Flood Control: Encyclopedia Entry

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Methods of Flood Control

Flooding is the process by which an expanse of water submerges land. Floods usually occur when a volume of water in a water body exceeds its total capacity. This results some of the water flowing outside of the normal perimeter of the body. In riverine systems (rivers and their tributaries), flooding commonly occurs when the strength of the river is high enough to force water out of the river channel, usually at corners or meanders. Although flooding is a natural process, rivers prone to flooding (particularly 'flashy' rivers, where floods can be unpredictable and very rapid; Dunne and Leopold 1978) are often carefully managed in developed nations.

There are two major categories of flood control methods: non-structural and structural. Non-structural control methods commonly involve land use policies that either prevent or limit development within floodplains (whether by prohibition or public purchase of land; Pinter 2005), or place limitations on the creation of impervious surface within specific river basins. Urban and agricultural development within floodplains is not only at risk of damage during natural flood events, it also displaces water that would have otherwise spilled out onto the surface of the land, thereby pushing flood events further downstream (Dunne and Leopold 1978). Concurrently, the creation of new impervious surfaces (parking lots, paved streets, building roofs, etc.) can significantly alter the hydrologic regime of a watershed. Here, water is directed into river channels through surface run-off at a much faster rate than it would ordinarily move across the landscape. As a result, the frequency and magnitude of flood events can increase substantially, thereby creating new risks for urban and agricultural developments that were constructed in areas that previously had little flood risk. Policies that limit deleterious effects of development on hydrologic regimes as well as the economic and physical damage due to natural flood events are now widely believed to be the only truly long-term methods of managing urban and agricultural development along riverine systems (Pinter 2005). However, the historic necessity of urban access to rivers, coupled with the pervasive view of floods as disaster events in need of control, has led to the development of sophisticated structural methods of flood control.

Structural methods of flood control in rivers involve the construction of individual or combinations of structures in or adjacent to rivers, including levees, bunds, reservoirs, and weirs. These structures can be used to prevent rivers from overflowing their banks, thereby restricting the flow of water to the river channel itself. Other structures either divert (channelization; Dunne and Leopold 1978) or prevent (embankments, including dams) the flow of water. Many structures have also been developed to prevent coastal flooding, including sea walls and beach nourishment (sand replacement on eroded beaches). In the United States, the U.S. Army Corps of Engineers is mostly responsible for permitting or building any structure (as well as overseeing and enforcing policies) related to flood control systems.

A levee is a natural (earthen) or artificial berm or wall that parallels the course of a river in order to prevent water from leaving the river channel. Levees are widely used along some of world's largest rivers as a means of disconnecting the river from its floodplain, thereby enhancing urban access to rivers (e.g. shipping access through ports) and access to the nutrient rich land that is often very productive for agriculture (Bayley 1995).

Although levees have been used successfully for centuries, they can cause major problems when they fail while rivers are at flood stages. Here, levees can fail in a number of ways. The most frequent form of levee failure is a *breach* (either above or below the soil surface), whereby part of the levee actually ruptures, leaving a large opening for water to flood the land protected by the levee. Another type of levee failure occurs when water *overtops* the 'crest' of the levee (equivalent to the levee 'ridgeline'). Here, either flood waters exceed the lowest crest of the levee system, or winds generate significant movement in the water body to bring waves crashing over the levee. This can cause significant soil erosion of the levee and can eventually lead to a complete breach. Although properly built levees are armored or reinforced with rocks or concrete to prevent erosion and failure, levees must be actively maintained in order to prevent failure. The most famous recent levee failure occurred during Hurricane Katrina in Metropolitan New Orleans at the end of August, 2005. Levees along Lake Ponchartrain and the Mississippi River breached in over 50 different places submerging nearly eighty percent (80%) of the city. Although many levees failed due to overtopping, some failed due to upward water pressure on their foundations, which subsequently caused shifts within the levees and sudden, catastrophic breaching.

Another technique involves the use of a wall (either earthen or artificial) to actually halt the flow of water. These structures include dams, embankments, and weirs. Dams are usually constructed as artificial walls that constrict the flow of water within an area. Dams have been used for generating electricity (hydro-electric power), maintaining water supplies (reservoirs), and creating impoundments (lakes and ponds), among many other uses. An embankment dam is often constructed of a mix of artificial and natural materials and situated so that the weight of the water compresses and reinforces the structure. A weir is a small dam that is used to raise the level of a river in order to create mill ponds or to enable navigation in a river channel. Weirs help navigation by 'leveling' out steeply sloping river reaches, thereby helping to maintain the type of deep channels that are required for navigation. Here, weirs are commonly used in conjunction with dam locks, allowing boats to travel up and down the river; Dunne and Leopold 1978).

Finally, the most drastic form of flood control is channelization, a type of river engineering whereby rivers are completely redirected, usually into straightened channels made of artificial materials. This action reduces the ability of the river to meander and slow its course, and thereby allows more water to move through the channel at a faster rate. Potentially the most famous example of this is the Los Angeles River, which flows through a narrow concrete channel for most of its length ([note to editor: a great photo of this can be seen at: http://www.flickr.com/photo_zoom.gne?id=274851934&size=l. This is licensed under creative commons and could be used if attributed.]).

Flood Control in the U.S. and around the World

In May 1933, the U.S Congress chartered the Tennessee Valley Authority (TVA), a federally owned corporation created to provide electricity generation, navigation, and flood control to the Tennessee Valley, a region whose economic development was strongly impacted by the Great Depression. The TVA has been responsible for creating a huge number of dam and electricity generation projects, and at one time represented a model for modernization around the world (Ekbladh 2002).

In the New Orleans Metropolitan Area, 35% of the land area sits below sea level and is currently protected by hundreds of miles of levees and flood gates. During Hurricane Katrina, this system experienced a catastrophic failure both in the City itself and in eastern sections of the metropolitan area. This level of storm surge resulted in the inundation of approximately half of the Metropolitan area, at levels ranging from a few inches to twenty feet deep in coastal communities.

The largest and most sophisticated flood control system can be found in the Netherlands, where the Dutch response to the North Sea flood of 1953 of the south western part of the Netherlands led to the creation of Delta Works, a series of dams, locks, and storm surge barriers built between 1950 and 1997. In 1994, the American Society of Civil Engineers has declared the Works to be one of the Seven Wonders of the Modern World (ASCE 2007).

Another example of a large flood control project is the Saint Petersburg Flood Prevention Facility Complex (Russia), scheduled for completion by 2008 (Dranitsyna 2005). This project is designed to protect Saint Petersburg from storm surges, as well as extending. It also has a main traffic function, as it completes a ring road around St Petersburg. 11 dams extend for 25.4 kilometers and stand eight meters above water level.

Environmental Consequences of Flood Control

Although there are many disruptive effects of flooding on human development and economic activities, flood events fulfill a great number of ecological functions. These include nutrient transfer to the floodplain, thereby enhancing soil fertility. When floodplain soil is flooded, an immediate surge of nutrients is released, including those left over from the last flood, as well as those created by the rapid decomposition of organic matter that has accumulated in the intervening period. Many microscopic organisms thrive during floods, and many larger species rapidly enter breeding cycle. Although the production of nutrients is sudden and brief, surge of new growth within the ecosystem endures for longer periods. All of this makes floodplain areas particularly valuable for agriculture. However, disconnecting the river from its floodplain can have drastic ecological consequences. Moreover, many flood control structures can inhibit species movement within rivers (e.g. salmon swimming upstream against dams), and can change the hydraulic patterns that many species rely upon for food, shelter, and mating.

Bibliography

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Ekbladh, David. 2002. "Mr. TVA": Grass-Roots Development, David Lilienthal, and the Rise and Fall of the Tennessee Valley Authority as a Symbol for U.S. Overseas Development, 1933–1973. *Diplomatic History* **26**(3): 335-374. This article reviews the actions and history TVA in establishing itself as a model of publicly-funded modernization for the developing world.

Pinter, Nicholas. 2005. One Step Forward, Two Steps Back on U.S. Floodplains. *Science* **308**: 200-208. This paper provides an excellent overview of U.S. views and policies towards flood control and river-floodplain reconnection.

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Interesting Websites:

U.S. Army Corps of Engineers: http://www.usace.army.mil/

Tennessee Valley Authority: http://www.tva.gov/

EPA Office of Watersheds: http://www.epa.gov/owow/watershed/

Information on Hurricane Katrina: http://en.wikipedia.org/wiki/Hurricane_Katrina