

## Using the World Wide Web to Leverage the Investment in Municipal Geographic Information Systems

James Hayes-Bohanan, Ph.D.

Department of Earth Sciences & Geography  
Latin American & Caribbean Studies Program  
Bridgewater State College  
Bridgewater, Massachusetts 02325 USA/EUA  
[jhayesboh@bridgew.edu](mailto:jhayesboh@bridgew.edu)

**Abstract:** This paper presents an overview of the online delivery of Geographic Information Systems (GIS). Online delivery is an increasingly important way to magnify the benefits of GIS systems. It can also assist those practitioners in developing economies who are searching for ways to make their work more relevant to public policy. The paper begins with an overview of the benefits of taking GIS systems online, describes the technical options for doing so, and provides contemporary examples of online GIS implementations.

**Keywords:** GIS on-line, Maps on internet, Database on internet.

**Resumo:** Este artigo apresenta uma visão geral dos Sistemas de Informação Geográfica (SIG) on-line. O sistema de SIG's on-line estão se firmando no mercado como uma ferramenta de auxílio importante aos usuários da internet. Além disso, permitem aos executores dos sistemas promover o desenvolvimento econômico, pois os mesmos procuram meios atuais tornarem seus trabalhos relevantes no contexto das políticas públicas. O artigo inicia com uma visão geral dos benefícios do sistema SIG on-line, descreve as opções de técnicas para fazê-lo, e fornece exemplos atuais de implementações de SIG's on-line.

**Palavras-chave:** SIG on-line, Mapas na Internet, Banco de dados na Internet.

### INTRODUCTION

This paper presents an overview of the online delivery of Geographic Information Systems (GIS), which has become an increasingly important way to gain leverage from the resources that have been invested in GIS. The subject is particularly relevant to GIS practitioners in developing economies who are searching for ways to bring their work more directly to bear in the policy arena and for the general public. The paper begins with an overview of the benefits of taking GIS systems online and then describes the technical options for doing so. It continues with some examples of online GIS implementations and concludes with some general observations.

### BENEFITS OF WEB-BASED GIS

It is now well-established that GIS can be used by local governments to solve a wide number of problems, including the deployment of resources, the planning of land-use, and the provision of emergency services. These benefits have justified the often considerable costs of establishing and maintaining GIS for many municipalities. Costs of GIS implementation have typically included:

- Professional staff to manage the GIS
- Technical staff to input data, often by hand

- The purchase of expensive hardware, including advanced processors, extra memory, and specialized peripherals such as large-format printers and digitizers
- Expensive software licenses, both for those who create the GIS and for those who use it

Technical changes in GIS in the past several years are starting to reduce some of these costs. For example, it is now possible to use digital scanners for data acquisition that formerly required more expensive and labor-intensive digitizers. As desktop computers have become more powerful, it has been more feasible to install GIS software on standard desktop computers, rather than dedicated workstations.

The professionals and technicians who develop GIS still need to use specialized software, but the integration of GIS and the World Wide Web is now allowing users in other parts of the organization to use GIS data without specialized software (Nelson, 2002). Moreover, Web technology is making data increasingly available to constituencies outside of the agencies that generate GIS.

Web-delivered GIS is an increasingly important aspect of data sharing between municipalities and larger organizations, such as state governments or national and international agencies. Municipalities are able to reduce costs by acquiring data from larger organizations, and increasingly this acquisition is mediated through web sites. Even when fees are charged, this is often less expensive than using internal staff and equipment to generate data.

Sharing GIS data among agencies was, of course, feasible prior to the advent of Web-based system, but the new technology offers at least two significant advantages. First, Web-based clearinghouses (Geography Network, 2004) make it increasingly convenient to find suitable data sources. Second, data that are shared via the web can be kept current more easily than data shared using other media. In cases where data are delivered directly through Web-based GIS clients (see below), data updates reach end users instantaneously. Even if data are downloaded from Web sites for use in “traditional” GIS software offline, data can be kept remarkably current.

## **GIS WEB DELIVERY**

If the rewards for moving a GIS program online are great, so also are the pitfalls. Careful planning is required to choose among many alternatives, based on many variables, some of which are internal, but many of which are external to the organization. At one extreme are solutions that require end users to have no special training or resources; more robust systems may assume that end users – or intermediate users – have invested either in training or specialized software.

### **Simple Model**

Consider first a system that delivers finished maps to end users who have no specialized software, beyond that which is normally required for web browsing. The GIS office of the town of Bridgewater, Massachusetts has such a system (Tavares 2004), which provides maps of the entire town (approximately 70 km<sup>2</sup>) that depict a variety of thematic variables of common interest to members of the community. These include environmentally sensitive areas, town-owned property, designated bicycle paths, and aerial photographs of selected landmarks.

Such a system is a relatively simple marriage between a basic municipal web site and a municipal GIS; it is easily created using a basic web-page editor and the file export function of the existing GIS software. Municipal GIS professionals can work with other municipal officials to determine the most appropriate material to make available to the public, and then they compose those maps much as they would for a traditional paper format. Then, they export the final map product to a commonly readable file format, such as \*.pdf, \*.jpg, or \*.gif. The author’s own house is depicted in Figure 1, which was extracted from a \*.jpg-format image delivered in just this manner.

In the case of the Town of Bridgewater, this system leverages the efforts of a small GIS office with limited resources. Information that previously was made available only on paper maps to a limited number of users is now available to all. This tremendous expansion in access was made possible with minimal investment in new resources. This approach is, however, limited in several key ways. First, each map view must be created in its entirety by the GIS staff. Even if external constituencies are given the opportunity to request maps, the total number of maps will always be relatively few. Second, metadata that would normally accompany GIS data sets are easily lost, unless the GIS staff has the time to make careful annotations of

each map or image it creates. For example, no date is readily available for Figure 1. Finally – and most important – this approach to online GIS dissemination imposes severe limitations on choices of spatial resolution. Most of the thematic maps made available in this program cover the entire town in one image (Figure 2), meaning that detail is rather limited. The \*.pdf format does allow the end user to change the apparent scale of the final image, but it does not provide the true spatial resolution that larger-scale maps would afford. To provide larger-scale maps would entail creating a prohibitively large number of customized maps, many of which would probably never be accessed. Only a small percentage of the town's land area is made available in images such as Figure 1.



Figure 1 : Maple Avenue, Bridgewater, Massachusetts USA. Undated.

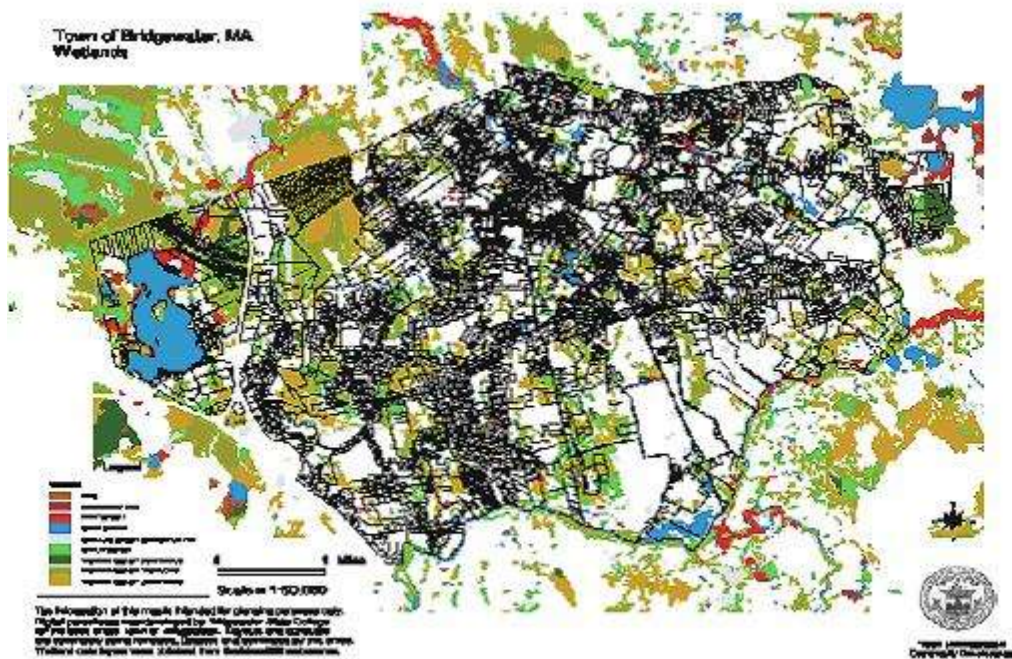


Figure 2 : Designated Wetlands in Bridgewater, Massachusetts

## Data Archives on the Web

In the Commonwealth of Massachusetts, municipal GIS programs such as that of Bridgewater described above have the advantage of being able to retrieve data from a state-wide system known as MassGIS. This well-developed program began in the late 1980s in the state government's environmental division (MassGIS 2004). For many years prior to the advent of the World Wide Web, MassGIS provided paper maps in response to particular requests and data files to users operating their own GIS software. End users could either obtain completed maps on paper, or they could acquire raw GIS data on a variety of media, provided they had the specialized hardware and software needed to process the data.

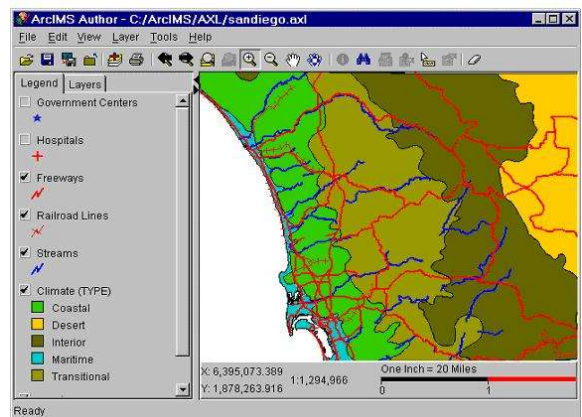
MassGIS has moved to the Web in several ways, including the creation of a Web-based archive of its data sets. For those municipalities and other organizations that operate their own GIS programs and have the appropriate software (i.e., ArcView, ArcInfo, or ArcGIS), data files are now available on the Web. This allows these intermediate users to acquire the latest available data whenever they wish, for inclusion in their own projects. Compared to the previous system of ordering data files on static media such as CD-ROM, this service provides more timely delivery and lower cost. MassGIS does still offer its data sets on CD-ROM, however, primarily because the spatial resolution of some layers can make delivery via the web tedious.

## Web Delivery Using ArcIMS

Municipalities with well-developed internal GIS can leverage that investment even further – and avoid some of the tradeoffs described above – by investing in a web-delivery system such as ArcIMS from ESRI (ESRI 2004a). A significant advantage of this approach is the greater flexibility it provides to end users – both internal and external – in determining the thematic coverage to be displayed and the spatial resolution of the maps that are rendered. Depending upon the degree to which geospatial data can be encoded, it is possible to provide end users with query-driven access to quite detailed information.

These advantages accrue only after an investment in software training and project planning (Nelson 2002). The project proceeds in three major stages: creating map content, moving it to a web server, and designing an interface for end users to retrieve the map data. ArcIMS is a package that includes a separate application for each of these tasks (ESRI 2004a).

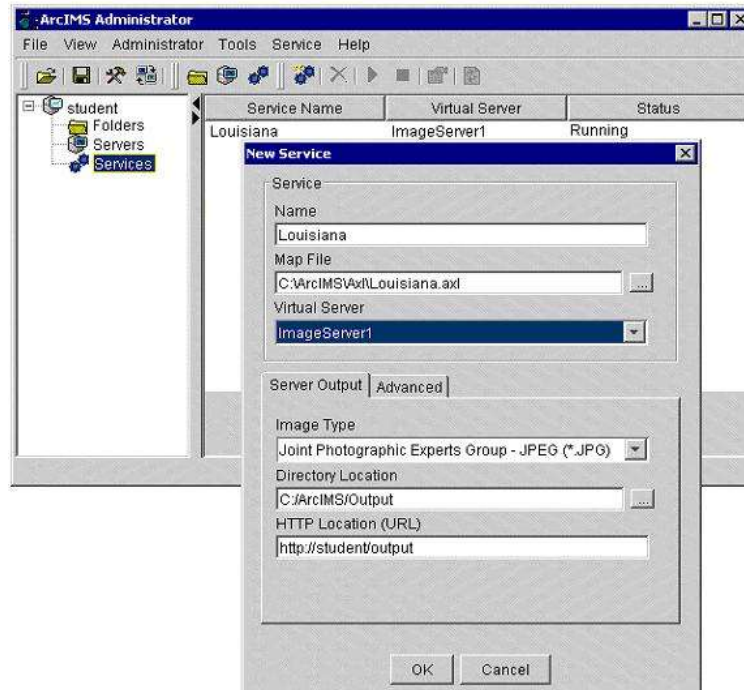
Much like ArcView, ArcIMS Author gives the GIS professional the ability to compose a map by selecting a combination of data layers, choosing colors, labels, and symbols (see Figure 3). Unlike ArcView, however, the Author application generates a map configuration file in a proprietary format known as an AXL. These files are written in a specialized markup language, known as ArcXML, an Extensible Markup Language.



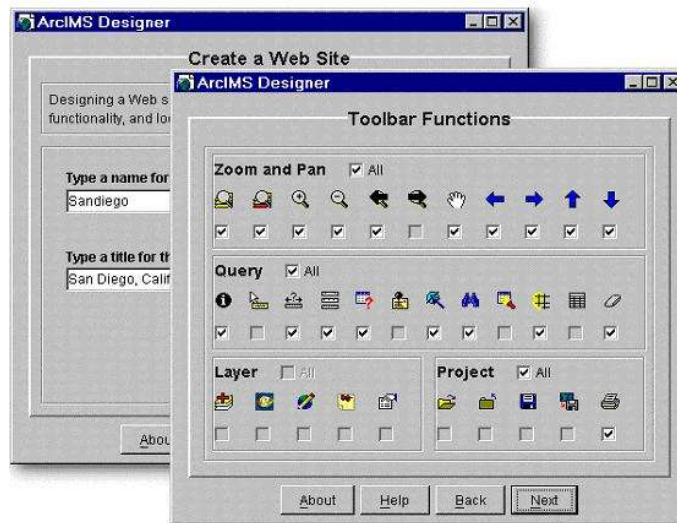
**Figure 3** : Map composition in Arc IMS Author

Once an AXL file is created on a local computer, it is analogous to an HTML file: that is, it is useless until activated in a Web server environment. ArcIMS Administrator is the application that creates a Web-based “service” for the AXL files, so that the server can process requests being made of the file. Some of the parameters for activating such a service are shown in Figure 4, and are broadly similar to those needed to publish other sorts of files to the Web.

Once a map file has been made available on a server, users can interact with it if they are provided tools through an appropriate interface. ArcIMS Designer allows the GIS professional to choose whether that interface will be HTML-driven or Java-driven, and which tools will be available to the end user. The Java-driven interface requires a Java-enabled browser – which has become almost universal – and allows for both vector and raster data to be delivered. HTML-driven interfaces do not support vector data. Figure 5 indicates some of the tools that can be included.



**Figure 4 :** Creation of Web Service for an AXL file in ArcIMS Administrator



**Figure 5 :** ArcIMS Designer controls map-viewing tools are made available to the end user

## EXAMPLES

The suite of applications described above are already in use at established GIS programs throughout the world, operating at a variety of spatial scales and encompassing an enormous thematic variety. Two examples presented here illustrate the potential uses of this spatial communication technology at the municipal level. The City Front Counter program (see Figure 6) allows end users to query Ontario, California property records by owner name, address, or parcel number, and to view essential property information together with a map of the property (ESRI 2004b). The City GIS Viewer (Figure 7) allows end users to view several data layers for any selected portion of Wilson, North Carolina, although it does not give end users control over which data layers are displayed (ESRI 2004b). Web-based GIS programs are not limited to

municipal applications (ESRI 2004c). The Lewis and Clark Education Center (Figure 8) provides a thoroughly interactive educational experience that explores the expedition itself and the natural environment encountered by Lewis and Clark (EOS 2004).



Figure 6 : Ontario, California's City Front Counter

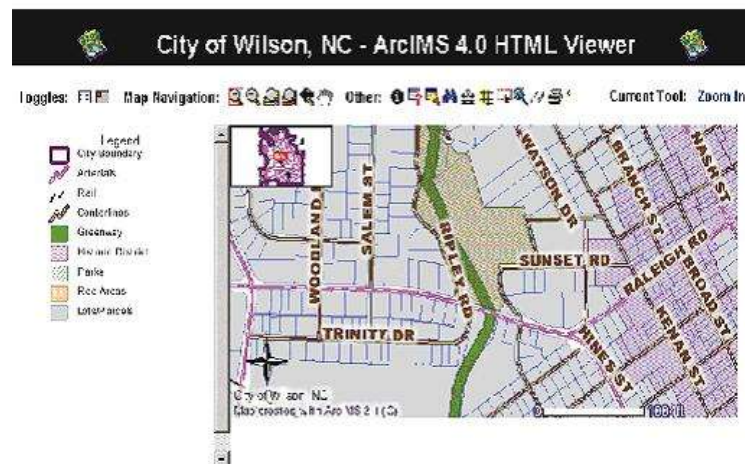


Figure 7 : Wilson, North Carolina's City Viewer

All of the examples shown so far can be accessed by end users with ordinary Web browsers, perhaps enhanced by such commonplace extensions as Java and Adobe Acrobat Reader. Another class of Web-delivered GIS programs makes somewhat stronger demands on end users, but rewards them with far greater flexibility in creating maps that suit their individual or institutional needs. Once again, MassGIS provides an excellent example. As discussed previously, MassGIS has made an enormous amount of information available on its web site. GIS professionals with access to such software as ArcView can use these data sets to create an almost endless variety of maps. MassGIS has created a client-side application known as the Oliver data viewer, available for download on its Web site. Oliver allows users with modest GIS skills to create customized maps, even if they lack the software normally available only to GIS professionals. In fact, high school and college students can easily be taught to use Oliver to make visual comparisons between spatial variables (Figure 9). Once an end user composes a map in Oliver, a command can be given to generate a unique URL that generates the map as an image in any browser. End users can therefore use Oliver to post maps to their own web sites, so that other users can view them as static image files. ESRI's free software program ArcExplorer is very similar to Oliver, but with an added benefit: it can be used to combine data layers from any number of local and Web-based data sources.

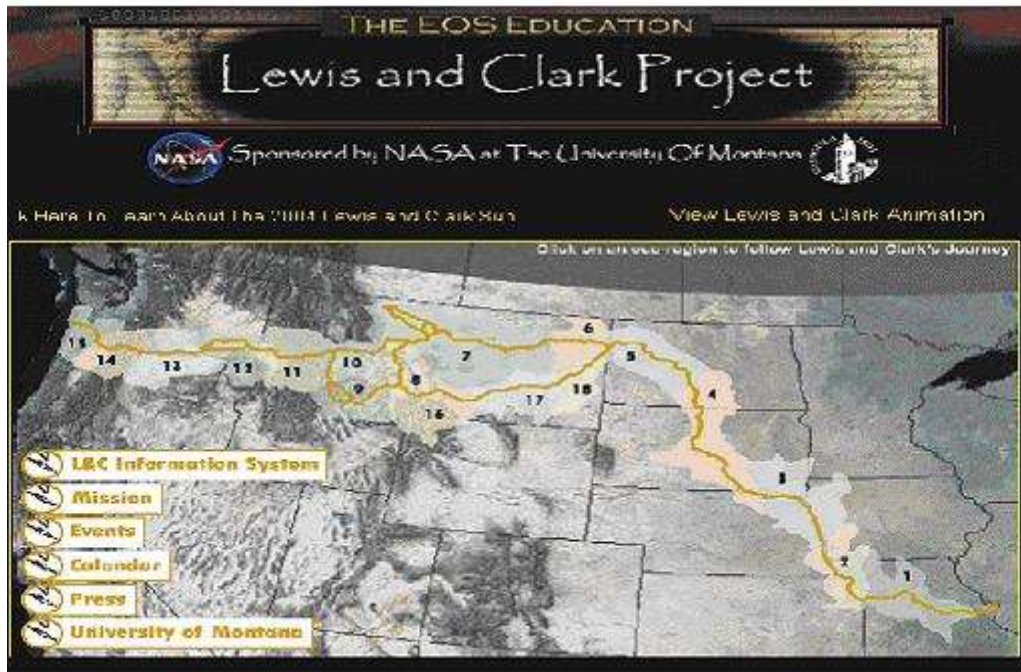


Figure 8 : Ecoregions along the Lewis and Clark route

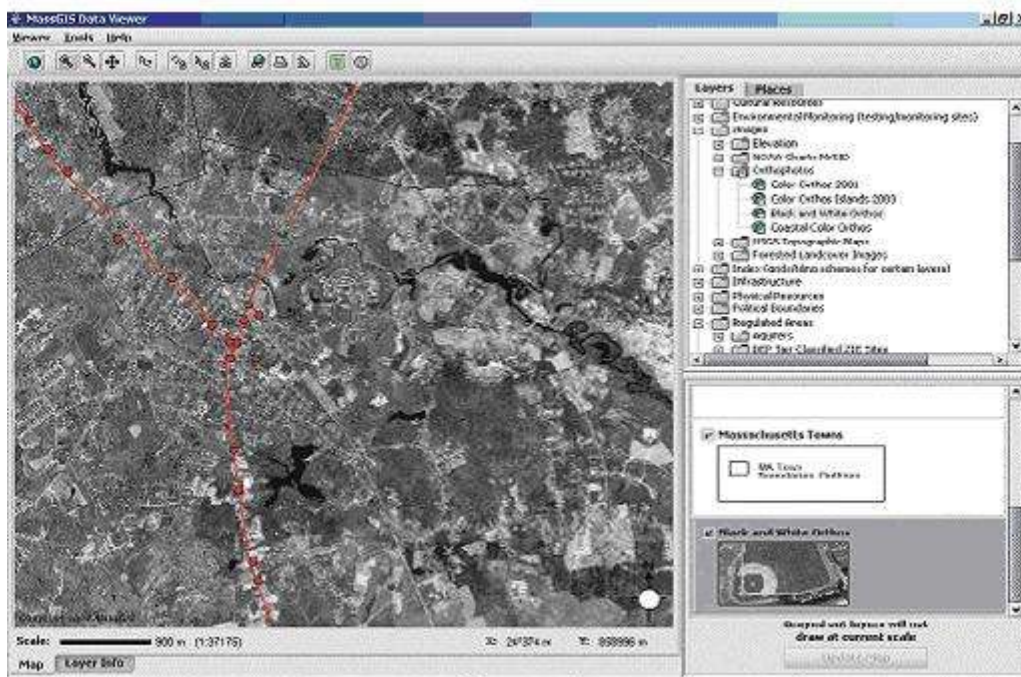


Figure 9 : Oliver used to overlay highway and underground storage tank data on an aerial photograph that includes the author's home. Note the great variety of data types that can be combined using this application.

## Considerations

The movement of GIS programs to the World Wide Web is accelerating and is motivated by a number of factors. The most important appears to be the ability to leverage existing GIS resources by expanding outreach to external constituencies many times over, even with very modest investments in new resources. An additional motivation appears to be the ability to minimize costs, often dramatically. New applications for

this blending of technologies are still being found.

Most of the applications to date have been in developed economies, in which both GIS and more general Web-based technologies are widely available. The fusion of these technologies is becoming more common, however, in some emerging economies, notably India and South Africa (Odendaal 2003). Given the very strong status of the Web in Brazil and the growing expertise of Brazilian GIS professionals, it seems likely that Web-based GIS will see rapid growth in Brazil in the near future. This represents a splendid opportunity for Brazil to overcome the gap that often exists between the increasingly accurate cadastral data available to GIS professionals and the rather slow progress in the *de facto* recognition of boundaries.

## REFERENCES

**EOS. 2004.** Lewis and Clark Education Center. <http://lewisandclarkeducationcenter.com/>

**ESRI. 2004a.** Learning ArcIMS 4. ESRI Virtual Campus. <http://campus.esri.com>

**ESRI. 2004b.** Explore our live Internet Map Server demos. <http://maps.esri.com/>

**ESRI. 2004c.** Web Sites Powered by ESRI Internet Solutions.  
[http://www.esri.com/software/internetmaps/visit\\_sites.html](http://www.esri.com/software/internetmaps/visit_sites.html)

Geography Network. <http://www.geographynetwork.com>

**MassGIS. 2004.** Introduction to MassGIS. <http://www.state.ma.us/mgis/intro.htm>

**Nelson, Eileen. 2002.** Low-cost options for creating a GIS. *American City and County*. November 2002: 10.

**Odendaal, Nancy. 2003.** Information and communication technology and local governance: Understanding the difference between cities in developed and emerging economies. *Computers, Environment, and Urban System* 27(6): 585-607.

**Tavares, Anne. 2004.** Bridgewater Geographic Information Systems.  
<http://www.bridgewaterma.org/Government/GIS.shtml>