WARD'S
Stormwater Floodplain Simulation System - Lab Activity

Name: ________________________________
Group: ________________________________
Date: ________________________________

ACTIVITY 1 - Case Study: A Flooded Community

OBJECTIVES:

- Examine and understand the importance of floodplains.
- Gain familiarity with basic terminology used in stormwater and floodplain management.
- Reflect on the factors that may affect the risk of flooding and generate a list.
- Practice designing experiments for testing a hypothesis.

TIME ALLOTMENT: 15-30 minutes

MATERIALS NEEDED PER GROUP:
Paper and pens
Newsprint
Markers
Glossary of Terms (see PDF on Resource CD)

BACKGROUND:
As the United States continues to grow and develop, flood damages are increasing. This has contributed to steadily rising flood losses and is increasing the potential for future flood damage. Floods are the leading cause of natural disaster losses in the United States. In fact, floods cause a greater loss of life and property in the United States than any other type of natural hazard, and the threat is increasing. Over three-quarters of all federally-declared disaster declarations are due, at least in part, to flooding. In an effort to reduce this threat, communities should consider the benefits of floodplains and wetlands.

A floodplain is that low area adjacent to a stream or river which provides a place for the water to go when it cannot be contained within the river channel. Floodplains are used for many human activities, including agriculture, grazing, parks and recreation, transportation, housing, and commercial development. Wetlands are areas where water saturates the soil or covers the land for most or all of the year. Wetlands function as natural sponges that trap and slowly release surface water, rain, snowmelt, groundwater and floodwaters. Floodplains and wetlands are a part of the larger watershed. A watershed is the land area that drains into a specific water body such as a lake, stream, or river. What happens in a watershed affects the movement of water through it to lakes, streams, or rivers.

PROCEDURE:

1. Review the background materials with your instructor and discuss why floodplains are important and the benefits of floodplains.

2. Consider the following story:

   A flood has just occurred in a community. The people living in that area were completely surprised. Although it is situated along a river, none of the residents could remember it flooding here before---at least not in the last 25 years. In fact, the generally attractive and safe nature of the area is one reason many of them moved to this community.

3. Now consider this question:

   "*What factors in the community could be different now that may have had an impact on the flooding?"*

4. Working in small groups, brainstorm about factors that may have affected flooding in this area.

5. Write down and discuss your group hypotheses and possible reasons for the flooding, using your new understanding of watershed and floodplain management.

6. Now present your group's ideas to the entire class. What are some ways you might find out whether or not the factors presented by each group could play a role in increasing the risk of flooding?

7. What experiments or data might you use to evaluate whether these factors could be important contributors to flooding?

ASSESSMENT:

1. Review your class responses to the question: **"***What factors in the community could be different now that may have had an impact on the flooding?"* **.** Which of the factors you discussed do you think might be most critical?

Name: ________________________________
Group: ________________________________
Date: ________________________________

ACTIVITY 2: Fate of Rain

OBJECTIVES:

- List the four primary routes of rainwater after it has hit the ground.
- Identify which routes of rainwater are increased and decreased when there is a more impermeable surface in a watershed.
- Identify why wetlands are important for minimizing the risk of flooding.

TIME ALLOTMENT: 10-15 minutes

MATERIALS NEEDED PER GROUP:
Student copymaster with Figures 2.1 and 2.3
Pens or pencils

BACKGROUND:
In this activity, you will explore what happens to rainfall as it hits the ground, and how it is transported in the watershed. Refer to **Figure 2.1 - Fate of Rain** in your activity worksheet. Notice that it has a downward arrow representing rain falling on a particular area. There are four other arrows going in appropriate directions representing evaporation, runoff, infiltration into soil, and infiltration into a groundwater aquifer. With each arrow is a number representing the percentage of the rain that leaves by each path. This data is based on a study of a typical natural field.

PROCEDURE:

1. Study **Figure 2.1 - Fate of Rain** and **Figure 2.3 - Surfaces Impact on Rainwater**. Using this information, answer the Assessment questions that follow.

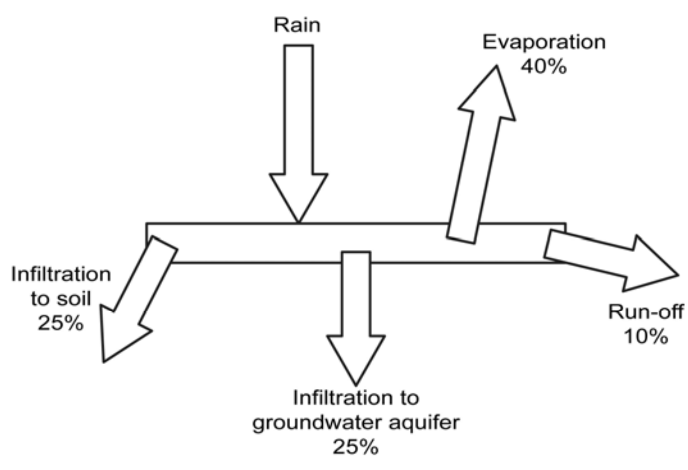


Figure 2.1 - Fate of Rain

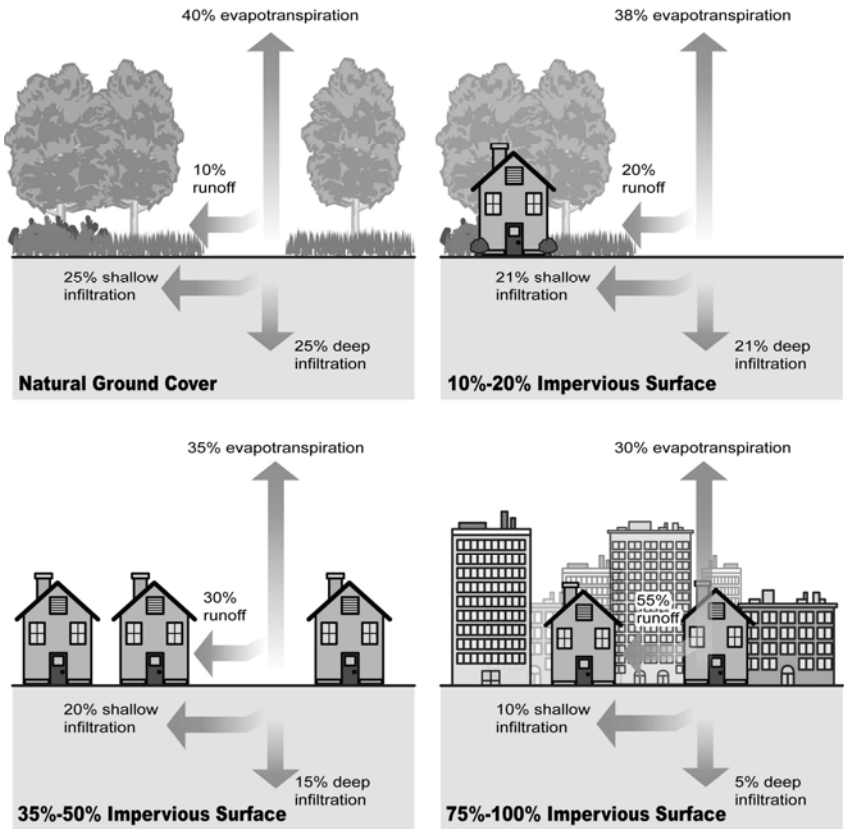


Figure 2.3 - Surfaces Impact on Rainwater

(Illustration based on "Stream Corridor Restoration: Principles, Processes, and Practices", 10/98, by the Federal Interagency Stream Restoration Working Group.)

ASSESSMENT:

1. If the ground is paved over, which of these routes for rainwater will be prevented?

2. In areas where 100% of the land is paved, which routes would most likely increase?

3. What do you think would happen to the water if only 25% of the land surface was paved over?

ASSESSMENT (continued)

4. If the ground contained a lot of clay rather then sand, which route do you think would be impacted the most?

5. If we were investigating snow rather than rain, would any of your answers be different?

6. Look at **Table 2.2**. For the ground conditions listed, fill in the appropriate responses and answer the summary question that follows.

TABLE 2.2 - Fate of Rain

Conditions in Area	**What routes would increase?**	**What routes would decrease?**
Frozen ground		
More wetlands		
Sandy soil		

7. What condition or combination of conditions would increase the risk of flooding in nearby rivers?

8. Now look closely at Figure 2.3. List the four primary routes rainwater takes after it hits the ground?

ASSESSMENT (continued)

9. Which routes of rainwater would be prevented if the ground were paved over?

10. If the ground were paved over, where would most of the water go?

11. List three changes in a watershed that would increase the risk of flooding?

12. List three changes in a watershed that would decrease the risk of flooding?

Name: ______________________________
Group: ______________________________
Date: ______________________________

ACTIVITY 3: Modeling Flood Risk Factors

OBJECTIVES:

- Develop hypotheses on what causes floods.
- Design and successfully carry out experiments to test these hypotheses.
- Plot and analyze data derived from wetland and parking lot headwater experiments.
- Determine the timing of the flood crest, crest height, amount of runoff, and the runoff footprint for each experiment.
- Recognize the floodplain, floodway, bankfull stage, and flood stage for a stream.
- Identify how changes in a watershed impact a river's flood crest, flow, velocity, erosion, sedimentation, and risk of flooding.

TIME ALLOTMENT: Allow about 10 minutes for each experiment. In a typical class time of 45 to 50 minutes, students should be able to complete at least 4 experiments.

MATERIALS NEEDED PER GROUP:
The activities are performed as one large group; all materials for this activity are shared.

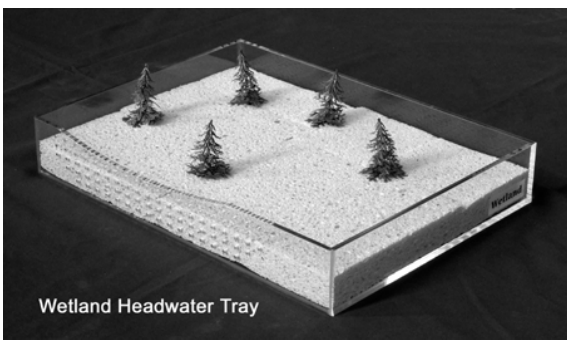
SHARED MATERIALS:
Stormwater Floodplain Model
Wetland Headwater Tray
Parking Lot/Plaza Headwater Tray
Rainmaker Trays (2) High/Low Rainfall Rates
Outflow Drain Hose
Catch Bucket
Water Bucket & Water Source
Graduated Pitcher 3L
Miniature Houses
Miniature Vehicles
Sponges (6)
Miniature Trees & Shrubs
Tank Slope Adjustment Bar
Stopwatch (not included)
Student Copymasters for Activity 3 (Resource CD)
Data Table and Graphing Spread Sheet (Resource CD)*
PC Computer/Projector (recommended)

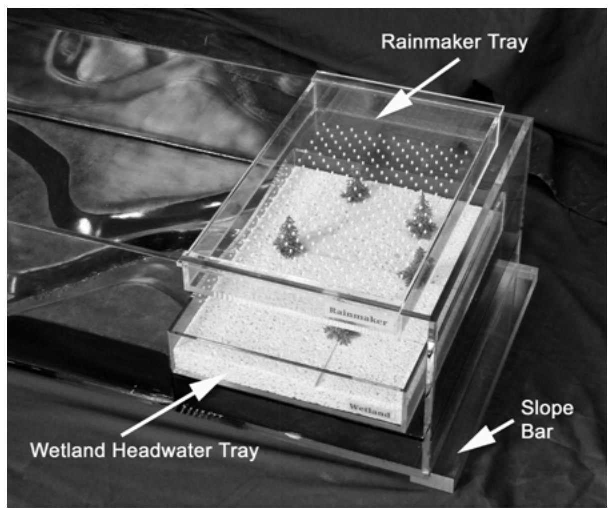
PROCEDURE - Part 1: Running the Wetlands Headwater Experiment

Divide the class into four groups of 5-8 students. Make the following assignments in each group: rainmaker, river reader, timer, recorder, data entry into spreadsheet (if plotting data using computers), levee builder (not used in Activity 3), and one student to measure runoff output.

1. The first experiment uses the Wetlands Headwater in the Stormwater Floodplain model. Assign a group to run the first experiment and the other groups to make observations. Each of the four groups will run one of the experiments, so everyone will have a chance to "play" with the model. For subsequent experiments, different students will take turns pouring in the water and observing the river stage. At the end of each experiment, the results need to be recorded by every student and will be used later to answer questions.

2. To run the first experiment modeling an undeveloped basin, insert the Wetlands Headwater tray into position on the headwater platform in the tank, and center the high-rainfall-rate-Rainmaker tray over the Wetlands Headwater tray.





3. Have your assigned "rainmaker" fill the graduated pitcher with water from the water bucket (or a faucet) up to the 2800ml (2.8L) line on the pitcher.

4. Before starting, have the river reader measure the beginning height of the river and record that value for time "0".

5. Students who are not performing the experiment should be observing the larger picture of events in the watershed. Students taking measurements may not even see when it is flooding or if houses are being moved.

6. Timing begins when the rainmaker begins pouring the water into the Rainmaker tray. The timer needs to alert the river reader to take a reading every 5 seconds. It will take several readings before the runoff reaches the river.

PROCEDURE - Part 1 (continued)

7. Have one student from the group record the river stages (height) as they are called out. If you are using a computer and are plotting the data into a spreadsheet, have an additional student conduct data entry. The river reader calls out a river height every 5 seconds for the recorder to input into the data sheets. Observations every 5 seconds will typically need to be made for at least 2 minutes, or until the river ceases to flow.

8. Once the river ceases to flow, have one student measure the runoff by pouring the water collected in the catch bucket back into the graduated pitcher. Record the volume of water measured in the data sheet.

9. After running each experiment, report your observations to the rest of the class., and record this in the data sheet.

10. Determine the timing of the crest, the crest height, and the runoff footprint. Record this in the space provided in the data sheet. Note that a formula for calculating the Runoff Footprint is also provided in the data sheet.

PROCEDURE - Part 2: Running the Parking Lot/Plaza Headwater Experiment

1. To run the second experiment modeling a developed basin, replace the Wetlands Headwater with the Parking Lot/Plaza Headwater tray. Have a second group repeat the experiment following the same procedure outlined in Part 1 of this activity. Record the results in the data sheets.

2. After performing these activities, review the data and design additional experiments using the model that are based on what you have discovered in Activities 1 & 2.

ASSESSMENT:

Assessment for this exercise is to be completed at the end of Activity 4.

ACTIVITY 3
DATA RECORDING SHEET

Headwater Type: Wetlands

Amount of water added: **2800ml**

Time interval of readings: **5 seconds**

Time (minutes:seconds)	Gage Height
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	
01:05	
01:10	
01:15	
01:20	
01:25	
01:30	
01:35	
01:40	
01:45	
01:50	
01:55	
02:00	
02:05	
02:10	
02:15	
02:20	
02:25	
02:30	
02:35	
02:40	
02:45	
02:50	
02:55	
03:00	

Bankfull Stage: ________________________

Flood Stage: _________________________

Timing of crest: _______________________

Crest height:__________________________

Rainfall
(amount of water added): _______________

Runoff
(amount of water that
came out of model): ___________________

Amount of water that must
have stayed in the model: _______________

Runoff footprint (%) =
(runoff amount/amount of
water added) X 100 ____________________

ACTIVITY 3
DATA RECORDING SHEET

Headwater Type: Parking Lot
Amount of water added: **2800ml** Time interval of readings: **5 seconds**

Time (minutes:seconds)	Gage Height
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	
01:05	
01:10	
01:15	
01:20	
01:25	
01:30	
01:35	
01:40	
01:45	
01:50	
01:55	
02:00	
02:05	
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02:15	
02:20	
02:25	
02:30	
02:35	
02:40	
02:45	
02:50	
02:55	
03:00	

Bankfull Stage: ________________________

Flood Stage: ________________________

Timing of crest: ________________________

Crest height: ________________________

Rainfall
(amount of water added): ________________

Runoff
(amount of water that
came out of model): ____________________

Amount of water that must
have stayed in the model: ________________

Runoff footprint (%) =
(runoff amount/amount of
water added) X 100 _____________________

Name: ______________________________
Group: ______________________________
Date: ______________________________

ACTIVITY 4: Man-Made Attempts to Minimize Flooding

OBJECTIVES:

- Explore options for protecting residents and property from flooding.
- Successfully carry out experiments using a physical model.
- Plot and analyze data derived from their own and pre-defined experiments.
- Determine the timing of the flood crest, crest height, amount of runoff, and the runoff footprint for each experiment.
- Compare and contrast the flood prevention effectiveness of man-made levees and retention ponds.
- Describe some of the impacts levees and retention ponds have on communities downstream.
- Explain some of the impacts levees and retention ponds have on stream flood characteristics.
- Identify how changes in a watershed impact a river's flood crest, flow, velocity, erosion, sedimentation, and risk of flooding.
- Describe the function of retention ponds and explain how they reduce the risk of flooding.

TIME ALLOTMENT: Allow about 10 minutes for each experiment. In a typical class time of 45 to 50 minutes, students should be able to complete at least 4 experiments (Activities 3 and 4).

SHARED MATERIALS:
Stormwater Floodplain Model
Parking Lot/Plaza Headwater Tray
Retention Pond Headwater Tray
Rainmaker Trays (2) High Rainfall Rate and Low Rainfall Rate
Outflow Drain Hose
Catch bucket
Water Bucket
Water Source
Graduated Pitcher 3L.
Miniature Houses
Miniature Vehicles
Miniature Trees & Shrubs
Tank Slope Adjustment Bar
Modeling Clay
Stopwatch
Student Copymasters for Activity 4 (Resource CD)
Data Table and Graphing Spreadsheet (CD)*
PC Computer/Projector (recommended)

BACKGROUND:

The United States has thousands of miles of **levee systems**—usually earthen embankments designed and constructed to contain, control, or divert the flow of water to provide some level of protection from flooding. Some levee systems date back as far as 150 years; some were completed recently or are underway. Levee systems built for agricultural purposes provide flood protection and flood-loss reduction primarily for farm fields. Other systems—urban levee systems—were built to provide flood protection and flood-loss reduction for population centers and the industrial, commercial, and residential facilities within them.

Earthen Levee

Because levees prevent flow into the floodplains, they take away the natural functions and benefits of floodplains discussed in our first activity. Levees only reduce the risk to individuals and structures behind them, they do not eliminate the risk. Levees should be considered as flood loss reduction structures, not flood protection structures. No levee system provides full protection from all flooding events to the people and structures located behind it. Some level of flood risk exists in these levee-impacted areas.

Retention ponds are man-made low areas designed to capture and store runoff for a limited period of time before being released through an outlet, at a controlled release rate. They are currently required in many zoning ordinances for business areas, apartment complexes, or other developed areas.

A retention pond is constructed to contain a permanent pool of water (not to be confused with a detention pond, which only contains water immediately after a rainfall event). Both types of ponds are constructed in neighborhoods and commercial developments to provide a means for capturing stormwater runoff. Most development replaces open land and forest with impervious surfaces such as roofs, roads, driveways, and parking lots (i.e., surfaces that water runs off of instead of soaks into). As stormwater runs off these impervious surfaces, it enters streams and rivers at a much faster rate and may cause stream bank erosion and flooding downstream.

Retention Pond Under Construction

Retention ponds are most often designed to reduce the rate of runoff water leaving a development in order to prevent flooding downstream. Retention ponds also provide an important water quality function. Brief heavy rainstorms carry debris and pollutants from lawns, driveways and streets straight into the ponds. The ponds allow suspended pollutants to settle out before the water enters local streams and rivers. These suspended pollutants can include soil, debris from roadways, dissolved metals, organic waste (such as pet and goose droppings), and dissolved nutrients (such as those found in lawn fertilizer.) Thus retention ponds can play an important role in keeping pollutants from reaching our rivers and streams.

PROCEDURE - Part 1: Developed Basin with Levee

1. What can be done to protect life and property from flooding? Make a list on the board. Discuss the best options with the rest of the class. Test at least 2 of these options with your model.

2. The first experiment in this activity uses the Parking Lot/Plaza Headwater tray in the Stormwater Floodplain model. With the Parking Lot tray in place in the model, use the modeling clay provided to build a levee to protect the homes located in the large floodplain.

3. Discuss with the rest of the class how to best construct and position the levee to protect the homes from flooding most effectively.

4. Assign a levee maker group to construct the levee.

5. Prepare your data sheets to record information as you did in Activity 3.

6. Center the high-rainfall-rate Rainmaker over the Parking Lot tray in the model.

7. As in Activity 3, have the river reader measure the beginning height of the river and record that value for time "0" in your data sheet.

8. Have the rainmaker you've assigned fill the pitcher from the water bucket (or faucet) up to the 2800-ml line on the pitcher.

9. Data collecting and timing begins when the assigned rainmaker begins pouring the water into the rainmaker tray. The water should be poured at a consistent rate, making sure the rate does not exceed the capacity of the rainmaker tray. The timer needs to alert the river reader to take a reading every 5 seconds. It will take several readings until the runoff reaches the river.

10. Have one student from your group record the river stages as they are called out. If you have a computer and are plotting the data into a spreadsheet, have an additional student conduct data entry. The river reader calls out a river height every 5 seconds for the recorder to input into the data sheets. Observations every 5 seconds will typically need to be made for at least 2 minutes or until the river cease to flow.

11. Once the river ceases to flow, have one student measure the runoff by pouring the water that drained into the catch bucket back into the pitcher. Record the volume measurement in your data sheet.

12. After each experiment, share your observations with the rest of the class. Record your observations in your data sheet.
.
13. From the data you've recorded, determine the timing of the crest, the crest height, and the runoff footprint for this experiment.

ACTIVITY 4
DATA RECORDING SHEET

Headwater Type: Parking Lot - Levee
Amount of water added: **2800ml** Time interval of readings: **5 seconds**

Time (minutes:seconds)	**Gage Height**
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	
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03:00	

Bankfull Stage: ________________________

Flood Stage: ________________________

Timing of crest: ________________________

Crest height: ________________________

Rainfall
(amount of water added): ________________

Runoff
(amount of water that
came out of model): ____________________

Amount of water that must
have stayed in the model: ________________

Runoff footprint (%) =
(runoff amount/amount of
water added) X 100 ____________________

ACTIVITY 4
DATA RECORDING SHEET

Headwater Type: Parking Lot - Retention Pond

Amount of water added: **2800ml** Time interval of readings: **5 seconds**

Time (minutes:seconds)	**Gage Height**
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
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02:55	
03:00	

Bankfull Stage: ________________________

Flood Stage: ________________________

Timing of crest: ________________________

Crest height: ________________________

Rainfall
(amount of water added): ________________

Runoff
(amount of water that
came out of model): ____________________

Amount of water that must
have stayed in the model: ________________

Runoff footprint (%) =
(runoff amount/amount of
water added) X 100 ____________________

PROCEDURE - Part 2: Developed Basin with Retention Pond

1. For this experiment, remove the Parking Lot tray from the headwater platform and replace it with the Retention Pond tray. Place the Retention Pond tray into the tank on the headwater platform snugly against the edge of the landform.

2. Now place the Parking Lot tray on top of the Retention Pond tray so that it rests on the raised side extensions of the lower tray. Make sure the back end of the Parking Lot tray is pressed against the rear wall of the tank. There should be about a 1" gap between the front edges of the two trays when properly placed.

3. Center the high-rainfall-rate-Rainmaker tray over the Parking Lot tray.

4. Repeat the same procedure as in Part 1 of this Activity and record your results.

5. Analyze and discuss your results with the rest of your class and answer the Assessment questions that follow.

ASSESSMENT (Parts 1 & 2):

1. Did the levee prevent flooding? Explain your answer.

2. Describe how the retention pond prevented flooding?

3. Choose the correct answer. What impact did the levee have on the smaller floodplain with the oxbow (and any community) downstream?
   (a) It had no impact
   (b) It reduced flooding
   (c) It caused more flooding downstream

4. Describe the headwater condition(s) that produced flooding in the model?

5. What headwater condition(s) reduce the chance of flooding?

ASSESSMENT (continued):

6. List other real-world developed and undeveloped land conditions that might be represented by the three headwater trays.

7. List four major impacts on a river system that occur due to the loss of floodplains, wet lands, and other natural water storage areas.

8. As a group, discuss the consequences of these four impacts on the watershed.

9. Describe how urbanization impacts the velocity, crest, flow, and erosion of a river?

10. When forecasting floods, which factor is more critical or more important…rainfall or runoff?

11. Summarize what you've learned so far by making a T-table in your notes. This is a table with two columns, each with a heading above the cross of the tee.

    The title of the table should be **"Factors that Affect the Risk of Flooding"**. One column will have the heading **"Increase Risk"** and the other column with the heading **"Decrease Risk".** Take a few minutes to make as complete a table as you can. Discuss your table with those around you to share ideas and make your lists more complete.

Table 4.3: Factors that Affect the Risk of Flooding T-Table

Increase Risk	Decrease Risk

12. Study the T-Table below. Put an 'X' in the box to indicate if the man-made structure had an effect that impacted the river.

Table 4.4: Impact of Man-Made Structures on the River

River Impacts	Effects of Levee	Effects of Retention Pond
Increase flood crest		
Decrease flood crest		
Increase velocity		
Decrease velocity		
Increase flow		
Decrease flow		
Increase erosion/sedimentation		
Decrease erosion/ sedimentation		

13. Comparing the effectiveness of the levee and the retention pond, which one has the least negative effect on areas downstream?

Name: ______________________________
Group: ______________________________
Date: ______________________________

ACTIVITY 5: Factors Affecting Flood Forecasting: Summary and Evaluation

OBJECTIVES:

- Describe various factors that impact flooding.
- Describe relationships between storm, soil, and surface conditions and changes in a river stage and the risk of flooding

TIME ALLOTMENT: 15-25 minutes

MATERIALS:
Pencil with Eraser
Student Copymasters for Activity 5 (Resource CD)

BACKGROUND:

Factors that impact flooding and flood forecasting

Soil moisture – Increased soil moisture increases the runoff potential and decreases the in filtration capacity. This results in a higher and earlier flood crest.

Soil Type – Fine soils, such as clays, increase the runoff potential because of their lower infiltration capacity. This results in a higher and earlier flood crest. Coarse soils, such as sand, decrease the runoff potential because of their higher infiltration capacity. This results in lower and later flood crests.

Slope – Steeper slopes increase the runoff potential and decrease the infiltration capacity, resulting in a higher and earlier flood crest.

Vegetation – Increased green vegetation reduces the runoff potential and increases the infiltration capacity, resulting in a lower and later flood crest.

Rainfall Intensity – Increased rainfall intensity increases the runoff potential because it rains faster than the rainfall can soak into the ground. This results in a higher and earlier flood crest.

Time of Year – Winters in the northern regions have dormant vegetation and possibly frozen soils, which increase the runoff potential and decrease the infiltration capacity (the ability for water to be absorbed in the ground). The re-sult is a higher and earlier flood crest. Summers have abundant green vegetation and non-frozen soils, which decrease the runoff potential and increase the infiltration capacity. This results in a lower and later flood crest.

BACKGROUND (continued)

Distribution of Rainfall – If the majority of the rain falls near the outlet (mouth) of the river, it will result in higher and earlier flood crests. If the majority of the rain falls near the headwaters, it will result in lower and later flood crests.

Storm Movement – If the storm moves from the head-waters to the outlet (down the basin), the flood crest will typically be higher and earlier. If the storm moves from the outlet to the headwaters (up the basin), the flood crest will typically be lower and later.

PROCEDURE:
In this activity, you will draw upon what you have observed from previous activities to complete the worksheet "Factors Affecting Flood Forecasts". You may need to think through how some conditions affect runoff and stream stage. Discuss factors you are unsure about with other students in your class and with your instructor.

1. Locate the worksheet "Factors Affecting Flood Forecasts". Along the left-hand side of the handout are variables that can affect the chance of flooding. Consider what would happen if each factor increased—either over time at one stream, or going from one river to another river. Then, for each factor, fill in the columns to the right with either up (increased risk of flooding) or down (decreased risk of flooding) arrows, based on what you have learned in the previous activities.

2. In the last column, circle how these factors might affect the timing of the crest (Earlier or Later).

3. After completing the handout, and answer the Assessment questions that follow.

ASSESSMENT:

1. From your observations and analyses, what conditions generally increase the risk of flooding?

2. For each of the following conditions, answer whether they would tend to (a) increase, (b) decrease, or have (c) no affect on the flood crest in a river.

   a. Steeper slope
   b. Soil contains more sand then clay
   c. Heavy rain in a short period of time
   d. Soil saturated with water (can't accept any more water)
   e. Rain storm in early spring when the ground is still frozen

ANALYSIS:
Factors Affecting Flood Forecasts

Characteristics of Basin or Storm	Trend	Runoff	Infiltration	Crest	Timing of Crest (Circle One)
Soil Moisture					Earlier or Later
Soil Type					
Fine/Clay					Earlier or Later
Coarse/Sandy					Earlier or Later
Slope					Earlier or Later
Vegetation					Earlier or Later
Rainfall Intensity					Earlier or Later
Time of Year					
Winter					Earlier or Later
Summer					Earlier or Later
Distribution of Rainfall					
@ Outlet					Earlier or Later
@ Headwater					Earlier or Later
Storm Movement					
Headwaters to Outlet					Earlier or Later
Outlet to Headwaters					Earlier or Later

Fill in the table above with ⬆ for increases and ⬇ for decreases and circle either earlier or later for the timing of the crest.

Name: ________________________________
Group: ________________________________
Date: ________________________________

ACTIVITY 6: Planning a Flood Safe Community

OBJECTIVES:

- Explain how land use decisions can increase or decrease the risk of flooding.
- Describe how land use actions in one community can affect the risk of flooding in a downstream community.
- Articulate reasons for land-use regulation.

TIME ALLOTMENT: 45-50 minutes

MATERIALS NEEDED PER GROUP:
Topographic Map Symbols Sheet
Scissors
Tape
Glue
Colored pencils or markers (optional)
Student Copymasters for Activity 6

MATERIALS NEEDED FOR PRESENTATIONS:
Scanned Topographic Map for Projecting and
PowerPoint[tm] Presentations
or
Overhead Projector with Overhead Masters & Topo Map
Newsprint
Markers

BACKGROUND:
Land-use planning and regulation is almost exclusively done by local governments. Laws allow a local government to designate the type of use allowed in different areas of their community. Traditionally, zoning designations such as residential, commercial, or agricultural, prevent incompatible land use (e.g., factory next to homes or traffic attracting shopping centers next to neighborhoods) and is also a convenience (e.g., preserving land for industry next to railroads or shipping docks). Land use regulations also include building codes (e.g., spacing and set back of buildings from the road), attempts to retain rural character of an area (e.g., farmland preservation efforts), even population and traffic controls (e.g., designating density of housing).

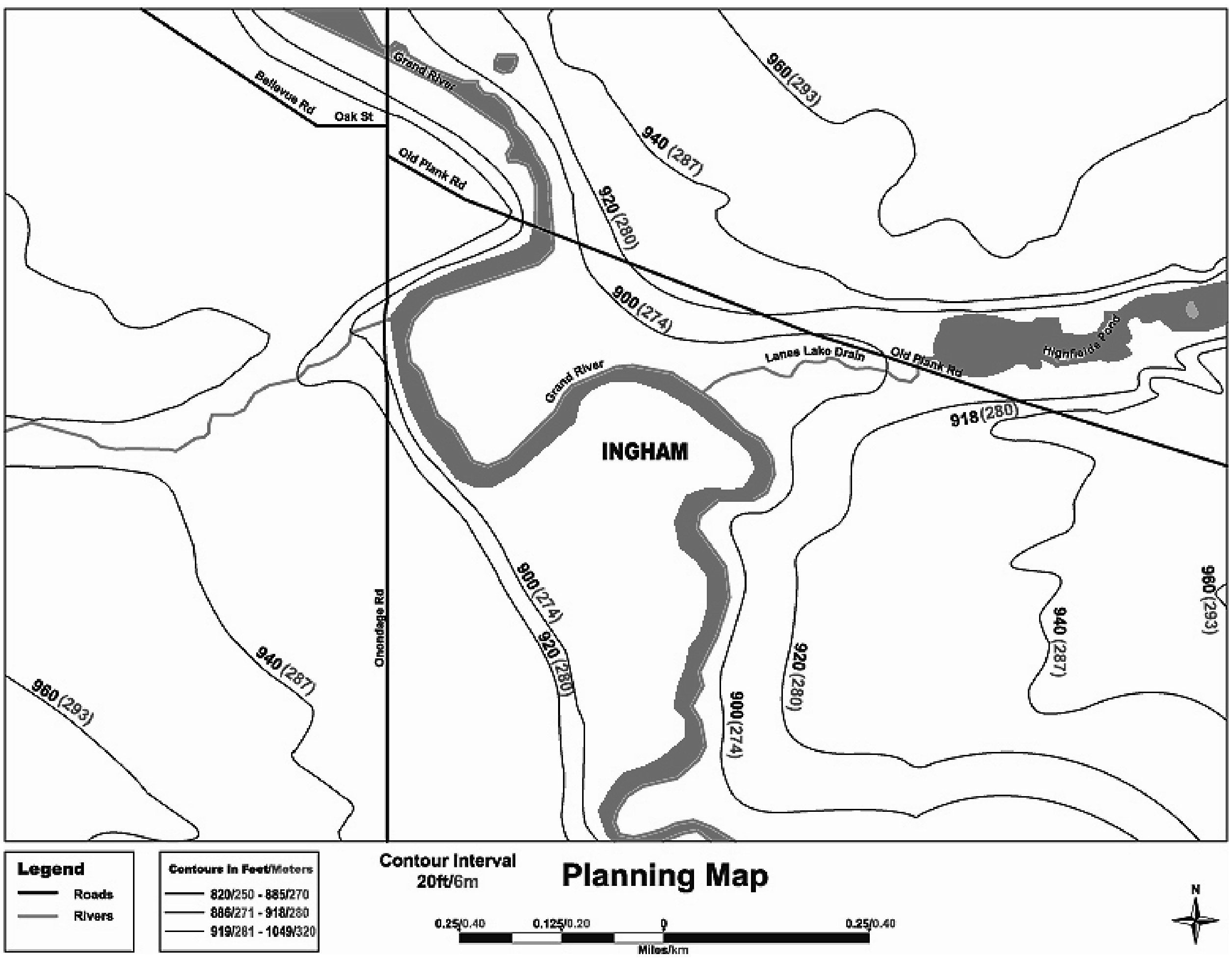
Environmental, health, and safety concerns have increasingly become considerations in establishing land use regulation. Protection of wildlife habitat, groundwater recharge areas, and flood risk reduction falls under these topics. The quality of life, health, and safety of humans and the broader environment usually underlie all plans. These can sometimes come into conflict with

BACKGROUND (continued)

what is perceived as individual property rights, where the rights of the larger community and rights of the individual property owner may seem to be contradictory. Such conflicts are nearly eliminated if land is zoned or designated before it is purchased, so that the owner knows the restrictions on the land ahead of time.

PROCEDURE:

1. Locate the Planning Map for the future town of Ingham found on your worksheet. Your group's task is to decide how various areas on the map are to be used to minimize the loss of life and property in the event of flooding. Think about whether your choices will decrease the chance of flooding or decrease the risk to life and property if flooding occurs. As town planners, your land use decisions will impact the long-term health and safety of the community.



Ingham Town Planning Map

PROCEDURE (continued)

2. Examine the map and the overall topography of the area and the location of rivers and streams and their floodplains. Next, identify and locate the map symbols for the following structures:

   1 – School
   1 – Hospital
   1 – Golf Course
   2 – Public Parking Lots
   1 – Picnic Area
   1 – Cemetery
   1 – Campground
   1 – Parks
   10 – Houses
   3 – Businesses
   1 – Wastewater Treatment Plant
   1 – Water Filtration Plant (Drinking water)
   1 – Emergency Management Center/Police HQ
   1 – Landfill (Garbage Dump)

   You may add more buildings and other land uses, such as farms, parks (picnic areas, playgrounds, etc.), wetlands, catch basins, and zoning designations. It would be helpful to first identify areas which are probably floodplains and possible wetlands. If you are unfamiliar with how to read topographic maps and contour lines, ask your instructor for additional help.

3. When you are finished with your Planning Map, your group will present its plan to the rest of the class. (See the Shared Materials section for ideas about how to facilitate this.) With each presentation, all groups should evaluate the merits of each plan. What are some good ideas? How might each plan be improved? Other than good planning and design, what are some other factors that might influence the town's ability to implement the best plan?

4. Now, consider how each plan would affect the next community downstream. Discuss any plan which minimized flooding by speeding the water downstream (by use of levees or straightening the river). Were there any actions which reduced the risk of flooding in one place but would increase the risk in a downstream community?

5. List actions that would reduce flooding for both the community taking the action and also any communities downstream.

6. Answer the Assessment questions that follow.

ASSESSMENT:

1. Where is one of the worst places to build a home if you don't want to risk it being flooded?

2. Explain how the placement of buildings can affect the risk of flooding to other buildings?

3. The construction of buildings often results in changes to the area surrounding the building. Describe one such change and explain how it might affect the risk of flooding.

4. Describe how land use in one community can increase the risk of flooding in another community downstream.

WARD'S
Stormwater Floodplain Simulation System - Lab Activity

Name: ______________________________
Group: ______________________________
Date: ______________________________

ACTIVITY 7: River Crest Analysis

OBJECTIVES:

- Describe what a river crest is and what produces it.
- Describe how a wave crest moves downstream, including a typical speed for such crests.
- Explain how flooding can occur in an area even when the storm did not occur there.
- Relate the impact of land use to the size of river crests and potential of flooding produced by a rainstorm.

TIME ALLOTMENT: 15-20 minutes

MATERIALS NEEDED PER GROUP:
Student Copymasters for Activity 7 (Resource CD)
Pen or Pencil

BACKGROUND:
After a rainstorm a river usually continues to rise even after the rain stops. This is important because the risk of flooding does not stop when the rain stops. In addition, flooding can occur on a river even when the rain fell a long distance away.

Rain occurring in one part of a watershed will result in more water in the river in that vicinity. The surface of the river will rise. A hydrologist would say there is an increase in the river's "stage". But other parts of the river initially are unaffected. As the newly added rainwater in the river moves downstream, other areas will experience rising water. If viewed over time, it would look like a bulge or crest in the river as it travels downstream. Hydrologists investigate these crests by constructing a hydrograph. When completing Activities 3 & 4 in this series, you created simple hydrographs. These are graphs of stream surface height at one location over time. In this investigation, the hydrographs represent three locations along a single river.

The National Weather Service defines flood stage as an established gage height for a given location above which a rise in water surface level begins to create a hazard to lives, property, or commerce. The issuance of flood (or in some cases flash flood) warnings is linked to flood stage.

<u>Jackson - Chapman River</u>

The forecast point at Jackson tends to have two peaks. The first peak is a result of urban runoff and outflow from the combined overflow from the treatment plant. The plant has an outlet just upstream of the gage. The first peak tends to be the highest peak and is very difficult to forecast. The second peak occurs due to runoff from the headwaters.

BACKGROUND (continued)

Lansing - Chapman River

The Chapman River at Lansing is located 64 river miles downstream from Jackson.

Grand Rapids – Chapman River

The Chapman River at Grand Rapids is located 175 miles downstream from Jackson. A sharp rise may occur in the first 24 hours due to the contribution from local tributaries and urban areas if the rainfall is localized. It will also show a slow rise or leveling off trend until the water from upstream makes its way down to Grand Rapids. The crest at Grand Rapids is mostly a function of the water coming down from upstream.

PROCEDURE:

1. Refer to **Figure 7.1 - Chapman River Watershed Map**. Note the river, watershed, and the cities. The objective of this activity is to observe how the river changes over time as a result of a heavy rainstorm that occurs in the area around Jackson.

2. Refer to **Figure 7.2 - Chapman River Hydrographs**. Each graph shows the height of the river at that location over a given time frame following the storm. The intent here is to identify the flood crest—the highest point the river reaches—and follow its movement downstream.

3. Work through the activity and Assessment questions. If you are uncertain about how to answer the last few questions, just imagine what might happen and give your best logical answer.

ANALYSIS:

After a rainstorm, runoff begins to reach the river causing it to rise and possibly to flood. This can be observed in the first graph of the Chapman River at Jackson. This graph shows the river height or "stage" along the left side, and time along the bottom (in hours). A rainstorm occurring in the Jackson area causes the river to rise, and then later it will fall as that "extra" water flows downstream. Refer to **Figure 7.1 - Chapman River Watershed Map** and observe the location of each city used in this activity. The storm occurs at time zero, and the highest point reached by the river is called the **crest**. Note carefully the units along both axes of the graphs. Then use the graphs (called hydrographs) to answer the following questions.

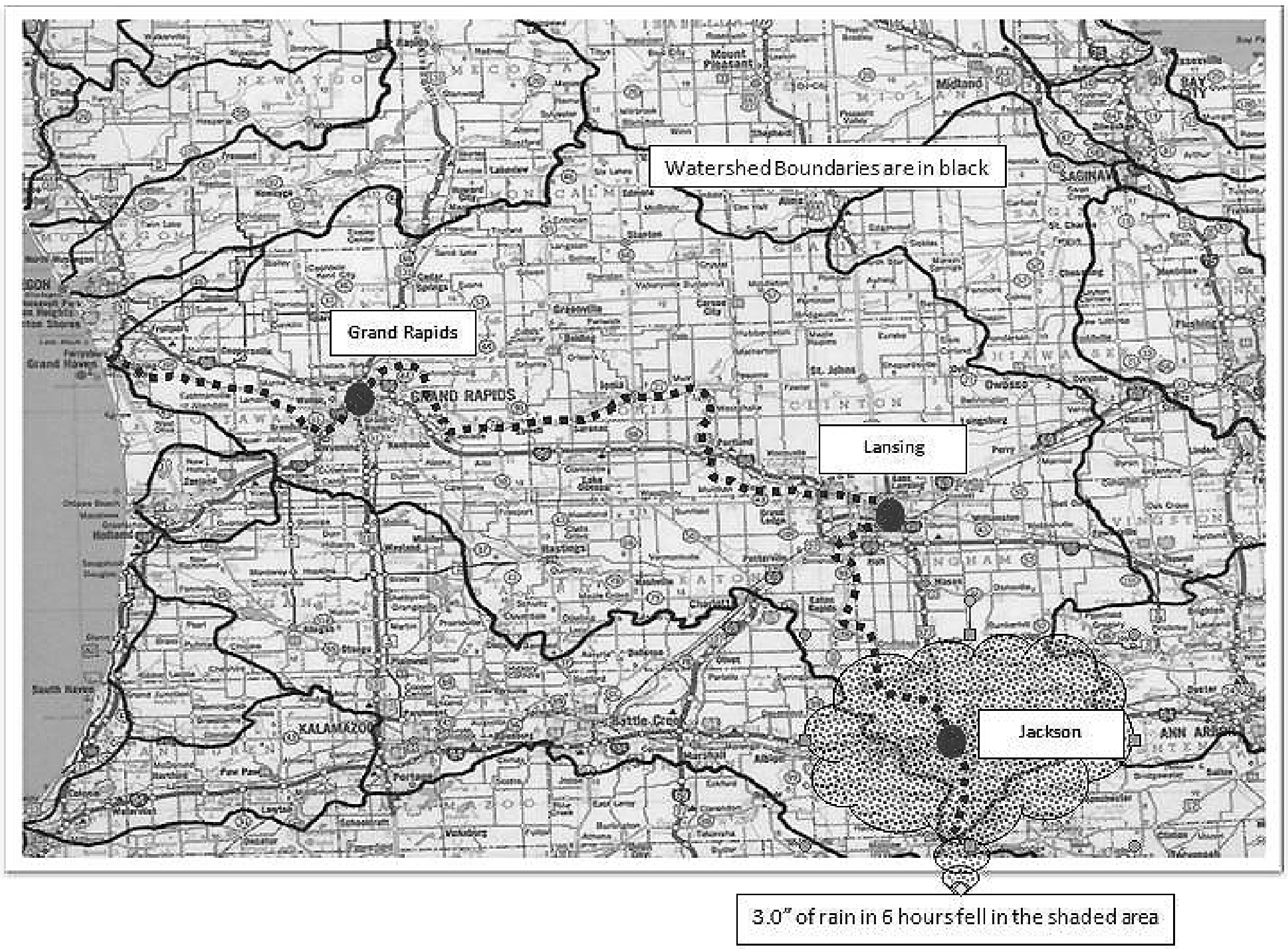
1. For Jackson, with a flood stage of 14 feet:

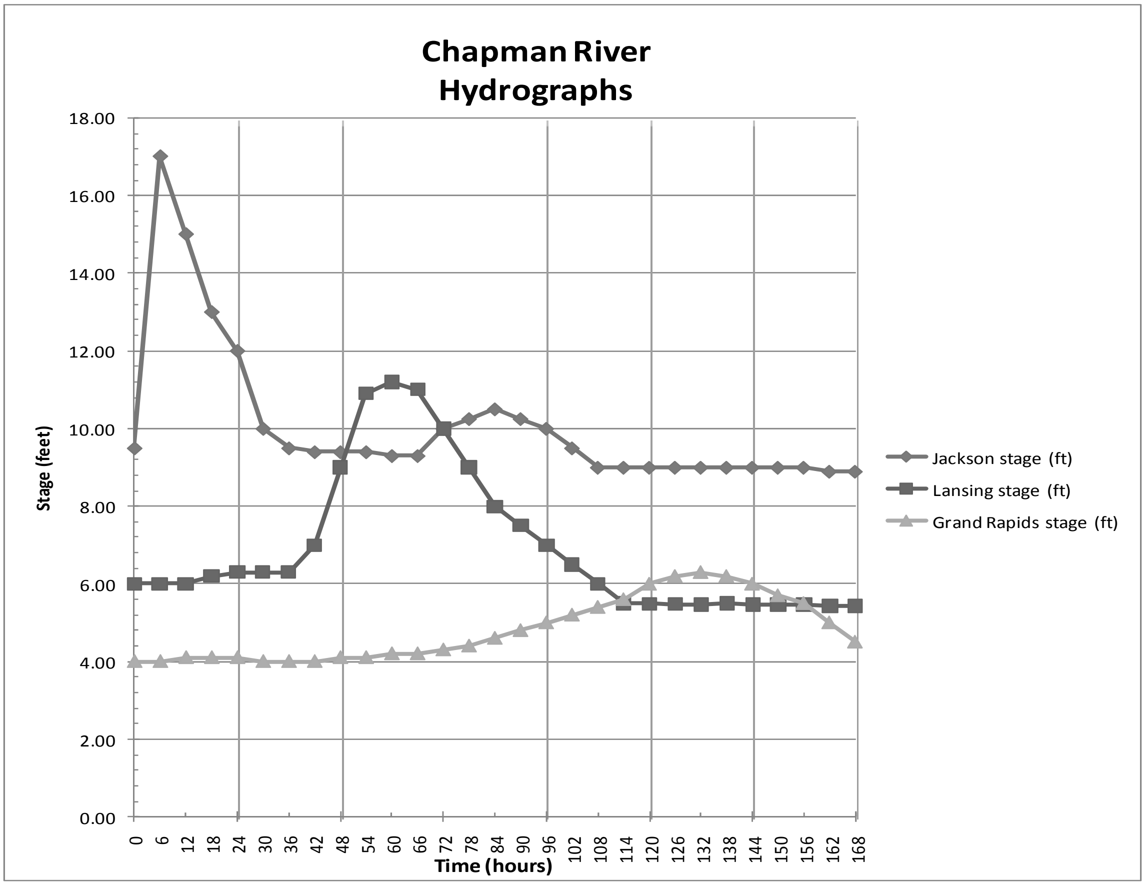
   What was the crest height? ____________

   What was the crest time? Time = ____________

   Was flood stage exceeded? ____________

Figure 7.1 - Chapman River Watershed Map





Time (hours)	Jackson stage (ft)	Lansing stage (ft)	Grand Rapids stage (ft)
0	9.50	6.00	4.00
6	17.00	6.00	4.00
12	15.00	6.00	4.10
18	13.00	6.20	4.10
24	12.00	6.30	4.10
30	10.00	6.30	4.00
36	9.50	6.30	4.00
42	9.40	7.00	4.00
48	9.40	9.00	4.10
54	9.40	10.90	4.10
60	9.30	11.20	4.20
66	9.30	11.00	4.20
72	10.00	10.00	4.30
78	10.25	9.00	4.40
84	10.50	8.00	4.60
90	10.25	7.50	4.80
96	10.00	7.00	5.00
102	9.50	6.50	5.20
108	9.00	6.00	5.4
114	9.00	5.50	5.6
120	9.00	5.49	6
126	9.00	5.48	6.2
132	9.00	5.47	6.3
138	9.00	5.50	6.2
144	9.00	5.47	6
150	9.00	5.46	5.7
156	9.00	5.46	5.5
162	8.90	5.43	5
168	8.90	5.43	4.5

Figure 7.2 - Chapman River Hydrographs

ANALYSIS (continued)

2. For Lansing, with a flood stage of 11 feet:
   What was the crest height? ____________
   What was the crest time? Time = ____________
   Was flood stage exceeded? ____________

3. For Grand Rapids, with a flood stage of 18 feet:
   What was the crest height? ____________
   What was the crest time? Time = ____________
   Was flood stage exceeded? ____________

4. How long did it take the crest to move from Jackson to Lansing?

5. How long did it take the crest to move from Jackson to Grand Rapids?

6. On average, how fast was the crest moving between Jackson and Lansing, which is a distance of 64 river miles? (Speed = distance/ time)

7. On average, how fast was the crest moving between Lansing and Grand Rapids, which is a distance of 175 river miles?

8. As the crest traveled downstream, did the crest generally reach the same height, increase in height, or diminish in height?

9. Would the crest occur <u>sooner</u> in Jackson if the area where the rain fell had (a) more wet lands or (b) more paved areas?

10. Would the crest be <u>larger</u> in Jackson if the area where the rain fell had (a) more wetlands or (b) more paved areas?

ASSESSMENT:

1. Describe a river crest. Under what conditions would you observe one?

2. Once a crest is produced in a river after a rainstorm, why doesn't the river stay that high?

3. A river crest traveling down the Chapman River would take how long to travel 40 miles?
   (a) a few minutes
   (b) a few hours
   (c) a little over a day
   (d) 3 days

4. Explain why flooding may occur on a river, even when it did not rain in the area where the flooding took place.

5. If more wetlands are filled in, it would tend to cause river crests after a storm to be:
   (a) higher
   (b) lower
   (c) unaffected

Name: ______________________________
Group: ______________________________
Date: ______________________________

ACTIVITY 8: Turn Around Don't Drown™ (Extension/Enrichment)

OBJECTIVES:

- Examine and understand the dangers associated with driving over a flooded road.
- Reflect individually and collectively about the reasons people drive over flooded roadways.
- Develop an educational campaign strategy with the goal of reducing the number of people who drive over a flooded road.
- Design and produce posters and/or other media as part of the "Turn Around, Don't Drown" campaign.

TIME ALLOTMENT 1-2 days

MATERIALS NEEDED PER GROUP:
Each student needs a copy of the handout "Turn Around, Don't Drown". Copies of the handout can be obtained by contacting your local National Weather Service office in your area or by going to the following web site: **http://tadd.weather.gov/**

Each group (or individual) needs materials for making a poster (construction paper, markers, crayons, or paint, etc.). If video or electronic products are to be produced, access to computers and/or video equipment must be provided.

TADD is a NOAA National Weather Service campaign to warn people of the hazards of walking, or driving a vehicle, through flood waters.

BACKGROUND:

What Is Turn Around Don't Drown™ (TADD)?
TADD is a NOAA National Weather Service campaign to warn people of the hazards of walking, or driving a vehicle, through floodwaters.

Why is Turn Around Don't Drown™ So Important?
Each year, more deaths occur due to flooding than from any other severe weather related hazard. The Centers for Disease Control reports that over half of all flood-related drownings occur when a vehicle is driven into hazardous floodwater. The next highest percentage of flood-related deaths is due to walking into or near floodwaters. Why? The main reason is people underestimate the force and power of water. Many of the deaths occur in automobiles as they are swept downstream. Of these drownings, many are preventable, but too many people continue to drive around the barriers that warn you the road is flooded.

BACKGROUND (continued)

What Can I Do to Avoid Getting Caught in This Situation?

Most flood-related deaths and injuries could be avoided if people who come upon areas covered with water followed this simple advice: **Turn Around Don't Drown™**.

The reason that so many people drown during flooding is because few of them realize the incredible power of water. A mere six inches of fast-moving flood water can knock over an adult. It takes only two feet of rushing water to carry away most vehicles. This includes pickups and SUVs.

If you come to an area that is covered with water, you will not know the depth of the water or the condition of the ground under the water. This is especially true at night, when your vision is more limited. Play it smart, play it safe. Whether driving or walking, any time you come to a flooded road, **TURN AROUND DON'T DROWN™!**

Driving on Flooded Roadways

Follow these safety rules:

- Monitor the NOAA Weather Radio, or your favorite news source for vital weather related information.
- If flooding occurs, get to higher ground. Get out of areas subject to flooding. This includes dips, low spots, canyons, washes etc.
- Avoid areas already flooded, especially if the water is flowing fast. Do not attempt to cross flowing streams. **Turn Around Don't Drown™**
- Road beds may be washed out under flood waters. NEVER drive through flooded roadways. **Turn Around Don't Drown™**
- Do not camp or park your vehicle along streams and washes, particularly during threatening conditions.
- Be especially cautious at night when it is harder to recognize flood dangers.

PROCEDURE:

1. Think about yourself or someone you may know driving up to a road that has water on it. Write down all the reasons why you think someone might continue to drive into the water. After a few minutes of thinking and writing, share your ideas with the rest of the class. Make a master list on the board. Group together similar ideas.

2. Visit the NOAA Website: **http://tadd.weather.gov** and research the focus and objectives of the "Turn Around Don't Drown™" (TADD) program.

PROCEDURE (continued)

3. Break into small groups (2-4 students each) to brainstorm ideas for a TADD education campaign. Think creatively about how you want to do this—not just fliers, but also television ads, internet pop-ups, pod-casts, websites, activities in drivers training classes, movie theater pre-film presentations, and posters. Try to address the reasons you gave before about why some people drive over roads with water over them.

ASSESSMENT:

1. What percent of flood related drownings occur when a vehicle is driven into floodwaters?

2. Most vehicles can be swept away by moving water that is as little as________feet deep.

3. What are some reasons people drive over flooded roadways?

4. What does the phrase "Turn Around, Don't Drown" mean?

5. Describe your contribution to the TADD campaign (poster, video, etc.) including an <u>explanation</u> of how this is expected to change drivers' behavior.