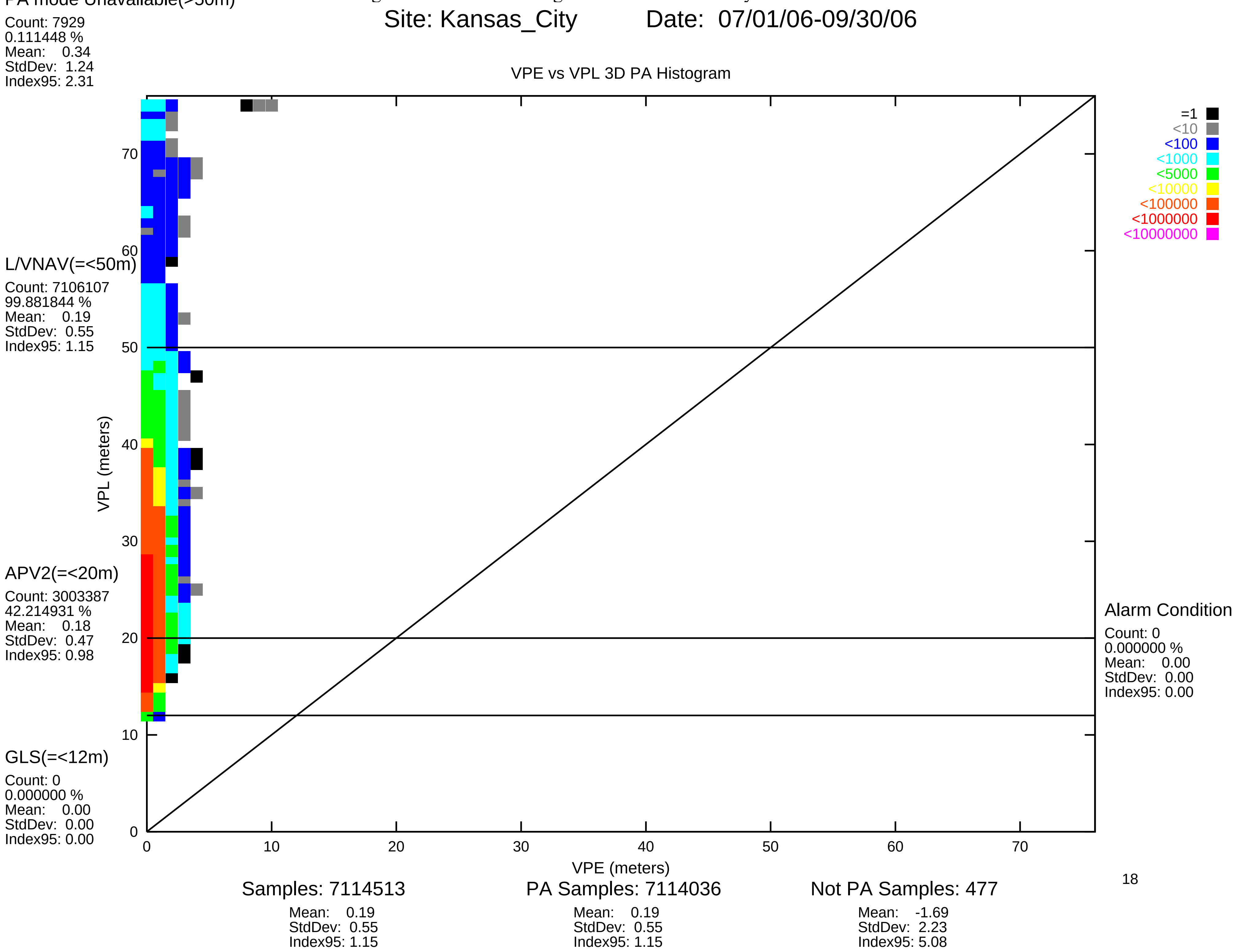


Figure 2-9 2-D Histogram for Kansas City

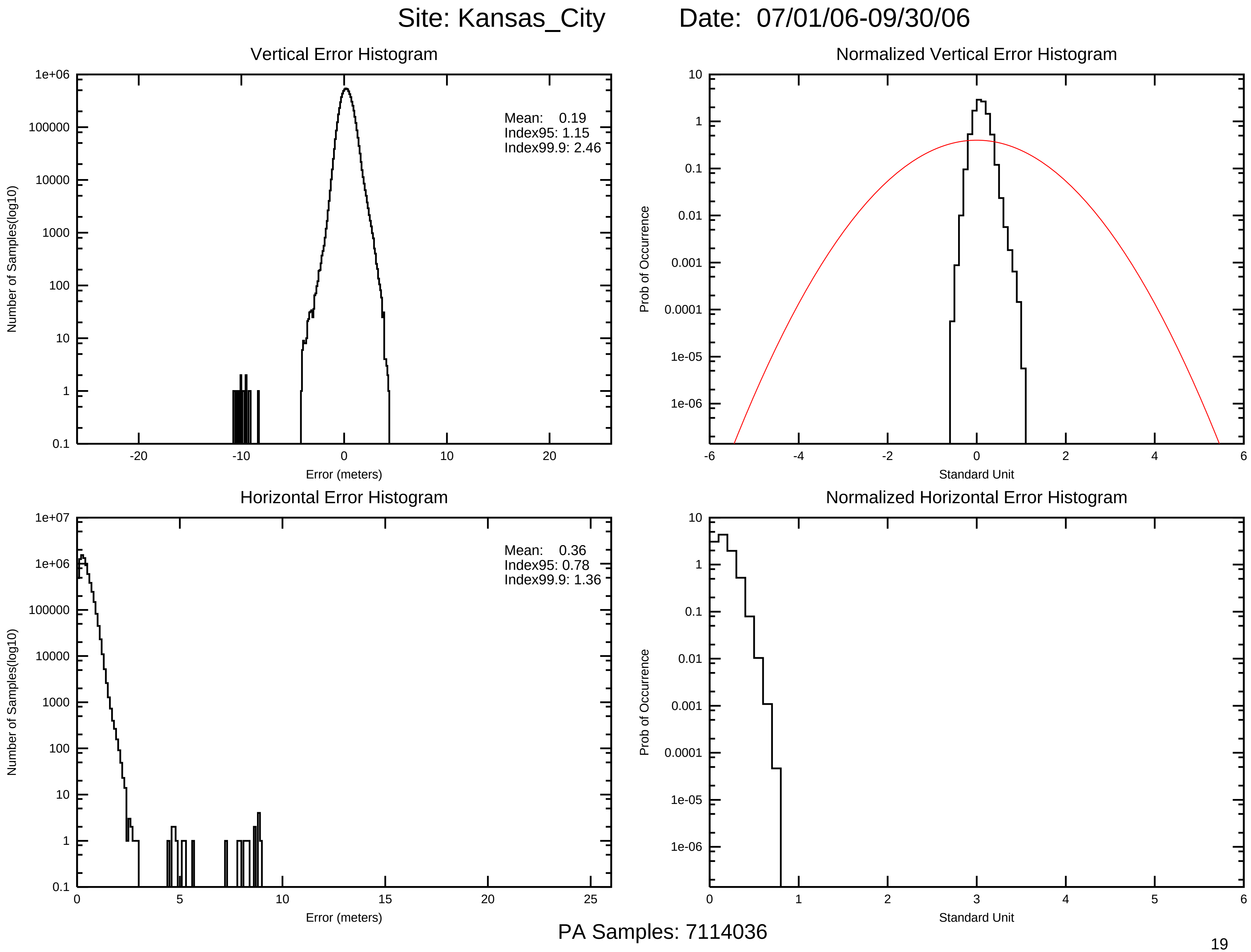


Figure 2-10 Horizontal Triangle Chart for Washington, DC

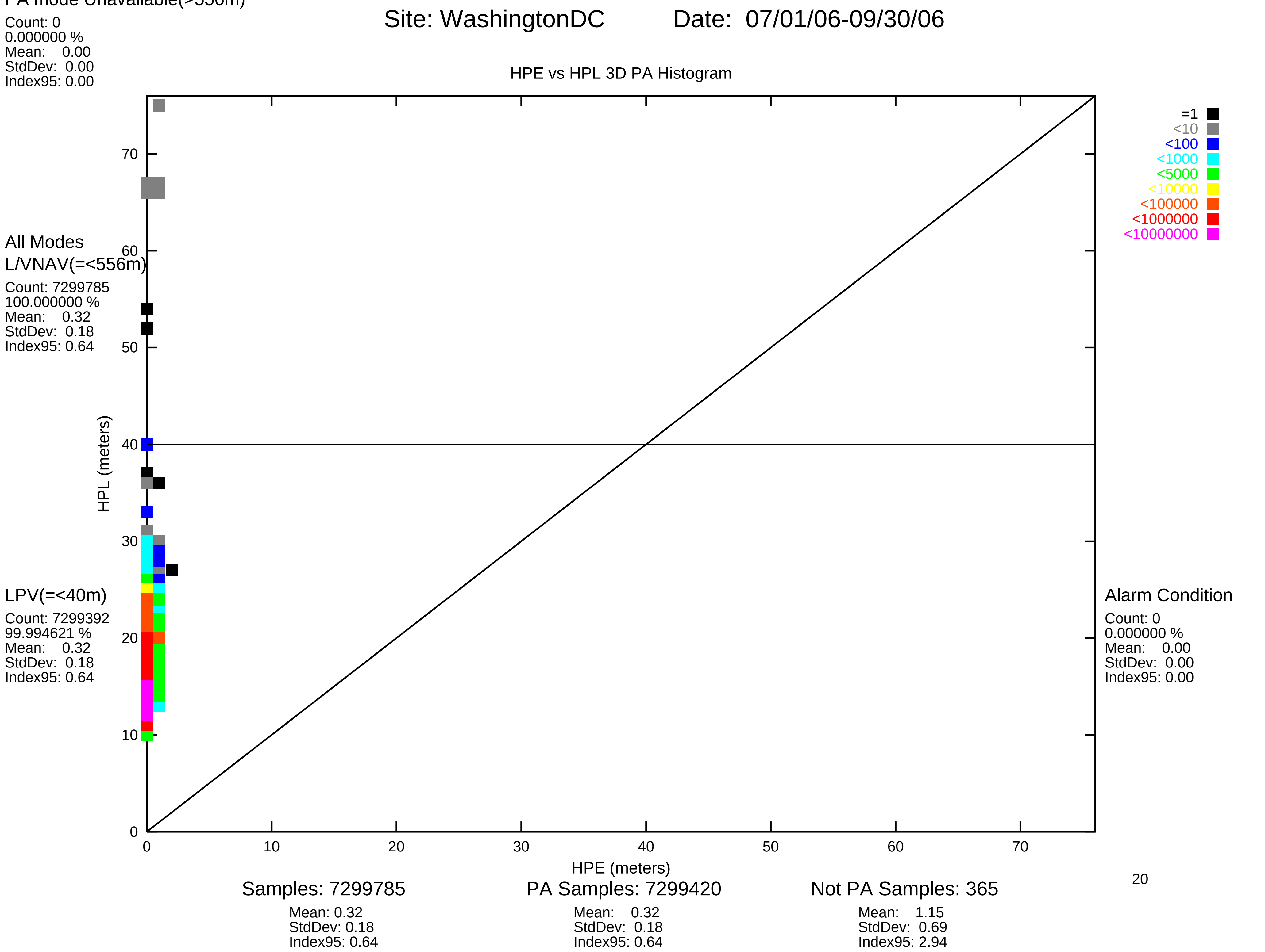


Figure 2-11 Vertical Triangle Chart for Washington, DC

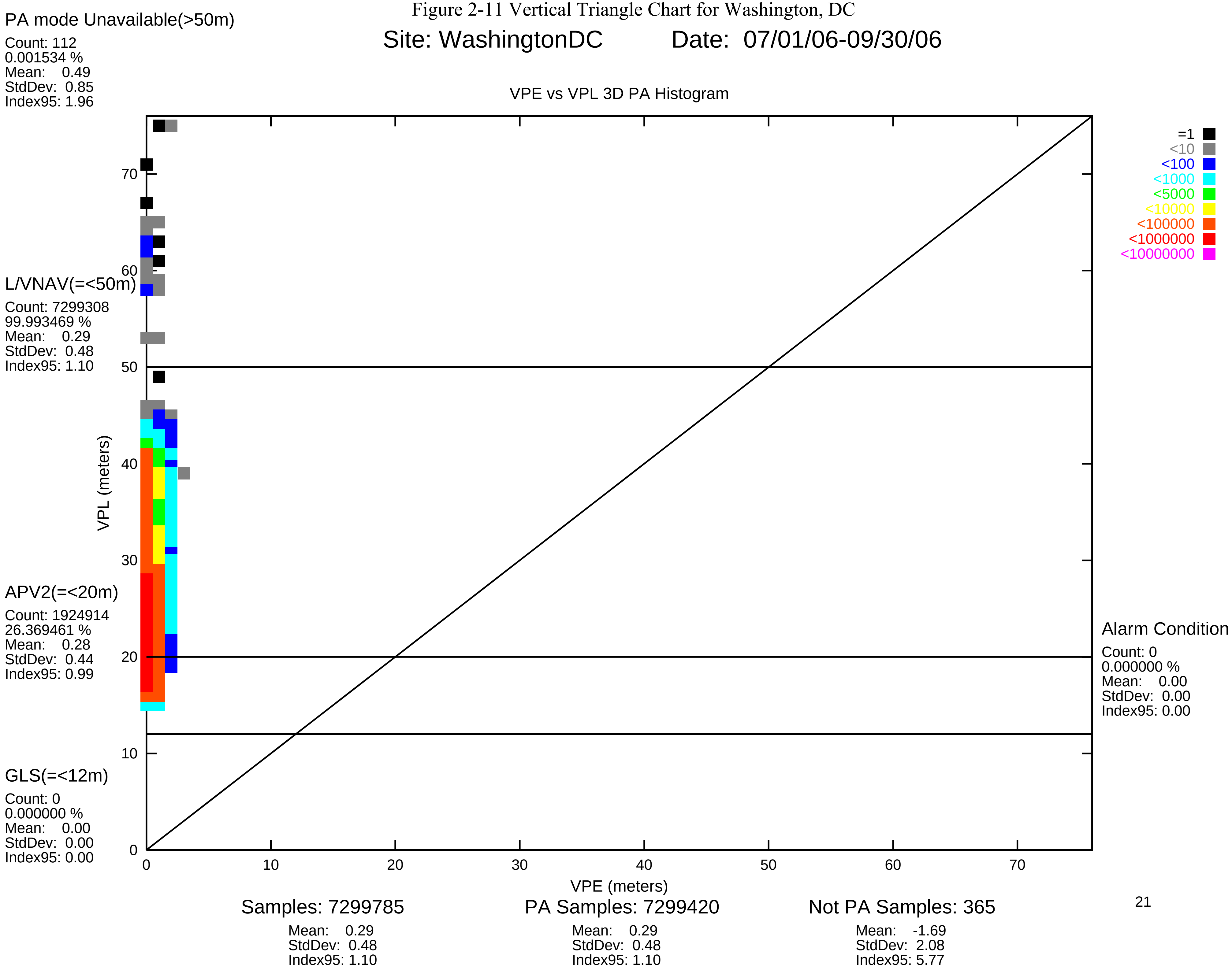


Figure 2-12 2-D Histogram for Washington, DC

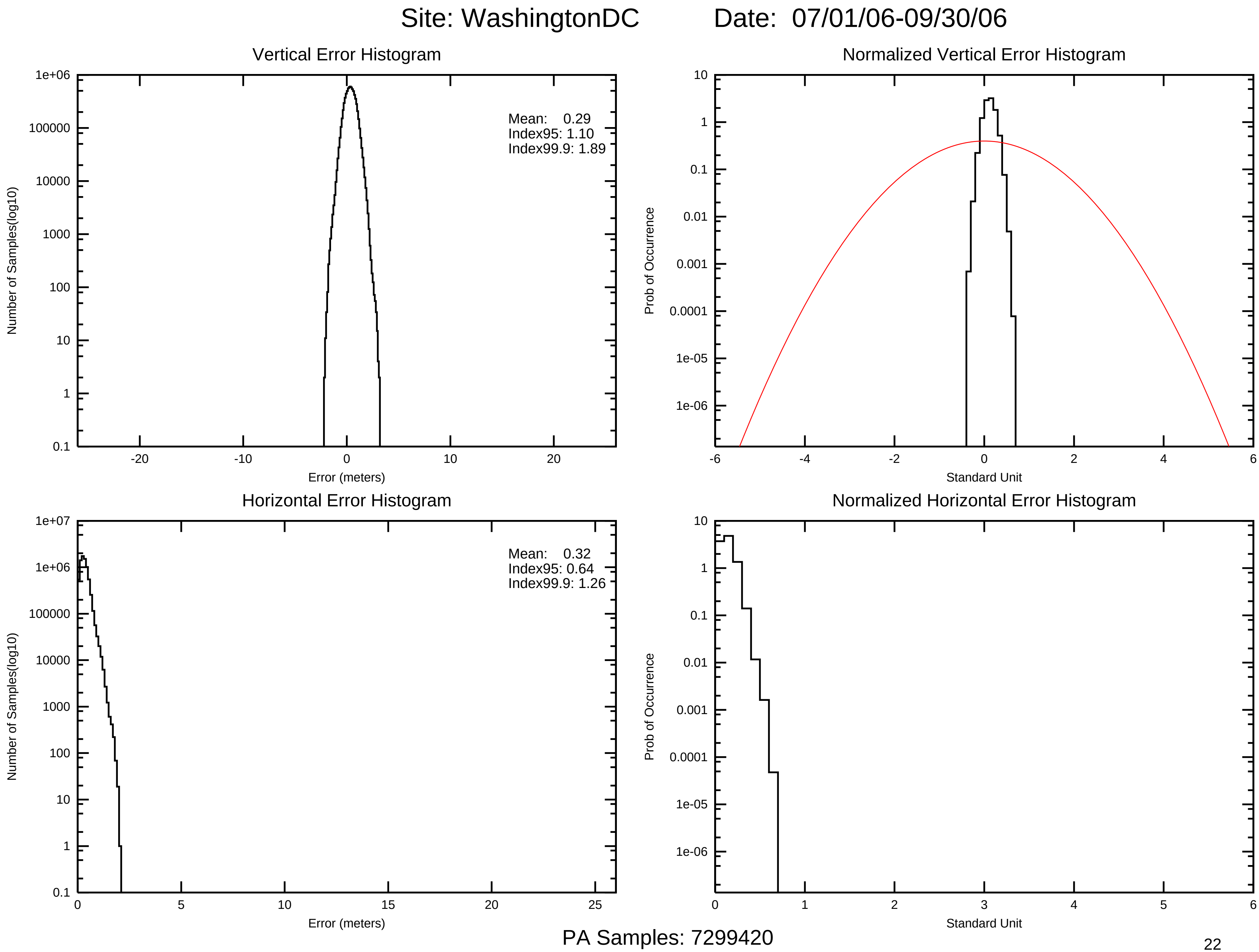


Figure 2-13 Horizontal Triangle Chart for Seattle

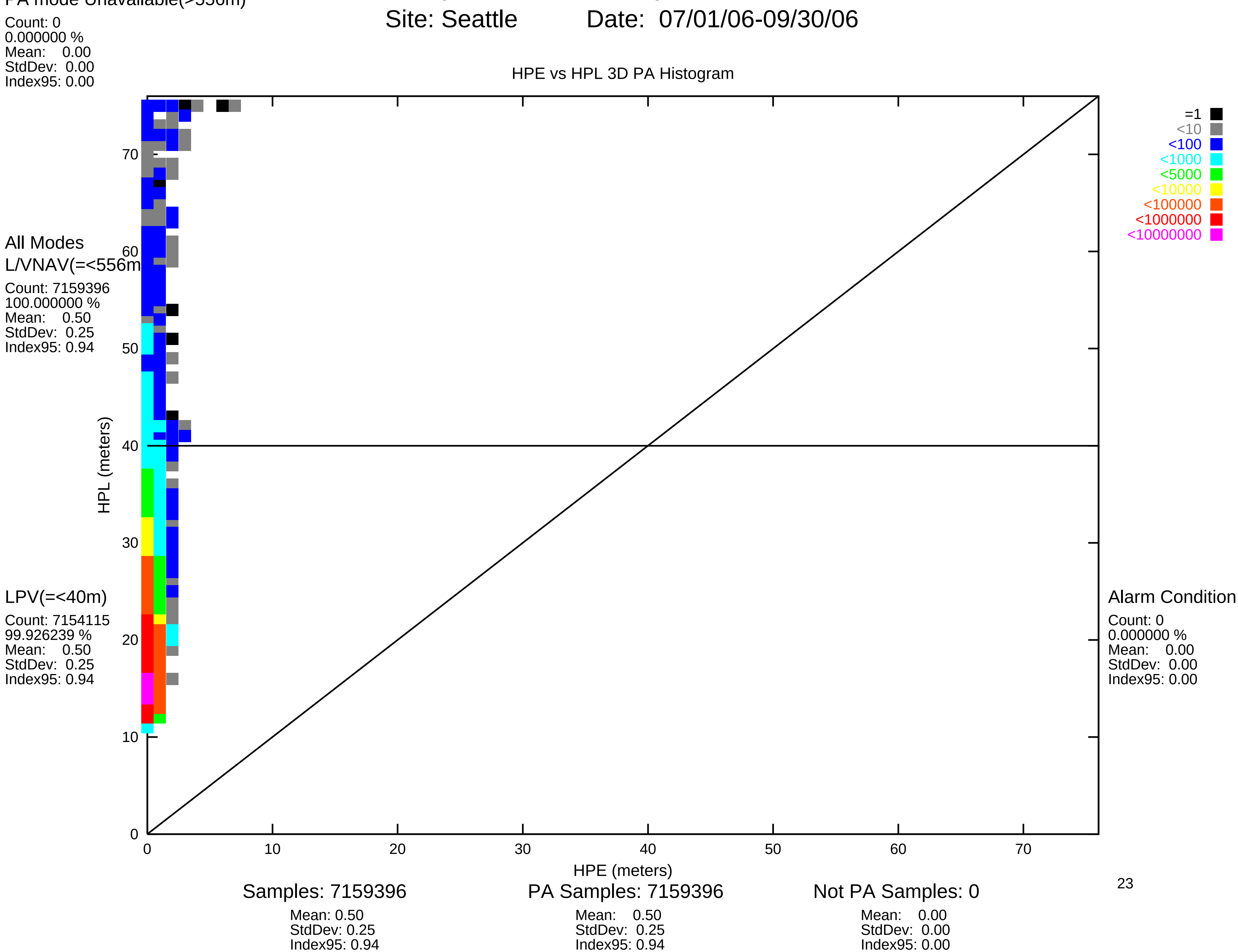


Figure 2-14 Vertical Triangle Chart for Seattle

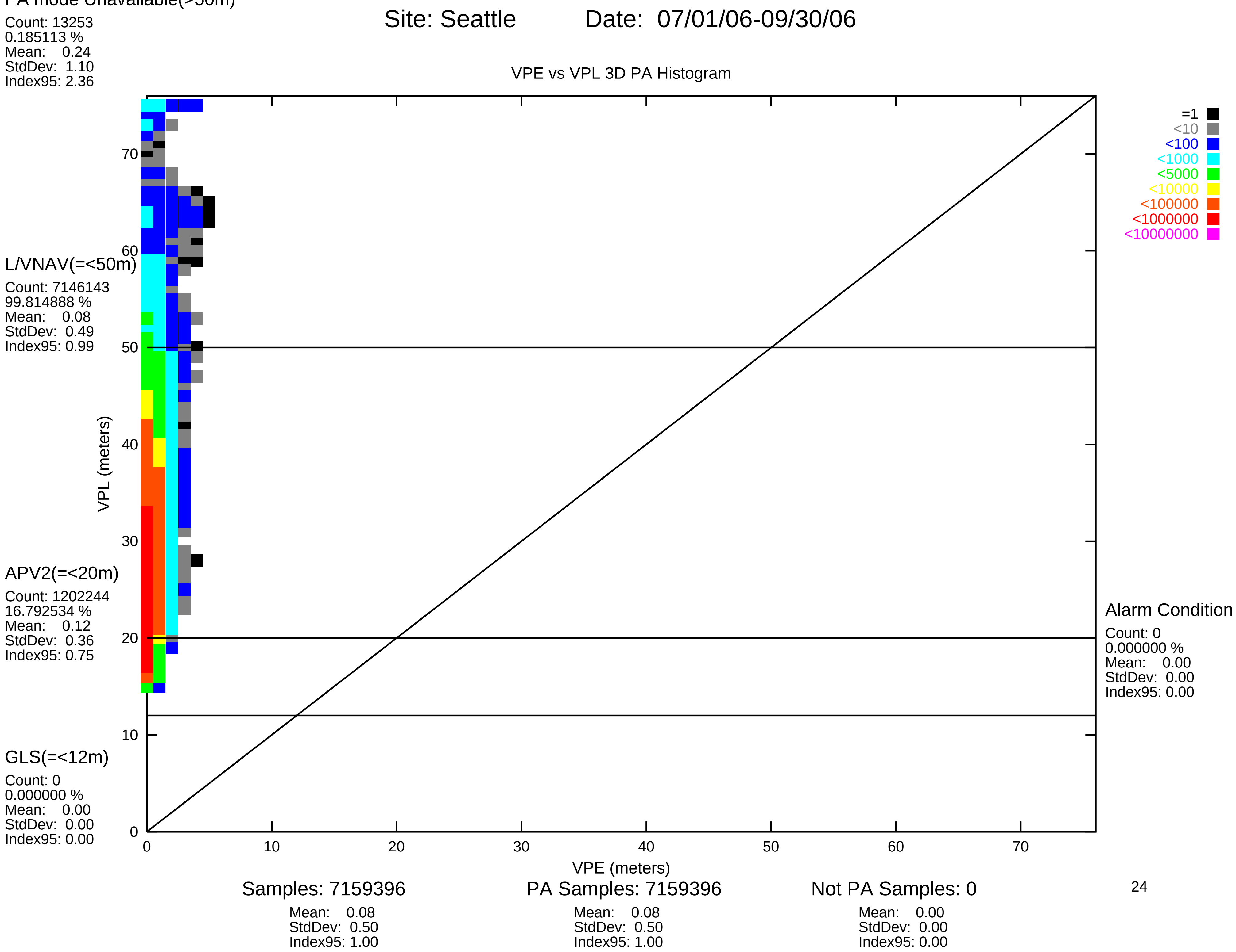
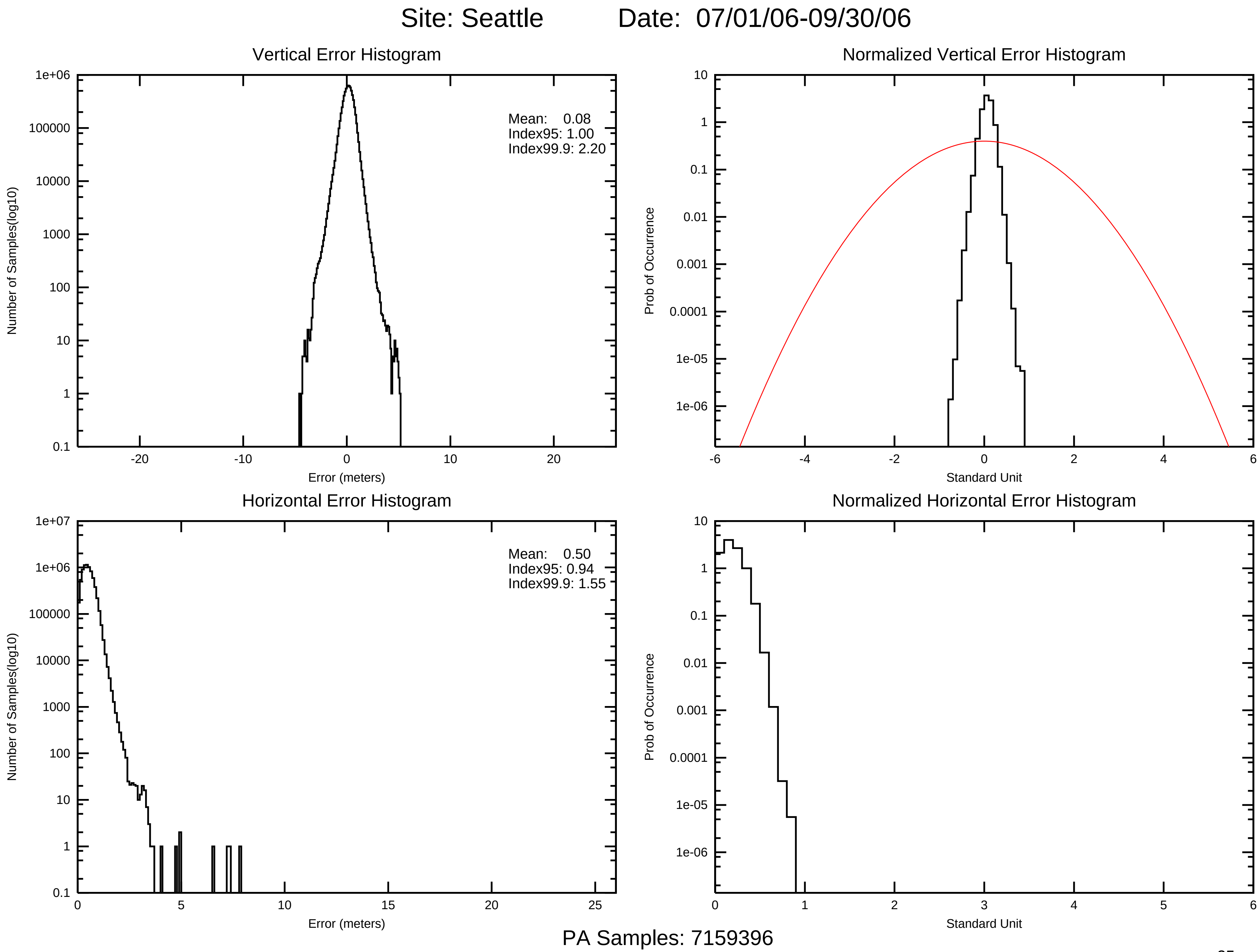


Figure 2-15 2-D Histogram for Seattle



3.0 AVAILABILITY

WAAS availability evaluation estimates the probability that the WAAS can provide service for the operational service levels (LPV and LNAV/VNAV) defined in Table 2.1. At each receiver, the WAAS message, along with the GPS/GEO satellites tracked, were used to produce WAAS protection levels in accordance with the WAAS MOPS. Table 3.1 shows the protection levels that were maintained for 95% of the time for each receiver location for the quarter. The table also included the percentage in PA mode as described in section 2.0. The first two columns of Table 3.2 presents the average portion of time that WAAS operational service levels are available at each receiver location.

Availability of LPV and LNVA/VNAV service is evaluated by monitoring the WAAS protection levels at receiver locations throughout the test period. If both the vertical and horizontal protection levels are not greater than their respective alert limits (VAL and HAL) then the service is available. If either of the protection levels exceeds the required alert level then the operational service at that location is considered unavailable and an outage in service is recorded with its duration. The operational service is not considered available again until the protection levels are both within the alert limits for at least 15 minutes. Although this will reduce operational service availability minimally, it substantially reduces the number of service outages and prevents excessive switching in and out of service availability. The percent of time that LPV and LNVA/VNAV service is available using the fifteen-minute window criteria is presented in the last two columns in Table 3.2. The LPV and LNVA/VNAV service outages and associated outage rate for the test period is presented in Table 3.4. The outage rate is the percent of approaches that theoretically would be interrupted by a loss of operational service once the approach had started. Figures 3.1 through 3.4 show the daily availability of LNAV/VNAV and LPV service levels for the evaluated period. Figures 3.5 through 3.8 show the daily interruptions of LNAV/VNAV and LPV service levels for the evaluated period.

During the evaluated period, the maximum 95% HPL and VPL are 29.689 meters and 47.16 meters both at Los Angeles, respectively. The minimum 95% HPL and VPL are 18.297 meters at Atlanta and 29.532 meters both at Atlanta.

Availability of NPA service is evaluated by monitoring the WAAS horizontal protection level at receiver locations throughout the test period. If the horizontal protection level is not greater than the horizontal alert limit (HAL = 556m) then the service is available. If the horizontal protection level exceeds the required alert level or if WAAS navigation message is not received then the NPA service at that location is considered unavailable and an outage in service is recorded with its duration. The NPA service is not considered available again until the horizontal protection level is within the alert limit for at least 15 minutes. The percent of time that NPA service is available using the fifteen-minute window criteria is presented in Table 3.3. The NPA service outages and associated outage rate for the test period is presented in Table 3.5. The outage rate is the percent of NPA approaches that theoretically would be interrupted by a loss of operational service once the approach had started.

Table 3-1 95% Protection Level

Location	95% HPL (meters)	95% VPL (meters)	Percentage in PA mode
Atlantic City	22.119	38.557	99.993050
Greenwood	19.558	32.310	99.994156
San Angelo	23.889	38.710	99.991280
Albuquerque	22.351	36.366	99.990883
Atlanta	18.297	29.532	99.993759
Billings	20.428	33.060	99.988472
Boston	28.828	46.649	99.993057
Chicago	19.202	30.478	99.993782
Cleveland	19.997	31.272	99.993607
Dallas	20.515	33.757	99.993706
Denver	18.978	31.450	99.991058
Houston	23.996	37.182	99.992851
Jacksonville	18.631	31.787	99.993645
Kansas City	19.798	32.721	99.993294
Los Angeles	29.689	47.160	99.999977
Memphis	18.327	30.346	99.994614
Miami	22.863	40.963	99.993637
Minneapolis	22.387	32.423	99.993805
New York	24.140	40.638	99.993858
Oakland	29.004	46.028	99.999191
Salt Lake City	19.404	33.507	99.999908
Seattle	22.625	35.658	100
Washington DC	20.117	31.586	99.995003

Table 3-2 Quarterly Availability Statistics

Location	LPV *Average Availability Percentage of time*	LNAV/VNAV *Average Availability Percentage of time*	LPV WAAS *With 15 minute window*	LNAV/VNAV *With 15 minute window*
Atlantic City	0.99890828	0.99891418	0.99862874	0.99863667
Greenwood	0.99879491	0.99879491	0.99868898	0.99871814
San Angelo	0.99536335	0.99567950	0.99483359	0.99526914
Albuquerque	0.99125540	0.99133724	0.99041292	0.99053338
Atlanta	0.99988198	0.99988198	0.99988092	0.99988092
Billings	0.99955469	0.99955481	0.99947826	0.99947826
Boston	0.97021532	0.97102040	0.95374992	0.95416733
Chicago	0.99981725	0.99981725	0.99981285	0.99981285
Cleveland	0.99942750	0.99942875	0.99933364	0.99933428
Dallas	0.99976510	0.99980235	0.99969093	0.99976744
Denver	0.99901980	0.99901992	0.99885688	0.99885701
Houston	0.99969167	0.99969167	0.99912158	0.99920249
Jacksonville	0.99984103	0.99984103	0.99982942	0.99982942
Kansas City	0.99863631	0.99881846	0.99850789	0.99880362
Los Angeles	0.95735365	0.96107441	0.95422929	0.95831035
Memphis	0.99987680	0.99987692	0.99987524	0.99987550
Miami	0.99362266	0.99377280	0.99051828	0.99067037
Minneapolis	0.99969822	0.99970204	0.99969225	0.99969645
New York	0.99682271	0.99689329	0.99555134	0.99564931
Oakland	0.96826726	0.96928728	0.95413366	0.95583527
Salt Lake City	0.99510217	0.99510229	0.99291866	0.99291891
Seattle	0.99752617	0.99814886	0.99050435	0.99558212
Washington DC	0.99993449	0.99993467	0.99993466	0.99993480

Table 3-3 NPA Availability

Location	NPA Availability (Excluding RAIM/FDE)
Albuquerque	0.99920844
Anchorage	0.99999987
Atlanta	0.99994602
Bethel	100
Billings	0.99995301
Boston	0.99994308
Cleveland	0.99994429
Cold Bay	0.99999848
Fairbanks	100
Honolulu	0.99994260
Houston	0.99994053
Juneau	100
Kansas City	0.99994142
Kotzebue	0.99999987
Los Angeles	0.99999975
Miami	0.99994502
Minneapolis	0.99994324
Oakland	0.99999962
Salt Lake City	0.99999975
Seattle	0.99999644
Washington DC	0.99994981

Table 3-4 LPV and LNAV/VNAV Outage Rate

Location	LPV Outages	LPV Outage Rates	LNAV/VNAV Outages	LNAV/VNAV Outage Rates
Atlantic City	94	0.001807	93	0.001788
Greenwood	34	0.000645	33	0.000626
San Angelo	62	0.001221	60	0.001181
Albuquerque	117	0.002247	114	0.002189
Atlanta	8	0.000152	8	0.000152
Billings	15	0.000322	15	0.000322
Boston	383	0.007652	381	0.007608
Chicago	9	0.000171	9	0.000171
Cleveland	46	0.000876	46	0.000876
Dallas	21	0.000399	20	0.000380
Denver	24	0.000458	23	0.000439
Houston	39	0.000922	28	0.000662
Jacksonville	16	0.000305	16	0.000305
Kansas City	29	0.000594	22	0.000451
Los Angeles	217	0.004328	209	0.004151
Memphis	11	0.000221	9	0.000181
Miami	237	0.004549	229	0.004395
Minneapolis	13	0.000248	11	0.000210
New York	166	0.003207	163	0.003148
Oakland	293	0.005834	259	0.005148
Salt Lake City	113	0.002162	111	0.002124
Seattle	105	0.002044	57	0.001104
Washington DC	7	0.000144	6	0.000123

Table 3-5 NPA Outage Rates

Location	NPA Outages	NPA Outage Rate
Albuquerque	14	0.00026588
Anchorage	1	0.00001898
Atlanta	9	0.00017068
Bethel	0	0.00000000
Billings	7	0.00015137
Boston	9	0.00017116
Cleveland	9	0.00017133
Cold Bay	2	0.00003807
Fairbanks	0	0.00000000
Honolulu	6	0.00011429
Houston	7	0.00016390
Juneau	0	0.00000000
Kansas City	8	0.00016312
Kotzebue	1	0.00002002
Los Angeles	1	0.00001898
Miami	9	0.00017064
Minneapolis	9	0.00017105
Oakland	1	0.00001894
Salt Lake City	1	0.00001895
Seattle	6	0.00011460
Washington DC	8	0.00016369

Figure 3-1 LPV Instantaneous Availability

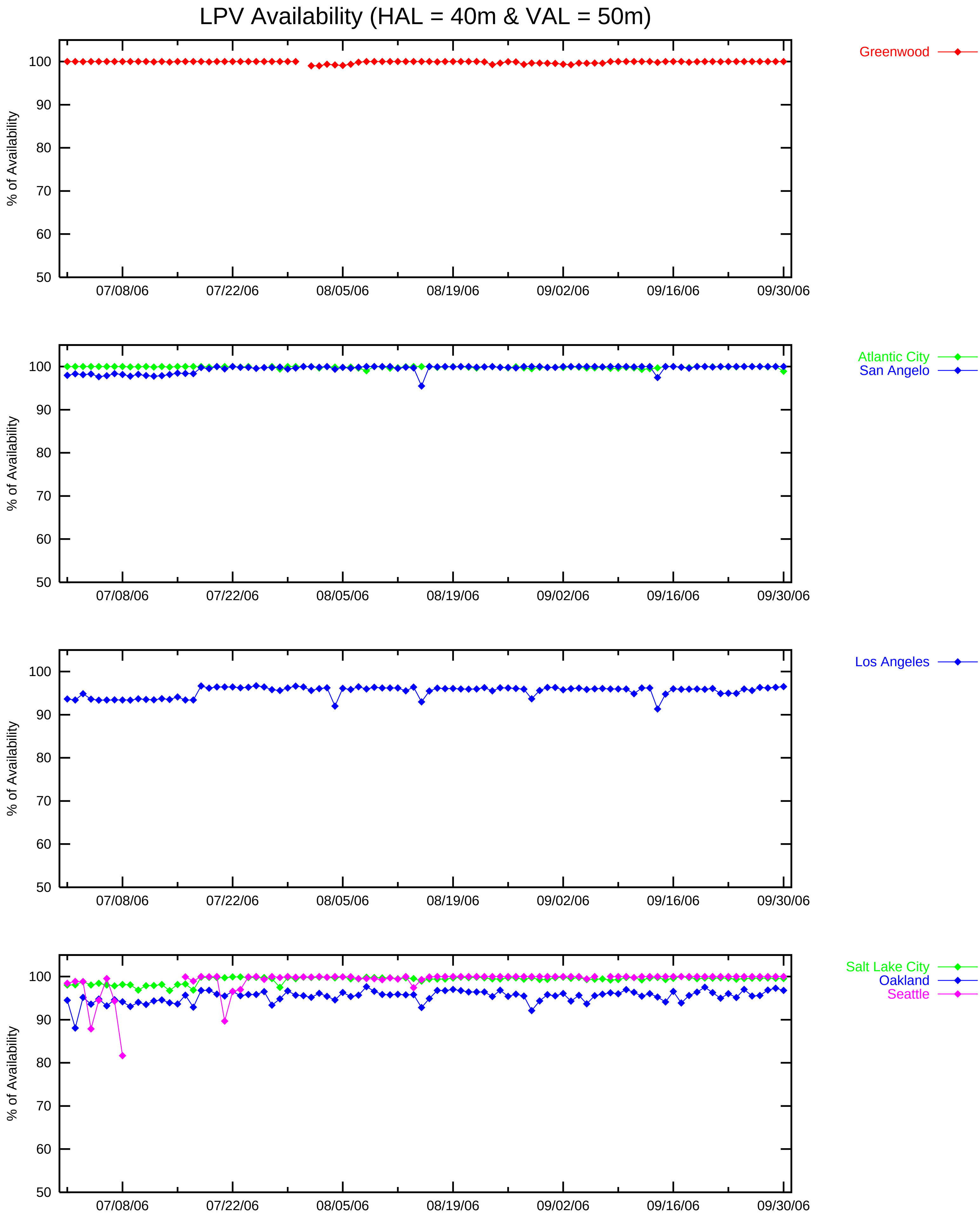


Figure 3-2 LPV Instantaneous Availability

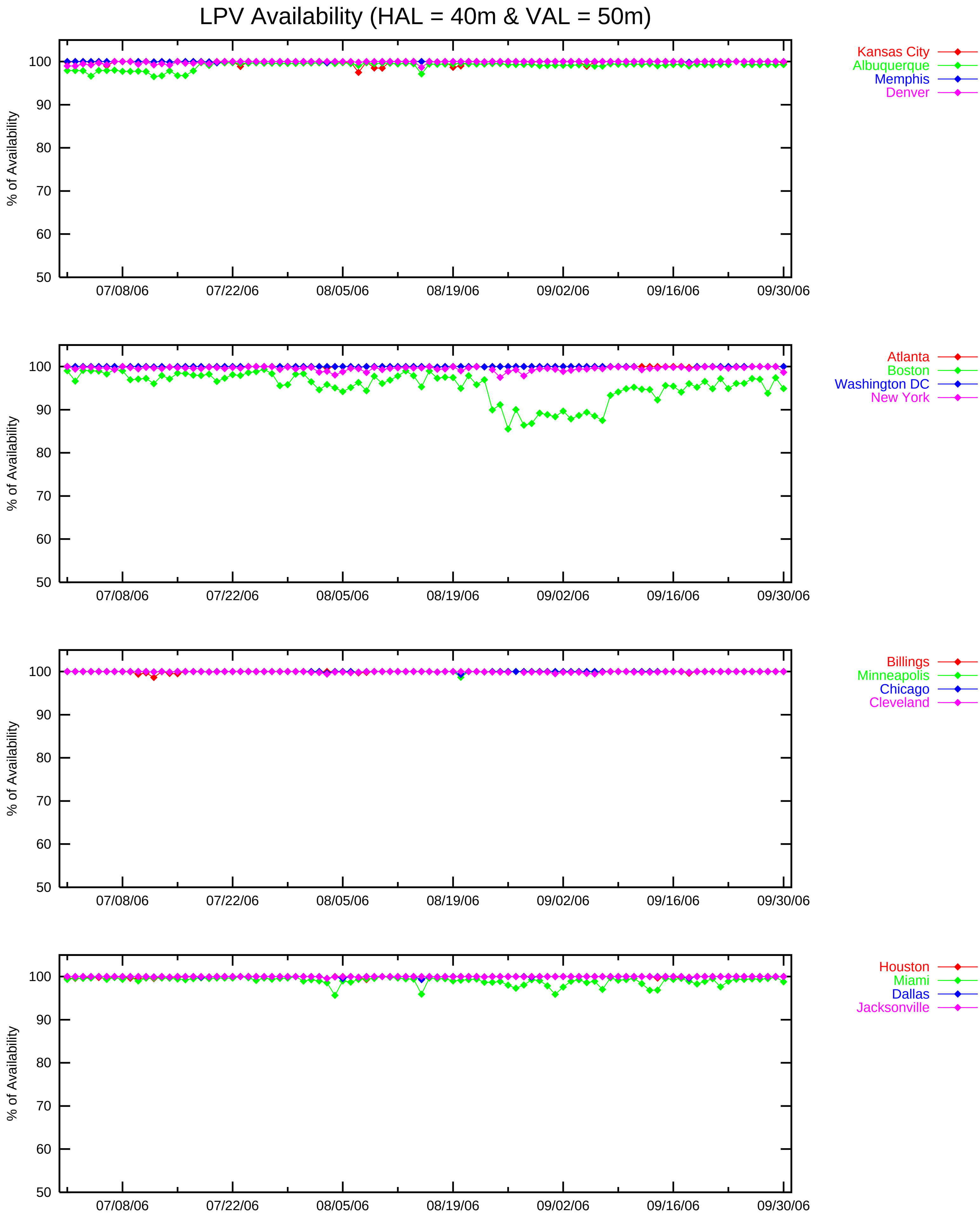


Figure 3-3 LNAV/VNAV Instantaneous Availability

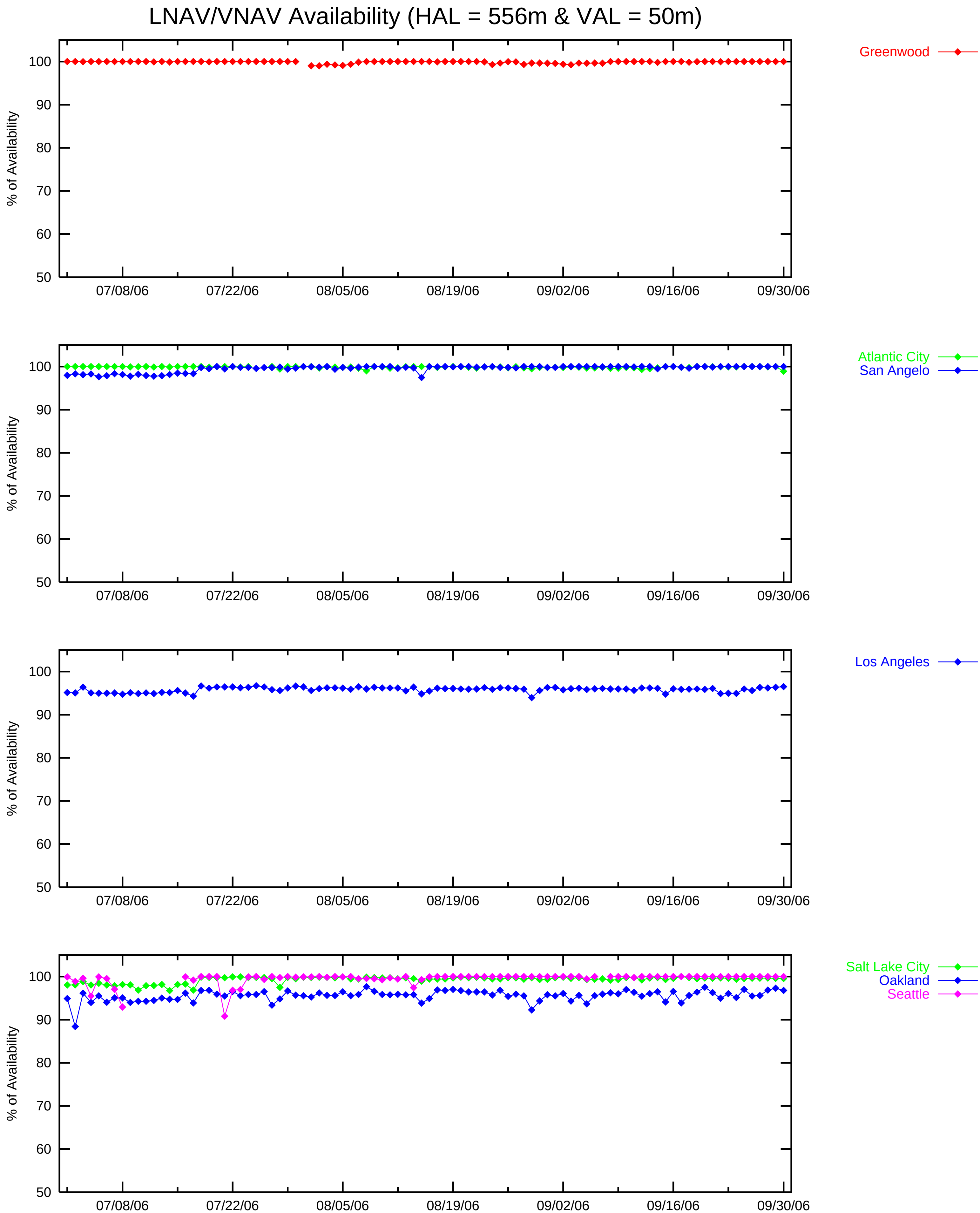


Figure 3-4 LNAV/VNAV Instantaneous Availability

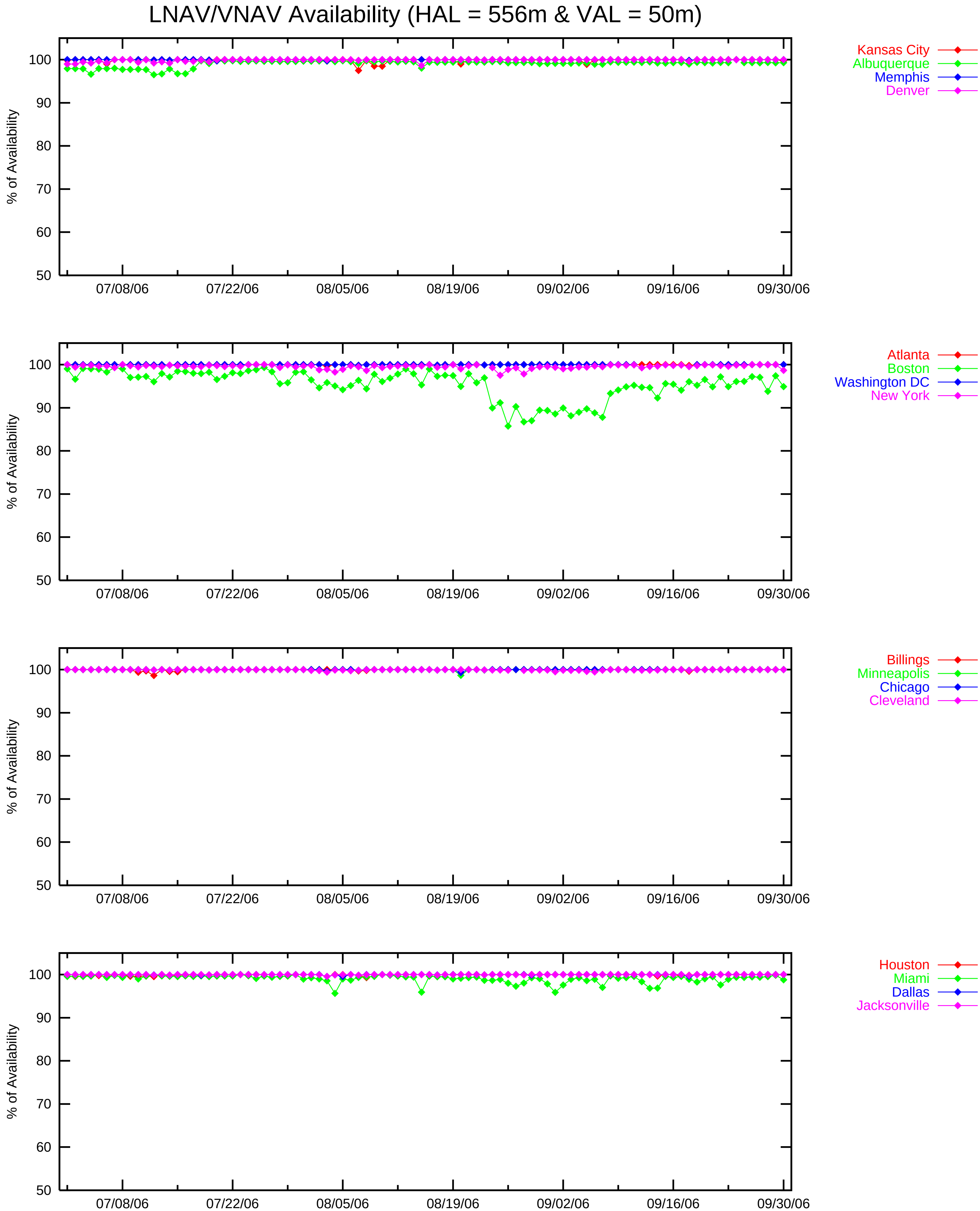


Figure 3-5 LPV Outages

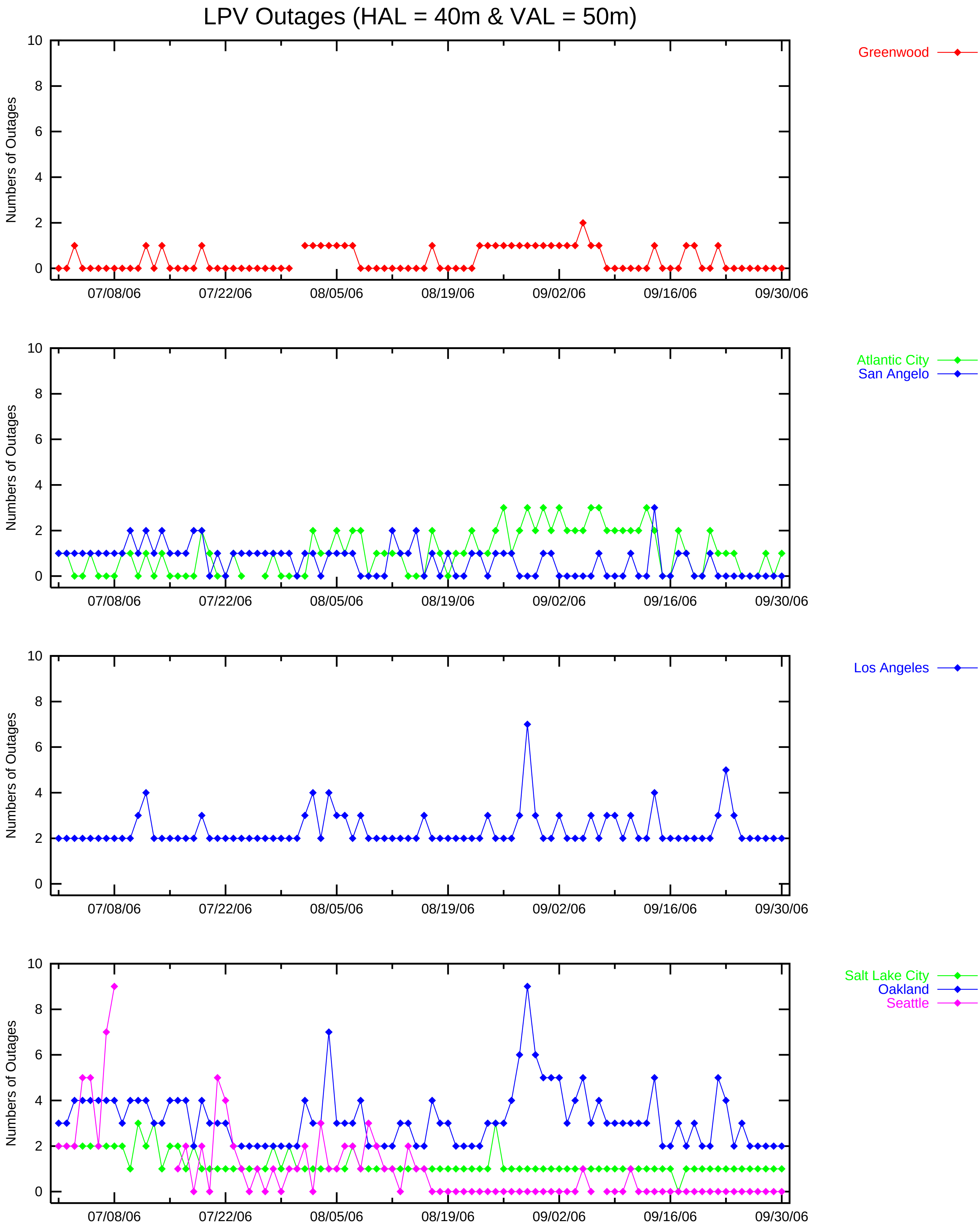


Figure 3-6 LPV Outages

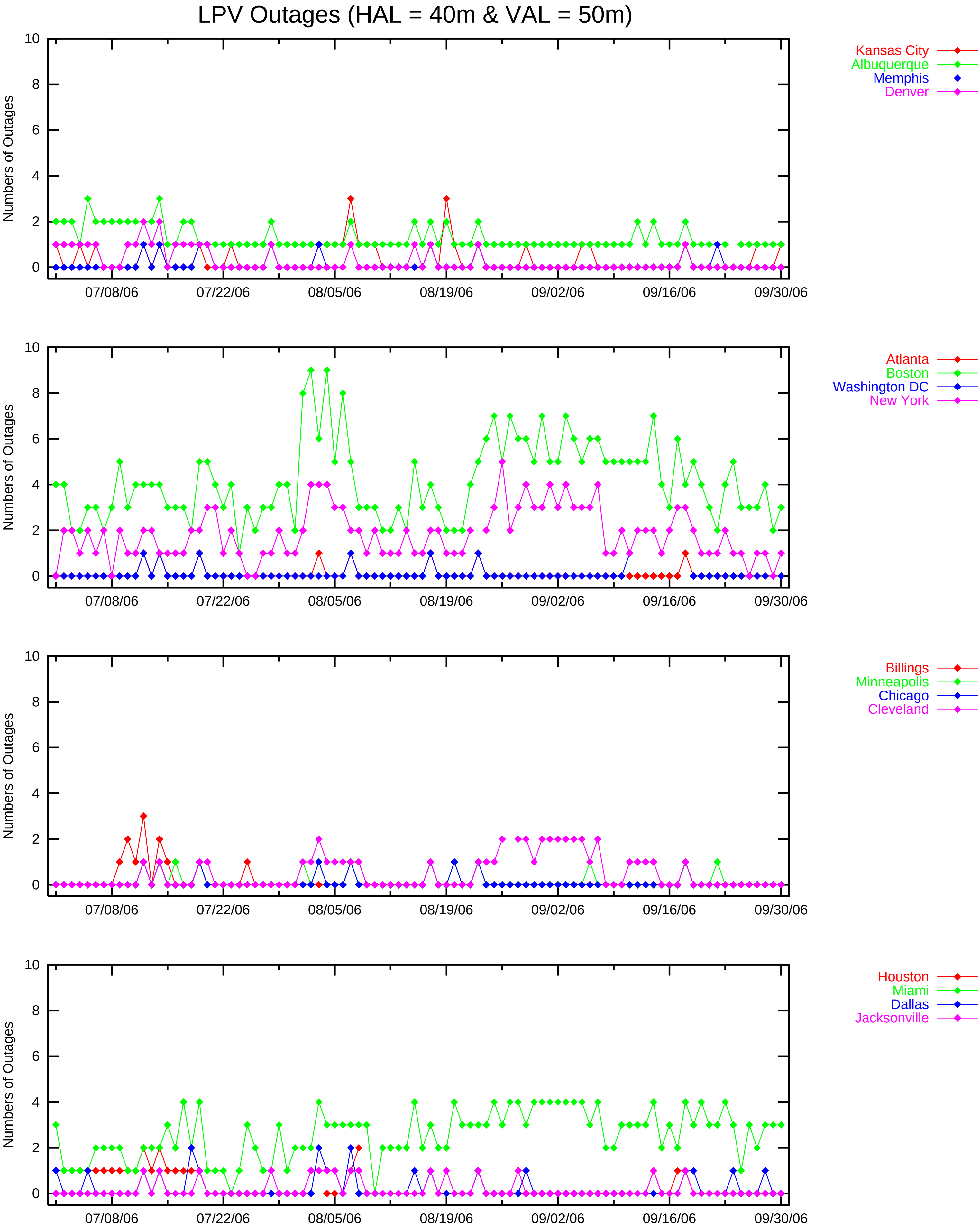


Figure 3-7 LNAV/VNAV Outages

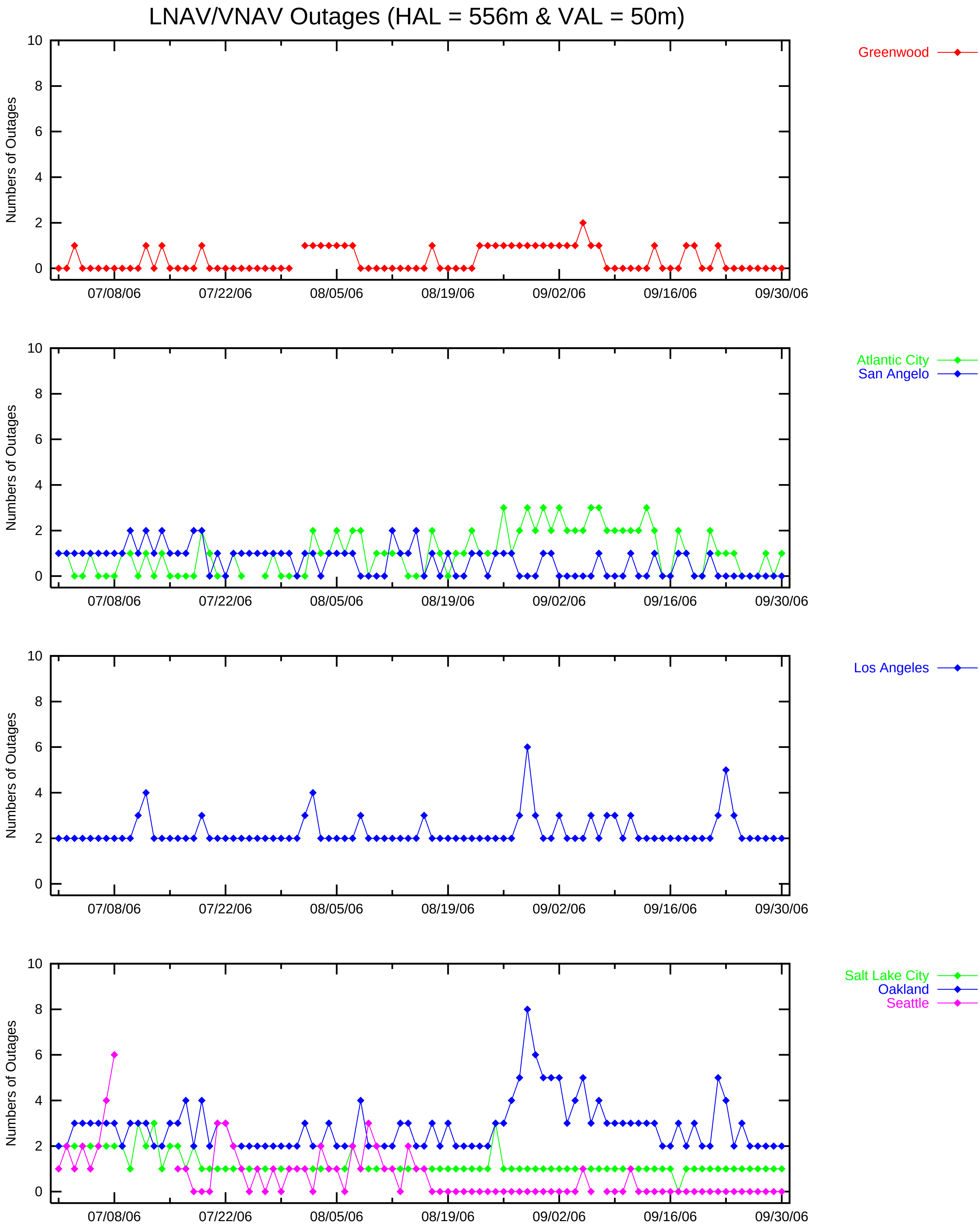
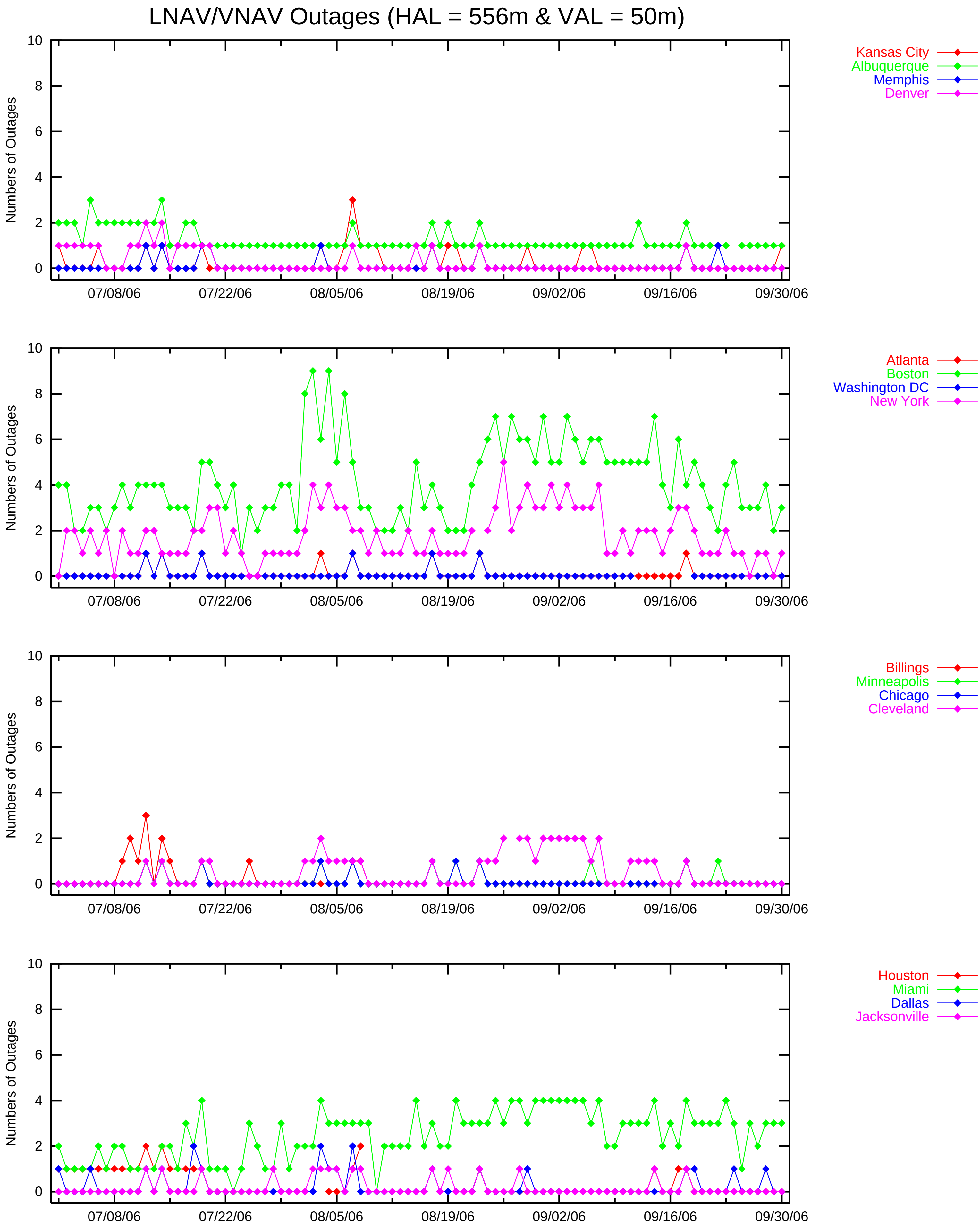


Figure 3-8 LNAV/VNAV Outages



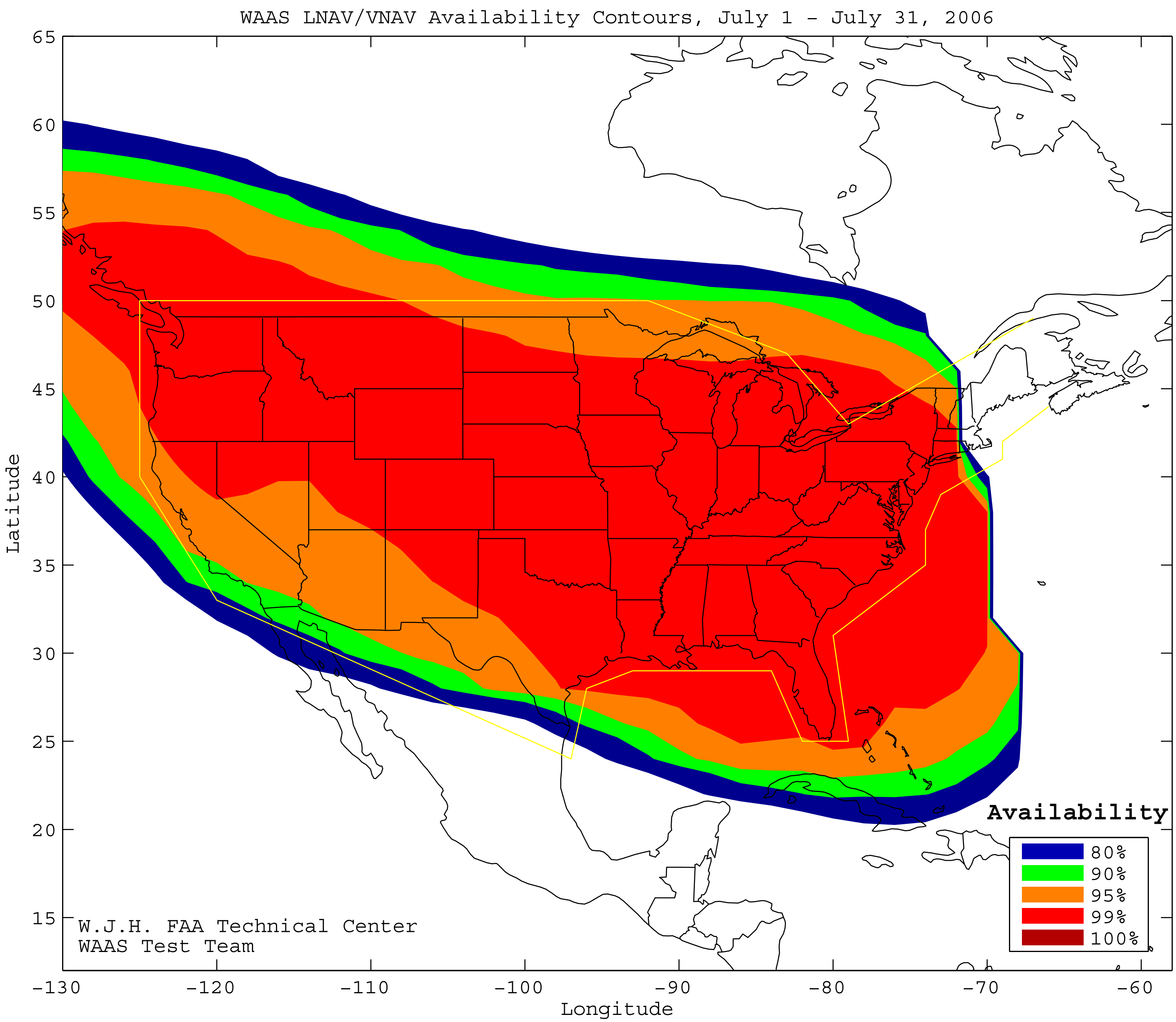
4.0 COVERAGE

WAAS coverage area evaluation estimates the percent of service volume where WAAS is providing LPV, LNAV/VNAV and NPA services. The WAAS message and the GPS/GEO satellite status are used to determine WAAS availability across North America. For PA coverage, protection levels were calculated at two-minute intervals and at two degree spacing over the PA service volume, while NPA coverage was calculated at two-minute intervals and five degree spacing over the NPA service volume.

Daily analysis for PA was conducted for both LPV and LNAV/VNAV service levels. Figures 4.1 to 4.3 and 4.5 to 4.7 show the WAAS LNAV/VNAV and LPV CONUS coverage area for each month for this quarter, respectively. Figures 4.4 and 4.8 show the rollup WAAS LNAV/VNAV and LPV CONUS coverage for the quarter. The coverage plots also provide 100, 99, 95, 90 and 80% availability contours. Figures 4.15 to 4.17 show WAAS LNAV/VNAV, LPV, and NPA CONUS coverage since WAAS commissioning (July 2003). Alaska coverage became available in August. Figure 4.18 to 4.19 show WAAS LPV Alaska coverage. Figure 4.13 shows the daily WAAS LNAV/VNAV and LPV coverage at 99% availability and ionosphere KP index values for this quarter.

Figure 4.9 to 4.11 show the NPA coverage area of each month and Figure 4.12 shows the rollup NPA coverage for the quarter. Daily analysis for NPA was based on a 99.9% availability requirement. The NPA coverage plots also provide 100, 99.9 and 99% availability contours. Figure 4.14 shows the daily NPA coverage at 99.9% availability and ionosphere Kp index values for this quarter.

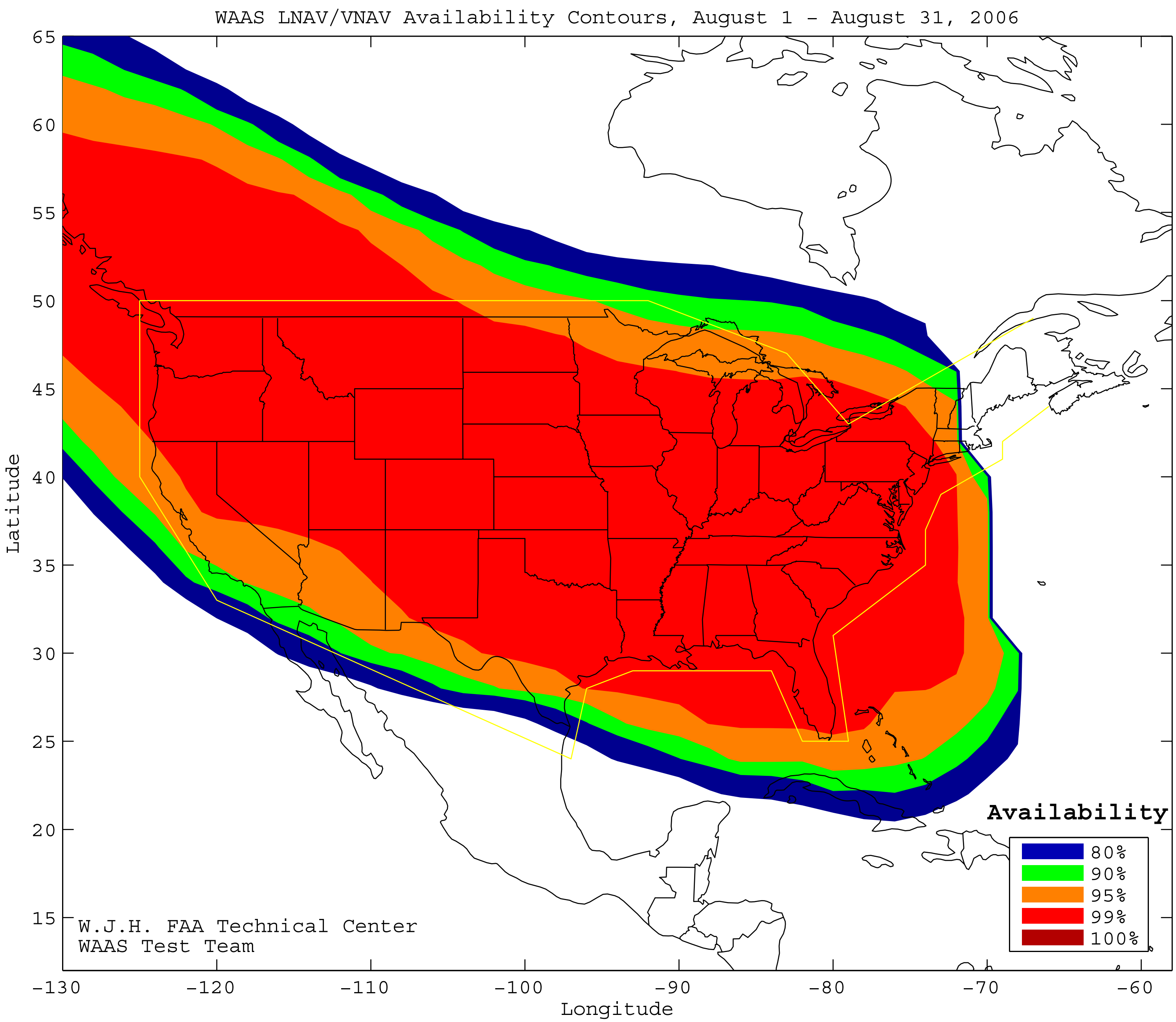
Figure 4-1 WAAS LNAV/VNAV Coverage - July



CONUS Coverage at 95% Availability = 92.71
CONUS Coverage at 99% Availability = 75.3
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

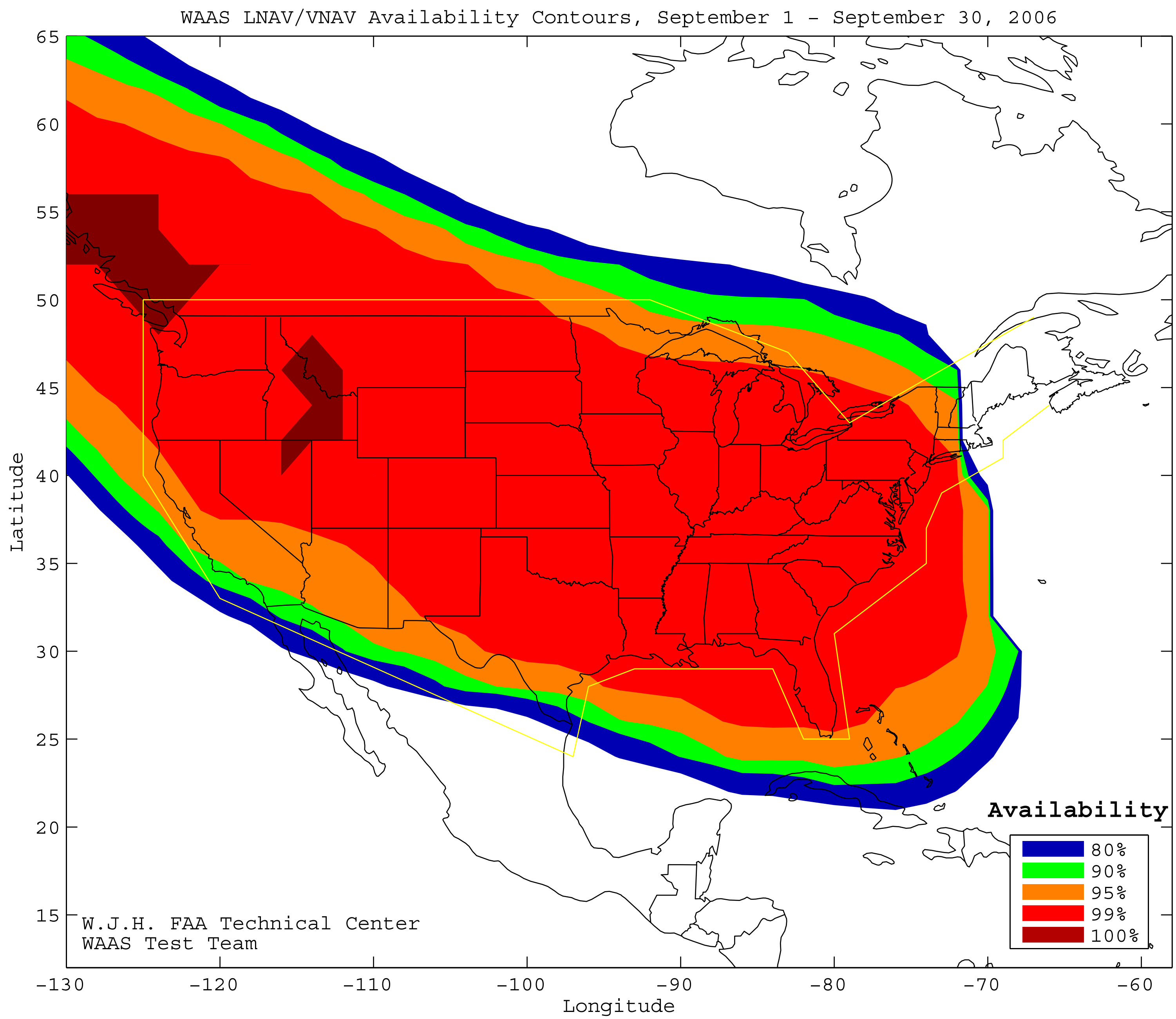
Figure 4-2 WAAS LNAV/VNAV Coverage - August



CONUS Coverage at 95% Availability = 92.71
CONUS Coverage at 99% Availability = 79.76
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

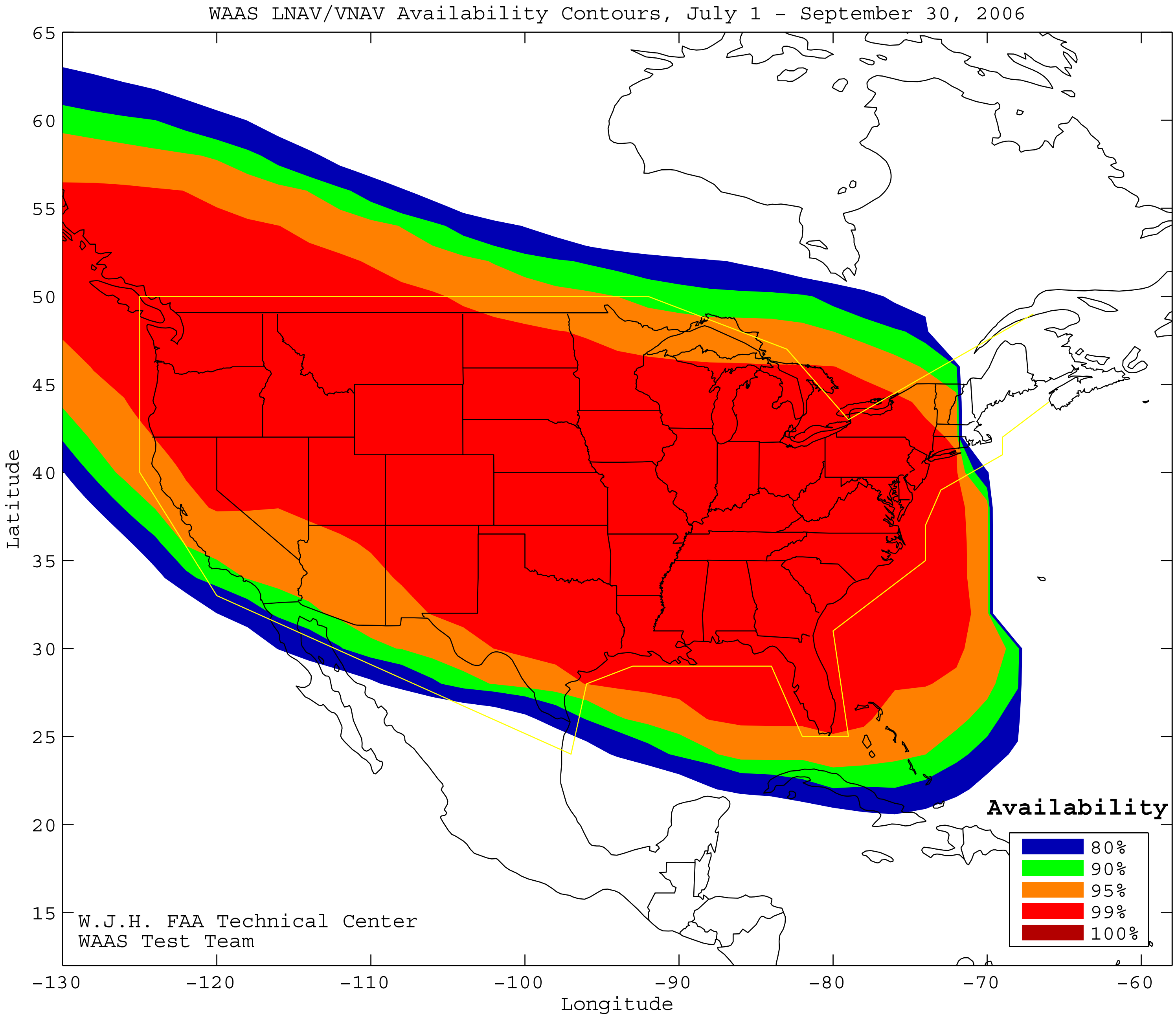
Figure 4-3 WAAS LNAV/VNAV Coverage - September



CONUS Coverage at 95% Availability = 93.12
CONUS Coverage at 99% Availability = 80.97
CONUS Coverage at 100% Availability = 4.858

SL = LNAV/VNAV

Figure 4-4 WAAS LNAV/VNAV Coverage for the Quarter



CONUS Coverage at 95% Availability = 93.12
CONUS Coverage at 99% Availability = 80.97
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

Figure 4-5 WAAS LPV Coverage - July

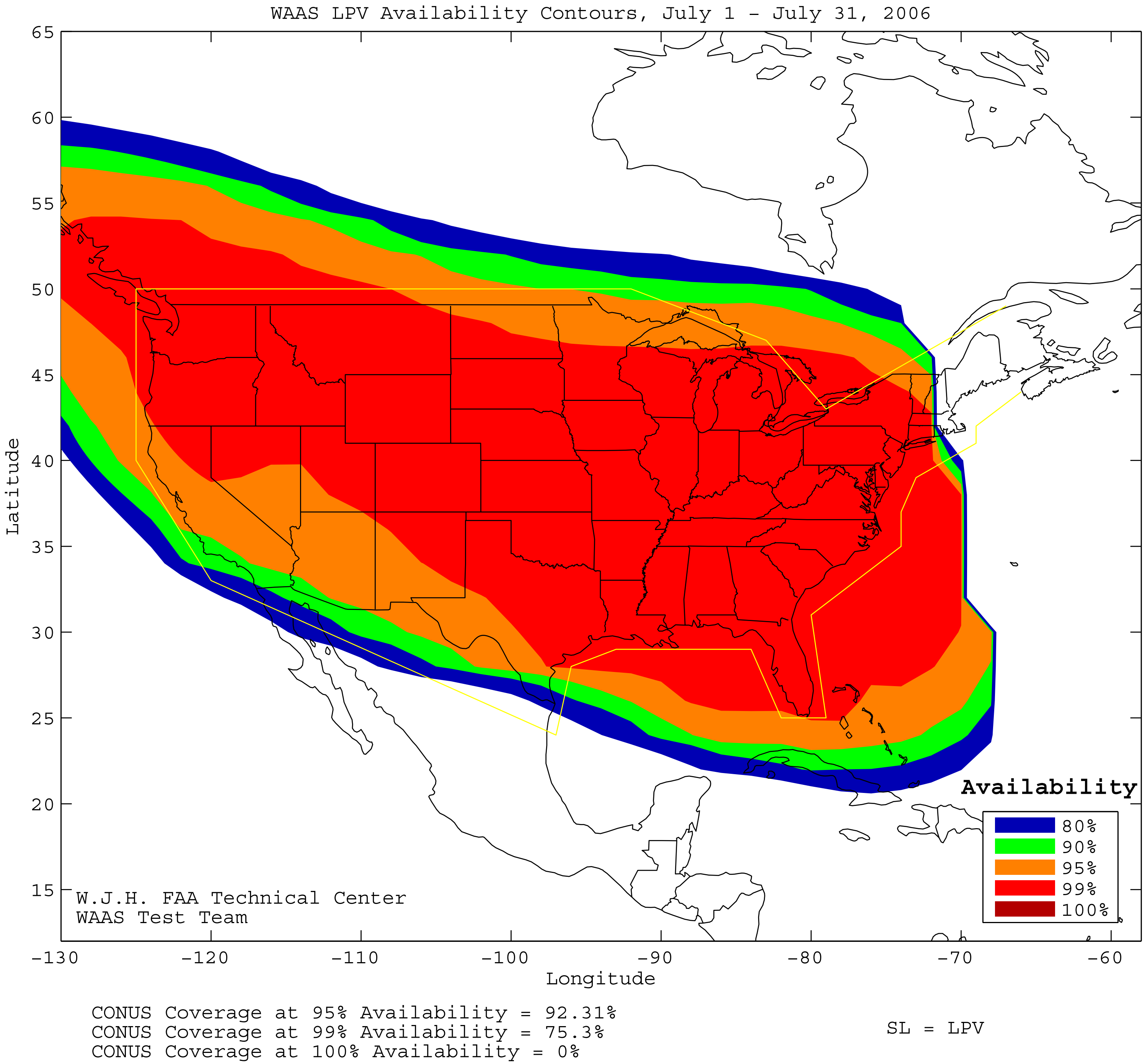
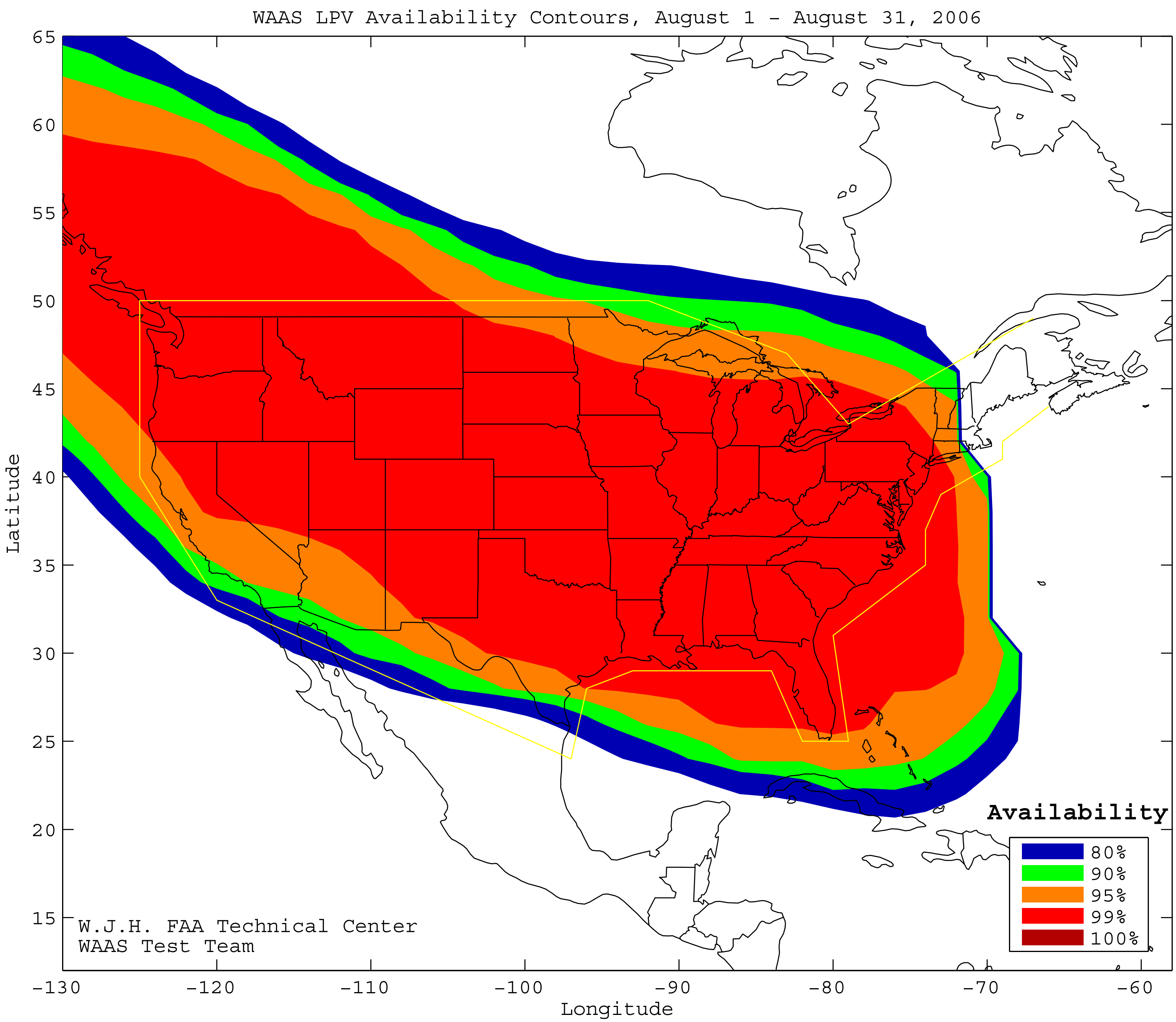


Figure 4-6 WAAS LPV Coverage - August



CONUS Coverage at 95% Availability = 92.31%
CONUS Coverage at 99% Availability = 78.95%
CONUS Coverage at 100% Availability = 0%

SL = LPV

Figure 4-7 WAAS LPV Coverage - September

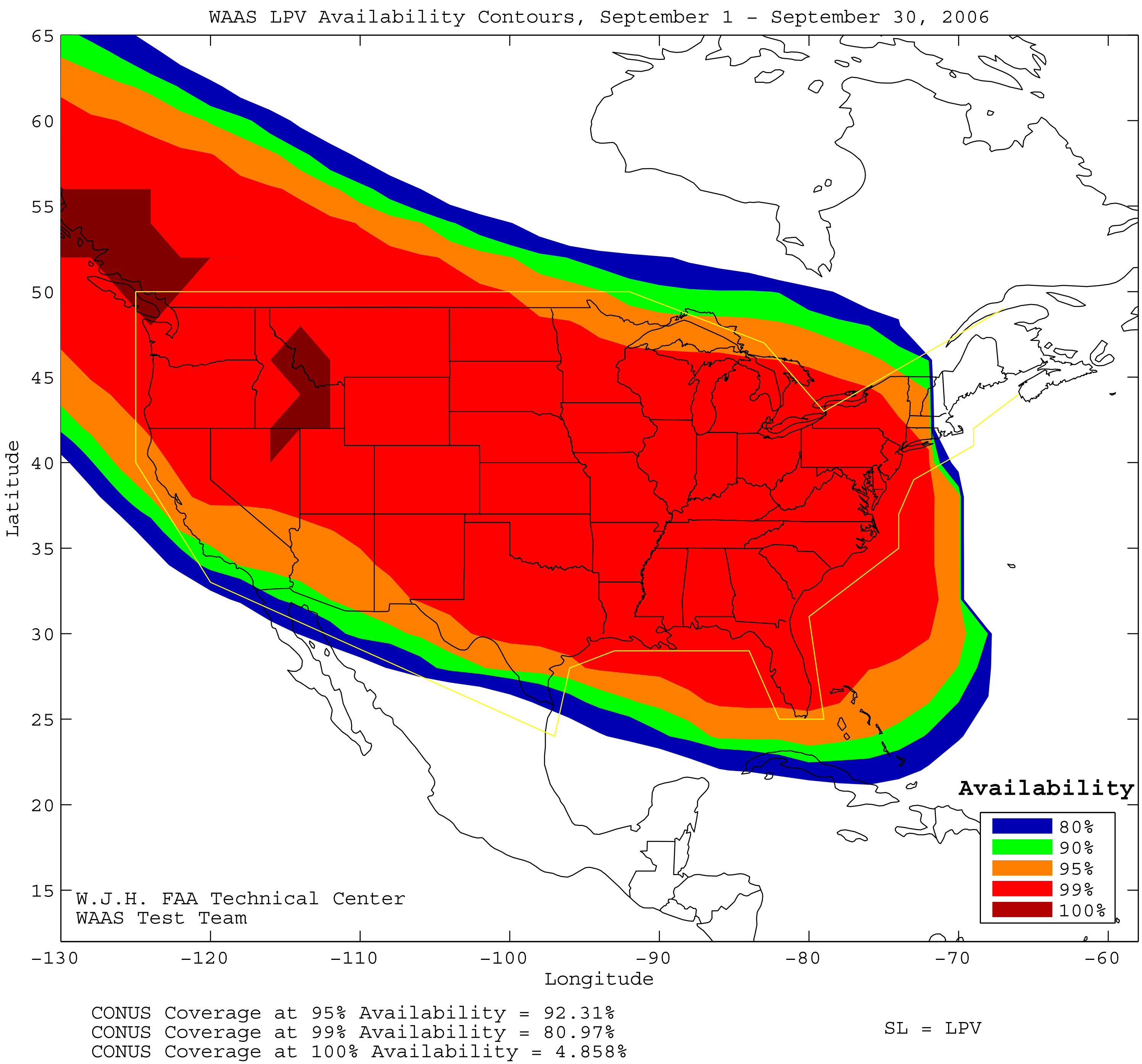
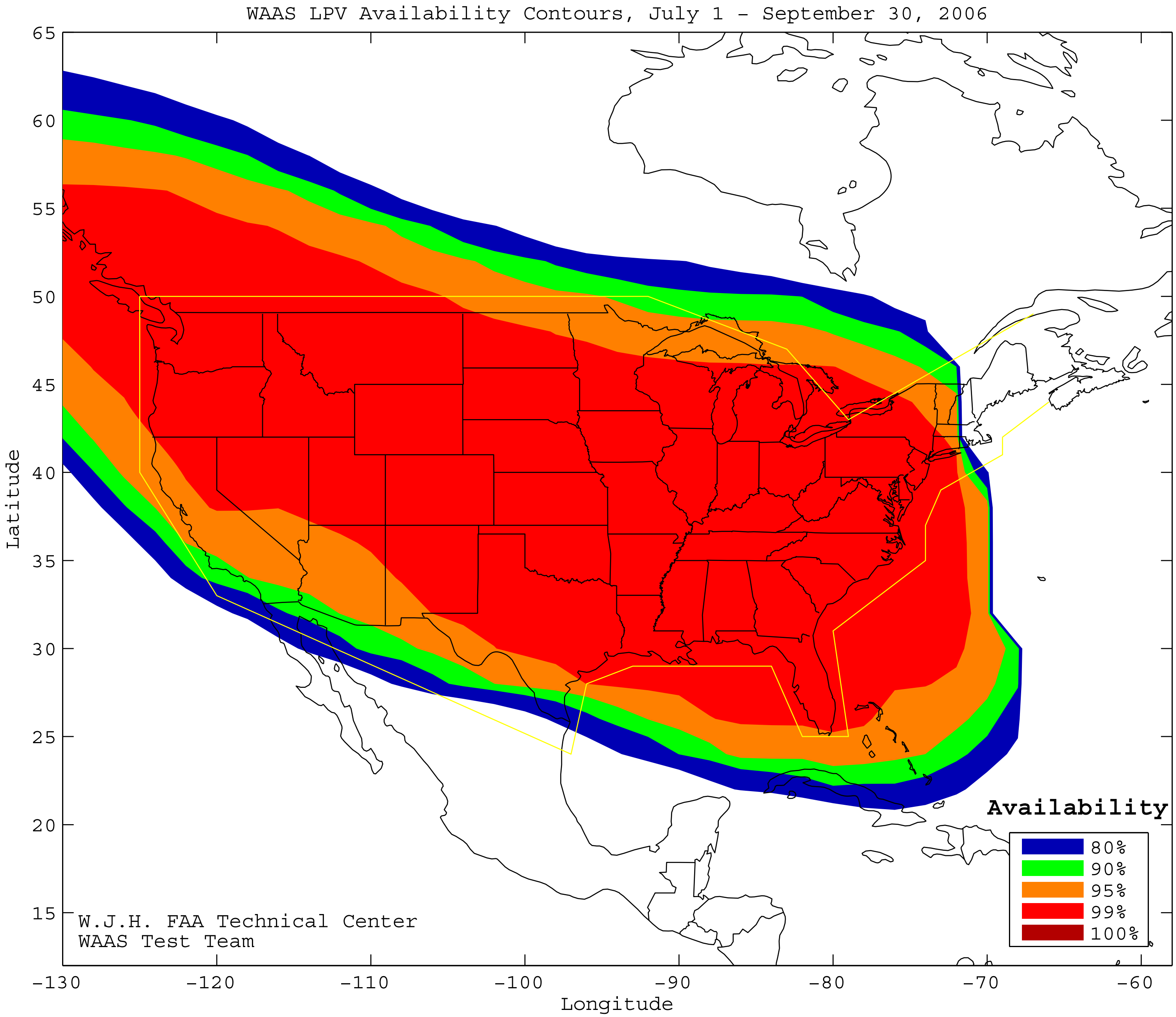


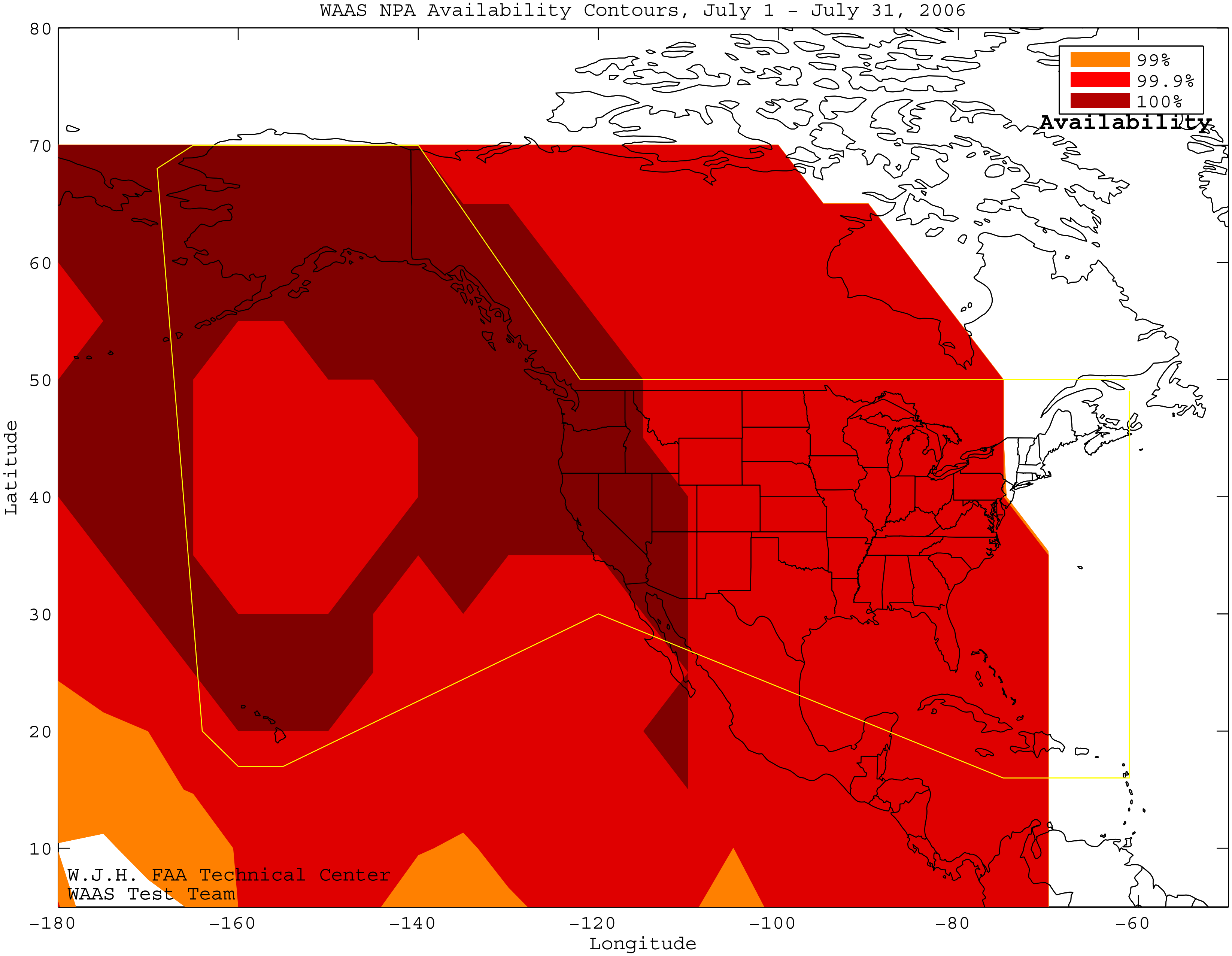
Figure 4-8 WAAS LPV Coverage for the Quarter



CONUS Coverage at 95% Availability = 91.9%
CONUS Coverage at 99% Availability = 80.16%
CONUS Coverage at 100% Availability = 0%

SL = LPV

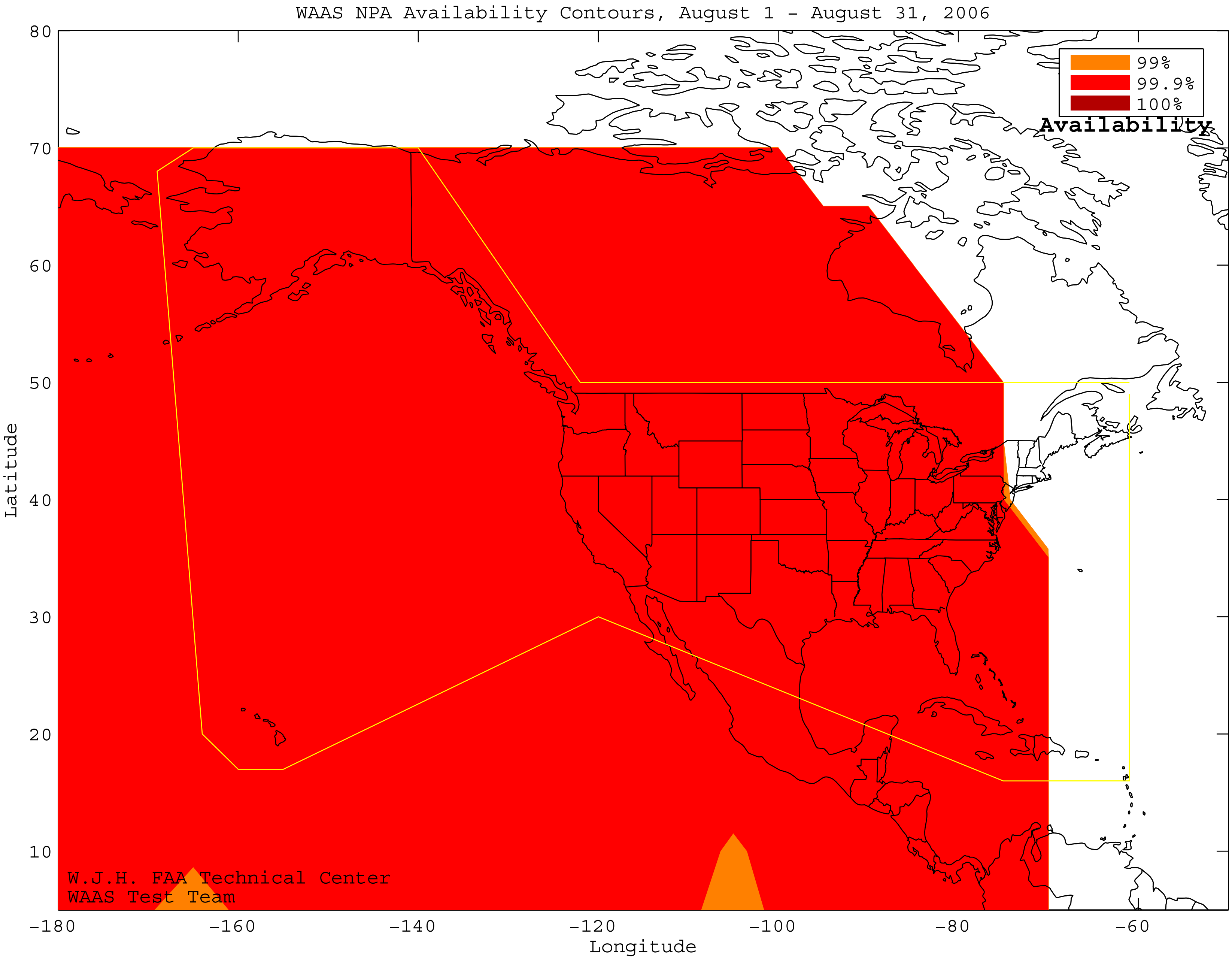
Figure 4-9 WAAS NPA Coverage - July



WAAS Coverage at 99% Availability = 94.12%
WAAS Coverage at 99.9% Availability = 94.12%
WAAS Coverage at 100% Availability = 49.26%

SL = NPA

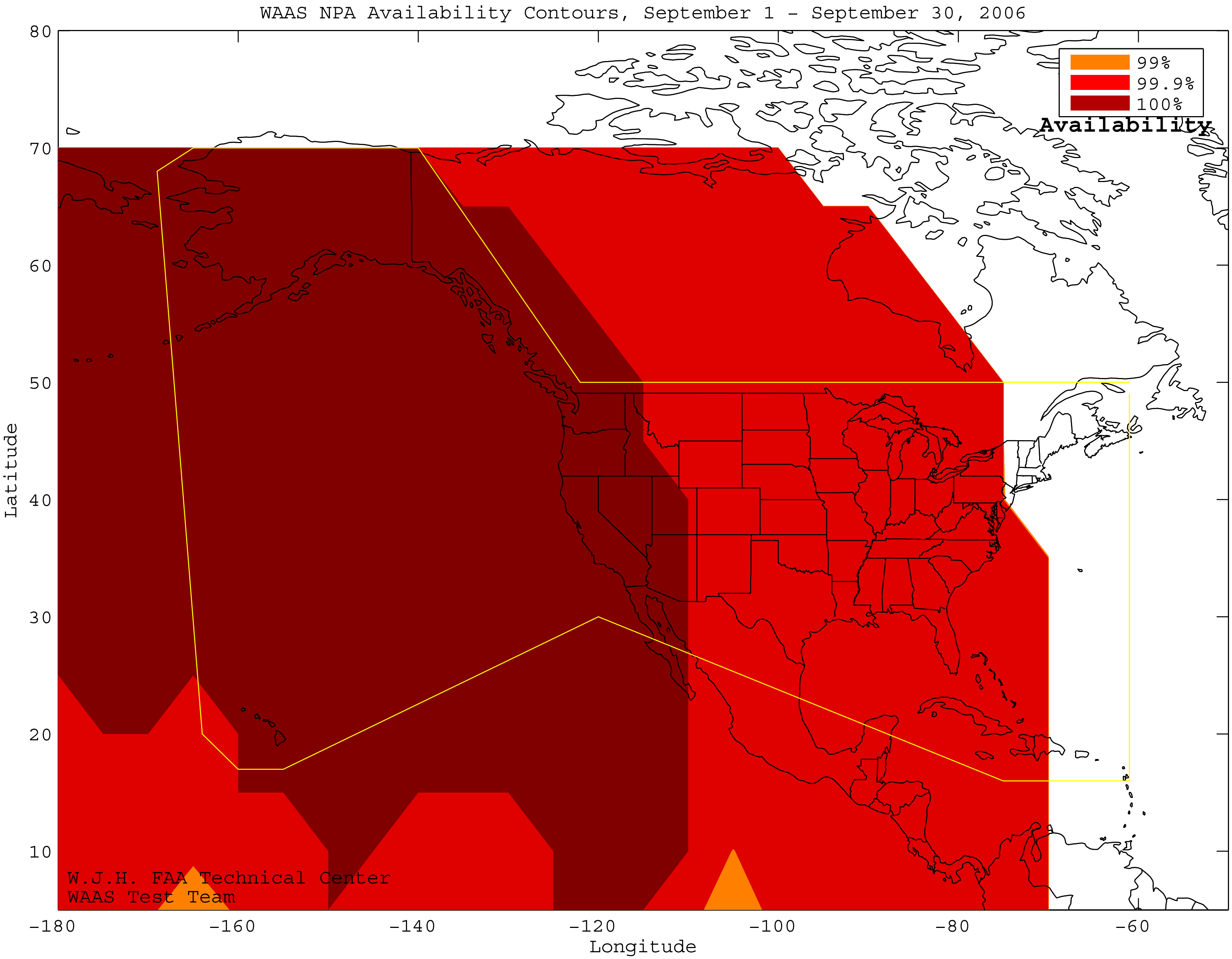
Figure 4-10 WAAS NPA Coverage - August



WAAS Coverage at 99% Availability = 94.12%
WAAS Coverage at 99.9% Availability = 94.12%
WAAS Coverage at 100% Availability = 0%

SL = NPA

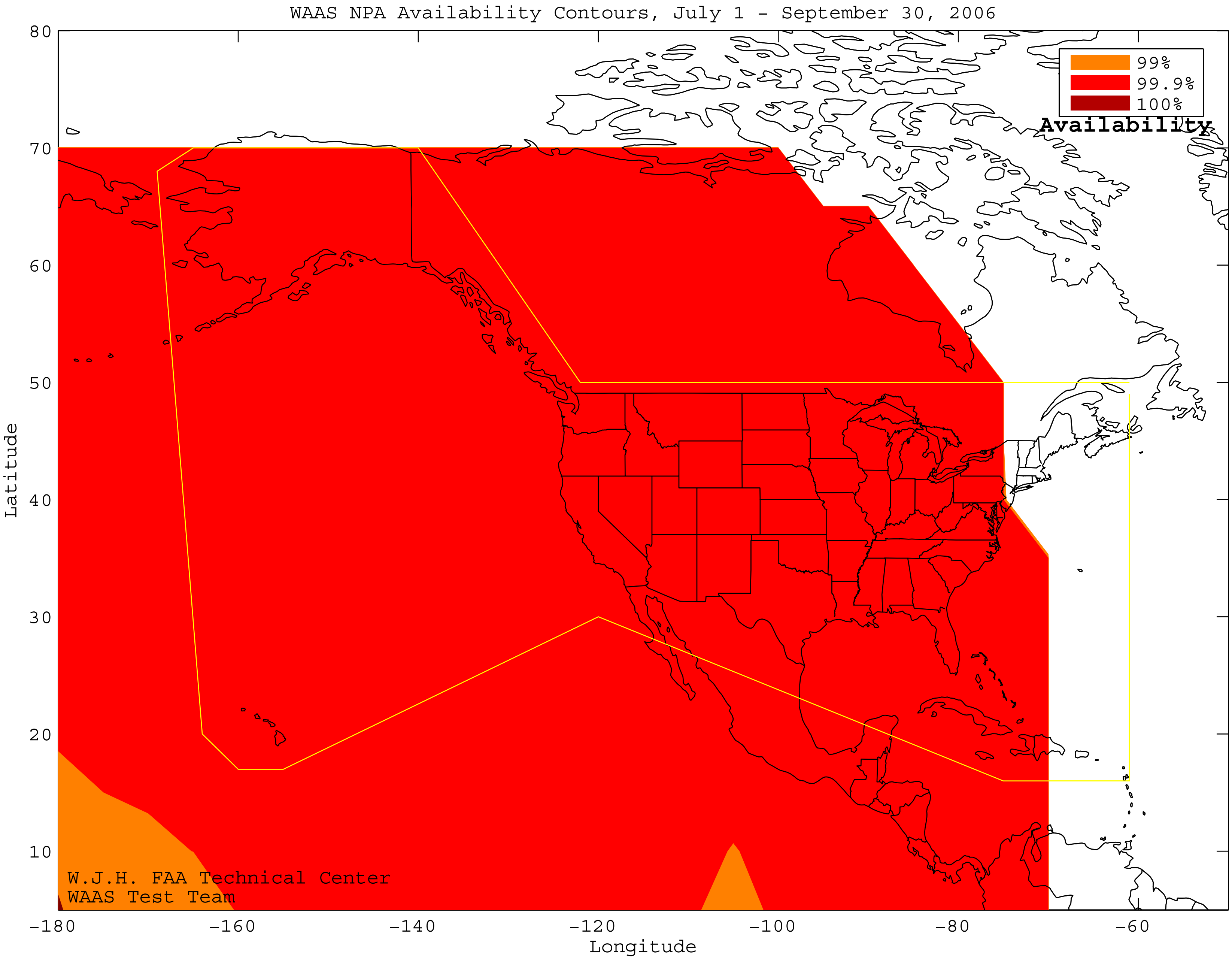
Figure 4-11 WAAS NPA Coverage - September



WAAS Coverage at 99% Availability = 94.12%
WAAS Coverage at 99.9% Availability = 94.12%
WAAS Coverage at 100% Availability = 63.24%

SL = NPA

Figure 4-12 WAAS NPA Coverage for the Quarter



WAAS Coverage at 99% Availability = 94.12%
WAAS Coverage at 99.9% Availability = 94.12%
WAAS Coverage at 100% Availability = 0%

SL = NPA

Figure 4-13 Daily WAAS LNAV/VNAV and LPV Coverage

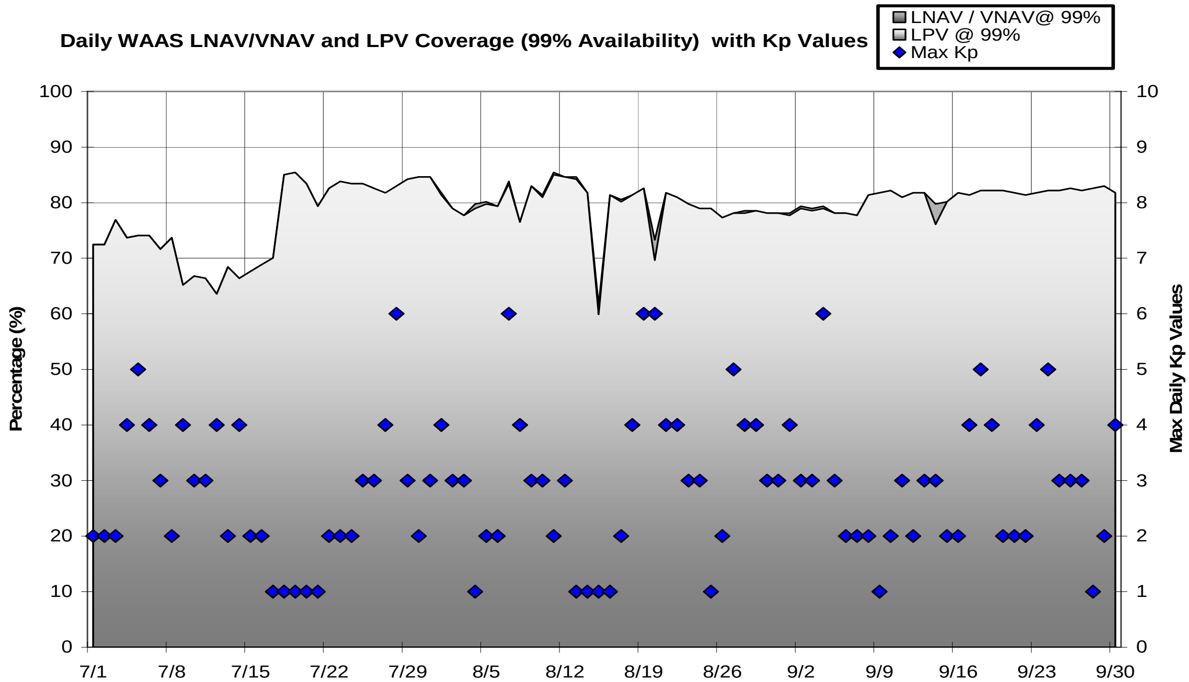


Figure 4-14 Daily NPA Coverage

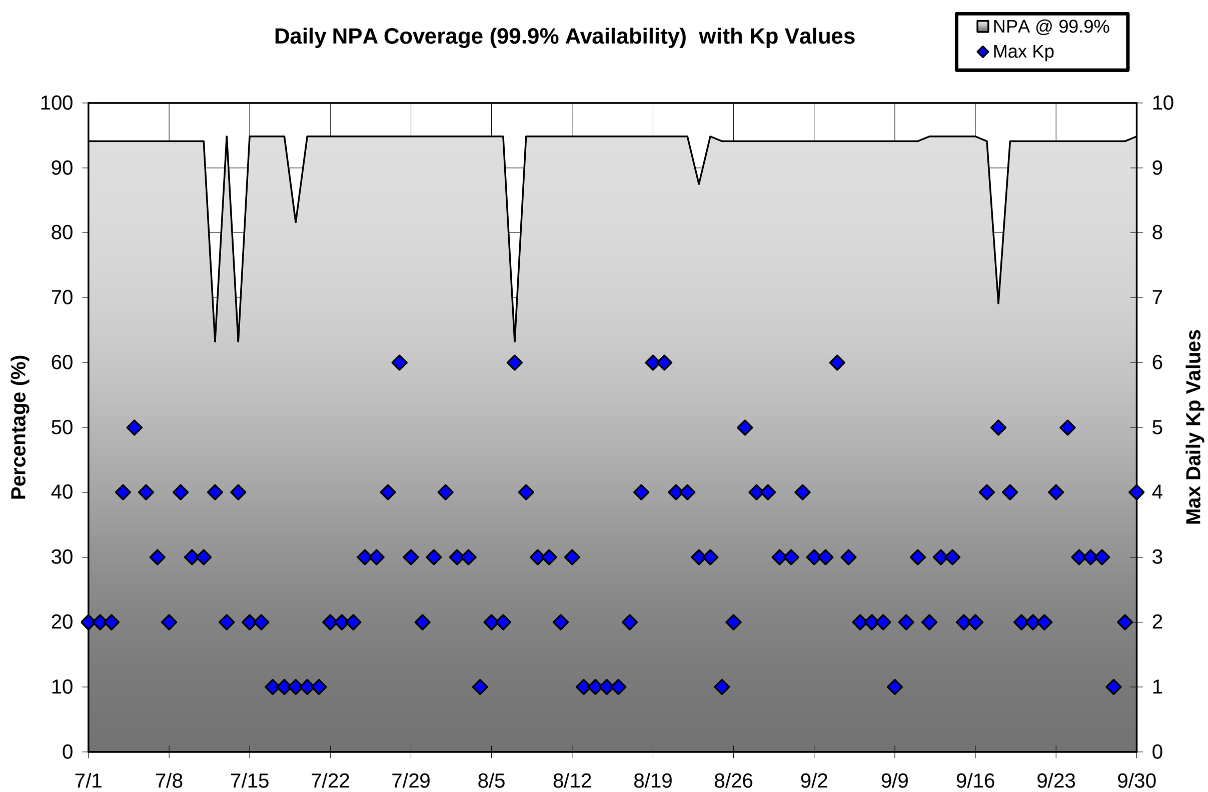
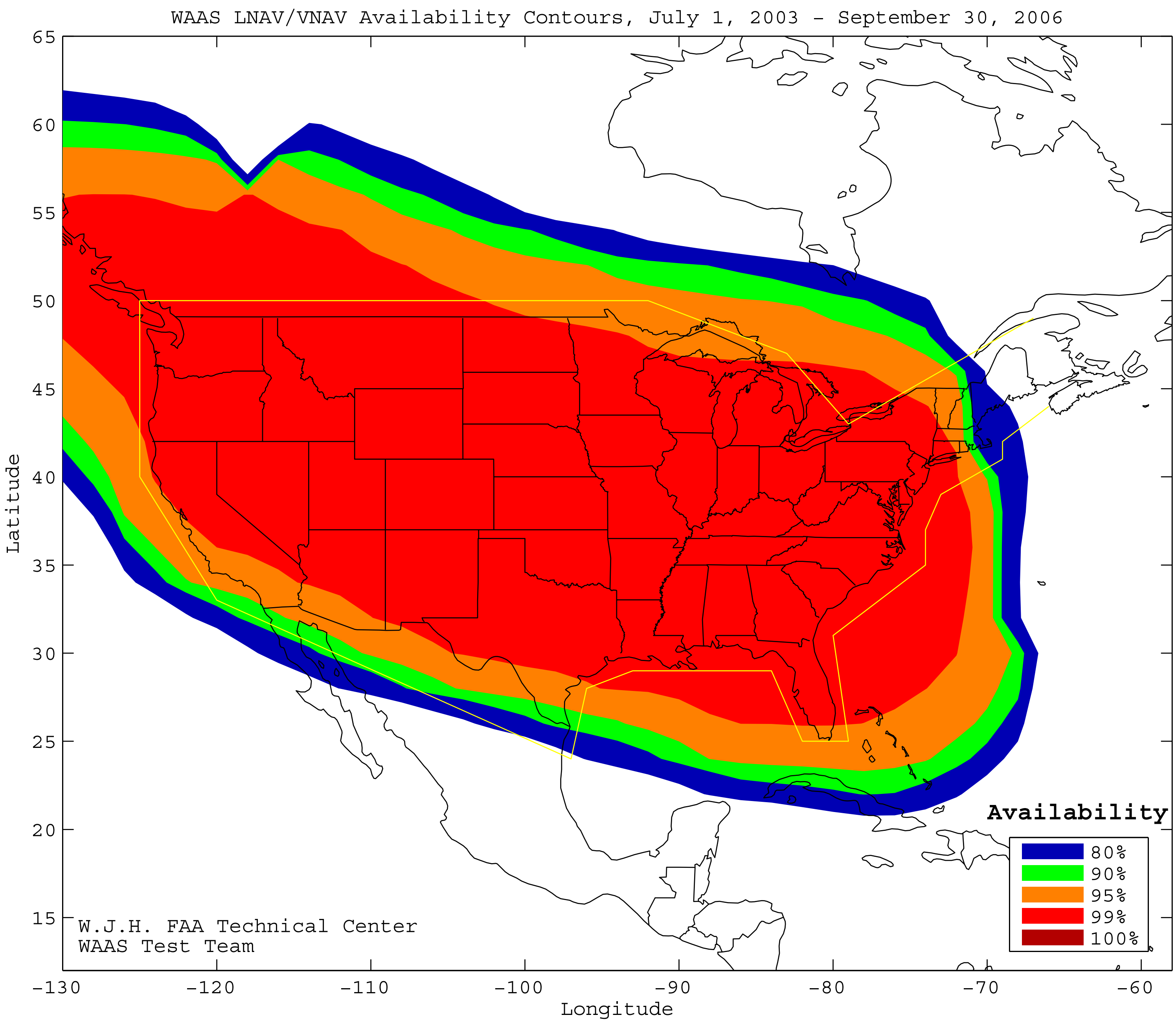


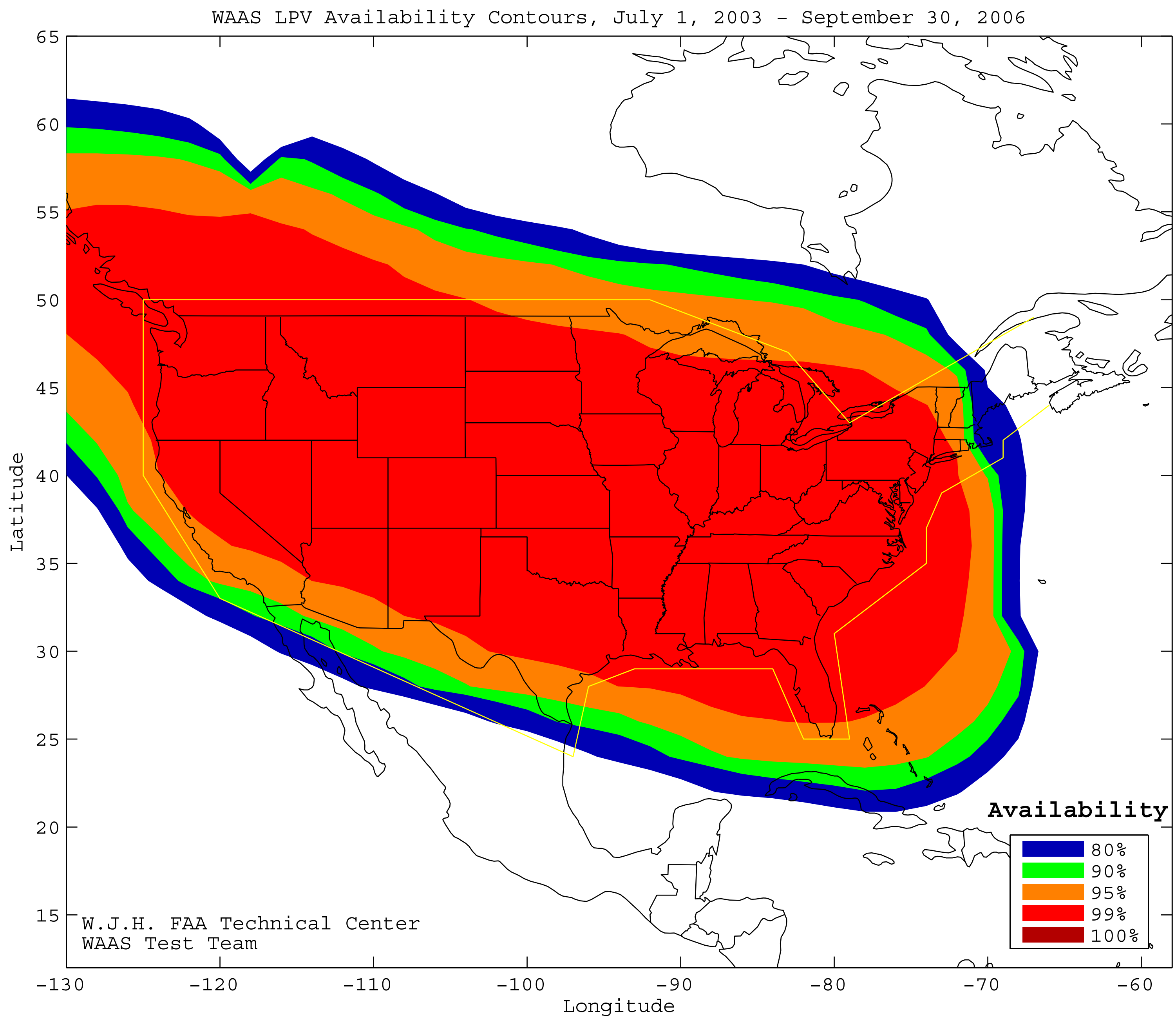
Figure 4-15 WAAS LNAV/VNAV Coverage Since Commissioning



CONUS Coverage at 95% Availability = 94.74
CONUS Coverage at 99% Availability = 86.64
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

Figure 4-16 WAAS LPV Coverage Since Commissioning



CONUS Coverage at 95% Availability = 93.93%
CONUS Coverage at 99% Availability = 85.02%
CONUS Coverage at 100% Availability = 0%

SL = LPV

Figure 4-17 NPA Coverage Since Commissioning

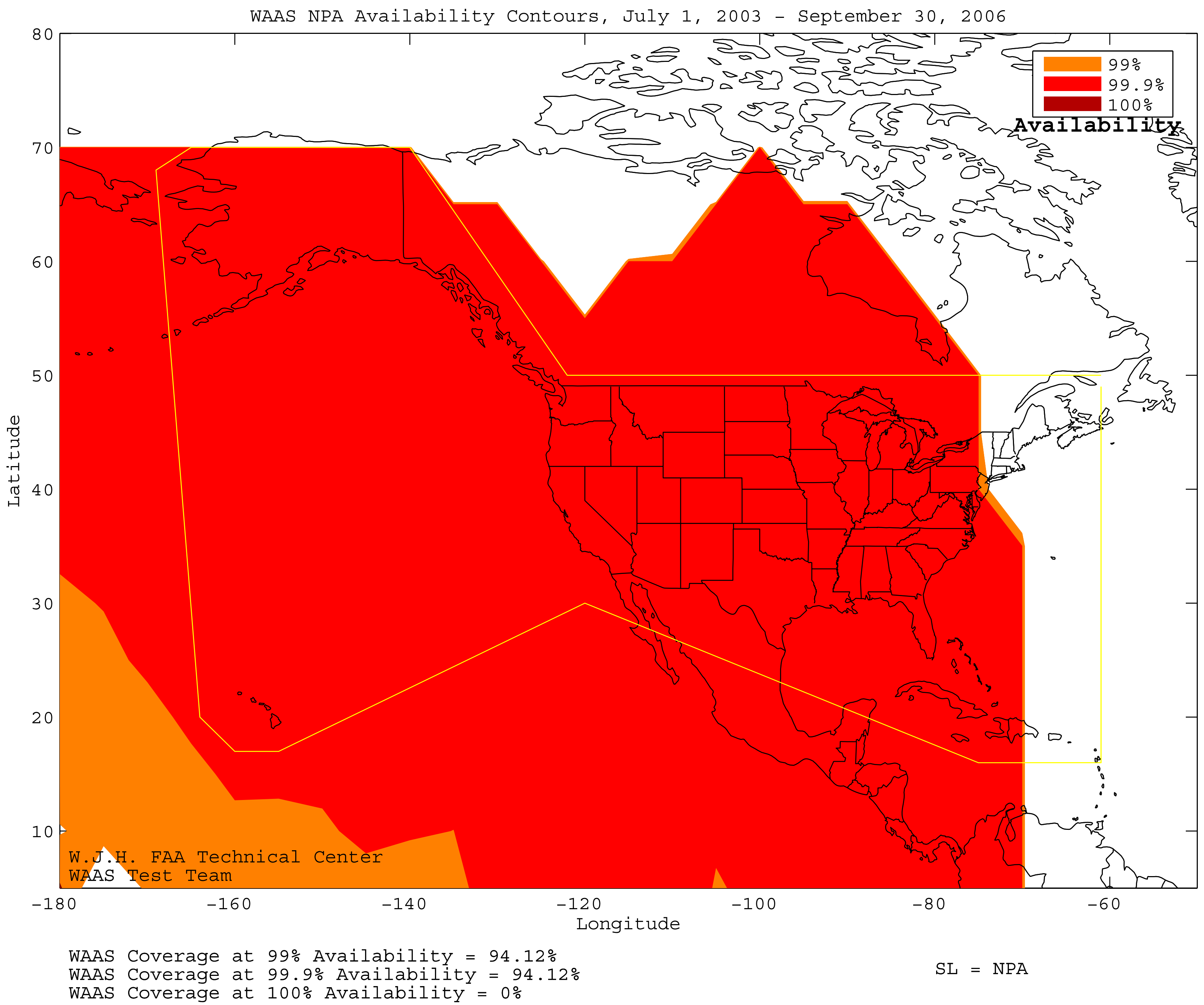
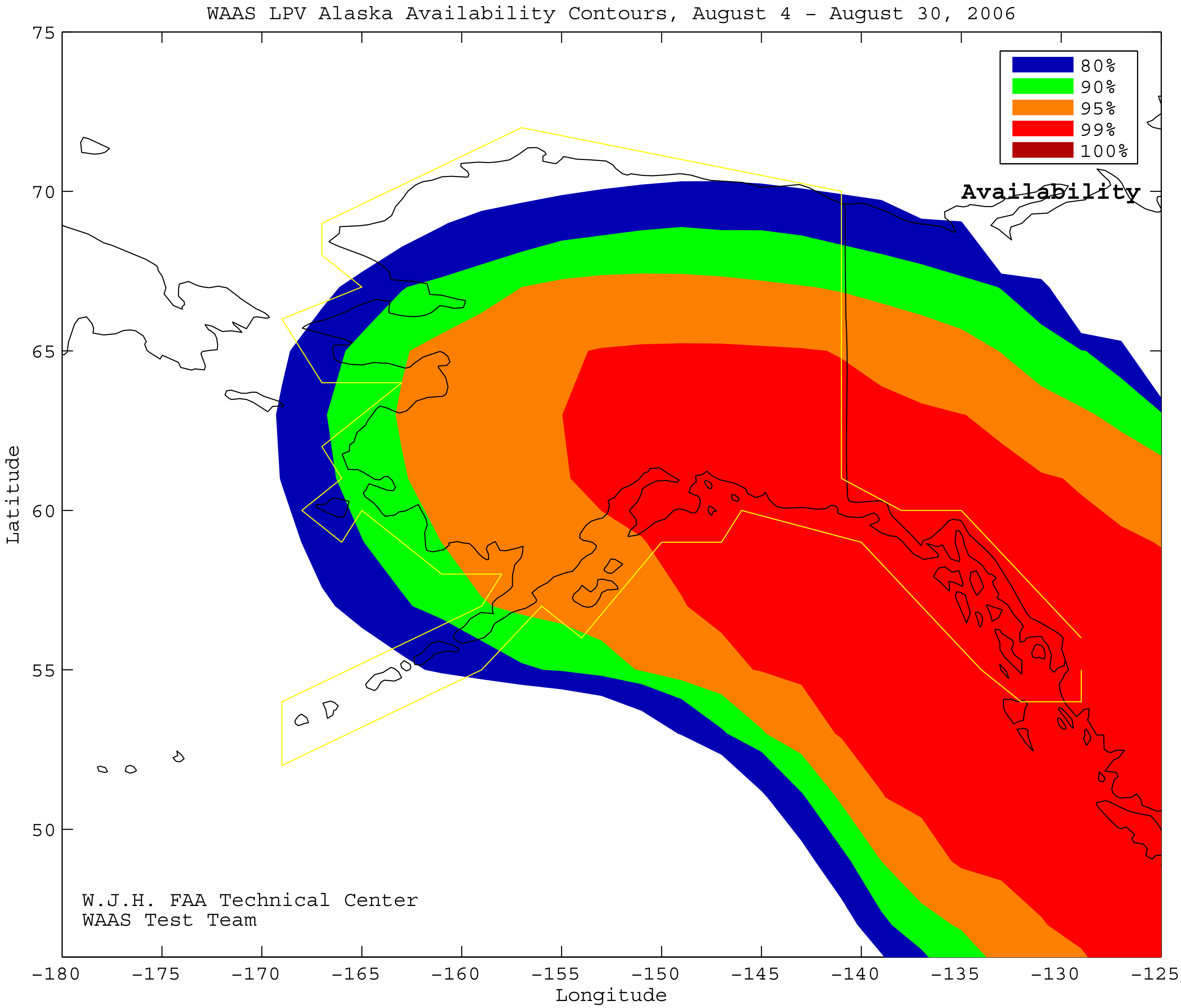


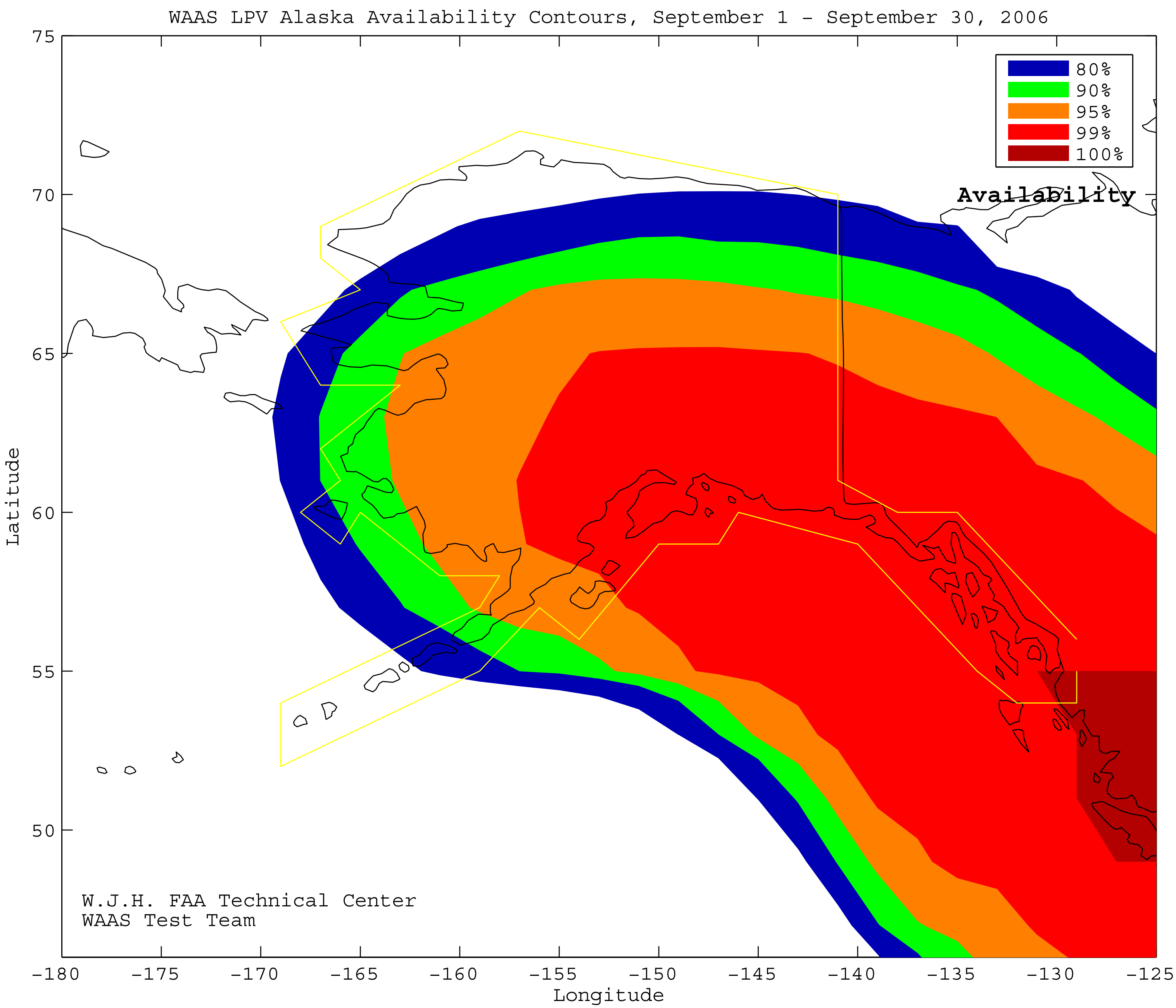
Figure 4-18 LPV Alaska Coverage - August



Alaska Coverage at 95% Availability = 63.04%
Alaska Coverage at 99% Availability = 31.52%
Alaska Coverage at 100% Availability = 0%

SL = LPV

Figure 4-19 LPV Alaska Coverage - September



Alaska Coverage at 95% Availability = 63.04%
Alaska Coverage at 99% Availability = 38.04%
Alaska Coverage at 100% Availability = 1.087%

SL = LPV

5.0 INTEGRITY

5.1 HMI Analysis

Analysis of integrity includes the identification and evaluation of HMI (hazardously misleading information), as well as the generation of a safety index to illustrate the margin of safety that WAAS protection levels are providing. The safety margin index (shown in Table 5.1) is a metric that shows how well the protection levels are bounding the maximum observed error. The process for determining this index involves normalizing the largest error observed at a site. This is accomplished by dividing this maximum observed error by the WAAS estimated standard deviation of the error. The safety margin requirement, 5.33 standard units for vertical and 6 standard units for horizontal, is then divided by this maximum normalized error.

Table 5-1 Safety Margin Index and HMI Statistics

Location	Safety Index		Number of HMIs
	Horizontal	Vertical	
Atlantic City	10.00	7.61	0
Greenwood	10.00	5.33	0
San Angelo	10.00	8.88	0
Albuquerque	12.00	7.61	0
Atlanta	8.57	5.33	0
Billings	10.00	7.61	0
Boston	6.00	6.66	0
Chicago	7.50	7.61	0
Cleveland	7.50	5.33	0
Dallas	5.45	4.85	0
Denver	8.57	6.66	0
Houston	10.00	7.61	0
Jacksonville	10.00	6.66	0
Kansas City	8.57	5.33	0
Los Angeles	10.00	8.88	0
Memphis	10.00	7.61	0
Miami	8.57	7.61	0
Minneapolis	5.45	5.92	0
New York	8.57	8.88	0
Oakland	8.57	6.66	0
Salt Lake City	8.57	7.61	0
Seattle	7.50	6.66	0
Washington DC	10.00	8.88	0

An observed safety margin index of greater than one indicates safe bounding of the greatest observed error, less than one indicates that the maximum error was not bounded, and a result equal to one means that the error was equal to the protection level. As evidenced by the statistics in the above table, the lowest safety margin index is 4.85 at Dallas. Also, Table 5.1 shows the number of HMIs that occurred during the quarter, of which there were none. An HMI occurs if the position error exceeds the protection level in the vertical or horizontal dimensions at any time and 6.2 seconds or more passes before this event is corrected by WAAS. Since WAAS was made available to the public in August 2000 there has not been an HMI event. Note that the FAA commissioned WAAS for safety of life services in July 2003.

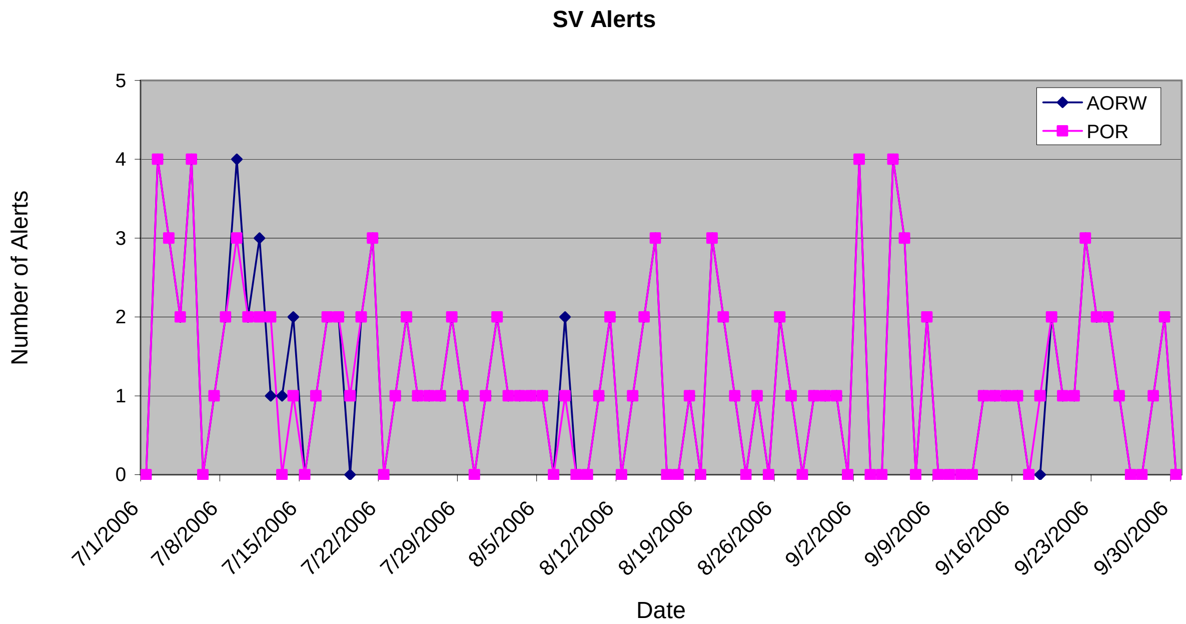
5.2 Broadcast Alerts

The WAAS transmits alert messages to protect the users from satellite degradation or severe ionospheric activity, both of which can cause unsafe conditions for a user. Space Vehicle (SV) alerts increase the User Differential Range Error (UDRE) of satellites, which can reduce the weighting of the satellite in the navigation solution, or completely exclude it from the navigation solution. An increase in UDRE's after an alert effectively increases the user protection levels (HPL and VPL), which affect the availability. Additionally, if an alert message sequence lasts for more than 12 seconds, WAAS fast corrections can time out, causing a loss of continuity. Table 5.2 shows the total number of alerts and the average number of alerts per day. Figure 5.1 shows the number of SV alerts that occurred daily during the reporting period. Often the number of alerts on one GEO is the same as the number of alerts on the other GEO. Therefore, lines tend to overlap in most points on this plot.

Table 5-2 WAAS SV Alert

	Number of Alerts		Average Alerts Per Day	
Message Type	**AORW**	**POR**	**AORW**	**POR**
2	37	39	0.4021	0.4239
3	54	59	0.5869	0.6413
6	0	0	0	0
24	41	34	0.4456	0.3695
26	0	0	0	0
Total Alerts	132	132	1.4346	1.4347

Figure 5-1 SV Daily Alert Trends



5.3 Availability of WAAS Messages (AORW & POR)

For an accurate and current user position to be calculated, the content of the WAAS message must be broadcast and received within precise time specifications. This aspect of the WAAS is critical to maintaining integrity requirements. Each message type in the WAAS SIS has a specific amount of time for which it must be received anew. Although the content of every message is relevant to the functionality of the system, the importance of different messages varies along with the frequency with which they must be received. Table 5.3 lists the maximum intervals at which each message must broadcast to meet system requirements.

GUS switchovers or broadcast WAAS alerts can interrupt the normal broadcast message stream. If these events occur at a time when the maximum interval of a specific message is approaching, that message may be delayed, resulting in its late transmittal.

All late messages statistics reported during the quarter were caused by GEO SIS outages, GUS switchovers and SV alerts except message type 7 and 10. Occasionally, message type 7 and 10 were late and they were not caused by GEO SIS outages, GUS switchovers or SV alerts. The lateness of type 7 and type 10 messages has little or no impact on user performance and safety. Tables 5.4 to 5.8 show fast correction, long correction, ephemeris covariance, ionosphere correction, and ionospheric mask message rates statistics broadcasted on AORW. The message rates statistics for POR are shown in table 5.9 to 5.13.

Table 5-3 Update Rates for WAAS Messages

Data	**Associated Message Types**	**Maximum Update Interval** (seconds)	**En Route, Terminal, NPA Timeout** (seconds)	**Precision Approach Timeout** (seconds)
WAAS in Test Mode	0	6	N/A	N/A
PRN Mask	1	60	None	None
UDREI	2-6, 24	6	18	12
Fast Corrections	2-5, 24	See Table A-8 in RTCA DO-229C	See Table A-8 in RTCA DO-229C	See Table A-8 in RTCA DO-229C
Long Term Corrections	24, 25	120	360	240
GEO Nav. Data	9	120	360	240
Fast Correction Degradation	7	120	360	240
Weighting Factors	8	120	240	240
Degradation Parameters	10	120	360	240
Ionospheric Grid Mask	18	300	None	None
Ionospheric Corrections	26	300	600	600
UTC Timing Data	12	300	None	None
Almanac Data	17	300	None	None

Table 5-4 WAAS Fast Correction and Degradation Message Rates - AORW

Message Type	**On Time**	**Late**	**Max Late Length (seconds)**
1	141327	0	0
2	1324769	71	29
3	1324836	61	24
7	75531	108	211
9	93150	0	0
10	75496	117	169
17	30049	4	534
24	1324791	68	24

Table 5-5 WAAS Long Correction Message Rates (Type 24 and 25) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	44440	1	167
2	46852	0	0
3	36442	0	0
4	47504	0	0
5	47842	0	0
6	38589	0	0
7	49360	0	0
8	45752	0	0
9	47509	0	0
10	47662	1	172
11	48496	0	0
13	46226	0	0
14	46779	0	0
15	24555	0	0
16	48104	0	0
17	47331	0	0
18	45667	0	0
19	47871	0	0
20	47940	0	0
21	41290	0	0
22	43492	0	0
23	45911	0	0
24	47283	0	0
25	47461	1	180
26	46137	0	0
27	43947	0	0
28	43437	1	171
29	36547	0	0
30	48377	0	0

Table 5-6 WAAS Ephemeris Covariance Message Rates (Type 28) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	42383	0	0
2	44354	1	149
3	34466	1	176
4	44891	1	128
5	45426	0	0
6	36405	0	0
7	46523	0	0
8	43089	0	0
9	45178	1	153
10	44875	0	0
11	45929	0	0
13	43477	0	0
14	44139	0	0
15	23200	1	150
16	44598	0	0
17	43946	1	176
18	42325	1	137
19	43616	0	0
20	43434	0	0
21	37487	0	0
22	39447	0	0
23	41352	0	0
24	42659	0	0
25	42919	0	0
26	41747	0	0
27	39732	3	195
28	39415	1	139
29	33209	0	0
30	43692	0	0
134	81036	2	165

Table 5-7 WAAS Ionospheric Correction Message Rates (Type 26) - AORW

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27610	5	421
1	0	27613	3	376
1	1	27636	3	504
1	2	27617	2	492
1	3	27638	4	491
1	4	27618	4	483
2	0	27622	4	486
2	1	27596	2	463
2	2	27640	2	458
2	3	27601	5	489
2	4	27595	3	493
2	5	27622	4	459
3	0	27639	3	439

Table 5-8 WAAS Ionospheric Mask Message Rates (Type 18) - AORW

Band	On Time	Late	Max Late Length (seconds)
0	68183	0	0
1	68236	0	0
2	68228	0	0
3	68198	0	0

Table 5-9 WAAS Fast Correction and Degradation Message Rates - POR

Message Type	On Time	Late	Max Late Length (seconds)
1	139855	0	0
2	1324778	69	32
3	1324844	59	26
7	74840	101	210
9	93142	2	337
10	74803	90	138
17	29940	4	412
24	1324780	69	26

Table 5-10 WAAS Long Correction Message Rates (Type 24 and 25) - POR

SV	On Time	Late	Max Late Length (seconds)
1	44437	0	0
2	46853	0	0
3	36441	0	0
4	47509	0	0
5	47822	0	0
6	38584	0	0
7	49362	0	0
8	45761	0	0
9	47513	0	0
10	47681	0	0
11	48501	0	0
13	46218	0	0
14	46775	0	0
15	24543	0	0
16	48106	0	0
17	47335	1	166
18	45669	0	0
19	47872	0	0
20	47942	0	0
21	41303	0	0
22	43493	0	0
23	45915	0	0
24	47280	0	0
25	47465	0	0
26	46141	0	0
27	43941	0	0
28	43450	0	0
29	36550	0	0
30	48369	1	175

Table 5-11 WAAS Ephemeris Covariance Message Rates (Type 28) – POR

SV	On Time	Late	Max Late Length (seconds)
1	42383	0	0
2	44355	0	0
3	34468	1	160
4	44894	0	0
5	45426	0	0
6	36407	0	0
7	46517	2	174
8	43091	0	0
9	45178	1	150
10	44871	0	0
11	45925	0	0
13	43475	0	0
14	44132	0	0
15	23200	0	0
16	44593	2	192
17	43945	1	182
18	42327	0	0
19	43618	0	0
20	43437	0	0
21	37485	2	192
22	39440	2	157
23	41344	0	0
24	42661	0	0
25	42913	0	0
26	41749	0	0
27	39731	1	130
28	39421	1	127
29	33212	0	0
30	43698	1	158
134	81043	0	0

Table 5-12 WAAS Ionospheric Correction Message Rates (Type 26) – POR

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27613	6	524
0	1	27598	5	522
0	2	27624	3	504
1	0	27610	4	492
1	1	27632	6	462
1	2	27612	5	507
1	3	27624	5	488
1	4	27614	4	483
2	0	27615	4	470
2	1	27629	6	469
2	2	27617	3	316
2	3	27658	2	307

Table 5-13 WAAS Ionospheric Mask Message Rates (Type 18) - POR

Band	On Time	Late	Max Late Length (seconds)
0	67868	0	0
1	67850	0	0
2	67912	0	0

6.0 SV RANGE ACCURACY

Range accuracy evaluation computes the probability that the WAAS User Differential Range Error (UDRE) and Grid Ionospheric Vertical Error (GIVE) statistically bound 99.9% of the range residuals for each satellite tracked by the receiver. A UDRE is broadcast by the WAAS for each satellite that is monitored by the system and the 99.9% bound (3.29 sigma) of the residual error on a pseudorange after application of fast and long-term corrections is checked. The pseudorange residual error is determined by taking the difference between the raw pseudorange and a calculated reference range. The reference range is equal to the true range between the corrected satellite position and surveyed user antenna plus all corrections (WAAS Fast Clock, WAAS Long-Term Clock, WAAS Ionospheric delay, Tropospheric delay, Receiver Clock Bias, and Multipath). Since the true ionospheric delay and multipath error are not precisely known, the estimated variance in these error sources are added to the UDRE before the comparing it to the residual error.

GPS satellite range residual errors were calculated for twelve WAAS receivers during the quarter. Table 6.1 and 6.2 show the range error 95% index and 99.9% (3.29 sigma) bounding statistics for each SV at the selected locations. Figures 6.1 and 6.2 show the range error for each SV as measured by the WAAS receivers at the Washington DC reference station.

A GIVE is broadcast by the WAAS for each IGP that is monitored by the system and the 99.9% (3.29 sigma) bound of the ionospheric error is checked. The WAAS broadcasts the ionospheric model using IGP's at predefined geographic locations. Each IGP contains the vertical ionospheric delay and the error in that delay in the form of the GIVE. The ionospheric error is determined by taking the difference between the WAAS vertical ionospheric delay interpolated from the IGP's and GPS dual frequency measurement at that GPS satellite.

GPS satellite ionospheric errors were calculated for twelve WAAS receivers during the quarter. Table 6.3 and 6.4 show the ionospheric error 95% index and 99.9% (3.29 sigma) bounding statistics for each SV at the selected locations. Figures 6.3 and 6.4 show the ionospheric error for each SV as measured by the WAAS receiver at the Washington DC reference station.

The evaluated receiver at Kansas City has gone malfunction for the last part of this quarter and therefore is not evaluated for range accuracy for this quarter.

Table 6-1 Range Error 95% index and 3.29 Sigma Bounding

Site →	Billings		Albuquerque		Boston		Washington DC		Houston	
SV ↓	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding
1	1.099	100.00	1.702	100.00	1.634	100.00	1.080	100.00	1.380	100.00
2	2.025	100.00	1.376	100.00	1.020	100.00	1.590	100.00	2.382	100.00
3	1.197	100.00	1.232	100.00	1.247	99.9053	1.279	100.00	1.491	100.00
4	1.441	100.00	1.620	100.00	1.894	100.00	1.354	100.00	1.886	100.00
5	1.248	100.00	1.262	100.00	0.888	100.00	1.011	100.00	1.068	100.00
6	2.223	100.00	1.715	100.00	1.397	100.00	1.476	100.00	1.584	100.00
7	1.516	100.00	1.186	100.00	1.243	99.9267	1.049	100.00	1.546	100.00
8	1.302	100.00	1.188	100.00	1.239	99.9348	1.267	100.00	1.195	100.00
9	1.558	100.00	1.888	100.00	1.651	100.00	1.066	100.00	1.832	100.00
10	1.554	100.00	1.122	100.00	0.935	100.00	1.569	100.00	1.268	100.00
11	1.555	100.00	1.004	100.00	1.191	100.00	1.614	100.00	2.155	100.00
12	-	-	-	-	-	-	-	-	-	-
13	1.249	100.00	1.805	100.00	1.383	99.9437	1.344	100.00	1.541	100.00
14	1.433	100.00	0.829	100.00	0.858	100.00	1.222	100.00	1.389	100.00
15	1.394	100.00	0.972	100.00	1.439	99.9854	1.305	100.00	1.208	100.00
16	1.249	100.00	1.605	100.00	0.886	99.9307	1.159	100.00	1.401	100.00
17	1.803	100.00	1.618	100.00	1.572	100.00	1.208	100.00	1.464	100.00
18	1.599	100.00	0.995	100.00	1.034	100.00	1.709	100.00	1.115	100.00
19	2.778	100.00	2.195	100.00	2.020	99.9340	2.689	100.00	2.292	100.00
20	1.323	100.00	1.341	100.00	1.162	100.00	1.073	100.00	1.749	100.00
21	1.911	100.00	1.469	100.00	1.254	100.00	1.665	100.00	1.472	100.00
22	1.253	100.00	1.099	100.00	1.051	100.00	1.273	100.00	1.247	100.00
23	2.706	100.00	2.157	100.00	2.585	99.9447	2.897	100.00	2.800	100.00
24	1.299	100.00	1.557	100.00	1.627	100.00	1.522	100.00	1.635	100.00
25	1.654	100.00	1.274	100.00	1.398	99.9390	1.164	100.00	1.569	100.00
26	1.451	100.00	1.809	100.00	2.146	100.00	1.937	100.00	2.040	100.00
27	1.102	100.00	1.360	100.00	1.336	99.8459	1.326	100.00	1.240	100.00
28	1.421	100.00	0.826	100.00	1.105	99.9074	1.187	100.00	1.358	100.00
29	1.267	100.00	2.145	100.00	2.045	100.00	1.526	100.00	1.832	100.00
30	2.048	100.00	1.812	100.00	1.774	100.00	1.338	100.00	1.777	100.00
31	-	-	-	-	-	-	-	-	-	-
122	-	-	-	-	-	-	-	-	-	-
134	-	-	-	-	-	-	-	-	-	-

Table 6-2 Range Error 95% index and 3.29 Sigma Bounding

Site →	Los Angeles		Salt Lake City		Miami		Minneapolis		Atlanta		Juneau	
SV ↓	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding
1	1.208	100.00	1.592	100.00	1.795	100.00	2.022	100.00	1.222	100.00	1.394	100.00
2	2.347	100.00	1.699	100.00	2.300	100.00	1.019	100.00	1.477	100.00	1.201	100.00
3	1.314	100.00	1.652	100.00	1.266	100.00	2.350	100.00	1.234	100.00	1.161	100.00
4	1.572	100.00	2.337	100.00	2.071	100.00	2.423	100.00	1.390	100.00	1.459	100.00
5	1.332	100.00	1.294	100.00	1.209	100.00	1.834	100.00	1.171	100.00	1.075	100.00
6	1.548	100.00	1.820	100.00	2.074	100.00	3.025	100.00	1.554	100.00	1.833	100.00
7	1.438	100.00	1.552	100.00	1.717	100.00	1.861	100.00	0.929	100.00	1.209	100.00
8	1.152	100.00	1.443	100.00	1.281	100.00	2.272	100.00	1.079	100.00	1.109	100.00
9	1.633	100.00	1.813	100.00	1.546	100.00	2.434	100.00	1.445	100.00	1.428	100.00
10	1.411	100.00	1.363	100.00	1.070	100.00	1.334	100.00	1.013	100.00	0.811	100.00
11	1.516	100.00	1.492	100.00	2.160	100.00	1.798	100.00	1.013	100.00	1.022	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.300	100.00	1.384	100.00	1.752	100.00	2.174	100.00	1.220	100.00	1.541	100.00
14	1.503	100.00	1.198	100.00	3.209	100.00	1.483	100.00	0.897	100.00	0.823	100.00
15	1.625	100.00	1.615	100.00	1.734	100.00	2.598	100.00	1.325	100.00	0.944	100.00
16	1.452	100.00	1.264	100.00	1.445	100.00	1.834	100.00	0.906	100.00	0.819	100.00
17	1.269	100.00	1.792	100.00	2.304	100.00	2.044	100.00	1.190	100.00	1.483	100.00
18	1.338	100.00	1.405	100.00	1.316	100.00	1.512	100.00	0.979	100.00	0.944	100.00
19	2.799	100.00	2.269	100.00	2.506	100.00	1.434	100.00	2.310	100.00	2.079	100.00
20	2.035	100.00	1.811	100.00	1.180	100.00	1.277	100.00	1.029	100.00	0.857	100.00
21	1.901	100.00	1.363	100.00	1.415	100.00	1.091	100.00	1.058	100.00	1.006	100.00
22	1.826	100.00	1.347	100.00	2.794	100.00	1.589	100.00	1.149	100.00	1.058	100.00
23	2.459	100.00	2.449	100.00	2.749	100.00	1.639	100.00	2.113	100.00	1.800	100.00
24	1.288	100.00	2.372	100.00	2.203	100.00	2.760	100.00	1.521	100.00	1.680	100.00
25	1.296	100.00	1.917	100.00	2.139	100.00	2.280	100.00	1.292	100.00	1.459	100.00
26	1.314	100.00	2.230	100.00	2.201	100.00	2.977	100.00	1.747	100.00	1.872	100.00
27	1.196	100.00	1.733	100.00	1.307	100.00	2.351	100.00	1.172	100.00	1.296	100.00
28	1.485	100.00	1.220	100.00	1.462	100.00	1.209	100.00	1.000	100.00	0.856	100.00
29	1.418	100.00	2.017	100.00	1.773	100.00	2.729	100.00	1.760	100.00	1.794	100.00
30	2.000	100.00	1.910	100.00	2.352	100.00	2.255	100.00	1.763	100.00	1.939	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-
122	-	-	-	-	-	-	-	-	-	-	-	-
134	5.986	100.00	2.284	100.00	-	-	-	-	-	-	2.982	100.00

Table 6-3 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Billings		Albuquerque		Boston		Washington DC		Houston	
SV ↓	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	0.648	100.00	0.632	100.00	0.773	100.00	0.297	100.00	0.633	100.00
2	1.621	100.00	0.948	100.00	0.697	100.00	1.203	100.00	1.452	100.00
3	0.534	100.00	0.448	100.00	0.441	100.00	0.538	100.00	0.732	100.00
4	0.944	100.00	0.951	100.00	1.090	100.00	0.743	100.00	1.472	100.00
5	0.572	100.00	0.418	100.00	0.428	100.00	0.403	100.00	0.436	100.00
6	0.992	100.00	0.780	100.00	0.734	100.00	0.648	100.00	0.838	100.00
7	0.577	100.00	0.543	100.00	0.529	100.00	0.368	100.00	0.673	100.00
8	0.628	100.00	0.566	100.00	0.571	100.00	0.588	100.00	0.705	100.00
9	0.677	100.00	0.735	100.00	0.558	100.00	0.359	100.00	0.614	100.00
10	0.941	100.00	0.540	100.00	0.250	100.00	1.006	100.00	0.674	100.00
11	0.861	100.00	0.581	100.00	0.408	100.00	0.679	100.00	1.190	100.00
12	-	-	-	-	-	-	-	-	-	-
13	0.655	100.00	0.705	100.00	0.586	100.00	0.463	100.00	0.695	100.00
14	1.029	100.00	0.464	100.00	0.409	100.00	0.750	100.00	0.787	100.00
15	0.626	100.00	0.391	100.00	0.648	100.00	0.390	100.00	0.614	100.00
16	0.762	100.00	0.833	100.00	0.359	100.00	0.657	100.00	0.819	100.00
17	1.168	100.00	0.930	100.00	0.906	100.00	0.465	100.00	0.735	100.00
18	1.060	100.00	0.572	100.00	0.720	100.00	1.139	100.00	0.711	100.00
19	1.869	100.00	1.440	100.00	1.282	100.00	1.817	100.00	1.561	100.00
20	0.784	100.00	0.642	100.00	0.706	100.00	0.585	100.00	0.895	100.00
21	1.370	100.00	0.854	100.00	0.810	100.00	1.211	100.00	1.088	100.00
22	0.995	100.00	0.737	100.00	0.719	100.00	0.854	100.00	0.946	100.00
23	2.076	100.00	1.666	100.00	1.899	100.00	2.284	100.00	2.193	100.00
24	0.695	100.00	0.842	100.00	0.838	100.00	0.734	100.00	1.342	100.00
25	0.764	100.00	0.369	100.00	0.617	100.00	0.346	100.00	0.810	100.00
26	0.674	100.00	0.957	100.00	0.859	100.00	0.839	100.00	1.150	100.00
27	0.695	100.00	0.618	100.00	0.572	100.00	0.546	100.00	0.673	100.00
28	0.989	100.00	0.388	100.00	0.548	100.00	0.667	100.00	1.001	100.00
29	0.542	100.00	0.880	100.00	0.637	100.00	0.502	100.00	0.763	100.00
30	0.904	100.00	0.897	100.00	0.779	100.00	0.462	100.00	0.763	100.00
31	-	-	-	-	-	-	-	-	-	-

Table 6-4 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Los Angeles		Salt Lake City		Miami		Minneapolis		Atlanta		Juneau	
SV ↓	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	0.791	100.00	1.086	100.00	0.448	100.00	1.142	100.00	0.491	100.00	0.633	100.00
2	1.042	100.00	1.145	100.00	0.998	100.00	0.475	100.00	0.833	100.00	1.038	100.00
3	0.516	100.00	0.772	100.00	0.559	100.00	1.232	100.00	0.494	100.00	0.563	100.00
4	1.137	100.00	1.364	100.00	1.136	100.00	1.594	100.00	0.754	100.00	0.682	100.00
5	0.456	100.00	0.821	100.00	0.473	100.00	0.832	100.00	0.454	100.00	0.406	100.00
6	0.962	100.00	1.170	100.00	0.931	100.00	1.675	100.00	0.774	100.00	0.795	100.00
7	0.577	100.00	0.788	100.00	0.524	100.00	0.942	100.00	0.376	100.00	0.365	100.00
8	0.409	100.00	0.968	100.00	0.748	100.00	1.330	100.00	0.484	100.00	0.559	100.00
9	0.542	100.00	0.833	100.00	0.545	100.00	1.271	100.00	0.597	100.00	0.689	100.00
10	0.749	100.00	0.618	100.00	0.400	100.00	0.588	100.00	0.308	100.00	0.564	100.00
11	0.623	100.00	0.582	100.00	0.869	100.00	0.783	100.00	0.413	100.00	0.402	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.570	100.00	0.823	100.00	0.863	100.00	1.186	100.00	0.520	100.00	0.806	100.00
14	0.461	100.00	0.759	100.00	1.325	100.00	0.616	100.00	0.402	100.00	0.491	100.00
15	0.408	100.00	0.937	100.00	0.580	100.00	1.188	100.00	0.272	100.00	0.360	100.00
16	0.646	100.00	0.626	100.00	0.496	100.00	0.944	100.00	0.438	100.00	0.520	100.00
17	0.907	100.00	1.141	100.00	1.468	100.00	1.256	100.00	0.638	100.00	0.660	100.00
18	0.429	100.00	0.858	100.00	0.789	100.00	0.590	100.00	0.582	100.00	0.699	100.00
19	1.517	100.00	1.478	100.00	1.373	100.00	0.912	100.00	1.471	100.00	1.645	100.00
20	0.951	100.00	0.708	100.00	0.574	100.00	0.535	100.00	0.604	100.00	0.622	100.00
21	0.769	100.00	0.875	100.00	1.195	100.00	0.457	100.00	0.846	100.00	0.898	100.00
22	0.687	100.00	0.835	100.00	1.536	100.00	0.547	100.00	0.701	100.00	0.734	100.00
23	1.583	100.00	1.891	100.00	1.913	100.00	1.172	100.00	1.698	100.00	1.519	100.00
24	0.680	100.00	1.286	100.00	1.255	100.00	1.699	100.00	0.834	100.00	0.828	100.00
25	0.861	100.00	1.213	100.00	0.753	100.00	1.297	100.00	0.552	100.00	0.662	100.00
26	0.686	100.00	1.222	100.00	0.994	100.00	1.706	100.00	0.877	100.00	0.935	100.00
27	0.555	100.00	1.119	100.00	0.744	100.00	1.403	100.00	0.459	100.00	0.694	100.00
28	0.674	100.00	0.709	100.00	0.991	100.00	0.539	100.00	0.527	100.00	0.603	100.00
29	0.694	100.00	1.123	100.00	0.757	100.00	1.397	100.00	0.697	100.00	0.757	100.00
30	1.073	100.00	1.123	100.00	0.925	100.00	1.330	100.00	0.805	100.00	0.876	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-

Figure 6-1 95% Range Error (SV 1 --SV 16) - Washington, DC

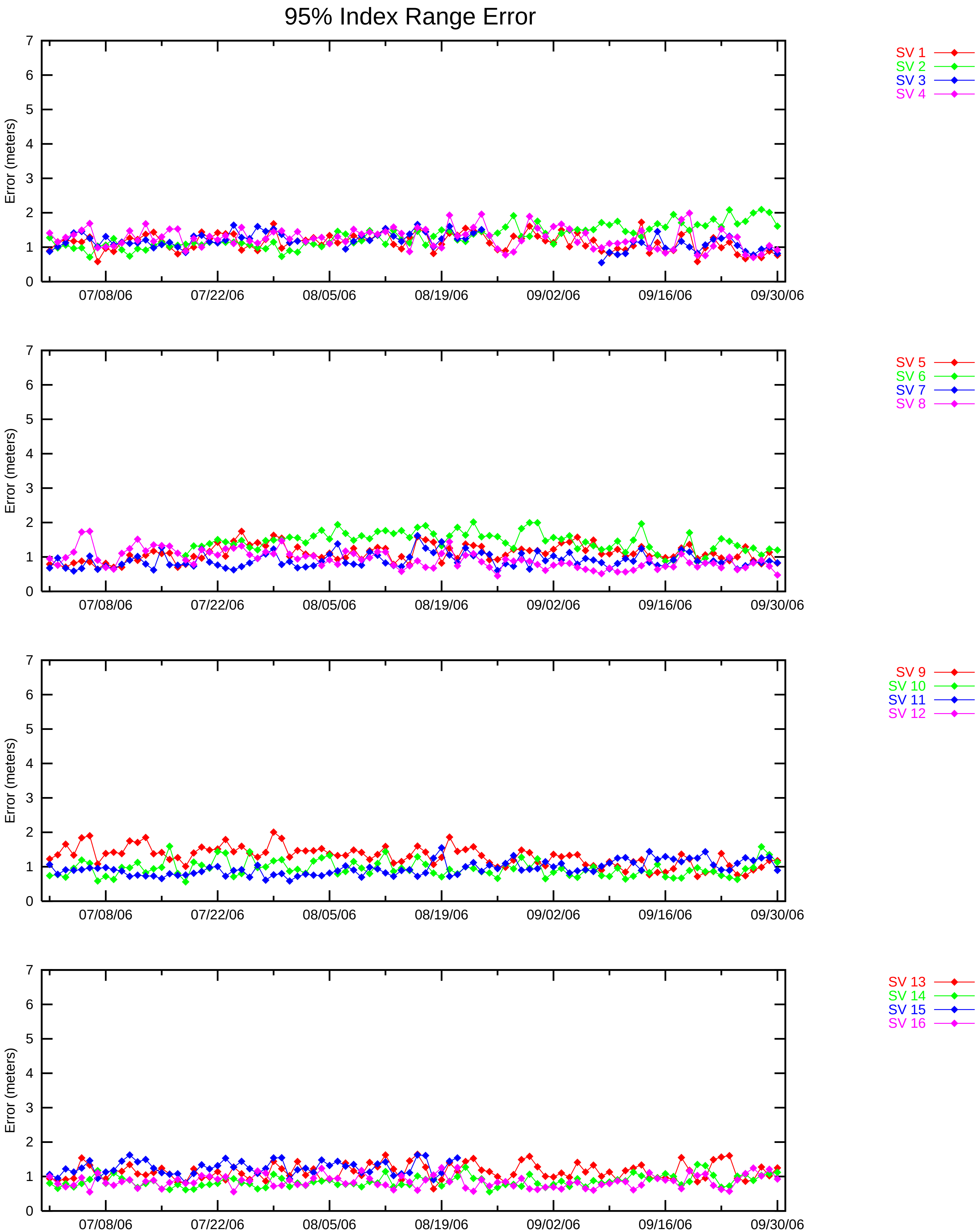


Figure 6-2 95% Range Error (SV 17 --SV 31 and SV 122) - Washington, DC

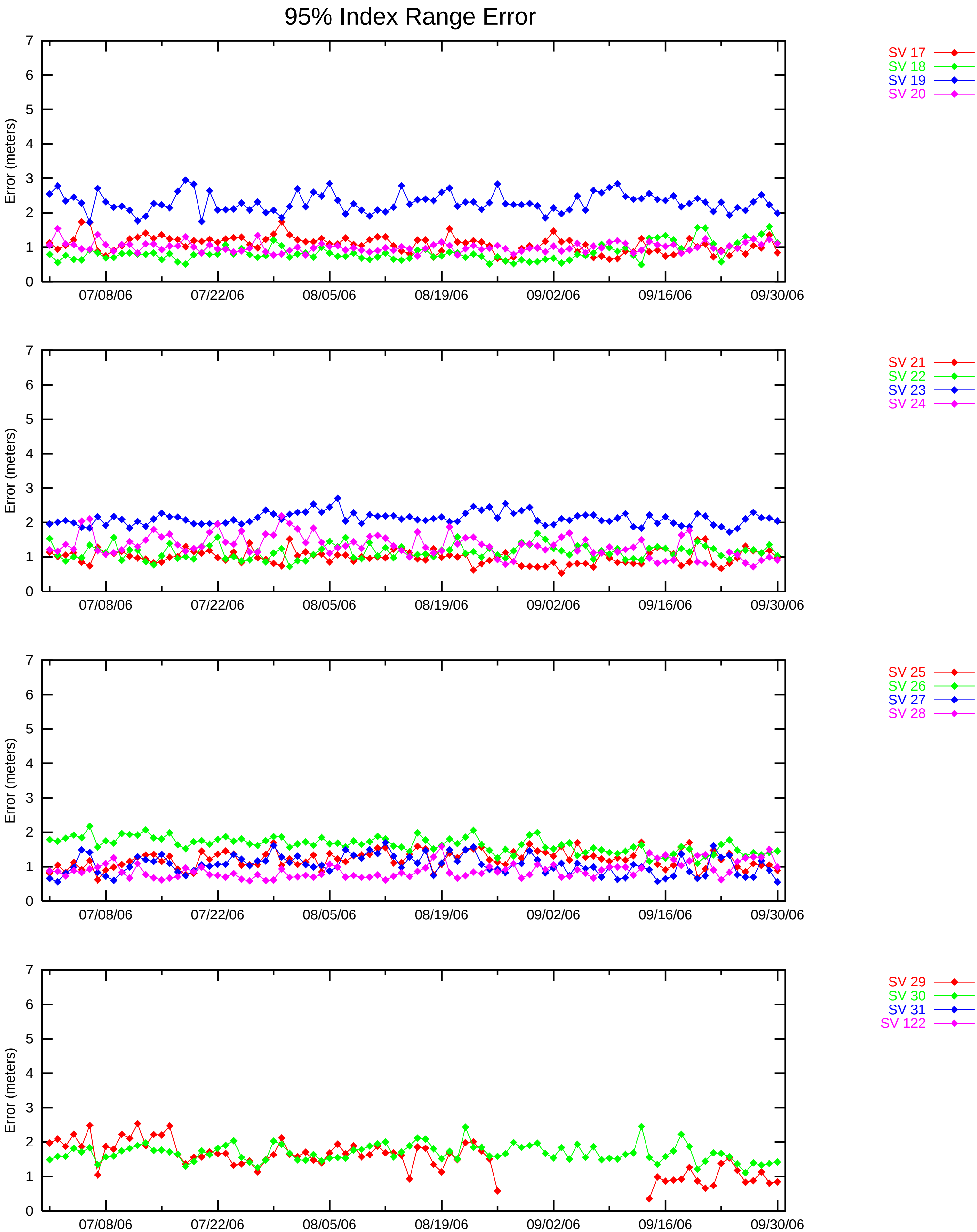


Figure 6-3 95% Ionospheric Error (SV 1 --SV 16) - Washington, DC

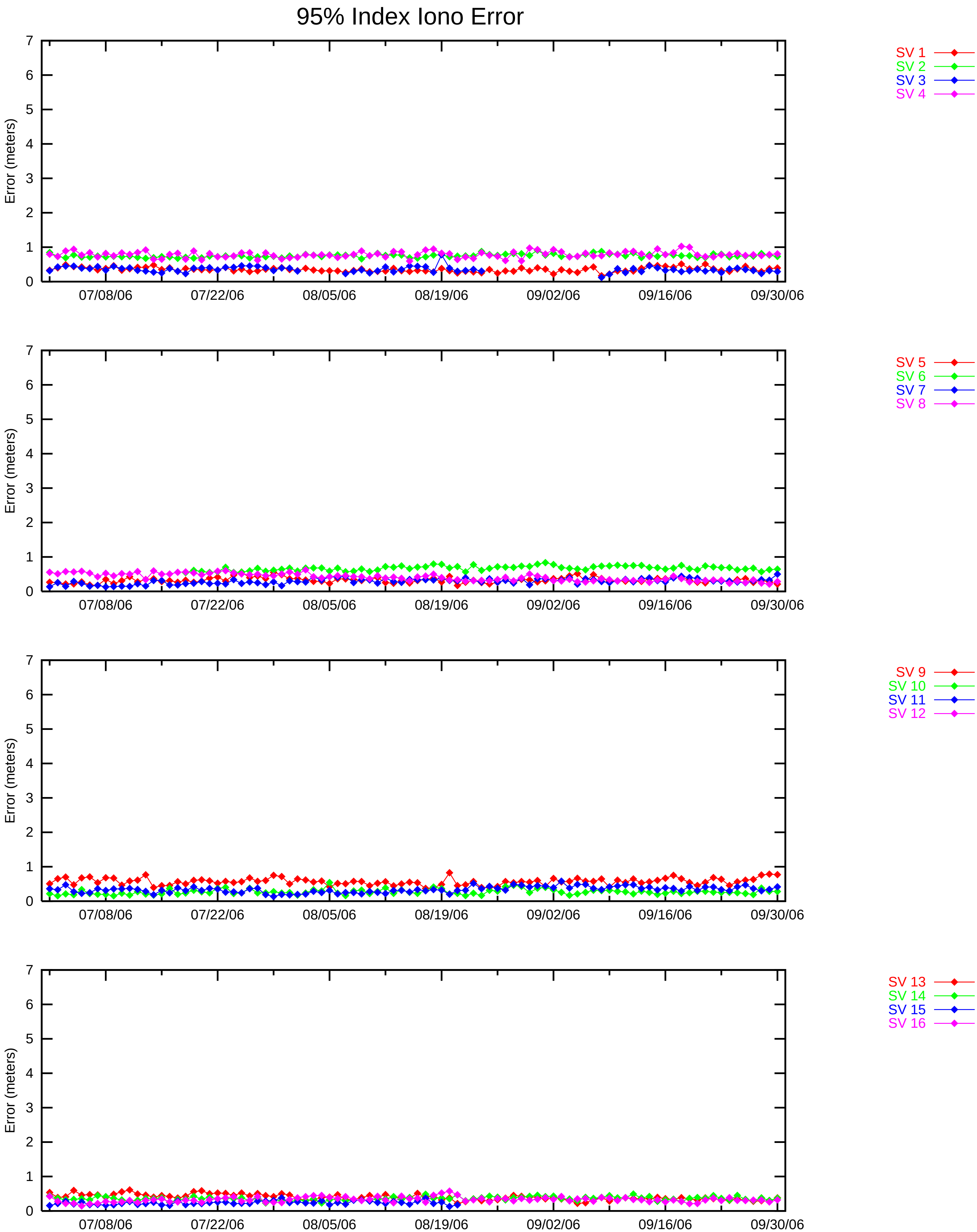
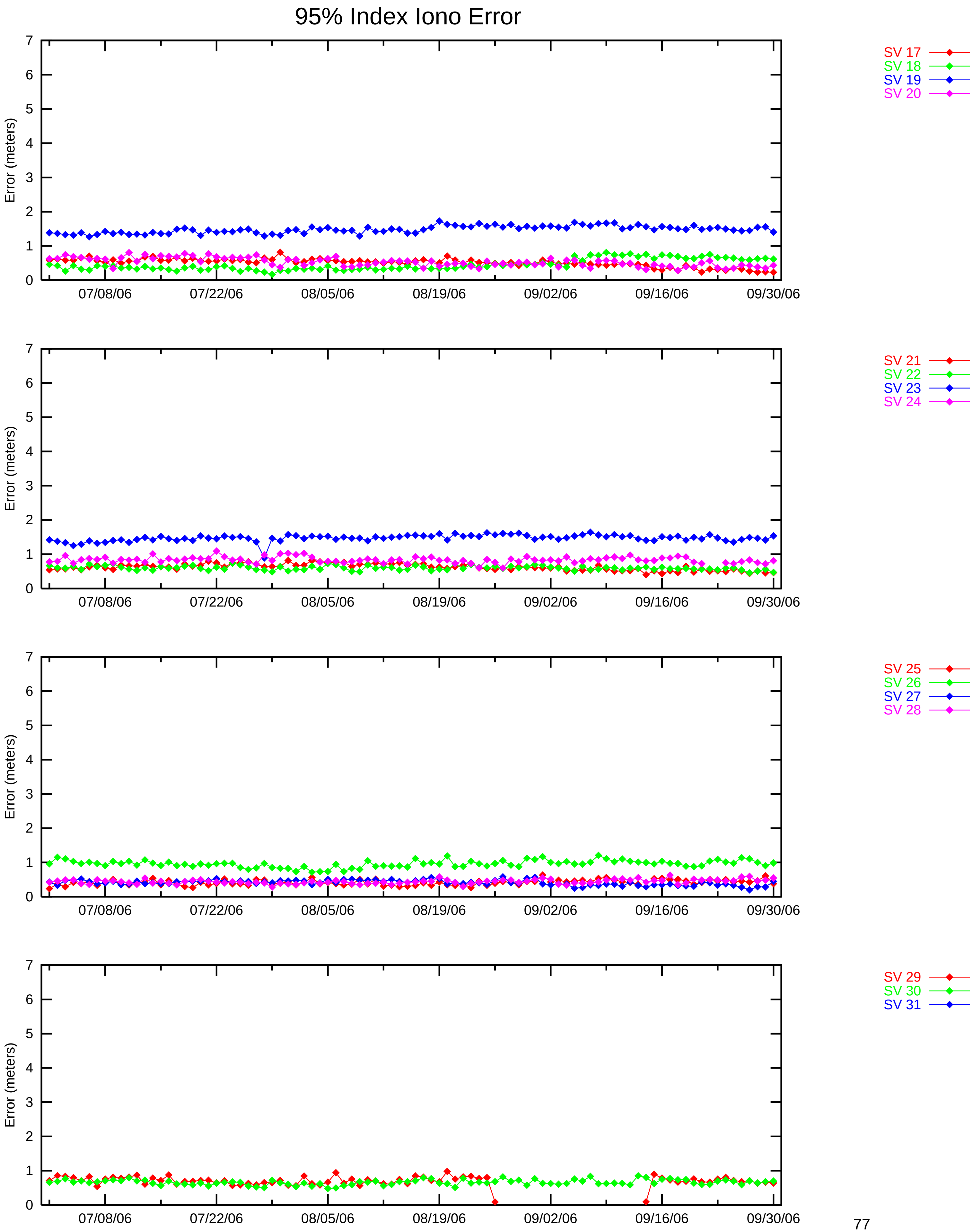


Figure 6-4 95% Ionospheric Error (SV 17 --SV 31) - Washington, DC



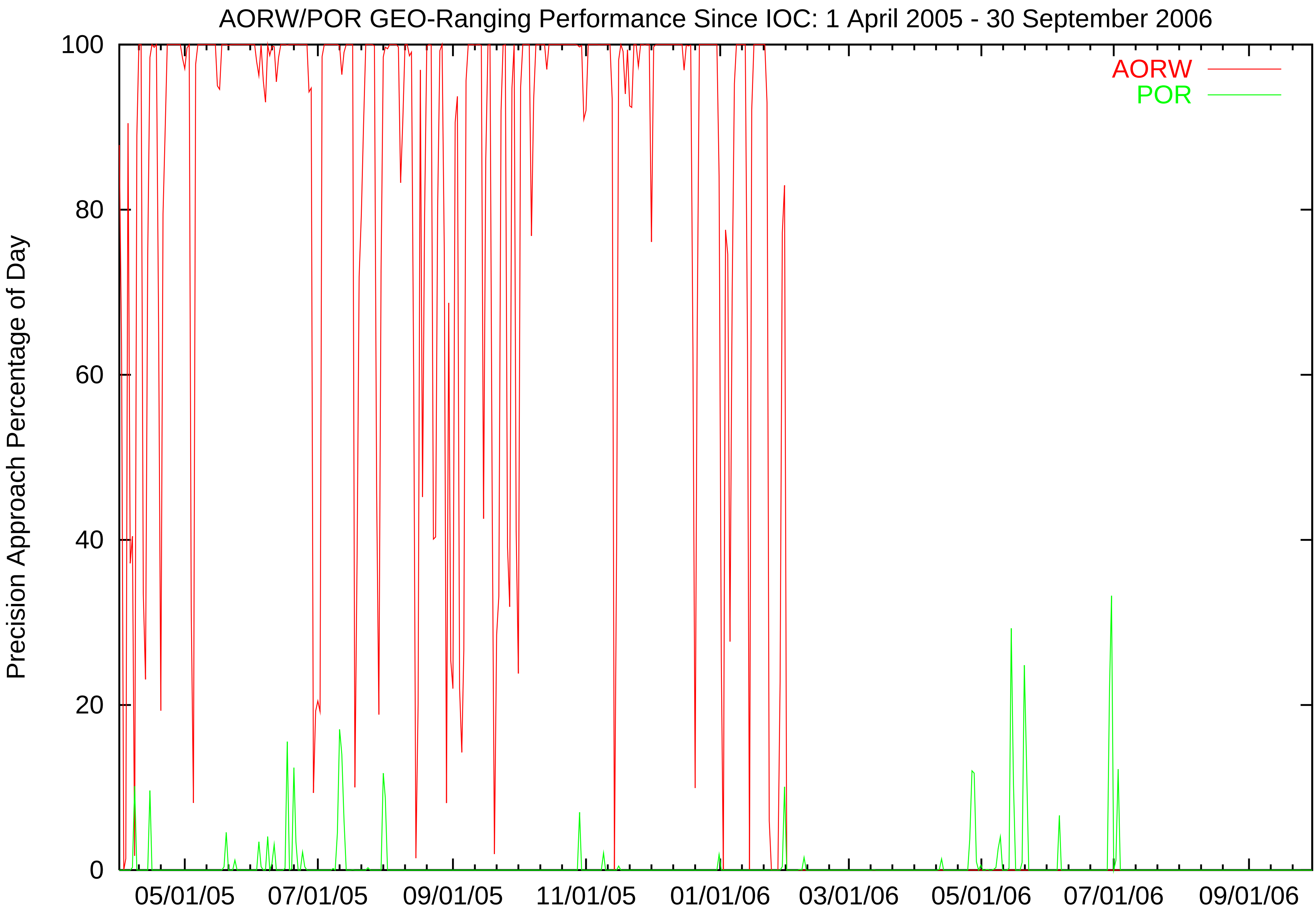
7.0 GEO RANGING PERFORMANCE

Table 7.1 shows the GEO-Ranging performance for AORW and POR satellites throughout the evaluated period. The percentage of PA ranging availability (i.e. the percentage of time a user receiver can use the GEO as a ranging source in a LNAV/VNAV or LPV position solution) for the AORW and POR is 0% and 0.146%, respectively. Figure 7.1 shows the trend of PA Ranging Availability for the AORW and POR satellite. The AOR-W GEO was unavailable for PA ranging this quarter as expected. The reason is the AOR-W GEO was repositioned to its new location and was not available. As in the past, the POR satellite as a ranging source has very low PA availability.

Table 7-1 GEO Ranging Availability

GEO	PA (%)	NPA (%)	Not Monitored (%)	Do Not Use (%)
AORW	0	0	99.398	0.600
POR	0.146	95.998	3.106	0.748

Figure 7-1 Daily PA GEO Ranging Availability Trend



8.0 WAAS PROBLEM SUMMARY

During this period, there are no significant events that affected WAAS service.

9.0 WAAS AIRPORT AVAILABILITY

The WAAS airport availability evaluation determines the number and length LVP service outages at selected airports from the transmitted WAAS navigation message. The navigation messages transmitted from both AORW and POR GEO satellites are processed simultaneously, and WAAS protection levels (VPL and HPL) are computed at each airport once a second in accordance with the WAAS MOPS. Once the protection levels have been produced at each airport an LPV service evaluation is conducted to identify outages in service (i.e. when protection levels exceed alert limits). WAAS LPV service is available for a user when the vertical protection level (VPL) is less than or equal to vertical alert limit (VAL) of 50 meters and the horizontal protection level (HPL) is less than or equal to horizontal alert limit (HAL) of 40 meters. If both conditions are met at a specified airport location then WAAS LPV service is available at that airport. If either one of the conditions are not met at a specified airport location then WAAS LPV service at that airport is unavailable and an outage in LPV service is recorded with its duration. When the LPV service becomes unavailable it is not considered available again until protection levels are below or equal to alert limits for at least 15 minutes. Although this will reduce LPV service availability minimally, it substantially reduces the number of service outages and prevents excessive switching in and out of service availability. When computing LPV service availability an extra two minutes of outage time was prefixed to each outage. The number of WAAS LPV service outages and the availability at selected airports for the period from June 20, 2006 to September 30, 2006 of WAAS operation is presented in Table 9.1. Figures 9.1 and 9.2 provide a graphical representation of WAAS LPV service availability and outage counts for the same period, respectively.

Table 9-1 WAAS LPV Outages and Availability

Airport Id	Airport Name	City	State	Outages	Availability
YEG	EDMONTON INTL	EDMONTON	AB	112	0.983837
CGA	CRAIG	CRAIG	AK	70	0.989969
HYD	HKDER	HKDER	AK	70	0.989976
JNU	JUNEAU INTL AIRPORT	JUNEAU	AK	252	0.957515
KTN	KETCHIKAN AIRPORT	KETCHIKAN	AK	66	0.990940
PEC	PELICAN	PELICAN	AK	230	0.963421
PSG	PETERSBURG MUNICIPAL	PETERSBURG	AK	155	0.983097
SIT	SITKA AIRPORT	SITKA	AK	185	0.976625
EET	SHELBY COUNTY	ALABASTER	AL	9	0.999715
79J	ANDALUSIA-OPP	ANDALUSIA/OP	AL	9	0.999715
KBHM	BIRMINGHAM INTL	BIRMINGHAM	AL	9	0.999715
KDHN	DOTHAN REGIONAL	DOTHAN	AL	9	0.999711
HSV	HUNTSVILLE INTL – CARL T JONES FIELD	HUNTSVILLE	AL	9	0.999715
MOB	MOBILE REGIONAL	MOBILE	AL	9	0.999688
MGM	MONTGOMERY REGIONAL/ DANNELLY FIELD	MONTGOMERY	AL	9	0.999715
MSL	MUSCLE SHOALS NORTWEST ALABAMA REGIONAL	SHEFFIELD	AL	9	0.999688
M73	ALMYRA	ALMYRA	AR	12	0.999623
KVBT	BENTONVILLE MUNICIPAL/ LM THADDEN FIELD	BENTONVILLE	AR	13	0.999619
BYH	BLYTHEVILLE	BLYTHEVILLE	AR	11	0.999660
CDH	HARRELL FIELD	CAMDEN	AR	11	0.999638
KXNA	NORTHWEST ARKANSAS REGIONAL	FAYETTEVILLE/SPRINGDALE /ROGERS	AR	13	0.999619
KFSM	FORT SMITH REGIONAL	FORT SMITH	AR	12	0.999644
HRO	BOONE COUNTY AIRPORT	HARRISON	AR	12	0.999630
LIT	ADAMS FIELD	LITTLE ROCK	AR	12	0.999593
SRC	SEARCY MUNICIPAL	SEARCY	AR	12	0.999598
ASG	SPRINGDALE MUNICIPAL	SPRINGDALE	AR	13	0.999619

KARG	WALNUT RIDGE REGIONAL	WALNUT RIDGE	AR	12	0.999623
IFP	LAUGHLIN/BULLHEAD INTL	BULLHEAD CITY	AZ	121	0.975038
KGCN	GRAND CANYON NATL PARK	GRAND CANYON	AZ	95	0.984395
KPHX	PHOENIX SKY HARBOR INTL	PHOENIX	AZ	104	0.971679
KPRC	ERNEST A LOVE FIELD	PRESCOTT	AZ	99	0.977476
KTUS	TUCSON INTL	TUCSON	AZ	292	0.950635
RQE	WINDOW ROCK	WINDOW ROCK	AZ	112	0.990414
BFL	BAKERSFIELD/MEADOWS FIELD	BAKERSFIELD	CA	203	0.952439
KCRQ	MC CLELLAN-PALOMAR	CARLSBAD	CA	339	0.919250
O60	CLOVERDALE MUNICIPAL	CLOVERDALE	CA	189	0.970048
KDAG	BARSTOW-DAGGETT	DAGGETT	CA	185	0.964212
IYK	INYOKERN	INYOKERN	CA	209	0.966420
KLAX	LOS ANGELES INTL	LOS ANGELES	CA	304	0.932389
KOAK	METROPOLITAN OAKLAND INTL	OAKLAND	CA	213	0.967366
ONT	ONTARIO INTL	ONTARIO	CA	239	0.947286
KPMD	PALMDALE PROD FLT/ TEST INSTLN	PALMDALE	CA	207	0.951638
KMHR	SACRAMENTO MATHER	SACRAMENTO	CA	126	0.981757
KSMF	SACRAMENTO INTL	SACRAMENTO	CA	125	0.980886
SAN	SAN DIEGO INTL – LINDBERGH FIELD	SAN DIEGO	CA	440	0.900259
KSFO	SAN FRANCISCO INTL	SAN FRANCISCO	CA	269	0.962366
SJC	SAN JOSE INTL	SAN JOSE	CA	248	0.964409
SVE	SUSANVILLE MUNICIPAL	SUSANVILLE	CA	111	0.993566
TNP	TWENTYNINE PALMS	TWENTYNINE PALMS	CA	186	0.961723
AKO	AKRON-COLORADO PLAINS REGIONAL	AKRON	CO	11	0.999650
COS	COLORADO SPRINGS	COLORADO SPRINGS	CO	13	0.999465
CEZ	CORTEZ MUNICIPAL	CORTEZ	CO	50	0.995956
KDEN	DENVER INTL	DENVER	CO	12	0.999485
HDN	YAMPA VALLEY	HAYDEN	CO	27	0.998808
LHX	LA JUNTA MUNICIPAL	LA JUNTA	CO	13	0.999480
LAA	LAMAR MUNICIPAL	LAMAR	CO	13	0.999523
2V2	VANCE BRAND	LONGMONT	CO	13	0.999473
EEO	MEEKER	MEEKER	CO	29	0.997947
TAD	PERRY STOKES	TRINIDAD	CO	28	0.998557
2V5	WRAY	WRAY	CO	12	0.999544
KBDL	BRADLEY INTL	WINDSOR LOCKS	CT	246	0.983165
KDCA	RONALD REAGAN WASHINGTON INTL	WASHINGTON	DC	12	0.999647
KIAD	WASHINGTON DULLES INTL	WASHINGTON	DC	11	0.999668
KFLL	FORT LAUDERDALE/ HOLLYWOOD INTL	FORT LAUDERDALE	FL	170	0.992161
FXE	FORT LAUDERDALE EXECUTIVE AIRPORT	FORT LAUDERDALE	FL	158	0.993173
KRSW	SOUTHWEST FLORIDA INTL	FORT MYERS	FL	71	0.997159
KGNV	GAINESVILLE REGIONAL	GAINESVILLE	FL	17	0.999494
KJAX	JACKSONVILLE INTL	JACKSONVILLE	FL	15	0.999593
KMIA	MIAMI INTL	MIAMI	FL	200	0.989661
KAPF	NAPLES MUNICIPAL	NAPLES	FL	105	0.995103
KOCF	OCALA INTL-JIM TAYLOR FIELD	OCALA	FL	22	0.999327
KMCO	ORLANDO INTL	ORLANDO	FL	32	0.998933
KPFN	PANAMA CITY-BAY COUNTY INTL	PANAMA CITY	FL	8	0.999726
KPNS	PENSACOLA REGIONAL	PENSACOLA	FL	10	0.999672

SRQ	SARASOTA/BRADENTON INTL	SARASOTA/BRADENTON	FL	36	0.998660
KPIE	ST PETERSBURG – CLEARWATER INTL	ST PETERSBURG-CLEARWATER	FL	33	0.998887
KTLH	TALLAHASSEE REGIONAL	TALLAHASSEE	FL	10	0.999692
TPA	TAMPA INTL	TAMPA	FL	32	0.998903
KVRB	VERO BEACH MUNICIPAL	VERO BEACH	FL	43	0.998562
KPBI	PALM BEACH INTL	WEST PALM BEACH	FL	72	0.997282
KACJ	SOUTHER FIELD	AMERICUS	GA	8	0.999726
KATL	WILLIAM B HARTSFIELD ATLANTA INTL	ATLANTA	GA	8	0.999726
KSAV	SAVANNAH INTL	SAVANNAH	GA	10	0.999685
KTBR	STATESBORO-BULLOCH COUNTY	STATESBORO	GA	9	0.999704
KIKV	ANKENY REGIONAL	ANKENY	IA	16	0.999433
CID	THE EASTERN IOWA	CEDAR RAPIDS	IA	15	0.999466
DSM	DES MOINES INTL	DES MOINES	IA	16	0.999435
KMXO	MONTICELLO REGIONAL	MONTICELLO	IA	13	0.999543
KBOI	BOISE AIR TERMINAL/ GOWEN FIELD	BOISE	ID	4	0.999889
EUL	CALDWELL INDUSTRIAL	CALDWELL	ID	5	0.999881
SUN	FRIEDMAN MEMORIAL	HAILEY	ID	3	0.999931
PIH	POCATELLO REGIONAL	POCATELLO	ID	18	0.998827
SZT	SANDPOINT	SANDPOINT	ID	10	0.999505
KENL	CENTRALIA MUNICIPAL	CENTRALIA	IL	11	0.999676
KORD	CHICAGO-O'HARE INTL	CHICAGO	IL	11	0.999609
MDW	CHICAGO MIDWAY	CHICAGO	IL	11	0.999618
KARR	AURORA MUNICIPAL	CHICAGO/AURORA	IL	11	0.999624
KFOA	FLORA MUNICIPAL	FLORA	IL	10	0.999700
MLI	QUAD-CITY	MOLINE	IL	13	0.999574
KPIA	GREATER PEORIA REGIONAL	PEORIA	IL	11	0.999683
KPPQ	PITTSFIELD PENSTONE MUNICIPAL	PITTSFIELD	IL	13	0.999573
KTIP	RANTOUL NATL AVN CTR/ FRANK ELLIOT FIELD	RANTOUL	IL	11	0.999683
KRFD	GREATER ROCKFORD	ROCKFORD	IL	12	0.999606
KSLO	SALEM-LECKRONE	SALEM	IL	11	0.999678
3CK	LAKE IN THE HILLS	UNKNOWN	IL	11	0.999607
KANQ	TRI-STATE STEUBEN COUNTY	ANGOLA	IN	11	0.999678
KBMG	MONROE COUNTY	BLOOMINGTON	IN	9	0.999715
0I2	BRAZIL CLAY COUNTY	BRAZIL	IN	9	0.999715
CEV	METTEL FIELD	CONNERSVILLE	IN	10	0.999694
FWA	FORT WAYNE INTL	FORT WAYNE	IN	11	0.999678
KIND	INDIANAPOLIS INTL	INDIANAPOLIS	IN	11	0.999683
SER	FREEMAN MUNICIPAL	SEYMOUR	IN	9	0.999715
SBN	MICHIANA REGIONAL TRANSPORTATION CTR	SOUTH BEND	IN	12	0.999648
KCBK	SHALTZ FIELD	COLBY	KS	11	0.999650
EHA	ELKHART-MORTON COUNTY	ELKHART	KS	12	0.999535
GLD	RENNER FIELD/ GOODLAND MUNICIPAL	GOODLAND	KS	11	0.999650
KHYS	HAYS REGIONAL	HAYS	KS	13	0.999501
LWC	LAWRENCE MUNICIPAL	LAWRENCE	KS	14	0.999495
KMHK	MANHATTAN REGIONAL	MANHATTAN	KS	14	0.999484
KOJC	JOHNSON COUNTY EXECUTIVE	OLATHE	KS	14	0.999493
TOP	PHILIP BILLARD MUNICIPAL	TOPEKA	KS	14	0.999496

KULS	ULYSSES	ULYSSES	KS	11	0.999650
ICT	WICHITA MID-CONTINENT	WICHITA	KS	13	0.999504
KWLD	STROTHER FIELD	WINFIELD/ARKANSAS CITY	KS	13	0.999504
KCVG	CINCINNATI/NORTHERN KY INTL	COVINGTON/CINCINNATI	KY	10	0.999694
KLEX	BLUE GRASS	LEXINGTON	KY	8	0.999726
LOZ	LONDON	LONDON	KY	9	0.999709
SDF	LOUISVILLE INTL – STANDIFORD FIELD	LOUISVILLE	KY	9	0.999711
KK22	BIG SANDY REGIONAL	PRESTONBURG	KY	11	0.999679
SME	SOMERSET-PULASKI COUNTY	SOMERSET	KY	8	0.999726
KAEX	ALEXANDRIA INTL	ALEXANDRIA	LA	12	0.999610
DRI	DE RIDDER/ BEAUREGARD PAIRISH APT	BEAUREGARD	LA	13	0.999531
LCH	LAKE CHARLES REGIONAL	LAKE CHARLES	LA	14	0.999526
L39	LEESVILLE	LEESVILLE	LA	12	0.999547
MSY	NEW ORLEANS INTL/ MOISANT FIELD	NEW ORLEANS	LA	9	0.999688
SHV	SHREVEPORT REGIONAL	SHREVEPORT	LA	12	0.999627
KBOS	GEN EDWARD LAWRENCE LOGAN INTL	BOSTON	MA	307	0.953356
MVY	VINEYARD HAVEN	MARTHA'S VINEYARD	MA	365	0.961413
OWD	NORWOOD MEMORIAL	NORWOOD	MA	299	0.958327
YWG	WINNIPEG AIRPORT	WINNIPEG	MB	404	0.944339
KBWI	BALTIMORE-WASHINGTON INTL	BALTIMORE	MD	13	0.999578
FDK	FREDERICK MUNICIPAL	FREDERICK	MD	11	0.999667
GAI	MONTGOMERY COUNTY AIRPARK	GAITHERSBURG	MD	12	0.999643
W00	FREEWAY	MITCHELLVILLE	MD	12	0.999610
RJD	RIDGELY AIRPARK	RIDGELY	MD	17	0.999495
DMW	CARROLL COUNTY REGIONAL/ JACK B. POAGE FIELD	WESTMINSTER	MD	12	0.999638
AMN	ALMA/GRATIOT COMMUNITY	ALMA	MI	12	0.999663
KARB	ANN ARBOR MUNICIPAL	ANN ARBOR	MI	10	0.999696
Y15	CHEBOYGAN COUNTY	CHEBOYGAN	MI	55	0.996887
KDTW	DETROIT METROPOLITAN WAYNE COUNTY	DETROIT	MI	10	0.999696
KFNT	BISHOP INTL	FLINT	MI	12	0.999663
KGRR	GERALD R FORD INTL	GRAND RAPIDS	MI	12	0.999645
KCMX	HOUGHTON COUNTY MEMORIAL	HANCOCK	MI	148	0.972711
BIV	TULIP CITY	HOLLAND	MI	12	0.999637
HTL	ROSCOMMON COUNTY	HOUGHTON LAKE	MI	13	0.999647
KMKG	MUSKEGON COUNTY	MUSKEGON	MI	12	0.999628
5D3	OWOSSO COMMUNITY	OWOSSO	MI	12	0.999663
KMBS	MBS INTL	SAGINAW	MI	12	0.999662
CIU	CHIPPEWA COUNTY INTL	SAULT STE. MARIE	MI	122	0.983877
HAI	THREE RIVERS MUNI DR. HAINES	UNKNOWN	MI	12	0.999651
HYX	SAGINAW CO H.W. BROWNE	UNKNOWN	MI	12	0.999663
KAXN	CHANDLER FIELD	ALEXANDRIA	MN	59	0.995628
KBDE	BAUDETTE INTL	BAUDETTE	MN	208	0.969138
KBRD	BRAINERD – CROW WING CO REGIONAL	BRAINERD	MN	80	0.990488
KDLH	DULUTH INTL	DULUTH	MN	113	0.984049
KMSP	MINNEAPOLIS-ST PAUL INTL/ WOLD CHAMBERLAIN	MINNEAPOLIS	MN	16	0.999409

KRGK	RED WING REGIONAL	RED WING	MN	15	0.999423
KRST	ROCHESTER INTL	ROCHESTER	MN	14	0.999450
STC	ST. CLOUD	SAINT CLOUD	MN	38	0.998367
KJYG	ST JAMES MUNICIPAL	ST JAMES	MN	15	0.999376
M05	CARUTHERSVILLE MEMORIAL	CARUTHERSVILLE	MO	10	0.999672
KMCI	KANSAS CITY INTL	KANSAS CITY	MO	14	0.999492
KLBO	FLOYD W JONES LEBANON	LEBANON	MO	13	0.999559
LXT	LEE'S SUMMIT MUNICIPAL	LEE'S SUMMIT	MO	14	0.999491
H41	MEXICO MEMORIAL	MEXICO	MO	13	0.999495
MYJ	MEXICO MEMORIAL	MEXICO	MO	13	0.999495
STJ	ROSECRANS MEMORIAL	ROSECRANS	MO	15	0.999476
KDMO	SEDALIA MEMORIAL	SEDALIA	MO	16	0.999445
SGF	SPRINGFIELD – BRANSON REGIONAL	SPRINGFIELD	MO	13	0.999614
KSTL	LAMBERT-ST LOUIS INTL	ST LOUIS	MO	9	0.999717
KMO6	WASHINGTON MEMORIAL	WASHINGTON	MO	11	0.999653
0M6	PANOLA COUNTY	BATESVILLE	MS	9	0.999692
GWO	GREENWOOD-LEFLORE	GREENWOOD	MS	9	0.999691
JAN	JACKSON INTL	JACKSON	MS	9	0.999688
MPE	PHILADELPHIA MUNICIPAL	PHILADELPHIA	MS	9	0.999688
CRX	ROSCOE TURNER	UNKNOWN	MS	9	0.999688
KBIL	BILLINGS LOGAN INTL	BILLINGS	MT	16	0.999388
6S5	RAVALLI COUNTY	HAMILTON	MT	3	0.999899
KHLN	HELENA REGIONAL	HELENA	MT	10	0.999624
KLWT	LEWISTOWN MUNICIPAL	LEWISTOWN	MT	18	0.999287
KMLS	FRANK WILEY FIELD	MILES CITY	MT	24	0.998949
KHBI	ASHEBORO MUNICIPAL	ASHEBORO	NC	9	0.999702
KAVL	ASHEVILLE REGIONAL	ASHEVILLE	NC	10	0.999694
MRH	MICHAEL J. SMITH FIELD	BEAUFORT	NC	28	0.999252
KCLT	CHARLOTTE/DOUGLAS INTL	CHARLOTTE	NC	10	0.999686
ECG	ELIZABETH CITY CGAS	ELIZABETH CITY	NC	23	0.999299
KFAY	FAYETTEVILLE REGIONAL/ GRANNIS FIELD	FAYETTEVILLE	NC	10	0.999679
GSO	PIEDMONT TRIAD INTL	GREENSBORO	NC	10	0.999687
PGV	PITT-GREENVILLE	GREENVILLE	NC	17	0.999548
HSE	BILLY MITCHELL	HATTERAS	NC	43	0.998621
HKY	HICKORY REGIONAL	HICKORY	NC	10	0.999686
KISO	KINSTON REGIONAL JETPORT AT STALLINGS FIELD	KINSTON	NC	17	0.999548
MEB	LAURINBURG	MAXTON	NC	9	0.999700
KEQY	MONROE	MONROE	NC	10	0.999686
KRDU	RALEIGH-DURHAM INTL	RALEIGH/DURHAM	NC	10	0.999687
RWI	ROCKY MOUNT – WILSON REGIONAL	ROCKY MOUNT	NC	11	0.999665
KRUQ	ROWAN COUNTY	SALISBURY	NC	10	0.999686
KTTA	SANFORD – LEE COUNTY REGIONAL	SANFORD	NC	9	0.999702
SUT	BRUNSWICK COUNTY	SOUTHPORT	NC	17	0.999497
OCW	WARREN FIELD	WASHINGTON	NC	20	0.999474
MCZ	MARTIN COUNTY	WILLIAMSTON	NC	19	0.999513
KILM	WILMINGTON INTL	WILMINGTON	NC	18	0.999488
W03	WILSON INDUSTRIAL AIR CTR	WILSON	NC	11	0.999665
KFAR	HECTOR INTL	FARGO	ND	76	0.991592
MOT	MINOT INTL AIRPORT	MINOT	ND	113	0.991353

KANW	AINSWORTH MUNICIPAL	AINSWORTH	NE	13	0.999361
AUH	AURORA MUNICIPAL	AURORA	NE	14	0.999457
BIE	BEATRICE MUNICIPAL	BEATRICE	NE	14	0.999474
CSB	CAMBRIDGE MUNICIPAL	CAMBRIDGE	NE	13	0.999506
CEK	CRETE MUNICIPAL	CRETE	NE	14	0.999473
GRN	GORDON MUNICIPAL	GORDON	NE	13	0.999413
KEAR	KEARNEY MUNICIPAL	KEARNEY	NE	13	0.999475
KLBF	NORTH PLATTE REGIONAL LEE BIRD FIELD	NORTH PLATTE	NE	13	0.999487
OMA	EPPLEY AIRFIELD	OMAHA	NE	15	0.999433
OKS	GARDEN COUNTY	OSHKOSH	NE	13	0.999504
SCB	SCRIBNER STATE	SCRIBNER	NE	14	0.999431
SNY	SIDNEY MUNICIPAL	SIDNEY	NE	12	0.999536
VTN	MILLER FIELD	VALENTINE	NE	13	0.999358
MHT	MANCHESTER	MANCHESTER	NH	316	0.951229
KACY	ATLANTIC CITY INTL	ATLANTIC CITY	NJ	36	0.998937
KMMU	MORRISTOWN MUNICIPAL	MORRISTOWN	NJ	52	0.997757
KEWR	NEWARK INTL	NEWARK	NJ	57	0.997610
7N7	SPITFIRE AERODROM	PEDRICTOWN	NJ	24	0.999332
K3NJ6	INDUCTOTHERM HELIPORT	RANCOCAS	NJ	33	0.999000
KABQ	ALBUQUERQUE INTL SUNPORT	ALBUQUERQUE	NM	80	0.993782
KFMN	FOUR CORNERS REGIONAL	FARMINGTON	NM	77	0.994767
KLRU	LAS CRUCES INTL	LAS CRUCES	NM	132	0.985011
ELY	ELY AIRPORT/YELLAND FELD	ELY	NV	91	0.991242
KLAS	MC CARRAN INTL	LAS VEGAS	NV	108	0.980837
ALB	ALBANY INTL	ALBANY	NY	236	0.986771
BUF	BUFFALO NIAGARA INTL	BUFFALO	NY	12	0.999618
KELM	ELMIRA/CORNING REGIONAL	ELMIRA	NY	31	0.998869
LGA	LA GUARDIA	FLUSHING	NY	79	0.996951
GFL	FLOYD BENNETT MEMORIAL	GLENS FALLS	NY	262	0.979502
KJHW	CHAUTAUQUA COUNTY/ JAMESTOWN	JAMESTOWN	NY	11	0.999660
LKP	LAKE PLACID	LAKE PLACID	NY	351	0.969067
KJFK	JOHN F KENNEDY INTL	NEW YORK	NY	74	0.997070
KSWF	STEWART INTL	NEWBURGH	NY	111	0.995416
PBG	PLATTSGURGH INTL	PLATTSGURGH	NY	377	0.949020
ROC	GREATER ROCHESTER INTL	ROCHESTER	NY	15	0.999488
KSYR	SYRACUSE HANCOCK INTL	SYRACUSE	NY	109	0.995537
B16	WHITFORDS	WEEDSPORT	NY	97	0.996645
FOK	THE FRANCIS S. GABRESKI	WESTHAMPTON BEACH	NY	176	0.990767
HPN	WESTCHESTER COUNTY	WHITE PLAINS	NY	111	0.995551
4F5	BELLEFONTAINE MUNICIPAL AIRPORT	BELLEFONTAINE	OH	10	0.999696
KRZT	ROSS COUNTY	CHILLICOTHE	OH	9	0.999711
KCLE	CLEVELAND-HOPKINS INTL	CLEVELAND	OH	10	0.999688
KCMH	PORT COLUMBUS INTL	COLUMBUS	OH	10	0.999696
OSU	OHIO STATE UNIVERSITY	COLUMBUS	OH	9	0.999711
KDAY	JAMES M COX DAYTON INTL	DAYTON	OH	10	0.999694
1G5	MEDINA MUNICIPAL	MEDINA	OH	10	0.999688
KTOL	TOLEDO EXPRESS	TOLEDO	OH	10	0.999696
I68	LEBANON-WARREN COUNTY	UNKNOWN	OH	10	0.999694
KAVK	ALVA REGIONAL	ALVA	OK	12	0.999524
KCQB	CHANDLER MUNICIPAL	CHANDLER	OK	13	0.999563
CHK	CHICKASHA	CHICKASHA	OK	12	0.999633

GCM	CLAREMORE REGIONAL	CLAREMORE	OK	14	0.999608
DUA	EAKER FIELD AIRPORT	EAKER	OK	12	0.999654
2O8	HINTON MUNICPAL	HINTON	OK	12	0.999621
KHBR	HOBART MUNICIPAL	HOBART	OK	12	0.999633
K2K4	SCOTT FIELD	MANGUM	OK	12	0.999535
MIO	MIAMI	MIAMI	OK	13	0.999621
MDF	MORELAND MUNICIPAL	MORELAND	OK	12	0.999568
KMKO	DAVIS FIELD	MUSKOGEE	OK	13	0.999633
OKC	WILL ROGERS WORLD AIRPORT	OKLAHOMA CITY	OK	13	0.999616
PVJ	PAULS VALLEY MUNICIPAL AIRPORT	PAULS VALLEY	OK	12	0.999640
PNC	PONCA CITY	PONCA CITY	OK	13	0.999507
SNL	SHAWNEE	SHAWNEE	OK	12	0.999647
TQH	TAHLEQUAH	TAHLEQUAH	OK	13	0.999623
KTUL	TULSA INTL	TULSA	OK	14	0.999501
1K4	DAVID J PERRY	UNKNOWN	OK	12	0.999640
YOW	OTTAWA AIRPORT	OTTAWA	ON	337	0.964676
S07	BEND MUNICIPAL	BEND	OR	11	0.999591
HIO	PORTLAND-HILLSBORO	HILLSBORO	OR	27	0.997961
LGD	UNION COUNTY	LA GRANDE	OR	6	0.999859
KONP	NEWPORT MUNICIPAL	NEWPORT	OR	45	0.996234
PDX	PORTLAND INTL	PORTLAND	OR	25	0.998106
SLE	MCNARY FIELD	SALEM	OR	30	0.998267
S47	TILLAMOOK	TILLAMOOK	OR	32	0.997207
ABE	LEHIGH VALLEY INTL	ALLENTOWN	PA	36	0.998834
KBFD	BRADFORD REGIONAL	BRADFORD	PA	11	0.999648
MDT	HARRISBURG INTL	HARRISBURG	PA	13	0.999600
KJST	JOHN MURTHA JOHNSTOWN - CAMBRIA COUNTY	JOHNSTOWN	PA	10	0.999687
LNS	LANCASTER	LANCASTER	PA	15	0.999512
LHV	WILLIAM T. PIPER MEMORIAL	LOCK HAVEN	PA	11	0.999629
PHL	PHILADELPHIA INTL	PHILADELPHIA	PA	28	0.999210
KAGC	ALLEGHENY COUNTY	PITTSBURGH	PA	10	0.999687
KPIT	PITTSBURGH INTL	PITTSBURGH	PA	10	0.999688
PVD	THEODORE FRANCIS GREEN STATE	PROVIDENCE	RI	264	0.969701
AND	ANDERSON REGIONAL	ANDERSON	SC	10	0.999694
KCHS	CHARLESTON AFB/INTL	CHARLESTON	SC	11	0.999667
KCAE	COLUMBIA METROPOLITAN	COLUMBIA	SC	10	0.999686
KGSP	GREENVILLE – SPARTANBURG INTL	GREER	SC	10	0.999694
KMYR	MYRTLE BEACH INTL	MYRTLE BEACH	SC	14	0.999594
KHON	HURON REGIONAL	HURON	SD	14	0.999345
1D1	MILBANK MUNICIPAL	MILBANK	SD	24	0.998897
KRAP	RAPID CITY REGIONAL	RAPID CITY	SD	15	0.999285
FSD	JOE FOSS FIELD	SIOUX FALLS	SD	16	0.999326
YXE	SASKATOON AIRPORT	SASKATOON	SK	236	0.965825
CHA	LOVELL FIELD	CHATTANOOGA	TN	8	0.999726
TYS	MC GHEE TYSON	KNOXVILLE	TN	9	0.999709
KMEM	MEMPHIS INTL	MEMPHIS	TN	10	0.999675
KBNA	NASHVILLE INTL	NASHVILLE	TN	9	0.999715
PHT	HENRY COUNTY	PARIS	TN	10	0.999699
TRI	TRI-CITIES REGIONAL TN/ VA AIRPORT	UNKNOWN	TN	10	0.999694

KABI	ABILENE REGIONAL	ABILENE	TX	30	0.996987
ALI	ALICE	ALICE	TX	223	0.963903
AMA	AMARILLO INTL	AMARILLO	TX	24	0.999034
KLBX	BRAZORIA COUNTY	ANGLETON/LAKE JACKSON	TX	49	0.997830
AUS	AUSTIN-BERGSTROM INTL	AUSTIN	TX	40	0.996798
7F9	COMANCHE	COMANCHE	TX	30	0.997361
KCXO	MONTGOMERY COUNTY	CONROE	TX	23	0.999296
CRP	CORPUS CHRISTI INTL	CORPUS CHRISTI	TX	184	0.968170
KDAL	DALLAS LOVE FIELD	DALLAS	TX	14	0.999558
ADS	ADDISON	DALLAS	TX	14	0.999562
KDFW	DALLAS-FT WORTH INTL	DALLAS-FT WORTH	TX	14	0.999558
KDRT	DEL RIO INTL	DEL RIO	TX	187	0.984887
ELP	EL PASO INTL	EL PASO	TX	160	0.983861
KHRL	VALLEY INTL	HARLINGEN	TX	804	0.814238
KAXH	HOUSTON-SOUTHWEST	HOUSTON	TX	37	0.998410
KDWH	DAVID WAYNE HOOKS MEMORIAL	HOUSTON	TX	30	0.998948
KEFD	ELLINGTON FIELD	HOUSTON	TX	31	0.998885
KHOU	WILLIAM P HOBBY	HOUSTON	TX	32	0.998776
KIAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	HOUSTON	TX	28	0.999140
KIWS	WEST HOUSTON	HOUSTON	TX	35	0.998528
KSGR	SUGAR LAND MUNICIPAL/ HULL FIELD	HOUSTON	TX	35	0.998382
KLBB	LUBBOCK INTL	LUBBOCK	TX	30	0.996988
MAF	MIDLAND INTL	MIDLAND	TX	33	0.994659
OSA	MOUNT PLEASANT MUNICIPAL	MOUNT PLEASANT	TX	11	0.999668
KSJT	SAN ANGELO REGIONAL/ MATHIS FIELD	SAN ANGELO	TX	34	0.995407
KSAT	SAN ANTONIO INTL	SAN ANTONIO	TX	55	0.995050
SGR	SUGARLAND MUNICIPAL/ HULL FIELD	SUGAR LAND	TX	35	0.998382
KTYR	TYLER POUNDS REGIONAL	TYLER	TX	13	0.999519
BMC	BRIGHAM CITY	BRIGHAM CITY	UT	21	0.996824
KCDC	CEDAR CITY REGIONAL	CEDAR CITY	UT	93	0.991119
KKNB	KANAB MUNICIPAL	KANAB	UT	94	0.988397
LGU	LOGAN-CACHE	LOGAN	UT	21	0.996884
SLC	SALT LAKE CITY INTL	SALT LAKE CITY	UT	23	0.996711
KCHO	CHARLOTTESVILLE-ALBEMARLE	CHARLOTTESVILLE	VA	10	0.999687
FKN	FRANKLIN MUNICIPAL – JOHN BEVERLY ROSE	FRANKLIN	VA	17	0.999547
LVL	BRUNSWICK MUNICIPAL	LAWRENCEVILLE	VA	11	0.999664
JYO	LEESBURG MUNICIPAL/ GODFREY FIELD	LEESBURG	VA	10	0.999687
HEF	MANASSAS REGIONAL/ HARRY P. DAVIS FIELD	MANASSAS	VA	11	0.999667
MTV	BLUE RIDGE	MARTINSVILLE	VA	10	0.999688
KPHF	NEWPORT NEWS/ WILLIAMSBURG INTL	NEWPORT NEWS	VA	19	0.999489
KORF	NORFOLK INTL	NORFOLK	VA	22	0.999394
RIC	RICHMOND INTL	RICHMOND	VA	12	0.999648
AKQ	WAKEFIELD MUNICIPAL	WAKEFIELD	VA	15	0.999593
WAL	WALLOPS FLIGHT FACILITY	WALLOPS ISLAND	VA	27	0.999227
BTV	BURLINGTON INTL	BURLINGTON	VT	365	0.947787

FHR	FRIDAY HARBOR	FRIDAY HARBOR	WA	27	0.997800
KMWH	GRANT COUNTY INTL	MOSES LAKE	WA	11	0.999409
KSEA	SEATTLE-TACOMA INTL	SEATTLE	WA	23	0.998262
BFI	BOEING FIELD/ KING COUNTY INTL	SEATTLE	WA	23	0.998260
KGEG	SPOKANE INTL	SPOKANE	WA	9	0.999568
KATW	OUTAGAMIE COUNTY REGIONAL	APPLETON	WI	15	0.999528
3T3	BOYCEVILLE MUNICIPAL	BOYCEVILLE	WI	17	0.999339
FLD	FOND DU LAC COUNTY	FOND DU LAC	WI	14	0.999547
KGRB	AUTIN STRAUBEL INTL	GREEN BAY	WI	17	0.999448
JVL	SOUTHERN WISCONSIN REGIONAL AIRPORT	JANESVILLE	WI	12	0.999594
MSN	DANE COUNTY REGIONAL-TRUAX FIELD	MADISON	WI	13	0.999562
MTW	MANITOWOC COUNTY	MANITOWOC	WI	14	0.999564
MKE	GENERAL MITCHELL INTL	MILWAUKEE	WI	11	0.999597
KCWA	CENTRAL WISCONSIN	MOSINEE	WI	18	0.999377
OSH	WITTMAN REGIONAL	OSHKOSH	WI	15	0.999526
RHI	RHINELANDER-ONEIDA COUNTY	RHINELANDER	WI	28	0.998591
SUE	DOOR COUNTY CHERRYLAND	STURGEON BAY	WI	17	0.999452
RYV	WATERTOWN MUNICIPAL	WATERTOWN	WI	12	0.999572
ETB	WEST BEND MUNICIPAL	WEST BEND	WI	12	0.999582
KMGW	MORGANTOWN MUNICIPAL – WLB HART FIELD	MORGANTOWN	WV	10	0.999687
KPKB	WOOD CO – GILL ROBB WILSON FIELD	PARKERSBURG	WV	10	0.999688
KCPR	NATRONA COUNTY INTL	CASPER	WY	13	0.999574
EVW	EVANSTON-UNITA CNTY – BURNS FIELD	EVANSTON	WY	20	0.997076
SAA	SHIVELY FIELD	SARATOGA	WY	12	0.999518

Figure 9-1 WAAS LPV Availability

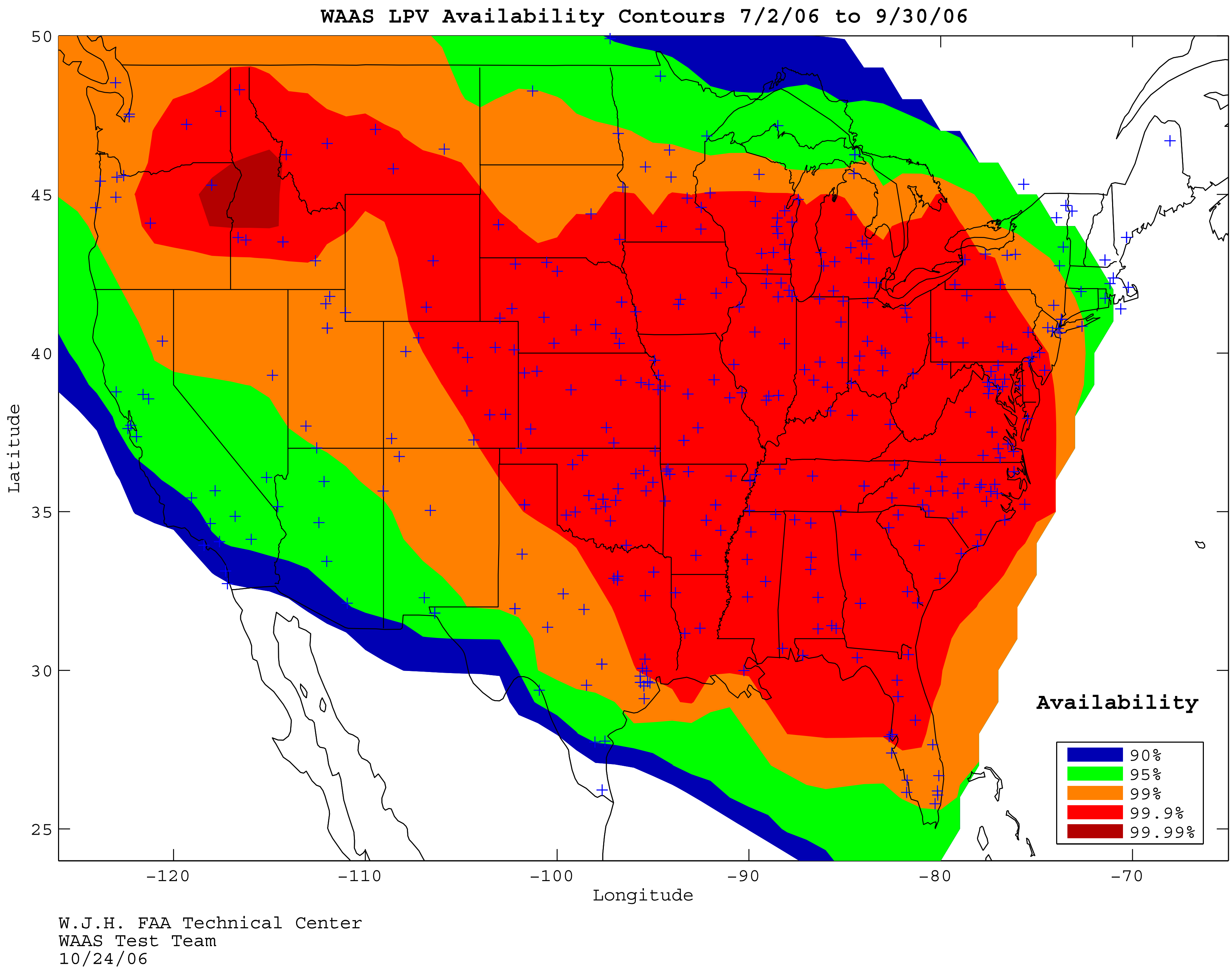
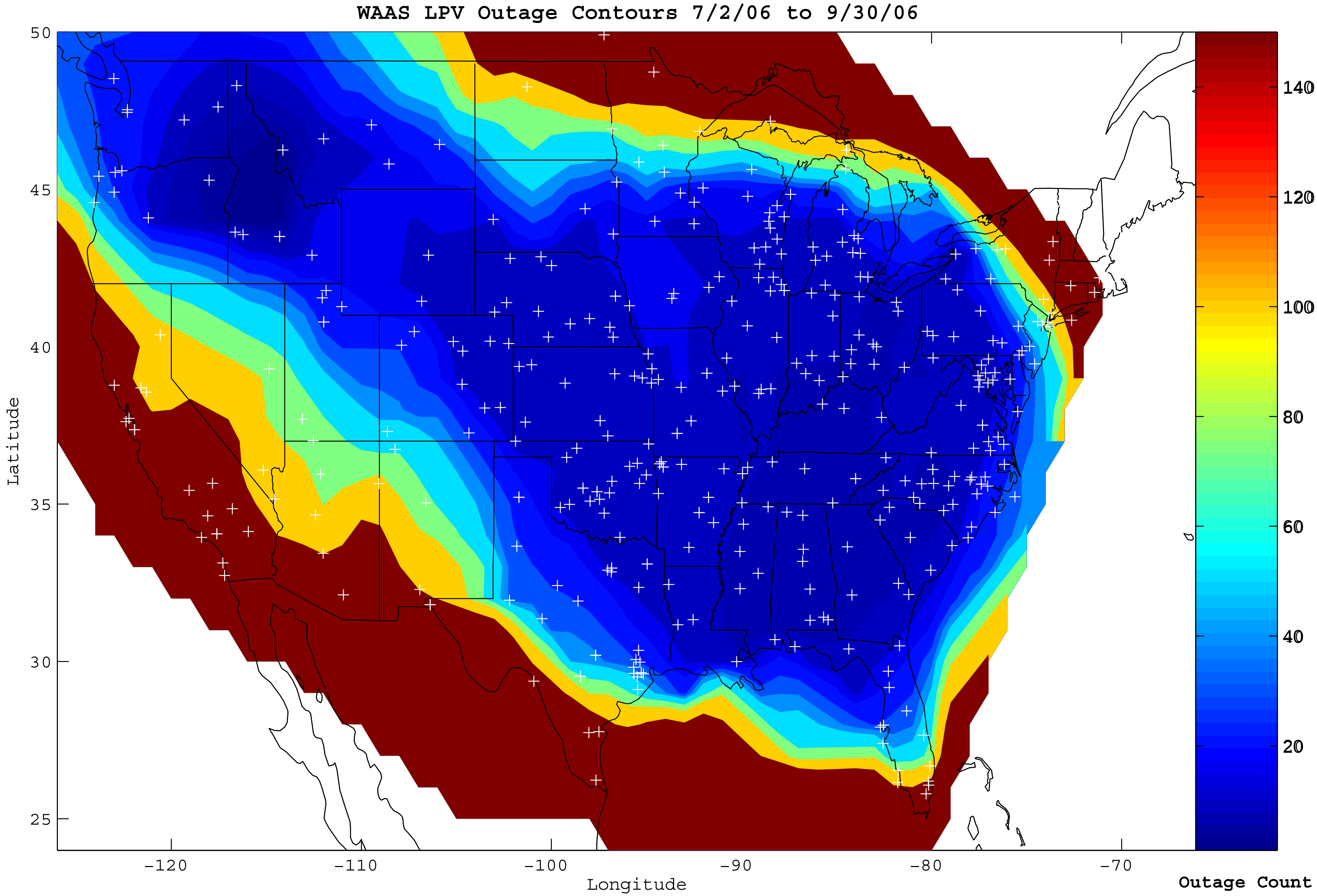


Figure 9-2 WAAS LPV Outage



W.J.H. FAA Technical Center
WAAS Test Team
10/24/06

10.0 WAAS DETERMINISTIC CODE NOISE AND MULTIPATH BOUNDING ANALYSIS

WAAS utilizes a deterministic model to estimate the residual CNMP noise after the application of standard dual frequency carrier smoothing techniques to minimize the effects of multipath and code noise. This analysis performs an assessment of how well that deterministic model bounds the actual errors. This analysis is periodically performed as part of the WAAS Test Team's off-line monitoring to ensure that there are no drastic detrimental changes to the multipath environment at the WAAS Reference Stations (WRSs). This analysis also ensures that WAAS system is not indefinitely exposed to conspiring receiver failure symptoms that would invalidate the CNMP bounding estimate in a manner that would exceed the assumption that no more than one receiver is conspiring to deceive the WAAS monitors at any time by underestimating the residual measurement noise the safety monitors. Although some failures mechanisms that cause CNMP bounding issues are occasionally seen, no "conspiring" errors have ever been detected. That is, data has caused the safety monitors to trip unnecessarily versus missing a necessary trip.

The analysis post processes measurement data to estimate the pseudorange code to carrier ambiguity for each entire arc of measurements for each satellite pass. The ambiguity estimate is then used to level the carrier measurement. The leveled carrier is then used as a multipath free truth estimate. The WAAS real time deterministic CNMP smoothing algorithm is then applied to the original measurements. The difference between the smoothed measurements and the leveled truth measurements is compared to the deterministic noise estimates. Only arcs with continuous carrier phase greater in length than 7200 seconds are utilized for this analysis to minimize the impacts of non-zero mean multipath biasing the truth estimates. The WAAS dual frequency cycle slip detector algorithm is used to detect any discontinuities in the carrier phase.

Statistics are calculated on how well the 0.1 multiples of the deterministically estimated standard deviation bounds the difference between the leveled truth and the real time smoothed measurements. Those statistics are then compared to a theoretical gaussian distribution and an extensive set of plots are generated and manually reviewed. Table 10.1 recaps the results of that manual analysis.

Table 10-1 CNMP Bounding Statistics

WAAS Site	WRE	Oct 05	Nov 05	Dec 05	Jan 06	Feb 06	Mar 06	Apr 06	May 06	Jun 06	Jul 06	Aug 06	Sep 06
Albuquerque	A	green	blue	yellow	yellow	yellow	yellow	green	blue	green	red	green	yellow
	B	blue	blue	blue	blue	yellow	yellow	green	green	blue	red	green	blue
	C	green	yellow	green	green	yellow	green	yellow	blue	yellow	blue	yellow	red
Anchorage	A	red	yellow	blue	green	blue	blue	green	red	red	green	red	red
	B	blue	green	blue	green	yellow	green	green	yellow	yellow	red	red	red
	C	red	green	blue	blue	blue	green	yellow	red	red	red	yellow	red
Atlanta	A	blue	yellow	blue	blue	blue	blue	blue	blue	yellow	yellow	blue	blue
	B	green	green	yellow	green	yellow	blue	blue	blue	blue	yellow	blue	blue
	C	blue	green	yellow	blue	green	yellow	blue	blue	green	green	yellow	blue
Billings	A	blue	green	blue	blue	blue	blue	blue	green	yellow	red	green	blue
	B	blue	blue	blue	blue	blue	blue	blue	yellow	green	yellow	green	blue
	C	blue	blue	blue	yellow	blue	blue	blue	yellow	green	green	blue	blue
Boston	A	green	green	blue	blue	blue	green	blue	yellow	yellow	yellow	blue	blue
	B	green	blue	green	red	yellow	yellow	green	yellow	blue	blue	blue	yellow
	C	green	green	blue	blue	blue	blue	blue	blue	blue	blue	yellow	blue
Chicago	A	green	green	blue	blue	red	blue	yellow	green	blue	green	yellow	blue
	B	yellow	yellow	green	green	blue	blue	green	green	green	blue	green	blue
	C	blue	green	blue	green	yellow	green	green	yellow	green	blue	blue	red
Cleveland	A	green	green	yellow	green	yellow	yellow	blue	blue	red	yellow	blue	blue
	B	blue	green	green	red	red	yellow	blue	yellow	green	blue	blue	green
	C	yellow	yellow	green	yellow	green	yellow	green	green	blue	blue	green	yellow
Cold Bay	A	green	blue	blue	green	yellow	green	green	red	yellow	yellow	yellow	red
	B	green	green	green	blue	blue	blue	blue	red	red	red	red	yellow
	C	green	green	green	blue	green	blue	blue	yellow	red	yellow	yellow	red
Dallas	A	blue	blue	blue	blue	green	yellow	green	red	red	yellow	yellow	red
	B	yellow	blue	yellow	green	yellow	yellow	yellow	red	red	red	red	red
	C	yellow	green	green	green	blue	green	green	red	yellow	red	red	red
Denver	A	red	red	yellow	green	yellow	red	yellow	green	blue	blue	blue	blue
	B	blue	blue	blue	blue	blue	blue	blue	green	blue	blue	blue	green
	C	green	green	red	green	green	green	green	green	red	yellow	yellow	green
Honolulu	A	red	green	yellow	yellow	yellow	red	yellow	green	green	blue	blue	yellow
	B	blue	blue	green	blue	yellow	blue	blue	blue	blue	blue	blue	blue
	C	green	blue	yellow	green	green	green	green	yellow	red	blue	blue	green
Houston	A	yellow	green	yellow	yellow	red	red	red	red	red	green	green	yellow
	B	yellow	yellow	green	red	green	yellow	red	green	blue	yellow	green	green
	C	yellow	red	green	yellow	yellow	blue	blue	yellow	blue	blue	green	yellow
Jacksonville	A	blue	blue	green	yellow	blue	green	blue	green	blue	blue	yellow	blue
	B	blue	blue	blue	blue	green	blue	green	blue	blue	blue	green	blue
	C	blue	blue	blue	blue	green	blue	yellow	yellow	yellow	blue	blue	blue
Juneau	A	red	green	green	yellow	yellow	yellow	blue	green	yellow	yellow	green	blue
	B	blue	yellow	blue	green	red	green	green	yellow	blue	blue	green	green
	C	green	yellow	blue	green	green	yellow	blue	yellow	blue	yellow	green	green
Kansas City	A	green	yellow	green	red	blue	blue	yellow	yellow	yellow	yellow	yellow	red
	B	blue	blue	green	blue	blue	green	yellow	red	red	red	red	red
	C	yellow	blue	blue	blue	blue	blue	green	red	yellow	green	green	blue
Los Angeles	A	blue	yellow	yellow	yellow	yellow	blue	blue	blue	yellow	blue	green	yellow
	B	blue	blue	yellow	blue	yellow	blue	blue	blue	blue	green	blue	blue
	C	blue	red	green	green	blue	blue	blue	blue	blue	yellow	blue	yellow
Memphis	A	blue	green	blue	blue	yellow	blue	blue	blue	blue	blue	blue	blue
	B	green	yellow	blue	yellow	blue	blue	blue	blue	blue	blue	blue	blue
	C	blue	green	blue	green	blue	blue	blue	blue	blue	blue	blue	blue
Miami	A	yellow	yellow	green	green	green	yellow	yellow	yellow	yellow	green	green	yellow
	B	yellow	yellow	yellow	green	yellow	blue	blue	blue	blue	blue	blue	red
	C	blue	red	yellow	yellow	blue	blue	blue	yellow	blue	yellow	yellow	red

Minneapolis	A	green	yellow	red	blue	blue	blue	blue	green	red	red	red	red
	B	blue	green	blue	green	green	blue	blue	green	red	red	red	red
	C	blue	blue	blue	yellow	green	blue	yellow	red	red	yellow	yellow	green
New York	A	blue	blue	blue	blue	blue	blue	blue	blue	blue	yellow	yellow	blue
	B	green	blue	green	yellow	blue	blue	green	green	yellow	blue	blue	blue
	C	green	blue	blue	green	red	blue	green	blue	blue	red	red	green
Oakland	A	green	blue	green	blue	red	green	yellow	red	blue	yellow	red	yellow
	B	blue	blue	green	yellow	blue	blue	green	green	red	red	red	red
	C	yellow	yellow	yellow	green	red	red	yellow	yellow	red	red	yellow	red
Salt Lake City	A	green	blue	green	green	green	blue	red	yellow	red	yellow	red	red
	B	yellow	blue	green	blue	blue	blue	green	green	red	yellow	blue	red
	C	blue	blue	blue	blue	blue	green	blue	green	green	yellow	red	red
San Juan	A	green	green	red	yellow	yellow	yellow	blue	blue	blue	blue	blue	blue
	B	green	blue	blue	blue	blue	blue	blue	blue	yellow	blue	yellow	blue
	C	yellow	yellow	green	green	blue	blue	blue	blue	blue	blue	blue	blue
Seattle	A	blue	blue	blue	yellow	blue	blue	green	yellow	red	red	red	red
	B	blue	blue	blue	green	blue	blue	blue	yellow	yellow	red	green	red
	C	blue	blue	blue	blue	blue	blue	blue	yellow	red	red	green	green
Washington, DC	A	blue	blue	green	blue	yellow	blue	blue	yellow	green	green	red	red
	B	blue	blue	green	green	blue	blue	blue	green	green	red	yellow	blue
	C	blue	blue	green	blue	blue	blue	blue	yellow	yellow	red	yellow	blue

- **Excellent** - 3.29σ bounded 100%
- **Good** - 4σ bounded 100%
- **Fair** - 4σ bounded 100% with one worst satellite excluded (Requires manual review if symptoms repeat from month to month)
- **Poor** – Requires manual review

Shaded receivers represent legacy receivers (non-G2). These receivers are predominantly the trouble receivers, with over 95% of their failures occurring on the L2 frequency.

Appendix A: Glossary

General Terms and Definitions

Alert. An alert is an indication provided by the GPS/WAAS equipment to inform the user when the positioning performance achieved by the equipment does not meet the integrity requirements.

APV-ILNAV/VNAV. APV-I is a WAAS operational service level with an HAL equal to 556 meters and a VAL equal to 50 meters.

Availability. The availability of a navigation system is the ability of the system to provide the required function and performance at the initiation of the intended operation. Availability is an indication of the ability of the system to provide usable service within the specified coverage area.

AVP-II. APV-II is a WAAS operational service level with an HAL equal to 40 meters and a VAL equal to 20 meters.

CONUS. Continental United States.

Continuity. The continuity of a system is the ability of the total system (comprising all elements necessary to maintain aircraft position within the defined airspace) to perform its function without interruption during the intended operation. More specifically, continuity is the probability that the specified system performance will be maintained for the duration of a phase of operation, presuming that the system was available at the beginning of that phase of operation.

Coverage. The coverage provided by a radio navigation system is that surface area or space volume in which the signals are adequate to permit the user to determine position to a specified level of accuracy. Coverage is influenced by system geometry, signal power levels, receiver sensitivity, atmospheric noise conditions, and other factors that affect signal availability.

Dilution of Precision (DOP). The magnifying effect on GPS position error induced by mapping GPS ranging errors into position through the position solution. The DOP may be represented in any user local coordinate desired. Examples are HDOP for local horizontal, VDOP for local vertical, PDOP for all three coordinates, and TDOP for time.

DR. Discrepancy Report

Fault Detection and Exclusion (FDE). Fault detection and exclusion is a receiver processing scheme that autonomously provides integrity monitoring for the position solution, using redundant range measurements. The FDE consists of two distinct parts: fault detection and fault exclusion. The fault detection part detects the presence of an unacceptably large position error for a given mode of flight. Upon the detection, fault exclusion follows and excludes the source of the unacceptably large position error, thereby allowing navigation to return to normal performance without an interruption in service.

GEO. Geostationary Satellite.

Global Positioning System (GPS). A space-based positioning, velocity, and time system composed of space, control, and user segments. The space segment, when fully operational, will be composed of 24 satellites in six orbital planes. The control segment consists of five monitor stations, three ground antennas, and a master control station. The user segment consists of antennas and receiver-processors that provide positioning, velocity, and precise timing to the user.

GLS. GLS is a WAAS operational service level with HAL equal to 40 meters and VAL equal to 12 meters.

Grid Ionospheric Vertical Error (GIVE). GIVEs indicate the accuracy of ionospheric vertical delay correction at a geographically defined ionospheric grid point (IGP). WAAS transmits one GIVE for each IGP in the mask.

Hazardous Misleading Information (HMI). Hazardous misleading information is any position data, that is output, that has an error larger than the current protection level (HPL/VPL), without any indication of the error (e.g., alert message sequence).

Horizontal Alert Limit (HAL). The Horizontal Alert Limit (HAL) is the radius of a circle in the horizontal plane (the local plane tangent to the WGS-84 ellipsoid), with its center being at the true position, which describes the region that is required to contain the indicated horizontal position with a probability of $1\text{-}10^{-7}$ per flight hour, for a particular navigation mode, assuming the probability of a GPS satellite integrity failure being included in the position solution is less than or equal to 10^{-4} per hour.

Horizontal Protection Level (HPL). The Horizontal Protection Level is the radius of a circle in the horizontal plane (the plane tangent to the WGS-84 ellipsoid), with its center being at the true position, which describes the region that is assured to contain the indicated horizontal position. It is based upon the error estimates provided by WAAS.

Ionospheric Grid Point (IGP). IGP is a geographically defined point for which the WAAS provides the vertical ionospheric delay.

LNAV. Lateral Navigation.

MOPS. Minimum Operational Performance Standards.

Navigation Message. Message structure designed to carry navigation data.

Non-Precision Approach (NPA) Navigation Mode. The Non-Precision Approach navigation mode refers to the navigation solution operating with a minimum of four satellites with fast and long term WAAS corrections (no WAAS ionospheric corrections) available.

Position Solution. The use of ranging signal measurements and navigation data from at least four satellites to solve for three position coordinates and a time offset.

Precision Approach (PA) Navigation Mode. The Precision Approach navigation mode refers to the navigation solution operating with a minimum of four satellites with all WAAS corrections (fast, long term, and ionospheric) available.

Selective Availability. Protection technique employed by the DOD to deny full system accuracy to unauthorized users.

Standard Positioning Service (SPS). Three-dimensional position and time determination capability provided to a user equipped with a minimum capability GPS SPS receiver in accordance with GPS national policy and the performance specifications.

SV. Satellite Vehicle.

User Differential Range Error (UDRE). UDRE's indicate the accuracy of combined fast and slow error corrections. WAAS transmits one UDRE for each satellite in the mask.

Vertical Alert Limit (VAL). The Vertical Alert Limit is half the length of a segment on the vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its center being at the true position, which describes the region that is required to contain the indicated vertical position with a probability of $1\text{-}10^{-7}$ per flight hour, for a particular navigation mode, assuming the probability of a GPS satellite integrity failure being included in the position solution is less than or equal to 10^{-4} per hour.

Vertical Protection Level (VPL). The Vertical Protection Level is half the length of a segment on the vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its center being at the true position, which describes the region that is assured to contain the indicated vertical position. It is based upon the error estimates provided by WAAS.

VNAV. Vertical Navigation.

Wide Area Augmentation System (WAAS). The WAAS is made up of an integrity reference monitoring network, processing facilities, geostationary satellites, and control facilities. Wide area reference stations and integrity monitors are widely dispersed data collection sites that contain GPS/WAAS ranging receivers that monitor all signals from the GPS, as well as the WAAS geostationary satellites. The reference stations collect measurements from the GPS and WAAS satellites so that differential corrections, ionospheric delay information, GPS/WAAS accuracy, WAAS network time, GPS time, and UTC can be determined. The wide area reference station and integrity monitor data are forwarded to the central data processing sites. These sites process the data in order to determine differential corrections, ionospheric delay information, and GPS/WAAS accuracy, as well as verify residual error bounds for each monitored satellite. The central data processing sites also generate navigation messages for the geostationary satellites and WAAS messages. This information is modulated on the GPS-like signal and broadcast to the users from geostationary satellites.