CONTAMINENTS IN THE ENVIRONMENT LESSON PLAN
Dirty Mud

Theme
Sediment Contamination

Links to Overview Essays and Resources Needed for Student Research
http://oceanservice.noaa.gov/topics/coasts/contaminants/
http://response.restoration.noaa.gov/cpr/watershed/christina/
chrisinatour.html

Subject Area
Earth Science

Grade Level
9-12

Focus Question
How can scientists analyze complex scientific data and geographic information to plan projects to restore environmental resources damaged by pollution?

Learning Objectives
- Students will identify specific types of wetland habitats and land uses in a watershed.

- Students will explain how data on chemical contaminants, land uses and habitat types can be integrated to develop restoration plans for environmental resources damaged by pollution.

- Students will use a geographic information system to retrieve and analyze data about specific benthic marine habitats.

Materials Needed
- (Optional) Computers with internet access; if students do not have access to the internet, download copies of materials cited under "Learning Procedure" and provide copies of these materials to each student or student group

> • Copies of "Christina River Project Review Worksheet," one copy for each student or student group

Audio/Visual Materials Needed
None

Teaching Time
Two or three 45-minute class periods, and possibly additional time for student groups to work with GIS data

Teachers should allow time to familiarize themselves with the GIS software (see Learning Procedure, page 5).

Seating Arrangement
Groups of 3 – 4 students

Maximum Number of Students
32

Key Words
Contaminated sediments
Restoration
Geographic Information System (GIS)
Wetlands

Background Information
In many coastal areas, pollution from human activities has serious impacts on natural resources, public health and the economy. There are many sources of this pollution, including industrial and commercial facilities, oil and chemical spills, sewage systems and non-point sources such as roads, parking lots and storm drains. Even sites that have been abandoned for decades can continue to cause harmful impacts. Similarly, contaminated sediments continue to affect large coastal areas long after the initial contamination occurs. This contamination threatens human health, as well as the well-being of communities that depend on a healthy coastal environment for food, recreation and economic opportunities such as tourism or commercial fishing.

NOAA's Coastal Protection and Restoration Division (CPRD) evaluates threats to aquatic species and habitats from toxic

contaminants; helps develop cleanup plans to protect these resources; and coordinates projects to restore rivers, estuaries and coastal ecosystems that have been damaged by contamination. These activities help produce cleaner coastal habitats and healthier fish stocks for recreational and commercial use.

When CPRD responds to a specific contamination issue, the first step is to evaluate the extent and magnitude of injury to coastal resources. This is based largely upon the extent of contamination. Next, CPRD determines what actions are needed to restore resources that have been damaged, and works with other agencies to develop a restoration plan that spells out how natural resources have been damaged and proposes actions that can restore these resources. The costs for implementing these actions are the responsibility of those who caused the contamination. These people or corporations are called responsible parties. The responsible parties have two options:

- they may carry out appropriate restoration activities themselves, under the supervision of the agencies that developed the restoration plan; or
- they may fund these agencies to conduct the restoration.

By working cooperatively with the responsible parties and using the best available science, CPRD is often able to reach an agreement regarding restoration without lengthy legal procedures, which means that injured resources are restored more quickly and economically.

Many different types of environmental information have to be considered to effectively restore aquatic resources damaged by contamination. CPRD scientists have found that one of the most effective ways to consider and understand complex environmental issues is to combine scientific data with maps of various watershed features such as wetlands, land uses, topography and water bodies. (For more information about watersheds, visit the USEPA Watershed Information Network at *http://www.epa.gov/win/*). This combination of data and maps is known as a Geographic Information System (GIS). A GIS is a computer-based system that can be used to organize and analyze information about specific geographic locations. Data about these locations are stored in layers, with each layer containing a specific type of data. The GIS allows researchers to

manipulate and analyze these layers one-by-one or in combination with other layers, so data on sediment contamination and toxicity, natural resources and potential restoration projects can be overlaid on geographic features and land uses, and displayed on maps. One of the most powerful features of a GIS is the ability to display information graphically—especially maps—which often makes it much easier to understand the relationships between many different factors in aquatic ecosystems.

The basic components of a GIS are the:
- hardware—including the computer that runs the GIS software and other peripheral hardware, such as printers, scanners, input devices (such as digital video) and storage systems (hard drives, CDs, etc);
- software—which is the GIS application package that includes tools for entering and manipulating information, a database management system, tools that create the digital maps and a graphical user interface;
- data—which may be spatial data (locations and shapes of map features, such as mountains, roads, countries, and cities), tabular data (data that describes map features, such as the height of mountains or population of cities) or image data (photographs, satellite images or scanned documents); and
- human resources—trained and knowledgeable people including cartographers, information analysts, programmers and system administrators.

The Christina River, a tributary of the Delaware River is one example of how CPRD has used the GIS approach to restore a coastal watershed damaged by pollution. In this lesson students will learn about the restoration process, and will use a GIS to examine some of the data used to develop the restoration plan.

Learning Procedure
1.
This lesson is divided into two parts. In Part A, students are guided to background information on the Christina River Project contained in documents that may be downloaded or reviewed online. In Part B, students use a free, public domain GIS to examine land use and wetlands data for the Christina River watershed.

If students do not have access to the internet, prepare for Part A by reviewing Introduction to the Christina River Project (*http://response.restoration.noaa.gov/cpr/watershed/christina.html*) as well as the Christina River Project Tour (*http://response.restoration.noaa.gov/cpr/watershed/christina/chrisinatour.html*). If students will not be able to review these materials online, download the Introduction and Glossary, as well as pages 1 through 9 of the tour. You may also want to download the full-size photographic images linked to the tour pages.

To prepare for Part B of the worksheet:
- Download ArcExplorer™ Java™ Edition for Education (AEJEE) and Using ArcExplorer™ Java™ Edition for Education from *www.esri.com/arcexplorer*. There are separate installers for AEJEE for Windows and Macintosh platforms.
- Download the DirtyMudData file from the Discovery Classroom Environmental Contaminant lesson page (*http://oceanservice.noaa.gov/education/classroom/12_environcontam.html*), and install this folder on the computers that students will use to complete Part B.

You should run through the GIS Tutorial section of the worksheet to become familiar with the AEJEE software and the two datasets. Because this lesson is only the beginning of what you may want to do with your GIS, you may also want to work through the lessons in Using ArcExplorer™ Java™ Edition for Education which will show you how to use AEJEE to
- analyze GIS data from sources on the internet;
- manipulate map projections;
- integrate image data with shapefiles;
- add point data with XY tables;
- work with georegistration; and
- share GIS projects between computers.

2.
Lead a brief discussion of sources of contaminants in coastal ecosystems and introduce the Christina River Project. Introduce the basic concept of geographic information systems, and tell students that they will be using GIS software to examine some of the data used to develop restoration plans for the river. Point out that GIS can be used in hundreds of different

applications, and that once students have mastered the basic concepts they may find many other ways to use these tools.

3.
Provide each student with copies of Introduction to the Christina River Project (*http://response.restoration.noaa.gov/cpr/watershed/christina.html*) and the Christina River Project Tour (*http://response.restoration.noaa.gov/cpr/watershed/christina/chrisinatour.html*), or direct students to review these materials online. When students have read these materials, provide each student with a copy of the "Christina River Project Review Worksheet."

Allow at least two classroom sessions for students to work through Part A and the GIS Tutorial and/or to ask questions and troubleshoot problems they may be having. Once students are comfortable with the topics in the tutorial, tell each group to complete Part B of the worksheet.

4.
Lead a discussion of students' answers to worksheet questions. The correct answers are:

Part A
1. **Anadromous** fish species spawn in freshwater environments, but spend at least part of their adult life in a seawater environment.

2. **Benthic** animals live on or in the bottom of a water body.

3. When certain chemicals increasingly accumulate as they pass through a food chain to higher trophic levels, they are said to **biomagnify**.

4. When contaminants are not likely to have adverse effects on animals that live in sediment, the contaminants are said to be below **Effects Range Low**.

5. When contaminants probably have adverse effects on animals that live in sediment, the contaminants are said to be above **Effects Range Median**.

6. An area equal to 10,000 square meters is called a **hectare**.

7. The **National Priorities List** is a list that identifies locations throughout the United States where hazardous wastes have been found in the environment and initial evaluation shows a significant risk of harm to human health or the environment.

8. The **Superfund** is money collected from a special tax on chemicals and petroleum that can be used to pay for investigating and cleaning up hazardous waste sites where there is no responsible party that can be required to pay for such work.

9. Swampy wetlands where soils are wet most of the time are called **palustrine**.

10. **Riparian** lands are along or beside the bank of a river.

11. **Three** Superfund waste sites are located along the Christina River in Delaware.

12. **Emergent** estuarine wetlands provide habitat for small fishes, and are characterized by plants that grow with their roots underwater and leaves above water.

13. Riparian palustrine wetlands are likely to be former tidal wetlands that have a dike or other structure that restricts **tidal flow**.

14. A **GIS** is used to link databases to maps to show environmental features at specific geographic locations.

15. A **bioassay** is a laboratory test that uses responses in organisms, such as survival, as a measure of a specific parameter.

16. The process of cleaning up a hazardous waste site is known as **remediation**.

17. The process of improving or replacing damaged habitat is known as **restoration** and usually follows or is integrated with the clean-up phase.

18. The goal of the Christina River Project is to restore migratory **fish** populations.

19. A **watershed** includes all the land, streams and rivers draining into a water body.

20. A **trustee** for natural resources has the responsibility to protect and restore specific organisms (known as "trust organisms") and their supporting habitats for current and future generations.

Part B

1. The total area of wetlands (ALUCS code 600) is **1,975,232,332.88 square meters**.

2. The land uses immediately adjacent to the Superfund site closest to the mouth of the Christina River are **Wetlands; Marinas/Port Facilities/Docks; Warehouses; Bays and Coves; Man-made Reservoirs and Impoundments**.

3. The area of wetlands closest to this site is **1,731,636.08 square meters**.

4. The NWI classification of the portion of the Christina River closest to this Superfund site is **E1OWL6**.

5. This classification means **estuarine (E) - subtidal (1) - open water (OW) - subtidal water regime (L; from the Modifiers table) - oligohaline (6; from the Modifiers table). Oligohaline means brackish or very low salinity, usually defined as a salinity between 0.5 - 5 parts per thousand**.

6. The two wetland types located near the Halby Chemical Superfund site are **E2EM5N6 (Estuarine - Intertidal - Emergent - Narrow-leaved, Persistent - Regularly Exposed - Oligohaline); and E2FLN6 (Estuarine - Flat - Regularly Exposed - Oligohaline**; note that "Flat" is an obsolete term, but is still commonly found on NWI maps).

7. The approximate total area of estuarine emergent wetlands in the "wilmis_p" dataset is about **5,112,662 square**

meters. Students may extract this information by constructing a long query using the OR expression, ATTRIBUTE = 'E2EM' OR ATTRIBUTE = 'E2EM1/5P' OR … or with a single a simple query using 'ATTRIBUTE' like 'E2EM%'.

8. The approximate total area of palustrine emergent wetlandsin the "wilmis_p" dataset is **2,641,760 square meters**.

9. The shapes corresponding to the highlighted area on the three images might not be identical because **different images were used to construct the polygons in the GIS datasets, and because the wetland areas might actually have been different when the different images were acquired**. Note in the following questions that many of these areas are seasonally flooded or irregularly flooded and thus could appear quite different at different times of the year. **Errors in interpreting the various wetlands are an another potential source of variation**.

10. In the "wilmis_p" dataset, the yellow area on the photograph is classified as **E2EM5PD (Estuarine, Intertidal, Emergent, Narrow-leaved Persistent Vegetation, Irregularly Flooded, Seasonally Flooded/Well Drained). Seasonal variation could account for differences in the classification of this area**.

11. Other types of wetland are adjacent to the yellow area on the photograph are:
   - **PFO1C (Palustrine, Forested, Hyperhaline, Seasonally Flooded);**
   - **PFO1E (Palustrine, Forested, Hyperhaline, Seasonally Flooded/Saturated);**
   - **POWH (Palustrine, Open Water, Permanently Flooded); and**
   - **PEM5C (Palustrine, Emergent, Mesohaline, Seasonally Flooded).**

12. Land use features adjacent to the highlighted area include **highways, utilities, deciduous forest, mixed urban uses, and recreation**.

13. Wetlands associated with the recreation area adjacent to the yellow highlighted feature include **Palustrine, Forested, Hyperhaline, Seasonally Flooded/Saturated (PFO1E) and Palustrine, Open Water, Permanently Flooded (POWH)**.

14. The large salvage yard on the river bank is located to the **northwest** of the highlighted area, across the highway. The easiest way to find this feature is to right-click (or ctrl-click on Macintosh platforms) on one of the colored symbols in the TOC corresponding to "Junk/Salvage" to select and highlight all polygons corresponding to this land use classification.

15. Wetlands adjacent to the river across from the salvage yard are **Estuarine, Emergent, Narrow-leaved Persistent Vegetation, Irregularly Flooded, Oligohaline (E2EM5P6)**.

The Bridge Connection

http://www.vims.edu/bridge/archive0203.html/ – February 2003 Data Tip, *What's In Your Watershed?*

http://www.vims.edu/bridge/data.html – Links to real-time data

The Me Connection

Have students identify a local area that has been (or might be) damaged by pollution, and write a brief description of how they would go about developing a plan to restore damaged natural resources.

Extensions

1. Download the Education World Technology Article on Geographic Information Systems from *http://www.educationworld.com/a_tech/tech/tech186.shtml* for more ideas and links to resources for using GIS in the classroom.

2. Visit the Ocean Explorers Web site (*http://www.exploreoceans.org/learn.html*) for links to educational resources including data and software downloads, videos, instructional materials, lesson plans, and much more.

3. QueryManager (*http://response.restoration.noaa.gov/cpr/ watershed/watershedtools.html*) is a freeware data delivery application (for Windows platforms only), that will allow students to download and explore the full data set for sediment and tissue contaminant levels in the Christina River. Benchmarks for evaluating the ecological implications of the concentrations observed are also included, so that students will be able to make these evaluations for themselves.

Resources

http://wetlands.fws.gov/ – National Wetlands Inventory Web site

http://response.restoration.noaa.gov/cpr/watershed/watershedtools.html – QueryManager, a freeware data delivery application

http://response.restoration.noaa.gov/cpr/cpr.html – Information about how and why we examine watersheds using GIS technology, plus actual contaminant data for several areas around the country. GIS tools plus freeware for data delivery and ampping can also be downloaded.

http://mapping.orr.noaa.gov/website/portal/elizriver/ or *http:// mapping.orr.noaa.gov/website/portal/portland/* – These sites allow for GIS examination of data and information for these two watersheds via any Web browser. These Internet Mapping Sites (IMS) allow for online, realtime GIS exploration of GIS themes without having to install any additional software.

http://www.exploreoceans.org/learn.html – Ocean Explorers Web site, with links to a variety of educational resources, including downloadable GIS data

http://www.esri.com/industries/k-12/education/basins.html – Information on how to obtain digital data collected by the U.S. Environmental Protection Agency for every watershed in the conterminous United States, including elevation, streams, main roads, dams, land use patterns, toxic release sites, etc.

http://www.educationworld.com/a_tech/tech/tech186.shtml – Education World Technology Article, *GIS Brings 'Real Life' to Learning*

www.esri.com/arcexplorer – ESRI, Inc. Web page providing information and access to ArcExplorer software

www.geographynetwork.com – Web site for the Geography Network, which is a global network of geographic information users and providers that supports sharing of geographic information and provides access to many types of geographic content including dynamic maps, downloadable data and more advanced Web services

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard D: Earth and Space Science
- Geochemical cycles

Content Standard E: Science and Technology
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Personal and community health
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Links to AAAS "Oceans Map" (aka benchmarks)

5D/H3 – Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

CONTAMINENTS IN THE ENVIRONMENT LESSON PLAN
Christina River Project Review Worksheet

Part A

1. _____ fish species spawn in freshwater environments, but spend at least part of their adult life in a seawater environment.

2. _____ animals live on or in the bottom of a water body.

3. When certain chemicals increasingly accumulate as they pass through a food chain to higher trophic levels, they are said to _____.

4. When contaminants are not likely to have adverse effects on animals that live in sediment, the contaminants are said to be below _____. (3 words)

5. When contaminants probably have adverse effects on animals that live in sediment, the contaminants are said to be above _____. (3 words)

6. An area equal to 10,000 square meters is called a/an _____.

7. The _____ (3 words) is a list that identifies locations throughout the United States where hazardous wastes have been found in the environment and initial evaluation shows a significant risk of harm to human health or the environment. (3 words)

8. The _____ is money collected from a special tax on chemicals and petroleum that can be used to pay for investigating and cleaning up hazardous waste sites where there is no responsible party that can be required to pay for such work.

9. Swampy wetlands where soils are wet most of the time are called _____.

10. _____ lands are along or beside the bank of a river.

11. _____ Superfund waste sites are located along the Christina River in Delaware.

12. _____ estuarine wetlands provide habitat for small fishes, and are characterized by plants that grow with their roots underwater and leaves above water.

13. Riparian palustrine wetlands are likely to be former tidal wetlands that have a dike or other structure that restricts _____. (2 words)

14. A _____ is used to link databases to maps to show environmental features at specific geographic locations. (abbreviation)

15. A _____ is a laboratory test that uses responses in organisms, such as survival, as a measure of a specific parameter.

16. The process of cleaning up a hazardous waste site is known as _____.

17. The process of improving or replacing damaged habitat is known as _____ and usually follows or is integrated with the clean-up phase.

18. The goal of the Christina River Project is to restore migratory _____ populations.

19. A _____ includes all the land, streams and rivers draining into a water body .

20. A _____ for natural resources has the responsibility to protect and restore specific organisms (known as trust organisms) and their supporting habitats for current and future generations.

CONTAMINENTS IN THE ENVIRONMENT LESSON PLAN
GIS Tutorial

The Introduction to the Christina River Project describes how a geographic information system was used to integrate information on land use, wetlands, contaminant concentrations and fish species distribution to plan clean-up and restoration projects. In this exercise, you will use a geographic information system [ArcExplorer™ Java™ Edition for Education (AEJEE)] to answer some other questions about the Christina River Project area. In addition to AEJEE, your computer should also contain a "DirtyMudData" folder which contains the following files:

  NEWCASTL.DBF
  NEWCASTL.SHP
  NEWCASTL.SHX
  wilmis_p.dbf
  wilmis_p.prj
  wilmis_p.shp
  wilmis_p.shx

These files include land use data for Newcastle County and information on wetlands in the Christina River Project area. These are the files that AEJEE uses to construct GIS maps.

The land use data describe land uses with a standard system of codes known as the Andersen Land Classification System (Table 1; also available online at *http://www.state.de.us/planning/info/lulcdata/lulccode.txt*). The data file NewcLU includes a field that contains the plain-English names for various land uses so you won't have to refer back and forth to a table to decode the land use classification numbers.

Wetlands data also use a system of codes to identify various types of wetlands. You can decipher these codes with the Wetland Maps Codes Legend available at *http://nwi.fws.gov/MapCodesLegend.pdf*, or use the online Wetland Code Interpreter at *http://www.nwi.fws.gov/atx/atx.html*. Note that some older wetlands maps include more subclasses for Emergent (EM) wetlands. Under the current classification system, subclass EM1 denotes persistent wetlands in which plants normally remain

standing at least until the beginning of the next growing season, and sublclass EM2 denotes nonpersistent wetlands in which plants fall to the surface of the substrate or below the surface of the water at the end of the growing season. Earlier maps may also contain subclasses EM3, denoting vegetation that is narrow-leaved and nonpersistent; EM4, denoting vegetation that is broad-leaved and nonpersistent; EM5, denoting vegetation that is narrow-leaved and persistent; and EM6, denoting vegetation that is broad-leaved and persistent.

[NOTE: Land use data were obtained from the Delaware Office of State Planning Coordination (*http://www.state.de.us/planning/info/lulcdata/lulc.htm*). The data file "NewcLU" is identical to the OSPC file except that an additional field has been added that contains the plain-English names for various land uses so you won't have to refer back and forth to a table to decode the land use classification numbers (for directions on how to add data to an existing data file, download: *http://www.baama.org/vlibrary/pastpresentations/gisday01/ArcExplorer_Adding%20Data.pdf*). Wetlands data come from the National Wetlands Inventory (NWI; *http://www.nwi.fws.gov/*), which was initiated by the U.S. Fish and Wildlife Service in 1975 in response to a dramatic loss of wetlands across the United States. To date, over 90 percent of the lower 48 states and over 50 percent of Alaska has been inventoried.]

Tutorial

1.

Open ArcExplorer™ Java™ Edition for Education (AEJEE). Click on the "Add Data" tool (fifth tool from the left in the toolbar, with a yellow "+" sign). Navigate to the "DirtyMudData" folder. Highlight the "DirtyMudData" folder, then click "OK." You should see a file named "NEWCASTL.SHP". Click on this file, and "NEWCASTL.SHP" should appear in the window beside "Name:". Click "OK." In a few seconds you should see a map of Newcastle County, Delaware, filled with a series of irregular lines that outline various land uses within the state (Figure 1). These lines are actually the borders of polygons that enclose areas that have the same type of land use. There are a lot of these polygons, and at this scale they are so crowded that it's hard to distinguish the details. You should be able to identify the Delaware
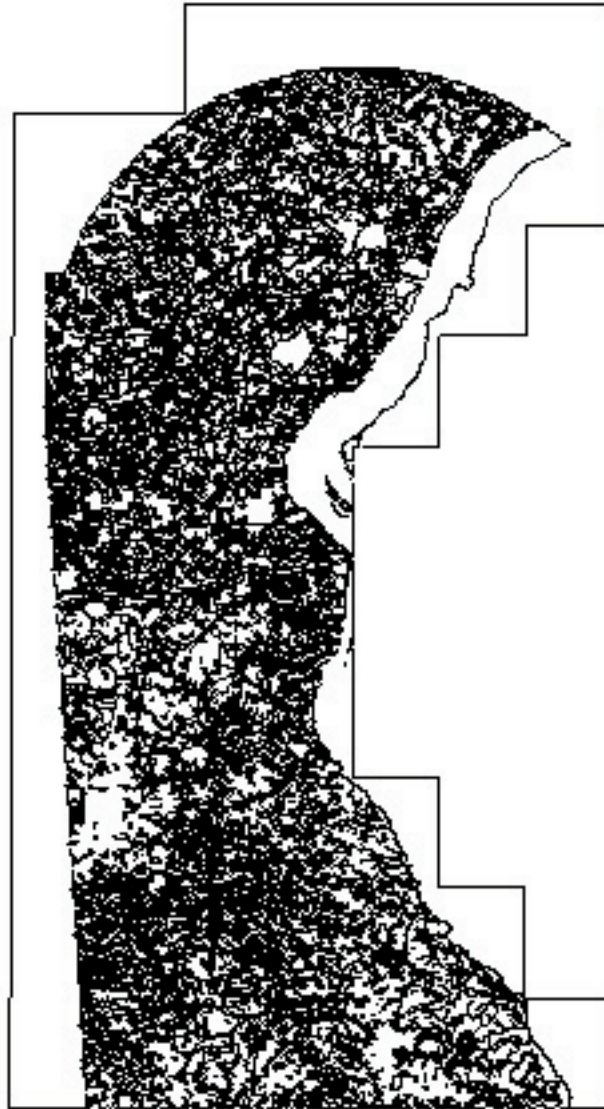
Figure 1

River as the largest feature, which appears as an irregular ribbon between the upper right and lower left of the image. The Christina River runs into the Delaware River from the west at approximate X = 191800, Y = 190625.

2.

The column to the left of the map is called the "Table of Contents" (TOC), which shows the various layers that have been used to build the map. At this point the map consists of only one layer called "NEWCASTL." The TOC also controls which layers are visible, and how the layers are stacked up. We won't worry about stacking at this point, since the map

only contains one layer. Layers can be made visible or invisible by clicking in the checkbox to the left of the layer name. A black check mark means the layer is visible; an empty checkbox means the layer is not visible.

To the left of the checkbox is a smaller box containing either a "+" or a "-". This box expands or collapses the legend for each data layer. Clicking on the box when it contains a "-" will collapse the legend, making more space available in the TOC. Clicking on the box when it contains a "+" will expand the legend.

A set of tools and menus is in the toolbar above the map. When you pause the cursor over one of the tools, a short description appears that tells what the tool does. The four tools on the left are for opening a new file, opening an existing file, saving the current file, and printing the current window. The next tool (with a yellow "+" sign) is for adding layers to the current file (more about this later). The "X" tool is for deleting layers, and is only active when one of the layers in the TOC is highlighted.

The six tools between the two barber poles are for navigating around the map display. From left to right, these tools "Zoom to the Active Layer", "Zoom Full Extent" (zoom out to show everything in the TOC), "Zoom In" (the magnifying glass with a "+" sign), "Zoom Out" (the magnifying glass with a "-" sign), "Pan" (the open hand), and "Identify" (the circle with an "i" in the center). Try zooming in on part of the map. You'll notice that the scale indicator below the map changes as you zoom. You'll also notice that as you move the "Zoom In" tool around, the coordinates in the box on the lower left change to show which part of the map is directly beneath the tool.

3.

Click on the "Zoom In" tool (the magnifying glass with a "+" sign). Move the "Zoom In" tool over the map image until the X map coordinate in the box on the lower left is between 187000 and 187100, and the Y map coordinate is between 191300 and 191400. Click the "Zoom In" tool, then re-position the tool so that it is over the same spot on the map. Repeat these steps until the scale (bottom center) is about 1:6,624,450,000. Now
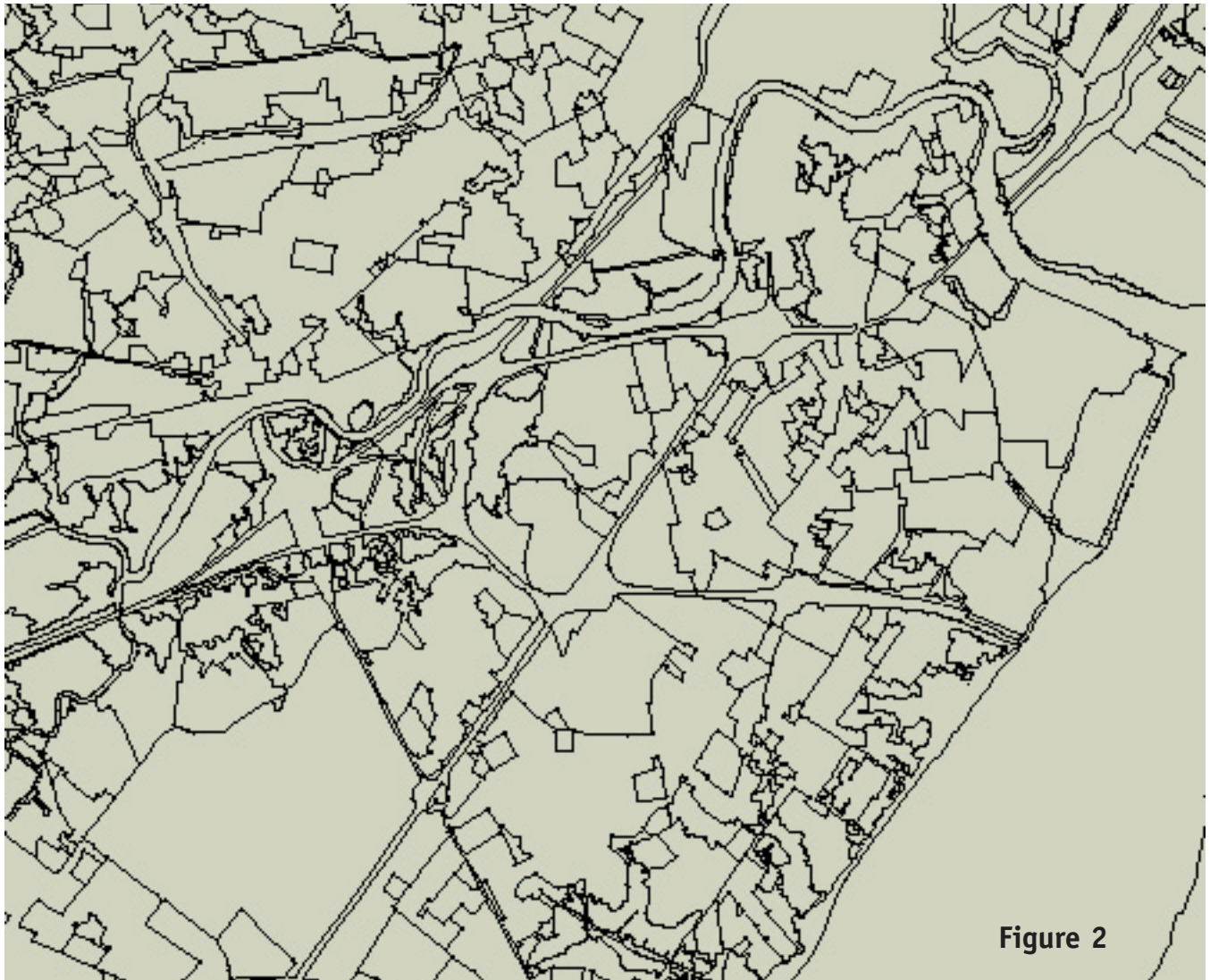
Figure 2

you should see lines outlining individual habitats more clearly (Figure 2). Notice that these lines outline irregular shapes called polygons.

4.

Click on the "Identify" tool, then click inside one of the polygons. Now you should see an "Identify Results" window that contains information about the polygon you clicked. In the left column you can see a number that is the land use code for that particular polygon. In the right column you can see a list of Fields. Fields may be followed by a Value; if there is no value next to the Field name, it means that there are no data for that Field in this particular polygon. The Fields and their meaning for this map layer are:

Area: the area of this polygon in square meters

Perimeter: the perimeter of this polygon in meters

NEWCASTL_ and **NEWCASTL_I:** Identifying numbers for this polygon

LULC: the Anderson Land Use Classification System code number

LAND_USE: the "plain English" translation of the LULC number

5.

Each polygon is linked to a table of information about that polygon. You could use the Identify tool to explore each polygon, one at a time, but this would quickly become pretty confusing, unless you were only interested in a few specific locations. To get a better picture of how land use and land cover are distributed around the Christina River, we need to assign a specific color to each habitat type. To do this, right-click (or ctrl-click on a Macintosh platform) on "NEWCASTL" in the TOC, and scroll down to "Properties." In the "Draw Features Using" box, select "Unique Symbols" from the pull-down menu. In the window next to "Field for Values" select "LAND_USE." You should now see a series of color bars underneath "Symbol" and a list of land use categories under "Value" and "Label." Each land use category corresponds to a different color bar. Click "OK" to apply these colors to the map and to close the "NEWCASTL Properties" window. [Note: If a window appears saying that there are more than 5,000 values, just click continue.]

Now it's much easier to see the relationship between various land use categories around the Christina River. You may want to change the colors assigned to a particular land use. To do this, re-open the "Properties" window as described above. Click on the color bar that you want to change, and a color palette will appear. Click on the color that you want to use, then click "OK." When you have finished making changes to the color bars, click "OK" to apply the new colors to the map and to close the "Properties" window.

You can also add labels to the map. Click "Labels" at the top of the "Properties" window. In the "Label Features Using" box select "TYPE" from the pulldown menu. To change the color of the labels, select "Custom" from the pulldown menu next to "Color", and a color palette will appear. Click on the color that

you want to use, then click "OK." You can change the font and font style, and add special effects to make the labels more visible. When you have selected the features for your labels, click "OK." After a few seconds, ArcExplorer should redraw the map with labels. Note that only one label will be applied for each land use category in the map window (so there will only be one label for "Wetlands", even there may be several polygons in the map window representing wetlands).

6.

The eight tools on the right side of the tool bar are used to extract various types of information from the map and its associated database.

- Clicking on the "Find" tool (binoculars) will open a dialogue box that allows you to search the database for a particular word. This is useful when you want to locate a particular place name or feature on the map. When the search is completed, you can pan or zoom to the places or features that have been found.

- The "Query Builder" tool (page with a "?" mark) is described below.

- The "Select Features" tool (containing a white arrow) is used to select groups of polygons.

- The "Clear All Selections" (eraser) tool will de-select all polygons.

- The "Attributes" tool (page with a yellow star) will open an Attributes window displaying information for each selected polygon.

  Another way to select features is to right-click (or ctrl-click on Macintosh platforms) on one of the colored symbols in the TOC. This will select and highlight all polygons corresponding to the habitat type selected in the TOC.

- You can use the "Measure" tool (ruler with a "?" symbol) to find the distance between points on the map. When you click on the tool, a popup menu appears in which you can specify the units of measurement. After you click on the

desired units, the cursor changes to a "+" symbol. Position the cursor over the desired starting point, then click and drag to the desired ending point. A window in the upper left corner of the map will show the length of the segment you have just drawn. You can continue to add segments, and the window will show the length of the most recent segment as well as the total length of all segments. You can clear the totals by clicking on the Measure tool again and selecting "Clear Measure Totals."

The "Buffer" tool (two orange circles joined by black lines) will draw a line of a specified radius around a selected area.

The "MapTips" tool (page with a light bulb) can be used to help identify features that are displayed on the map. In the TOC, click on "NEWCASTL" to make it active, then select the "MapTips" tool from the tool bar. In the "MapTip Layer Selection" window, select " NEWCASTL." In the Field Selection window select "LAND_USE" then click on the "Set MapTips" button. "LAND_USE" should appear in the box below "MapTip Field." Click "OK." Now, as you place the cursor over a polygon on the map, the land use for that polygon will appear.

7.

Now let's see how we can use the map and the data linked to each polygon to answer some specific questions. Suppose we are interested in agriculture and want to know the total area of idle fields in Newcastle County. Be sure the layer name "NEWCASTL" is highlighted, then click on the "Query Builder" tool (the tool with the "?" symbol just to the right of the binoculars). Now you should see the Query Builder window, which you can use to build a set of criteria that AEJEE will apply to the map data. In the upper left column under "Select a Field:" double-click "LAND_USE". Notice that "LAND_USE" has been transferred to the window just above the "Execute" and "Clear" buttons. In the function palette between the "Select a Field:" and "Values:" windows, click "=" and notice that it has been added to the query statement next to "LAND_USE". In the "Values:" column, scroll down and click "Idle Field". Now the query statement should read

"(LAND_USE = 'Idle Field')". Click "Execute". In a few seconds, a list will appear of all the polygons whose "LAND_USE" field contains "Idle Field". Notice that there 67 polygons were found that match the query statement.

To find the total area of idle fields, click on the "Statistics" button. The "Select a Field to Get Statistics" window will open. Choose "AREA" from the list beneath "Select a field:". Click inside the box next to "Use Query Results?", then click "OK". Now you should see a window titled "Statistics Results for field "AREA". This window shows:

    Count: the number of polygons (67);

    Max: the size of the polygon having the greatest area of
        idle fields (396,538.23 square meters);

    Min: the size of the polygon having the smallest area of
        idle fields (2281.76 square meters);

    Mean: the mean area of idle fields in all 67 polygons
        (62,552.94 square meters);

    Std Dev: the standard deviation of this mean (70,882.48);
        and

    Total: the total area of idle fields habitat in the database
        (4,191,046.82 square meters).

8.

Query Builder has several other useful features. If you select one or more of the polygons in the results window then click on "Highlight," each of the selected polygons will be outlined and tinted in yellow. If you select a polygon and then click on "Pan," the map window will pan so that the selected polygon is near the center of the window. If you select a polygon and then click on "Zoom", the map window will zoom in so that the selected polygon is magnified in the center of the window.

So if you wanted to locate the polygon with the largest area of idle fields (396,538.23 square meters), you could scroll through the list until you found the polygon with this area (NEWCASTL_ polygon number 3447), click to highlight that line, click "Highlight," then click "Zoom." Now the map shows a highlighted idle field area surrounded by areas of Mixed Range and Other Urban uses. You can use the Identify tool to be sure it's polygon number 3447.

Syntax is important when building queries. Strings such as names are always enclosed with single quotation marks ('), and are case sensitive, so if a string field's value is 'Delaware' you can select this record with

NAME = 'Delaware'.

When querying strings, you can use % as a "wildcard" to represent one or more characters. The wildcard is used in conjunction with the "Like" operator, so you could select 'Delaware' with

NAME like 'Dela%'.

When the AND operator is used, both expressions must be true. When the OR operator is used, at least one expression must be true.

9.

Finding the polygon with the largest area by scrolling through the Query Builder results list isn't too difficult when there are only 67 polygons on the list; but what if there were several hundred? We can deal with this problem by using the Attribute Table for the "NEWCASTL" layer. Right-click (or ctrl-click on a Macintosh platform) on "NEWCASTL" in the TOC, and scroll down to "Attribute Table." This table shows all of the data associated with every polygon is the database. To find the one we want, right-click (or ctrl-click on a Macintosh platform) on "AREA" and select "Sort Descending" from the popup menu that appears. Now the list is arranged according to polygon size, with the largest polygon (458,362,979.14 square meters) at the top of the list. Right-click (or ctrl-click) on "LAND_USE", and scroll down until "Idle Field" appears under "LAND_USE". The first "Idle Fields" polygon is the largest (since we sorted according to descending area), NEWCASTL_ polygon number 3447).

Table 1
Anderson Land Use Classification System Codes

CODE	LANDUSE
111	Single Family Dwellings
112	Multi Family Dwellings
114	Mobile home Parks/Courts
120	Commercial
121	Retail Sales/Wholesale/Professional Services
122	Vehicle Related Activities
123	Junk/Salvage Yards
125	Warehouses and Temporary Storage
129	Other Commercial
130	Industrial
140	Transportation/Communication
141	Highways/Roads/Access roads/Freeways/Interst
142	Parking Lots
143	Railroads
144	Airports
145	Communication - Antennas
146	Marinas/Port Facilities/Docks
149	Other Transportation/Communication
150	Utilities
160	Mixed Urban or Built-up Land
170	Other Urban or Built-up Land
180	Institutional/Governmental
190	Recreational
210	Cropland and Pasture
211	Cropland
212	Pasture
213	Idle Fields
214	Plowed, Unvegitated Fields
215	Truck Crops
220	Orchards/Nurseries/Horticulture
230	Confined Feeding Operations/Feedlots/Holding
240	Farmsteads and Farm Related Buildings
290	Other Agriculture

310	Herbaceous Rangeland
320	Shrub/Brush Rangeland
330	Mixed Rangeland
410	Deciduous Forest
420	Evergreen Forest
430	Mixed Forest
440	Clear-cut
510	Waterways/Streams/Canals
520	Natural Lakes and Ponds
530	Man-made Reservoirs and Impoundments
540	Bays and Coves
590	Other
600	Wetlands
720	Beaches and River Banks
730	Inland Natural Sandy Areas
750	Extraction
760	Transitional (incl. cleared, filled, and graded areas)

CONTAMINENTS IN THE ENVIRONMENT LESSON PLAN
Christina River Project Review Worksheet

Part B

Launch ArcExplorer™ Java™ Edition for Education and open the NEWCASTL.SHP file in the "DirtyMudData" folder as described above. Open a new window that will contain wetlands data by choosing "New Window" from the "Window" pull-down menu. A new, empty display will appear on top of the window containing land use data. Slide the new window just a bit so you can see that there are two windows. In the new window, open the file "wilmis_p" from the "DirtyMudData" folder. Assign a unique color to each wetland type as described in Step 5 of the GIS Tutorial, selecting "ATTRIBUTE" for the "Field for Values." Note that the large areas with a "U" classification are not wetlands. Use the data in the "NEWCASTL" and "wilmis_p" windows and the maps in "Introduction to the Christina River Project" to answer the following questions:

1. What is the total area of wetlands (ALUCS code 600)?

   _____

2. Locate the Superfund site closest to the mouth of the Christina River. Zoom in so the scale is about 1:20,000. What land uses are immediately adjacent to this site?

   _____

   _____

   _____

   _____

3. What is the area of wetlands closest to this site?

   _____

4. What is the NWI classification of the portion of the Christina River closest to this Superfund site?

   _____

5. What does this classification tell you about the salinity and tidal characteristics of this part of the river?

6. What are the two wetland types located near the Halby Chemical Superfund site?

7. A goal of the Christina River Project is to increase the numbers of blueback herring and alewife. Both of these species are more successful in rivers that have riparian estuarine emergent wetlands (tidal wetlands that are adjacent to a river whose plants have roots underwater and leaves above water). If a river is tidal, adjacent palustrine (non-tidal) emergent wetlands can be converted to estuarine wetlands by connecting them to the river. What is the approximate total area of estuarine emergent wetlands in the "wilmis_p" dataset? Hint: All estuarine emergent wetlands begin with the characters 'E2EM'.

8. What is the approximate total area of palustrine emergent wetlands in the "wilmis_p" dataset?

9. Refer to page 6 of "Introduction to the Christina River Project." Locate the portion of the Christina River discussed on this page, and zoom in to the "NEWCASTL" and "wilmis_p" maps so that these windows resemble the photograph on page 6 ("Organic Contaminant Distribution at Potential Restoration Site"). Notice the yellow highlighted area on the photograph, and locate this feature in the

"NEWCASTL" and "wilmis_p" windows. What are some reasons that these shapes might not be identical on the three images?

_____

_____

_____

_____

_____

_____

10. The text on Page 6 states that the yellow area on the photograph represents the largest palustrine emergent wetland. How is this area classified in the "wilmis_p" dataset? Does this classification suggest an explanation for differences in the classification of this area?

_____

_____

_____

_____

11. What other types of wetland are adjacent to the yellow area on the photograph?

_____

_____

_____

_____

_____

_____

12. What land use features are adjacent to the highlighted area?

_____

_____

13. What type of wetlands are associated with the recreation area adjacent to the yellow highlighted feature?

_____

_____

_____

14. Page 5 refers to a large salvage yard on the river bank. Where is this feature relative to the yellow highlighted area?

_____

_____

_____

_____

_____

15. What type of wetlands are adjacent to the river across from the salvage yard?

_____

_____

_____