Excerpts from the Active Watershed Education Curriculum (AWESome!) developed by the RI Southern Conservation District and updated by Denise Poyer, Program Director, Wood-Pawcatuck Watershed Association

Unit VI:

Effects of Land Use On the Watershed

Unit VI Land Use
Introduction

Land use has a major impact on the water quality of both surface and ground water. Land use refers to the human use of the land. What are the historical uses as well as the current uses of land in the watershed? How was the land used by indigenous people before European settlers? How did the early settlers use it? Did the industrial revolution affect the watershed with dams, mills and concentrated village areas? What has the population movement been like over the last 100 years? Where are the cities and large towns in the watershed? Is there agriculture or industry in the watershed? Are there any wastewater treatment plants?

Certain kinds of land use can change the hydrology of the Watershed, altering the way water and pollutants move through the drainage basin. For example, as an area of land is converted from open space (e.g., woodland) to residential, the amount of runoff for that area of land will increase as the amount of impervious surface increases. Rain, which would have once seeped into the soils beneath the forest floor and been absorbed by tree roots, instead flows off impervious surfaces (roofs, driveways, streets, parking lots, etc.) into the nearest stream, pond, or lowland area. As rainwater runs off these surfaces, it will also carry off any existing pollutants. Thus, not only has the rate of runoff increased for that area, but the amount of pollution that enters nearby waterbodies may also increase. In addition to hydrologic changes, some land uses may not be appropriate for certain types of soils (See previous chapter). It would not be advisable, for example, to install a septic system in an area characterized by wet soils as this may cause the system to fail, releasing untreated waste into the surrounding environment. These are just some examples of how land use can determine the health of a watershed. Other examples will be provided in the following activities and units.

Humans have lived in the Pettaquamscutt Watershed for at least 3,000 years, perhaps as long as 10,000, using the land as needed. Prior to European arrival most of the Watershed, like all of Rhode Island, was forested. The Narragansett and Niantic Tribes, who originally inhabited this area, cleared small portions of the Watershed for sustenance crops of beans, corn, and squash. Early settlers, however, soon displaced the Native Americans from this bountiful land, and cleared much of the area for pasture and large agricultural fields. Numerous stone walls still mark the efforts of the area's early European farmers and their slaves. By the early 1700's, significant parts of the Watershed were included in "Narragansett Country," a fertile agricultural area that supported large plantations and exported horses, cattle, cheese, and tobacco. Agriculture remained a significant activity in Narragansett Country well into the nineteenth century. However, much of the Watershed reverted to forest during 1800s when first the canals and later the railroads opened up the American Midwest and West. This drew people away from the Watershed in droves, leaving it relatively unpopulated until the mid twentieth century.

Land use today is devoted primarily to residential use, with over 35% of the land area in the Watershed already developed. Development has been increasing steadily over the *past fifty years within the Watershed towns, with the most accelerated growth rate occurring in Narragansett. This development has occurred in a piecemeal fashion, particularly in the lower portions of the Watershed, and has resulted in the creation of high-density neighborhoods close to the Narrow River. The proximity of housing close to the River has contributed significant negative impacts to this already fragile ecosystem. Most of the remaining undeveloped land is located in the northern and northwestern regions of the Watershed. Natural features such as steep slopes, high water tables, and wetlands have prevented much of this area from being developed. However, due to recent technological advances and the installation of public utilities in these areas, there is a potential for a 36% increase in residential development (over 1000 more houses).*

References:

Applied Science Associates, Rhode Island Watershed Watch, SAIC Engineering, Inc., Urish, Wright, and Runge. 1995. *Narrow River Stormwater Management Study Problem Assessment and Design Feasibility*, prepared for the Towns of Narragansett, South Kingstown, and North Kingstown.

Ernest, L. M., L. K. Miguel, and J. Willis. 1999. *The Narrow River Special Area Management Plan.* Coastal Resources Management Council, South Kingstown, RI.

Gibbs, E., T. Corey, M. Schwartz, D. Grossman-Garber, C. Jaworski, and M. Bucheit. 1995. *A Guide to Rhode Island's Natural Places.* Rhode Island Sea Grant, University of Rhode Island, Narragansett, RI.

Narrow River Preservation Association. 2002. *The Narrow River Handbook – A Guide to Living in the Watershed*, second edition. Narrow River Preservation Association, Narragansett, RI.

Town of Narragansett. 1994. *Narragansett Comprehensive Plan.*

Town of South Kingstown. 1992. *Town of South Kingstown Comprehensive Plan.*

<u>NOTE:</u> This Introductory Discussion should describe the historical and current land uses and hydrology in your watershed. This whole page is an example.

INTRODUCTORY DISCUSSION:

Land use in the Flat River Reservoir Watershed has changed over the last 500 years. These changes have altered the hydrology of the watershed. Hydrology refers to the movement of water through the watershed, both through infiltration to ground water and surface water runoff. Land use changes have altered the hydrology because different land uses have different effects on the way water moves through a watershed.

1. How has land use changed over time?
    a. <u>What was the original land use?</u>
        The vegetation following the last glacier was an evergreen hardwood mixed forest.
    b. <u>What happened when the Indians settled here?</u>
        They used very small clearings in the forests for some crops and their villages.
    c. <u>What happened when the Europeans settled in the New World?</u>
        They began clearing large areas for homesteads, pastures, crops, and, in the case of Coventry, mills along the waterways, in addition to roads, similar to the "urban" areas they had experienced in Europe. Eventually all of the original forests in Rhode Island were cleared. Therefore, all of the forests you see in the state now are second and third growth forests.

2. What are some of the many different current land uses in Rhode Island?
    Land uses include: forest, agriculture, industry (factories), residential (homes), commercial (stores and businesses), recreational (parks and preserves), roads and streets, etc.

ACTIVITY I: HOW DOES LAND USE AFFECT INFILTRATION AND RUNOFF?

OBJECTIVE: Students will demonstrate to each other how various land uses affect rates of runoff and infiltration.

METHOD: Students will pour equal amounts of water onto a model simulating pavement, bare earth, and sod. A comparison of the volume of water collected in runoff from each treatment will be made.

MATERIALS: water, quart jar, watering can, soil, sod, runoff model*, bucket

BACKGROUND INFORMATION:

1. Infiltration is water that seeps into the soil and recharges the aquifer. An aquifer, or ground water reservoir, is the saturated water-bearing portion of the Earth's crust. Runoff is water that does not infiltrate into the aquifer, but instead runs over the surface of the land.

2. Runoff water, or overland flow, eventually collects in surface water bodies such as rivers, streams, or wetland swamps.

3. Forests have less runoff because the leaves and trees slow the rainfall that hits the ground, plant roots absorb water, and water is able to infiltrate into the earth. Pavement has greater runoff because nothing slows the rainfall, and water is not able to soak into the ground.

4. Rates of infiltration for various land uses are as follows (from greatest infiltration to smallest):

forest > pasture > row crops > bare earth > pavement > surface water

Thus rates of runoff are the opposite (from greatest runoff to smallest):

surface water > pavement > bare earth > row crops > pasture > forest

PROCEDURE:

1. Discuss the terms infiltration, runoff, and review aquifer and surface water. Draw the relationships in #4 above to illustrate how the rates of infiltration and runoff compare for different land uses.

2. Place the runoff model on a table in such a manner that the tubing will drain all runoff water to the bucket. Sprinkle a measured volume of water, (1/2 full quart jar) over the

bare surface and record the amount collected in the bucket. What does the bare surface represent? (pavement)

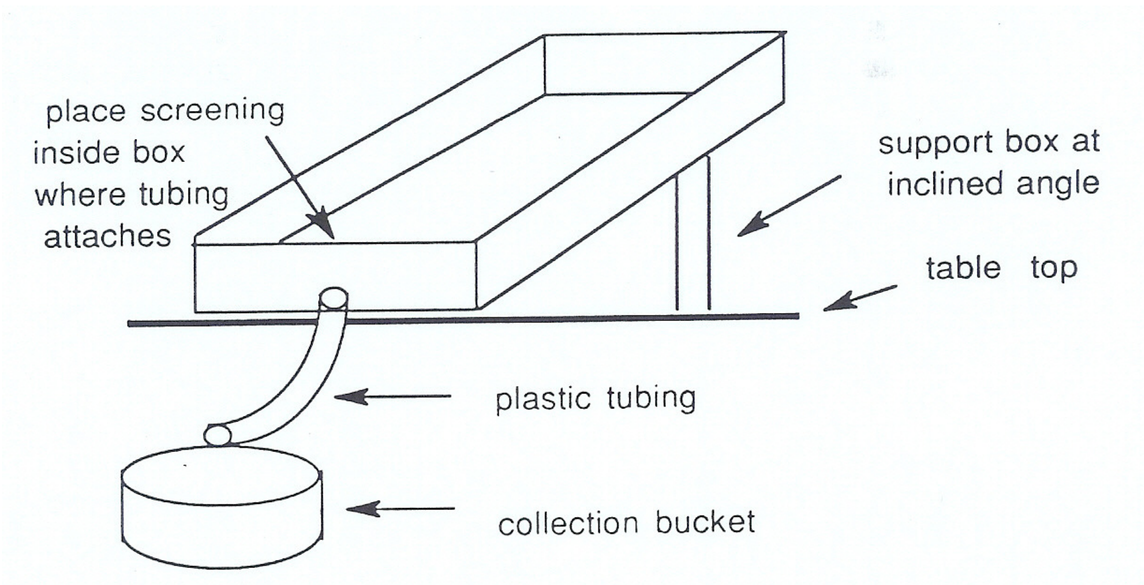
3. Place a mesh screen over the inlet to the tubing and cover the surface with soil. Sprinkle the same volume of water over the soil-covered surface and record the amount collected in the bucket. Now what does the model represent? (bare soil, e.g., from agriculture or construction sites)

4. Place turf grass over the surface and sprinkle the same volume of water over it. Record the amount of water collected.

5. Discuss differences in the amounts of water collected. Almost all of the water should be collected from the bare surface, as would runoff from a rainstorm over pavement. A moderate amount of murky water should be collected from the bare soil. This also demonstrates the effect of erosion on surface water quality, but this concept will be covered later in the "Non-point Sources of Pollution" section. Hardly any water should be collected from the turf, illustrating how plants covering the bare earth greatly increase infiltration.

6. How have the changes in land use over time affected the hydrology of the watershed? Is there more runoff now than there was 200 years ago? Does the runoff water reach the mouth of the (**river(s) your watershed flows into** [*Hunt River and Potowomut River*]) faster now than it did back then?

* You can make your own **Runoff Model** by constructing a shallow wooden box, drilling a hole at one end, and attaching plastic tubing. Old window screening fastened to the inside of where the tubing drains runoff from the box is necessary to keep the tubing from becoming clogged with “eroded” soil.



ACTIVITY II: HOW DOES DEVELOPMENT AFFECT RUNOFF?

OBJECTIVE: Students will understand how a very small change in land use can greatly affect the volume of runoff that occurs.

METHOD: Students will use math skills to calculate cubic feet of runoff on a 100 acre parcel of land. They will compare runoff for pre- and post-development scenarios.

MATERIALS: paper, calculators, runoff graph

BACKGROUND INFORMATION:

1. Runoff increases as developed land increases. Hydrologists use curve numbers to calculate the expected amount of runoff that will result from various land uses. <u>Curve numbers</u> are values assigned to sites based on their soil type and inherent ability to absorb water. The lower the number, the more water will infiltrate, and the less water will run off. Thus pavement has a much higher curve number than forest.

2. In this sample problem, curve numbers are assigned to different land uses. Note that in reality curve numbers will vary with soil type, cropping practices, zoning acreage, etc. For example, farms that use <u>cover cropping</u> (planting a winter grass to hold the soil in the winter) will have lower curve numbers than farms that do not use cover cropping. Two acre zoning areas will have lower curve numbers than ½ acre zoning areas, because the proportion of vegetated land (lawns, trees) to pavement will be higher in the two acre zoning areas.

3. Civil engineers design <u>retention basins</u> which catch runoff from highways, parking lots, and other developed areas. These basins help store and slow down overland flow and thus help to reduce flooding. Retention basins also help to control pollution that may be carried in runoff; thus they will be cover in more detail in the "Non-point Sources of Pollution" section.

PROCEDURE:

1. For this activity, use the following data:

<u>pre-development land use</u>	<u>curve #</u>	<u>area</u> (acres)
woodland	55	30
pasture	79	40
potato farm	81	30

<u>post-development land use</u>	<u>curve #</u>	<u>area</u> (acres)
roads	98	3
homes	75	27

pasture	79	40
potatoes	81	30

Put the data on the board and ask students to identify what area of land was developed, and what it was developed into (30 acres of woodland were developed into 3 areas of roads and 27 acres of homes).

2. The first step is to calculate an average curve number for the whole area of land, properly weighted such that it takes the varying acreage of the different land uses into account. To do this, expand the table of data on the board, adding another column entitled "curve # x area". Have students multiply the curve number x area for each land use in the pre-development scenario and list the products in this new column. A weighted average curve number is obtained by summing these products and dividing the sum by the total acreage. The weighted average curve number for the pre-development scenario is 72.4 (see chart below).

land use	curve #	area	curve# x area
woodland	55	30	1650
pasture	79	40	3160
potatoes	81	30	2430
sums		100	7240

to calculate weighted average curve number: 7240/100 acres = 72.4

2. The next step is to find the amount of runoff, using the curve number graph provided. Rainfall is on the x-axis, runoff is on the y-axis. Assume the rainfall is (**amount of rain you receive in a typical 10 year, 24 hour storm** [*5*]) inches, which is the amount of rain that falls in a typical 10 year, 24 hour storm in (**your state** [*Rhode Island*]) (A (**amount of rain you receive in a typical 10 year, 24 hour storm** [*5*]) inch rainfall occurs about every 10 years). Find (**amount of rain you receive in a typical 10 year, 24 hour storm** [*5*]) inches on the x-axis and follow up the graph until you intersect the curve number 72.4 (halfway between the curves for 70 and 75). From this point, follow horizontally across to the y-axis to find the inches of runoff. In this case, the answer is 2.2 inches.

3. To find the total runoff for the 100 acre parcel, multiply the inches of runoff by the total area. You will need to convert inches to feet and acres to square feet to get a cubic foot value:

$$2.2 \text{ inches} \times \frac{1 \text{ foot}}{12 \text{ inches}} = 0.183 \text{ feet of runoff}$$

$$100 \text{ acres} \times \frac{43560 \text{ square feet}}{1 \text{ acre}} = 4{,}356{,}000 \text{ square feet of area}$$

0.183 feet x 4,356,000 square feet = 798,000 cubic feet of runoff

To convert this figure to gallons:

$$798{,}000 \text{ cubic feet} \times \frac{7.48 \text{ gallons}}{1 \text{ cubic foot}} = 5{,}969{,}040 \text{ gallons of runoff}$$

4. Discuss the fact that a lot of water runs off a 100 acre parcel of land!

5. To find the runoff for the post-development scenario, repeat procedures 2 – 4, using the post-development data:

land use	curve #	area	curve# x area
roads	98	3	294
homes	75	27	2025
pasture	79	40	3160
potatoes	81	30	2430
sums		100	7909

to calculate weighted average curve number: 7909/100 acres = 79

Using the graph, (**amount of rain you receive in a typical 10 year, 24 hour storm** [*5*]) inches of rainfall with a curve number of 79 corresponds to 2.8 inches of runoff.

To calculate total runoff:

$$2.8 \text{ inches} \times \frac{1 \text{ foot}}{12 \text{ inches}} = 0.233 \text{ feet of runoff}$$

$$100 \text{ acres} \times \frac{43560 \text{ square feet}}{1 \text{ acre}} = 4{,}356{,}000 \text{ square feet of area}$$

0.233 feet x 4,356,000 square feet = 1,016,400 cubic feet of runoff

To convert this figure to gallons:

$$1{,}016{,}400 \text{ cubic feet} \times \frac{7.48 \text{ gallons}}{1 \text{ cubic foot}} = 7{,}602{,}672 \text{ gallons of runoff}$$

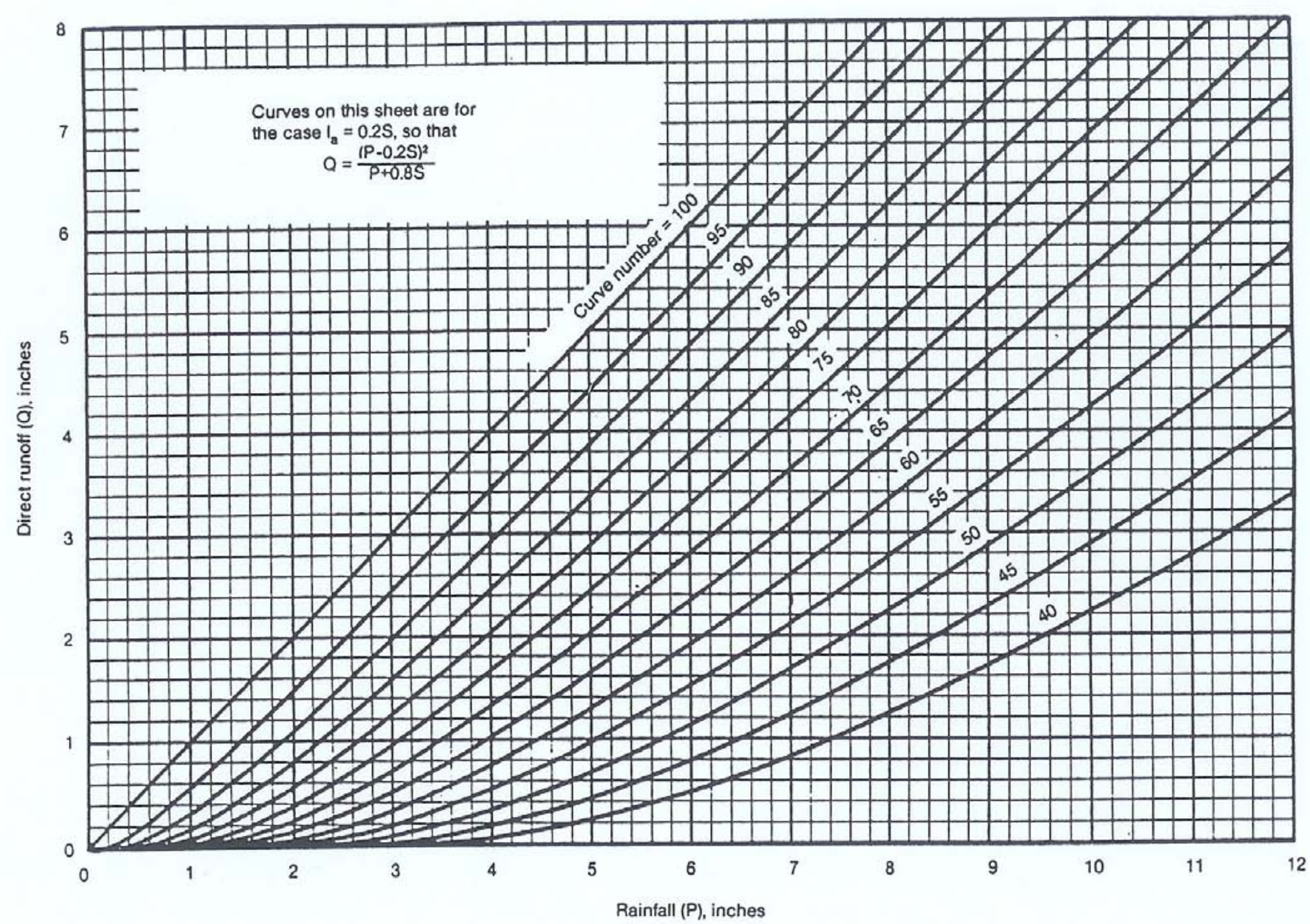
6. Note the difference in volume of runoff between the pre- and post-development scenarios. There was an increase of 1,633,632 gallons, a 27% increase in runoff when just 30 acres were developed. Remind students that this amount would only result from a (**amount of rain you receive in a typical 10 year, 24 hour storm** [*5*]) inch rainstorm, which occurs about every 10 years in (**your state** [*Rhode Island*]).

7. Is runoff bad? Not necessarily. It depends on what is downstream and if structures are built to prevent flooding.

8. How could this development be designed to reduce the amount of runoff that would result?

9. What structures can be built to control runoff once it occurs?

2-40



Runoff Graph

ACTIVITY III: **LAND USE PLANNING**

OBJECTIVE: Students will be able to evaluate an area's suitability for development, based on soil limitations.

METHOD: Students will use soil survey sheets and tables from the Soil Survey of (**your state** [*Rhode Island*]) to determine if an area is suitable for a certain type of development.

MATERIALS: Soil Survey of (**your state** [*Rhode Island*])*, loose soil survey sheets of an area near your school*, GIS maps*, soil survey activity sheets

BACKGROUND INFORMATION:

1. Soils have certain characteristics that make them more or less suitable for certain development projects. A few of these characteristics are wetness, stoniness, depth to ground water, excessive slope, and erodibility. It is important to understand the limitations of the soil to determine if the development is feasible.

2. Look through the Soil Survey of (**your state** [*Rhode Island*]) until you feel comfortable with its contents. You will need to help your students find the proper tables to look up the soil suitabilities for all the given development projects.

PROCEDURE:

1. Divide the students into 4 working groups. Assign each group one of the development projects given in the soil survey activity sheets. Each activity sheet tells the students which tables they will need to use from the Soil Survey of (**your state** [*Rhode Island*]). You may want to Xerox the proper tables for each group if you only have one copy of the Soil Survey.

2. Pass out the loose soil survey sheets. Students can then follow the directions on the activity sheets.

* Copies of your state's Soil Survey, loose soil survey sheets, and GIS maps are all available from your local office of the USDA Natural Resources Conservation Service.

SOIL SURVEY ACTIVITY SHEET

Task: Find an area on your map with about 25 acres to make into a wildlife refuge with a pond.

1. Pick an area that will be good for woodland and wetland wildlife.

2. Decide which type of trees will work best in this area, conifers or hardwoods. What will grow well that the animals can eat?

3. Look at the table on water management and see if the soil is suitable for a pond reservoir.

4. Look for soils that paths can be put on so that people can hike through the wildlife area.

You will need to use tables 21, 22, and 23.

1. Look up the soils and check if they are suitable for all of the requirements.

2. For a site to be acceptable, all limitations should be "slight" or "good".

3. Draw a circle around all of the areas that have soils that meet all of the requirements.

Follow-up activity:

Find a wildlife refuge on the GIS maps. Use the Soil Survey to determine if the soils are suitable for wildlife habitat development. If not, why do you think they were located there? (HINT: Is the land not suitable for any other use?)

SOIL SURVEY ACTIVITY SHEET

Task: Find an area on your map with about 25 acres that you can make into a recreational area with playgrounds, soccer fields, and baseball fields. You also want a pond and a walking and biking path.

---

1. This area will need to have bathroom facilities on it so the soil has to be acceptable for a septic tank absorption field.

2. You need to see if the ground is acceptable for large grassy areas with no rocks and if the area is dry enough to use most of the year. Check if the soil is good for paths.

3. Look at the table on water management and see if the soil is suitable for a pond reservoir.

You will need to use tables 19, 21, and 22.

1. Look up the soils and check if they are suitable for all of the requirements.

2. For a site to be acceptable, all limitations should be “slight” or “good”.

3. Draw a circle around all of the areas that have soils that meet all of the requirements.

Follow-up activity:

Find a park or open space recreation area on the GIS maps. Use the <u>Soil Survey</u> to determine if it is located on suitable soils. If not, why do you think they were located there? (HINT: Was the land donated to the state or town?)

SOIL SURVEY ACTIVITY SHEET

Task: Find an area on your map with about 25 acres to build into a subdivision with 20 houses.

---

1. To pick an area for your subdivision, you will have to be able to build roads to the site.

2. The contractor wants to use fill material from the site, so good road base material should be available.

3. The soil will have to be acceptable for basements, since the contractor wants one half of the houses to have basements.

4. You will need to be careful of any wetlands on your property. You can not build near them, nor put roads through them.

5. The last thing to look for is if the soil is acceptable for septic tank absorption fields, since there will be no sewer lines in the area.

You will need to use tables 18, 19, and 20.

1. Look up the soils and check if they are suitable for all of the requirements.

2. For a site to be acceptable, all limitations should be "slight" or "good".

3. Draw a circle around all of the areas that have soils that meet all of the requirements.

Follow-up activity:

Look at the GIS maps of urban areas. Use the <u>Soil Survey</u> to determine if the urban areas are generally found in areas where the soils are suitable for urban development. If not, why do you think these urban areas were first settled in these locations? (HINT: Are they near water?)

SOIL SURVEY ACTIVITY SHEET

Task: Find an area on your map with about 25 acres that you can grow crops on.

1. You want to grow the crop that has the highest yields.
2. Make sure that the soil is not going to flood.
3. Make sure that the soil is not too steep or too stony.

You will need to use the soil legend and tables 15 and 26.

1. Look up the soils and check if they are suitable for all of the requirements.
2. For a site to be acceptable, all limitations should be "slight" or "good".
3. Draw a circle around all of the areas that have soils that meet all of the requirements.

Follow-up activity:

Look at the GIS map of agricultural areas in the watershed. Use the Soil Survey to determine if they are generally located in areas with soils suitable for growing crops.

UNDEVELOPED LAND
Flat River Reservoir Watershed