

# Understanding Our Streams and Rivers

## Are Minnesota Streams Healthy?

Just as our human health is determined by the factors that influence our bodies, including environment, lifestyle, and healthcare, so too is stream health determined by the combined factors of the stream's configuration, environment, resilience, and our stewardship. A stream, like the human body, has several interdependent features that indicate health of the stream. These features can be grouped into the following **five** components: *shape*, *flow*, *connectivity*, *biology*, and *water quality*.

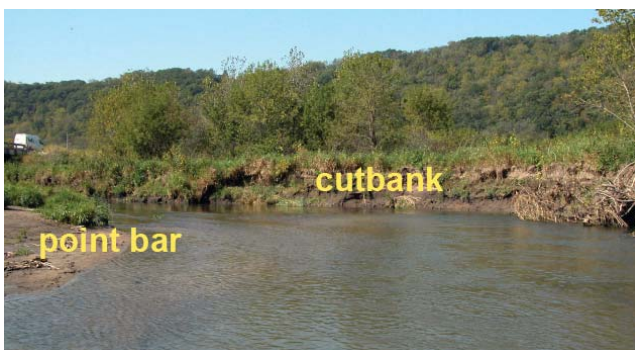
### 1. Stream shape

A stream's shape is formed over time through the continuous interaction between water and the watershed, including its size, climate (wet or dry), topography, soil types, and vegetation. The channel is shaped by the predominant floodflow, known as *bankfull* flow, in which the water fills the banks and just begins to overflow onto the floodplain. Natural streams of all types and sizes have a tendency toward a balanced, stable state. In this state, streams transport water and sediment and dissipate the water's energy while maintaining over time their shape: pattern, profile, and dimension (see graphics at right). In other words, when erosion and deposition and scour and fill are balanced, the channel does not widen or narrow, nor does the streambed rise (*aggrade*) or deepen (*degrade*).

This does not mean a stream channel's position is permanent; instead, the channel is able to adjust over time as the bends, or meanders, of the channel slowly migrate down the valley. Naturally shaped streams provide aquatic organisms a variety of habitats, like *riffles* (shallow, rocky rapids), pools, sandbars, and backwaters, because of variations in stream depth, width, water currents, and streambed materials.

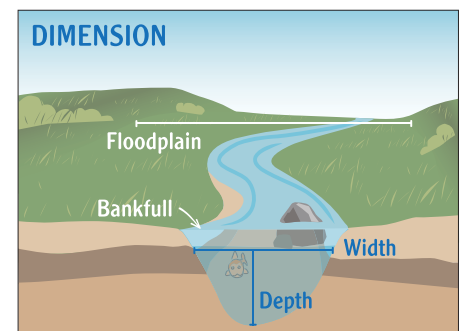
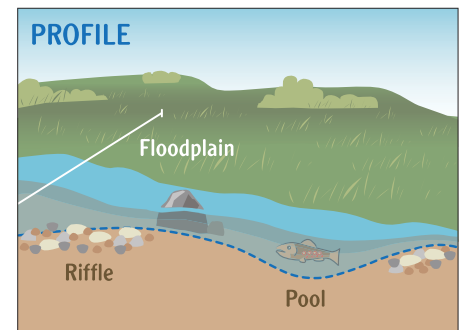
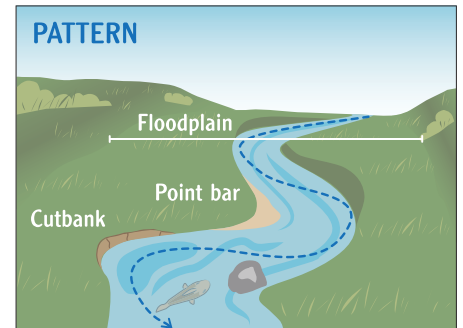
### 2. Streamflows

Streamflows vary seasonally and interannually depending on snow melt, rain-on-snow events, growing season rains, drought, and climatic changes such as increasing temperatures. Variations in seasonal and annual precipitation yield a range of flows that are fundamental to sustaining river ecosystems. Aquatic organisms such as spawning fish have evolved to these seasonal cues. Streamflows are also altered by land-use changes, from agriculture and urbanization to timber harvest. These changes generally inhibit infiltration of precipitation into the ground. Reduced infiltration increases runoff, which increases the volume of water that streams must transport, resulting in stream instability and excessive erosion.



Streamflow is faster along the outer bend of a stream and will erode a streambank lacking stabilizing native vegetation, creating a cutbank. Excessive erosion increases the sediment load of the stream. Streamflow is slower on the inside of the bend, which allows sediment to settle and form a point bar.

In the stream channel, flows vary because of stream features such as *sinuosity* (curving shape), width, depth, and bed and bank materials (e.g., sand, gravel, boulders, vegetation). For example, flows are faster along the outside of bends and slower along the inside of bends. Consequently, strong erosional forces along outside bends form pools, or scours, and cutbanks if the banks are weak; slower flows along inside bends deposit sediment, forming point bars (see photo at left). Streams create bends to reduce the speed of the flows just as a downhill skier carves from side to side down the hillside. Also like a skier gaining speed, the tighter the turns, the deeper the scours or pools left by the streamflow. The strongest streamflow generally follows the *thalweg* (deepest part of the channel), travels from pool to pool or bend to bend, and crosses from one side of the channel to the other depositing sediment, which creates riffles.

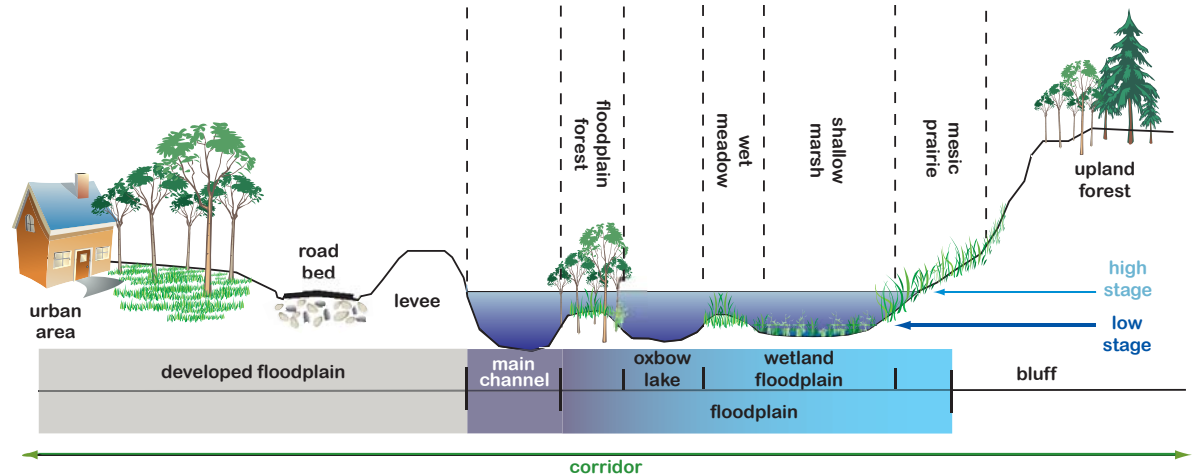


### 3. Stream connectivity

Fragmenting streams with dams and culverts disrupts the *longitudinal connectivity* of a stream. Uninterrupted flow along the entire length of the stream is essential for the proper flow and exchange of water, energy, sediments, nutrients, and organisms. Structures that fragment streams disrupt the progression of stream habitats from small, shaded, rocky, steep headwater streams to large, sandy, flat, warm, slow-flowing valley streams.



*Lateral connectivity* between the stream channel and its floodplain is crucial to stream health and stability. Floodplains play an important role because this land reduces the floodwater's energy with plants and trees and provides temporary storage space for floodwaters and sediment. Floodplains also provide habitat for various plant and wildlife communities, some of which depend on flood events to reproduce and grow. Floodwaters nourish floodplains with sediments and nutrients and provide temporary aquatic habitat for invertebrate communities, amphibians, reptiles, and spawning fish.



*Lateral connectivity.* The stream is connected to its floodplain on the right but is disconnected on the left by development. At various stream stages, the stream and its floodplain provide a range of habitat settings.

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#### 4. Stream biology

Streams are complex networks of terrestrial and aquatic communities. Streams and their floodplains provide diverse habitats including uplands, riparian zones (streambanks), floodplain forests, marshes, fens, oxbow lakes, riffles and pools. The diverse habitats and their plant and animal species are key to maintaining healthy ecosystems.

Terrestrial plants, aquatic plants, and aquatic animals in the stream are important to the stream's health. Terrestrial plants in the floodplain and riparian zones strengthen and stabilize the soil; intercept runoff; filter out nutrients, sediment, and other pollutants; and provide habitat. Similarly, aquatic plants protect the shoreline, stabilize the streambed, are a food source, provide refuge, absorb nutrients and contaminants from the water, and produce oxygen. Aquatic animals such as freshwater mussels are important to aquatic systems because they stabilize the streambed by anchoring themselves into the sediment, clean the water of particles and chemicals during their feeding process, and are a source of food and habitat for fish and invertebrates. They also use fish as hosts for their larvae, relying on fish health, abundance, and migration for dispersal. This demonstrates the interconnections of aquatic systems.

#### 5. Water quality

Water quality includes the chemical, biological, and physical characteristics of water. Good water quality is maintained by natural channel shapes and flows, naturally vegetated riparian zones, a healthy biological community, and proper stewardship. The most common pollution sources in Minnesota are sediment, herbicides, insecticides, industrial chemicals, sewage effluent (outflow), and fertilizers. Some of these sources such as industrial and sewage effluent are point sources, which are identifiable, local sources that are relatively easy to monitor and regulate. Others are nonpoint sources such as herbicides and fertilizers, which are contaminants from sources that are much harder to assess and regulate.



Freshwater mussels are sedentary, long-lived (some more than 100 years) mollusks that nestle in sediments while filtering particles and oxygen from the water to feed and breathe. Mussels are vulnerable to stream habitat disturbances (dams, channelization, pollution, exotics) and are good biological indicators of stream health. They are one of the most endangered animals in North America.

Healthy stream systems ensure good water quality and are paramount to human and ecological health. This crucial resource provides drinking water from lakes and rivers for many cities, in addition to habitat for wildlife, fish, and aquatic organisms, some of which are valuable food sources.



Naturally vegetated streambanks protect streams and stream organisms. Desirable woody vegetation includes willow, cottonwood, and dogwood. Beneficial forbs and grasses include monkeyflower, blue vervain, fox sedge, swamp milkweed, and river bulrush.



## How do stream alterations affect the five components of stream health?

Structures in a stream, such as dams and culverts, and some land use practices in a watershed can significantly affect the five components of natural, healthy streams: shape, flow, connectivity, biology, and water quality.

### How structures affect stream health

- 1. Shape:** Dams, culverts, and handmade structures alter the natural stream pattern, dimensions, and profile. The water flowing over a dam is “sediment hungry,” leading to scouring or down cutting the streambed and erosion of streambanks. Dams also create unnatural reservoirs upstream that slowly fill with settling sediment.
- 2. Flow:** Dams and improperly sized or placed culverts limit the flow of water, energy, sediments, and nutrients downstream. These structures also lock the channel in place, which restricts the stream from adjusting to maintain stability.
- 3. Connectivity:** Dams and perched culverts create barriers that disrupt the flow downstream and prevent fish migration upstream to spawning, over-wintering, or other habitat areas. Levees and dikes disconnect the channel from the floodplain, forcing the channel to carry floodflows.
- 4. Biology:** Dams create reservoirs or impoundments that initially flood and eventually bury critical wildlife habitat. Dams and levees also disrupt the flow and exchange of material longitudinally and laterally on which biological communities depend.
- 5. Water quality:** In the upstream reservoirs, contaminants and nutrients accumulate, which ultimately degrades water quality.



Dams and culverts: (above) A handmade dam disconnects fish from upstream migration and alters the streamflow. (below) A perched culvert also inhibits fish passage and disrupts the longitudinal connectivity of the stream.



### How land use practices affect stream health

- 1. Shape:** Digging ditches converts headwater streams into unstable straight trenches and increases the stream slope. This leads to excessive erosion upstream and sediment deposition downstream of the ditched area. Removal and degradation of natural riparian vegetation weakens streambanks, resulting in excessive erosion and ultimately a change in stream shape.
- 2. Flow:** Irrigation from streams can lower streamflows to potentially critical levels, especially during dry periods when water levels are low and aquatic communities need refuge. Urbanization and tiling on farmland funnel excess rainwater directly into streams, forcing the streams to carry higher, flashier flows.
- 3. Connectivity:** Connection to the floodplain is commonly degraded or removed. Floodplains converted to farmland, pasture, or developments do not effectively dissipate or store floodwaters. Riparian zones that are farmed, mowed, grazed, deforested, or developed replace natural and diverse vegetation with crops, lawns, bare soil, and pavement.
- 4. Water quality, and 5. Biology:** Excessive erosion of topsoil commonly degrades water quality, primarily by decreasing water clarity. Field and lawn fertilizer and manure inputs add excess nutrients to streams, causing extreme plant and algal growth followed by decomposition that extracts oxygen from the water. Pesticides, herbicides, and insecticides have been found at dangerous levels in streams. Research indicates that these chemicals kill aquatic organisms, inhibit reproduction, and upset hormones in animals in addition to a multitude of adverse physiological effects.



Land use: (above) Parking lot runoff, (below left) eroded fields, and (below right) unvegetated ditches transport pollutants and excess sediment to streams.







## To what extent have we disturbed Minnesota streams and watersheds?

Minnesotans take great pride in and enjoy the state's 92,000 miles of large and small streams. However, throughout our history, humans have had a growing impact on our streams and watersheds due to a booming population and technological advancements. The following are a few examples of the extreme changes that have degraded stream health in Minnesota:

- Nearly one-third of the streams have been converted to ditches.
- Nearly 18,000 miles of tile are added to farmland in Minnesota every year. That is nearly three-fourths of the circumference of the earth.
- More than 900 dams greater than 6 feet in height and hundreds of smaller (low-head) dams have been built on Minnesota streams.
- More than 56 percent of the landscape has been converted from native prairies, wetlands, and forests to farmland and urban areas.

These land-use changes and resulting changes in stream shape lead to excessive stream-bank or streambed erosion and degraded stream health. These impacts, in addition to climate change, lead to increased erosion and deposition, altered hydrology, more frequent and destructive flooding, degradation of aquatic and riparian habitat, and decrease in species diversity. Moreover, these effects have huge economic impacts. In the deep loess soils (highly erodible, windblown fine sediments) of western Iowa there has been an estimated

\$1.1 billion in damage to private and public infrastructure due to channelization and ditching. In Minnesota, flowing water carries off more than 60 million tons of upland topsoil each year. That amount would fill the Metrodome with topsoil 21 times every year. Consequently, stream stability is crucial to our environment and our own well being.

### How can you and the community correct stream disturbances and improve stream health?

As individuals, riparian landowners can restore, protect, and maintain naturally vegetated riparian buffers and floodplains realizing that rivers are dynamic. However, many stream health problems are the result of widespread land use issues. In these cases, communitywide efforts are needed for recovery to begin.

Watershed planning engages citizens, landowners, businesses, local governments, interest organizations, and other agencies. Watershed protection and planning becomes effective through cooperation toward long-term goals like improving water quality, reducing surface runoff, reducing soil loss, improving habitat, restoring natural biodiversity, and allowing for sustainable development. Furthermore, focusing on a watershed scale makes it easier to integrate social, economic, and cultural factors into planning and implementation efforts.

### Additional information

The Healthy Rivers instructional CD and resource sheets on stream health, such as techniques to stabilize a streambank, are on the DNR web site. Research sources are available on request.

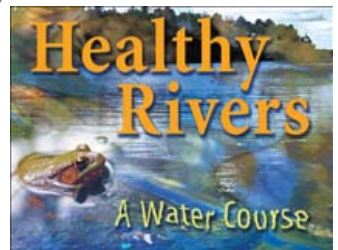


*Reconnecting the Red River.* Since the early 1800s, more than 500 dams have been built on the Red River of the North and its tributaries. Lake sturgeon could no longer migrate to critical spawning habitat in the higher gradient tributaries. By the mid-1900s, the sturgeon were gone, victims of a fragmented river that no longer provided the habitat the fish needed to reproduce. The DNR is working with local communities to "reconnect the Red" by removing or modifying dams into artificial rapids. This has successfully opened hundreds of miles of streams to migrating fish.



(above) *Buffered:* The vegetated buffer along the Pelican River decreases the contaminants and sediment carried by runoff to the stream.

(below) *Unbuffered:* The South Branch of the Buffalo River lacks such protection from runoff.



### DNR Contact Information

DNR Stream Habitat Program is described on the Ecological Services website: <http://mndnr.gov/eco/streamhab>  
The DNR Waters website: <http://mndnr.gov/waters>

DNR address in St. Paul:  
500 Lafayette Road  
St. Paul, MN 55155  
DNR Ecological Services: (651) 259-5100  
DNR Waters: (651) 259-5700

### DNR Information Center

Twin Cities: (651) 296-6157  
Minnesota toll free: 1-888-646-6367  
Telecommunication device for the deaf (TDD): (651) 296-5484  
TDD toll free: 1-800-657-3929

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