Pennsylvania Geospatial Data Sharing Standard (PGDSS)

Version 1.0
October 2004

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1.0 Foreword

This initial version of the Pennsylvania Geospatial Data Sharing Standard (PGDSS) is the result of a multi-year effort by a large and dedicated group of volunteers. The PGDSS is largely derived from labors of the Pennsylvania Mapping and Geographic Information Consortium (PaMAGIC). PaMAGIC, beginning in 1999, produced a GIS Best Practices Handbook to guide the development of spatial data by local governments within the Commonwealth. The Best Practices Handbook provided a set of framework data descriptions, development methods, and content standards to be used by jurisdictions as they built or updated spatial data.

The establishment of the Pennsylvania Map (PAMAP) portion of the USGS National Map led to a renewed effort to define how PAMAP data would be developed and shared, particularly among the different levels of government in the Commonwealth. PaMAGIC extended the efforts of the Best Practices Handbook data content standards to provide an initial data standard for PAMAP. PaMAGIC was joined by the Pennsylvania Geospatial Information Council (PAGIC) and other volunteers in revising and refining these standards. Under the direction of the Director of Geospatial Technologies, Office for Information Technology, Governor's Office of Administration, the standards were finally distilled into the Pennsylvania Geospatial Data Sharing Standard.

The PaMAGIC Presidents, Boards, and members have worked diligently to produce this standard and promote interoperability. They have been aided and joined by many other groups and individuals, from PAGIC and the PAMAP Office at the state level, FGDC at the federal level, numerous counties and municipalities, other governmental organizations, educational institutions, and GIS businesses. Additional information on PaMAGIC and the standards process can be found at the PaMAGIC website, http://www.pamagic.org. The following provides a more detailed history of PaMAGIC and the Best Practices Handbook, precursor to the PGDSS.

What is PaMAGIC?

PaMAGIC is a 501(c)(3) not-for-profit Pennsylvania corporation that provides leadership and offers guidance in the establishment of Geographic Information Systems (GIS) throughout the Commonwealth of Pennsylvania. The activities of PaMAGIC are guided by a volunteer board of directors who are nominated by the general membership. Board members have managerial and technical experience in geographic information systems. PaMAGIC directors and members are employed by firms engaged in consulting, engineering, software publishing, surveying; and by county GIS departments, universities, utility companies, professional and membership associations, municipalities and municipal authorities, and by departments and bureaus in county, state and the Federal governments. Membership is open to any individual that is interested in helping Pennsylvania to become a leader in the deployment of GIS technology.

The concept leading to the formation of the Pennsylvania Mapping and Geographic Information Consortium originated in May 1996 at the PA GIS Conference in Harrisburg, PA. Approximately 200 persons attended a Conference session dedicated to discussing the need for GIS coordination and standardization within the Commonwealth. The strong interest voiced at the Conference led to a series of organizing meetings held at the Penn State Harrisburg campus during the summer of 1996. Approximately 250 people convened and elaborated goals and objectives of the proposed group. Later in the summer a sub-group of about 60 individuals met to define the organization further, to name it, and to select an interim board of directors. The vision of PaMAGIC is:

> **The Citizens of Pennsylvania will have a coordinated, flexible, and integrated geographical information infrastructure to support better decision making and more efficient use of limited resources.**

A guiding principle of PaMAGIC is to facilitate and encourage the exchange of spatial data between local, regional, and state governments in order to reduce redundancy in mapping to the benefit of taxpayers in the Commonwealth. It is not uncommon for state agencies, regional councils of governments, and county governments to acquire and maintain digital spatial data at various resolutions. Aside from politics and lack of a coordinated funding mechanism in Pennsylvania, there is no reason why key land base layers cannot be mapped at the larger scales required by local governments and shared between local, regional, and state government agencies. While it might be a long time for this level of coordination and cost sharing to become a reality in Pennsylvania, a beginning step is the development of a common framework for the exchange of spatial data sets.

What is the Best Practices Handbook?

The original goal of the Best Practices Handbook was to compile recommendations for building a spatial data framework to enhance interoperability (data sharing) among counties in the Commonwealth of Pennsylvania. The Handbook was inspired and guided by the PaMAGIC mission:

> **To provide leadership, coordination, and guidance to enhance the development, use, and access to spatial information and related services in Pennsylvania.**

Considering there are 67 counties and 2,571 cities, townships, and boroughs (per the 1990 Census) within the Commonwealth of Pennsylvania, there is great opportunity for incompatibility and inconsistency to evolve among local government spatial datasets. This would be tragic, since local governments are responsible for managing information that is of high importance to emergency response, economic development, and inter-municipal and regional planning such as land use and zoning, regional watershed management, and transportation studies. Recent emphasis on homeland security also argues for a common framework enabling rapid exchange of interoperable spatial data sets. Fortunately, many local governments are still in the early phases of GIS implementation and there is an opportunity to evolve coherency and consistency in the way spatial data sets are structured and formatted in order to facilitate data exchange. This concern of evolving spatial data incompatibility, coupled with the realization that there is still time to act, led to the Best Practices Handbook.

The Handbook was developed by experienced GIS managers and technicians to:

- assist Pennsylvania jurisdictions in development of their respective geographic information systems and take advantage of the common experience to avoid mistakes,
- facilitate interoperability (data sharing) among jurisdictions at various levels of system development,
- reduce duplication of effort and inefficient use of limited resources for such activities,
- assist in the development of consistent content, format, and exchange standards for digital geographic information users within the Commonwealth,
- establish a baseline of data elements across the Commonwealth.
- assist and encourage local jurisdictions in the acquisition and maintenance of new GIS land bases from primary sources, and converting local data such as zoning and tax parcels to fit to the new land base,
- develop consistency in local government data sets to facilitate response and regional studies across municipal and county lines.

PaMAGIC conducted a series of "Best Practices Convention" meetings beginning in early 2000, to respond to the pressing need of developing best practices for system interoperability at the local level. The intent of the meetings was to develop the minimum mapping and key attribute requirements for spatial data sets acquired from primary sources such as photogrammetry and Global Positioning Systems (GPS). For this reason initial topics included: scale, resolution, metadata and projections, parcels, roads, hydrology and addressing. Meetings began with a general assembly to review the current status of the handbook and then were followed by break-outs into technical groups that focused on specific topics. Technical groups were encouraged to research, reference, and incorporate existing standards by federal agencies and professional associations wherever possible. Most meetings were held at the Penn State University campus in State College, PA. A series of eight Town Meetings were convened in the fall of 2000, held throughout the Commonwealth, to ensure the broadest possible input from GIS users. These meetings were jointly sponsored by PaMAGIC and PAGIC, and were facilitated by the PA Department of Environmental Protection.

Revisions were made to the Handbook following the Town Meetings based on comments from the meetings and other reviews. The Handbook was edited and formatted during the first months of 2001. The first edition of the Best Practices Handbook was introduced in digital form just in time for the 2001 PA GIS Conference, where copies were distributed.

It must be emphasized that the Handbook was not released as a set of data standards to be met by everyone, but rather as a collection of best practices, based on extensive experience at the local level, that could guide local governments and other data developers as they put layers together. The Handbook was described as a living document, which it remains now, meaning that it would be updated and revised on a periodic basis based on comments and evolving standards and practices such as NSDI and Geo-Spatial One-Stop. PaMAGIC designated Chairpersons or leaders for each data layer. These leaders were tasked with receiving and reviewing comments, and monitoring layer standards as they evolved elsewhere. Each leader provided updates to the layer documentation as needed throughout 2001 and 2002.

As mentioned earlier, the PAMAP program began to build in the Bureau of Topographic Survey of the PA Department of Conservation and Natural Resources. It was recognized that PAMAP and the Best Practices were complementary activities, and PaMAGIC was tapped to modify the Best Practices to serve as a data content standard for the framework data layers of PAMAP. The intent of the PAMAP standard was to provide a consistent and usable set of layer attributes for data going into PAMAP from local and state government data developers, and coming out of PAMAP to data users. PaMAGIC distilled the Best Practices into a minimum set of standards for PAMAP during 2003.

The position of Director of Geospatial Technologies in the Office for Information Technology, Governor’s Office of Administration was established in late 2003. The Director was tasked with coordinating GIS activities at the state level, and a major point of emphasis was collaboration and cooperation with all levels of government. The PAMAP standards were seen as an important element in this coordination. A concerted effort was made, in conjunction with PaMAGIC and PAGIC, to complete a first version of the PAMAP standards in early 2004. A workshop was held to further refine the standards while also defining how the data would be used across governmental levels and jurisdictions. It was also recognized that the standards would serve a bigger purpose than for PAMAP; thus they were named the Pennsylvania Geospatial Data Sharing Standards to more accurately define their role in Commonwealth GIS usage.

PaMAGIC and all of the other participating organizations and individuals can be proud of what was achieved during all those months and years of dedicated volunteer effort. This first version of the Pennsylvania Geospatial Data Sharing Standard represents a milestone in the vision of a ‘coordinated, flexible, and integrated geographical information infrastructure’.

2.0 Introduction

2.1. Message from the State GIS Coordinator

For several years, Pennsylvania GIS practitioners from across all segments of the industry have been clamoring for the implementation of The Pennsylvania Map (PAMAP) program. This program, defined as a cooperative collaboration between local governments and state agencies, calls for new digital aerial photography to be collected by the state and provided to local governments. In turn local governments would then share their accurate and current vector GIS data layers back to the state on a regular basis. The concepts of the PAMAP program continue to be supported and promoted by state agencies, the Pennsylvania Geospatial Information Council (PAGIC), and the Pennsylvania Geographic and Mapping Information Consortium (PaMAGIC).

Several events in the past eighteen months have helped to make PAMAP a reality and get the program off the drawing board and into action. First, an attempt was made by PAGIC and PaMAGIC to educate and garner support from Governor Rendell's transition team by the creation and delivery of a white paper on the program called "PAMAP: A Next-Generation GIS Basemap for the Commonwealth of Pennsylvania". On May 15, 2003, a meeting of the House Subcommittee on Veterans Affairs and Military Preparedness raised additional awareness for PAMAP and the concept of using more accurate and current local data at the state level.

The Department of Conservation and Natural Resources (DCNR), through the Bureau of Topographic and Geologic Survey (Topo/Geo), was able to acquire imagery through a USGS contract mechanism that meets the PAMAP accuracy definition in 2003 for ten counties. The Department of Environmental Protection (DEP) and the Department of Transportation (PENNDOT) provided some modest funds to help pay for the imagery acquisition in 2003, demonstrating the commitment of state agencies to the cooperative spirit required for PAMAP.

Gov. Rendell's administration has officially recognized the importance of GIS and Geospatial Technologies to the Commonwealth and created an official State GIS Coordinator position in October 2003 to provide for leadership and coordination that is necessary to ensure the success of statewide GIS initiatives such as PAMAP. This position was created in the Office for Information Technology in the Governor's Office of Administration, giving it credibility and organizational support as part of the centralized Information Technology (IT) office for the state.

For years, state agencies have created and tried to maintain statewide GIS data sets for transportation, hydrography, other infrastructure assets, and natural resources. When many agencies started using GIS technologies more than a decade ago, this was a prerequisite to using GIS analysis tools, because most county and local government organizations had not implemented Geographic Information Systems. In fact, state agencies provided many of the first counties who adopted GIS technology with their initial data sets as subsets of these statewide data sets. Most of the statewide datasets originated by digitizing 1:24,000 USGS Topographic Quad Sheet maps, which took years to accomplish.

Today, a majority of counties in Pennsylvania are using GIS and Geospatial Technologies to collect, update, and manipulate countywide GIS data layers. Counties are faced with many of the same challenges as state agencies in keeping their business-driven GIS data layers current, and have adopted new technologies and built mission-critical databases to make their jobs easier. Public works, property tax assessment, and emergency services offices tend to be the primary users of GIS data and technologies in the county government organizations. Each of these offices has a common need for addressable road centerlines, parcel databases, hydrography, and other countywide GIS data layers.

Counties typically use digital orthophotography to create and maintain their GIS data layers. The scale of the collected imagery varies from 1”=400’ map scale (1:4,800 relative scale or 4’ pixels) to 1”=50’ map scale (1:600 relative scale or 6” pixels). Most imagery used today is still airborne-derived as opposed to satellite photography, due to the limits of imagery resolution provided today by most satellite sensors. In the next few years, satellite imagery sensor technology will improve to the point that satellite imagery can be collected with the same ground resolution accuracy as airborne digital imagery.

Establishing a cooperative and collaborative program that facilitates data sharing between counties and the state is a difficult and challenging prospect. The state has no jurisdiction to enforce county participation, so we need to find ways to encourage counties to participate in the PAMAP program voluntarily. In addition, for PAMAP to truly be successful, we need to find ways to build and maintain sustainable GIS capabilities in those counties that have no GIS operations today. Otherwise, we will end up with a partially-completed statewide dataset with some county data, but with varying levels of accuracy and currency. This cannot be allowed to happen.

The final issue related to PAMAP in this discussion is that the state does not have the capability nor capacity to combine sixty-seven different data formats for each of the defined PAMAP data layers into one comprehensive statewide GIS layer database. Therefore, we must establish a common data standard to facilitate data sharing. PaMAGIC has played a primary role in working to establish data standards, starting with the PaMAGIC Best Practices Handbook. This evolved into the PAMAP Data Standards draft document and efforts that have been accomplished in the past two years.

To finalize the data standards, a decision was made to change the name of the standards. This was done for several reasons. The first was due to the issue that when PAMAP was being discussed, it was unclear if the discussion was about the collaborative imagery collection and data sharing program between the state and the counties or the related data definitions initiatives. Also, it is the general feeling of the State GIS Coordinator that the Geospatial Data Sharing Standards will be a much broader initiative than the PAMAP imagery collection and creation of the foundation data layers defined in this initial standards document that will directly support The National Map Program initiatives of the USGS.

The result is the creation and publication of this document, the Pennsylvania Geospatial Data Sharing Standards, version 1.0 (PGDSS v.1.0). We have separated the standards from the PAMAP program, recognizing that the success of the PAMAP program requires the use of data standards to facilitate the desired data sharing. The name of the standard also addresses the fact that most counties today have already defined database record and field definitions for many of these data layers already, and the standard will not supplant their production system data definitions. Instead, it is expected that on a cyclical basis, the counties will execute some data utilities that transform their county-specific production system data records into PGDSS standard record formats.

Local government support for PGDSS will have several significant benefits. First, it will allow a county to share data with their respective municipalities. Municipalities and counties will be able to share data with their adjacent counterparts, across the political borders that hamper many of these capabilities today. The business community should also benefit from the adoption of a set of data sharing standards by potentially enabling some new applications to be created that can be used in multiple counties and municipalities using the standard data definitions. Finally, the state will benefit from the use of more accurate and current data provided by the local government community.

As Pennsylvania's first State GIS Coordinator, it falls to me to help make the PAMAP program and the PGDSS data standards become a reality. Both of these initiatives are critical to changing how GIS and Geospatial Technologies are used in Pennsylvania in support of the Governor's initiatives and making state agency and local government GIS operations more efficient. Jay Parrish and I will continue to work on funding for imagery for PAMAP and my office will take responsibility for the data standards.

2.1.1. Bureau of Geospatial Technologies

The Bureau of Geospatial Technologies will be a new Bureau in the Office for Information Technology, in the Governor's Office of Administration. The position reports directly to the Deputy Secretary for Information Technology, currently Art Stephens. The Director works in close coordination with the Director for Enterprise-wide projects, currently Kristen Miller, and the Director for Enterprise Architecture, currently Jem Pagán.

The Bureau of Geospatial Technologies has developed several guiding principles related to GIS and Geospatial Technologies:

- Create data once, use it a bunch
- Reduce overlap and duplication of efforts
- Provide Homeland Security support
- Create and communicate standards initiatives
- Provide leadership, coordination, and governance
- Maintain current knowledge of agency operations and business
- Participate in enterprise projects and make them successful

- Develop an enterprise strategic plan
- Identify, prioritize, and build enterprise assets and resources
- (e.g. imagery, geocoding solution)
- Promote strategic sourcing and enterprise licensing for commercial data and software
- Seek sustainable funding sources and achieve sustainability of operations
- Manage contracts actively and effectively
- Support the Governor's initiatives
- Communication is critical to the mission

The Bureau of Geospatial Technologies will have the primary responsibility and ownership of the Pennsylvania Geospatial Data Sharing Standards (PGDSS) document and will have ultimate authority for encouraging their use throughout the Commonwealth. The Bureau will also be a partner with the Topo/Geo PAMAP Program Office and will assist with planning, prioritization, strategy, and funding.

Finally, it is important to note that the mission of the Office for Information Technology has determined that its customers include all parties in the extended enterprise, including federal, state agency, local government, academic, and private industry partners. This creed will actively be supported by the Bureau of Geospatial Technologies in all of its various endeavors.

2.2. PGDSS Layers and Document Sections

2.2.1. Layers in Version 1.0

The PGDSS Version 1.0 data layers are:

1. Road Centerlines
2. Other Transportation
3. Parcels
4. Geodetic Monumentation
5. Buildings
6. Elevation
7. Hydrography
8. Orthophotography
9. Political Boundaries
10. Names

These layers were selected due to their role in the National Map program, of which PAMAP is a part. The Version 1.0 review process may identify additional data layers that could become part of later versions of the PGDSS.

2.3. Document Sections

Each layer standard contains the following sections:

1. Subject Discussion – a general discussion of the layer, its importance, benefits, development and maintenance issues, etc.
2. Use Cases – comprised of a table indicating how the data might be used by various entities, and the data needed to support the use.
3. Recommendations – the layer recommendations, including spatial organization of the layer and required or recommended fields (attributes).
4. Responsibilities – discussion of what entity or entities are responsible for data development and maintenance. This section is intended to be started as part of Version 2.0.
5. Definitions – a glossary of terms associated with the layer. This section is intended to be started as part of Version 2.0.
6. References – a listing of references cited in developing the standard.

2.4. Roles and Responsibilities for PGDSS

2.4.1. Role of PGDSS

PGDSS is a ***conversion*** data standard. It is not intended to be a production data standard for most organizations. Many county governments have already defined data naming conventions and created record definitions that meet their 67 individual and different business processes. They will not be willing to abandon their data definitions and adopt the PGDSS data definitions for their production systems. It is also defined as a minimal data standard, in that only those fields that have been deemed necessary for the common good have been included. For those counties that do not have established and sustainable GIS operations today, it may be easier to adopt the PGDSS data definitions as a base and augment the initial data records with county-specific business fields. This makes the conversion and state submission much easier, and may facilitate starting GIS operations where they do not exist today. Standards may also provide the business community with new opportunities to create products that meet the needs of local governments for asset management, data collection, etc.

2.4.2. Responsibility for PGDSS

PGDSS encompasses all levels of data producers and users in the Commonwealth. Data producers translate their data into the PGDSS format for use by others. Data producers can be municipalities, counties, state agencies, federal agencies, vendors; any organization that creates or maintains information associated with one of the PGDSS layers. Data users translate data from the PGDSS format to use in their own operations. Data users will be the same organizations, as well as other groups and the public; any organization or individual that uses geospatial data.

No single entity in the state will be responsible for implementing PGDSS methods and procedures; rather, each data producer and user will take on their appropriate role. Different data producers may be responsible for different portions of a single data layer. The data creator may be different from the data maintainer. It is anticipated that data translation routines for moving data in and out of the PGDSS format will be developed, but by whom is yet to be determined. Some municipalities or counties may develop their own translators; others may rely on translators developed by the PAMAP program or a state agency.

These roles and responsibilities have only begun to be defined. Some of them may be identified during the PGDSS review process, and the PGDSS update process will incorporate those definitions. Other roles may be identified in other initiatives, including the GIS Strategic Plan for the Commonwealth. This definition process will play a large part in the ultimate acceptance of PGDSS.

2.5. PGDSS Review and Comment Procedures

2.5.1. Review Timeline

Review of Version 1.0 by stakeholders, organizations, or individuals will begin upon release of Version 1.0 in late October 2004. The review and comment period will be open until December 17, 2004.

2.5.2. Comment Submissions

The comment form and instructions for completing the form are provided below. There will be digital copies available at www.pamagic.org as well as other sites, yet to be determined.

Where to return comment forms:

Please send all digital responses to standards@pamagic.org. Hard copy submissions may be faxed to 717-399-7015, however digital responses are preferred. Please return the forms as email attachments in Microsoft .doc or .xls format, if possible.

Form instructions:

Name of individual submitting comments: Please put your name in this field. This will allow the reviewers to know who to contact if there is a question regarding a comment.

Contact information: Please provide an email address and/or phone number where the reviewer can reach you, depending on how you would prefer to be contacted should the need arise,

Date: Fill in date of the comment submission. Please use format dd/mm/yyyy.

Comment type: Please use one of the following categories for each comment:
G = Grammatical (spelling, punctuation, typo, etc.).
T= Technical (where you have a comment regarding the technical aspects of the document).
S= Scope (where you have a comment regarding the subject matter discussed in a section).

Section number: Please fill in with the specific section the comment addresses (ex., 1.1.2)

Section title: Please fill in with the name of the section the comment addresses (Address attribute for road centerlines)

Comment: Please fill in with a detailed description of your comment. Be as specific as you can so the reviewer will be sure to clearly understand the intent.

Suggested Change: Please provide a suggestion as to how your comment may be implemented.

Questions:

Please address any questions regarding PGDSS and the comment process to:

Chris Markel
PAMAGIC President
cmarkel@atsincorp.com

2.5.3. Comment Form

The following table is a copy of the comment form. It may be copied to another document to be used for comment submissions. The form is also provided at the end of this document.

<table>
<tr><th colspan="5">PGDSS Comment Submission Form</th></tr>
<tr><td colspan="3">Name:</td><td colspan="2">Contact information:</td></tr>
<tr><td colspan="3">Date:</td><td colspan="2">See Comment Submission Instructions for help filling out this form</td></tr>
<tr><th>Comment Type</th><th>Section Number</th><th>Section Title</th><th>Comment</th><th>Suggested Change</th></tr>
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2.6. PGDSS Next Steps

Upon completion of the review and comment period, PGDSS volunteers, Subject Matter Experts (SMEs), and document compilers will gather, record, and sort all submitted comments. The SMEs will be responsible for reviewing comments and determining how they apply to the standard. Pertinent standards from other sources such as FGDC or other states will also be reviewed. The SMEs, volunteers, and compilers will then determine how each layer standard should be amended or updated, and make the appropriate changes. These changes will begin to be made in January of 2005, and this work is expected to continue through March of 2005. A draft Version 2.0 document will be produced at that time for review, with revisions of the draft scheduled to be completed by the end of April 2005. The final PGDSS Version 2.0 will be presented at the Pennsylvania GIS Conference in May of 2005, as well as at other meetings through the summer of 2005.

3.0 Road Centerlines

3.1. Subject Discussion

Accurate, measured, and addressable road centerlines can greatly enhance the business processes of many organizations and businesses in the Commonwealth. Creating and maintaining attributed road centerlines in the PGDSS format have many uses.

In order to take advantage of these and other uses, data creators and maintainers should assign the following attributes to each segment of a road centerline (intersection to intersection).

3.2. Use Cases

Use Case	User	Data Needs
Address Geocoding		• Warrant serving • Emergency services • Crime analysis • Public health analysis
Linear Measurement Event Modeling		• Security type • Roadway maintenance activities • Roadway projects • Corridor studies • Safety analysis • Traffic analysis • Roadway management
Routing		• Emergency services • Warrant serving • Meals-on-wheels • Para transit • Towing services • Plowing • Refuse pick-up
Cartography		• Planning • Asset inventory

3.3. Recommendations

3.3.1. Unique Identifier

In a complete road centerline layer (all roads for the Commonwealth), each segment or object must be unique. A unique identifier must be maintained for all segments or objects of a road centerline data set, and this identifier must be constructed in a way to ensure state wide uniqueness when data sets are combined. A combination or concatenation of the STF, COF, MCF, and RDSEGID fields serves to ensure uniqueness across all jurisdictions.

Name	Type	Definition
STF	2 alpha	Federal Information Processing Standard (FIPS) code for state. Code for Pennsylvania is 42 (required)
COF	3 alpha	FIPS code for county road centerline is located in. Defined as character to preserve leading zeros (required). Roads must be split at boundaries to reflect multiple county addressing. If a road lies directly on a boundary, the left and right sides should reflect the appropriate county.
MCF	5 alpha	FIPS code for municipality road centerline is located in. Defined as character to preserve leading zeros (required). Can be '00000' provided municipality is not a practical unit of government (For example, Philadelphia)

If a road segment defines a boundary between two states, two counties or two municipalities, it should arbitrarily be assigned a FIPS code for the state, county, or municipality with the higher FIPS code value.

Name	Type	Definition
RDSEGID	8 alpha	A unique segment identifier (required). This is a unique integer number stored in character format using only characters zero through nine. No two segments within a single entity boundary composed of a combination of STF, COF and MCF will have the same RDSEGID number.

Unique key will consist of concatenated stf+cof+mcf+rdsegid. This still does not insure unique name or jurisdiction. Include emergency service number/zone (esn or esz) left and right to do that.

3.3.2. Address Attributes

The National Emergency Numbering Association (NENA) standard for address related attributes is used to provide a complete definition of all required and optional attributes associated with a centerline segment. Each of these attributes can have an alias field name applied to accommodate software-specific needs or practices.

Name	Type	Definition
LLO	10 digit numeric	Lowest address on the left side of street segment.

Name	Type	Definition
LHI	10 digit numeric	Highest address on the left side of street segment.
RLO	10 digit numeric	Lowest address on the right side of street segment
RHI	10 digit numeric	Highest address on the right side of street segmen
PRD	2 alpha	Street name directional prefix [N, S, E, W, NE, NW, SE, SW
STN	60 alpha	Street name
STS	4 alpha	Street suffix (use USPS Publication 28 for street type abbreviations)
POD	2 alpha	Street name directional suffix [N, S, E, W, NE, NW, SE, SW]
MODIFY DATE	8 digit numeric	Created in YYYYMMDD format
SOURCE	25 alpha	Agency creating the data, acronyms are not acceptable

3.3.3. Roads Forming Boundaries

Attribute items to identify roads that form county or municipality boundaries.

Name	Type	Definition
MCL	35 alpha	Name of municipality on left side of street segment
MCR	35 alpha	Name of municipality on right side of street segment
ESNL	8 alpha	Combined state (2 character) and county (3 character) FIPS codes for county plus ESN on left side of street segment
ESNR	8 alpha	Combined state (2 character) and county (3 character) FIPS codes for county plus ESN on right side of street segment
MUNI	5 character	FIPS code for municipality that has jurisdiction for the road

ESNR/L will require a table of emergency service providers that service the ESN. ESN's are limited to three characters by telco's but the format of these fields could change if there were a state wide format developed. Emergency service information can be submitted in a database table.

3.3.4. PennDOT Data Attribute Fields

In most cases, the following attributes will not be added at the local level unless the data producer is familiar with dynamic segmentation models used by PennDOT. In no case should this data be submitted when the local producer has made alterations to PennDOT assignments to these segments.

Name	Type	Definition
NLF_ID	10 digit numeric	PennDOT's unique route identifier used for purposes of building a dynamic segmentation model
NLF_BGN	10 digit numeric	PennDOT's cumulative measure in feet
NLF_END	10 digit numeric	PennDOT's cumulative measure in feet

ST_RT_NO	4 alpha	The PennDOT state route number designation.

3.3.5. Road Characteristics

The following attributes provide indicators of traffic properties of road segments. Codes provided are only for example; they must be further developed based on state or national needs.

Name	Type	Definition
RLane	2 digit numeric	Number of traffic lanes
RType	3 alpha	Type of road. For example: a. 1U one way, unlimited access, b. 2L bidirectional, limited access (East Bound I80), c. ML limited access, controlled direction (direction depends on time of day such as express lanes)

3.3.6. Homeland Security Infrastructure Program Property Fields (HSIP)

The USGS and the National Geospatial-Intelligence Agency (NGA) have created a Homeland Security Infrastructure Program (HSIP) set of roadway and other feature attributes. If captured, HSIP data should be submitted to the PA Department of Homeland Security/PA Emergency Management Agency or designee. It is expected that PENNDOT may be responsible for adding HSIP information to the PAMAP roads layer. For more information and an attribute listing contact the Mitre Corporation at www.mitre.org.

3.4. Responsibilities

Responsibilities for creation and maintenance of layer features and attributes must be defined.

3.5. Definitions

Definitions of layer terms (glossary) should be developed if needed.

3.6. References

1. Road Data Model Content Standard and Implementation Guide - Working Draft. October 28, 1998. Federal Geographic Data Committee (FGDC).

2. *NSDI Framework Transportation Identification Standard* – Working Draft: Ground Transportation Subcommittee, Federal Geographic Data Committee. December 2000. http://www.bts.gov/gis/fgdc/web_intr.html

3. *Road Centerline Spatial Data – Interim Standard.* Part 2: Standards - Section G. VGIS Handbook, Vermont Geographic Information System. Copy is available in acrobat pdf format at http://geo-vt.uvm.edu/cfdev2/Library/handbook/standards/partii_section_g.pdf

4. *Linear Referencing Practitioners Guide Book*, March 1999, Federal Highway Administration (FHWA).

5. National Emergency Number Association (NENA), http://www.nena9-1-1.org. For E-911 related standards regarding address elements for road centerlines was extracted from NENA-02-010 Exhibit 22 Version 1.0 GIS Data Model Format, Table 22.3 Line Data, (pp.68). A copy of the standard can be obtained from http://www.nena.org/9-1-1TechStandards/Standards_PDF/NENA_02-010.pdf

4.0 Additional Transportation Layers

Additional transportation layers include rail, air, and transit. These standards must be developed. The Bureau of Transportation Statistics, U.S. Department of Transportation, has developed draft data content standards as part of Geospatial One-Stop and FGDC initiatives.

5.0 Parcels

5.1. Subject Discussion

1. A number of benefits are derived by developing consistency in the structure of a tax parcel layer to facilitate data exchange:
   - Allows rapid exchange of parcel data in a timely fashion to address cross border emergency dispatch and evacuation.
   - Enables regional land use and zoning studies for better coordination of development, transportation infrastructure, and green space planning.
   - Allows assessment of potential or actual impacts before or after natural or man-made disasters.
   - Provides for better coordination of taxation for lots crossing county lines, where the lot is taxed in one of the two counties.

2. The goal of these recommendations is to achieve a continuous statewide layer of land ownership showing current property lines and a minimum set of tax parcel attribute data that can be used to achieve the above objectives.

3. These recommendations include development of a consistent statewide Geographic Parcel Identifier or GPIN based on the geographic coordinates of a lot's center. There are several primary benefits of a GPIN:

   - Frees organizations from being tied to an arbitrary map sheet layout that is prone to change.
   - Facilitates joining data from multiple counties by providing a standard formatted unique primary key across the state.
   - Can be used to link to any County's assessment records.
   - Provides a means of determining the lot's location by virtue of the geographic coordinate.

4. The GPIN recommendation is not intended to replace or supersede the Parcel Identifier presently used by the local Tax Assessment agencies, which frequently consists of concatenated Municipality, Map, Block, and Lot numbers. For this reason, a separate PIN data item is also included in the recommendations.

5. According to Pennsylvania law, the legal description for a property boundary is the property deed. A tax parcel layer should be viewed as a graphical representation the property's location, not the legal description.

6. Some counties draft the property boundary according to the deed description, which in some cases results in property boundaries extending into the centerline of a road. This results in a tax parcel layer in which it is difficult to identify the road right-of-way system because it is contained within the lots. Other counties uniformly draft the tax parcel

boundary to a road right-of-way (regardless of what the deed says) in order to show approximate property location relative to the road right-of-way system. Any statewide tax parcel layer will contain both types of representation.

5.2. Use Cases

Use cases for parcels must be developed.

5.3. Recommendations

5.3.1. Spatial Data

1. At a minimum, tax parcels should be represented as polygon topology. In the event that some local governments may choose to use other data models such as regions to represent tax parcel geometry, the tax parcel layer should be capable of being converted to polygon features.

2. While local governments might choose to convert and maintain easement and road rights-of-way embedded within the tax parcel layer or as separate layers, it is imperative that the design does not preclude the ability to extract and transfer polygons representing tax parcels separate from easements and rights-of-way. Easement and road rights-of-way can exist and be submitted as separate layers.

3. Because it is unlikely that parcels will perfectly edge match across political boundaries and that multiple properties may occupy the same space data will be exchanged in ESRI shape files using a region model.

4. Data provided for inclusion into the parcel database must have a detailed, textual description of how it was converted from paper maps to an electronic format and how it is maintained. It must have a description as to spatial file design to describe how multiple ownership, multipart parcels, easements, rights of way, non-taxed lands, etc. are handled.

5.3.2. Attribute Data

Data stored in a separate CAMA system will be requested as a separate file, with CAMAKey used to join tables.

Name	Length	Type
STF	2 character	FIPS code for state. Code for Pennsylvania is 42. Cannot be blank.
COF	3 character	FIPS code for county with taxing jurisdiction. Defined as character to preserve leading zeros. Cannot be blank.
MCF	4 character	FIPS code for municipality with taxing jurisdiction. Defined as character to preserve leading zeros. Cannot be blank.
MCN	35 character	Name of municipality which has taxing jurisdiction
PIN	30 character	The current county tax parcel identification number as assigned and maintained

Name	Length	Type
		by a county on tax maps and in CAMA systems.
CAMAKey	30 character	The Commonwealth has many different CAMA systems in operation using many different formats. This field is the link to the CAMA data. May be identical to PIN, but must be identical to unique identifier (Primary Key) in CAMA data extract table.
GPINLat	8 digit numeric	The latitude of the parcel centroid in decimal degrees. This will be loaded by a conversion tool.
GPINLong	8 digit numeric	The longitude of the parcel centroid in decimal degrees. This will be loaded by a conversion tool.

5.4. Responsibilities

Responsibilities for creation and maintenance of layer features and attributes must be defined.

5.5. Definitions

Definitions of layer terms (glossary) should be developed if needed.

5.6. References

1. *Procedures and Standards for a Multipurpose Cadastre*. National Academy Press. Washington, D.C. 1983.
2. *Multipurpose Land Information Systems: The Guidebook, Volumes I and II*. Federal Geodetic Control Committee. First printed 1989 with subsequent updates through 1997.
3. *GIS Guidelines for Assessors*. Urban & Regional Information Systems (URISA). 1993. Washington.
4. *Standard Land Use Coding Manual: A Standard System for Identifying and Coding Land Use Activities.* U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. Reprinted 1977.
5. *Standard on Property Use Codes.* International Association of Assessing Officers (IAAO). 1980. Chicago: IAAO.
6. *Standard for Tax Parcels and Tax Parcel Identifiers.* International Association of Assessing Officers (IAAO). 1980. Chicago: IAAO.
7. *Cadastral Data Content Standard for the National Spatial Data Infrastructure.* Cadastral Subcommittee, Federal Geographic Data Committee (FGDC). December, 1966. Copy is available in acrobat pdf format at: http://www.fgdc.gov/standards/documents/standards/cadastral/

8. *Section A: Municipal Property Mapping*. Part 3: Guidelines - Section A. VGIS Handbook, Vermont Geographic Information System. http://geo-vt.uvm.edu/cfdev2/VCGI/tac/parcel_revision/munguideline_revision.cfm

9. *Guideline: Codes for Named Populated Places, Primary County Divisions, and Other Locational Entities of the United States, Puerto Rico, and the Outlying Areas* -- 94 Dec 28. FIPS Publication 55-DC3, updated 1998. National Institute of Standards and Technology (NIST), US Department of Commerce.

10. FIPS codes for state and counties can be obtained from http://www.itl.nist.gov/fipspubs/co-codes/states.htm. FIPS codes for Publication 55-DC3 can be researched and retrieved at http://www.nist.gov/itl/fipspubs/55new/nav-top-fr.htm.

6.0 Geodetic Monumentation

6.1. Subject Discussion

Widely-spaced, permanent monuments serve as the basis for computing lengths and distances between relative positions. In the past, ground-based theodolites, tapes, and electronic devices were the primary geodetic field measurements used. Today, the technological expansion of GPS has made it possible to perform extremely accurate geodetic surveys at a fraction of the former cost.

In order to ensure the accuracy of land record systems as well as natural resource, communication, transportation, and other mapping projects, it is essential to have a consistent coordinate system. The National Spatial Reference System (NSRS), under the control of the National Geodetic Survey (NGS) and managed by the Federal Geodetic Control Subcommittee (FGCS), is the standard in defining the latitude, longitude, elevation, scale, gravity, and orientation of control points throughout the United States. Both state and local governments have producers that generate geodetic control data for smaller-scale needs.

Geodetic control is normally established by, either, terrestrial measurements of angles and distances or the Global Positioning System (GPS). GPS uses electronically measured ranges between ground receivers and a constellation of satellites operated by the US Department of Defense. No matter which measuring system is employed, geodetic control is established in a hierarchical manner. More densely spaced points are established by starting from a most precise, but rather sparse, network of points. This method is generally less precise but sufficient to meet most specific user needs (SMAC, Date Unknown).

The various requirements for geodetic control demand different levels of positional accuracy. Traditionally, geodetic control is categorized as primary, secondary, or supplemental. Primary or First Order control is used to establish geodetic points and to determine the size, shape, and movements of the earth. Secondary or Second Order, Class I control is used for network densification in urban areas and for precise engineering projects. Supplemental or Second Order, Class II and Third Order control is used for network densification in non-urban areas and for surveying and mapping projects (Wisconsin State Cartographer's Office 1, Date Unknown).

6.1.1. Accuracy Standards for Geodetic Control

The absolute positions of points can never be exactly known since all measurements contain some error. Instead, we usually speak of relative accuracy and the relationships between points. The National Spatial Reference System (NSRS) is based upon a hierarchical classification of accuracy whereby new geodetic control is referenced to previously existing control of a higher order. The accuracy of a geodetic control point is determined by the accuracy of the survey and the quality of the adjustment (Wisconsin 1, Date Unknown).

Prior to GPS, surveys designed to achieve first-order positions were performed by very few agencies or private firms using very expensive surveying equipment. These agencies and firms would require significant training and education in geodesy and least squares adjustment theory. By 1985, GPS could easily outperform first-order horizontal accuracy, and was becoming increasingly more affordable and accessible to the average surveyor. To accommodate the improved positional capability of GPS, new standards for horizontal data were submitted for adoption to the Federal Geodetic Control Committee (FGCC 1989b). A- and B-orders of accuracy specify horizontal positional tolerances of 5 mm + 1:10,000,000 of the observed base line, and 8 mm + 1:1,000,000 of the observed base line, respectively. There is no vertical accuracy implied by A- or B-order (Doyle, D., Date Unknown).

Many standards exist for geodetic control, depending on the type of survey work to be accomplished and the methods to be used. The Federal Geodetic Control Subcommittee (FGCS) is responsible for developing the standards and specifications used in the NSRS, the nation's primary control network. The FGCS has developed standards for horizontal and vertical control work, both by conventional and GPS surveying methods, as well as standards for gravity surveys, baseline calibration, and other activities (Wisconsin 1, Date Unknown).

6.1.2. Development of Geodetic Control

Geodetic control surveys are usually performed to establish a basic control network (framework) from which supplemental surveying and mapping work is performed. Geodetic network surveys are distinguished by use of redundant, interconnected, permanently monumented control points that comprise the framework for the National Spatial Reference System (NSRS) or are often incorporated into the NSRS (FGDC, 1998).

These surveys must be performed to far more rigorous accuracy and quality assurance standards than those for control surveys for general engineering, construction, or small scale topographic mapping purposes (FGDC, 1998).

Geodetic network surveys included in NSRS must be performed to meet automated data recording, submittal, project review, and least squares adjustment requirements established by the National Geodetic Survey (NGS) (FGDC, 1998).

Most geodetic surveying activities begin from a monumented station in the National Spatial Reference System (NSRS), which is developed and managed by the National Geodetic Survey (NGS).

In Pennsylvania, the most active producers of geodetic control is PENNDOT.

Geodetic control stations are substantially monumented so that they will be both stable and durable. To support precise positioning, monuments must be stable and protected, minimizing movement due to frost, soil conditions, crustal motion, and human disturbance. To be of value in a control network, monuments must be durable and recoverable for future use.

6.1.3. Standards for Geodetic Data in the National Geodetic Survey Data Base

The National Geodetic Survey (NGS) defines and manages the National Spatial Reference System (NSRS) - the framework for latitude, longitude, height, scale, gravity, orientation and shoreline throughout the United States. NSRS provides the foundation for transportation, communication, and defense systems, boundary and property surveys, land records systems, mapping and charting, and a multitude of scientific and engineering applications (NGS, Date Unknown). Point position information from the NSRS data base is distributed as *Data Sheets*.

Most municipal mapping projects that require an ortho photo base utilize a adjusted control network for photogrammetric data processing. It is recommended that the entire network, or at least a functional subset of it be permanently monumented to preserve these points for future reference. This network of control will provide convenient ties for local surveyors to establish geodetic coordinates for their local projects. This will serve the local community in developing a consistent base for region wide mapping and the ability to tie into a statewide coordinate system, PA SPCS.

6.2. Use Cases

Use cases must be developed.

6.3. Recommendations

Geodetic control should include the following items.

Name	Length	Type
Lat	8 digit numeric	The latitude of the monument in decimal degrees.
Long	8 digit numeric	The longitude of the monument in decimal degrees.
Name	35 character	Name of monument.
Owner	25 character	Agency who placed and/or maintains the monument.
Order	15 character	Accuracy level of monument.
Description	50 character	Description of monument. Stone pile, pin, etc.

The Coordinate system used; Pa State Plane North or South, UTM, Etc

Horizontal Adjustment; NGVD 86, 92 etc.

Geoid used for the calculations 93, 96 etc.

Coordinate listing of the Base Points and/or Monuments that were used such as existing HARN Points or newly determined by OPUS, CORS, (which CORS Stations used) etc.

Vertical Datum; NGVD 29, NAVD 88 or other.

Adjustment was constrained or not.

If multiple baselines were used for the location of all points.

Project accuracy requirements: Short summary on field procedures, including make of receiver, antenna (fixed height or measureup), time of day and information on number of satellites monitored and any other important data on field procedures such as were monuments set, type and location, (Permanent or not). Location diagram and any ties should be available for recovery purposes.

Summary of office procedures; Software brand and version used. Was Corpscon, Vertcon or any mathematically shifted data utilized and held as control and where.

Summary of the final accuracy of both the horizontal and vertical points, including expected accuracy.

Name of the firm doing the work, address, phone no., e-mail address, contact person should be included. Also any field collected data files, final data files, loop closures, statistics, summaries, exclusions, etc, could be included for future reference

6.4. Responsibilities

Responsibilities for creation and maintenance of layer features and attributes must be defined.

6.5. Definitions

Definitions of layer terms (glossary) should be developed if needed.

6.6. References

1. Search & Retrieval of Data Sheets are available from the NGS website , found at http://www.ngs.noaa.gov/datasheet.html

2. State Mapping Advisory Committee (SMAC) of South Carolina., *DRAFT: Geodetic Control Standards For South Carolina* http://www.scgs.state.sc.us/smac/Geodetic%20Control%20Standards.htm

3. Doyle, D., *DEVELOPMENT OF THE NATIONAL SPATIAL REFERENCE* SYSTEM http://www.ngs.noaa.gov/PUBS_LIB/develop_NSRS.html

4. Federal Geographic Data Committee, 1998,. *Geospatial Positioning Accuracy*

Standards Part2: Standards for Geodetic Networks. FGDC-STD-007.2-1998 http://www.fgdc.gov/standards/documents/standards/accuracy/chapter2.pdf

5. Federal Geodetic Control Committee, 1989b, *Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques*, version 5.0, reprinted with corrections August 1, 1989.

6. National Geodetic Survey, Data Unknown. *National Geodetic Survey: Who We Are* http://www.ngs.noaa.gov/INFO/WhoWeAre.html

7. Wisconsin State Cartographer's Office, Date Unknown., *Accuracy Standards for Geodetic Control* http://www.geography.wisc.edu/sco/geodetic/accuracy.html

8. Wisconsin State Cartographer's Office, Date Unknown., *Producers of Geodetic Control* http://www.geography.wisc.edu/sco/geodetic/producers.html

9. Wisconsin State Cartographer's Office, Date Unknown., *Geodetic Monuments* http://www.geography.wisc.edu/sco/geodetic/producers.html

7.0 Buildings

7.1. Subject Discussion

A number of benefits are derived by developing consistency in the structure of a buildings GIS data layer standard to facilitate data exchange:

- Supports the mapping requirements for the National Map Program.
- Allows rapid exchange of building data in a timely fashion to address cross border emergency dispatch and evacuation.
- Allows assessment of potential targets and emergency response to natural disasters and terrorism.
- Supports statewide inventories for historic preservation, economic redevelopment, and building asset management.

Buildings will be modeled as points and as perimeter footprints. The delivery of both is desired, but for those counties who do not collect the vector data for building footprints, points representing building centroids that fall inside the building footprint are acceptable.

To the extent possible, the entity being modeled reflects separately addressed units. So, while the majority of points will represent a single structure, a point should be placed for each attached row home, townhouse, or condominium where there is evidence that the inhabited unit consists of all floors from the foundation to the roofline. Evidence such as separate driveways and garages, separate walkways and front entrances, fenced back yards, and tax maps will be used to determine correct placement of multiple points relative to a single residential or business structure. Limitations in 2-D planar data models, combined with the usual lack of floor plans to identify the location of individual apartment units in multi-story apartment, precludes modeling every apartment unit within a multi-floor apartment building. However, a range of addresses could be modeled for multi-addressed unit buildings.

Mobile homes should be treated as buildings and each modeled as a point since they:

- are inhabited and therefore may require emergency services or evacuation.
- represent assets that are taxable.

7.2. Use Cases

Use Case	User	Data Needs
Replicate the look and functionality of a 1:24000 Topo Map	USGS National Map Program	Review USGS Topo Map Requirements for symbolization column(s) • Map revision history • Building Function Primary structures 500 sq. ft minimum
Response to or planning for terrorism (National Emergency)	Dept. of Homeland Security PEMA Local police and fire National Guard	Name Usage Address Ownership Physical characteristics (size, number of stories, structural material, dimension, sq footage) Floor plans All critical infrastructure as defined by HSIP sub-layer list Assessed value Year built
Hazardous material inventory, tracking, mitigation	EPA DEP Fire responders HAZMAT	Material type stored Name Building function Address Ownership Utility services Physical characteristics (size, number of stories, structural material, dimension, sq footage) Floor plans Assessed value Year built
Local government assessments	County tax assessors	Parcel identifier Physical characteristics (size, number of stories, structural material, dimension, sq footage) Ownership Owner's address Assessed value Year built Building function Tax category

Use Case	User	Data Needs
		(taxable/nontaxable)
Economic planning and economic development, redevelopment	Economic redevelopment authorities, chambers of commerce, regional industrial development corporations, industry	Physical characteristics (size, number of stories, structural material, dimension, sq footage) Ownership Owner's address Assessed value Year built Building function Tax category Zoning Historical uses
Historic preservation	Historic preservation commissions and boards	Year built Building function Historical significance Ownership Owner's address Historic Registrar number
Building asset management	Industry Academia Government	Year built Building function Physical characteristics (size, number of stories, structural material, dimension, sq footage) Floor plans Current condition HVAC plans

Use Case	User	Data Needs
Health care	Home healthcare agencies Ambulance services	Ownership Occupancy Occupant mobility Physical access Physical characteristics (size, number of stories, structural material, dimension, sq footage) LAND land line number Wireless access provider
Emergency dispatch and home delivery services	Ambulance services Fire Police Businesses	Building address Municipality Zip code Owner name (s) Renter name (s)

7.3. Recommendations

7.3.1. Spatial Data

All buildings will be modeled and delivered as point features, with each assigned a unique Building ID. In most cases, the point will represent the center of the building footprint. A separate point will be placed for each attached row home, townhouse, or condominium where there is physical evidence and tax map records indicate the unit of ownership extends from the basement to the roofline.

Polygon representations for buildings are not required, but if submitted, should be assigned the same unique Building ID (BID) as the equivalent point representation. Separate polygons will be created for each attached row home, townhouse, or condominium where there is physical evidence and tax map records indicate the unit of ownership extends from the basement to the roofline. The attribute definitions for polygon representations will be identical to that of points.

The minimum building mapping requirement should be 100 sq. ft (approximately 10’ square in size).

7.3.2. Attribute Data

Name	Type	Definition
STCOFIPS	5 alpha	Combined state and county FIPS codes for county. Cannot be null
MCF	5 alpha	FIPS code for municipality. Left padded with zeroes as necessary. Cannot be null.
BID	16 alpha	A unique Building ID serving as the primary key.
PIN	30 alpha	The Parcel Identifier for parcel the building is in.
LatDD	12 digit	The latitude of the structure (decimal degree)
LongDD	14 digit	The longitude of the structure (decimal degree)
SAN	10 digit	Site address number (also known as the situs address house number) assigned by the municipality.
PRD	2 alpha	Street name directional prefix [N, S, E, W, NE, NW, SE, SW]. Field should only be used if it is part of the official street name
STN	60 alpha	Street name assigned by the municipality
STS	4 alpha	Street suffix (use USPS Publication 28 for street type abbreviations, e.g. "AVE") assigned by the municipality.
POD	2 alpha	Street name directional suffix [N, S, E, W, NE, NW, SE, SW]. This field should only be used if it is part of the official street name.
MCN	35 alpha	Name of municipality that assigned the address
MULTIADR	1 alpha	[1 = true, 0 = false]. Flag field to indicate multiple addresses in building.
BuildingName	80 alpha	The geographic name for the building.
Feature Type	7 alpha	HSIP required field. Indicates feature geometry: Point or Polygon.
Building Type	24 alpha	Indicates building type *****

*HSIP required field. Indicates building type: *Airport*, Arena, Armory, Auditorium, *Barn*, Capitol, City Hall, Community Center, Courthouse, Firehouse, Grain Elevator, Grange Hall, Hospital, House of Worship, *Industry*, Library, Medical Center, Memorial, Museum, Observatory, *Police Station*, Post Office, Radio Facility, Railroad Station, *Residence*, *Shopping Mall*, School, Stadium, Town Hall, *Warehouse*, and Unspecified. The italicized building types were added to the HSIP specification in order to accommodate USGS National Map requirements for 1:24000 topographic maps and other local planning needs. Cannot be null.

7.4. Responsibilities

Responsibilities for creation and maintenance of layer features and attributes must be defined.

7.5. Definitions

Definitions of layer terms (glossary) should be developed if needed.

7.6. References

1. Homeland Security Infrastructure Program (HSIP), TIGER Team Report. Table E-2.Z.1 Sublayer: Building, page 169.
2. *Addressing Systems: Training Guide for 9-1-1*. William M. Lucy. National Emergency Number Association. 1995.
3. *E 9-1-1 Data Base Guide*. Beth Ozanich. National Emergency Number Association. 1994.
4. "*Address Issues and IS/GIS Implementation", Video workshop by the Urban and Regional Information Systems Association, refer to* www.urisa.org
5. "*The Benefits of GIS/911 Integration*—An Approach Worth Emulating", in Third Annual Street Smart and Address Savvy Conference, August 12-14, 2001, Milwaukee, Wisconsin, p. 55-69.
6. *Street Naming and Property Numbering Systems*. Margaret A. Corwin. Planning Advisory Service Report Number 332. American Planning Association. 1978. pp.46.
7. *Postal Addressing Standards Publication 28*, November 2000. US Postal Service. Copy available at:: http://pe.usps.gov/cpim/ftp/pubs/pub28/pub28.pdf. A copy of the standards can also be obtained from http://www.usps.gov/ncsc/lookups/abbr_suffix.txt
8. The web site for the National Emergency Number Association (NENA) is http://www.nena9-1-1.org. For E-911 related standards regarding terminology, data exchange, etc., a good web reference is found at http://www.nena9-1-1.org/9-1-1_Standards_Development/nena_recommended_standards.htm. The recommendations regarding formatting of address elements for road centerlines and situs addresses was extracted from NENA-02-010 Exhibit 22 Version 1.0 GIS Data Model Format (pp.65-73). A copy of the standard can be obtained from http://www.nena.org/9-1-1TechStandards/Standards_PDF/NENA_02-010.pdf.

8.0 Elevation Data

8.1. Subject Discussion

1. This document addresses the development of elevation data for three primary uses: 1) The creation of orthophoto maps; 2) The creation of topographic maps; and 3) The creation of three dimensional surfaces used for 3D visualization.

2. Elevation data hierarchy generally accepted in the mapping industry must be observed. This includes: 1) Digital Elevation Models (DEMs); 2) Digital Terrain Models (DTMs); and 3) Topographic (contour) maps, which are usually created for visual representation from an interim Triangulated Irregular Network (TIN) file, which can be created from a DTM file, which includes mass points, breaklines and spot elevations.

8.1.1. Definitions

Mass Points are point data features that represent locations on the ground in three dimensions. A mass point is defined in terms of an x, y and z coordinate, typically represented as an easting, northing and elevation. Mass points are used as components of digital elevation models and digital terrain models to represent terrain. Mass points are generally created in evenly spaced grid patterns.

Spot elevations are point data features that represent locations on the ground in three dimensions. A spot elevation is defined in terms of an x, y and z coordinate, typically represented as an easting, northing and elevation. Spot elevations are used as components of digital terrain models to represent terrain. Spot elevations are typically created individually and placed at specific locations to depict terrain features that may not be accurately represented by mass points. Spot elevations are commonly created using photogrammetric methods from aerial photography. Spot elevations are placed at hilltops, saddles, bottoms of depressions, intersections of principal streets and highways and ends of bridges. Spot elevations can also be derived by other methods, including field surveys.

Breaklines are line data features that represent sudden changes in terrain, usually associated with linear ground features such as retaining walls, road edges and ridgelines. Breaklines consist of vertices that are defined in terms of x, y and z coordinates, typically represented as eastings, northings and elevations. Breaklines are used as components of digital elevation models and digital terrain models to represent terrain.

A **digital elevation model (DEM)** is a dataset that represents the terrain of an area at a level of accuracy suitable for the generation of orthophoto imagery. A DEM generally consists of mass points and breaklines that define the elevation of a surface. Mass point and breakline accuracy, spacing and density requirements are determined by the accuracy requirements of the orthophotos that are generated using the DEM data. In the context of this document, the DEM will be considered to be the minimum terrain data standard for the generation of horizontally accurate Digital Orthophoto Imagery. The term “ortho-grade” accuracy is often used to describe the accuracy of a DEM in contrast to terrain data sets used for other purposes.

A **digital terrain model (DTM)** is similar to a DEM, but incorporates mass points, breaklines and spot elevations at irregular spacing so as to more accurately depict the character of the terrain. DTM data is typically more robust than DEM data, and is typically based on more accurate and more robust ground control than that required for the generation of a DEM. In the context of this document, the DTM will be considered to be the minimum standard for the generation of topographic contours.

A **triangulated irregular network (TIN)** is a data set consisting of adjacent, non-overlapping triangles that represent planar facets that are sloped in three-dimensional space. The triangles are formed from lines contructed between mass points, spot elevations and breaklines. Each triangle side has a uniform slope.

A **contour line** portrays points of equal elevation on a land surface. Contours, along with spot elevations, have long been accepted as the visual representation of elevation change for the technical and lay person. Contour lines are typically generated using digital technology wherein the contour lines are interpolated from sources such as DTM data sets or TIN data sets. Contour lines can also be “string collected” photogrammetrically, in stereo plotting instruments.

8.2. Use Cases

Use Case	**User**	**Data Needs**
Development of Orthophoto base mapping	- Mapping producers (usually vendors but could be government agencies)	DEM Data Set - X,Y and Z coordinates of point features - X, Y and Z coordinates of 3D line feature vertices - Break line type - Point type
Development of topographic Mapping	- Mapping producers - State government agencies - Local government agencies - Public and private utility organizations	DTM Data Set - X,Y and Z coordinates of point features - X, Y and Z coordinates of 3D line feature vertices - Break line type - Point type

Use Case	User	Data Needs
3D Visualization	-Federal government agencies - State government agencies - Local government agencies - Planning organizations - Developers	Topographic Map Data Set - Contour line type - Contour line elevations - Spot elevations - Water elevations
3D Surface analysis	-Environmental organizations - Planners - Tax assessors - Developers - Public and private utilities -Agricultural organizations - Public safety organizations	DEM Data Set - X,Y and Z coordinates of point features - X, Y and Z coordinates of 3D line feature vertices - Break line type - Point type DTM Data Set - X,Y and Z coordinates of point features - X, Y and Z coordinates of 3D line feature vertices - Break line type - Point type Topographic Map Data Set - Contour line type - Contour line elevations - Spot elevations - Water elevations

8.3. Recommendations

8.3.1. Digital Elevation Model (DEM) Data – General Requirements

Elevation data is needed to rectify orthophoto imagery and to facilitate 3D visualizations. Typically, a DEM data set is used for this purpose. A TIN data set will typically be created as a step in the production process.

1. A DEM data set must be delivered to the procuring agency along with completed orthophoto imagery in cases wherein the procuring agency has requested orthophoto mapping. This facilitates the future usage of the DEM data set for orthophoto image rectification and 3D visualization by the procuring agency.
2. Blind QA (quality assurance) ground control points should be used by the procuring agency to verify the integrity of the DEM data and the orthophoto products that may be created from it.

3. The process used to produce and perform quality assurance on the DEM data for a project should be documented by the producer of the data.
4. The quality assurance process should include the derivation of interpolated elevations from the DEM at quality assurance check point locations. These interpolated elevations can then be compared to field measured elevations.

8.3.2. DEM Data – Specifications

1. Breaklines must be collected as necessary to depict sudden changes in terrain. Breaklines must be collected to the extent necessary to ensure accurate representation of visible features on orthophoto imagery produced using the DEM data set. Breaklines should also be used to delineate exclusion areas (areas within which elevation data is not to be collected). Exclusion areas may include such features as bodies of water, quarries and stockpiles.
2. The elevated decks of bridges must be sufficiently delineated and separately coded in the DEM data set. The data set must facilitate the orthorectification of bridges in their proper horizontal locations.
3. DEM data must have accuracy sufficient to produce orthophoto mapping at scales required by the procuring agency and create elevation surfaces useful for 3D visualization.
4. Whether photogrammetric compilation, LIDAR, IFSAR, or other sensor technologies or methodologies are used, elevation data deliverables must meet the same vertical accuracy specifications.
5. Elevation data must be delivered as a continuous DEM surface with no mismatches, overlaps or underlaps between models or tiles.
6. DEM data must meet orthophoto rectification and 3D visualization accuracy requirements and will not be considered adequate to be used for contour generation. A more rigorous DTM (Digital Terrain Model) must be provided if contours are to be interpolated or generated.

8.3.3. DEM Data Deliverables

1. Tiles encompassing geographic areas of 5,000’ by 5,000’ for 1” = 200’ scale, and 10,000’ by 10,000’ for 1” = 400’ scale, must be used to deliver DEM elevation data unless the procuring agency agrees that another size may be more practical.
2. All delivery media must be labeled to reflect jurisdiction name, project, client, author, date, contents and other pertinent information required by the procuring agency.
3. An ASCII point file of XYZ coordinates with separate coding for mass points and breaklines will be delivered. ASCII file formats will contain five aligned and space-delimited columns containing X-coordinate, Y-coordinate, Z-coordinate, breakline type and point code.
4. Breakline types are:
    a. 1 = soft
    b. 2 = hard

   c. 3 = mass
   d. 4 = lake or exclusion area
   e. 5 = spot
5. Point code attributes are:
   a. 1 = start of breakline
   b. 2 = point within breakline
   c. 3 = not used
   d. 4 = end of breakline
   e. 5 = mass point, not part of breakline
6. An alternative ASCII delivery format may be defined and approved by the procuring agency prior to delivery.
7. An FGDC-compliant metadata file must be delivered along with each ASCII DEM file.
8. Interpolated quality assurance point coordinates should be reported in a file named Z_QA (area) (procuring agency) yymmdd.xls. The spreadsheet should have columns to store point ID, Map file, measured X-Y and interpolated Z coordinates.

8.3.4. DEM Elevation Data Acceptance Criteria

1. Vertical accuracy of data delivered should be tested by comparing interpolated elevations against aerotriangulation passpoint coordinates and blind field survey points.
2. Vertical accuracy specifications must be met or exceeded.
3. A visual inspection must be made to ensure that there are no overlaps, no underlaps or surface irregularities.
4. Written certification must be provided by the data producer stating that orthophoto image products created using the delivered DEM data set will meet or exceed required accuracy specifications.

8.3.5. Digital Terrain Model (DTM) Data – General Requirements

Elevation data is needed to generate topographic mapping. Typically, a DTM data set is used for this purpose. A TIN data set will typically be created as a step in the production process.

1. A DTM data set must be delivered to the procuring agency along with completed topographic mapping data in cases wherein the procuring agency has requested topographic mapping. This facilitates future usage of the DTM data set for topographic mapping, orthophoto image rectification and 3D visualization by the procuring agency.
2. Randomly placed blind QA (quality assurance) ground control points should be used by the procuring agency to verify the integrity of the DTM data and the topographic mapping products that are created from it.
3. The process used to produce and perform quality assurance on the DTM data for a project should be documented by the producer of the data.
4. The quality assurance process should include the derivation of interpolated elevations from the DTM at quality assurance check point locations. These interpolated

elevations can then be compared to field measured elevations.

8.3.6. DTM Data - Specifications

1. Breaklines must be collected as necessary to depict sudden changes in terrain. Breaklines must be collected to the extent necessary to ensure accurate representation of the terrain on topographic maps produced using the DTM data set and to ensure accurate representation of visible features on orthophoto imagery that may be produced using the DTM data set. Breaklines should also be used to delineate exclusion areas (areas within which elevation data is not to be collected). Exclusion areas may include such features as bodies of water, quarries and stockpiles.
2. The elevated decks of bridges must be sufficiently delineated and separately coded in the DTM data set. The data must be sufficient to facilitate the orthorectification of bridges in their proper horizontal locations on orthophotos that may be produced using the DTM data set.
3. DTM data must meet the horizontal accuracy requirements for topographic contour mapping.
4. DTM data shall be delivered which can be tested to meet a vertical accuracy of 3' at 95% confidence level at 1" = 200' scale and 6' at 95% confidence level at 1" = 400' scale, consistent with NSSDA (National Standard for Spatial Data Accuracy). The DTM data must also be of sufficient accuracy such that topographic contours can be generated to provide five foot contour interval mapping at 1" = 200' scale and ten foot contour interval mapping at 1" = 400' scale which meets National Map Accuracy Standards. The procuring agency may rely on analytical triangulation pass points and/or other field survey points to assess accuracy.
5. Whether photogrammetric compilation, LIDAR, IFSAR, or other sensor technologies or methodologies are used, elevation data deliverables must meet the same accuracy specifications.
6. Elevation data should be delivered as a continuous DTM surface with no mismatches, overlaps or underlaps between models or tiles.
7. DTM data sets must be created for contour generation. A less rigorous DEM data set can be provided if contours are not to be generated. A DEM can support orthophoto rectification and less rigorous 3D visualization requirements.

8.3.7. DTM Data Deliverables

1. Tiles encompassing geographic areas of 5,000' by 5,000' for 1" = 200' scale, and 10,000' by 10,000' for 1" = 400' scale, shall be used to deliver elevation data unless the procuring agency agrees that another size may be more practical.
2. All delivery media must be labeled to reflect jurisdiction name, project, client, author, date, contents and other pertinent information required by the procuring agency.
3. An ASCII point file of XYZ coordinates with separate coding for mass points and breaklines must be delivered. ASCII file formats will contain five aligned and space-delimited columns containing X-coordinate, Y-coordinate, Z-coordinate, breakline type and point code.

4. Breakline types are:
    a. 1 = soft
    b. 2 = hard
    c. 3 = mass
    d. 4 = lake or exclusion area
    e. 5 = spot
5. Point code attributes are:
    a. 1 = start of breakline
    b. 2 = point within breakline
    c. 3 = not used
    d. 4 = end of breakline
    e. 5 = mass point, not part of breakline
6. An alternative ASCII delivery format may be defined and approved by the procuring agency prior to delivery.
7. Interpolated quality assurance point coordinates shall be reported in a file named Z_QA (area) (procuring agency) yymmdd.xls. The spreadsheet should have columns to store point ID, Map file, measured X-Y and interpolated Z coordinates.

8.3.8. DTM Elevation Data Acceptance Criteria

1. Vertical accuracy of data delivered shall be tested by comparing the interpolated elevations against aerotriangulation passpoint coordinates and blind field survey points.
2. Vertical accuracy specifications shall be met or exceeded.
3. A visual inspection must be made to ensure that there are no overlaps, no underlaps or surface irregularities.
4. Written certification must be provided by the data producer stating that topographic mapping products created using the delivered DEM data set will meet or exceed required accuracy specifications.

8.3.9. Topographic Contour Mapping – General Requirements

Contours must be created to portray the shape of terrain within the accuracy standards specified herein. Contours must reflect the crown or cross slope of all paved areas and must truly depict all drainage ways. Contours must be topologically clean, meaning that in general contours can not cross each other or arbitrarily end in space. Contours may only cross each other at overpasses as explained below and shall end only as they extend outside the project area limits.

Contour lines are usually shown at a vertical interval of 2 feet on 1" = 100' scale topographic maps, 5 feet on 1" = 200' scale topographic maps and 10 feet on 1" = 400' topographic maps. Every fifth contour line is an index contour, graphically indicated by a line heavier than that used for the intermediate contours. Index contours are usually labeled with elevation annotation inside a break in the contour line at a frequency that permits ease of interpretation and that is aesthetically pleasing. All contour line symbols are to be solid and unbroken except where the lines pass through dense ground cover, in which case dashed line symbols are to be used. In areas where vegetation prohibits accurate plotting of contours, the contour line elevations will be interpolated as accurately as possible from spot elevations collected where the ground is visible. Coding should be applied to contour lines to facilitate display and plotting of the contour lines as described above.

DTM elevation data is typically required to generate contour information. If used in the contour generation process, a DTM data set should be delivered to the procuring agency along with the contour data.

1. Contours will be generated from DTM data or may be photogrammetrically "string collected".
2. The process used to collect and perform quality assurance on the contour data for a project must be documented.
3. The quality assurance process should include the derivation of interpolated elevations from the topographic mapping data set at quality assurance check point locations. These interpolated elevations can then be compared to field measured elevations.

8.3.10. Topographic Contour Mapping - Specifications

1. Contour line features should be continuous, uninterrupted lines with no gaps or dangling endpoints. In the context of the discussion herein, any reference to "breaks" in contour lines means that a segment of line should be placed in the area to be "broken". This segment should be snapped cleanly to the segments of the contour line outside of the area to be broken. The broken area segment must be coded to facilitate independent control of the display and plotting of the line segment. For example, a contour line may pass through a building. For cases in which planimetric data is to be used along with topographic data, a segment of contour line within the building footprint should be coded in such a way that its display and plotting can be controlled independently from the segments of the contour that do not fall within the building footprint. Such contour line segments will be referred to herein as hidden segments.
2. For cases in which planimetric data is to be used along with topographic data, contours should be broken for man-made structures that do not conform to the terrain. Examples of such structures include buildings, retaining walls, and bridges. Contours should join cleanly to exclusion area boundaries or planimetric feature line segments that surround these features.
3. Contours should be broken for active quarries, areas under construction, debris piles, or storage piles. Contours should join cleanly to exclusion area boundaries or planimetric feature line segments that surround these features.
4. Contours should turn back on single-line streams and should cross double-wide streams as a straight line from shore to shore.
5. A depression contour is a contour that closes within the mapping limits (or obviously closes outside the mapping limits) such that the area enclosed by the contour is lower than the contour elevation. Depressions often occur around catch basins. If the contour turns back on a stream or ditch or into a culvert or headwall, it is not a depression

contour unless it closes on the other side of the culvert or headwall or under the road.

6. Every fifth contour shall be annotated with its elevation and must have coding that facilitates its display using a thicker line weight than intermediate contours. Index contours should not be broken for spot elevations.
7. Contours that are obstructed by dense vegetation must be coded as obscured contours.
8. Annotation indicating the elevation of an index contour must be placed on the index contour in such a manner that the bottom of the number corresponds to the ground that is lower than the index elevation.
9. Spot elevations must be used in conjunction with contour lines to accurately portray the terrain. Spot elevations should be placed at the following points:
    a. All road and/or railroad intersections.
    b. At each end of bridges on center line of road.
    c. At center line of roads above culverts.
    d. At the highest point of closed contour tops.
    e. At the lowest point of closed depressions, significant saddles, and quarries. 0. At points visible through dense vegetation in obscured areas.
    f. Any place in which there is more than 2 inches between contours and/or spot elevations at the map presentation scale.
10. Water elevation points and their accompanying elevation annotation should be placed at or near the centers of water bodies. Water elevations should not be shown along streams.
11. Coding must be applied to contour lines to differentiate between the following contour features:
    a. Index contour
    b. Intermediate contour
    c. Depression index contour
    d. Depression intermediate contour
    e. Obscured index contour
    f. Obscured intermediate contour
    g. Obscured depression index contour
    h. Obscured depression intermediate contour
    i. Index contour hidden segment
    j. Intermediate contour hidden segment
    k. Depression index contour hidden segment
    l. Depression intermediate contour hidden segment
    m. Obscured index contour hidden segment
    n. Obscured intermediate contour hidden segment
    o. Obscured depression index contour hidden segment
    p. Obscured depression intermediate contour hidden segment

12. Ninety percent (90%) of the elevations determined from the solid-line contours shall have an accuracy with respect to true elevation of one-half of the contour interval or better and the remaining ten percent (10%) shall not be in error by more than one contour interval.
13. Whether photogrammetric compilation, field survey methods, LIDAR, IFSAR, or other sensor technologies or methodologies are used, elevation data deliverables shall meet the

same vertical accuracy specifications.

8.3.11. Contour Data Deliverables

1. Tiles encompassing geographic areas of 5,000’ by 5,000’ for 1” = 200’ scale, and 10,000’ by 10,000’ for 1” = 400’ scale, shall be used to deliver topographic data unless the procuring agency agrees that another size may be more practical.
2. All media shall be labeled to reflect jurisdiction name, project, client, author, date, contents and other pertinent information.
3. An alternative delivery format may be defined and approved by the procuring agency prior to delivery.
4. Vertical accuracy of contour data delivered shall meet with National Map Accuracy Standards.
5. Written certification must be provided by the data producer stating that topographic mapping products meet or exceed required accuracy specifications.

8.4. Responsibilities

Responsibilities for creation and maintenance of layer features and attributes must be defined.

8.5. Definitions

Definitions of layer terms (glossary) should be developed if needed.

8.6. References

1. Falkner, Edgar, 1994. Aerial Mapping: Methods and Applications. Boca Raton, FL: Lewis Publishers.

2. Lillesand, Thomas, M., and Kiefer, Ralph W., 2000. Remote Sensing and Image Interpretation, 4th Edition. New York: John Wiley & Sons.

3. Wolf, Paul R. and Dewitt, Bon A., 2000. Elements of Photogrammetry, with Applications in GIS, 3rd Edition. Madison, WI: McGraw-Hill.

4. Greve, Clifford (Ed.), 1996. Digital Photogrammetry: An Addendum to the Manual of Photogrammetry. Bethesda, MD: American Society for Photogrammetry and Remote Sensing.

5. Maune, David F. (Ed.), 2001. Digital Elevation Model Technologies and Applications: The DEM Users Manual. Bethesda, MD: American Society for Photogrammetry and Remote Sensing.

6. Slama, Chester, (Ed.), 1980. Manual of Photogrammetry, 4th Ed., Falls Church, VA: American Society of Photogrammetry.

7. American Congress on Surveying and Mapping, American Society for Photogrammetry and Remote Sensing, and American Society for Civil Engineers, 1994. The Glossary of the Mapping Sciences. Bethesda, MD & New York: Author.

8. North Carolina Land Records Management Program, 1987. Technical Specifications for Base, Cadastral and Digital Mapping. Raleigh, NC: Author.

9. American Society of Civil Engineers, 1996. Photogrammetric Mapping, (Technical Engineering and Design Guides as Adapted from the US Army Corps of Engineers, No. 14. New York: Author.

9.0 Hydrography

9.1. Subject Discussion

1. Hydrography and the hydrographic data set is defined as a set of digital spatial data that contain basic information about naturally occurring bodies of water and natural paths through which water flows.

2. The hydrographic spatial data developed and distributed in accordance with this standard will have a wide impact not the least will be on hydrologic modeling and environmental analysis.

3. The goal is to adopt a hydrographic standard that will facilitate a high-resolution base map for Pennsylvania and reconcile preexisting Federal, State, Local and other governmental datasets.

4. Hydrographic features such as streams or rivers can be defined as centerlines, dual lines, or polygons or as points such as springs or seeps. This leads to potential problems when different parties depending on their own definition of hydrography develop digital hydrography. Linking hydrographic data sets across jurisdictional boundaries then becomes a difficult process when each jurisdiction adopts a different hydrography definition. A centerline, dual line, or a polygon representation of a stream each has a unique application. Features are described according to characteristics or attributes. This standard provides only the fundamental common set of attributes for each type of hydrographic features taking into consideration both natural and man-made features.

5. At the federal level, the U.S. EPA is the data custodian for the National Hydrography Dataset (NHD) that is at a scale of 1:100,000. The U.S. Geological Survey and the Environmental Protection Agency are currently developing the National Hydrography Dataset (USGS, 1999a, 1999b, 1999c) at a scale of 1:24,000 for the United States. The NHD initiative is also designed to accommodate higher resolution data. The USGS (1999a) defines the NHD as "a comprehensive set of digital spatial data that contains information about naturally occurring and constructed bodies of water, natural and artificial paths through which water flows, and related hydrographic entities. Within the NHD, features are combined to form reaches, which provide the framework for linking (or geocoding) water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data in upstream and downstream order."

6. The Pennsylvania Department of Environmental Protection, the state data steward for Hydrography data, will be adopting the 1:24,000 NHD as its standard Hydrography layer when it is completed and published.

9.2. Use Cases

Use cases must be developed.

9.3. Recommendations

1. The scope of standards for hydrologic modeling is beyond the scope of these_standards. However, the modeling standards have been reported and are available in a report by DeBarry and others (1999). The US Army Corps of Engineers (USACE, 2000a and USACE, 2000b) hydrologic Engineering Center has also established standards for hydrologic data. The scale and accuracy of data specified by HEC, however, may be on a much broader level than that required for a localized watershed since the Corps is generally addressing large regional modeling perspectives. In addition, each model utilized may require its own data input standards such as Grid-cell File Format. Therefore it is recommended to obtain the standards source most applicable to the situation at hand, before attempting hydrologic modeling utilizing existing GIS data.

2. The recommendations for developing digital data for hydrographic features are organized by feature types and characteristics. For each feature type, guidelines for feature requirements and attributes are presented.

3. The NHD represents a significant effort by many entities to develop a comprehensive Hydrography dataset standard that all states can adopt. To the end the continued maintenance of the Pennsylvania Stream Code may prove to be unwarranted. The opportunity for inconsistencies between the NHD and the PA Stream Code is real, and may introduce doubt and confusion if two standards are allowed to exist.

4. The Federal Homeland Security Infrastructure Program (HSIP), TIGER Team Report defines specific attribute guidance for various Hydrographic data layers. These attributes will become part of a common set of Hydrography attributes that all states will maintain. The adoption of these attributes has the potential for extensive changes to many of DEP’s existing databases and therefore requires substantial resources. DEP is recommending that inclusion of these HSIP requirements be delayed until implementation and conflation of the NHD and DEP’s existing datasets has been completed. Only then can an accurate picture of resource requirements be obtained.

9.3.1. Stream Centerline

1. The stream centerline represents a path through which water flows and contains characteristics that comprise the surface water drainage network. Streams are comprised of a series of reaches. Each reach represents the segmentation of the stream centerline that contains similar hydrologic characteristics. Stream reaches can also be defined as the segment between tributaries. Attributes define the hydrologic characteristics of the

reach.

2. Centerlines representing stream channels should be digitized and oriented in the direction of flow in order to perform stream flow analysis and other segmentation analysis.

3. Reaches are continuous stretches of the stream centerline that are delineated at a confluence or waterbody (reservoirs, wetlands, etc). At waterbody's such as a wetland, lake or reservoir, an interpolated centerline of the most likely flow path will maintain the continuous segment of the centerline.

4. Segments of rivers, streams, and canals that flow under features such as bridges, buildings and roads should be captured as continuous portions of the river, stream or canal.

4.2.1.1. Stream Centerline Attributes

Name	**Type**	**Definition**
Geograpic Name		The geographic names that are found in Hydrographic data layers are referenced from the Geographic Names Information System (GNIS). This system is developed by the U.S. Geological Survey (USGS) and is federally recognized as the standard for geographic names. Although USGS topographic maps contain these names, the established standard is GNIS. Where a stream is not named, but flows through a named hollow the hollow name, e.g. "Jones Hollow" should be used. If the stream is not named according to GNIS, then the identifier should be the unnamed tributary of the named creek. e.g. "unnamed tributary of Pine Creek." Where new streams and additions are needed, use “Tributary of" and “Tributary to” as distinction does not go to a more detailed level. Ditches should follow USGS standards referenced in the back of this section.
Pennsylvania Stream Code	5 digit numeric	The Pennsylvania Department of Environmental Protection (PADEP) maintains a database of stream codes. The stream code or Water Resource Data System (WRDS) number is a 5-digit numeric code identifying named and un-named streams in Pennsylvania. Therefore a series of reaches that comprise a stream will have the same 5-digit code. The stream code for all named streams is published in the report Pennsylvania Gazetteer of Streams. The most current version of this document is dated 2001. When the NHD is fully

Name	Type	Definition
		implemented, the Pennsylvania Gazetteer of Streams will use the NHD to extract named streams from the Geodatabase. The 5-digit code for named streams may also be obtained from a digital watershed coverage developed by USGS (Hoffman, Scott A. and Kernan, James T., 1996) where the stream code is referred to as the WRDS#. Codes for unnamed streams can be obtained from PA DEP's, Bureau of Watershed Management. Once the NHD has replaced the PA DEP streams database and GIS layer, a crosswalk at the time of conversion will be extracted. PA DEP plans to cease updating the streams database and layer because it would require synchronization of the two databases.
Hydrologic Unit Code (HUC)	12 digit numeric 12 - the Region 1234 - the Sub Region 123456 - the Basin 12345678 - the Sub Basin 12345678XX - the Watershed 12345678XXYY - the Sub-Watershed (will vary by HUC)	The hydrologic unit code (HUC) is a hierarchical, numeric code that uniquely identifies hydrologic units. Hydrologic units are subdivisions of watersheds nested from largest to smallest areas and are used to organize hydrologic data. The first two digits identify the region, the first four digits identify sub regions, the first six digits identify the basin, the first eight digits identify the sub basin**,** the first ten digits identify watershed units, and the full twelve digits identify sub watershed units. The U.S. Geological Survey has developed the first 8-digit HUC for the United States. While the Department of Agriculture, Natural Resource Conservation Service within each state is developing the full 12-digit HUC (USDA-NRCS); the Commonwealth of Pennsylvania has delineated two distinct sets of watershed boundaries. The large watershed boundary layer commonly referred to as 104 watersheds and the small watersheds. The large watersheds consist of a total of 104 separate watersheds statewide and are known as the State Water Plan watersheds. However, when the state water plan was developed these 104 watersheds were identified as regional planning areas and did not always represent a "watershed". The HUC areas are slowly replacing them as they represent more accurately a watershed. The small watersheds consist of 9,895 separate watersheds or portions thereof statewide.
Stream Order	1 alpha	

Name	Type	Definition
(Strahler)	1 – first order 2 – second order	
Stream Level		This stream level classification shall be denoted in an upstream order.
Hidden	1 digit numeric 1 – hidden 0 - visible	Denotes if the stream centerline is hidden from view such as when the stream passes under bridges. This code can be used to suppress drawing of hidden stream segments when making maps. Spatial accuracy of "hidden l" data may suspect and documentation of such data should be provided. Standards for hidden hydrography should be coordinated with the utility section of these standards.
Stream Centerline		Falls under the category of "Streams/Rivers" of both the HSIP Standards and the NHD Standards. In this case the only HSIP Standard has specific detail regarding individual attributes.

9.3.2. Dual Line Streams

1. Dual line streams are represented as polygons from bank to bank following a path through which water flows. Streams twenty (20) feet and wider will be collected as dual line streams. A feature requirement for dual line streams includes direction of flow.

2. At the confluence of two dual-lined streams, a closure line is typically added to separate one water body from the other. This enables assigning different names to distinguish the water bodies.

4.2.2.1. Dual Line Stream Attributes

Name	Type	Definition
Geographic Name		The geographic names that are found in Hydrographic data layers are referenced from the Geographic Names Information System (GNIS). This system is developed by the U.S. Geological Survey (USGS) and is federally recognized as the standard for geographic names. Although USGS topographic maps contain these names, the established standard is GNIS. Most streams 20 feet and wider usually are named or pass through a

Name	Type	Definition
		named hollow. If a dual line stream does not have a name, then the geographic name should follow the naming convention specified in the Stream Centerline section.
Pennsylvania Stream Code	5-digit code	The Pennsylvania Department of Environmental Protection (PADEP) maintains a database of stream codes. The stream code for all named streams is published in the report Pennsylvania Gazetteer of Streams. The most current version of this document is dated 2001. When the NHD is fully implemented, the Pennsylvania Gazetteer of Streams will use the NHD to extract named streams from the Geodatabase. The 5-digit code for named streams may also be obtained from a digital watershed coverage developed by USGS (Hoffman, Scott A. and Kernan, James T., 1996) where the stream code is referred to as the WRDS#. Codes for unnamed streams can be obtained from PA DEP's, Bureau of Watershed Management. Once the NHD has replaced the PA DEP streams database and GIS layer, a crosswalk at the time of conversion will be extracted. PA DEP plans to cease updating the streams database and layer because it would require synchronization of the two databases.
Hydrologic Unit Code (HUC)	12-digit national standard 02 the Region (Mid Atlantic) 0205 the Sub Region (Susquehanna) 020503 the Basin (Lower Susquehanna) 02050305 the Sub Basin (this is currently known under the 8-digit system as Lower Susquehanna /	The hydrologic unit code (HUC) is a hierarchical, numeric code that uniquely identifies hydrologic units. Hydrologic units are subdivisions of watersheds nested from largest to smallest areas and are used to organize hydrologic data. The first two digits identify the region, the first four digits identify sub regions, the first six digits identify the basin, the first eight digits identify the sub basin**,** the first ten digits identify watershed units, and the full twelve digits identify sub watershed units. The U.S. Geological Survey has developed the first 8-digit HUC for the United States. While the Department of Agriculture, Natural Resource Conservation Service within each state is developing the full 12-digit HUC (USDA-NRCS); the Commonwealth of Pennsylvania has delineated two distinct sets of watershed boundaries. The large watershed boundary layer commonly referred to as 104 watersheds and the small watersheds. The large watersheds consist of a total of 104 separate watersheds statewide and are

Name	Type	Definition
	Swatara.) 02050305XX- the Watershed (Yellow Breeches for example) 02050305XXxx- the Sub-Watershed (Mountain Creek for example)	known as the State Water Plan watersheds. However, when the state water plan was developed these 104 watersheds were identified as regional planning areas and did not always represent a "watershed". The HUC areas are slowly replacing them as they represent more accurately a watershed. The small watersheds consist of 9,895 separate watersheds or portions thereof statewide.
(Strahler) Stream Order	1=first order 2=second order	The stream order based upon Strahler's (1957) classification
Stream Level		Stream level classification shall be denoted in an upstream order
HIDDEN	1 numeric 1=hidden 0=visible	Denotes a closure line that should be hidden from view. Typically assigned to segments used as a closure line interface between two dual-lined streams assigned different names. This code can be used to suppress drawing of closure lines when making maps.
Dual Line Streams		HSIP Standard has specific detail regarding individual attributes.

9.3.3. Water Bodies

1. Lakes and ponds are represented as polygons where visible and clearly definable from aerial photography. Delineate the shoreline of all standing bodies of water designated as a lake or pond. Ponds greater than 0.1 acre in size should be included.

2. Swamps and Marshes are represented as polygons where visible and clearly definable from aerial photography. Marshes greater than 0.1 acre in size should be included.

3. Reservoirs are represented as polygons where visible and clearly definable from aerial photography. Delineate the shoreline of all standing bodies of water designated as a reservoir. Reservoirs greater than 0.1 acre in size should be included.

4. At the confluence of a dual-lined stream and a water body, a closure line is typically added to separate one water body from the other. This enables assigning different names to distinguish the water bodies.

5. Canal/Ditch is defined as an artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft. The NHD and the HSIP Standards provide guidance.

6. Estuaries are defined as the lower end of a river, or a semi enclosed coastal body of water with access to the open ocean, which is affected by the tides and where fresh and salt water mix. The NHD and the HSIP Standards provide guidance.

7. Ice Mass is defined as a field of ice, formed in regions of perennial frost. The NHD and the HSIP Standards provide guidance.

9.3.4. Water Bodies Attributes

Name	Type	Definition
Geographic Name.		The geographic names that are found in Hydrographic data layers are referenced from the Geographic Names Information System (GNIS). This system is developed by the U.S. Geological Survey (USGS) and is federally recognized as the standard for geographic names. Although USGS topographic maps contain these names, the established standard is GNIS. If the name is not in GNIS or is not shown on the USGS Map, then: the identifier should be "unnamed pond/lake". Where a named stream flows to or through the unnamed lake or pond, then the phrase, "unnamed pond on named stream" can be used, e.g., "unnamed pond on Pine Creek". If a marsh, the identifier should be "unnamed marsh". Where a named stream flows to or through the unnamed marsh, follow the same procedures as defined above for lake or pond. If a reservoir, the identifier should be named based on reservoir owner or named as "unnamed reservoir". Where a named stream flows to or through the reservoir, follow the same procedures as defined above for lake or pond.
Hydrologic Unit Code (HUC)	12-digit national standard 02 the Region (Mid Atlantic) 0205 the Sub Region (Susquehanna) 020503 the Basin (Lower	The hydrologic unit code (HUC) is a hierarchical, numeric code that uniquely identifies hydrologic units. Hydrologic units are subdivisions of watersheds nested from largest to smallest areas and are used to organize hydrologic data. The first two digits identify the region, the first four digits identify sub regions, the first six digits identify the basin, the first eight digits identify the sub basin**,** the first ten digits identify watershed units, and the full twelve digits identify sub watershed units. The U.S. Geological Survey has developed the first 8-digit HUC for the United States. While the Department of Agriculture, Natural Resource Conservation Service within each state is developing the full 12-digit HUC (USDA-NRCS); the Commonwealth of Pennsylvania has delineated two distinct sets of watershed boundaries. The large watershed boundary layer commonly referred to as 104 watersheds and small watersheds. The

Name	Type	Definition
	Susquehanna) 02050305 the Sub Basin (Cumberland, Dauphin, Lebanon and Perry Counties) 02050305XX the Watershed (Yellow Breeches for example) 02050305XXxx- the Sub-Watershed (Mountain Creek for example)	large watersheds consist of a total of 104 separate watersheds statewide and are known as the State Water Plan watersheds. However, when the state water plan was developed these 104 watersheds were identified as regional planning areas and did not always represent a "watershed". The HUC areas are slowly replacing them as they represent more accurately a watershed. The small watersheds consist of 9,895 separate watersheds or portions thereof statewide.
HIDDEN	1 integer 1 = hidden 0 = visible	Denotes a closure line that should be hidden from view. Typically assigned to segments used as a closure line interface between dual-lined stream and water body features. This code can be used to suppress drawing of closure lines when making maps.
Water Bodies		A sub-layer of the Hydrography section of the HSIP Standard. These topics are also part of the NHD Standard, which has a focus on water related subjects as opposed to database structures.

9.3.5. Springs or Seeps

1. Springs or seeps are represented as points where visible from aerial photography and verified by on-site verification. Delineate the centroid of the spring or seep area.
2. There is no specific mention of Springs and Seeps in the HSIP Standard however, there is in the NHD.

9.3.6. Springs or Seeps Attributes

Name	Type	Definition
Geographic Name		The geographic names that are found in Hydrographic data layers are referenced from the Geographic Names Information System (GNIS). This system is developed by the U.S. Geological Survey (USGS) and is federally recognized as the standard for geographic names. Although USGS topographic maps contain these names, the established standard is GNIS. If the reservoir is not named according to the USGS, then the identifier should be named as unnamed spring.
Hydrologic Unit Code (HUC)	12-digit national standard 02 the Region (Mid Atlantic) 0205 the Sub Region (Susquehanna) 020503 the Basin (Lower Susquehanna) 02050305 the Sub Basin (Cumberland, Dauphin, Lebanon and Perry Counties) 02050305XX the Watershed (Yellow Breeches for example) 02050305XXxx- the Sub-Watershed (Mountain Creek for example)	Hydrologic Unit Code (HUC), 12-digit national standard. The hydrologic unit code (HUC) is a hierarchical, numeric code that uniquely identifies hydrologic units. Hydrologic units are subdivisions of watersheds nested from largest to smallest areas and are used to organize hydrologic data. The first two digits identify the region, the first four digits identify sub regions, the first six digits identify the basin, the first eight digits identify the sub basin**,** the first ten digits identify watershed units, and the full twelve digits identify sub watershed units. The U.S. Geological Survey has developed the first 8-digit HUC for the United States. While the Department of Agriculture, Natural Resource Conservation Service within each state is developing the full 12-digit HUC (USDA-NRCS); the Commonwealth of Pennsylvania has delineated two distinct sets of watershed boundaries. The large watershed boundary layer commonly referred to as 104 watersheds and small watersheds. The large watersheds consist of a total of 104 separate watersheds statewide and are known as the State Water Plan watersheds. However, when the state water plan was developed these 104 watersheds were identified as regional planning areas and did not always represent a "watershed". The HUC areas are slowly replacing them as they represent more accurately a watershed. The small watersheds consist of 9,895 separate watersheds or portions thereof statewide.

9.3.7. Drainage Networks

This category is listed in the HSIP as a sub-layer under the major sector of Hydrography. Although there is no such category in the NHD the individual items are also contained in the NHD.

9.3.8. Drainage Networks Attributes

With regards to the HSIP Standards, all of the below data items have the same attribute requirements. The NHD however, treats each of the below listed items separately and therefore are contained herein.

1. Artificial Path is defined as an abstraction to facilitate hydrologic modeling through open water bodies and along coastal and Great Lakes shorelines and to act as a surrogate for lakes and other water bodies.
2. Canal/Ditch is defined as an artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft. The NHD and the HSIP Standards provide guidance.
3. A connector is a known, but nonspecific connection between two nonadjacent network segments.
4. Pipelines are a closed conduit, with pumps, valves and control devices, for conveying fluids, gases, or finely divided solids.
5. Streams and Rivers are bodies of flowing water.

9.3.9. Islands

1. Although not specifically a hydrographic attribute, islands are an important factor. Typically islands are shown geographically based upon the time of the aerial flight. It must be noted that islands exist to a large degree on the water level at the time of the aerial flight. Catastrophic events such as floods may obscure an island until the floodwaters recede. Applicable standards towards defining islands should be made upon consideration of mean water level.
2. The geographic names that are found in Hydrographic data layers are referenced from the Geographic Names Information System (GNIS). This system is developed by the U.S. Geological Survey (USGS) and is federally recognized as the standard for geographic names. Although USGS topographic maps contain these names, the established standard is GNIS. Therefore, islands of some significance are named. However, islands should have the word “island” as part of the official name.
3. There is no mention of Islands in the NHD or the HSIP Standards.

9.3.10. Coastlines

Coastlines are a separate sub layer of the HSIP Standard. As there is no NHD standard for coastlines, the HSIP Standard and its attribute requirements would apply.

9.4. Responsibilities

Responsibilities for creation and maintenance of layer features and attributes must be defined.

9.5. Definitions

Definitions of layer terms (glossary) should be developed if needed.

9.6. References

1. *Standards for National Hydrography Dataset – High Resolution.* National Mapping Program Technical Instructions. U.S. Environmental Protection Agency, U.S. Department of the Interior, U.S. Geological Survey National Mapping Division. July 1999, version 1.0.
2. *USGS National Mapping Program Standards*, United States National Map Accuracy Standards. Revised June 17, 1947.

10.0 Orthophotography

10.1. Subject Discussion

1. The objective of this standard is to set a common baseline that will ensure the widest utility of Digital Orthophoto Imagery (DOI) data for the user and producer communities through enhanced data sharing and the reduction of redundant data processing and production. The framework will provide a base on which to collect, register, and integrate digital geospatial information accurately

2. A DOI is a scanned aerial photograph(s) whose geometric distortions, caused by camera angle and terrain, have been removed, resulting in a positionally correct depiction of the earth. It combines the image characteristics of a photograph with the geometric qualities of a map. Since the geographic locations of all features appearing on an orthophoto image are represented in their true position (coordinate), this dataset is typically regarded as the 'official' GIS base map. It is one of the framework data layers that comprise Pennsylvania’s PAMAP program, the United States Geologic Survey’s (USGS) National Map Program, the Geospatial One-Stop (GOS) Initiative and the Homeland Security Infrastructure Plan (HSIP).

3. A DOI can be incorporated into any geographic information system (GIS) that can manipulate raster images. It can function as a cartographic base for displaying, generating, and modifying associated digital planimetric data. Other applications include critical infrastructure management, homeland security and emergency response, land management, environmental and habitat analysis, flood analysis, soil erosion assessment, and ground-water and watershed analysis. The accuracy and extraordinary detail provided by the DOI allow users to evaluate their data for accuracy and completeness, make real-time modifications to their data, and even generate new files.

4. The PAMAP project is a separate project. The Pennsylvania DCNR Bureau of Topographic and Geologic Survey manages the PAMAP program office. That office has been designated as the State steward for the statewide imagery project. The goal of this project is for the State to provide color digital orthophoto imagery at a *minimum* scale of 1”=200’ and a *minimum* pixel resolution of 2’ for all 67 counties in return for the collection and sharing of their infrastructure layers at a mapping scale of 1”=200’ in the defined PAMAP data standard format. The state plans to supply the imagery on a cyclical basis so that the entire state is flown every 3 years.

10.2. Use Cases

Use Case	User	Data Needs
Asset Management	State & local government agencies Private organizations (commercial development orgs., utility orgs.)	(All imagery)
Homeland Security-Emergence Response	Dept. of Homeland Security PEMA Local police and fire National Guard	
Hazardous material inventory, tracking	EPA DEP Fire responders HAZMAT	
Local government assessments	County tax assessors Business development agencies	
Economic planning and economic development, redevelopment	Economic redevelopment authorities, chambers of commerce, regional industrial development corporations, industry	
Local and statewide planning	Federal, State and Local government planning agencies Private development companies	
Emergency dispatch and home delivery services	Ambulance services Fire Police Businesses	
Travel and Tourism		
Revenue		
Recreation		
Crime analysis	Ambulance services Fire Police Businesses	
Education		

10.3. Recommendations

10.3.1. Standards

DOI should, at a minimum, meet the applicable standards developed by the Federal Geographic Data Committee (FGDC) including:

- Geospatial Positioning Accuracy Standards, Part 1:Reporting Methodology (FGDC-STD-007.1-1998);
- Geospatial Positioning Accuracy Standards, Part 2:Standards for Geodetic Networks (FGDC-STD-007.2-1998);
- Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (FGDC-STD-007.3-1998)
- Content Standards for Digital Orthoimagery (FGDC-STD-008-1999)
- Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998).

These and other FGDC standards can be viewed at http://www.fgdc.gov/standards/standards.html.

10.3.2. Accuracy

1. DOI should, at a minimum, have a horizontal positional accuracy not exceed 4.8-feet at the 95% confidence level. It is possible that some user applications (i.e. utility mapping) may require development of DOI having a greater positional accuracy (< 4.8-feet).
2. All DOI should be tested for positional accuracy using the FGDC Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (NSSDA). NSSDA procedures will be used to validate the accuracy of the DOI.

10.3.3. Map Scale, Resolution, Datum, and Projection

1. At a minimum, the DOI should be produced at a design scale of 1”=200’ (1:2400) with a 2’ pixel resolution. It is possible that some user applications may require development of DOI having a larger scale (i.e. 1”= 50’ or 100’) and smaller (finer) pixel resolution (i.e. .5’ or 1’) Typically, land use density is a factor in determining pixel resolution as the level of detail takes on greater importance in more developed areas. In urban areas greater resolution may be required to visually differentiate geographic features because of their proximity to one another.
2. All DOI will reference the North American Datum 1983, Pennsylvania State Plane Coordinates, in the appropriate zone (north or south), cast on the Lambert Conformal Conic projection, expressed in units of Survey Foot.

10.3.4. Tiling Strategy, Schema and Naming Convention

1. DOI will be structured to conform to a ten thousand foot square tile forming a grid across the entire commonwealth. A PAMAP DOI tile layout has been designed for state-wide coverage and includes a total of approximately 8,400 tiles, at a scale of 1”=200’; each tile covers an area measuring 10,000 feet X 10,000 feet with no over edge imagery. Imagery should completely fill each DOI tile (no partial image tiles). At a minimum, this tiling structure should be used to produce 1”=200’ DOI.

2. For larger scale, finer resolution DOI development (i.e. 1”=100’, 1’ pixel or 1”=50”, .5’ pixel), a nested tiling schema based on the 10,000’x 10,000’ PAMAP tiling schema should be employed. For 1’=100’, 1’ pixel DOI a nested tile schema would suggest tiles measuring 5,000’ x 5,000’.and for 1”=50’, .5’ pixel a nested schema would suggest 2,500’ x 2,500’. The PAMAP Program office should be consulted for nested tiling naming conventions.

3. The approximate tile count of 8,400 does not include additional tiles that must be developed in the transition area between the northern and southern zones of the Pennsylvania State Plane coordinate system. In this area, there will be an overlap of DOI in the respective state plane zone by 1 full tile. All completed digital files should contain a designation indicating whether the orthophoto is referenced to the northern or southern zone. Due to the fact that all production blocks have yet to be defined, the precise number of overlapping tiles is not known but this number will be added to this plan once a state-wide mapping strategy is finalized.

4. DOI filenames should be derived from the northwest corner of each ortho tile using the first four digits of the northing and easting coordinates referenced to the Pennsylvania State Plane coordinate system, followed by the State designator “PA”, and the State Plane zone designator “S”.

   For example: xxxxyyyyPAS
   Where: xxxx = first 4 coordinates, northing
   yyyy = first 4 coordinates, easting
   PA = State Designator
   S = Pennsylvania South Zone designator

10.3.5. File Formats

DOI tiles should be 3 band (RGB), 24-bit natural color in a GeoTIFF computer file format with no internal tiling or overviews. (Panchromatic imagery and/or Color Infrared imagery are acceptable additions to natural color, if required for specific applications.) Other formats could include Tiff and BIL with associated header files. GeoTIFF files shall include the following GeoTIFF tags and keys:

- ModelTiepointTag
- ModelPixelScaleTag
- GTModelTypeGeoKey
- GTRasterTypeGeoKey
- ProjectedCSTypeGeoKey

- PCSCitationGeoKey
- ProjLinearUnitsGeoKey

DOI tiles should also be produced in a compressed MrSID format, using 10:1 compression.

10.3.6. Image Characteristics

1. Radiometric, or spectral, processing represents a challenge in a multi-phase statewide program. Changes in the radiometry of the DOI will be introduced by changes in camera systems, film emulsions and time-of-year of acquisition. Every effort should be made to minimize changes in the radiometric appearance between anticipated production phases.

2. At a minimum, the relative join (misalignment) of transportation and other linear features between adjacent image tiles shall not exceed 4.8-ft for 1”=200’, 2’ pixel DOI. DOI should be tonally balanced to produce a uniform contrast and tone across the image tiles. Changes in color balance across the subject area, if they exist, shall be gradual. Abrupt tonal variations between tiles are not acceptable. The PAMAP Program Office should develop and distribute three sample image patches which illustrate acceptable, marginal, and unacceptable orthophoto tonal balancing characteristics.

3. Whenever practical, building tilt should be corrected, to the extent possible using the aerial photography, such that transportation features are not obscured. Additionally, tall buildings and critical infrastructure features, such as water towers and radio towers, should not be clipped at tile seam lines. In addition, tile seam lines should be established in such a manner that minimizes distortion of ground feature detail. Image artifacts introduced during the scanning process and appearing in the final DOI should be unacceptable, except for very minimal artifacts falling in non-critical coverage areas and/or where they do not affect the user’s ability to interpret or understand the underlying imagery (i.e. a small piece of lint appearing in a timbered area).

10.3.7. Metadata

The geospatial data products produced under each DOI production phase should be fully documented through the preparation of FGDC compliant metadata. The metadata record should be validated using the FGDC MP parser routine. The metadata records should reflect the production block rather than the file level and the metadata record should be written on all delivery or archival media. FGDC-compliant metadata should be provided in extensible markup language (.xml). The following ftp site contains information pertaining to the content and creation of the required metadata: f**tp://ftpmcmc.er.usgs.gov/release/xmlinput/.** This site contains the following files designed to define and support production of FGDC compliant orthoimage metadata:

- Xml_Input1_63.zip, application for reading and creating .xml metadata files.
- Help.pdf , Users guide for .xml input.

- MetaData_overview.doc
- orthotemplate.xml

10.4. Production Components

10.4.1. Aerial Imagery

1. Aerial film based imagery is the image source currently used to produce PAMAP's high resolution DOI. However, DOI's produced from digital aerial cameras/sensors and/or commercial imaging satellites continue to evolve towards higher resolution and greater accuracy and are finding growing acceptance among the user community.

2. At a minimum, imagery to support the development of the PAMAP DOI should be acquired in natural (true) color format. Typical imagery formats include black and white (panchromatic), color infrared (CIR), and natural (true) color. Black and white ortho imagery may be generated from CIR and natural color source. Depending on user application (i.e. wetland delineation) additional formats (i.e. color infrared) may be desirable.

3. Currently, natural color aerial photography is being obtained for each DOI production block at an altitude of 9,600 feet AMT yielding an approximate photo scale of 1"=1,600'. All aerial photography captured in support of PAMAP should be planned and acquired using industry best practices to support the respective scale, accuracy, and resolution of the final DOI.

4. Specifically, photography should be captured in the spring prior to the emergence of deciduous foliage but when there is no snow cover that obscures important information. Also, aerial photographs should be taken in late morning through mid afternoon, when shadow is less prevalent.

5. The aerial missions should be conducted using airborne GPS control with accompanying ground based GPS stations in a manner suitable to support the final accuracy requirements of the DOI. Processed airborne GPS data should then be used to support the other phases of DOI development. At a minimum, photography and airborne GPS control should be capable of supporting the photogrammetric development of Digital Elevation Model (DEM) data to support DOI development. In addition, the airborne GPS control and aerial acquisition should be capable of supporting future development of five (5) foot topographic contour data that meets National Map Accuracy Standards (NMAS).

6. At a minimum, forward overlap within each flight line should be 60% and the overlap between adjacent flight lines should be 30%. Aerial photographic acquisition plans for subsequent production phases should be designed to overlap previous phases by a

minimum of 2 stereo models to ensure continuity between production blocks. Every attempt should be made to use camera/film/exposure combinations and to select time for aerial acquisition that will ensure continuity in the color and contrast of production blocks.

10.4.2. Scanned Imagery

Film based aerial photography should be scanned using a high precision film scanner. The scanning resolution and the scale of the source imagery will determine the pixel ground resolution which can be attained for the DOI. Resampling to a final pixel ground resolution greater (coarser) than that of the original input scan (finer) should always be practiced. However, excessive subsampling to attain a pixel ground resolution value less (finer) than that of the source imagery should be discouraged.

10.4.3. Control

A Pennsylvania licensed Land Surveyor should develop a control configuration, supervise qualified surveyors, and review all of the survey results necessary to establish the needed ground control to support DOI accuracy requirements. Additionally, control placement and density should be adequate to support the future development of five (5) foot topographic contour data that meets National Map Accuracy Standards (NMAS). Field crews should also tie ground points used to locate stationary GPS receivers to support airborne GPS acquisition in the control network. Due to the fact that a state-wide plan has not been finalized, the precise number of control points is unknown. The plan should be designed to ensure that each subsequent production phase uses the control from the previous phase and that the overall network is tied to the Pennsylvania HARN (Hi-accuracy Reference Network). Existing NGS and PennDOT control should be utilized to the maximum extent that is practical.

10.4.4. Aerotriangulation

A fully analytical bundle adjustment should be developed for each DOI production block of aerial photography/airborne GPS. All point selection, measurement and adjustment should be accomplished using digital photogrammetric processes and the bundle adjustment for each production phase will be completed using best practices. The final RMSE adjustment should meet the recognized standard of 1:10,000 of the flying height horizontally and 1:9,000 of the flying height vertically to be deem acceptable for use in support of the PAMAP program. At the conclusion of the bundle adjustment for each phase, a complete report detailing the ground control and aerotriangulation adjustment should be developed and archived.

10.4.5. Elevation Data

1. Digital Elevation Model (DEM) data is used to correct displacement must be sufficiently

accurate to ensure the DOI meets user defined accuracy requirements for the intended scale. Producers of DOI will use elevation data with the appropriate ground sample distances and areal coverage to reliably describe the terrain and meet the accuracy requirements of the image. Standards for DEM development are described in detail elsewhere in the PAMAP Standard.

2. Using the triangulated photography, a DEM that is suitable for generation of DOI at 1”=200’ should be developed. The DEM files should contain gridded mass points with minimal breaklines to ensure proper alignment of linear features. DEM data should be cut into tiles matching each aerial frame used for differential rectification. It should be stressed that initially the DEM data that will be created for PAMAP DOI program is not suitable for use in the development of topographic products. However, the scale of photography and underlying control network will support the enhancement of the elevation data to create a digital terrain model (DTM) which will support the future generation of topographic mapping expressing a five (5) foot contour interval.

10.4.6. Orthorectification

Production of a DOI generally requires: (1) a minimum of three ground positions that can be identified on the photograph to be rectified, (2) camera calibration parameters, such as the calibrated focal length and the coordinates of the camera fiducials, (3) a digital elevation model (DEM), and (4) a digital image produced by scanning an aerial photograph with a precise, high-resolution scanner. The digital image is rectified to generate an orthophoto by processing requirements 1 through 3 above for each image picture element (pixel), using rigorous photogrammetric equations on a computer. The finished product is a spatially accurate image with planimetric ground features represented in their true geographic positions.

Due to the subjective nature of imagery, both quantitative and qualitative quality control/quality assurance checks should occur throughout the DOI production process, starting at the beginning when a representative number of raster image files are visually checked for completeness, cleanliness, and image quality on the workstation. After the image files are oriented using basic project parameters and each pixel in an image should be referenced by sample and line (its horizontal and vertical position) and matched to project control, the newly resected image should be visually checked for pixel drop-out and/or other artifacts which may degrade the final DOI. At this stage, the coordinate/projection system should also be verified.

All digital orthophotos should be edge-matched to ensure proper rectification. Radiometric balancing should be performed in order to correct the DOI prior to completing the mosaicking and clipping of the final tiles. Once final DOI tiles are clipped, a final visual check for image quality should be performed. If required, DOI tiles are then compressed (typically as MrSid files). Final orthophoto images are then written out into Tiff, GeoTIFF, or BIL format as required in the user’s standard/specification.

10.5. Responsibilities

Responsibilities for creation and maintenance of layer features and attributes must be defined.

10.6. Definitions

Definitions of layer terms (glossary) should be developed if needed.

10.7. References

1. Compiled PA MAP I-Plan, ITEAM Plan for the Commonwealth of Pennsylvania, Interim Draft Document, Dated December 15, 2002. Visit the web site at: http://www.pamagic.org/

2. PA ITEAM Summary 2002-03, Visit the web site at: http://www.pamagic.org/

3. South-Central Pennsylvania Orthophoto Production Task Order, Task Order No: 01017C0020, Contract No. 01CRCN0017, USGS/DCNR, Dated August 27, 2003.

4. Federal Geographic Data Committee, Standards for implementing the NSDI, in consultation and cooperation with State, local, and tribal governments, the private sector and academic community, and, to the extent feasible, the international community. Visit the web site at: http://www.fgdc.gov/standards/standards.html

5. Digital Ortho-photo Quarter Quadrangle (DOQQ) image standards and specifications for the US Geological Survey (USGS) National Mapping Program can be obtained from: http://rmmcweb.cr.usgs.gov/public/nmpstds/doqstds.html

6. For a description of the Virginia Geographic Information Network (VGIN) Program to develop a state-wide, high accuracy, digital orthophoto base map for the entire Commonwealth of Virginia, visit http://www.vgin.vipnet.org/news/digortho.html

7. For a description of the Ohio Digital Orthophotography Project, Final Report. Center for Mapping, The Ohio State University. Sept. 5, 1997. Visit the web site at: http://www.state.oh.us/das/dcs/ogrip/pdf/ODOPrpt.htm

8. DIGITAL ORTHOPHOTOGRAPHY AND GIS, Gary Smith. A paper presented at the 1995 ESRI User Conference that provides an understanding of the digital ortho-photo production process and spatial accuracy. A copy of the paper can be obtained at: http://www.esri.com/library/userconf/proc95/to150/p124.html

9. *Demystifying Advancements in Digital Orthophotography*. Brian Mayfield, Surdex Corporation. http://www.giscafe.com/TECHNICAL/Papers/Demystifying.htm

10. The TIFF Version 6.0 specification was completed in September of 1995. A copy of the specification can be downloaded at http://partners.adobe.com/asn/developer/PDFS/TN/TIFF6.pdf. Additional information about the TIFF format can be found on http://home.earthlink.net/~ritter/tiff/.

11. The GeoTIFF version 1.0 specification can be found on: http://www.remotesensing.org/geotiff/geotiff.html

11.0 Political Boundaries

11.1. Subject Discussion

1. Accurate county and municipal boundaries are an essential data set among the framework layers for the Commonwealth of Pennsylvania. Political boundaries define administrative jurisdictions for voting districts; legislative representation in local, state, and federal governments; judicial elections and court jurisdiction; tax administration and collection; human services, land use regulation, and emergency services. It stands to reason, then, that one would expect the boundaries of these counties and municipalities to be surveyed accurately, well documented, and marked clearly in the field via boundary monuments because they impart legal authority and jurisdiction to governments. If boundaries are unclear or approximate, it could lead to confusion or even litigation over court jurisdiction or regulatory authority. It is for this reason that Pennsylvania law stipulates that county courts are responsible for adopting and filing county and municipal boundary surveys as legal documents.
2. In the GIS environment, a political boundary consists of thee types of object representations (Section 8.0, Local Government Handbook for GIS Within the Commonwealth of PA, PaMAGIC, June 20, 2002)
    - Point – survey boundary monument location or unmarked point of inflection along the survey traverse
    - Line – boundary line traverse with Coordinate Geometry (COGO) attributes such as bearing and distance
    - Area – the jurisdictional area of the county or municipality with name of legal entity as attributes
3. As all counties bordering other states share state line boundaries, it is pertinent to review the status of the perimeter of the Commonwealth. The NY, OH, and MD lines are all reasonably well-monumented historically and land surveyors from all those states have accurately located all known monuments within the past decade. Their work provides a framework into which all other political boundaries could fit.
4. It is clear that most municipal and county boundaries used by local government GIS depict *cartographic representations* of boundaries that are of varying accuracy, but do not reflect the actual surveyed legal boundary. It appears that most counties use a consistent source, scale, and method internally for acquiring their own municipal and county boundaries. Statewide, the scales for county and municipal boundary sources range from 1:1,200 to 1:30,000. The sources for boundaries include county tax maps, USGS 1:24,000 topographic quadrangles, the digital boundary file from the Pennsylvania Dept. of Transportation (PennDOT), and field surveyed sources
5. The problem of *cartographic* political boundary representations rendered from multiple sources and scales becomes apparent when adjoining county GIS data sets are used for a regional study. Because counties typically compile various thematic layers such as tax parcels, zoning, land use, etc. to their *cartographic* county boundary, gaps and overlaps will be experienced not only in the political boundary layer but also in all other

associated county data sets that are compiled to the boundary edge. Clearly, if the goal of PaMAP is to construct seamless statewide local government data sets, it will be necessary to address the long-term need for a political boundary framework that avoids the pitfalls of each county adopting different cartographic boundary representations.

6. The development of statewide *accurate legal boundary representations* of county boundaries that are based on surveyed boundary information is a high priority, because it will provide the necessary boundary framework for counties and municipalities that are just starting GIS programs. It will also provide a geographic framework for spatially adjusting existing county data sets to an accurate boundary. This requirement is directly attributable to the increased spatial accuracy in base mapping and public access to images and other digital files.

11.2. Use Cases

Use Case	**User**	**Data Needs**
Test Fairness of Subsidies and Grants	PennDOT (Liquid Fuels) Dept of Education Etc.	Municipal Boundaries – lines Relationships/equivalencies to Census Blocks and other demographics
Legislative reapportionment	PA Legislature US Congress	Municipal Boundaries – lines Relationships/equivalencies to Census Blocks and other demographics
Tax fairness and compliance -more important under property tax reform to ensure taxing jurisdiction is correct	PA Dept Revenue	Municipal Boundaries – lines Relationships/equivalencies to Census Blocks and other demographics Relationships to parcel information and addresses
Land use rights	County Planning	Municipal Boundaries – lines Relationships to parcel information and addresses

11.3. Recommendations

11.3.1. Spatial Data

This theme is currently envisioned as only political boundaries. Many *other jurisdictional* *boundaries* are derivative of political boundaries and their accuracy is generally subject to the accuracy of political boundaries. Other jurisdictional boundaries would require a similar set of attributes in their own standard(s). The major types of jurisdictional boundaries not treated here include:

- **Taxing –** school district, municipal authority
- **Administrative –** regulatory/agency, law enforcement, emergency service zones
- **Legislative –** state and federal legislative districts, election wards

11.3.2. Attribute Data

Boundary corners referenced by the boundary description; represented as point features. The attributes for the points should be:

Name	Type	Definition
XCOORD	2 numeric	State Plane Coordinate NAD 1983 in feet
YCOORD	2 numeric	State Plane Coordinate NAD 1983 in feet
MONUMENT	40 alpha	Description/name of the monument, if any. Cannot be null; none is a real answer.
MONUMENT TYPE		{corner/line marker}
EXIST	Boolean	Does a marker exist? Yes or no.
VERIFIED	Date, 4 digit	Has the marker been verified by field visitation?
POSITIONAL ACCURACY	1 numeric	Circular Error in feet.
IMAGE FILE		location of image taken at time of verification

Boundary line between jurisdictions should be represented as a line feature to facilitate appropriate symbolization. The attributes for boundary line feature are:

Name	Type	Definition
BDYTYPE	4 alpha	Type of boundary [STAT, CNTY, MUNI]. STAT supercedes CNTY and MUNI when line represents all three. CNTY supercedes MUNI when line represents both. MUNI includes township, borough, and city boundaries.
DISPUTE	Boolean	Is this boundary in dispute? Yes or no.
VALIDITY	8 alpha	Valid answers are: UNKNOWN – Source and quality not verifiable. DIGIONLY – Digitized and source is known. COGOREAL – Coordinate geometry from original survey. MONOMONU – Monumented one end, coordinate geometry for line. MONUMENT – Fully monumented both ends.

Name	Type	Definition
ADOPTED	8 alpha	Date the boundary was adopted by the court. Formatted as YYYYMMDD.
CITATION	30 alpha	Citation referencing for court file/folder number

Note – If the boundary line is intended to be coincident with a hydrologic feature there must be a point feature at the point of intersection and actual coincidence along the line. Accuracy is that of the coincident feature.

Note – If the boundary line is intended to be coincident with a road feature there must be a point feature at the point of intersection and actual coincidence along the line. Accuracy is that of the coincident feature.

Governmental unit The identity for the area within the boundaries should be represented as a polygon. Attributes are:

Name	Type	Definition
STF	2 alpha	Federal Information Processing Standard (FIPS) code for state.
COF	3 alpha	FIPS code for county. Defined as character to preserve leading zeros.
MCF	4 alpha	FIPS code for municipality. Defined as character to preserve leading (required)

11.4. Responsibilities

Responsibilities for creation and maintenance of layer features and attributes must be defined.

11.5. Definitions

Definitions of layer terms (glossary) should be developed if needed.

11.6. References

1. *County and Municipal Boundary in Pennsylvania. A Compilation of Boundary Descriptions Contained in Pennsylvania Law.* Michael Brinkash P.L.S. 1997.
2. *Boundary Change Procedures*. Dept. of Community and Economic Development, prepared by Charles Hoffman 5th Ed., 1999.
3. PaMAGIC Best Practices Handbook.

12.0 Names

The Names layer is intended to be based on the USGS Geographic Names Information System (GNIS). Standards information must be developed for this layer.

This layer could become a landmarks layer if interest warrants.

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Comment Type	**Section Number**	**Section Title**	**Comment**	**Suggested Change**