Section A

INTRODUCTION

Approved ~~11/26/2000~~ ~~8/23/2000~~
3/12/02

The primary responsibility for developing and adopting standards rests with the individual state associations, professional registration boards, state surveying agencies and federal agencies. These model standards of practice are to be used as guidelines for those that have the authority to develop and adopt standards. These recommended standards are intended to foster uniformity in the professional practice of surveying.

Standards are not intended to be used in place of professional judgment. It must be understood that there will be circumstances and conditions that make it impossible to comply with some provisions of a standard. If the professional surveyor deviates from the standard or guideline, this deviation should be noted, described and justified.

Section B

NSPS MODEL STANDARDS
FOR
PROPERTY SURVEYS

Approved 3/12/02

1. INTRODUCTION

Standards for property surveys have been adopted by almost all of the state associations and professional registration boards. This model standard is not intended to take the place of those standards, but to serve as a guide to review and evaluate existing or proposed standards.

Standards are not intended to be used in place of professional judgment. It must be understood that there will be circumstances and conditions that make it impossible to comply with some provisions of a standard. If the professional surveyor (Surveyor) deviates from the standard or guideline, this deviation should be noted, described and justified by the Surveyor**.**

2. RESEARCH, IDENTIFICATION, MEASUREMENTS AND COMPUTATIONS

The Surveyor in conducting a property survey shall:

a. Execute a survey based on the legal description of the parcel or tract taken from the last deed of record as provided by the client.
b. Search pertinent documents that may include, but are not limited to maps, deeds, title reports, title opinions, and United States Public Land Survey records**.**
c. Diligently search for and identify monuments and other physical evidence that could affect the location of the boundaries.
d. Conduct field measurements to correlate all found evidence.
e. Make all measurements to a precision compatible with the size and geometric shape of the parcel, and consistent with the accuracy desired for the class of property being surveyed.
f. Compare and analyze all of the data gathered and reach a professional opinion as to the most probable location of the corners of the property**.**

3. IDENTIFICATION AND RESOLUTION OF CONFLICTS

If a Surveyor has a material disagreement with the measurements or monumented corner positions of another surveyor, the Surveyor shall contact the other surveyor and they shall attempt to resolve the disagreement.

The Surveyor shall advise the client of discrepancies that raise concerns as to the integrity of the surveyed boundary line and provide a written report to the client detailing the basis for those concerns.

4. IDENTIFICATION AND DESCRIPTION OF MONUMENTS

All monuments must be thoroughly described and specifically identified as set or found, whenever shown on maps or referred to in documents prepared by the Surveyor. Descriptions of monuments must be sufficient in detail to readily facilitate future recovery by other surveyors and to enable positive identification.

5. SURVEY DRAWING AND CERTIFICATION

The Surveyor shall prepare an appropriately scaled drawing of the survey. The survey drawing should include at a minimum, the following items:

a. The record description of the property or the reference to the source of the record description. The survey description shall be given if the survey is an original survey.
b. North arrow
c. Scale
d. Bearings, azimuth or angles, and the distances for all courses
e. Basis of bearings or azimuth
f. Monuments identified per Section 4 above
g. Observed evidence of possession or use by others in the parcel or across any perimeter lines of the property
h. Sufficient data to indicate the theory of location applied in formulating the opinions as to the probable location of the boundaries and corners of the property
i. Name, registration number, address and phone number of the Surveyor
j. Name of the client
k. Date of survey
l. Certification

6. CLASSIFICATION AND ACCURACY STANDARDS

The various classifications of property surveys and the positional accuracy of these classes are described in Section C of these model standards.

7. LEGAL DESCRIPTIONS OF PROPERTY

If a Surveyor is called upon to prepare a legal description of a property the following items shall be included:

a. A clear statement of the relationship between the described property and the survey control or the basis of the unique location.
b. The basis of bearings when bearings are used.
c. Metes and bounds descriptions shall include bearings or angles and distances in order to allow for the computation of a mathematical closure.
d. Citations to the recording information or other identifying documentation for any maps, plats and other documents referenced.
e. Detailed description of any natural or artificial monument referenced.
f. The Surveyor's name, address, telephone number, registration number and professional seal.

8. CORNER RECORDS

When a corner record is required to be presented for recordation pursuant to state statutes or regulations, the Surveyor shall reconstruct or rehabilitate the monument and accessories to the corner, such that it shall be, as much as reasonably possible, permanent and locatable with ease by Surveyors in the future.

9. ELECTRONIC DATA DISTRIBUTION

The client may request the Surveyor to provide the survey data in an electronic format. These formats include such files as CADD drawing files, digital terrain model (DTM) files, or digital elevation model (DEM) files. When the Surveyor provides these files, they are only for the benefit of the client on this specific survey. In every case the surveyor shall also provide a signed and sealed hard copy drawing or representation of the survey. This drawing shall be the official plat or map and shall be deemed to be correct and superior to the electronic data. The electronic data file shall also contain a statement that the file is not a certified document and that the official document was issued and sealed by (*name and registration number of the Surveyor*) on (*date*).

The Surveyor may also need to address additional liability issues in appropriate contract language.

Section C

NSPS CLASSIFICATION AND ACCURACY STANDARDS FOR PROPERTY SURVEYS

Approved 3/12/2002

1. PURPOSE

The purpose of this standard is to prescribe accuracy standards to be used by a professional surveyor (Surveyor) for the execution of property surveys.

2. RELATIVE POSITIONAL ACCURACY

Relative Positional Accuracy of a survey is a value expressed in feet or meters that represents the uncertainty of the location of any point in a survey relative to any other point in the same survey at the 95 percent confidence level. Therefore, it is also the accuracy of the distance between all points on the same survey.

Relative Positional Accuracy may be tested by comparing the relative location of points in a survey as measured by an independent survey of higher accuracy. The test should include both distances and direction. Relative Positional Accuracy may also be tested by the results from a minimally constrained, correctly weighted least square adjustment of the survey.

3. PROCEDURE

The Surveyor shall select the proper equipment and methods necessary to achieve the Acceptable Relative Positional Accuracy required of this standard. The survey work shall be executed in a professional manner by the Surveyor or by personnel under the direct personal supervision of the Surveyor. The Surveyor shall conduct check measurements to assure that the intended accuracy of the survey is achieved.

4. CLASSIFICATION OF SURVEY BY LAND USE

The degree of precision and accuracy necessary for a particular property survey shall be based upon the intended use of the land. If the client does not include information regarding the intended use, the classification of the survey shall be based upon the current use of the land.

The classifications of surveys are as follows:

a. Urban Surveys - Urban surveys are performed on land lying within or adjoining a city or town, and include commercial and industrial properties condominiums, townhouses, apartments and other multi-unit developments, regardless of geographic location. All ALTA/ACSM Land Title Surveys are included in this classification.

b. Suburban Surveys - Suburban surveys are performed on land lying outside of urban areas and developed for single family residential use.

c. Rural Surveys - Rural surveys are performed on undeveloped land lying outside of urban and suburban areas such as farms.

5. RELATIVE POSITIONAL ACCURACY

Classification of Survey	Acceptable Relative Positional Accuracy
Urban	0.07 feet (21 mm) plus 50 ppm
Suburban	0.13 feet (40 mm) plus 100 ppm
Rural	0.26 feet (79 mm) plus 200 ppm

Accuracy is given at the 95 percent confidence level.

Section D

NSPS MODEL STANDARDS

FOR CONSTRUCTION LAYOUT SURVEYS

Approved 3/12/02

1. INTRODUCTION

A professional surveyor (Surveyor) shall approach the task of construction staking in precisely the same manner as any survey in which a high degree of competence is required. The public welfare shall be paramount in the Surveyor's decision to take on such a task.

Surveyors shall only concern themselves with the direct interpretation of an approved set of plans. It is not the responsibility of the Surveyor or the surveyor's staff to correct or revise erroneous architectural or engineering plans. If the approved design plans are found to lack sufficient information for proper layout, the Surveyor shall immediately notify his client, the owner, the engineer and/or architect responsible for the project.

Proper field procedures shall be employed to ensure correct placement of construction stakes or other control. Appropriate precautionary measures shall be taken to protect the Surveyors employees, agents, and others from undue physical risks associated with construction projects.

2. PROCEDURAL STANDARDS

A. **Preliminary Research and Planning**

The Surveyor shall:

1. Obtain from the client, or other proper sources, the approved contract documents (plans and specifications) setting forth the project for which the layout survey is to be performed.
2. Determine the appropriate number of horizontal and vertical monuments to be established and the relationship of those monuments to construction lines, grades and offsets.

B. Analysis of Research and Preliminary Conclusions

The surveyor shall:

1. Examine and analyze the data.
2. Test the consistency of the data and bring any inconsistencies to the attention of the client.
3. Plan the necessary methods and procedures for conducting the construction survey.

C. Field Investigation and Layout

The Surveyor shall, in coordination with the client:

1. Search for and substantiate monuments, lines or objects indicated by the construction documents as the intended references for the horizontal and vertical project datum.
2. When necessary, establish, adjust and monument the control points and lines needed to perform the layout survey.
3. Establish the final layout control monuments in proper relationship to construction lines and grades.
4. Obtain sufficient check measurements to verify the work.
5. Record all information on/in an appropriate form.
6. Immediately bring to the attention of the client or his designated representative any inconsistencies disclosed by the survey or by examination of the plans.
7. Refuse to set layout monuments for any inconsistent portion of the project until authorized to do so in writing by the client.

3. TECHNICAL MINIMUMS

A. Measurements

Measurements shall be obtained with an accuracy compatible with Section 4 of these construction standards or as required in a written agreement with the client or within the construction documents.

B. Monumentation.

1. Construction layout monuments shall be of a type and character consistent with intended use.
2. Monuments shall be set in a manner providing a degree of permanency consistent with the terrain, physical features and intended use.
3. Sufficient monuments and offset information shall be provided to enable the user to check the accuracy of any point or line established therefrom.
4. Monuments shall be witnessed in a manner that will allow them to be easily found by the user for a reasonable period of time. Any witness stakes or laths that show offsets and/or cut-and-fill data should be labeled with sufficient information to identify the position of the point being referenced.

C. Field Notes

All pertinent information, measurements and observations made in the field during the course of the survey shall be recorded on an appropriate form (e.g., cut sheet) and in a manner that is clear and legible.

D. Presentation of Data

When requested, the client shall be furnished with the results of the survey on an appropriate form, such as plats, maps, grade sheets, etc. It is important to note that to be effective and useful, any document depicting completed fieldwork must be prepared in a timely manner and reviewed by the client prior to construction taking place. The form selected should show the following:

1. The client's name, date of the fieldwork, file number and the Surveyor's name, address, signature and registration number.
2. A location description of the project referenced to the title description and political subdivision or to the geographic location, and when appropriate, the specific description of the constructed facility surveyed.
3. The identification of the construction documents used in the survey, a statement as to whether they were marked on their face as "approved," and the date of their latest revision.
4. Sufficient information to reference the layout to the construction documents.
5. Identification of the horizontal and vertical datum on which the survey was based and the specific descriptions of the monuments that were used.
6. North arrow and scale.

7. Horizontal dimensions and directions with sufficient notations to indicate their source, such as per plans or calculated from data shown on plans.

8. All pertinent monuments with a notation indicating which were found and which were set, and identified as to their character. Found monuments should be accompanied by a reference as to their origin when it is known. Where there is no available documented reference, this should be so stated.
9. Sufficient information for all layout control lines and points to allow retracement of the work with minimal difficulty.
10. Any discrepancies or inconsistencies between the construction documents and the layout as surveyed and shown on markups, with a statement of the Surveyor's authority for deviating from the construction documents.
11. A qualifying statement of excluded information.
12. An index and cross reference when the presentation consists of more than a single document.
13. When requested, a certificate stating the final date of the field survey and that the survey was conducted either by or under the direction the Surveyor. The certificate should bear the signature, registration number and seal of the Surveyor and the date of certification.

4. RELATIVE POSITIONAL ACCURACY

The following relative positional accuracies are provided as a guide for the placement of stakes or other materials utilized to mark the location of proposed fixed works:

	Horizontal Positional Accuracy		**Vertical Positional Accuracy**	
	Meters	**Feet**	**Meters**	**Feet**
Rough Grading Stakes	± 300 mm	± 1.0 ft	± 60 mm	± 0.20 ft
Subgrade Red Head Stakes	± 150mm	± 0.50 ft	± 15 mm	± 0.05 ft
Finish Grade Blue Top Stakes	± 150 mm	± 0.50 ft	± 15 mm	± 0.05 ft
Building Offset Stakes	± 10 mm	± 0.03 ft	± 10 mm	± 0.03 ft
Sewer Offset Stakes	± 30 mm	± 0.10 ft	± 10 mm	± 0.03 ft
Waterline Offset Stakes	± 30 mm	± 0.10 ft	± 30 mm	± 0.10 ft
Hydrant Offset Stakes	± 30 mm	± 0.10 ft	± 15 mm	± 0.05 ft
Street Lights	± 60 mm	± 0.20 ft	± 30 mm	± 0.10 ft
Curb Offsets	± 15 mm	± 0.05 ft	± 10 mm	± 0.03 ft

Positional Accuracy is given at the 95 percent confidence level

5. ELECTRONIC DATA DISTRIBUTION

The client may request the Surveyor to provide the survey data in an electronic format. These formats include such files as CADD drawing files, digital terrain model (DTM) files, or digital elevation model (DEM) files. When the Surveyor provides these files, they are only for the benefit of the client on this specific survey. In every case the surveyor shall also provide a signed and sealed hard copy drawing or representation of the survey. This drawing shall be the official plat or map and shall be deemed to be correct and superior to the electronic data. The electronic data file shall also contain a statement that the file is not a certified document and that the official document was issued and sealed by (*name and registration number of the Surveyor*) on (*date*).

The Surveyor may also need to address additional liability issues in appropriate contract language.

Section E
NSPS MODEL STANDARDS
FOR
TOPOGRAPHIC SURVEYS

Approved 3/12/02

1. INTRODUCTION

This standard is written to provide the professional surveyor (Surveyor) and the client with a guideline for producing an adequate topographic survey.

2. APPLICATION OF THE STANDARD

This standard applies to topographic surveys that are intended to show the contour of the earth's surface and/or the position of fixed objects thereon. The Surveyor in making topographic surveys uses accepted terrestrial or GPS surveying methods. This standard does not apply to topographic surveys using photogrammetric methods. Topographic surveys that additionally depict the location of property lines must also be in compliance with the current standard for property surveys.

3. DEFINITIONS

A. Bench Mark is a relatively permanent material object, natural or artificial, bearing a marked point whose elevation above or below and adopted datum is known.
B. A Contour is an imaginary line on the ground, all points of which are of the same elevation above or below a specified datum.
C. The Parcel is the area designated by the client and is usually, but not necessarily, given by a legal description of the property.
D. Utilities are services provided by governmental and private entities that provide the following: electric power, telephone, water, sanitary and storm sewer, gas, etc.

4. RESEARCH AND INVESTIGATION

The Surveyor shall acquire the elevation and datum of all bench marks to be used in the survey. The elevation used shall be based on a nationally accepted datum whenever practical or unless otherwise instructed by the client. The client shall specifically describe the parcel to be surveyed.

5. THE SURVEY

The topographic survey shall be performed on the ground to obtain the information required in this standard and any additional information requested by the client. The Surveyor shall select the equipment and procedures necessary to obtain the horizontal and vertical positional accuracy required by these standards.

6. THE PUBLISHED RESULT

A topographic map or plat shall be prepared that shall be of a scale, size and accurately to clearly show the results of the survey.

7. DATA

The surveyor shall locate and show on the topographic survey map or plat the following information:

A. Existing contours lines indicating the shape and elevation of the land over the entire parcel in accordance with the following table, unless specifically excluded in the contract with the client:

Map or Plat Scale	Contour Interval
1" = 20'	1 foot
1" = 30'	1 foot
1" = 40'	1 foot
1" = 50'	1 foot
1" = 100'	1 or 2 feet
1" = 200'	2 or 4 feet
1" = 400'	4, 5 or 10 feet

B. The location of permanent structures including retaining walls, bridges, and culverts.
C. The location of street or road paving, entrance drive openings and sidewalks.
D. Elevations on the top of curbs, gutters and sidewalks.
E. The official street or road names and address numbers assigned to the parcel.
F. North arrow and scale of drawing.
G. Legend depicting the symbols and abbreviations used on the drawing.
H. Spot elevations covering the entire survey limits showing high points, low points, grade changes, and at sufficient intervals to represent the general character of the terrain.
I. Provide main floor elevations of buildings.
J. Location and elevation of lakes, rivers, streams or drainage courses on or near the surveyed parcel.
K. Description, location and elevation of bench marks used in the survey.
L. All Optional items required in Section 9.

8. POSITIONAL ACCURACY

The following relative positional accuracies are provided as a guide for topographic surveys.

	Vertical Positional Accuracy Feet	Horizontal Positional Accuracy Feet
Contour line 1’ interval	± 0.65 ft	± 1 ft
Contour line 2’ interval	± 1.30 ft	± 2 ft
Contour line 4’ interval	± 2.60 ft.	± 4 ft
Contour line 5’ interval	± 3.20 ft	± 4. ft
Contour line 10’ interval	± 6.50 ft	± 8 ft
Floor elevations	± 0.05 ft	± 1 ft
Spot paving elevations	± 0.05 ft	± 1 ft
Spot ground elevations	± 0.20 ft	± 2 ft
Sewer invert elevations	± 0.05ft	± 1 ft
Well defined planimetric features	± 0.10 ft	± 1 ft

Positional Accuracy is given at the 95 percent confidence level.

9. OPTIONAL ITEMS

The following items may be included in the requirements to be shown on a topographic survey if specifically and mutually agreed upon by the client and surveyor:

A. Boundary survey of the parcel. (Must comply with boundary survey standards)
B. Plot the location of easements and rights-of-way as shown on the recorded subdivision plat and all easements evidenced by a recorded document provided by the client. The reference book and page, or document number of each shall be shown.
C. Vicinity map with subject property highlighted.
D. Observable evidence of site use as a solid waste dump, sump or sanitary landfill.
E. Observable evidence of recent earth moving work, borrow or fill.
F. Location and the top elevation of soil borings or monitoring wells if ascertainable. (Performed by others)
G. Cross-section of offsite drainage courses for engineering studies.
H. Location and elevation of at least one bench mark within the limits of the survey.
I. Existing contours shall not be drawn but the drawing shall show existing elevations in both directions over the parcel at 25-foot intervals in rough ground and 50-foot intervals on level ground and spot elevations at any abrupt changes.

J. Elevations at the inside of walk, top of curb, and gutter at approximately one-inch (1”) intervals at the final map scale.
K. Dimensions of curb, sidewalk, and gutter lines or ditch lines and centerline of all streets, alleys or roads adjoining the parcel. Indicate type of paving surface and condition.
L. Location, width and elevation at both ends of all existing sidewalks. Include a description of the kind and general condition of the sidewalk.
M. Location, diameter, and species of all trees over a _____ inch diameter.
N. Perimeter outline only of thickly wooded areas unless otherwise directed.
O. Electric utilities – the location of power poles, guy wires, anchors, vaults, etc., on the parcel or in the streets, roads, alleys, or railroad right of way adjoining the parcel.
P. Storm, sanitary or combined sewers – the location of all observable manholes and other structures such as culverts, headwalls, catch basins and clean-outs on the parcel or in streets, roads alleys or railroad right of way adjoining the parcel. Include elevations of the top and bottom of manholes and catch basins. Show type, size, direction of flow and invert elevation of all pipes or culverts.
Q. Water – the location of any water valves, standpipes, regulators, fire hydrants, etc. that are visible on the parcel.
R. Gas – the location of all valves, meters, and gas line markers that are visible on the parcel. Show elevation on top of any valves.
S. Telephone – the location of all poles, manholes, boxes, etc that are visible on the parcel.
T. Street lighting – the location of all lamp poles, boxes etc
U. Heating – the location of all steam manholes and vaults that are visible on the parcel.
V. Location and dimensions of any existing buildings, tanks, fences, miscellaneous structures, driveways, or other obstructions on the parcel.
W. Location and description of any building or major structure on adjoining land that is not more than ____ feet outside the parcel being surveyed
X. Location and elevation of the 100 year floodplain, if applicable for the surveyed parcel.
M. Location and elevation of swamps, or wetland limits if determined by other experts.
Y. Location of visible rock formations.
Z. Information about the utilities providing service to the parcel. This shall include as a minimum the name of the corporation, address, phone number, fax number and type of service.

10. ELECTRONIC DATA DISTRIBUTION

The client may request the Surveyor to provide the survey data in an electronic format. These formats include such files as CADD drawing files, digital terrain model (DTM) files, or digital elevation model (DEM) files. When the Surveyor provides these files, they are only for the benefit of the client on this specific survey. In every case the surveyor shall also provide a signed and sealed hard copy drawing or representation of the survey. This drawing shall be the official plat or map and shall be deemed to be correct and superior to the electronic data. The electronic data file shall also contain a statement that the file is not a certified document and that the official document was issued and sealed by (*name and registration number of the Surveyor*) on (*date*).
The Surveyor may also need to address additional liability issues in appropriate contract language.

Section F

NSPS MODEL STANDARDS
FOR
LAND INFORMATION/GEOGRAPHIC INFORMATION SYSTEM SURVEYS

Approved 3/12/02

1. PURPOSE:

The purpose of these standards is to provide the professional surveyor (Surveyor) with a guideline for surveys that provide the location of infrastructure information used in a land information system (LIS) or a geographic information system (GIS). The primary objective of this standard is to insure that surveyed information in an LIS/GIS is reliable and can be used to make definitive decisions. These standards are not to be used in place of professional judgment.

2. THE SURVEY:

The Surveyor shall select the proper equipment and methods necessary to achieve at least the Minimum Horizontal and Vertical Accuracy required in Sections 6 and 7 of these standards. The survey work will be executed in a professional manner by the Surveyor or by personnel under the direct personal supervision of the Surveyor.

3. COORDINATE SYSTEM AND DATUM:

Coordinate values should be in the National coordinate systems. Horizontal coordinate values should be in the North American Datum of 1983 (NAD 83). Vertical coordinate values should be in the North American Vertical Datum of 1988 (NAVD 88) or the National Geodetic Vertical Datum of 1929 (NGVD 29). If coordinates are not referenced to the National coordinate system, identify the local coordinate system used and its relationship to the National coordinate system. Coordinates shall be given in either metric or English units. Unless otherwise defined by state statutes, the preferred English unit is the U.S. Survey foot.

4. THE SURVEY REPORT:

The results of the survey shall be transmitted to the client in either the form of a drawing or in a digital format. The following information shall be included in the drawing and/or in the Metadata:

1. The accuracy classification to which the data was gathered.
2. The methods used to obtain the data (such as EDM, GPS, etc.)
3. Date of the survey work.
4. Datum used for the survey.

5. ACCURACY STANDARD:

The minimum positional accuracy of the survey data is a Geospatial Positional Accuracy that is relative to the mapping scale, and therefore it is the accuracy of the base map on which the GIS/LIS is based.

The reporting methodology shall be in accordance with the Federal Geographic Data Committee, Geospatial Positioning Accuracy Standards, Part 1 Reporting Methodology.

The Geospatial Position Accuracy shall be reported by positional accuracy as defined in two components: horizontal and vertical.

Horizontal Positional Accuracy is the radius of the circle of uncertainty, such that the true or theoretical location of the point falls within that circle 95-percent of the time. Horizontal Accuracy may be tested by comparing the planimetric coordinates of surveyed ground points with the coordinates of the same points from an independent source of higher order.

Vertical Positional Accuracy is a linear uncertainty value, such that the true or theoretical location of the point falls within +/- of that linear uncertainty value 95-per cent of the time. Vertical Accuracy may be tested by comparing the elevation of surveyed ground points with the elevations of the same point determined from a source of higher accuracy.

6. MINIMUM HORIZONTAL ACCURACY

The horizontal accuracy is based upon the American Society of Photogrammetry and Remote Sensing (ASPRS) Standard for Class 2 and reported in agreement with the National Standard for Spatial Data Accuracy. The NSSDA Horizontal Positional Accuracy Statistic at the 95% confidence level is determined by multiplying the Root Mean Square Error (RMSE) of the data set by 1.7308.

Base Mapping Scale of LIS/GIS	Acceptable Positional Accuracy Statistic of Survey Data
1”= 20 ft.	0.7 feet
1”= 50 ft.	1.7 feet
1”= 100 ft.	3.5 feet
1”= 200 ft.	6.9 feet
1”= 400 ft.	13.8 feet
1”= 500 ft	17.3 feet
1”= 1000 ft.	34.6 feet
1”= 2000 ft.	69.2 feet

7. MINIMUM VERTICAL ACCURACY

The vertical accuracy is based upon the ASPRS Standard for Class 1 and reported in agreement with the National Standard for Spatial Data Accuracy. The NSSDA Vertical Positional Accuracy Statistic at the 95% confidence level is determined by multiplying the Root Mean Square Error (RMSE) of the data set by 1.9600.

Acceptable

Base Mapping Contour Interval	Positional Accuracy Statistic of Survey Data
1 foot	0.7 feet
2 feet	1.3 feet
5 feet	3.2 feet
10 feet	6.5 feet
15 feet	9.7 feet

Section G

POSITIONAL ACCURACY DEFINITIONS AND PROCEDURES

Approved 3/12/02

1. INTRODUCTION

Modern surveying standards use the concept of positional accuracy instead of error of closure. Although the concepts of positional accuracy are well known and completely discussed in surveying textbooks, it is important that the concepts and procedures be discussed as part of national standards.

The surveying methods used by the professional surveyor (Surveyor) vary with the purpose of survey to be made and the equipment available. Also, surveying technology is constantly changing, therefore a national standard for a particular type or class of survey cannot specify methods or equipment lest it become obsolete even before it is adopted. A modern standard must be limited to a general description of the survey along with reporting and accuracy requirements. A national survey standard should tell (1) what the survey is to accomplish and what items are to be investigated, (2) how the results are to be reported, and (3) how accurate the results are to be.

It is the responsibility of the Surveyor to select the appropriate procedures and equipment to obtain the accuracy required by the standard. In other words, the surveyor is expected to design a survey measurement specification that will obtain the required accuracy. A standard should not specify surveying procedures but only results.

The NSPS Model Standards use two types of accuracy standards. Relative Positional Accuracy is used in property surveys, construction surveys and topographic surveys. Geospatial Positional Accuracy is used in mapping, geographic information systems (GIS), and geodetic control surveys.

2. RELATIVE POSITIONAL ACCURACY

A. Definitions

Relative Positional Accuracy is a value expressed in feet that represents the uncertainty of the location of any point in a survey relative to any other point in the same survey at the 95 percent confidence level. Therefore it is also the accuracy of the distance between all points on the same survey.

Relative Positional Accuracy may be tested by comparing the relative location of points in a survey as measured by an independent survey of higher accuracy. The comparison should include the measurement of both distances and directions. Relative Positional Accuracy may also be tested by the results from a minimally constrained, correctly weighted least squares adjustment of the survey data. Note that sufficient redundancy in the survey measurements is required, if accuracy is to be tested this way, so as to make the application of the least squares adjustment a valid process.

B. Design of a measurement specification

The NSPS Standards prescribe the level of accuracy that should be obtained in the survey and not survey procedures. Accuracy is the deviation of survey measurement of quantities such as distances, angles or elevations from the correct values. The Surveyor has two responsibilities with regard to the accuracy of a survey. First, the Surveyor must use his or her judgment and experience to determine what procedures and equipment are necessary to obtain the required accuracy. Second, the Surveyor must test the accuracy of the completed survey measurements.

The Surveyor is the expert in land measurements and this expertise is used to develop a measurement specification for the survey. This specification describes the equipment and procedures to be used in the field survey. The equipment to be used will, to a large extent, determine the methods that are to be followed. The surveyor should be guided by experience, computations and the recommendations of the equipment suppliers in the development of this specification. Error analysis computations can be used to determine what accuracy can be expected with the procedures and equipment prescribed in the specification. The Surveyor is not expected to make these computations for every survey. The scope, extent, requirements and objectives of many surveys are of a repetitive nature and therefore the same specification can be used on similar surveys. The error analysis computations are completely discussed and examples are given in many surveying texts and printed articles.

The measurement specifications should be designed so that the accuracy of the measurements meet or exceed the positional accuracy required in the NSPS Standards. It is very likely that each Surveyor will have a specification for various sizes and types of surveys**.** In any event the Surveyor should know what accuracy he or she can expect with the procedures and equipment selected.

Survey measurement specifications must cover some of following items:

1. Periodic testing of EDM equipment over an approved base line.
2. Accurately taking into account atmospheric condition.
3. Periodic testing of optical plumbing.
4. Using the correct prism constant for the equipment.
5. Calibration and testing of steel tapes.
6. Examination and testing of the adjustment and performance characteristics of survey equipment and accessories to verify that the errors resulting from using them according to the Surveyor's procedures are within the error that the specifications allow.

7. Periodic adjustment of equipment by the surveyor or workshops specializing in such work, when examination and testing indicates a need for such adjustment or when good practice indicates that sufficient time has elapsed since the last adjustment.

C. Testing the completed survey

The Surveyor must check the survey work to assure that the intended accuracy is being achieved. Most standards in the past used relative error of closure as a measure of the quality of the survey. That was because many surveys were based upon traverse procedures. Many standards were issued by federal and other agencies for the same reason.

The Surveyor in private practice today performs many surveys that contain measurements that do not result in a closed traverse. This is a result of new equipment and changes in the computing capability available today. Relative error of closure is primarily a measure of the consistency of measurements, but it also can be a valuable tool in testing for accuracy.

Relative Positional Accuracy does not pertain to the location of a particular point or corner in the world but to the accuracy of the measurements used in the survey. Therefore a good test of the relative positional accuracy is to take check measurements of some of the distances in the survey.

The Surveyor should check his or her survey fieldwork by making redundant measurements whenever possible. This is not a new concept. It has always been one of the best ways to make sure that the fieldwork has met the quality that was expected. This does not mean that every survey must have a series of detailed checks. The Surveyor must realize that when a statement is made or inferred that the survey meets a specific standard, the Surveyor has the responsibility to be certain that it actually does meet that standard.

There are many opportunities to check the quality of the survey. For example, in laying out a rectangle (stake out of a building), one of the final checks the Surveyor will probably use before concluding that the work is correct is to measure and compare the diagonals of that rectangle. The Surveyor can easily compute the length of the diagonals and this can be compared with what was measured. In fact just comparing each of the diagonal measurements against each other is important. The allowable variation between the computed diagonal and the measured diagonal or the allowable variation between the two diagonals is a measure of the accuracy of the survey work. The variation should be less than the positional accuracy specified in the standard. The surveyor will also know from developing the measurement specification and from experience what variation can be expected, and anything that is greater than that value would cause the original measurements to be suspect.

There are many instances when distances are obtained by indirect measurements. For example a radial survey used to lay out the lot corners in a subdivision. The actual distance between the exterior corners and the corners of lots are not directly measured in the field. The Surveyor can check the quality of work by directly measuring some of the lines that were indirectly determined. When radial survey procedures are used the

Surveyor recognizes that the distances to be shown on the plat are indirectly determined. As many as possible of those indirect distances should be directly measured to check that the procedures have produced the required accuracy.

The positional accuracy standard is a yardstick by which the Surveyor can judge the quality of the work. The result of the Surveyor's comparison between the computed measurement and the actual measurement must be within the guidelines given in the standards. This comparison not only checks the quality of the distance measurements but also the quality of the angles.

An example of this type of a check is as follows:

The Surveyor uses a total station having an angle quality of 10 seconds (DIN) and a distance quality of 5 mm plus 5 ppm. One corner of the property is measured to be 100.00 feet from the instrument and the other is 200.00 feet. The angle between the corners is measured to be 20 degrees 0 minutes and 0 seconds. The distance between the corners is computed to be 111.41 feet. As a check the distance is directly measured and is 111.37 feet. The variation is 0.04 feet or approximately 0.08 feet at the 95 % confidence level. The required accuracy according to the Standards is 0.08 feet for Urban or 0.14 feet for Suburban Survey. The survey appears to be acceptable for both classes of survey.

The required procedure is to test the quality of the survey by making selected measurements and comparing those measurements with the intended or computed distances. It also stands to reason that the check measurements must have a quality at least equal to or better than the work that it is intended to be check.

Another application of positional accuracy can be seen in the following example:

The Surveyor is to measure a closed traverse having a total length of 1400 feet. The equipment used will be a total station having an angle accuracy of 5 seconds (DIN) and distance quality of 5 mm plus 3 ppm. The survey is to meet Urban Standards and therefore the required positional accuracy is computed to be 0.14 feet. The actual traverse closure is computed to be 0.05 feet and this is similar to a closure of 0.10 feet at the 95 percent confidence level of the NSPS Standard. The survey appears to be in compliance with the standards. If the actual closure had been 0.10 feet or 0.20 at 95% it would not have appeared to meet the standard. In this latter situation one of the diagonals should be computed and measured. The diagonal is computed to be 500 feet and the computed positional accuracy from the standard for an Urban survey will be 0.10 feet. Therefore the measured and computed diagonals should not vary by not more than 0.05 feet or ½ of the required value. If the Surveyor is using a computer program that adjusts the traverse by least squares it probably will analyze the traverse. The error ellipses from these programs should be compared for compliance with the positional accuracy standard.

D. Confidence levels

Most standards in use today are specified at the 95 percent confidence level. This means that if we have a measured distance of 1000 feet with stated reliability of plus or minus 0.10 feet at 95 percent confidence level we can be confident that a measurement of that line will be between 999.90 feet and 1000.10 feet 95 out of 100 times.

As an example, a Surveyor establishes two corners by a radial survey. The distance between the corners is computed and shown on the plat. As a check the Surveyor measures directly between the corners not once, but 100 times. The measurements are made on different days and under different conditions. If all corrections for systematic error are made, the average of those measurement probably approaches the correct length of that line and the standard deviation of those measurements is a good measurement of the accuracy of that distance. If the value of the standard deviation is 0.05 feet, then we would say that the line length is equal to the average distance, plus or minus 0.05 feet at the 68 percent confidence level. In other words, of the 100 measurements there could have been 32 measurements that differed by more than 0.05 feet from the average. At the 95 percent confidence level we can expect that there will be 5 measurements that are 2 times 0.05 feet or 0.10 feet more or less than the average distance. As a practical matter a Surveyor does not measure a line 100 times. The Surveyor makes one high quality check measurement. The Surveyor makes the assumption that this check measurement is the correct value. The difference between the correct distance and the calculated distance is assumed to be an approximation of the standard deviation. The 95 percent confidence interval value will be 2 times the approximate standard deviation. This double value is the value that is compared in the NSPS Standard**.** It must be pointed out again that the check measurements should be a very reliable measurement based on a specification that will provide accuracy above those being checked.

For many years experienced Surveyors have recognized a value that they considered an acceptable variation for their measurements in the field. This value is similar to the standard deviation, or a value at the 68 percent confidence level. Therefore this value is ½ of the value at the 95 percent confidence level that is used in the NSPS Standards. In other words, if the Surveyor's normally acceptable variation is 0.05 feet, that really is 0.10 feet at the 95 percent confidence level.

3. GEOSPATIAL POSITIONAL ACCURACY FOR SPATIAL DATA

A. Definitions

The Geospatial Position Accuracy shall be reported by positional accuracy as defined in two components: horizontal and vertical.

Horizontal Positional Accuracy is the radius of the circle of uncertainty, such that the true or the theoretical location of the point falls within that circle 95-percent of the time. Horizontal Accuracy may be tested by comparing the planimetric coordinates of surveyed ground points with the coordinates of the same points from an independent source of higher accuracy.

Vertical Positional Accuracy is a linear uncertainty value, such that the true or theoretical location of the point falls within the sum of the positive and negative ranges of that linear uncertainty value 95-per cent of the time. Vertical Accuracy may be tested by comparing the elevation of surveyed ground points with the elevations of the same point determined from a source of higher accuracy.

The development of geographic information systems (GIS) and global positing systems (GPS) has created the need for the development of the National Standard for Spatial Data Accuracy. These national standards speak to the quality of data developed in and for GIS applications. The standards apply to both geographic data developed from map products (photogrammetry) and from survey data to be used in a GIS.

B. Design of a measurement specification

The design of survey measurement specification is the responsibility of the Surveyor. The equipment and methods in this area of professional surveying is new and ever changing. The Surveyor should be guided by the latest published methodologies and the recommendations of the equipment manufactures. The Surveyor should develop methods to test procedures before they are used in an actual survey situation.

C. Testing the completed survey

The geospatial data set is tested by comparing the coordinates of several points within the data set to the coordinates of the same points from a control data set of greater accuracy. The points used in the test must be well defined and easy to measure both in the field and on the digital data product.

The control data set must be of a higher quality than the data being tested. It is best that the quality of the control data set be at least twice as accurate as the expected accuracy of the data set being tested. The control data set should uniformly cover the area of the data being tested and there should be a sufficient number of points to determine valid results.

The positional accuracy statistic is computed for the data being reviewed. This statistic is a value for all the data not for individual data. It is actually the Root Mean Square Error (RMSE) for the data. The value of the statistic is compared with the positional accuracy value in the standards.

The following example illustrates the testing of this kind of data. A Surveyor is employed to provide the location of sewers (manhole lids) to a city for the inclusion in a Geographic Information System (GIS). The data to be provided is the state coordinates of the manholes. The coordinates are to be obtained by a combination of methods including GPS, total stations and laser ranging. This data is to meet the standards for a base mapping scale of 1” = 100’. In order to check compliance with the standards a higher accuracy GPS survey is conducted. The coordinates of some of the manhole covers determined in the GIS project are determined by this check survey. The GPS procedures used in the check survey should be designed to produce accuracy at least in the 0.10 feet range at 68 percent confidence level. The difference between the x and the y coordinates for the GIS data and the check data are determined. The difference in the x and y coordinates is squared and added together. The average of these values is computed. The square root of the average is the RMSE and is used to calculate the statistic for the data set. The RMSE value is multiplied by 1.7308 to obtain the accuracy statistic value at the 95% confidence level used in the standards. Note that there should be enough test points to have a statistically correct result.

As an example: One inch equal 400 feet base maps for a county level GIS were checked for compliance with the standards. The coordinates of points on the maps were compared with high quality GPS coordinates of the same points. Thirty three (33) points were used in the test and the RMSE was calculated to be 6.53 feet therefore the geospatial horizontal accuracy statistic was 11.30 feet (1.7308*6.53). The allowable geospatial horizontal accuracy statistic for this project was 13.48 feet. The project was accepted as meeting the accuracy standard for 1"= 400' mapping.

4. GEOSPATIAL POSITIONAL ACCURACY FOR GEODETIC NETWORKS

A. Definitions

The national standard is published by the FGDC as the Draft Geospatial Positioning Accuracy Standards, Part 2: Standards for Geodetic Networks - December 1996. These standards define the accuracy that is to be evaluated. They are as follows:

The **local accuracy** of a control point is a value expressed in centimeters that represents the uncertainty in the coordinates of the control point relative to the coordinates of other directly connected, adjacent control points at the 95- percent confidence level.

The **network accuracy** of a control point is a value expressed in centimeters that represents the uncertainty in the coordinates of the control point with respect to the geodetic datum at the 95- percent confidence level.

B. Design of a measurement specification

For a detailed description of this standard please refer to the FGDC standard.

C. Testing the completed survey

Accuracies of geodetic control surveys are tested by the results of a minimally constrained, least squares adjustment of the survey measurements. Both the local accuracy and the network accuracy should be reported for horizontal control, ellipsoidal height and orthometric height. For details see the FGDC standard.

Section H
STANDARDS REFERENCES
Approved 3/12/02

I. TEXTS

Analysis and Adjustment of Survey Measurements, by Mikhail and Gracie, 1981.

Errors in Practical Measurements in Science, Engineering and Technology, by Bro. Barry 1978.

Adjustment Computations, by Paul R. Wolf, 1980.
Urban Surveying and Mapping, by Blachut, Chrzanowski, Saastamoinen, 1979.

Evidence and Procedures for Boundary Location, by Brown and Eldridge, 1967.

Surveying Measurements and their Analysis, by R.B. Buckner, 1983.

II. ARTICLES

"Positional Tolerance in Land Surveying", by David Tyler, Journal of Survey Engineering October, 1987.

Principles of Error Theory and Cartographic Applications: Technical Report No 96. United States Air Force aeronautical chart and information center St Louis MO. By C.R. Greenwalt and M.E. Shultz.

III. STANDARDS

Standards and Guidelines for Cadastral Surveys using Global Positioning System Methods, US Forest Service and Bureau of Land Management. April 28, 2000.

Standards and Specifications for Cadastral Control Surveys, Bureau of Land Management, March 1989.

Implementing the National Standard for Spatial Data Accuracy, Minnesota Governor's Council on Geographic Information, GIS Standards Committee, October 1998

American Society for Photogrammetry and Remote Sensing (ASPRS) Specification and Standards Committee. 1990. "ASPRS Accuracy Standards for Large Scale Maps." *Photogrammetric Engineering & Remote Sensing.* Washington, DC. V56, no7,pp 1068-1070.

Federal Geographic Data Committee. 1998. *Geospatial Positioning Accuracy Standards; Part 3:* National Standards for Spatial Data Accuracy FGDC-STD-007.3. FGDC. Washington D.C.

Federal Geographic Data Committee. 1998. *Content Standards for Digital Geospatial Metadata (version 2.0)* FGDC-STD-001. FGDC. Washington, DC.

Best Practice Guidelines – Use of the Global Positioning System (GPS) for Surveying Applications from Australia and New Zealand