GEOGRAPHIC INFORMATION SYSTEMS FOR WATER RESOURCE RISK ASSESSMENT

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Mark A. Gross and John F. Murdoch

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16. Abstract

Transportation of hazardous material or potential environmental contaminants presents the potential for spill or accidental releases to surface or groundwater resources. The use of a Geographical Information System (GIS) to locate transportation routes as well as springs, wells and surface water bodies offers the opportunity for tracking and monitoring the effects of accidental releases from transported waste in the case of an overturned truck. The four-county area of Washington, Madison, Benton, and Carroll counties in Northwest Arkansas was chosen for this GIS demonstration project. Previous work by the University of Arkansas Department of Geology and the Center for Advanced Spatial Technology (CAST) provided base maps including springs, wells, and surface water bodies in the four-county area. In addition, TIGER/Line data were readily available for locating transportation routes. The Intergraph software, GeoMedia was chosen to manipulate the data because the Arkansas Highway and Transportation Department currently uses GeoMedia for GIS applications. The following report includes descriptions of data manipulation, layer construction, computer code, and a basic tutorial for the results of this research. The resulting product is the ability to call up a region, and either "point and click" on a particular location, or to input Universal Transverse Mercator (UTM) coordinates of a location. The software will locate the mapped water resources within a specified radius of those points.

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Geographic Information Systems
For
Water Resource Risk Assessment

MBTC #1091

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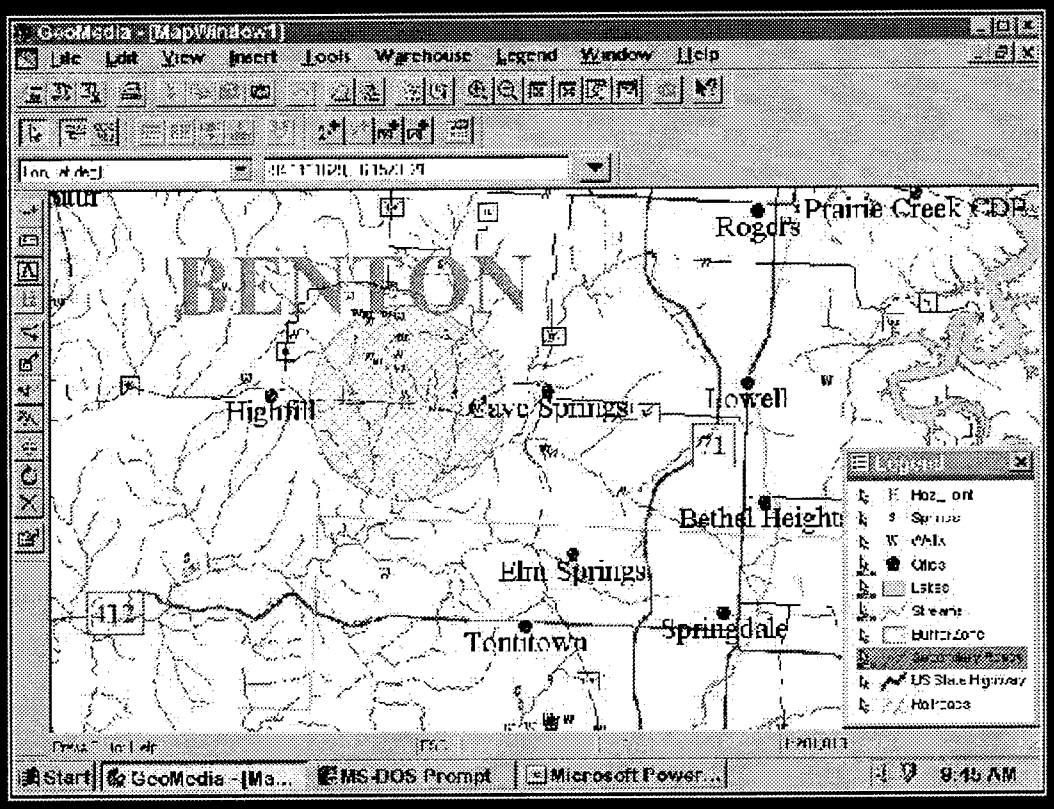
August 1999

Geographic Information Systems for Water Resource Risk Assessment



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I. Abstract

Transportation of hazardous material or potential environmental contaminants presents the potential for spill or accidental releases to surface or groundwater resources. The use of a Geographical Information System (GIS) to locate transportation routes as well as springs, wells and surface water bodies offers the opportunity for tracking and monitoring the effects of accidental releases from transported waste in the case of an overturned truck. The four-county area of Washington, Madison, Benton, and Carroll counties in Northwest Arkansas was chosen for this GIS demonstration project. Previous work by the University of Arkansas Department of Geology and the Center for Advanced Spatial Technology (CAST) provided base maps including springs, wells, and surface water bodies in the four-county area. In addition, TIGER/Line data were readily available for locating transportation routes. The Intergraph software, GeoMedia was chosen to manipulate the data because the Arkansas Highway and Transportation Department currently uses GeoMedia for GIS applications. The following report includes descriptions of data manipulation, layer construction, computer code, and a basic tutorial for the results of this research. The resulting product is the ability to call up a region, and either "point and click" on a particular location, or to input Universal Transverse Mercator (UTM) coordinates of a location. The software will locate the mapped water resources within a specified radius of those points.

II. Project Description (Task)

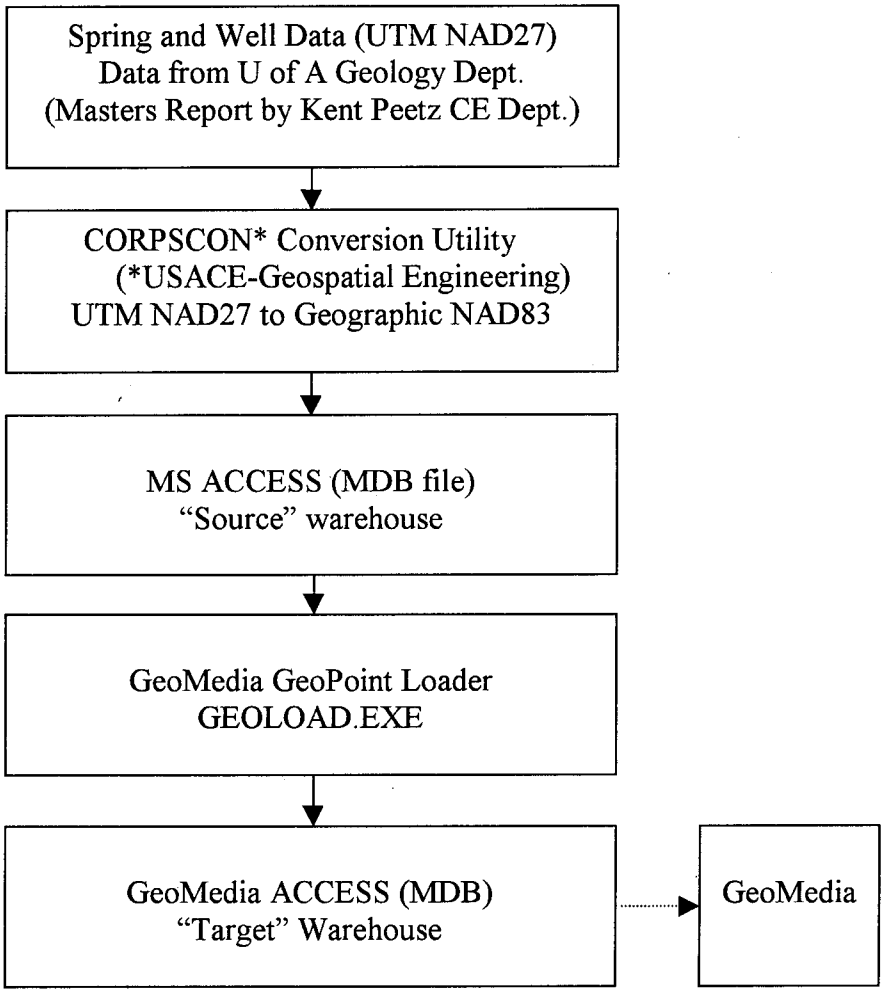
"The proposed project is to develop a Geographical Information System (GIS) program and a usable product for locating discrete points in a four county area of Northwest Arkansas and showing all of the mapped surface water sources, wells and springs along with highway and roads. The software will incorporate the ability to use a "point and click" locator or input UTM coordinates. Once the coordinates are input, all of the mapped wells, springs, and the surface water bodies will be shown within a one mile or other specified distance of the selected point. The project will be a demonstration project to show the ability to expand the system to cover the entire state. The project will be developed using the existing databases in Northwest Arkansas, as archived in the University of Arkansas Center for Advanced Spatial Technologies (CAST), but the programming and demonstration center will be developed using the Intergraph computing technology. The Intergraph laboratory at the University of Arkansas Department Civil Engineering will be utilized as it is available."

II. DATA MANIPULATION

A. Point Data

The origin of the well and spring data used in this demonstration project was adapted from earlier work by Kent Peetz, a graduate student with the University of Arkansas (UA) Civil Engineering Department. ("Project Demonstrating the Use of Geographical Information Systems in Performing Phase One Environmental Assessments of Leaking Underground Storage Tanks". May 1995.) This data was selected from the UA Geology Department database. The coordinate system for each of the selected wells and springs was in a Universal Transverse Mercator (UTM) coordinates and referenced to the North America Datum 1927 (NAD27). The data was transformed to North America 1983 Decimal Degree (Latitude/Longitude) for this project. The transformed data was placed in a Microsoft Access database and converted into a GeoMedia Access Warehouse using the program called GEOLOAD.EXE provided by Intergraph Corporation. The flow chart below illustrates the details concerning the data conversion.

Geographic Data Point Conversion



B. Line Data

TIGER/Line data (1997) provided data for the transportation, railroads, streams, lakes and county boundaries. The Census Bureau's TIGER (Topologically Integrated Geographic Encoding and Referencing) System, was chosen for the line features used in the four county demonstration project. Conversion of the TIGER/Line data to GeoMedia warehouse data required ArcView GIS Version 3.0 Shapefile(s). A shareware program called "TGR2SHP" was used for this conversion. The program is available from the following source:

GisTools
408 Kituwah Trail
Knoxville, TN 37919
http://www.gistools.com/

ArcView provides a means of merging the four county data into a single layer. This was useful for quarries where buffer zones spanned more than one county. An ArcView script file called MRGTHEMS.AVE will merge select features. Each feature will generate a specific layer (transportation, railroads, etc.) The code for MRGTHEMS.AVE is produced and annotated in detail below.

MRGTHEMS.AVE (ArcView Script File)

```
' Name:  View.MergeThemes
'
' Title:  Merges two feature themes
'
' Topics:  GeoData
'
' Description:  Merges the selected themes into a single theme.  A new
' shapefile is created which combines the shapes and attributes of the
' active themes.  The themes to be merged should have the same set of
' attributes (fields).  Only the fields from the first active theme are
' preserved in the output theme.
'
' Requires:  At least two themes of the same feature type must be in the
' active view.
```

```
' Self:
' Returns:
theView = av.GetProject.FindDoc("View1")
theThemes = theView.GetThemes
if (theThemes.Count < 2) then
  MsgBox.Error( "Must have at least two themes in a view to merge.","")
  exit
end
' Allow the user to choose themes from the view to be merged...
themesToMerge = List.Make
while (true)
  t = MsgBox.Choice( theThemes, "Choose themes in view to merge:"+NL+
    "(Click Cancel to end):", "Merge Themes" )
  if (t <> Nil) then
    themesToMerge.Add(t)
  else
    break
  end
end
if ((themesToMerge = Nil) or (themesToMerge.Count < 2)) then
  MsgBox.Error("Not enough themes to merge.", "")
  exit
end

' Themes must have matching shape types for merging.  Using the first
' active theme verify that this is the case...

checkType  = themesToMerge.Get(0).GetFtab.FindField("Shape").GetType
for each i in 1 .. (themesToMerge.Count - 1)
```

```
  t = themesToMerge.Get(i)
  if (checkType <> t.GetFTab.FindField("Shape").GetType) then
    MsgBox.Error("Theme feature type mismatch - Unable to merge.","")
    exit
  end
end
' Specify the output shapefile...
outFName = av.GetProject.MakeFileName("theme", "shp")
outFName = FileDialog.Put(outFName, "*.shp", "Output Merged Shapefile")
if (outFName = Nil) then
  exit
end
' Create the list of fields used for the output theme.  The fields
' are taken from the first active theme only, it is assumed that
' other themes have an identical set of fields.  If this is not the
' case the themes will still be merged, however fields not found in
' other themes will be empty...
fieldList = List.Make
for each f in themesToMerge.Get(0).GetFTab.GetFields
  if (f.GetName = "Shape") then
    continue
  else
    fCopy = f.Clone
    fieldList.Add(fCopy)
  end
end
' Get the class of new FTab to create, create the new FTab and
' add fields that we've gathered from the input themes....
```

```
shapeType = themesToMerge.Get(0).GetFTab.FindField("Shape").GetType
if (shapeType = #FIELD_SHAPELINE) then
  outClass = POLYLINE
elseif (shapeType = #FIELD_SHAPEMULTIPOINT) then
  outClass = MULTIPOINT
elseif (shapeType = #FIELD_SHAPEPOINT) then
  outClass = POINT
elseif (shapeType = #FIELD_SHAPEPOLY) then
  outClass = POLYGON
else
  MsgBox.Error("Invalid shape field type.", "Merge Themes")
  exit
end
mergeFTab = FTab.MakeNew( outFName, outClass )
if (fieldList.Count > 0) then
  mergeFTab.AddFields( fieldList )
end
' Populate the new FTab from the FTabs of the input themes...
for each t in themesToMerge
  av.ShowMsg( "Merging"++t.GetName )
  inFTab  = t.GetFTab
  if (inFTab.GetSelection.Count = 0) then
    theRecordsToMerge = inFTab
    numRecs = inFTab.GetNumRecords
  else
    theRecordsToMerge = inFTab.GetSelection
    numRecs = theRecordsToMerge.Count
  end
```

```
  for each rec in theRecordsToMerge
    av.SetStatus( (rec / numRecs) * 100 )
    newRec   = mergeFTab.AddRecord
    inField  = inFTab.FindField( "Shape" )
    outField = mergeFTab.FindField( "Shape" )
    mergeFTab.SetValue( outField, newrec, inFTab.ReturnValue( inField, rec ))
    if (fieldList.Count > 0) then
      for each f in fieldList
        fName    = f.GetName
        inField  = inFTab.FindField( fName )
        ' Skip field if not found in inFTab...
        if ( inField <> Nil ) then
          outField = mergeFTab.FindField( fName )
          aValue    = inFTab.ReturnValue( inField, rec )
          mergeFTab.SetValue( outField, newRec, aValue )
        end
      end   ' for each f
    end   ' if count
  end   ' for each rec
end   ' for each t
av.ClearMsg
av.ClearStatus
if (MsgBox.YesNo("Add shapefile as theme to a view?",
  "Merge Themes", true).Not) then
  exit
end
' Create a list of views and allow the user to choose which view to
' add the new theme to...
```

```
viewList = {}
for each d in av.GetProject.GetDocs
  if (d.Is(View)) then
    viewList.Add( d )
  end
end
' Include a choice for a new view...
viewList.Add("<New View>")
addToView = MsgBox.ListAsString( viewList,"Add Theme to:", "Merge Themes" )
' Get the specified view, make the theme, and add it...
if (addToView <> nil) then
  if (addToView = "<New View>") then
    addToView = View.Make
    addToView.GetWin.Open
  end
  mergeTheme = FTheme.Make( mergeFTab )
  addToView.AddTheme( mergeTheme )
  ' Bring the View to the front...
  addToView.GetWin.Activate
end
```

The transportation feature required additional division into the following "sub features" (primary, secondary and neighborhood roads). ArcView can perform individual quarries for the sub features.

Example for Selecting "Sub Features" from an ArcView Shapefile

---

Using ArcView, load the roads (*lkA.shp) into arcview. On the ArcView button bar there is a button with a picture of a hammer on it (for building a query). Click on that button. You can build a query to select the features you want.

For example, suppose you wanted all the A21 roads. The query would be:

[Cfcc] = "A21"

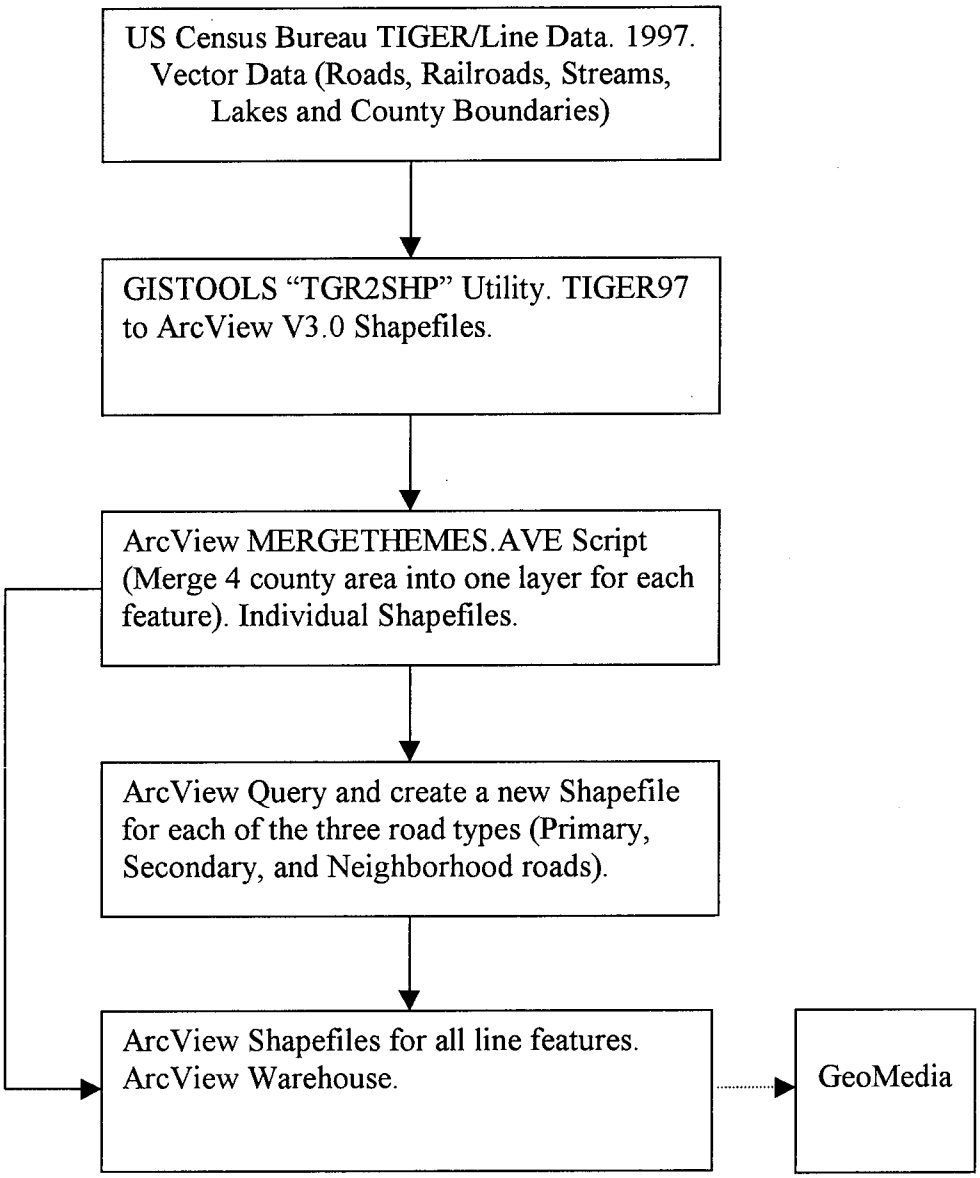
That would select all roads of that type. If you wanted all roads that started with A2, the query would be:

[Cfcc] = "A2*"

Once you have selected the roads you need, click on Theme, then on "Convert to Shapefile". This will write out all the selected roads to a new shapefile. Name it whatever you like.

Once the TIGER/Line data is converted into ArcView Shapefiles a GeoMedia "Coordinate System File" (csf) with an initialization file (ini) must be set up and placed in the directory where the ArcView warehouse data is stored. For this project the State Plane Coordinate System (SPCS) for Northern Arkansas Zone = 301 was used as the projection for the map.

TIGER/Line Data Conversion



IV. Project Results

The proposed four county area water resource risk assessment map was successfully completed with the aid of the Intergraph Corporation GeoMedia 2.0 GIS. The US Bureau of Census TIGER/Line data was used in conjunction with spring and well data from the University of Arkansas Department of Geology for the map layer data warehouses. The GIS software was selected to meet the Intergraph criteria written in the original proposal and provides a practical solution to the proposed task. The TIGER/Line data is readily available for all the counties in the state. All data types were converted into the North American 1983 Datum (NAD83) with map projections in the form of State Plane Coordinate System (North Arkansas Zone 301). GeoMedia provides a means inserting a buffer zone around a given potentially hazardous point. GeoMedia will query within each buffer zone and yield attribute data that would provide details about wells, springs, streams, and lakes within the buffer zone. GeoMedia will allow direct insertion of a potentially hazardous point by use of a "point and click" method or by inserting points using an external program provided by Intergraph. The later technique is useful if several points are to be entered at once. This project was installed on a laptop computer. This provided a means for field usage. An attempt was made to keep the data in a form where it can be directly transported into other GIS systems like ArcView (Environmental Systems Research Institute, Inc. ERSA), MGE (Intergraph Corporation), Blackland Grass (TAMU), etc. This should allow the efforts of this project to be easily utilized by other researchers that might be using different GIS software platforms. Other application ideas may easily build on the use of the databases available from this project.

V. Conclusions

The need for a water resource risk assessment tool is very important with the growth of our state. Databases need to be supplemented and refined as to provide the best possible coverage. GeoMedia provided a practical and economical means to accomplish the task. This project has successfully demonstrated a method for approaching this task.

VI. Recommendations for Continuation of Project

One major recommendation is an expansion of the area of coverage to include the major transportation routes and hopefully a complete coverage of the state in time.

A second recommendation is to add data points for the spring and well database. This would enhance the usefulness of this system. There are large voids in the coverage with clumping of data elsewhere. To accomplish this would require a review and update of the current map to include areas that need to be supplemented. This would involve integrating and updating data that might be available in tabular form, from field notes, map notation, well logs, etc. The data needs to be checked and edited for any incorrect values that might have been entered improperly. Additional data from landowners in conjunction with the aid of a portable GPS system to add data point coordinates would be very useful to record new spring and well locations. It is likely that interviewing local residents would yield sources of many unknown locations that may not be in the current databases.

A third possible addition is to enter cave entrance location, sink holes, faults, and other significant geological features that might be an inlet or outlet for water transport. These areas might offer additional clues for risk assessment and management strategies.

GeoMedia Pro and GeoMedia Web may provide useful as additional tools to integrate with other state agency's databases (ADPCE, AHTD, Arkansas Health Department. Etc.).

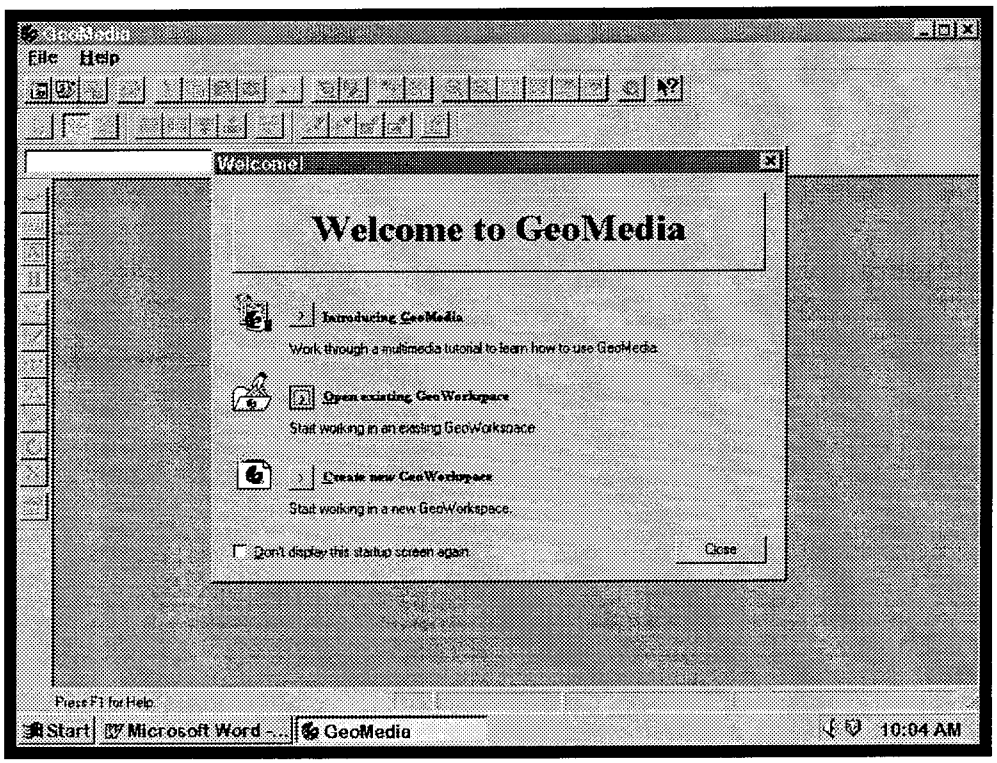
Acknowledgements

I would like to thank the Mack-Blackwell Transportation Center for funding this project and providing an opportunity to develop and demonstrate this GIS application. Thanks to CAST for providing access to their workstations, software and technical assistance. Thanks to Intergraph Corporation Technical Support for providing additional assistance with the GeoMedia software. Thanks also to Bruce Ralston of GisTools for technical assistance and providing TGR2SHP software.

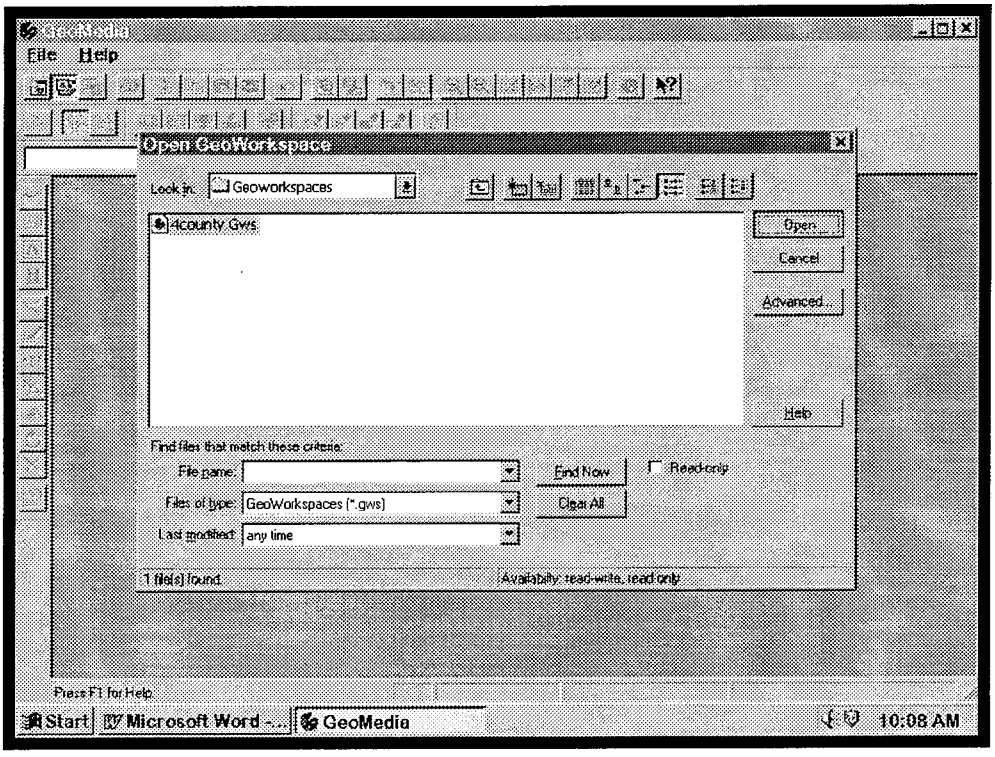
Appendix A

A Tutorial Example for the Four County Area *

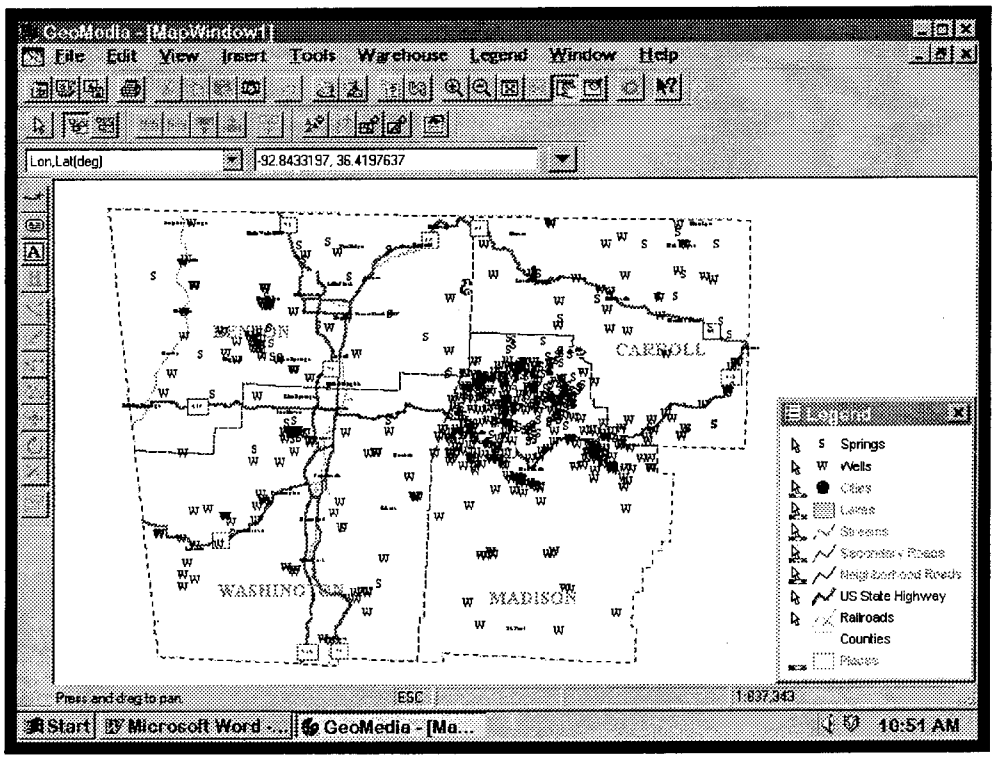
* NOTE: The following examples require the warehouse data for the four county study area.



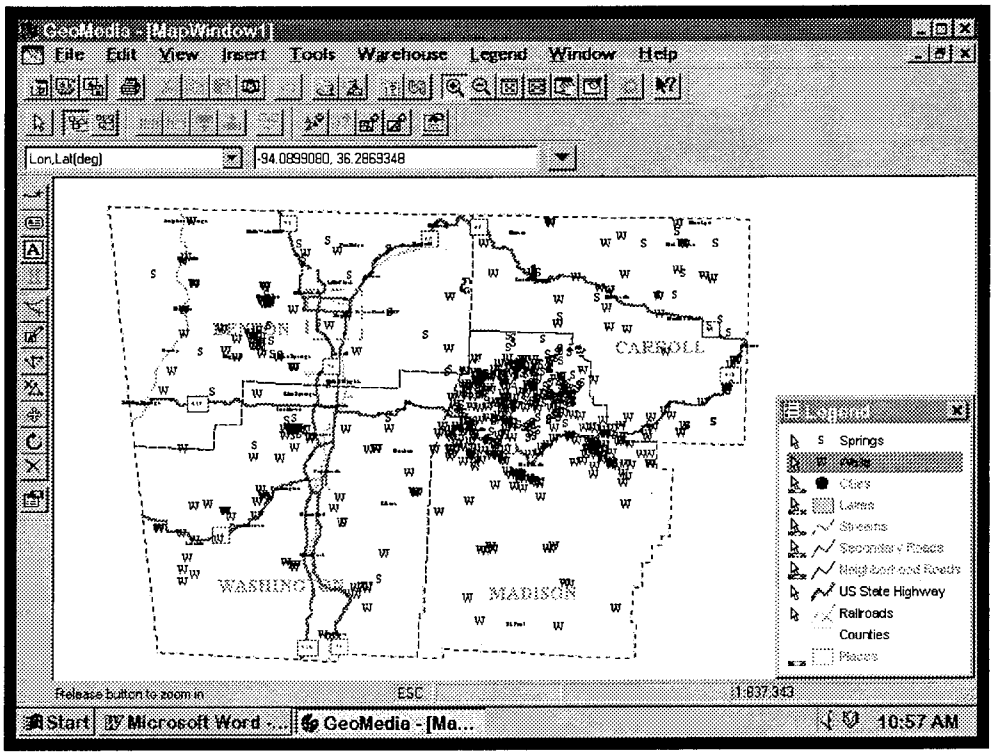
Open an existing Geo Workspace.



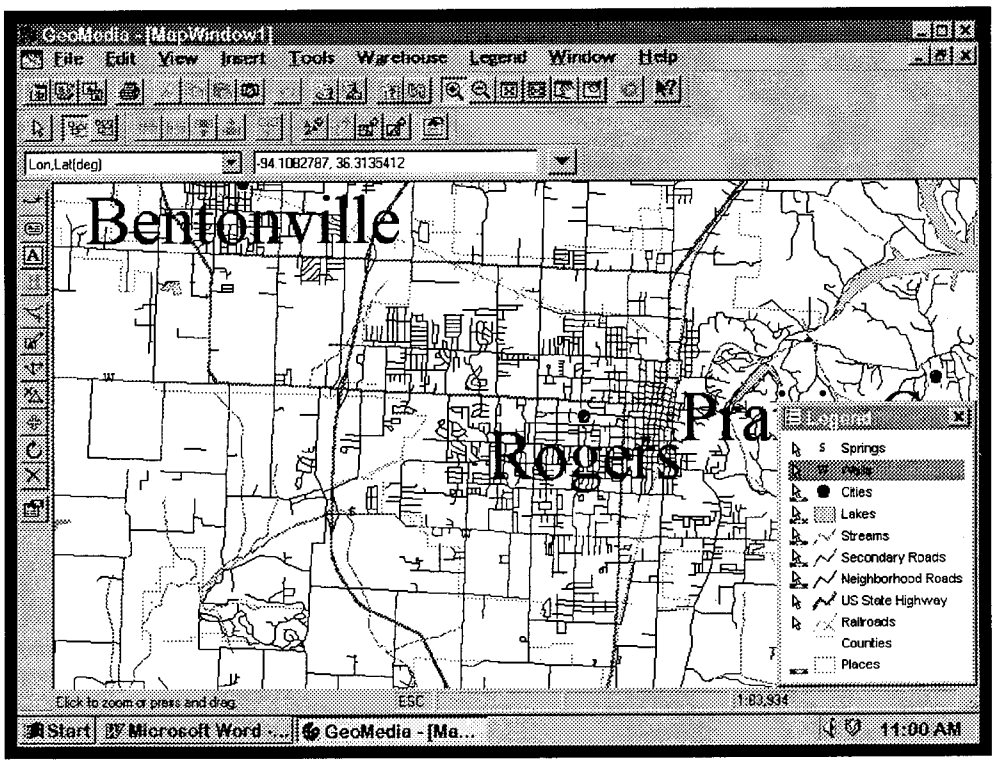
Select 4COUNTY.GWS Geo Workpace.



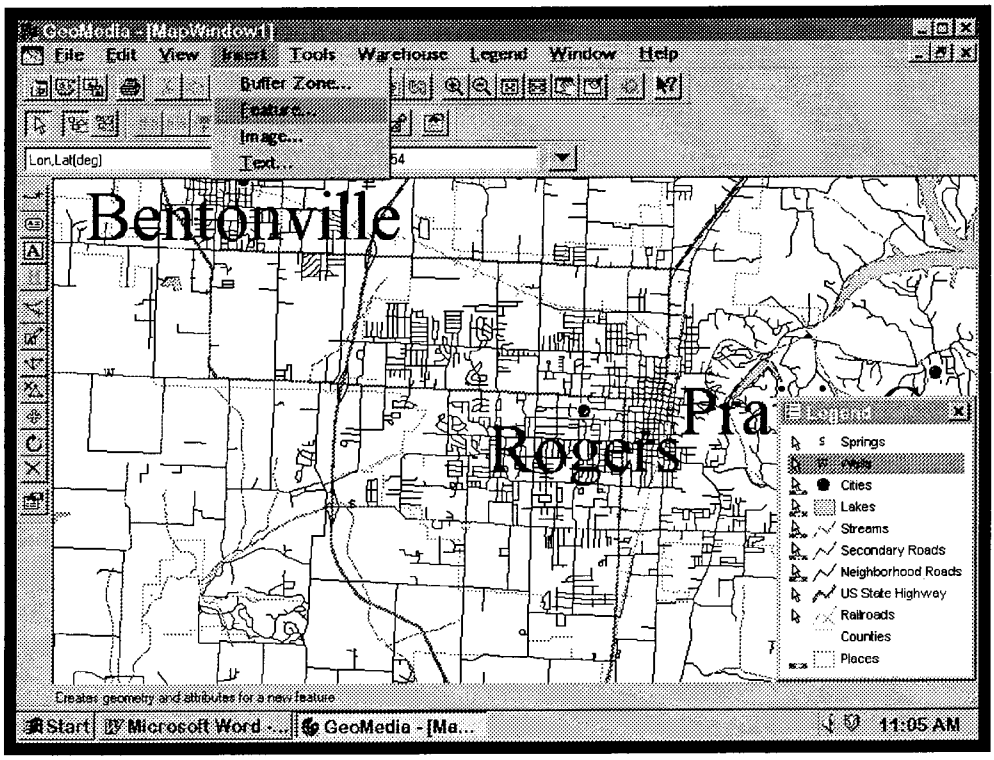
A map of the four county area will appear.



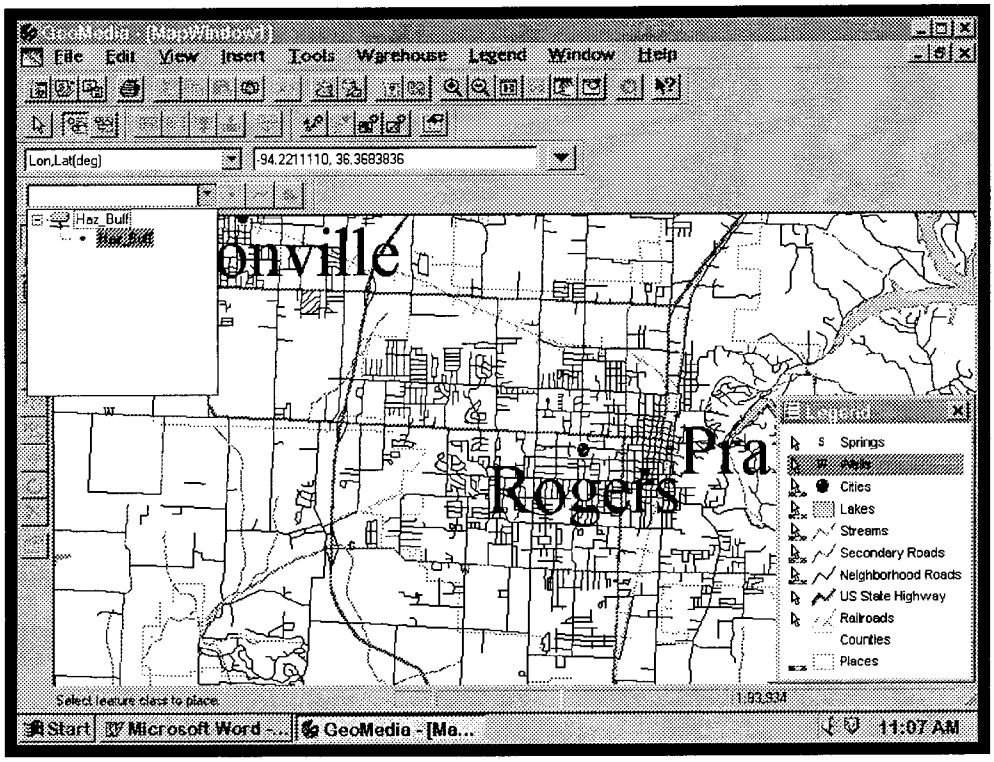
"Zoom in" on the potential hazardous location.



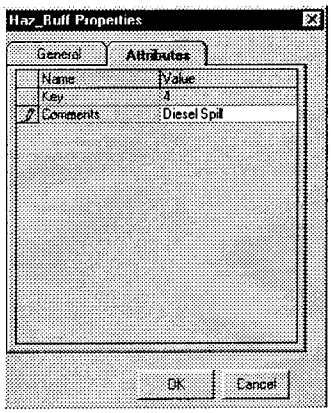
A detailed map of the area of interest will appear.

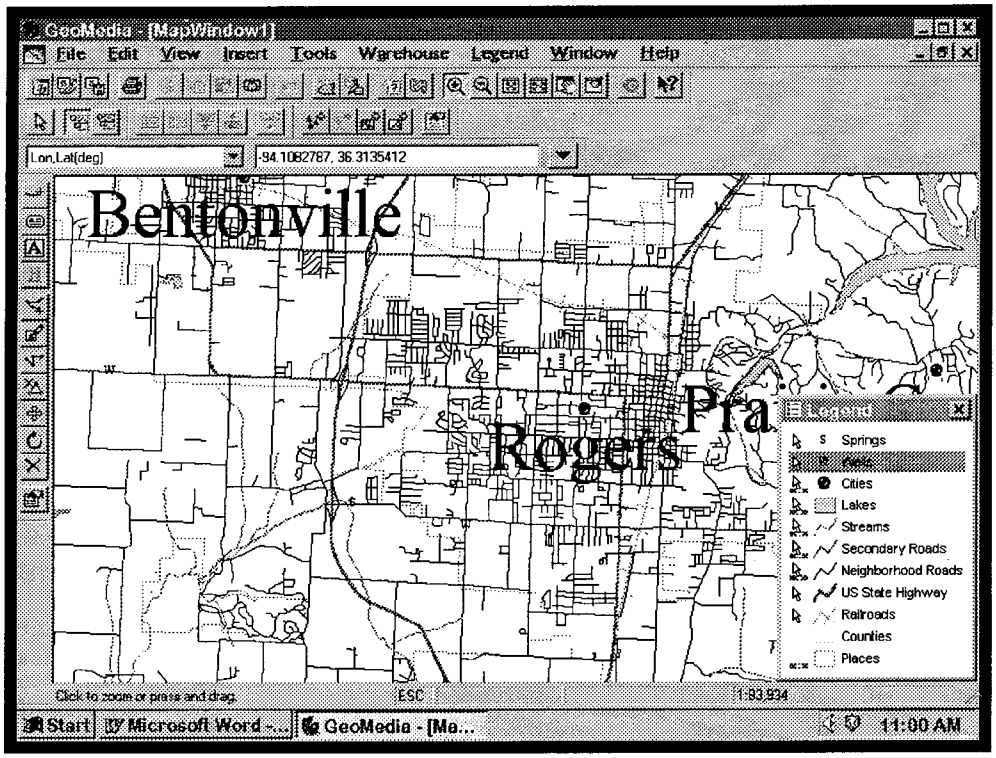


Place a point (feature) at the location of the potential hazard.



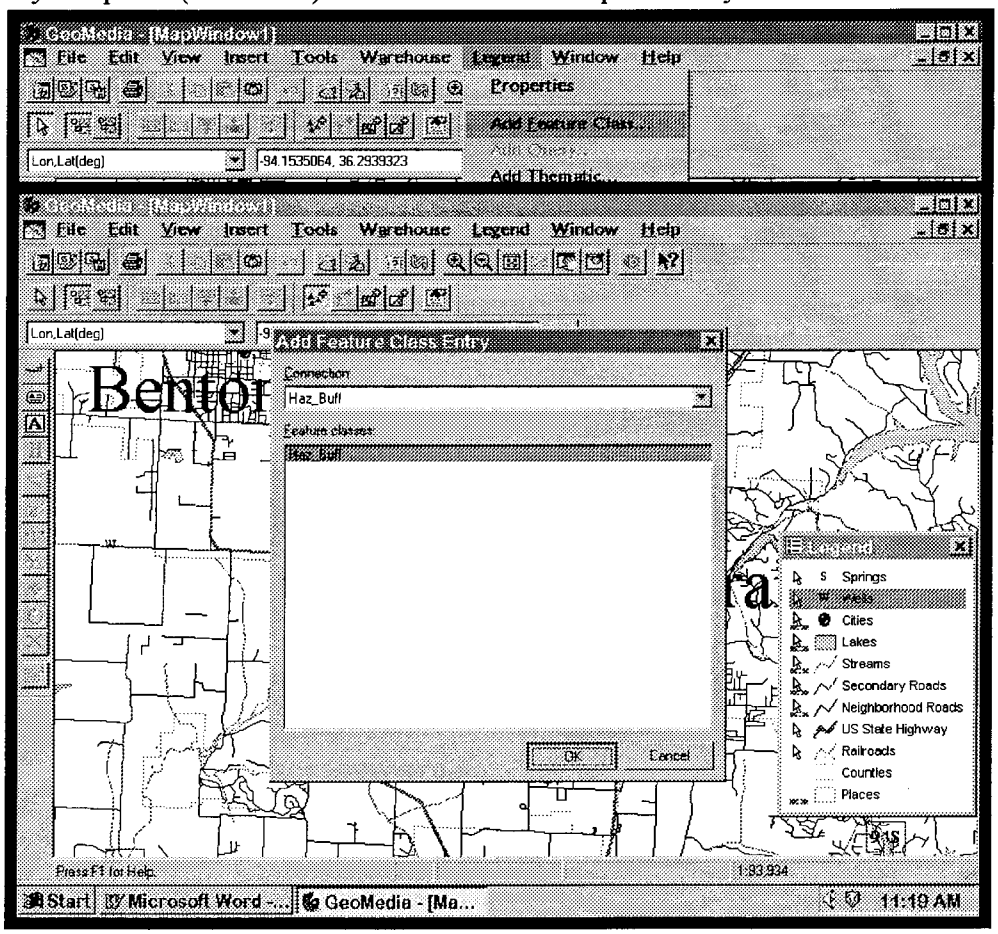
Select the warehouse where the point geometry and comments will be stored.



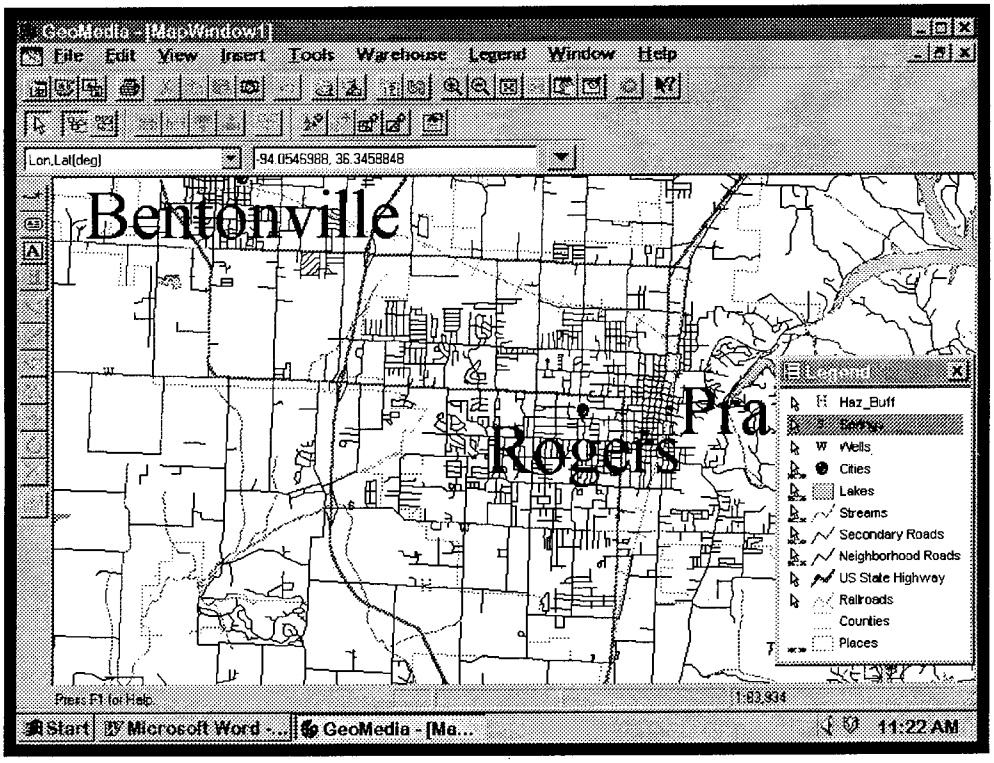


Click on the location and enter any comments in the popup form.

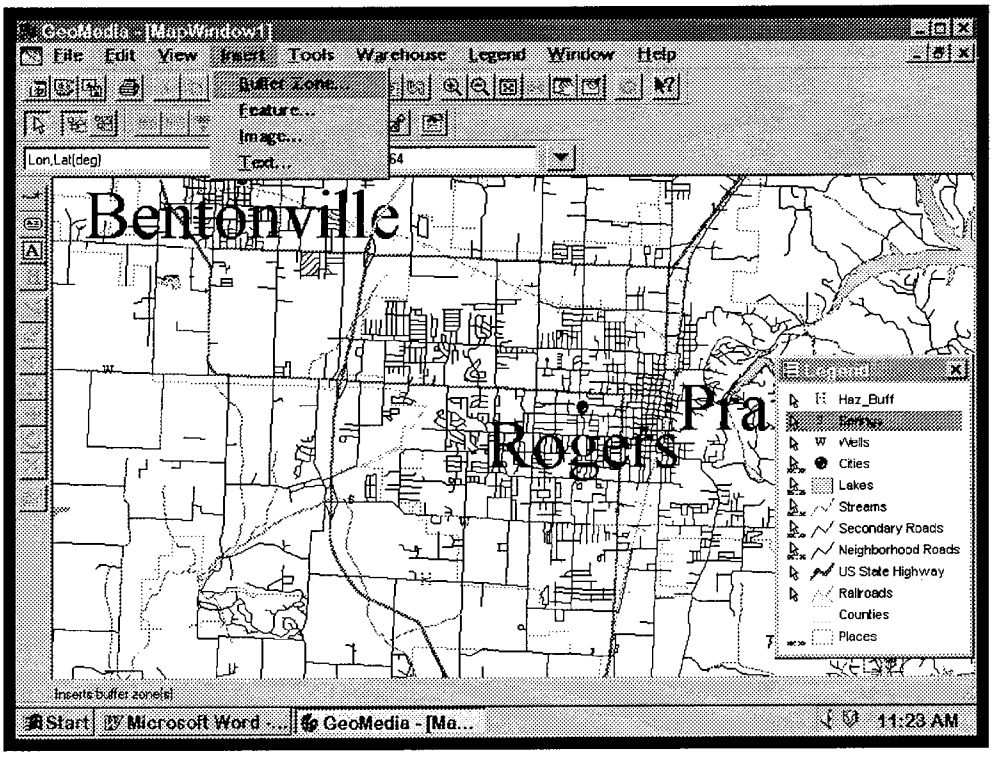
Display the point (or feature). This command is required only once for each session.



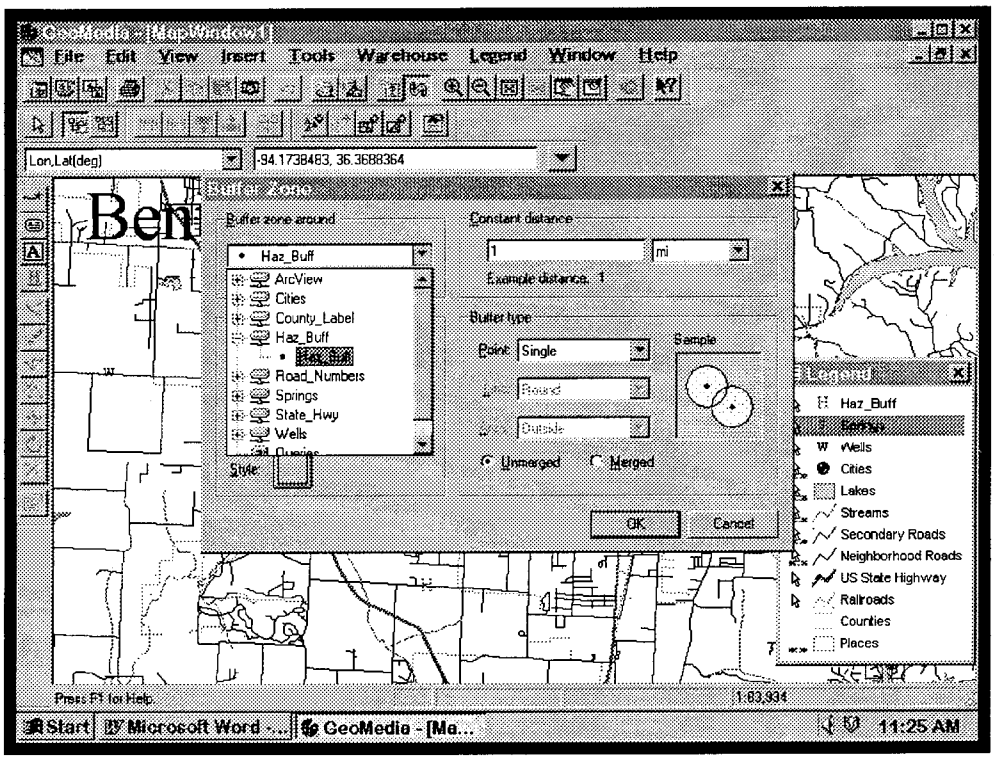
The feature in this example is Haz_Buff in the Haz_Buff warehouse.



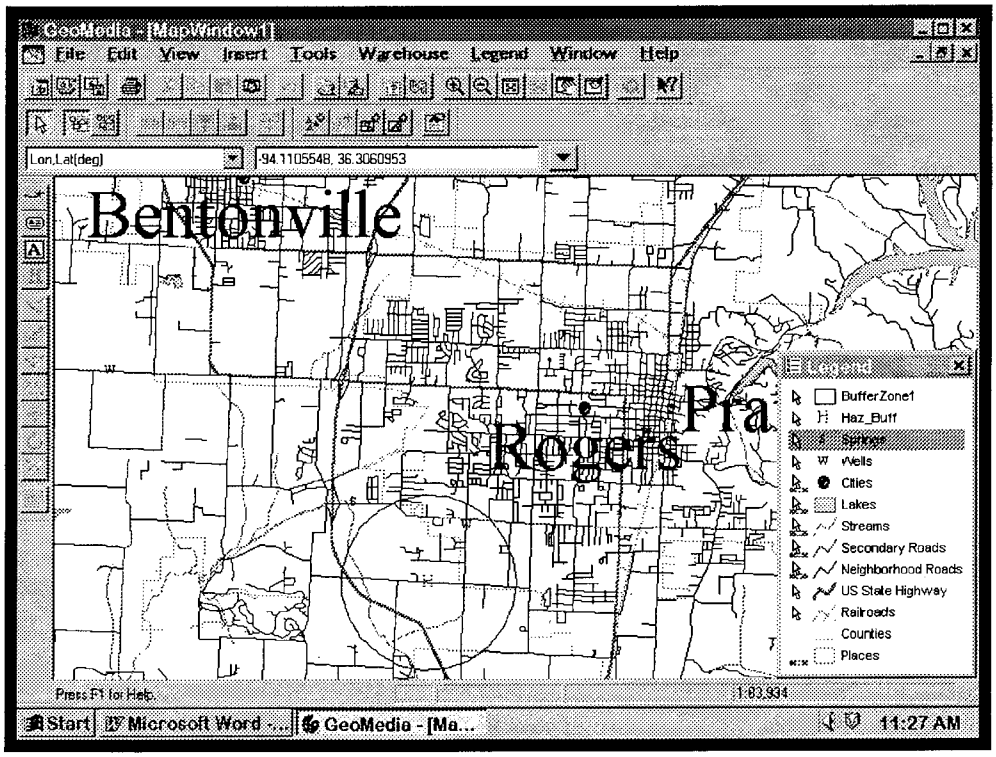
The hazardous point is noted as "H" on the map above.



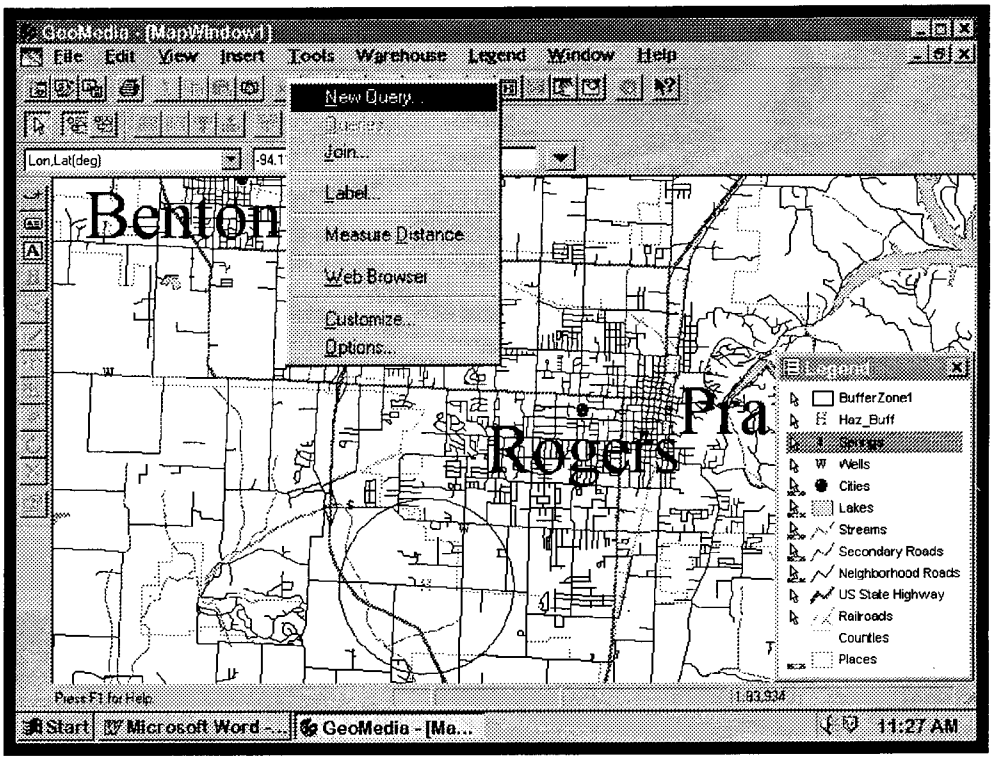
Insert a buffer zone around the hazardous point.



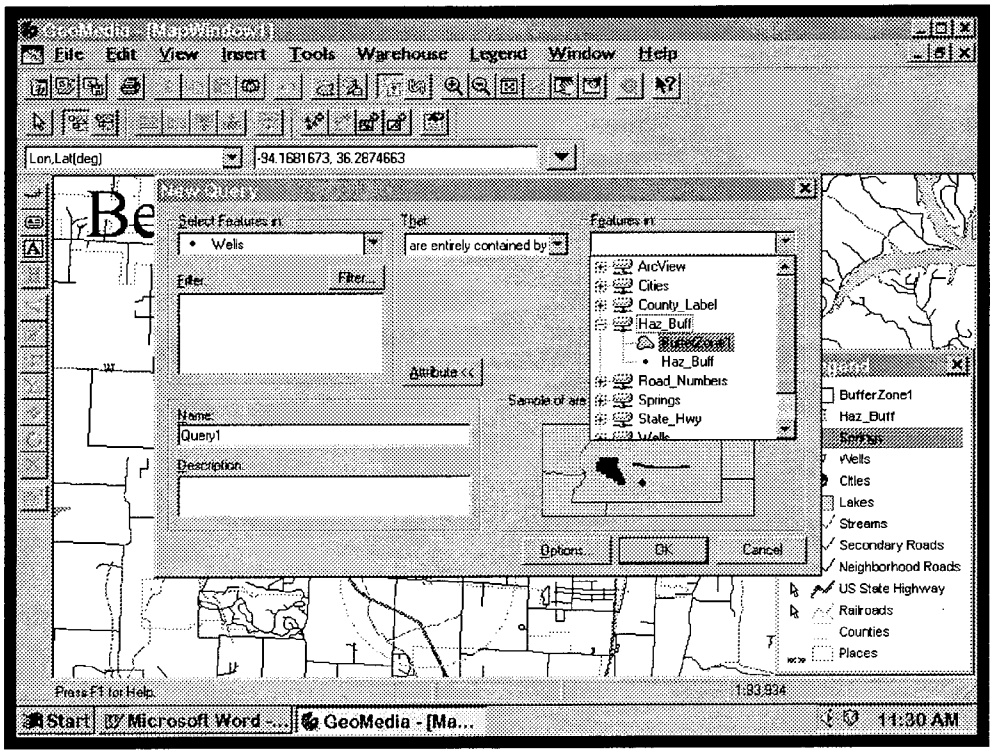
Place a buffer around the point Haz_Buff. (Example = 1 mile radius)



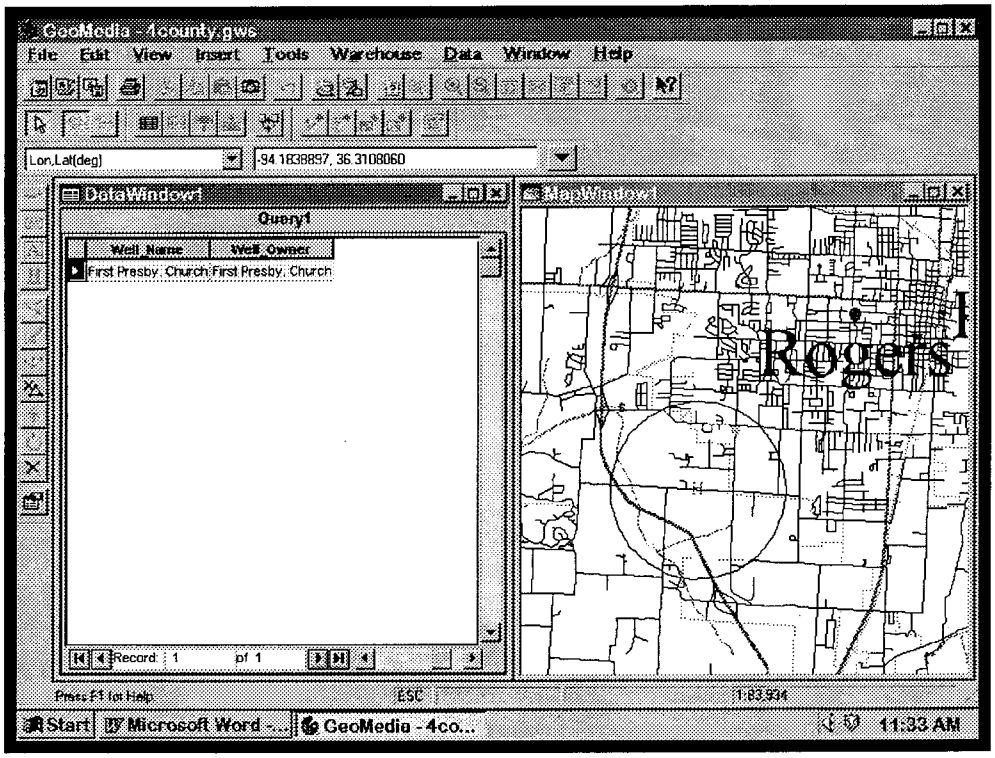
A buffer zone will appear representing the 1 mile radius.



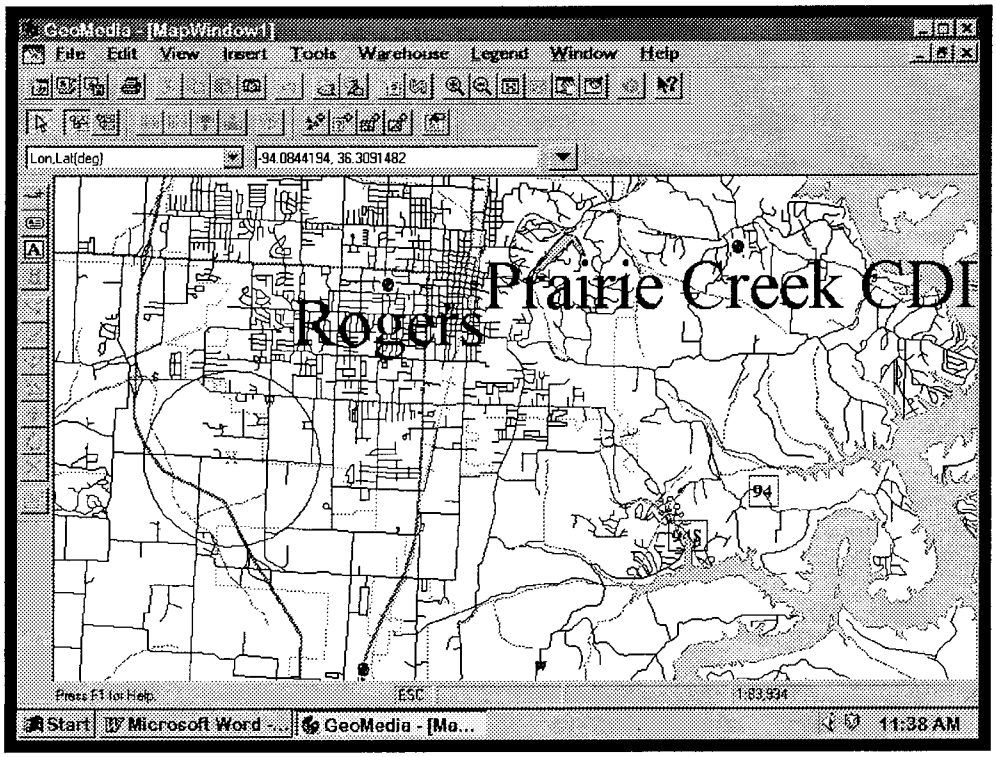
Submit a query.



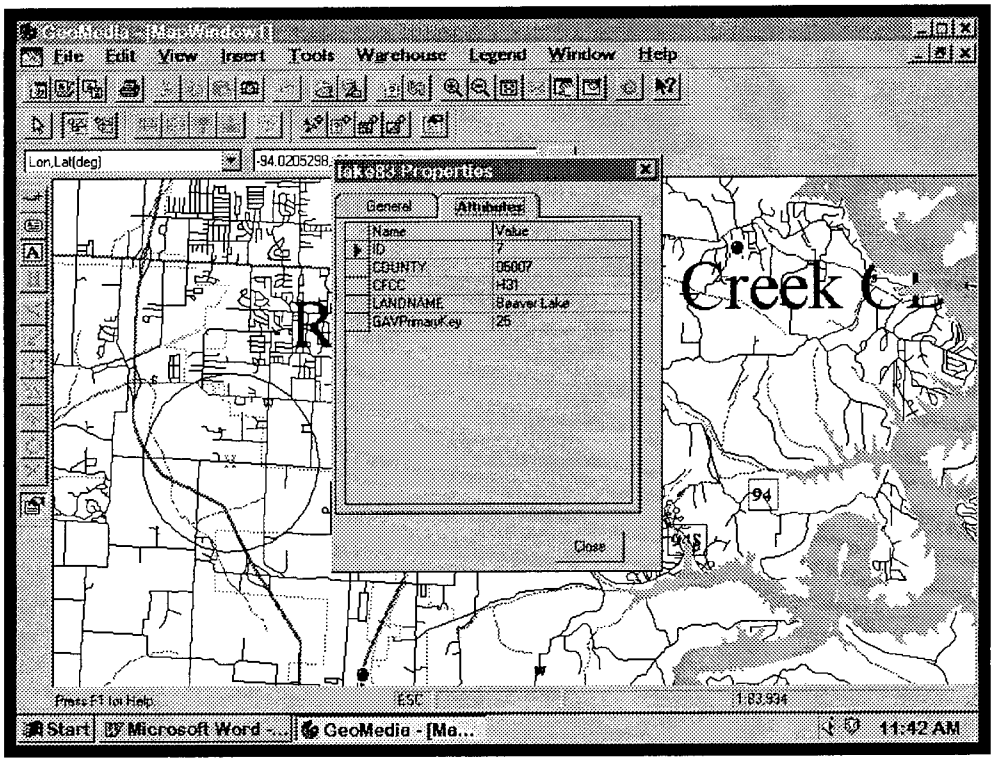
The example creates a query of all the wells that are entirely contained by the Haz_Buff point.



The query creates a Data Window that contains information about the well(s) located.



Clicking on a "selectable" feature provides attribute information about that feature



The feature in this example was Beaver Lake.