Guidelines for New and Existing Continuously Operating Reference Stations (CORS)

National Geodetic Survey

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Summary of Updates

Guidelines Effective: 1 January 2006
Document Updated: 21 June 2006
Revisions:

19 Jul 2006 **Section E2** added link for blank log and corrected reference for sample log. **Appendix 3** modified location of blank log.

28 Mar 2006 Fixed two bad URL's

08 Feb 2006 Procedures: Added explanation for appeals of SST modification request; Added explanation of applicability of guidelines to existing stations. Modified **Procedures for becoming a CORS,** requested native binary data rather than RINEX and access to ftp site; **Section B.5**, added explanation for need of a leveling and orienting device, restricted use of tribrachs, corrected filename how_to_modify_a_tribrach adaptor; **C.2**. Defined PCV; **D** corrected GPS to UTC time; **D**. National archiving by site operator of native binary files increased from 14 days to 30 days; **D** corrected error in file name for RINEX archive and specified file name for archiving obs,nav,eph etc files; **E.1** Azimuthal photographs must include the antenna in the picture if at all possible; Previous **G.** was Day-to-Day Operations now Cooperative CORS Web Specifications **H.** Day-to-day specifications; **Appendix 1** Completely revised to make it consistent with sections in this document and easier to understand.

15 Dec 2005 Expanded section on procedures for becoming a CORS. Clarified language in Sections **B.3.a, B.4.b, B.5; B.7** expanded discussion on possible antenna cable problems and lightning arrestors; **E.1** specified photograph resolution.

04 Nov 2005 Corrected 1 typo.

14 Oct 2005 Corrected typos and wrong URL's.

07 Oct 2005 Added section on monument stability.

22 Sep 2005 Added cover page.

20 Sep 2005 Expanded section on procedures for becoming a CORS.

19 Sep 2005 Reordered sections switched A with C.

NGS welcomes comments on any part of these guidelines. Please contact Giovanni Sella giovanni.sella@noaa.gov or ngs.proposed.cors@noaa.gov

Introduction

This document outlines the requirements and recommendations for establishing and operating GPS stations in the Continuously Operating Reference Station (CORS) network, managed by NOAA's National Geodetic Survey (NGS). The CORS network is a multi-purpose cooperative endeavor involving more than 150 government, academic, commercial, and private organizations. Although participation in the CORS network is voluntary site operators must adhere to certain basic standards and conventions. CORS sites have a fundamental role in establishing and giving access to the National Spatial Reference System. These guidelines aim to minimize GPS signal distortion and maximize the quality of calculated positions, in accordance with models used in processing GPS data, to obtain centimeter to sub-centimeter accuracy.

NGS emphasizes it will **not automatically** include a station in the CORS network simply because it meets the criteria described in this document. Selection is made on a case-by-case basis; taking into account current CORS network coverage needs, the quality of data and robustness of communication of existing or potential nearby stations.

Conventions and Definitions

The following conventions have been adopted for this document.

The term "**must**" means that compliance is required; the term "**should**" implies that compliance is strongly recommended, but not required.

***Monument*:** The structure (e.g., pillar, building, etc), including the mount, which keeps the GPS antenna attached to earth's surface.

***Mount**:* The device used to attach the antenna to the monument.

***Mark*:** This is a unique and permanent point on the monument to which the antenna reference point is measured. This mark must remain invariant with respect to the monument.

***Antenna Reference Point (ARP)*:** The point on the exterior of the antenna to which NGS references the antenna phase center position.

***Antenna phase center*:** The electrical point, within or outside an antenna, at which the GPS signal is measured. The realization of the phase center is determined by the set of antenna phase center variations (PCV) corrections that have been defined/adopted by NGS to account for the non-ideal electrical response as a function of elevation and azimuth angles.

***Antenna eccentricity**:* The vertical and horizontal distances from the mark to the ARP.

Site operator: Point of contact responsible for operating the CORS site

Site log: Plain ASCII file that contains all historical information about a site and details the equipment and monument used.

Time of Applicability of Guidelines

CORS sites accepted **before 1 January 2006** may deviate from monumentation requirements (Sections A and B), but must comply with all C.3 Equipment Settings, D: Communications and Data Archiving, and D: Site Metadata.

CORS sites accepted **after 1 January 2006** must abide by all sections of the guidelines.

The guidelines will continue to be revised as technology and NGS's needs change. NGS will be responsible for ensuring that site operators are informed of any needed changes and giving them an appropriate time frame to incorporate any changes.

Procedures for Becoming a CORS

1) Site operators should ensure that their site meets all the criteria outlined in sections A-E of this document. NGS **strongly recommends** that **before** a CORS site is built NGS is contacted, ngs.proposed.cors@noaa.gov to obtain site specific advice on the proposed location, choice of equipment, and installation method; this should significantly reduce the chance that a site is rejected or require major and/or costly modifications
2) Send e-mail to **ngs.proposed.cors@noaa.gov** with "Proposed CORS Site" in the subject line and in the body of the e-mail a short description of the site, its location, and contact information. By using this e-mail address rather than an individual NGS employee's site operators will ensure a more timely response.
3) Supply the following (Appendix 1 will help):
   - Site photographs (Section E.1.)
   - Completed site log (Section E.2.)
   - Link to ftp or http archive with native binary files, if this is not possible then 3 24hr RINEX observation files with GPS day of year included in the file name.
4) NGS will check data quality and verify the completeness and accuracy of the site log
5) If between the time the site is proposed and the site is accepted any changes are made to the site or equipment the site operator must immediately send an e-mail to **ngs.proposed.cors@noaa.gov** with the **site ID** in the **subject line** and a description of the changes, including serial numbers or firmware versions and updated pictures if necessary.
6) NGS's Site Selection Team (SST) meets every 1-2 weeks and will evaluate the site using the criteria outlined in Appendix 1. The site will be accepted, conditionally accepted, or declined. The SST consists of 5-6 volunteer members from the Spatial Reference Division and Geosciences Research Division, these individuals are involved in a variety of tasks including daily analysis of CORS data, archiving of CORS data, and installing CORS sites.

   If the site is **conditionally accepted**: The site operator must comply with the requested changes. These may involve changing the equipment setup, removing nearby obstructions, or modifying metadata after which the information is resubmitted with updated photographs, if needed, to the SST.

   If the site is **accepted** into either National or Cooperative CORS:

7) – National - NGS will coordinate with the site operator to establish data flow to NGS and begin archiving of data
7) – Cooperative - NGS will coordinate with the site operator to ensure that the operator's web page, and data archiving are acceptable
8) Once a site is accepted the site is transferred from the SST to the CORS archive and operations group. Any changes that are made after this time to the site or equipment must be immediately sent via e-mail to **ngs.corscollector@noaa.gov** with the **site ID** in the **subject line** and a description of the changes e.g. new serial number(s), firmware versions, updated picture(s), etc.
9) NGS will add the site to the CORS webpage
10) NGS will begin analyzing the data and upload all site metadata to NGS's internal database
11) NGS will publish the official coordinates and velocity for the site
12) NGS will publish in its newsletter and on its base map the new site.

If a site operator disagrees with the SST decision they are encouraged to appeal the decision to the SST. They should explain in detail why they believe the decision is not appropriate and how the guidelines should be modified or reconsidered.

Guidelines for Establishing and Operating a CORS
A. General Site Operator Requirements

All correspondence about an **accepted and operating** CORS site must be sent to: **ngs.corscollector@noaa.gov** with the 4-character site ID in the subject line, or city and state name if no site ID is assigned. By using this e-mail address rather than an individual NGS employee's site operators will ensure a more timely response.

The site operator provides and maintains all CORS equipment. Since NGS does not operate the site(s) NGS should not be considered the primary verifier of a site's data quality, the site operators should have their own data integrity checks.

The site operator must inform NGS of any planned outages, changes in equipment and firmware -- **especially changes in antenna, radome, and physical space surrounding the antenna** -- as soon as they become known to the site operator.

A CORS site is expected to have high data quality and a lifetime of at least 15 yrs. The latter also applies to the critical volume of space around the antenna that should remain undisturbed throughout the lifetime of the CORS site. Power and Internet outages should be infrequent and short-lived,

B. Monument

Since there is no "perfect" monument, these guidelines only aim to avoid designs that are known to cause (or are likely to cause) data quality issues, based on designs used in CORS/IGS (International Global Navigation Satellite System Service) during the last 12 years.

GOALS: *First, ensuring that the antenna is well anchored to the ground is essential so the position and velocity associated with a given site represents the crustal position and velocity of the site, not just of the antenna. Second, minimize multipath and differences in antenna phase center position as compared to models used in data analysis.*

B.1. Stability

A CORS monument should be designed to maximize its stability (maintain a fixed position in three dimensions) and minimize measurement of near-surface effects. The uppermost part of the ground is subject to the greatest amount of motion e.g. soil expansion and contraction due to changes in water saturation, frost heave, soil weathering, thus **increasing the depth of the monument improves its stability**. A detailed discussion of benchmark stability that is equally applicable to CORS monuments is given in "NOAA Manual NOS NGS 1 Geodetic Bench Marks" especially pages 1-11. See: http://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs

CORS sites should be designed to be at least Class B and hence minimize the impact of:

-Caverns, sink holes, and mines
-Areas where there is active fluid/gas pumping.
-Frost heave, shrinking and swelling of soil and rock
-Soil expansion and contraction
-Slope instability
-Soil consolidation
-Motion intrinsic to a monument e.g. thermal expansion and contraction

NGS strongly recommends that if in doubt about the soil and geologic conditions, a conservative "worst case" scenario is assumed.

B.2. Location, Obstructions and Radio Frequency Environment

B.2.a. Location

Choose an open area with minimal obstructions and minimum likelihood of change in the environment surrounding the monument; e.g. avoid sites with future tree or shrub growth, building additions, rooftop additions, new antenna masts, satellite dishes, parking lots, chain link fences, etc.

B.2.b. Obstructions

No obstructions 10 degrees above the horizon from the ARP and minimal obstructions from 0 to 10 degrees.

WHY: *The greater the volume through which uninterrupted/unreflected signal can reach the antenna, the greater the likelihood of a robust position estimate. No lightning rods, RTK broadcast antennas, or any other objects should extend above the antenna or be anywhere within 3 m of the antenna and all should be below the 0 degree of the horizontal surface containing the ARP.*

B.2.c. Radio Frequency Environment

The signals received by a CORS antenna and receiver can be detrimentally affected by interference from other radio frequency sources (e.g. TV, microwave, FM radio stations, cellular telephones, VHF and UHF repeaters, RADAR, high voltage power lines). This can cause additional noise, intermittent or partial loss of lock or even render sites inoperable. Every effort should be made to avoid proximity to such equipment now and in the future, and all such equipment **must be documented in the site log**.

B.3. Ground-based Monument

B.3.a. Pillar

-Should be approximately 1.5 m above the ground surface to mimic the geometry used at NGS's antenna phase center calibration facility. However, in light of possible obstructions (see B.2. Location, Obstructions, and Radio Frequency Environment), a taller monument may be necessary.

-Must have a deep foundation, Class B, that extends at least 4 m below the frost line and/or the center of mass of the pillar must be below the frost line (see B.1. Stability).

-The top of the pillar **MUST** be narrower than the widest part of the antenna, and the smaller the surface the better. In constructing the pillar, consider that future antennas may be smaller; hence the narrower the top of the pillar the better. The distance between the top of the pillar (if it has a surface) and the antenna should be less than 5 cm or greater than 1 GPS wavelength (~20 cm). This will allow enough room to manipulate a leveling and orienting device (see B.5. Attaching Antenna, Mount, and Monument). These recommendations apply to the top of the pillar only; a very narrow pillar would be unstable and not recommended, however tapered pillars are good.

WHY: *This will mitigate multipath issues. For construction of pillar type monuments consult the following web links:*

www.ngs.noaa.gov/CORS/CorsPP/forum2004/ray.ppt

gsc.nrcan.gc.ca/geodyn/wcda/gpsmon_e.php

B.3.b. Braced

These monuments are especially stable and well anchored to the ground, although more expensive than pillars. Extensive diagrams with details of all aspects of constructions are available at:
http://pboweb.unavco.org/?pageid=45
http://www.unavco.org/facility/project_support/permanent/monumentation/deepdrilled.html
http://www.unavco.org/facility/project_support/permanent/monumentation/sdbm.html

B.4. Roof-based Monument

B.4.a. Building characteristics

Only masonry buildings are permitted and solid brick or reinforced concrete ones are recommended. The building should have been built at least 5 years previously, to increase the likelihood that all primary settling of the building has occurred. There should be no visible cracks on the outside or inside walls. Buildings taller than two stories are not recommended. No wood or simple metal frame with metal walled buildings, and no metal roofs.

WHY: *This will minimize the effects of thermal expansion as well as multipath issues. The following links are instructive but not exhaustive:*
www.cement.ca/cement.nsf/0/7427088E8CB2AFF285256BF30063F29C?OpenDocument
hyperphysics.phy-astr.gsu.edu/hbase/tables/thexp.html
www.masonryinstitute.com/guide/part4/construction_b2_pg1.html

B.4.b. Location and Attachment to a Building

-Stainless steel is recommended for longevity (Angle iron or circular pipe). Aluminum is not recommended as it has approximately twice the thermal expansion of steel/concrete.

-The mount must be bolted **directly** to the main part of the building; a load-bearing wall near a corner is recommended.

-The use of epoxy and threaded lock adhesives fasteners (bolts/anchors/rods) is **strongly recommended**.

-Mounting on a chimney is not recommended unless it has been filled with concrete or if it is particularly robust.

-The mount should not interfere with the building's replaceable roof. This will minimize the chance that the mount will be disturbed when the roof is replaced.

Attaching laterally to a load bearing wall:

The mount should extend about 0.5 m above the roofline and be attached to the building for a length of at least 1 m, with at least 3 anchors/bolts. The ratio of freestanding part to bolted part should be approximately 1:3.

The bolts/anchors must penetrate directly through the mount, e.g. no u-bolts or unistrut brackets with metal ties/clamps. Spacers to keep the mount from sitting flush against the wall are acceptable.

Attaching vertically to a master wall:

A bolt or rod must be anchored into a load-bearing wall. Take care not to void a roof warranty. Avoid metal flashing on a parapet wall.

B.5. Attaching Antenna, Mount and Monument

A device must exist between the monument and the antenna that allows: First, the antenna to be leveled and oriented to north (see B.6. Orienting Antenna). Second, if the antenna is changed, the new ARP must return to the **exact same point in 3-dimensional space** as the previous ARP,

or the change in position between the mark (See definitions) and the ARP must be measured to within 1 mm.

WHY: *If the antenna is simply attached to a threaded rod when it is replaced the new antenna may not return to the same 3-D position or may be oriented differently (the latter would be immaterial only if the phase center variation model is perfectly symmetrical). Both events would require a new position to be computed, which is undesirable.*

The antenna must be leveled to within 0.15 degrees or 2.5 mm/meter (This is easily achieved using a good quality spirit level available in most hardware stores)

Tribrach's are not permitted, as there is no mechanism to lock the adjustable wheels in place.

A number of devices exist that will do this:

www.ngs.noaa.gov/CORS/Articles/modifying_a_tribrach_adaptor.pdf
www.unavco.org/facility/project_support/permanent/equipment/mounts/levelingmount.html
www.unavco.org/facility/project_support/permanent/equipment/mounts/scignmount.html

B.6. Orienting Antenna

The antenna must be oriented to true north using the convention of aligning the antenna cable attachment point, unless the antenna has a different inscribed North point. Remember that declination is the angle between magnetic north and true north. A magnetic declination calculator for setting a compass correctly is available at:

http://www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp

The declination used must be recorded in the log file (see E.2. Site Log).

WHY: *All antenna phase center patterns assume an oriented antenna, and phase center values can differ between north and east by up to a centimeter.*

B.7. Antenna Cable

The antenna cable should not be under tension. Looping the first section of cable next to the antenna and attaching it to the mount can best avoid this problem. If the cable is not encased in conduit, then care should be taken that it will not move around and be damaged. Take particular care at any point where the cable is subject to increased friction, e.g. edges and egress points. Typical GPS antenna cables for CORS (RG213/RG214) have a signal loss of 9 db/100ft/30m at 1Ghz. Total loss for installed length of cable at a CORS must be 9 db or less, implying a maximum cable length of 100ft/30m. If a longer cable is needed then a lower loss cable must be used (The type, manufacturer, and length of cable must be listed in the site log, see E.2).

The antenna cable should directly connect to the receiver and antenna, no connectors should be inserted e.g. TNC to N-type. The junction point of the antenna cable and antenna after the two have been connected should be sealed with waterproof material e.g. butyl wrap.

Site operators are strongly recommended to insert a lightning arrestor in the antenna cable between the antenna and the receiver with its own independent ground. The arrestor should be located on the outside of the building at or near the egress point of the cable into the building. This should protect the receiver in the event of a lightning strike on or near the antenna. The following URL may be helpful, and clearly indicates the potential signal loss created by a poorly selected arrestor:
http://www.unavco.org/facility/project_support/permanent/equipment/lightning/lemp_report.html

C. Equipment

Site operators must keep all receiver firmware updated, and inform NGS as soon as updates occur by e-mailing ngs.corscollection@noaa.gov, please specify 4-character site ID in the subject line.

NGS strongly recommends that equipment be upgraded and/or replaced as technology changes, e.g. new GPS signals added. Equipment changes should however be minimized as they have the potential of resulting in a change in position. If data quality decreases and the site operator is unable to replace /upgrade equipment or otherwise mitigate a problem, NGS may choose to remove the site from the CORS network (see H. Quality Control and Day-to-Day Site Operations)

C.1. Antenna

-The antenna must be at least dual-frequency (L1 and L2).

-An NGS calibrated phase center model for the antenna model must be available. If the user chooses to install a radome (see C.2. Antenna Radome), an NGS calibrated antenna phase center model for the antenna and radome pair must be available. The NGS database of calibrated antenna and radome combinations is available at:

http://www.ngs.noaa.gov/ANTCAL

WHY: *A consistent phase center and ARP for the antenna is essential to tie the GPS measurements to the mark. Ignoring the phase center variations can lead to multi-centimeter errors. All analysis of GPS data at NGS requires that an NGS-validated phase center model be used to calculate the official positional coordinates for a CORS site.*

Antennas must be inspected regularly for damage.

C.2. Antenna Radome

NGS strongly recommends that no antenna radome be used.

WHY: *It is well documented that an antenna radome changes the antenna phase center position. Its benefit is limited as antennas are constructed so they do not need the "protection" of a radome. The choice of material used, the effects of UV radiation, as well as possible manufacturing inhomogeneities in the thickness of certain radomes, may create additional problems in using a single Phase Center Variation (PCV) model for a particular radome model. These two problems imply that either a time-dependent effect on the PCV exists as the radome deteriorates or a calibration of each individual radome is needed, as a general model calibration would not be valid e.g.*

http://pasadena.wr.usgs.gov/scign/group/dome

If a radome is used, the antenna and radome pair **must** have been calibrated together by NGS (see C.1. Antenna).

C.3. Receiver, Settings, and Power Supply

Receivers must be able to:

- Track at least L1 and L2
- Track at least 10 satellites above 0 degrees
- Automatically switch between operating modes to retain full wavelength L2 when Antispoofing (AS) is switched on
- Provide L1 C/A-code pseudorange or P-code pseudorange and L1 and L2 full wavelength carrier phase
- Sample at a frequency of at least 30-seconds

Receivers must be programmed:

- So that no smoothing is applied to the observables
- Track with an elevation cutoff angle of 5 degrees and 0 degrees is strongly preferred
- Record at 30, 15, 10, 5 or 1-second sampling intervals
- Log hourly blocks (strongly preferred), or 24hr blocks of GPS time. Optimal configuration is to deliver data in real time to NGS
- Track all satellites regardless of health status
  WHY: *The criteria used by the Department of Defense for designating an unhealthy satellite are not always applicable to certain CORS users.*

Receivers must have an uninterrupted power supply with a minimum of 5 minutes backup power, 30+ minutes strongly preferred.

D. Communications and Data Archiving

All data transfers between NGS and the operator's site **must be done via the Internet**.

NGS must be able to retrieve or receive the data immediately after the hour if logging hourly or after 2400h GPS time.

Site operator's web and ftp server must operate 24hrs a day.

National CORS Archiving	***Cooperative CORS Archiving***
NGS will create RINEX-2 files that will be archived by NGS, indefinitely.	Site operator will create RINEX-2 formatted data that must be stored on-line for a minimum of 30 days.
Native binary data must be made available to NGS immediately after the hour if logging hourly, or after 2400h GPS time.	Site operator must make RINEX-2 data available to the public immediately after the hour if logging hourly, or 2400h GPS time.
Site operator must keep native binary data on-line and accessible by NGS for at least 30 days, (NGS will not archive native binary data).	Site operator may also make native binary data available on-line, 30 days preferred.

All file names and associated dates must be recorded with respect to GPS time (UTC plus 14s) **NOT** local time (Most GPS receivers will convert UTC to GPS time without user input).

Directory structure at operator's site **MUST** use the following convention and be all in lowercase**:**

/base_directory/native/yyyy/ddd/ssss/ssssdddh[mm].[c]
/base_directory/rinex/yyyy/ddd/ssss/ssssdddh[mm].yyt.[c]

If a site operator wants to deliver RINEX observation, meteorological, navigation, etc. files as a group/archive, the files within the archive must be **uncompressed** and the archive must be labeled: ssssdddh[mm].yy.c

Files **must** use the following convention all in lowercase, which follows the RINEX convention: ssssdddh[mm].yyt.[c]

base_directory – can be any directory on the site operator's ftp server where data are going to be stored.
ssss - the four-character site ID (see E.2. Site Log)
ddd - the GPS day of year,
yyyy – four digit GPS year
h - a letter that corresponds to an hour-long GPS time block (see below) or 0 (zero) for a full 24hr GPS time block.
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
a b c d e f g h i j k l m n o p q r s t u v w x
mm applies only to sites that record in less than 1 hour time blocks and consists of the minutes after the hour that the file begins e.g. if 30 minute files are collected then 00 and 30 would be used.
yy - the last two digits of four digit GPS year (e.g. 2004 is 04)
t - the file type as:
o – observation
d – observation Hatanaka compressed. The source code for creating and uncompressing this format is available at: ftp://terras.gsi.go.jp/software/RNXCMP
m – meteorological
n – navigation
s – summary
c - compression is optional, but recommended as it saves bandwidth, but must be one of the following three types:
zip – zip
gz – gzip GNU zip (preferred) and available at: http://www.gnu.org/software/gzip/gzip.htm
Z – UNIX compressed

The native binary files will obviously have the manufacturer specific extensions but should mimic the afore mentioned format as closely as possible.

E. Site Metadata

E.1. Digital Photographs

A set of sharply focused digital photographs, at least 300 dpi at 5"x7", are required to evaluate and document a site. When taking photographs, please remember that their purpose is to give a clear view of the equipment being used, how it is assembled, as well as the space around it for someone who has not visited the site. Photographs **must use the filename specified in bold** between the dashes – (where ssss is the 4-charcter site ID). The convention to use for azimuth direction is 000 - north, 090 - east, etc. Jpg format is preferred. The photographs must include:

– **ssss_monu.jpg –** A photograph showing the monument (pillar/braced/building) and antenna. The ground surface of the building or monument and antenna must be visible.
– **ssss_mark.jpg –** A photograph showing the mark. If no unique mark exists then a photograph of the threaded section of the mount, either laterally or from above the monument should be taken. (If the site has been collecting data then **DO NOT REMOVE the antenna** and instead ignore this photograph.
– **ssss_ant_monu.jpg –** A close-up photograph that shows how the antenna is attached to the monument.

-Four oriented photographs taken at the height of the ARP surface. The antenna should be included in the photograph but it should not significantly block the ability to view what lies behind the antenna, stand about 3-5m away. If this is not possible place the camera directly at the top center of the antenna, and point the camera in the required direction:

– ssss_ant_000.jpg – North (000)
– ssss_ant_090.jpg – East (090)
– ssss_ant_180.jpg – South (180)
– ssss_ant_270.jpg – West (270)

(If photographs from additional directions are useful please use the appropriate azimuth in the file name.

If the antenna is on a roof, you must include the following:

– ssss_ant_bldg.jpg – A photograph showing "clearly" how the antenna is attached to the building.
– ssss_ant_roof.jpg – A photograph showing the antenna and the roof surface.
– ssss_ant_sn.jpg – A close-up photograph of the antenna showing its model and serial number.
– ssss_rec_sn.jpg – A close-up photograph of the receiver showing its model and serial number.
– ssss_rec.jpg – A photograph of the receiver location.

These photographs must be updated if the equipment changes or changes occur in the physical space around the antenna.

E.2. Site Log

The site log used at NGS follows the format specified by the International Global Navigation Satellite System Service (IGS). This file contains all the historical information about a site and details the equipment and monument used. **The site log is of equal importance as the GPS data collected at a site**. Detailed instructions are given in APPENDIX 2; a blank log is given in APPENDIX 3 and at ftp://cors.ngs.noaa.gov/cors/station_log/blank.log; a completed example log is given in APPENDIX 4. Please fill out **ALL** parts for which you have information. DO NOT DELETE any empty or inapplicable sections. Please remember that these files must be "machine readable" and therefore should be saved as **ASCII files and have the exact spacing as described in the instructions** (APPENDIX 2). **Most entries can only be on one line,** if more information is needed please enter it in the Additional Information part of each section**. A web-based interface is being built.**

F. Assessment of National Versus Cooperative CORS

The main difference between National and Cooperative CORS is that for National CORS sites the public obtains the data from NGS, whereas for Cooperative CORS sites the public obtains the data from the site operator.

National	Cooperative
Site operates 24 hours/day, 7 days/week	Site operates 24 hours/day, 7 days/week
NGS make RINEX-2 data publicly available indefinitely	Site operator makes RINEX-2 data publicly available for 30 days minimum on-line
NGS produces RINEX-2 files and ensures accuracy of RINEX headers.	Site operator produces RINEX-2 files and ensures accuracy of RINEX headers.
NGS maintains web site, with all meta data (photos, site log, NGS position information)	Site operator maintains web site with all meta data (photos, site log, and **link to NGS position**

	information) and a link to the NGS Cooperative CORS web page
CORS map located on NGS web site links to GPS data in NGS archive	CORS map located on NGS Web site links to GPS data on site operator's web site
NGS checks positional coordinates daily	NGS checks positional coordinates daily
OPUS utility automatically selects three National CORS for calculating positions	OPUS utility allows manual user selection of up to three Cooperative CORS for calculating positions
For inclusion, the site must significantly enhance the functionality of the National CORS network in terms of coverage, data quality, reliability, latency, equipment quality, real-time data, etc.	Most qualified sites are accepted

G. Cooperative CORS Web Page Guidelines:

The Cooperative CORS site operator must establish a web page through which the public can access information and data for the site. It **must** contain the following in a clear and simple way:

-Access to RINEX-2 data via an anonymous ftp or web server. The archive must follow the structure listed in section D.

-The 10-12 photographs that serve as pictorial metadata of the site labeled as specified in Section E1.

-The site log as a plain ASCII formatted file as described in Section E2.

WHY: *NGS must be able to routinely download this file, parse it and verify that the metadata at the site is consistent with the information used to compute the daily coordinates. It must not be a .pdf, .doc, .wpd, .ppt, etc. as these formats cannot be parsed by NGS.*

-A link, not a copy, to the official NGS coordinates to a site.

-A link to the NGS Cooperative CORS page:
http://www.ngs.noaa.gov/CORS/Coop

-A link to the NGS CORS page
http://www.ngs.noaa.gov/CORS

Optional content:

A link to the 60-day plots published by NGS. These plots show the difference between the NGS published coordinates and the daily computed coordinates for the previous 60 days.

H. Quality Control and Day-to-Day Site Operations:

To ensure data quality the following verifications will be made on a daily basis using TEQC (Translating, Editing, Quality Checking) to check the quality of the incoming 24hr RINEX files decimated to 30-s epochs. TEQC is freeware available for a variety of computer platforms and operating systems from: http://www.unavco.org/facility/software/teqc/teqc.html

- MP1 represents the RMS multipath in meters on the L1 pseudorange observable, averaged for a 50-point moving window (25 minutes for 30-s epochs).
- MP2 represents the RMS multipath in meters on the L2 pseudorange observable, averaged for a 50-point moving window (25 minutes for 30-s epochs).
- o/slp represents the average number of complete observations before a slip occurs simultaneously on the derivative of the ionospheric delay observable and/or both MP1 and MP2.
- IODslp represents the number of slips on the derivative of the ionospheric delay observable.

The TEQC statistics will be supplemented with those obtained by forming the ionospheric free linear combination of the L1 and L2 phases by the method of double differences. This is the method used by NGS to calculate daily site coordinates. Note that double differences are dependent on data quality from two sites, unlike TEQC statistics.

The combination of the aforementioned performance measures will be used to recommend equipment upgrades for prospective or existing sites whose data under-perform compared to its established peers (CORS network). In addition, these results will be used to search for systematic effects in the CORS network, such as a tendency for a model of receiver or antenna to under-perform when compared to its peers.

APPENDIX 1: Form for Evaluating a Proposed CORS

21 June 2006

Dear ,

Thank you for submitting your GNSS site, _____** to be considered as part of the National Geodetic Survey's CORS network. The Site Selection Team (SST) has reviewed your site and has the following comments.

If you have any questions or once you have updated the missing or updated information please:

1) e-mail **ngs.proposed.cors@noaa.gov**
2) Ensure you include the 4-character Site ID** or city and state in the subject line.

These steps will result in all members of the SST receiving your e-mail and hence a faster response than an e-mail to an individual NGS employee.

Yours sincerely,
CORS-SST

**This is a proposed SITE ID unless NGS has already assigned you this 4-character site ID. Otherwise, once your site has been accepted the NGS operations and data archive group will check if your preferred 4-character site ID is available in a global database of GNSS 4-character site ID's and reserve it or offer an alternative one.

In the table below unless otherwise specified "Sections" refer to those in Guidelines for New and Existing CORS available at:

http://www.ngs.noaa.gov/PUBS_LIB/CORS_guidelines.pdf

Site Location and Obstructions Section B.2		N/A	Invalid	Modify	Accept
B.2.a	Location				
B.2.b	Obstructions				
B.2.c	Radio Frequency Environment				

Additional comments:

Ground-based Monument Section B.3.		N/A	Invalid	Modify	Accept
B.3.a	Top of pillar width narrower than antenna				
B.3.b	Braced monument				

Additional comments:

Roof-based Monument Section B.4.		N/A	Invalid	Modify	Accept
B.4.a	Building made of mortar				
B.4.b	Mount attachment bolts				

B.4.b	Mount bolted length to free standing length				

Additional comments:

Attach. Antenna, Mount and Monument, Orienting Antenna, Antenna Cable Section B.5-B.7.		**N/A**	**Invalid**	**Modify**	**Accept**
B.5	Leveling and orienting device				
B.5	Antenna level				
B.6	Antenna oriented to North				
B.7	Antenna cable tension				

Additional comments:

Equipment Section C.		**N/A**	**Invalid**	**Modify**	**Accept**
C.1	Valid antenna type				
C.2	Valid radome type				
C.3	Valid receiver type				

Additional comments:

Site Metadata: Digital Photographs Section E.1.		**Photograph name**	**N/A**	**Missing**	**Modify**	**Accept**
A	Photograph showing the monument (pillar/ braced/building) and antenna	**ssss_monu**				
B	Photograph showing the mark	**ssss_mark**				
C	Photograph that shows how the antenna is attached to the monument	**ssss_ant_monu**				
D	Photograph of view 000 (north)	**ssss_ant_000**				
E	Photograph of view 090 (east)	**ssss_ant_090**				
F	Photograph of view 180 (south)	**ssss_ant_180**				
G	Photograph of view 270 (west)	**ssss_ant_270**				
	If the antenna is on a roof, you must include the following:					
H	Photograph showing "clearly" how the antenna is attached to the building.	**ssss_ant_bldg**				
I	A photograph showing the antenna and the roof surface	**ssss_ant_roof**				
J	A photograph of the antenna showing model and serial number	**ssss_ant_sn**				
K	A photograph of the receiver showing model and serial number	**ssss_rec_sn**				
L	A photograph of the receiver location	**ssss_rec**				

M	Resolution and size of photographs					

Additional comments:

Site Metadata: Site Log **Section E.2** (S.1,S.3,S.4 are log file sections)		**N/A**	**Missing**	**Modify**	**Accept**
S.1	Detailed monument information				
S.1	Height of monument and dimensions of material				
S.1	Dimensions of building/monument foundations				
S.1	Description of materials used				
S.1	Date Installed				
S.3	Receiver name and serial number match photograph				
S.3	Receiver install and removed dates are valid				
S.4	Antenna name and serial number match photograph				
S.4	Antenna install and removed dates are valid				
S.4	Antenna cable type and length				
S.11-12	Contact information				

Additional comments:

Data Quality and Geographic Location	**N/A**	**Missing**	**Modify**	**Accept**
3 24hr days of data				
TEQC results				
Distance to nearest CORS				

Additional comments:

Site is recommended as **Section F.**	**Denied**	**National**	**Cooperative**
Site is recommended			

Additional comments:

APPENDIX 2: Instructions for Completing Site Log

Instructions for filling out NGS site logs
Modified by NGS from IGS version of Jul 2003

See log form at ftp://cors.ngs.noaa.gov/cors/station_log/blank.log

General
=======

Please prepare site logs in plain ASCII.

Line length is limited to 80 characters.

When ready, submit site logs by sending as a plain text email message to ngs.corscollector@noaa.gov

Date and time formats within the site log follow the basic format "CCYY-MM-DDThh:mmZ" from ISO 8061; see
http://www.iso.ch/iso/en/prods-services/popstds/datesandtime.html
As a summary, CC=2 digit century
YY=2 digit year
MM=2 digit month
DD=2 digit day of month
T=date/time separator
hh=2 digit hour
mm=2 digit minutes of hour
Z=UTC indicator
/=separator when begin & end times are given

A date without a time is specified like "2003-07-30", not "2003-07-30Thh:mmZ"

Latitude/Longitude formats are aligned to ISO 6709:
Lat: +/-DDMMSS.SS
Long: +/-DDDMMSS.SS
A + or - sign is required. Leading zeroes must be used as appropriate to maintain the DDMMSS and DDDMMSS format.

Valid longitude range is from -180 degrees to (infinitesimally less than) +180 degrees. Valid latitude range is -90 degrees to +90 degrees.

"etc" indicates you may enter any relevant answer, not just a choice of the suggestions shown.

"F7.4," "A4" and so on indicate the FORTRAN-style format which the response should have.
Example 12345.7 = F7.1
ABED = A4

Blocks which have a "Nix" definition (namely sections 3-10) should always have the complete historic set of information; when a change is made, the previous information is left (for example in section 3.1) and the new information is placed in a new block numbered 3.2. Please leave the .x sections uncompleted to remind yourself of the format when the next change occurs.

Please remove the response hints such as "(F7.4 N/S)" as you fill out the log (except in the .x sections and Date Removed fields for currently installed equipment, which you must not alter). If an answer in an optional field is unknown, try to learn the answer for the next log update.

If you have any questions not answered here, please feel free to contact the NGS: ngs.corscollector@noaa.gov

Special Instructions by section
==========

0. Form

If Update:
Previous Site Log : (ssss_CCYYMMDD.log)
ssss = 4 character site name

If Update:
Modified/Added Sections : (n.n,n.n,...)
Enter the sections which have changed from the previous version of the log. Example: 3.2, 4.2

1. Site IDentification of the GNSS Monument

Four Character ID : (A4)
This will be assigned by NGS

IERS DOMES Number : (A9)
This is NOT required. NGS may choose to assign one at a later time

Monument Description : (PILLAR/BRASS PLATE/STEEL MAST/FICTIVE/etc)
Enter one or more elements as necessary to describe the monument and mount.

Additional Information : (multiple lines)
Give a short paragraph description of the monument and mount used at your site. In particular describing the materials and methods used in building the monument.

2. Site Location Information

Approximate Position (ITRF)
This should be to a one meter precision. Use OPUS coordinates in ITRF. If the site is accepted official coordinates will be determined by NGS.

3. GNSS Receiver Information

Receiver Type : (A20, from rcvr_ant.tab; see instructions)
Please find your receiver at ftp://igscb.jpl.nasa.gov/pub/station/general/rcvr_ant.tab

and use the official name i.e. receiver type not description, taking care to get capital letters, hyphens, etc. exactly correct. If you do not find a listing for your receiver, please notify NGS: ngs.corscollector@noaa.gov

Serial Number : (A20)
Keep the 5 significant characters of the serial number field in SINEX in mind: do not enter "S/N 12345" instead of "12345" since valuable information will be lost. Ensure that 0(zero) are not O(ohs) or vice a versa).

Firmware Version : (A11)
Keep the 11 significant characters of the field in SINEX in mind. Ensure that 0(zero) are not O(ohs) or vice a versa).

Elevation Cutoff Setting : (deg)
Please respond with the tracking cutoff as set in the receiver, regardless of terrain or obstructions in the area. NGS requires that the receiver is set to 5 degrees or preferably 0 degrees.

Temperature Stabiliz. : (none or tolerance in degrees C.)
This refers to the temperature of the room in which the receiver is housed.

Date Removed : (CCYY-MM-DDThh:mmZ)
In the block for the receiver currently in operation, leave this line as is to remind yourself of the format when the next receiver change is made.

4. GNSS Antenna Information

Antenna Type : (A20; see instructions)
Please find your antenna type at
http://www.ngs.noaa.gov/ANTCAL/index.shtml
Do not enter the antenna description, taking care to get capital letters, hyphens, etc. exactly correct. If you do not find a listing for your antenna, please notify NGS (ngs.corscollector.gov).

Serial Number : (A20)
Do not enter "S/N 12345" instead of "12345" since valuable information will be lost. Ensure that 0(zero) are not O(ohs) or vice a versa).

Antenna Reference Point : BPA
Locate your antenna in the file
http://www.ngs.noaa.gov/ANTCAL/index.shtml
The arrow on the diagram for your antenna is the ARP. The most commonly used abbreviation used at NGS for this point is the BPA.

Marker->ARP Up Ecc. (m) : (F8.4)
Marker is the permanent and unique mark, dimple/cross hair, to which the antenna ARP is referenced. This is the antenna height measured to an accuracy of 1mm and defined as the vertical distance of the ARP from the mark described in section 1. If zero then enter 0.0000.

Marker->ARP North Ecc(m) : (F8.4)
Marker->ARP East Ecc(m) : (F8.4)
These must be filled in and will usually be 0.0000.

Alignment from True N : (deg; + is clockwise/east)

The positive direction is clockwise, so that due east would be equivalent to a response of "+90"

Antenna Radome Type : (A4 from rcvr_ant.tab; see instructions)

Place a radome code from
ftp://igscb.jpl.nasa.gov/pub/station/general/rcvr_ant.tab
"NONE" indicates there is no external radome. If an antenna has a cover which is integral and not ordinarily removable by the user, it is considered part of the antenna and "NONE" is to be used for the radome code.
Ensure that the antenna and radome pair are present in the NGS calibration page

Date Removed : (CCYY-MM-DDThh:mmZ)

In the block for the antenna currently in operation, leave this line to remind yourself of the format when the next antenna change is made.

5. Surveyed Local Ties

Local ties to other marks on the site should be determined in ITRF coordinates to 1mm precision in all 3 dimensions. Offsets are given in geocentric Cartesian coordinates (ITRF).

8. Meteorological Instrumentation

Height Diff to Ant : (m)

Positive numbers indicate met instrument is ABOVE GPS antenna.

12. Responsible Agency (if different from 11.)

The primary contacts listed here should always be the first choice for questions about operation of the site. This person will receive automated emails regarding site log or RINEX errors and should be someone who can answer questions about the configuration and data delivery for this site.

13. More Information

Primary Data Center :
Secondary Data Center :

If National CORS then Primary Data Center is
ftp://cors.ngs.noaa.gov/cors
If Cooperative CORS it is site operator's ftp or http RINEX file archive

URL for More Information :

This would be the site operator's web page if any additional information exists.

Additional Information:

Anything you feel is important. (This could also be kept at your local www site and referred to by URL in the log).

APPENDIX 3: Blank Site Log

```
   XXXX Site Information Form (site log)
   International GPS Service


0.   Form

   Prepared by (full name)  :
   Date Prepared           : (CCYY-MM-DD)
   Report Type              : (NEW/UPDATE)
   If Update:
    Previous Site Log      : (ssss_ccyymmdd.log)
    Modified/Added Sections : (n.n,n.n,...)


1.   Site IDentification of the GNSS Monument

   Site Name              :
   Four Character ID       : (A4)
   Monument Inscription  :
   IERS DOMES Number       : (A9)
   CDP Number                 : (A4)
   Monument Description  : (PILLAR/BRASS PLATE/STEEL MAST/etc)
     Height of the Monument : (m)
     Monument Foundation    : (STEEL RODS, CONCRETE BLOCK, ROOF, etc)
     Foundation Depth      : (m)
   Marker Description      : (CHISELED CROSS/DIVOT/BRASS NAIL/etc)
   Date Installed         : (CCYY-MM-DDThh:mmZ)
   Geologic Characteristic  : (BEDROCK/CLAY/CONGLOMERATE/GRAVEL/SAND/etc)
     Bedrock Type         : (IGNEOUS/METAMORPHIC/SEDIMENTARY)
     Bedrock Condition    : (FRESH/JOINTED/WEATHERED)
     Fracture Spacing      : (1-10 cm/11-50 cm/51-200 cm/over 200 cm)
     Fault zones nearby  : (YES/NO/Name of the zone)
       Distance/activity    : (multiple lines)
   Additional Information   : (multiple lines)


2.   Site Location Information

   City or Town             :
   State or Province        :
   Country                  :
   Tectonic Plate         :
   Approximate Position (ITRF)
     X coordinate (m)      :
     Y coordinate (m)      :
     Z coordinate (m)      :
     Latitude (N is +)    : (+/-DDMMSS.SS)
     Longitude (E is +)  : (+/-DDDMMSS.SS)
     Elevation (m,ellips.)  : (F7.1)
   Additional Information   : (multiple lines)


3.   GNSS Receiver Information

3.1  Receiver Type              : (A20, from rcvr_ant.tab; see instructions)
```

```
   Satellite System          : (GPS/GLONASS/GPS+GLONASS)
   Serial Number           : (A20, but note the first A5 is used in SINEX)
   Firmware Version          : (A11)
   Elevation Cutoff Setting : (deg)
   Date Installed          : (CCYY-MM-DDThh:mmZ)
   Date Removed              : (CCYY-MM-DDThh:mmZ)
   Temperature Stabiliz.     : (none or tolerance in degrees C)
   Additional Information    : (multiple lines)

3.x  Receiver Type               : (A20, from rcvr_ant.tab; see instructions)
   Satellite System          : (GPS/GLONASS/GPS+GLONASS)
   Serial Number           : (A20, but note the first A5 is used in SINEX)
   Firmware Version          : (A11)
   Elevation Cutoff Setting : (deg)
   Date Installed          : (CCYY-MM-DDThh:mmZ)
   Date Removed              : (CCYY-MM-DDThh:mmZ)
   Temperature Stabiliz.     : (none or tolerance in degrees C)
   Additional Information    : (multiple lines)


4.   GNSS Antenna Information

4.1  Antenna Type           : (A20,; see instructions)
   Serial Number           : (A*, but note the first A5 is used in SINEX)
   Antenna Reference Point  : (BPA/BCR/XX; see instructions)
   Marker->ARP Up Ecc. (m)  : (F8.4)
   Marker->ARP North Ecc(m) : (F8.4)
   Marker->ARP East Ecc(m)  : (F8.4)
   Alignment from True N    : (deg; + is clockwise/east)
   Antenna Radome Type     : (A4 from rcvr_ant.tab; see instructions)
   Radome Serial Number  :
   Antenna Cable Type       : (vendor & type number)
   Antenna Cable Length  : (m)
   Date Installed          : (CCYY-MM-DDThh:mmZ)
   Date Removed              : (CCYY-MM-DDThh:mmZ)
   Additional Information    : (multiple lines)

4.x  Antenna Type           : (A20, from www.ngs.noaa.gov/ANTCAL/index.shtml)
   Serial Number           : (A*, but note the first A5 is used in SINEX)
   Antenna Reference Point  : (BPA/BCR/XX; see instructions.)
   Marker->ARP Up Ecc. (m)  : (F8.4)
   Marker->ARP North Ecc(m) : (F8.4)
   Marker->ARP East Ecc(m)  : (F8.4)
   Alignment from True N    : (deg; + is clockwise/east)
   Antenna Radome Type     : (A4 from rcvr_ant.tab; see instructions)
   Radome Serial Number  :
   Antenna Cable Type       : (vendor & type number)
   Antenna Cable Length  : (m)
   Date Installed          : (CCYY-MM-DDThh:mmZ)
   Date Removed              : (CCYY-MM-DDThh:mmZ)
   Additional Information    : (multiple lines)

5.   Surveyed Local Ties

5.x  Tied Marker Name        :
   Tied Marker Usage        : (SLR/VLBI/LOCAL CONTROL/FOOTPRINT/etc)
   Tied Marker CDP Number   : (A4)
   Tied Marker DOMES Number : (A9)
```

```
  Differential Components from GNSS Marker to the tied monument (ITRS)
    dx (m)                : (m)
    dy (m)                : (m)
    dz (m)                : (m)
  Accuracy (mm)           : (mm)
  Survey method           : (GPS CAMPAIGN/TRILATERATION/TRIANGULATION/etc)
  Date Measured           : (CCYY-MM-DDThh:mmZ)
  Additional Information   : (multiple lines)


6.   Frequency Standard

6.1  Standard Type              : (INTERNAL or EXTERNAL H-MASER/CESIUM/etc)
     Input Frequency        : (if external)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
     Notes                  : (multiple lines)

6.x  Standard Type              : (INTERNAL or EXTERNAL H-MASER/CESIUM/etc)
     Input Frequency        : (if external)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
     Notes                  : (multiple lines)


7.   Collocation Information

7.1  Instrumentation Type     : (GPS/GLONASS/DORIS/PRARE/SLR/VLBI/TIME/etc)
     Status                 : (PERMANENT/MOBILE)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
     Notes                  : (multiple lines)

7.x  Instrumentation Type     : (GPS/GLONASS/DORIS/PRARE/SLR/VLBI/TIME/etc)
     Status                 : (PERMANENT/MOBILE)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
     Notes                  : (multiple lines)


8.   Meteorological Instrumentation

8.1.1 Humidity Sensor Model   :
     Manufacturer         :
     Serial Number       :
     Data Sampling Interval : (sec)
     Accuracy (% rel h)  : (% rel h)
     Aspiration             : (UNASPIRATED/NATURAL/FAN/etc)
     Height Diff to Ant  : (m)
     Calibration date      : (CCYY-MM-DD)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
     Notes                  : (multiple lines)

8.1.x Humidity Sensor Model   :
     Manufacturer         :
     Serial Number       :
     Data Sampling Interval : (sec)
     Accuracy (% rel h)  : (% rel h)
     Aspiration             : (UNASPIRATED/NATURAL/FAN/etc)
     Height Diff to Ant  : (m)
     Calibration date      : (CCYY-MM-DD)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
```

```
    Notes                 : (multiple lines)

8.2.1 Pressure Sensor Model   :
    Manufacturer         :
    Serial Number       :
    Data Sampling Interval : (sec)
    Accuracy                 : (hPa)
    Height Diff to Ant  : (m)
    Calibration date      : (CCYY-MM-DD)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                 : (multiple lines)

8.2.x Pressure Sensor Model   :
    Manufacturer         :
    Serial Number       :
    Data Sampling Interval : (sec)
    Accuracy                 : (hPa)
    Height Diff to Ant  : (m)
    Calibration date      : (CCYY-MM-DD)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                 : (multiple lines)

8.3.1 Temp. Sensor Model       :
    Manufacturer         :
    Serial Number       :
    Data Sampling Interval : (sec)
    Accuracy                 : (deg C)
    Aspiration            : (UNASPIRATED/NATURAL/FAN/etc)
    Height Diff to Ant  : (m)
    Calibration date      : (CCYY-MM-DD)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                 : (multiple lines)

8.3.x Temp. Sensor Model       :
    Manufacturer         :
    Serial Number       :
    Data Sampling Interval : (sec)
    Accuracy                 : (deg C)
    Aspiration            : (UNASPIRATED/NATURAL/FAN/etc)
    Height Diff to Ant  : (m)
    Calibration date      : (CCYY-MM-DD)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                 : (multiple lines)

8.4.1 Water Vapor Radiometer  :
    Manufacturer         :
    Serial Number       :
    Distance to Antenna    : (m)
    Height Diff to Ant  : (m)
    Calibration date      : (CCYY-MM-DD)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                 : (multiple lines)

8.4.x Water Vapor Radiometer  :
    Manufacturer         :
    Serial Number       :
    Distance to Antenna    : (m)
    Height Diff to Ant  : (m)
```

```
    Calibration date      : (CCYY-MM-DD)
    Effective Dates       : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                 : (multiple lines)

8.5.1 Other Instrumentation   : (multiple lines)

8.5.x Other Instrumentation   : (multiple lines)


9.  Local Ongoing Conditions Possibly Affecting Computed Position

9.1.1 Radio Interferences     : (TV/CELL PHONE ANTENNA/RADAR/etc)
    Observed Degradations  : (SN RATIO/DATA GAPS/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)

9.1.x Radio Interferences     : (TV/CELL PHONE ANTENNA/RADAR/etc)
    Observed Degradations  : (SN RATIO/DATA GAPS/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)

9.2.1 Multipath Sources   : (METAL ROOF/DOME/VLBI ANTENNA/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)

9.2.x Multipath Sources   : (METAL ROOF/DOME/VLBI ANTENNA/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)

9.3.1 Signal Obstructions     : (TREES/BUILDINGS/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)

9.3.x Signal Obstructions     : (TREES/BUILDLINGS/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)

10.  Local Episodic Effects Possibly Affecting Data Quality

10.1 Date                     : (CCYY-MM-DD/CCYY-MM-DD)
  Event                      : (TREE CLEARING/CONSTRUCTION/etc)

10.x Date                     : (CCYY-MM-DD/CCYY-MM-DD)
  Event                      : (TREE CLEARING/CONSTRUCTION/etc)

11.   On-Site, Point of Contact Agency Information

  Agency                   : (multiple lines)
  Preferred Abbreviation   : (A10)
  Mailing Address       : (multiple lines)
  Primary Contact
    Contact Name         :
    Telephone (primary)    :
    Telephone (secondary)  :
    Fax                       :
    E-mail                :
  Secondary Contact
    Contact Name         :
```

```
    Telephone (primary)    :
    Telephone (secondary)  :
    Fax                       :
    E-mail                 :
  Additional Information   : (multiple lines)


12.  Responsible Agency (if different from 11.)

  Agency                     : (multiple lines)
  Preferred Abbreviation   : (A10)
  Mailing Address        : (multiple lines)
  Primary Contact
    Contact Name         :
    Telephone (primary)    :
    Telephone (secondary)  :
    Fax                       :
    E-mail                 :
  Secondary Contact
    Contact Name         :
    Telephone (primary)    :
    Telephone (secondary)  :
    Fax                       :
    E-mail                 :
  Additional Information   : (multiple lines)


13.  More Information

  Primary Data Center    :
  Secondary Data Center    :
  URL for More Information :
  Hardcopy on File
    Site Map                  : (Y or URL)
    Site Diagram          : (Y or URL)
    Horizon Mask          : (Y or URL)
    Monument Description   : (Y or URL)
    Site Photographs          : (Y or URL)
  Additional Information   : (multiple lines)
  Antenna Graphics with Dimensions

  http://www.ngs.noaa.gov/ANTCAL/index.shtml
```

APPENDIX 4: Sample Site Log:

```
International GPS Service
   KNGS Site Information Form

0.   Form

   Prepared by (full name)  : Mike Craymer
   Date Prepared           : 2002-12-30
   Report Type              : UPDATE
   If Update:
    Previous Site Log      : kngs_20020918.log
    Modified/Added Sections : 1, 11


1.  Site IDentification of the GNSS Monument

   Site Name              : Kingston
   Four Character ID       : KNGS
   Monument Inscription  : M023003
   IERS DOMES Number       : 40161M001
   CDP Number                 : N/A
   Monument Description  : Stainless steel plate
     Height of the Monument : N/A
     Monument Foundation    : Concrete block
     Foundation Depth      : N/A
   Marker Description      : Steel bolt
   Date Installed         : 2002-06-12
   Geologic Characteristic  : Bedrock
     Bedrock Type         :
     Bedrock Condition    :
     Fracture Spacing      :
     Fault zones nearby  : No
       Distance/activity    :
   Additional Information   : The GPS reference mark consists of a stainless
                            steel plate with a forced centering stainless
                            steel bolt embedded on top of a 8 m high, 25 cm
                            wide concrete abutment reportedly anchored to
                            bedrock. The concrete abutment acts as a door
                            frame for the City of Kingston, Portsmouth
                            Marina and Recreation Office.


2.   Site Location Information

   City or Town             : Kingston
   State or Province        : Ontario
   Country                  : Canada
   Tectonic Plate         : North American
   Approximate Position (ITRF)
     X coordinate (m)      : 1067510.934
     Y coordinate (m)      : -4452412.976
     Z coordinate (m)      : 4425573.166
     Latitude (N is +)    : 441307.28535
     Longitude (E is +)  : -0763102.15272
     Elevation (m,ellips.)  : 48.908
   Additional Information   : ARP  ITRF00 POSITION (EPOCH 1997.0)
```

```
                        : Computed in May, 2003 using 22 days of data.


3.  GNSS Receiver Information

3.1  Receiver Type              : TRIMBLE 5700
   Satellite System          : GPS
   Serial Number           : 0220268821
   Firmware Version          : NP 1.04/SP 0.00
   Elevation Cutoff Setting : 0 deg
   Date Installed          : 2002-06-12
   Date Removed              : CCYY-MM-DDThh:mmZ
   Temperature Stabiliz.     : None
   Additional Information    :

3.x  Receiver Type              : (A20, from rcvr_ant.tab; see instructions)
   Satellite System          : (GPS/GLONASS/GPS+GLONASS)
   Serial Number           : (A5)
   Firmware Version          : (A11)
   Elevation Cutoff Setting : (deg)
   Date Installed          : (CCYY-MM-DDThh:mmZ)
   Date Removed              : (CCYY-MM-DDThh:mmZ)
   Temperature Stabiliz.     : (none or tolerance in degrees C)
   Additional Information    : (multiple lines)


4.  GNSS Antenna Information

4.1  Antenna Type           : TRM41249.00
   Serial Number           : 12281766
   Antenna Reference Point  : BPA
   Marker->ARP Up Ecc. (m)  : 0.1000
   Marker->ARP North Ecc(m) : 0.0000
   Marker->ARP East Ecc(m)  : 0.0000
   Alignment from True N    : 0 deg
   Antenna Radome Type    : NONE
   Radome Serial Number  :
   Antenna Cable Type       : N/A
   Antenna Cable Length  : 17 m
   Date Installed          : 2002-06-12
   Date Removed              : CCYY-MM-DDThh:mmZ
   Additional Information    :

4.x  Antenna Type           : (A20, from rcvr_ant.tab; see instructions)
   Serial Number           : (A*, but note the first A5 is used in SINEX)
   Antenna Reference Point  : (BPA/BCR/XXX from "antenna.gra"; see instr.)
   Marker->ARP Up Ecc. (m)  : (F8.4)
   Marker->ARP North Ecc(m) : (F8.4)
   Marker->ARP East Ecc(m)  : (F8.4)
   Alignment from True N    : (deg; + is clockwise/east)
   Antenna Radome Type    : (A4 from rcvr_ant.tab; see instructions)
   Radome Serial Number  :
   Antenna Cable Type       : (vendor & type number)
   Antenna Cable Length  : (m)
   Date Installed          : (CCYY-MM-DDThh:mmZ)
   Date Removed              : (CCYY-MM-DDThh:mmZ)
   Additional Information    : (multiple lines)
```

```
5.  Surveyed Local Ties

5.x  Tied Marker Name       :
   Tied Marker Usage        : (SLR/VLBI/LOCAL CONTROL/FOOTPRINT/etc)
   Tied Marker CDP Number   : (A4)
   Tied Marker DOMES Number : (A9)
   Differential Components from GNSS Marker to the tied monument (ITRS)
     dx (m)                 :
     dy (m)                 :
     dz (m)                 :
   Accuracy (mm)            : (mm)
   Survey method            : (GPS CAMPAIGN/TRILATERATION/TRIANGULATION/etc)
   Date Measured            : (CCYY-MM-DDThh:mmZ)
   Additional Information   : (multiple lines)


6.   Frequency Standard

6.1  Standard Type              : INTERNAL
     Input Frequency        :
     Effective Dates        : 2002-06-08/CCYY-MM-DD
     Notes                  :

6.x  Standard Type              : (INTERNAL or EXTERNAL H-MASER/CESIUM/etc)
     Input Frequency        : (if external)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
     Notes                  : (multiple lines)


7.   Collocation Information

7.x  Instrumentation Type     : (GPS/GLONASS/DORIS/PRARE/SLR/VLBI/TIME/etc)
     Status                 : (PERMANENT/MOBILE)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
     Notes                  : (multiple lines)


8.   Meteorological Instrumentation

8.1.x  Humidity Sensor Model  :
     Manufacturer         :
     Serial Number       :
     Data Sampling Interval : (sec)
     Accuracy (% rel h)  : (% rel h)
     Aspiration             : (UNASPIRATED/NATURAL/FAN/etc)
     Height Diff to Ant  : (m)
     Calibration date      : (CCYY-MM-DD)
     Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
     Notes                  : (multiple lines)

8.2.x  Pressure Sensor Model  :
     Manufacturer         :
     Serial Number       :
     Data Sampling Interval : (sec)
     Accuracy                  : (hPa)
     Height Diff to Ant  : (m)
     Calibration date      : (CCYY-MM-DD)
```

```
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                  : (multiple lines)

8.3.x  Temp. Sensor Model      :
    Manufacturer         :
    Serial Number       :
    Data Sampling Interval : (sec)
    Accuracy                : (hPa)
    Aspiration             : (UNASPIRATED/NATURAL/FAN/etc)
    Height Diff to Ant  : (m)
    Calibration date      : (CCYY-MM-DD)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                  : (multiple lines)

8.4.x  Water Vapor Radiometer :
    Manufacturer         :
    Serial Number       :
    Distance to Antenna    : (m)
    Height Diff to Ant  : (m)
    Calibration date      : (CCYY-MM-DD)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Notes                  : (multiple lines)

8.5.x  Other Instrumentation  :


9.  Local Ongoing Conditions Possibly Affecting Computed Position

9.1.x  Radio Interferences    : (TV/CELL PHONE ANTENNA/RADAR/etc)
    Observed Degredations  : (SN RATIO/DATA GAPS/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)

9.2.x  Multipath Sources       : (METAL ROOF/DOME/VLBI ANTENNA/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)

9.3.x  Signal Obstructions    : (TREES/BUILDLINGS/etc)
    Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
    Additional Information : (multiple lines)


10.   Local Episodic Effects Possibly Affecting Data Quality

10.x Date                      : (CCYY-MM-DD/CCYY-MM-DD)
  Event                       : (TREE CLEARING/CONSTRUCTION/etc)


11.   On-Site, Point of Contact Agency Information

  Agency                    : Natural Resources Canada
  Preferred Abbreviation   : NRCan/GSD
  Mailing Address       : 615 Booth Street
  Primary Contact
    Contact Name         : Mike Craymer
    Telephone (primary)    : (613) 947-1829
    Telephone (secondary)  :
    Fax                       : (613) 992-6628
```

```
    E-mail                : craymer@nrcan.gc.ca
  Secondary Contact
    Contact Name         : Jason Silliker
    Telephone (primary)    : (613) 992-4367
    Telephone (secondary)  :
    Fax                       : (613) 992-6628
    E-mail                : jsillike@nrcan.gc.ca
  Additional Information   : (multiple lines)
```

12. Responsible Agency (if different from 11.)

```
  Agency                    : (multiple lines)
  Preferred Abbreviation   : (A10)
  Mailing Address       : (multiple lines)
  Primary Contact
    Contact Name         :
    Telephone (primary)    :
    Telephone (secondary)  :
    Fax                       :
    E-mail                :
  Secondary Contact
    Contact Name         :
    Telephone (primary)    :
    Telephone (secondary)  :
    Fax                       :
    E-mail                :
  Additional Information   : (multiple lines)
```

13. More Information

```
  URL for More Information :
    Hardcopy on File
    Site Map                  : (Y or URL)
    Site Diagram         : Y
    Horizon Mask         : Y
    Monument Description   : Y
    Site Pictures       : Y
  Additional Information   : (multiple lines)
  Antenna Graphics with Dimensions
```