Web Feature Services and
Information Dissemination in the State of Rhode Island

A 2005 National Spatial Data Infrastructure Cooperative Agreement Program;
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Final Report

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d. Project Narrative:

The Environmental Data Center at the University of Rhode Island has created three Web Feature Services (WFS) to support the FGDC Framework: Governmental Units, Hydrography, and Transportation. The WFS's GetCapabilities URL's are as follows:

Governmental Units:
http://mapper.edc.uri.edu/wfs/governmental_units.exe?SERVICE=WFS&VERSION=1.0.0&REQUEST=getcapabilities

Hydrography:
http://mapper.edc.uri.edu/wfs/hydrography.exe?SERVICE=WFS&VERSION=1.0.0&REQUEST=getcapabilities

Transportation:
http://mapper.edc.uri.edu/wfs/transportation.exe?SERVICE=WFS&VERSION=1.0.0&REQUEST=getcapabilities

Since sharing our interim report in April 2006, the development team worked toward completing the project using MapServer software. ESRI ArcIMS software version 9.1 was unable to help us meet our goal of creating WFS compliant with the Open Geospatial Consortium (OGC) WFS v1.1 standard. We subsequently reduced our sights to implementing WFS that offer data that meet the OGC Geographic Markup Language Simple Features (GML-SF) profile, WFS v1.0. ESRI ArcIMS 9.1 does have this capability, but unfortunately we were unable to successfully configure the software to adapt to the schemas outlined by the INCITS geographic data standards. While discussing our situation with ESRI staff, we learned that ESRI ArcGIS Server 9.2 may include a capacity for schema translation, but this software will not be released until after the completion deadline for this project.

After sharing these challenges with our fellow CAP participants and learning from their own experiences, we decided to redirect and renew our efforts by using alternative software. We eventually chose to implement MapServer. The most recent release of MapServer supports GML-SF. We first experimented with installing MapServer on a Debian Linux server, then later transitioned to a Windows server simply because the Windows-based server boasted more robust hardware, leading to faster processing of WFS requests. Both installations were successful and proved to be stable platforms for Web Feature Services with MapServer. Step-by-step Mapserver configuration instructions for a Windows Server 2003-based server are included in Appendix A.

We manipulated our selected data (Table 1) to conform to the INCITS geodata standards in the early stages of our project. During this process, we discovered that the standards set a very high expectation for these data, so high that full schema compliance is impossible at this time with our existing data. One example of the high standard set by full INCITS schema compliance is that it is difficult to create a spatial relationships table. A spatial relationships table defines how one region, such as a town, relates to another

town or to a larger region, such as a county. The table would document if the towns in question shared boundaries, or if the towns were encompassed by a county, or if a town was split by a political boundary such as voting districts. Such data can be generated within a GIS, however the tables generated would be substantial and to our knowledge, no current software package would support serving out these tables of data. Integration of the spatial relationship table is beyond the current scope of GML-SF.

Due to these technical challenges, we reduced out expectations and pursued manipulating our existing data to conform to GML-SF standards. We attempted to meet any field listed as "mandatory obligation" within the INCITS schemas.

We had the most success with modifying the attributes of our Governmental Units data to meet its respective INCITS schema. The Governmental Unit standard is the most versatile since it is flexible enough to adapt to many different types of geodata. Our data for this particular WFS ranges from traditional political boundaries, to shellfish closure areas and water supply districts.

The Hydrography schema seeks more specific data than Governmental Units. The current schema's primary focus is on stream relationships and flow data, resulting in a networked system of streams well-suited to hydrologic modeling. While we included a simple streams network in our Hydrography WFS, the State of Rhode Island will not be receiving a full stream network database for at least another year (one has been contracted and is now in production). We have also included relevant Hydographic layers such as surface water bodies, drainage basins, and public water supply reservoirs.

The Transportation schema presented a challenge similar to Hydrography because they both share a tightly focused vision of data that are expected to be included in this category. The Transportation schema focuses solely on road-related data (Part 7c: Roads). Pertinent datasets such as bike paths, ferry routes, bus routes, and bus stops do not have a place in the current Transportation schema. Furthermore, the Transportation schema requires a level of detail that would require extensive rebuilding of our existing data to a point beyond our project's capacity. Currently the existing RIGIS transportation data do not contain the information needed to meet the INCITS Transportation schema requirements. In an effort to find some middle ground, we manipulated our Transportation layer to offer data compatible with the core minimum standards of the Transportation schema.

In general, MapServer is an excellent platform for offering Web Feature Services. The MapServer configuration files, known as map files, allow for much customization of how data are presented to the users. Our MapServer configuration files as they currently stand are listed in Appendix B. The map files allows one to drop and add attribute fields from the geodata on-the-fly, as well as rename them using the MapServer *alias* command. This functionality allowed us to largely conform our data to the minimum requirements of the INCITS schemas. We also found the enthusiastic MapServer community to be extremely helpful. During the course of this project, we took advantage of the wealth of knowledge and assistance available from the general MapServer email listserv.

The Carbon Project's *Gaia 2* client software served as the primary test bed for our project. The WFS also tested successfully with Refractions Research's *uDig* and Cadcorp's *Map Browser*. On the other hand, our services do not function with the National Geospatial One-Stop's (GOS) Map Viewer. When one tries to use the GOS Map Viewer to access one of our WFS, the result is an "XML response is bad" error with no accompanying diagnostic information. We do not know at this time if this error is attributed to our WFS' or to the geodata.gov Map Viewer. There has been some recent discussion in the MapServer community that the current release of MapServer creates GML with some extraneous fields that may prevent the xml from being validated correctly, a problem that will likely be fixed in the next release of MapServer..

This project was presented at the New England GIS conference in Danvers, Massachusetts in May 2006. The audience in attendance was small, but they seemed interested in building their own respective WFS', though their work will likely not be designed with INCITS standards in mind. We also heavily marketed our efforts in personal conversations during the Spring Meeting of the Northeast Arc Users Group (NEARC) in April 2006 and at the ESRI International User Conference in August 2006. Our efforts have generated interest in Rhode Island with several individuals who have worked with our WFS', all of whom expressed interest in creating their own. We are certain the results of this project will assist others in the region as they weigh the possibilities of WFS technology.

Overall, we are enthused with data we are now able to provide via our Governmental Unit, Hydrography, and Transportation Web Feature Services. The process of exploring Web Feature Services was very educational and we feel we are providing a useful service to the geospatial technology community. With further advances in WFS-related technology, perhaps most importantly the growth of network speed and bandwidth in support of the Internet, the WFS protocol will certainly come to its own in the not-so-distant future.

d. Status of our data management activities:

What Framework data theme(s) are being managed for service under this project?

Governmental Units, Hydrography, and Transportation.

What is the data volume of Framework data being managed for service (number of features, megabytes)?

We currently have 29 datasets totaling approximately 130 MB of data. Two categories, Hydrography and Transportation, each contain 10 datasets while Governmental Units contains 9.

Who are the primary organizations providing data for this project?

All of our data is provided by the Rhode Island Geographic Information System (RIGIS) consortium. The most significant contributors of the RIGIS data used for this project are the Rhode Island Department of Transportation, Rhode Island Department of Environmental Management, and the Rhode Island Statewide Planning Program.

What hardware and software are being deployed for data management, configuration and WFS service?

We are using a Dell PowerEdge server sporting one Intel Xeon 3.20 GHz CPU with 2 GB of RAM. We eventually used MapServer 4.8.4 as our final software solution. Originally we had planned to use ESRI ArcIMS software, but found that would not be feasible with the current release of the software. ESRI has plans to expand the WFS capabilities with their release of ArcGIS Server 9.2, however the anticipated release date is scheduled for after the termination date of this project. MapServer was found to have the speed and functionality to meet our needs. Furthermore, MapServer seemed to have a noticeably faster response time in processing and sending down the WFS-based data to the client than ESRI ArcIMS.

e. Status of Framework Web Feature Services

Has the service been registered with geodata.gov?

Yes, via Rhode Island's Geodata Gateway, a new metadata clearinghouse hosted by the University of Rhode Island Environmental Data Center. Approval of these metadata is still pending by geodata.gov as of when this final report was submitted.

Describe your experience and purpose in accessing the data through geodata.gov or dedicated application clients.

We attempted to use geodata.gov to locate statewide data for our use, but our search yielded no results that improved on the existing RIGIS data catalog. The interaction with the website was good, however finding data proved difficult due to metadata quality control issues, such as inaccurate geographic scopes in much metadata we encountered. We suspect future users will have an easier time locating data for Rhode Island once RIGIS metadata are harvested by geodata.gov from Rhode Island's Geodata Gateway.

Describe any internal or external users and applications that are using this WFS

At this time, only external users are casually using the WFS for experimentation. The most common prohibiting factor is likely network bandwidth, which slows down the amount of time it takes to stream data from our server to the client. Known software clients consist of *Gaia 2* and *uDig*.

f. Project Management:

Will this project's activities continue in the future.

Yes. However, it is noteworthy that there is currently little incentive for state agencies to develop data that comply with FGDC Framework and INCITS data standards. Schema translation will go a long way towards adapting state-based data to the Framework standards should it be necessary in the future. In the meantime, we are exploring the possibility of placing the remainder of the RIGIS data holdings online in a WFS format for easier access by RIGIS data consumers. This dramatic offering would likely not be under consideration if it were not for the experience we earned during the course of this project.

Describe the next phase in your project.

Once ESRI releases their ArcGIS Server 9.2 software, we plan to rebuild our WFS constructed for this project and compare with our existing MapServer-based WFS'. We are interested keeping up with state-of-the-art of WFS technology and will remain in contact with USGS to not only keep up our knowledge of the WFS, but also to report on our experience with the WFS capabilities of the latest versions ArcGIS Server software.

g. Feedback on Cooperative Agreements Program:

What are the program strengths and weaknesses?

The program's greatest strength lies in the potential of a group of specialists working together toward the same end, all of whom have the ability to aid each other. Unfortunately in our experience, most CAP participants did not willingly share their trials and tribulations in a public forum, such as the regular conference calls, making it difficult for us to learn from their experiences. The most useful advice we received was from Steve Sharp from VCGI through personal communication, whose project goals were similar to our own.

Where does the program make a difference?

It allows groups to explore cutting-edge technology that are not yet commonly funded, allowing for true advancements.

Was the assistance you received sufficient or effective?

We would prefer more feedback directly from FGDC on our work, and would appreciated learning from more matter-of-fact participant conversation during the regularly scheduled CAP conference calls.

What would you recommend doing differently?

Post briefings on the WFS CAP area of the new FGDC website that succinctly describe the goals of each of the CAP participants projects (software, hardware, framework themes) and each group's respective contact information. Encourage CAP participants to actively communicate with each other using the new FGDC website in a public forum, allowing current and future CAP participants to learn from their discussions and community-based knowledge.

Are there factors that are missing or need to consider that were missed?
No.

Are there program management concerns that need to be addressed? Time frame?

No.

If you were to do this again, what would you do differently?

Our team has enjoyed the opportunity to experiment with different methods of developing our WFS despite the steep learning curve we initially encountered. If we were to do this differently, we would have focused less on data development and configuration, such as perhaps dropping to just a single Framework theme, and more on committing a significant portion of our budget to an interested software development team to create a schema translator. The schema translator seems to the most common factor that inhibits most WFS development at this time. It's now clear to us that existing software used to drive WFS is still not yet ready to handle the full library of information requested by the INCITS schemas. It would certainly benefit the user community if software providers found greater possibilities in WFS and committed more resources to developing this largely untapped data delivery mechanism.

Table A: RIGIS data implemented using Web Feature Services

Framework Theme	Vector Data Description	Source Scale	Edition
Governmental Units	Congressional Voting Districts		
	Counties	1:5,000	2004
	Historic Districts	1:24,000	1999
	Municipal Boundaries	1:5,000	2004
	Rhode Island House Districts	1:24,000	2002
	Rhode Island Senate Districts	1:24,000	2004
	Shellfish Closure Areas	1:5,000	2005
	State Boundary	1:5,000	2004
	Water Supply Districts	1:24,000	1995
Hydrography	Community Wellhead Protection Areas	1:24,000	2005
	Groundwater Classification	1:24,000	2005
	Groundwater Recharge Areas	1:24,000	2005
	Lakes and Ponds	1:5,000	2002
	Non-community Wellhead Protection Areas	1:24,000	2005
	NRCS HUC12 Drainage Basins	1:24,000	2003
	Public Water Supply Reservoirs	1:24,000	1994
	Sole Source Aquifers	1:24,000	1992
	Streams	1:5,000	2001
	Surface Water Protection Areas	1:24,000	2002
Transportation	Airports	1:5,000	2001
	Bike Paths	1:5,000	2002
	E-911 Driveways	1:5,000	2004
	Exit Ramps	1:5,000	2002
	Ferry Routes	1:5,000	2004
	Park & Ride Lots	1:24,000	1996
	Railroad Rights of Way	1:5,000	2003
	RIPTA Bus Routes	1:5,000	2006
	RIPTA Bus Stops	1:5,000	2006
	Roads (1:5000)	1:5,000	1997

Appendix A: Instructions for installing and configuring Mapserver 4.8.4 for Windows Server 2003

We chose to use FWTools, and Open Source GIS Binary Kit for Windows and Linux assembled and compiled by Frank Warmerdam. We chose FWTools because we had wished to install MapServer on a server with an existing Apache instance, and it saved a considerable amount of time over assembling and compiling the components of FWTools on our own. If you are starting from scratch, you may prefer to use *MapServer for Windows (MS4W)* instead.

1) Download the latest version of FWTools from http://fwtools.maptools.org/. This consists of a precompiled version of UMN Mapserver for Windows.

2) Run the FWTools setup program. Accept all the defaults.

3) If Apache isn't already being used as a traditional webserver for any other services, change DocumentRoot and <Directory> within the Apache httpd.conf file to a new directory on the server, such as "D:/website". (NOTE: direction of the slashes).

4) Create the directory titled "tmp" in D:/website.

5) Add the following directory alias to httpd.conf:
   Alias /tmp/ "D:/website/tmp/"

<Directory "D:/website/tmp/">
  AllowOverride None
  Options Indexes FollowSymLinks Multiviews
  Order allow,deny
  Allow from all
</Directory>

6) Add the following ScriptAlias variable to httpd.conf (note your FWTools version number in the paths below could be different):
   ScriptAlias /wfs/ "C:/Program Files/FWTools1.0.5/bin/"

7) Add the following CGI directory in the section after the ScriptAlias area in httpd.conf:
   <Directory "C:/Program Files/FWTools1.0.5/bin">
AllowOverride None
Options None
Order allow,deny
Allow from all
</Directory>

Note the path. You may need to update it.

8) Add the following SetEnv variable to the end of the httpd.conf file:
SetENV PROJ_LIB "C:/Program Files/FWTools1.0.5/proj_lib"

9) OPTIONAL: Add the environmental variable "GDAL_DATA" to the server. Set it to:
C:\Program Files\FWTools1.0.5\proj_lib

10) Restart Apache. Hopefully it'll work! If it doesn't, review the installation instructions on the MapServer website, or execute Internet searches for specific error messages you might encounter in the Apache log files.

Appendix B: MapServer .map configuration files

Map file 1: Governmental Units

```
#
# Start of map file
#

NAME WFS_Governmental_Units
STATUS ON
EXTENT 250000 4550000 330000 4660000
UNITS METERS
SHAPEPATH "./governmental_units/"

WEB
 IMAGEPATH "../../tmp/"
 IMAGEURL "/tmp/"
 METADATA
  WFS_TITLE "Rhode Island Governmental Units"
  WFS_ONLINERESOURCE "http://mapper.edc.uri.edu/wfs/governmental_units.exe?"
  WFS_SRS "EPSG:32619 EPSG:4269 EPSG:4326" #
 END
END

PROJECTION
        "init=epsg:32619" # UTM Zone 19N, WGS84
END

###############################################

LAYER
 NAME county_utm
 METADATA
        WFS_TITLE "Rhode Island Counties"
        GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,government"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"

 END
 TYPE POLYGON
 STATUS ON
 DATA county_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # county_utm

LAYER
 NAME federal_dis_utm
 METADATA
        WFS_TITLE "Rhode Island Congressional Voting Districts"
        GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,administra"
```

```
            GML_GEOMETRIES "geometry"
            GML_GEOMETRY_TYPE "multipolygon"
  END
  TYPE POLYGON
  STATUS ON
  DATA federal_dis_utm
  PROJECTION
          "+init=epsg:32619"
  END
  DUMP TRUE
END # federal_dis_utm

LAYER
  NAME historic_utm
  METADATA
          WFS_TITLE "Rhode Island Historic Zones"
          WFS_ABSTRACT "Historic districts listed in the National Historic Register"
          GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,otherUnitT"
          GML_GEOMETRIES "geometry"
          GML_GEOMETRY_TYPE "multipolygon"
  END
  TYPE POLYGON
  STATUS ON
  DATA historic_utm
  PROJECTION
          "+init=epsg:32619"
  END
  DUMP TRUE
END # historic_utm

LAYER
  NAME house_utm
  METADATA
          WFS_TITLE "Rhode Island House Legislative Voting Districts"
          GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,administra"
          GML_GEOMETRIES "geometry"
          GML_GEOMETRY_TYPE "multipolygon"
  END
  TYPE POLYGON
  STATUS ON
  DATA house_utm
  PROJECTION
          "+init=epsg:32619"
  END
  DUMP TRUE
END # house_utm

LAYER
  NAME senate_utm
  METADATA
          WFS_TITLE "Rhode Island Senate Legislative Voting Districts"
          GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,administra"
          GML_GEOMETRIES "geometry"
          GML_GEOMETRY_TYPE "multipolygon"
```

```
    END
    TYPE POLYGON
    STATUS ON
    DATA senate_utm
    PROJECTION
            "+init=epsg:32619"
    END
    DUMP TRUE
END # senate_utm

LAYER
    NAME shellfish_utm
    METADATA
            WFS_TITLE "Rhode Island Shellfish Closure Areas"
            WFS_ABSTRACT "Rhode Island coastal waters & Narragansett Bay shellfish closure areas."
            GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,otherUnitT"
            GML_GEOMETRIES "geometry"
            GML_GEOMETRY_TYPE "multipolygon"
    END
    TYPE POLYGON
    STATUS ON
    DATA shellfish_utm
    PROJECTION
            "+init=epsg:32619"
    END
    DUMP TRUE
END # shellfish_utm

LAYER
    NAME state_utm
    METADATA
            WFS_TITLE "Rhode Island State Boundary"
            WFS_ABSTRACT "Rhode Island state line boundary including coastline"
            GML_INCLUDE_ITEMS "FID,government"
            GML_FID_alias "UnitId"
            GML_GEOMETRIES "geometry"
            GML_GEOMETRY_TYPE "multipolygon"
    END
    TYPE POLYGON
    STATUS ON
    DATA state_utm
    PROJECTION
            "+init=epsg:32619"
    END
    DUMP TRUE
END # state_utm

LAYER
    NAME towns
    METADATA
            WFS_TITLE "Rhode Island Municipal Boundaries"
            WFS_ABSTRACT "City and town political boundaries for RI"
            GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,government"
            GML_GEOMETRIES "geometry"
```

```
                GML_GEOMETRY_TYPE "multipolygon"
      END
      TYPE POLYGON
      STATUS ON
      DATA towns_utm
      PROJECTION
              "+init=epsg:32619"
      END
      DUMP TRUE
   END # towns_utm

   LAYER
      NAME water_code_utm
      METADATA
              WFS_TITLE "Narragansett Bay Water Classification"
              WFS_ABSTRACT "Water zone classifications in Narragansett Bay by RICRMC and RIDEM"
              GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,otherUnitT"
              GML_GEOMETRIES "geometry"
              GML_GEOMETRY_TYPE "multipolygon"
      END
      TYPE POLYGON
      STATUS ON
      DATA water_code_utm
      PROJECTION
              "+init=epsg:32619"
      END
      DUMP TRUE
   END # water_code_utm

   LAYER
      NAME water_utm
      METADATA
              WFS_TITLE "Rhode Island Water Supply Districts"
              WFS_ABSTRACT "Boundaries for public water districts"
              GML_INCLUDE_ITEMS "UnitId,InstanceNa,InstanceCo,otherUnitT"
              GML_GEOMETRIES "geometry"
              GML_GEOMETRY_TYPE "multipolygon"
      END
      TYPE POLYGON
      STATUS ON
      DATA water_utm
      PROJECTION
              "+init=epsg:32619"
      END
      DUMP TRUE
   END # water_utm

   END # Map File
```

Map File 2: Hydrography

```
#
# Start of map file
#

NAME WFS_Hydrological_Units
STATUS ON
EXTENT 250000 4550000 330000 4660000
UNITS METERS
SHAPEPATH "./hydrological_units/"

WEB
 IMAGEPATH "../../tmp/"
 IMAGEURL "/tmp/"
 METADATA
  WFS_TITLE "Rhode Island Hydrological Units"
  WFS_ONLINERESOURCE "http://mapper.edc.uri.edu/wfs/hydrography.exe?"
  WFS_SRS "EPSG:32619 EPSG:4269 EPSG:4326" #
 END
END


PROJECTION
        "init=epsg:32619" # UTM Zone 19N, WGS84
END

#################################################

LAYER
 NAME community_wellheads_utm
 METADATA
        WFS_TITLE "Community Wellhead Protection Areas"
        WFS_ABSTRACT "Areas around public community wells considered critical for the protection of their source
water supplies."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"

 END
 TYPE POLYGON
 STATUS ON
 DATA community_wellheads_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # community_wellheads_utm

LAYER
 NAME drainage_basins_utm
 METADATA
        WFS_TITLE "Rhode Island Drainage Basins"
        WFS_ABSTRACT "Surface water drainage basins and sub-basins in RI."
```

```
        GML_INCLUDE_ITEMS "featuredat,featuretyp,name,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"

 END
 TYPE POLYGON
 STATUS ON
 DATA drainage_basins_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # drainage_basins_utm

LAYER
 NAME groundwater_classification_utm
 METADATA
        WFS_TITLE "Rhode Island Groundwater Classification"
        WFS_ABSTRACT "Groundwater quality classifications for major aquifers, public well head areas and other
subsurface resources."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,name,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"

 END
 TYPE POLYGON
 STATUS ON
 DATA groundwater_classification_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # groundwater_classification_utm

LAYER
 NAME ground_recharge_areas_utm
 METADATA
        WFS_TITLE "Rhode Island Ground Water Rechage Areas"
        WFS_ABSTRACT "Critical portions of recharge areas for major RI groundwater aquifers suitable as sources for
untreated drinking water."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,name,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"

 END
 TYPE POLYGON
 STATUS ON
 DATA ground_recharge_areas_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # ground_recharge_areas_utm
```

```
LAYER
 NAME lakes_and_ponds_utm
 METADATA
        WFS_TITLE "Rhode Island Lakes and Ponds"
        WFS_ABSTRACT "All freshwater lakes, ponds and reservoirs including delineation of major rivers wide enough
to be represented as polygon areas on USGS 7.5 minute quad maps."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,name,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"
 END
 TYPE POLYGON
 STATUS ON
 DATA lakes_and_ponds_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # lakes_and_ponds_utm

LAYER
 NAME non_community_wellhead_utm
 METADATA
        WFS_TITLE "Rhode Island Non-Community Well Head Protection Areas"
        WFS_ABSTRACT "Areas around public non-community wells considered critical for the protection of their
source water supplies."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,name,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"
 END
 TYPE POLYGON
 STATUS ON
 DATA non_community_wellhead_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # non_community_wellhead_utm

LAYER
 NAME sole_source_aquifers_utm
 METADATA
        WFS_TITLE "Rhode Island Sole Source Aquifers"
        WFS_ABSTRACT "Areas in RI and nearby CT designated as sole source aquifers by the U.S. EPA."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,name,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"
 END
 TYPE POLYGON
 STATUS ON
 DATA sole_source_aquifers_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
```

END # sole_source_aquifers_utm

LAYER
 NAME streams_5k_utm
 METADATA
        WFS_TITLE "Rhode Island Streams"
        WFS_ABSTRACT "Rivers and streams in Rhode Island."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,name,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multiline"
 END
 TYPE POLYGON
 STATUS ON
 DATA streams_5k_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # streams_5k_utm

LAYER
 NAME surface_water_protection_area_utm
 METADATA
        WFS_TITLE "Rhode Island Surface Water Protection Areas"
        WFS_ABSTRACT "Designated protection areas around surface water bodies used as public drinking water
sources."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"
 END
 TYPE POLYGON
 STATUS ON
 DATA surface_water_protection_area_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # surface_water_protection_area_utm

LAYER
 NAME water_supply_reservoirs_utm
 METADATA
        WFS_TITLE "Rhode Island Public Water Supply Reservoirs"
        WFS_ABSTRACT "Surface reservoirs used as sources for public drinking water supplies."
        GML_INCLUDE_ITEMS "featuredat,featuretyp,value_,units,metadata"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"
 END
 TYPE POLYGON
 STATUS ON
 DATA water_supply_reservoirs_utm
 PROJECTION
        "+init=epsg:32619"
 END

```
 DUMP TRUE
END # water_supply_reservoirs_utm

END # Map File
```

Map File 3: Transportation

```
#
# Start of map file
#

NAME WFS_Transportation
STATUS ON
EXTENT 250000 4550000 330000 4660000
UNITS METERS
SHAPEPATH "./transportation_units/"

WEB
 IMAGEPATH "../../tmp/"
 IMAGEURL "/tmp/"
 METADATA
  WFS_TITLE "Rhode Island Transportation Units"
  WFS_ONLINERESOURCE "http://mapper.edc.uri.edu/wfs/transportation.exe?"
  WFS_SRS "EPSG:32619 EPSG:4269 EPSG:4326" #
 END
END

PROJECTION
        "init=epsg:32619" # UTM Zone 19N, WGS84
END

#################################################

LAYER
 NAME airports_utm
 METADATA
        WFS_TITLE "Rhode Island Airports"
        WFS_ABSTRACT "Airports for fixed-wing aircraft in RI"
        GML_INCLUDE_ITEMS "airports_,name,status"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multipolygon"
 END
 TYPE POLYGON
 STATUS ON
 DATA airports_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # airports_utm

LAYER
 NAME bike_paths_utm
 METADATA
        WFS_TITLE "Rhode Island Bikepaths"
        WFS_ABSTRACT "This data set contains center lines for all bicycle paths, bicycle routes, and bicycle lane
center lines for all statewide and local bikeways, bike routes, and bike lanes for the entire state of Rhode Island."
        GML_INCLUDE_ITEMS "road_name,status,proj_name,type"
```

```
          GML_GEOMETRIES "geometry"
          GML_GEOMETRY_TYPE "multiline"
 END
 TYPE POLYGON
 STATUS ON
 DATA bike_paths_utm
 PROJECTION
          "+init=epsg:32619"
 END
 DUMP TRUE
END # bike_paths_utm


LAYER
 NAME e_911_driveways_utm
 METADATA
          WFS_TITLE "Rhode Island Driveways (E-911)"
          WFS_ABSTRACT "Driveways and private roadways."
          GML_INCLUDE_ITEMS "AT_ID,DWID,SITEID"
          GML_GEOMETRIES "geometry"
          GML_GEOMETRY_TYPE "multiline"
 END
 TYPE POLYGON
 STATUS ON
 DATA e_911_driveways_utm
 PROJECTION
          "+init=epsg:32619"
 END
 DUMP TRUE
END # e_911_driveways_utm


LAYER
 NAME exit_ramps_utm
 METADATA
          WFS_TITLE "Rhode Island Exit Ramps"
          WFS_ABSTRACT   "Exit/entrance ramps or road locations for all numbered exits in Rhode Island on state
divided highways"
          GML_INCLUDE_ITEMS "exit_numbe,exit_route,exit_signa,exit_descr,direction"
          GML_GEOMETRIES "geometry"
          GML_GEOMETRY_TYPE "point"
 END
 TYPE POLYGON
 STATUS ON
 DATA exit_ramps_utm
 PROJECTION
          "+init=epsg:32619"
 END
 DUMP TRUE
END # exit_ramps


LAYER
 NAME ferry_routes_utm
 METADATA
          WFS_TITLE "Rhode Island Ferry Routes"
```

```
        WFS_ABSTRACT   "Established commercial passenger and vehicle water ferry routes for Rhode Island ports
and ferry landings."
        GML_INCLUDE_ITEMS "run_time,route,ferry_comp"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multiline"
 END
 TYPE POLYGON
 STATUS ON
 DATA ferry_routes_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # ferry_routes_utm

LAYER
 NAME park_ride_lots_utm
 METADATA
        WFS_TITLE "Rhode Island Park and Ride Lots"
        WFS_ABSTRACT "Bus and car commuter park and ride lots"
        GML_INCLUDE_ITEMS "town,location,number_"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "point"
 END
 TYPE POLYGON
 STATUS ON
 DATA park_ride_lots_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # park_ride_lots_utm

LAYER
 NAME railroad_right_of_way_utm
 METADATA
        WFS_TITLE "Rhode Island Railways"
        WFS_ABSTRACT  "Active and inactive railroad lines and rights of way."
        GML_INCLUDE_ITEMS "name,alias,status,railuse,owner,type"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multiline"
 END
 TYPE POLYGON
 STATUS ON
 DATA railroad_right_of_way_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # railroad_right_of_way_utm

LAYER
 NAME ripta_bus_routes_utm
 METADATA
```

```
        WFS_TITLE "Rhode Island RIPTA Bus Routes"
        WFS_ABSTRACT "Rhode Island Public Transit Authority, RIPTA, statewide bus routes with frequency of
service and individual route information "
        GML_INCLUDE_ITEMS "route,name"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multiline"
 END
 TYPE POLYGON
 STATUS ON
 DATA ripta_bus_routes_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # ripta_bus_routes_utm

LAYER
 NAME ripta_bus_stops_utm
 METADATA
        WFS_TITLE "Rhode Island RIPTA Bus Stops"
        WFS_ABSTRACT   "Rhode Island Public Transit Authority, RIPTA, statewide bus route stops with stop name
and route information."
        GML_INCLUDE_ITEMS "route,dir,town,name"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "point"
 END
 TYPE POLYGON
 STATUS ON
 DATA ripta_bus_stops_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # ripta_bus_stops_utm

LAYER
 NAME roads_5k_utm
 METADATA
        WFS_TITLE "Rhode Island Roads"
        WFS_ABSTRACT "Road centerlines in Rhode Island"
        GML_INCLUDE_ITEMS "name,rtno,ltwn,rtwn,division,roadtype,county"
        GML_GEOMETRIES "geometry"
        GML_GEOMETRY_TYPE "multiline"
 END
 TYPE POLYGON
 STATUS ON
 DATA roads_5k_utm
 PROJECTION
        "+init=epsg:32619"
 END
 DUMP TRUE
END # roads_5k_utm

END # Map File
```