Chapter 9 Study Guide and Case Studies: Floods

Key Concepts

- Flash floods appear suddenly and are often fatal, while regional flood build up more slowly. They can be massive and destructive but less fatal.
- The breach of any containing and/or retaining structure, such as a dam or levee, leads to flash floods.
- Flash floods in the desert are particularly dangerous as the associated thunderstorm may be far away and people may be unaware of the coming water.
- Severe, local thunderstorms also cause flash floods. Seasonal snow melt typically causes regional floods.
- A flood plain is the area covered by a stream or river during the flood stage. Flood plains provide fertile ground for agriculture. Building housing and structure in the flood plain are prone to flooding and/or destruction.
- Discharge is the amount of water that flows through the cross-section of a river in a given time.
- Gradient is the height overcome for a horizontal distance traveled.
- A meander is a loop in the river. Meanders are more likely to form in low-gradient area than in steep areas.
- Rivers are often 'corrected' through dredging to allow ships with larger draft to pass.
- Meander loops are cut off by canals to shorten travel distance but this increases flow speed and erosion downstream.
- The stream profile (longitudinal profile) is the elevation profile of a river along its course. It has a concave shape with a steep gradient near the top and a weak gradient near the bottom. The base level of a stream profile is the lowest elevation to which a river can erode.
- The top of the stream profile typically marks the spring of a stream or river. Then bottom end is where a stream or river flows into another river, a lake or an ocean. In some karst and desert regions, the end of the river can be the last remains of water infiltrating into the ground.
- The steep gradient at the top of a stream profile signifies the capacity of erosion and sediment transport. A lowering gradient typically means that a river loses kinetic energy and the capacity to carry sediments. It may start dumping sediments to be able to continue to flow.
- The drainage basin of a river is the area that includes all tributaries to the river.

- While the cross-section of a river in steep terrain is V-shaped and both river banks are similar, the banks of a meander are not. The other bank is steep and undergoes erosion. Undercutting and bank collapse is a hazard. The inner bank is flatter, the river deposits sediments, and the bank is prone to flooding.
- The Nile River is the longest river in the world, while the Amazon has the largest drainage basin. The latter also has the highest average discharge. In the U.S. the Missouri/Mississippi River system is the longest, has the largest drainage basin, and has the highest average discharge.
- Large rivers typically flow into an ocean an can build large deltas with thick accumulations of water-saturated sediments. The sediments compact slowly but ultimately lead to land subsidence. Subsidence is accelerated when the natural sediment supply is cut off (e.g. through the construction of drainage/shipping canals).
- Levees are built to protectable structure from flooding by rivers or other bodies of water.
- Levees can fail through direct wave attack, overtopping, slumping and piping.
- Levees may provide a false sense of security, encouraging more development in an unsafe area. Building and maintenance costs may exceed the value of structures levees are supposed to protect. Increases sedimentation in the river bound by levees may over time raise the river bed above the flood plain thereby tremendously increasing the risk of flooding.
- Flood frequency curves (FFC) draft a certain discharge of a river against recurrence time. Each stream and river has its own individual FFC.
- FFCs are used to plan and build levees and other protective structures. They help FEMA estimate flood risk and prepare for first response and disaster aid. An often-used discharge threshold is the 100-year flood.
- In the U.S. the Army Corps of Engineers (ACE) is responsible for building and maintaining levees.
- The FFC provides statistical information of the likelihood of a certain flood to occur in a given year. So has the 100-year flood a 1% chance to occur in a given year, but only a 63% chance to occur within 100 years (because in 37% if the cases it may be a bit late).
- The balance of run-off and infiltration also help in estimating the risk of flooding. In urban areas, run-off is much higher than in rural areas where infiltration is much higher and the risk of flooding lower.
- Hydrographs draw the discharge of a stream of river over time after rainfall. The rising limb is steeper than the fall. The discharge is reached earlier in the city than in rural areas, and it is higher.

Key Terms

- Flash floods
- Regional floods

- Floods in the desert
- Discharge
- Flow velocity
- Gradient
- Cross-section
- Stream profile (longitudinal profile)
- Base level
- Erosion and sedimentation
- Meanders
- Inner- and outer bank
- Drainage basin
- Flood plain
- Recurrence time
- River delta
- Levees
- Overtopping
- Slumping
- Piping
- Flood frequency curves
- 100-year flood
- flood probability
- FEMA
- ACE
- Run-off and infiltration
- Urban and rural areas
- hydrographs

Questions for Review

1. Describe the difference between flash floods and regional floods.

2. Provide examples for causes of both types of flood.

3. Why are flash floods in the desert particularly dangerous?

4. What is the discharge of a river?

5. Draw and describe a stream profile. Include basic features. Discuss gradients and the consequences in terms of erosion and sedimentation.

6. What is the base level of a river?

7. What is the drainage basin of a river?

8. What is the flood plain of a river?

9. What is a meander? Compare the two river banks? How do they differ from a straight river?

10. What happens to the discharge downstream when a meander is cut off. What consequences may this have for structures built along the river?

11. What is the purpose of levees?

12. What are some of the pros and cons of levees? Discuss the cons in more detail.

13. What are the modes of failure of a levee? Describe them.

14. What are flood frequency curves? Describe some of the features in a flood frequency curve. For what are they used?

15. What is the significance of the 100-year flood? What is its likelihood to occur in a given year and in a given 100-year time span? Discuss your answers.

16. Discuss the balance of run-off and infiltration in an urban vs a rural environment.

17. What is a hydrograph?

18. Discuss the difference in features of a hydrograph between an urban and a rural area.

Case Studies

Case Study 1: The Galveston Flood (TX Sep 8, 1900); A Hurricane

- **deadliest natural disasters in U.S. history**
- more than 6000 (might be as high as 7200) of the 38,000 residents perished
- more than 3600 houses destroyed
- caused by a surge from a category 4 hurricane:
  - high winds pile up water for 60-80km and push it onshore
  - low pressure raises water level
  - particularly dangerous at times of high tides
    NB: hurricanes can rage through a coastal town for a significant fraction of a tidal cycle; 12h
- used to be Texas' wealthiest town at the time, thanks to its importance as a port for trading ships (more than 1000 ships per year)
- factors that made Galveston an easy victim
  - Galveston is located near the end of a barrier island
  - the surge reached one foot above Galveston's highest point
  - winds were clocked at 120mph
  - waves up to 30ft high
- at the time, meteorologists were unable to forecast hurricanes
  - morning of Sep6, U.S. weather bureau sent telegraph about a tropical disturbance near Cuba
  - long ocean swell by afternoon of Sep7; tide higher than usual
  - morning of Sep8, air pressure dropped dramatically and winds picked up
  - head of Galveston Weather Bureau, Isaac Cline, recommended to evacuate city
  - few left; most sought shelter in higher-lying brick houses
  - 4pm: tides surging from ocean and bay
  - 6:15pm: anemometer ripped off at 84mph (gusts topping 100mph)
  - 7pm: 4-ft wave surged through city, then a 20-ft wave
  - storm waves on top of high tides and winds > 120mph for rest of evening
  - 8:30pm: Cline's house destroyed; 32 of 50 people perished, including his wife
  - Cline and his family (three children, brother and a woman) drifted on wreckage for three hours
  - 9pm: eye of the storm passed town; barometric pressure: 27.91inches
  - 10 inches of rain

        - tide reached records high of 15.2ft above normal
    - residents then built a sea wall 3mi long, 17ft high and 16ft wide (at base)
    - a following category 4 hurricane in 1915 caused minor damage
    - since then, city has grown into unprotected areas
    - residents rely on satellite technology to forecast hurricanes (from:"The Weather Book" by Jack Williams; Vintage Books)

CASE 2: The Johnstown Flood (PA May 31, 1889); Aggressive Development

- worst dam burst disaster in U.S. history
- 2200 people perished
- town used to be booming coal-and-steel town in the mountains about 60mi east of Pittsburgh
- an old earth dam above the town has been hastily rebuilt to create lake for exclusive summer resort
- repeated warning of a disaster were ignored
- dam burst on May 31
    - a storm had started out of Kansas and Nebraska on May 28
    - hard rains in Kansas, Missouri, Illinois, Michigan, Indiana, Kentucky, Tennessee on May29
    - train delayed; roads washed out
    - farms by Cottonwood River/Kansas flattened by tornadoes
    - sudden snow squalls in Michigan and Indiana
    - nigh of May 29, U.S. Signal Service issued notices the Middle Atlantic states were in for severe storms
    - May 30 storm struck western Pennsylvania; worst downpour ever recorded locally (6-8in in 24h)
    - noon, May 31, dam started to fail; messages of approaching disaster ignored
    - 3:15pm, lake "was running toward the town"

CASE 3: The May 2011 Levee Breach to Protect Cairo, IL[1], [2], [3]

After prolonged rainfall in April 2011, both the Ohio and upper Mississippi Rivers experienced severe flooding. The Ohio River reached a flood stage level of 61.5 ft on 2 May and so eclipsed the historic 1937 level of 59.5 ft. With more rain to come (5 inches of rain fell overnight), the river threatened to flood Cairo, a city of 2800 people at the confluence of the Ohio and Mississippi rivers. The Ohio River was expected to reach 63 ft by May 5, just one foot below the level the Cairo floodwall was designed to hold. According to the news account, the U.S. ACE blasted a two-mile-wide hole on 2 May in an earthen levee at Bird's Point across the Mississippi River from Cairo just below the confluence of the two rivers, thereby inundating 130,000 acres of rich farmland and about 100 homes in Missouri. The area was evacuated before the breach. Engineers expected that this deliberate breach would lower the flood stage at Cairo by about 4 feet in two days though other estimates where only 2 feet in four days, bringing the flood stage down to the 1937 level.

The farmland is actually situated in the Bird's Point-New Madrid floodway. The floodway was built in response to the epic 1927 Mississippi River flood. It was "activated" (a hole blasted in the levee) only once before, in 1937. The flood reached the high level of 59.5 ft but did not erode the levee enough to allow the water to flow into the floodway as planned. The ACE then dynamited the levee to relief the river flooding.

The 2011 "activation" did not happen before the U.S. Supreme Court decided not to hear Missouri's appeal to block the blast. Missouri contended that the activation would destroy rich farmland and homes and create environmental hazards. On the other hand, the city of Cairo was in imminent danger of flooding, and Missouri's farmland and buildings were located in the floodway. Even though the last flooding happened nearly 75 years ago – about a human lifetime - the question arises whether the floodway should be cultivated and inhabited at all or whether the floodway should be set aside for recreational uses or as a nature reserve. Should a U.S. state be able to sue the ACE for doing its intended job?

As rain continues, it is also not clear if breaching the Bird's Point levee is the only measure necessary to prevent greater flooding downstream along of the Mississippi River. Officials in Louisiana and Mississippi have warned the river could bring floodwaters not seen since the epic 1927 Great Mississippi River Flood.

CASE 4: Gilgamesh and the Great Diluge

- nearly all cultures in the world have tales of ancient deluges far greater than seen in modern times
- interesting case is the deluge that is shared in many epics in the Mediterranean Sea/ Near Middle East area
- e.g. tales of Noah in Bible and Homer's Odyssee thought to be based on epics of Gilgamesh where Utnapishtim built an ark
- Gilgamesh was a Sumerian king (B.C. 2,500) in the area of Mesopotamia that is now Iraq (earliest written language)
- deluge may have occurred before written language and tales been handed down through songs
- for such a deluge to be topic of an epic, flood must have occurred while people were not living a nomadic life anymore but in communities; only a mass exodus would make a story; so deluge was likely not before B.C. 8000
- the lower Tigris and Euphrates River floodplains are thought to be one of the possible locations of a 1000-year flood (B.C. 6000 - B.C. 1000) (river system then thought similarly powerful as that of Mississippi or Yellow today)
- some think that flooding of the flood plain would have occurred too often to make an epic; also people would not abandon area to seek new land
- other scenarios include the opening of the Southern Red Sea and the Black Sea
- Black Sea was fresh water late during last ice age (likely attractive to people settling down in communities); while sea level was 150m lower than today
- end of ice age would fill Mediterranean and then spill over narrow Bosporus Straight to cause an immense water fall (200 times as large as Niagara Falls)
- the coastal area flooded after only a short time, forcing people to migrate away
- evidence supporting this idea would be to find remains of these town in the sediments that now accumulate on the shelves of the Black Sea (evidence has recently been found by geophysicists)

References:

[1] San Diego Union Tribune, 3 May 2011.
[2] Los Angeles Times, 3 May 2011.
[3] http://www.wikipedia.org /wiki/Bird's_Point,_Missouri