WAAS Technical Report
William J. Hughes Technical Center
Pomona, New Jersey
11/30/10

Author(s): David A. Nelthropp

DR# 98: WAAS LPV200 Service Outage at Washington DC WRE-A caused by L1 Radio Frequency Interference (RFI)
GPS Week/Day: Week 1611 Day 3 (11/24/10)

Discussion:

On GPS Week 1611 Day 3, an unexpected WAAS LPV200 service outage at Washington DC WRE-A occurred for approximately 80 seconds. The number of satellites tracked by WAAS reference receiver WRE-A dropped suddenly and the vertical protection level (VPL) jumped in response from 13.6m to 36.5m at 325100 GPS time of week (18:18 GMT) as shown in figure 1. There were no GPS satellite or WAAS GEO satellite navigation signal problems that would affect the LPV200 service at this time. The receiver L1 frequency signal to noise ratio (C/No) for WAAS GEO satellites PRN135 and PRN138 was analyzed and two drops in the received signal level were observed (see figure 2) to correlate with loss of receiver satellite tracking at 295000 and 325100 GPS time of week.

Figure 1 WAAS WRE-A VPL and Satellites Tracked Wide View

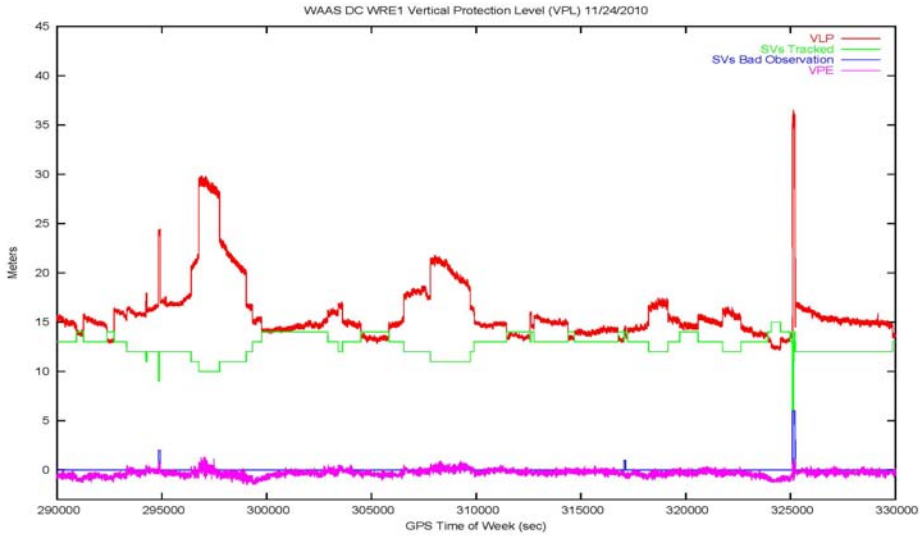
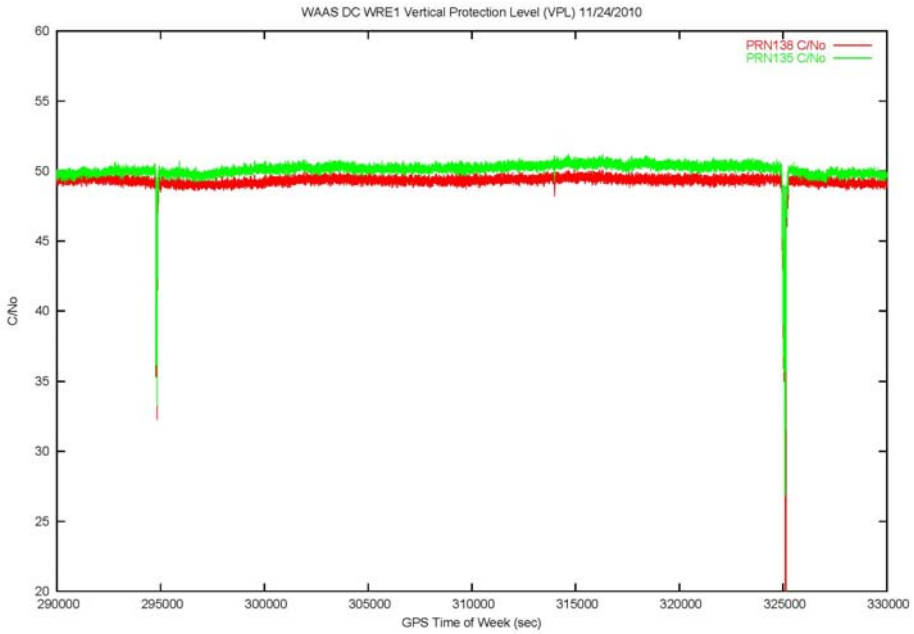


Figure 2 WAAS WRE-A GEO Satellites Signal to Noise Wide View



The WAAS reference site (WRS) has two additional receivers and the satellites tracked were also affected, with receiver 1 (WRE-A) dropping 6 satellites above 5 degrees from the track list shown in figure 3 and receivers 2 & 3 (WRE-B & WRE-C) dropping 4 and 5 satellites respectively above 5 degrees from the track list as shown in figure 4. Although the the VPL increased after the loss of satellite tracking the vertical position error (magenta trace figure 3) remained less than 1 meter during the event.

Figure 3 WAAS WRE-A VPL and Satellites Tracked Zoom View

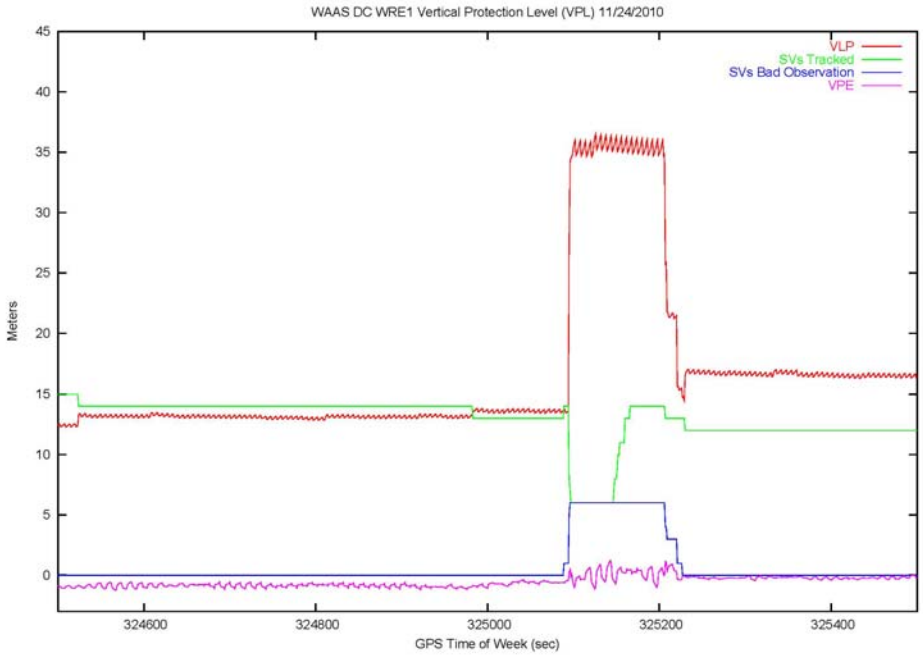
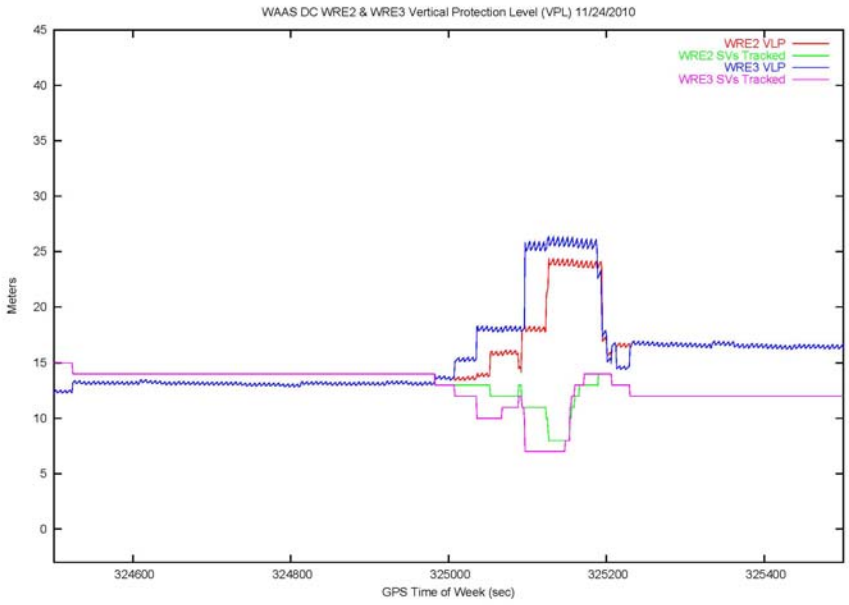


Figure 4 WAAS WRE-B & WRE-C VPL and Satellites Tracked Zoom View



The C/No for GEO's PRN135 & PRN138, during the time of the LPV200 outage for receiver 1 (WRE-A), in figure 5 shows a decreasing signal to noise from 50 db Hz to approximately 28 db Hz over a period of 100 seconds as L1 radio frequency interference (RFI) increased in the local environment. The C/No increased on PRN135 over the next 100 seconds to normal values as the apparent L1 frequency noise source was attenuated. Receiver WRE-A loss track GEO PRN138 for 60 seconds during the peak time of RFI, which also affected the other two WAAS receivers in the same manner as seen in figure 6. The RFI appears to centered at the L1 frequency since GPS satellite signal level at L2 frequency remained at 45 db Hz during the RFI event (PRN10 green & PRN17 magenta trace figure 7) on two GPS satellites that the receiver 1 (WRE-A) was able to continue tracking.

Figure 5 WAAS WRE-A GEO Satellites Signal to Noise Zoom View

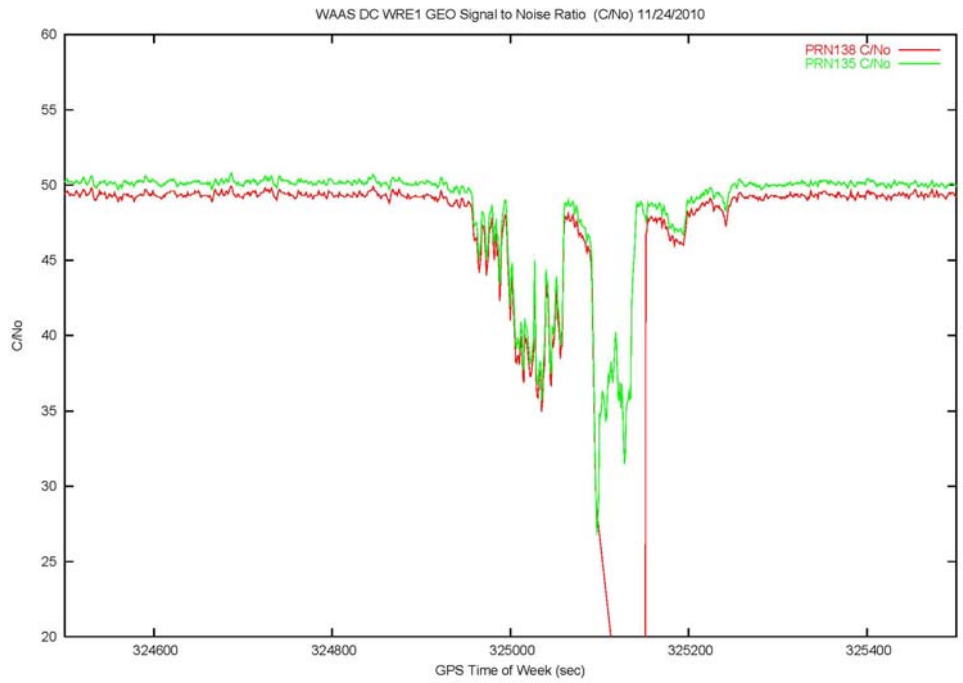


Figure ***6 WAAS WRE-B & WRE-C GEO Satellites Signal to Noise Zoom View***

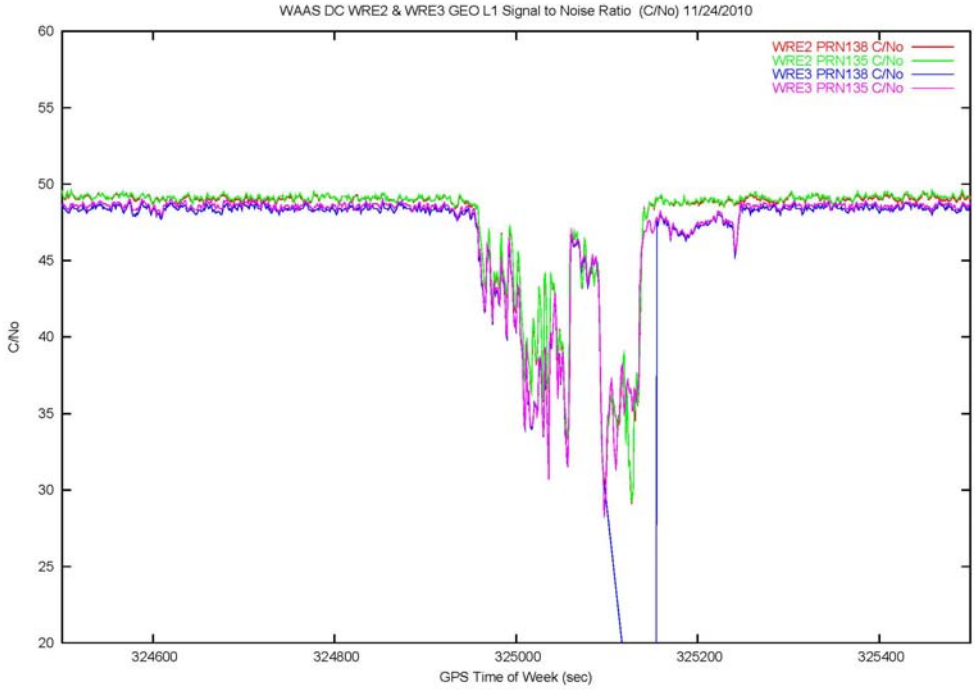
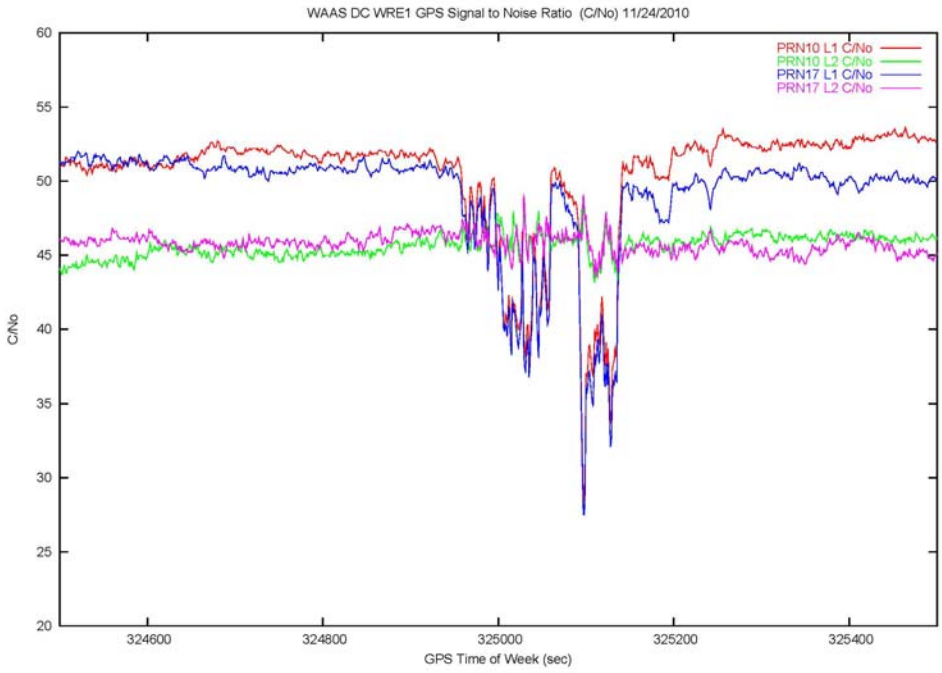


Figure 7 WAAS WRE-A GPS Satellites PRN10 & PRN17 Signal to Noise Zoom



A review of the geographic location of the WAAS WRS at DC (figure 8) shows the facility housing the antenna assembly in close proximity to RT 7 to the North East and RT15 to the North West. The receiver 1 (WRE-A) antenna is oriented to north was most affected by RFI and receiver 2 (WRE-B) antenna is oriented to the south was least affected by RFI. Considering the antenna configuration along with signature of the GEO satellites C/No, it is suspected that the RFI source originated from north of the facility.

Figure 8 WAAS WRS Washington DC Facility

The GEO signal level on receiver 1 (WRE-A) was analyzed for similarities during the week (11/21/2010 – 11/27/2010) and several other weaker RFI events were detected as shown in figure 9. There were no LPV200 service outages caused by these other events which degraded the L1 signal by 10 – 15 db Hz for duration of less than 200 seconds and occurred between 9:40 and 10:20 GMT (4:40 – 5:20 EST) on six days. RFI events on 11/24/2010 and 11/26/2010 were strong enough to affect all three WAAS reference receivers. Figure 10 shows the C/No for GEO PRN135 at receiver 2 & 3 (WRE -B & WRE-C) on three days 11/24 - 11/26/2010.

Figure 9 WAAS WRE-A GEO PRN135 Satellite Signal to Noise Week View

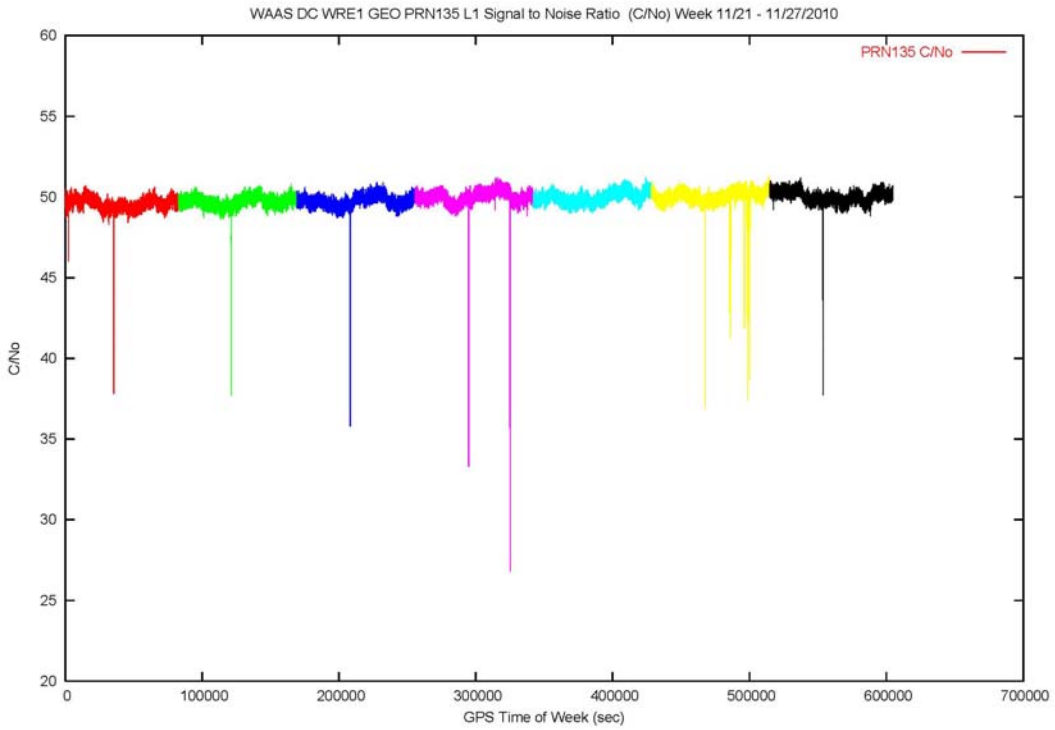
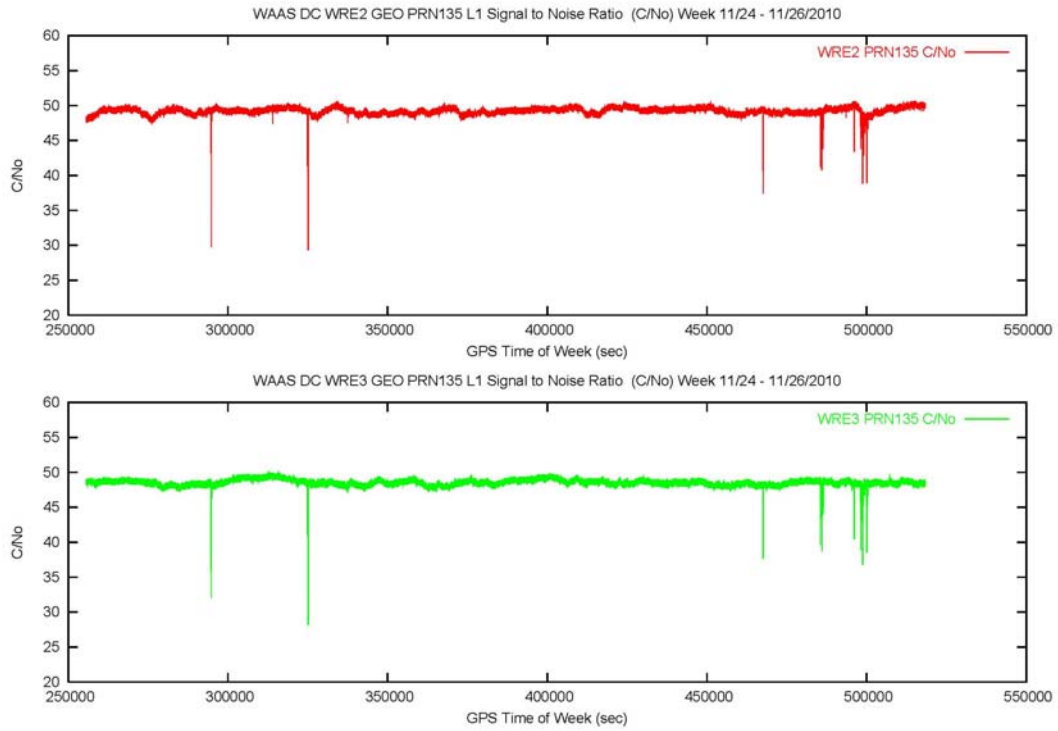


Figure 10 WAAS WRE-B & WRE-C GEO PRN135 Satellite Signal to Noise Wide View



Conclusion:

The local L1 RFI in the vicinity of WAAS DC WRS affected the receiver ability to maintain track of GEO and GPS satellites for 200 seconds causing the calculated VPL at receiver 1 (WRE-A) to exceed the LPV200 threshold of 35 meters. The amplitude of the L1 RFI changes over time and occurs for short periods reducing L1 C/No on tracked satellites by 10 – 22 db Hz .