

# Strategic Municipal Mapping: Choosing the Right Foundation for ArcGIS Projects

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**Abstract:** When building a house, the builder begins with a strong foundation. When building a municipal GIS, the cartographer begins with an accurate base map. Just as the foundation determines how well the house will stand, the base map will determine how functional the municipal GIS will be. There are a variety of base maps readily available, and this paper will explore the municipal GIS applications best suited to many. Tax Maps, MOD IV parcel data and ArcGIS are presented as the ultimate combination for utility infrastructure, emergency address location, law enforcement, environmental, municipal land use, and urban planning applications.

**The Importance of Base Maps:** It is difficult to imagine the intricate data analysis and geographic comparison functions of a GIS database without the ever-present base map in the background to provide needed points of reference. The customized layers of geographic and attribute data regarding regional land use, for example, are generally defined by the use of color. Yet without an accurate base map to overlay them on or compare them to, these splashes of color will look more like an abstract painting on your computer screen than designations of residential, commercial or agricultural properties.

Even a simple relativity query, such as establishing the distance between two places, becomes an abstract proposition without a map. It may be helpful to know that fifty miles separates Point A from Point B, but without the base map, it is difficult to determine where those fifty miles are, or how to navigate them. Websites offering travel directions, such as Mapquest.com, routinely provide maps to accompany their step-by-step driving instructions to a specified destination.

The true advantage of a GIS database over conventional maps or analytical spreadsheets alone is the ability to utilize mapping and related data together. The base map remains the constant in the ever-changing kaleidoscope of interactive data analysis and comparison functions that is only possible with GIS technology.

**Types of Base Maps:** The Federal Geodetic Control Committee defined the two general types of base maps in its 1993 publication, *Multipurpose Land Information Systems: The Guidebook*:

- ◆ “There are several ways to classify base maps, and one of the most useful ways is by their information content. The base map consists of either cadastral information (the legal identification of features), or planimetric information (the physical identification of features), or it may consist of a combination of both cadastral and planimetric features.”

Planimetric mapping notes the features that can be seen with the human eye, either at ground level or from an airplane. These features may include streets, roads, highways, bodies of water, building locations, vegetation, bridges, fencelines, dams, and differences in elevation. A USGS Quadrangle Map is an example of a planimetric map.

Cadastral mapping notes the features not as easily traced by sight, which have often been established by means of land surveys. These features are generally associated with property use and ownership issues, and most often used in municipal planning applications. They include tax parcels and property boundaries, municipal boundaries, zoning and land use designations, political boundaries (such as election districts), flood plains, riparian areas, and soil classifications. A municipal tax map is an example of a cadastral map.

For municipal GIS applications, it is often necessary to utilize a combination of both types of mapping when creating the pivotal base map for a project. Planimetric mapping, as well as the aerial photography it is based upon, offers an old-fashioned “lay of the land” perspective with a modern slant. Maps have been created in this way for a number of years, even before the advent of aerial and satellite photography. The ability to look down on a place from above, even from a mountainside, provides a powerful visual reference in establishing the relational aspects of one location to another. Combine this with the cadastral layout of a municipality, georeference them to the appropriate State Plane Coordinate System or similar point of spatial reference, and the resulting base map will support municipal GIS applications ranging from parcel mapping to environmental studies.

**Other Considerations:** The accuracy of the geographic and attribute data utilized in GIS development will ultimately determine the functionality of any GIS database. The Federal Geodetic Control Committee’s *Multipurpose Land Information Systems: The Guidebook* states that “GIS/LIS developers should keep in mind that it is easy to build a less accurate map on a more accurate base, but virtually impossible to build a more accurate map on a less accurate base.”

There are various regulations in each state that govern map creation to some degree. In New Jersey, for example, there are general guidelines for map size and scale in the State’s Map Filing Law. In addition, the New Jersey Division of Taxation publishes *Tax Maps: Regulations and Standards*, which provides strict guidelines for the preparation, revision and maintenance of tax maps in either manual or computerized format. The New Jersey Department of Environmental Protection has prepared *Mapping and Digital Data Standards* as an online publication and resource handbook for GIS professionals in the State.

Anyone providing GIS or cartographic services for hire should fully understand all applicable State or local guidelines for the creation of maps in his or her area. This information is often available over the Internet through State legislative and/or Department of Environmental Protection websites. These guidelines must be strictly adhered to in all cartographic projects.

In addition to any local guidelines, there are national mapping standards to be considered. The United States Bureau of the Budget issued the National Map Accuracy Standards in 1941, with revisions through 1947. Although these standards were originally developed for paper maps, they can still provide guidance for digital cartographers today in the following key areas:

- ◆ Horizontal accuracy standards to be applied in accordance with map scale
- ◆ Vertical accuracy as applied to contour maps
- ◆ Testing the accuracy of any map by comparing point positions
- ◆ Noting the map's compliance with map accuracy requirements in the map legend
- ◆ Omission of the compliance statement when accuracy levels are not met
- ◆ Proper disclaimers when enlarging maps from their original scale
- ◆ Facilitating the interchange and use of map information by conformance with set latitude and longitude standards

Other organizations, such as the American Congress on Surveying and Mapping (ACSM), the American Society for Photogrammetry and Remote Sensing (ASPRS), and the International Association of Assessing Officials (IAAO), also offer guidelines for base map accuracy, including suggested scales and positional accuracy for different applications. Because a GIS map can be enlarged or reduced in size and scale so easily, positional accuracy standards are even more important to note on a GIS map than actual scale. For example, a positional accuracy of plus-or-minus 26.7 feet, which is recommended for map scales of 1"=800', will probably be acceptable for locating tracts of undeveloped land in a large area. However, using a map with this same positional accuracy to locate utility infrastructure systems in a municipal setting could be a disaster. A positional accuracy of plus-or-minus 3.3 feet, which is recommended for map scales of 1"=100', or even plus-or-minus 1.7 feet, which is recommended for map scales of 1"=50', would be much more suitable.

The importance of positional accuracy in mapping was dramatically illustrated in July 2002, when nine miners were trapped in Quecreek Mine, near Somerset, Pennsylvania. The miners had accidentally drilled into an adjacent, abandoned mine, releasing a torrent of water that blocked their escape for more than three days. The map they had been using to direct their drilling efforts did not show the correct location of the adjacent mine, so they believed they were approximately three hundred feet away when they broke through the adjoining wall. If a more accurate map had been available to the miners, the accident would most likely never have occurred.

For more conventional mapping purposes, particularly where base maps are concerned, land surveys provide the most accurate data. Modern survey data is based on Global Positioning System (GPS) information and created on the appropriate State Plane Coordinate System. This allows precise positioning when determining property boundaries. Surveys are most often used when buying, selling, subdividing or making improvements to real estate. A good survey can establish true property lines, identify easements, or determine land elevation and contour for building purposes. However, the

expense incurred in creating this type of mapping is often prohibitive for large-scale municipal use.

A less expensive alternative for municipal GIS purposes is to recycle existing survey and mapping data whenever possible. When using existing data, whether from State, County or more local resources, it is often necessary to scan and digitize hardcopy maps. Digital mapping data can be acquired or created in either a raster or vector format. Raster data is composed of numerous grid cells, similar to a sheet of graph paper. Each cell contains a very small portion of the overall map or aerial photograph. Although useful for capturing and displaying large amounts of surface information, the raster format limits the analytical uses of a GIS database. It is not possible to store a great deal of useful attribute data in a raster format, as the data must be confined to and associated with a single grid cell. Since even the smallest geographic features are composed of multiple grid cells, accessing overall information about a specific feature would be virtually impossible.

Vectorization is a coordinate-based data structure better suited to GIS mapping purposes. Instead of using a grid system, the vector format relies on points, lines and polygons to represent map features. Since a single vector can represent an entire geographic feature, the attribute information associated with it can be almost unlimited. With utility infrastructure mapping, for example, the attributes for a line vector representing a sewage collection line might include pipe size, construction material, location, cleaning date, and average daily flow. This format is also more useful for analytical functions, since it is now possible to isolate specific features on a GIS map by choosing one or more of their associated attributes.

The use of municipal tax maps as an adjunct to aerial photography combines the best features of both raster and vector data for municipal GIS applications. All parcel boundaries, street right-of-way lines, road centerlines, railroads, waterways and easements are available as a vectorized data layer that can be queried and analyzed as needed. Georeferencing the vectorized municipal data layer to the rasterized aerial photography of the same region provides an additional point of reference. The functionality that is lacking in rasterized base maps alone becomes available through the vectorized overlay. This allows the GIS user to study the planimetric and cadastral aspects of an area simultaneously.

**Needs Assessment:** Budgetary constraints often make the GIS implementation process very challenging in a municipal environment. A complete inventory is necessary to determine the current software and hardware configurations utilized within the municipality overall, as well as the needs and requirements of individual departments and users. Even the best GIS database with the most accurate base map possible will be essentially useless if the available operating system cannot support it. The following issues must be considered very carefully before proceeding with any municipal GIS project:

- ◆ What is the municipality's initial budget for GIS implementation?
- ◆ What departments will be using the GIS?

- ◆ What data or layers of information will these users require?
- ◆ What functions do these users expect from their GIS?
- ◆ Who will maintain the database involved?
- ◆ What about training for potential users?

ESRI ArcView Version 8.3 is the GIS software of choice for any municipal client with the operating system in place to support it. It provides the greatest functionality, and it is compatible with the GIS resource data readily available in most States. Minimum requirements for running ArcView 8.3 are a PC with an Intel 450 MHz processor and 128 MB RAM, and a Windows NT 4.0 operating system with Service Pack 6A, or a Windows 2000 or Windows XP operating system. For an additional fee, the software can even be licensed for concurrent use on a network. This means it would be available to a specific pool of users in a network environment, and a pre-determined number of these users could access it simultaneously.

For municipal clients who cannot upgrade their operating systems to accommodate ArcView 8.3, there are other options available. ESRI ArcView Version 3.3 software can be used on any standard computer with a Pentium or higher Intel-based microprocessor and hard disk drive. Recommended minimum computer memory is only 24 MB. Operating systems include Windows 98/98SE, Windows ME, Windows NT 4.0, Windows 2000 and Windows XP (with limitations). The only drawback to ArcView 3.3 is that concurrent licensing is not available. The software can only be run on the computer it is installed on. However, most municipal clients would be able to utilize ArcView 3.3 right away without making changes or upgrades to their existing operating systems.

Another option for reducing costs for a municipal client would be to install the ArcView 3.3 or 8.3 software on one central computer, and ESRI ArcExplorer software on all other systems. ArcExplorer is a GIS viewer that is available as a free download from the ESRI website. The download is simple to complete, and the system requirements are the same as for ArcView 3.3. ArcExplorer allows the user to measure distances on digital maps, pan and zoom through multiple map layers, find features, perform address matches, view and download Internet data, identify and query geographic data, and create simple maps that can be labeled and printed. A complete user's manual for ArcExplorer, with step-by-step instructions in its use, is available for download and printing at the ESRI website. This is often very helpful for municipal clients with limited or non-existent GIS experience.

Training a municipal client in the use of a GIS database can be as simple as phone support, or as involved as on-site instruction and customized resource materials for all potential users, depending on needs and budget. Knowing the basic GIS functions a specific client will use on a regular basis makes it relatively easy to create customized instruction sheets outlining the steps involved. Tax Assessors and Tax Collectors, for example, often need to create Abutters Lists, which list all properties within a specified proximity of a particular parcel. Going through this or any similar querying process on

site with the municipal GIS user, then providing a step-by-step outline as a follow-up, is often all it takes to start them on the road to GIS proficiency.

**Maintenance:** There seems to be a prevailing misconception among many municipal clients that once it has been created, a GIS database is also complete. These users are so enamored with the keystroke technology that maintaining the integrity and immediacy of the data involved simply does not occur to them. Allowing the data comprising a GIS database to become obsolete is almost as nonsensical as purchasing a new car for its style and ride, and then becoming so wrapped up in the newness of it that routine service is never performed. Unfortunately, this is exactly the approach many municipal clients are taking to GIS technology. It must be stressed from the outset of any GIS implementation project that database maintenance is critical, and must be an ongoing process. For municipal purposes, it can be likened to and incorporated with the annual tax map maintenance programs mandated by most States. It is often helpful for municipalities to include GIS maintenance fees in their tax escrow accounts and/or application fees. When GIS maintenance is performed and charged on a per-lot basis, strictly as needed, it is somewhat more palatable. Having the municipal ordinances in place to escrow the maintenance fees from developers rather than from the municipal budget makes it even more achievable for most clients.

With careful advance planning, implementation and enforcement of standards, followed by frequent client consultation along the way, it is possible to create and maintain a high quality, cost-effective GIS database to fit even the leanest municipal budgets.

**MOD IV:** Once the needs assessment has determined the client's hardware and software capabilities, and the necessary resource material has been collected to compile the base map, a fully-functional GIS database can be built.

For municipal GIS purposes, the local Tax Assessor's Office is the springboard to customized data layers suitable for land use, planning and related applications. This is made possible by incorporating tax assessment data into the GIS attributes table. In New Jersey, this data is referred to as MOD IV.

According to the New Jersey MOD IV User Manual, "MOD IV provides for the uniform preparation, uniform maintenance, uniform presentation and uniform storage of the property tax information required by the Constitution of the State of New Jersey, the New Jersey Statutes, and the rules promulgated by the Director of the Division of Taxation."

In more simplified terms, MOD IV, or the equivalent program in any state, contains virtually everything you need to know about property location and usage for municipal GIS applications.

It is highly recommended that MOD IV or equivalent data be provided as tab delimited text for GIS purposes, in both electronic and hardcopy formats. If there are corruption or incompatibility issues to be resolved with the electronic file, at least the hardcopy version will be available to keep the project moving in the meantime. In the State of New Jersey,

MOD IV information is available from State Division of Taxation or County Data Processing Centers, as well as local Tax Assessors. However, the information is not made available to just anyone. The municipal client will need to provide it directly, or will need to provide written permission allowing the GIS provider to obtain it from other sources. In New Jersey, MOD IV data is updated in its entirety on at least an annual basis, with additional updates as needed throughout the year to reflect growth and change within each municipality. In this way, every citizen is fairly taxed based on the most accurate property information available.

MOD IV or similar property data is comprised of numeric or character fields of specified length that translate into descriptive information about each property. The numeric digits 0 through 9, the twenty-six letters of the alphabet, and the punctuation marks representing a period, comma, dash, colon or ampersand, are used to complete the fields. The character limit and specified use for each field must be strictly observed, or the Statewide Master File will be adversely affected. This adherence to a consistent format is beneficial to GIS providers as well, particularly when dealing with multiple municipal clients. The same fields and field lengths will be consistent throughout each GIS project. Only the alphanumeric entries will change.

In order to link this data about each municipal property to its graphical “polygon” counterpart on the GIS base map, it will be necessary to “tag” each land parcel with a unique identifier code. This identifier code will correspond with the two-digit County Number, two-digit District Number, and up to seventeen-digit Property Identification Number unique to each parcel. Since no two tax parcels ever consist of exactly the same identification number, the written attributes regarding a specific parcel will always match the “polygon” image of that parcel on any mapping products generated from a GIS database created in this manner.

The Property Identification Number in New Jersey’s MOD IV database is comprised of two parts. The first ten digits consist of a property’s block number and lot number. A seven-digit sub-field consists of various qualification codes that further distinguish the property. These include ward numbers, sector numbers, qualified farmland designations, condominium indicators with unit numbers, mobile home indicators with unit numbers, and indicators for wetlands or limited development zones. Just by utilizing this data alone, a GIS query can create maps and spreadsheets of an area’s condominium properties, mobile home properties, farmland properties, wetlands properties, and applicable development zone properties.

There is additional information to be gleaned from MOD IV or similar tax assessment programs that will further enhance the functionality of a municipal GIS database. The Street Address Field or Property Location Field will reflect the physical address of the property apart from its block and lot number. This information is critical for many municipal GIS applications. Since fire, police and rescue personnel respond to an emergency call by street address, not block and lot number, accurate address information could literally mean the difference between life and death. It is also an essential

reference for Utility Infrastructure Maps, Postal Delivery Maps, and all other applications where driving or directions may be involved.

The Property Class Field is another important indicator of property usage. In New Jersey's MOD IV, a three-character field, presented exactly as written and without leading zeroes, represents the following classifications of taxable or exempt property:

- 1 Vacant Land
- 2 Residential Use (Four Families or Less)
- 3A Regular Farm (Farm Buildings and Barns)
- 3B Qualified Farm (Land Only)
- 4A Commercial Use
- 4B Industrial Use
- 4C Apartment
- 5A Class I Railroad Property
- 5B Class II Railroad Property
- 6A Public Utilities Personal Property Telephone
- 6B Machinery, Apparatus or Equipment of Petroleum Refineries
- 6C Phase Out Personal Property Assessment
- 15A Public School Property
- 15B Other School Property
- 15C Public Property
- 15D Church and Charitable Property
- 15E Cemeteries and Graveyards
- 15F Other Exempt Properties

Querying a municipal GIS database to isolate properties by property class or classification code, or by varying combinations of classes or codes, will create an almost unlimited array of GIS maps for use by municipal departments.

Class 4 Use Codes are three-digit numeric codes used to describe the specific use of commercial property (property classified as 4A, 4B or 4C in the Property Class Field). This field provides a wealth of information beyond the generic "commercial use" designation on a Land Use Map, and is important for municipal planning and development studies. A small sampling of Class 4 Use Codes in the State of New Jersey includes:

- 020 Apartment – Garden
- 021 Apartment – High Rise
- 030 Auto Show Room
- 050 Bank – Main Office
- 130 Church
- 210 Garage – Service/Gas
- 211 Garage – Parking
- 271 Hospital – General
- 280 Hotel

- 560 Office – General
- 611 Recreation – Community Center
- 613 Recreation – Gymnasium
- 641 Restaurant – Fast Food
- 649 Restaurant – Other
- 730 Store – Convenience
- 732 Store – Mall
- 770 Theater – Drive In
- 771 Theater – Movie
- 781 Tower – TV
- 951 Warehouse – General Storage

The Tax Exempt Property designation (property classified as 15A, 15B, 15C, 15D, 15E or 15F in the Property Class Field) is also accompanied by special codes to further define it, this time to indicate ownership, purpose, and specific property description. The code consists of seven digits, which are divided into three parts.

Part One is the first two numeric characters in the seven-digit string, and represents ownership of tax exempt property. Several examples of ownership in the State of New Jersey include:

- 01 Federal Government
- 02 State Government
- 10 New Jersey Turnpike Authority
- 11 Garden State Parkway Commission
- 16 Port Authority of New York and New Jersey
- 20 Charitable and Non-Profit Organizations
- 23 Religious Organizations
- 27 New Jersey Economic Development Authority

Part Two consists of the second two numeric characters in the seven-digit string, which indicate principle use or purpose of each tax exempt property. Examples of exempt property use or purpose in the State of New Jersey include:

- 01 General Government: All lands, buildings or other properties devoted to general government purposes, such as town halls, county buildings and state offices.
- 02 Military Purposes: All properties used for the armed forces and their establishments, such as camps and barracks.
- 06 Police and Fire Protection: All properties and structures used for police and fire protection (or training), such as firehouses, police stations and fire towers.
- 08 Utilities: All lands, buildings and structures used for sewage, water, electricity, steam and other utility productions, storage and distribution.

09 Recreation and Conservation: All lands, buildings and other properties used primarily for the recreation or entertainment of persons, or used for the conservation of natural resources and wildlife. This includes parks, golf courses, pools, beaches, bird sanctuaries and nature preserves.

Part Three consists of the last three numeric digits in the seven-digit string, which reflect the specific property description. Some examples of specific descriptions associated with tax exempt property in the State of New Jersey include:

010 Municipal Building  
013 Post Office  
019 Courthouse  
106 Cemetery  
235 Water Tank  
310 Red Cross Facility  
381 Historic Site  
652 Beach  
740 Toll Booth  
845 Railroad Station  
984 Lighthouse  
992 Marine Terminal

Each exempt property is ultimately described by combining the appropriate codes from Part One, Part Two and Part Three, as outlined above. For example, a county hospital in New Jersey would have the seven-digit Exempt Property Classification Code 03-04-301.

By color-coding the tax parcels according to their Property Class and sub-class, a comprehensive Land Use Map can be created. Variations on the land use theme can also be created when specific Property Classes are selected or isolated. Potential maps for municipal departments may include:

- ◆ Recreational Land Use Maps (for Municipal Planning or Parks Departments)
- ◆ Residential and Commercial Land Use Maps (for Community Development Departments or Chambers of Commerce)
- ◆ School Property Maps (for Fire/Emergency/Police Personnel or Boards of Education)
- ◆ Farmland Maps (for Environmental or Farmland Preservation Groups)
- ◆ Public Buildings and Businesses Maps (specifying public buildings and businesses by type, for distribution to residents or customers)

The possibilities are almost limitless, depending on a client's needs, budget, timeframe or imagination.

**Additional MOD IV Fields:** Property Description Data is another category of information included within MOD IV. Two of its key fields are the Land Dimension Field and the Building Description Field.

The Land Dimension Field includes the size of the property. This may be listed in terms of length times width, square feet, or acreage. Adding this data to a GIS mapping database will allow the GIS user to create queries based on property size, which are often needed for planning and development purposes.

The Building Description Field is a fifteen-character alphanumeric field that provides detailed information about the buildings associated with each property. The information is listed in the following order:

- ◆ Number of Stories (listed as the number of stories followed by the letter *S*, such as *2S*)
- ◆ Exterior Structural Material (listed in alphabetical code, such as *AL* for aluminum siding, *B* for brick, *CB* for concrete block, *S* for stucco, etc.)
- ◆ Style (listed in alphabetical code, such as *R* for rancher, *L* for colonial, *X* for duplex, *E* for English Tudor, etc.),
- ◆ Number of Stalls (listed numerically as *1* for one-car garage, *2* for two-car garage, etc.)
- ◆ Type of Garage (listed in alphabetical code, as *AG* for attached garage, and *UG* for unattached garage)

The completed Building Description Field *2SALD2AG* describes a two-story aluminum sided Dutch Colonial with a two-car attached garage.

An optional field within the Property Description Data category is Zoning. This will provide residential, commercial and industrial designations, as well as any designations specific to a municipality. These special designations might include redevelopment zones, HOPE VI Revitalization Zones, conservation districts, historic districts, Urban Enterprise Zones, mixed residential and commercial use properties, agricultural areas, or downtown business districts. If this information is entered into the GIS database, a variety of GIS Zoning Maps can be created.

Other fields within the Property Description Data category include the Construction Year Field (optional), Tax Map Page Field, Deed Field, Deed Date Field, and Sales Price Field.

Assessed property value is obviously beneficial to Tax Assessors, but it can be very helpful to current and prospective municipal residents as well. Many municipalities post tax assessment and zoning information on their websites in basic GIS format. Visitors to the website can access general information about the municipality, such as a color-coded map of property values, and then click on a specific parcel to learn more. Block and lot information, street addresses, zoning standards, assessed values and estimated taxes are often included for each parcel. For the Municipal Tax Assessor, Tax Collector and/or Zoning Officer, having this information readily available on the Internet can save countless hours on the telephone answering questions and providing the same repetitive information. It can also be an efficient means of complying with any Open Public Records Act that may be in place on a Statewide level.

**Conclusion:** Taxation has been the subject of endless commentary for many years. Benjamin Franklin once wrote that nothing is certain in this world but death and taxes. Author and publisher William Feather stated that the reward of energy, enterprise and thrift – is taxes. Entertainer Arthur Godfrey boasted that he was *proud* to pay taxes in the United States – but he could be equally proud for half the money.

Combining MOD IV data with an accurate, georeferenced base map allows a GIS provider to turn the tables on this controversial issue. Why not let the reward of energy, enterprise and thrift be a municipal GIS database built with pride and certainty from the property tax rolls? A GIS map, like a house, is only as strong as its foundation.

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