THE CITY OF
LAKE FOREST
CHARTERED 1861

A Resident Guide for Protecting Ravines and Bluffs

Prepared by The City of Lake Forest, Illinois

INTRODUCTION

The City encourages residents to inspect their ravines and bluffs regularly and to take appropriate steps to preserve the stability of these features. The City's objective is to prevent extensive erosion and bluffs which can lead to property damage adjacent to ravines and sometimes in areas far from the site of the initial erosion.

By protecting and caring for the ravines and bluffs, the integrity of the City's drainage system is protected, the special character of our neighborhoods is preserved, and the value of individual properties is maintained and enhanced.

The ravines throughout the community serve as a natural drainage system that carries storm water runoff to Lake Michigan from over 1,500 acres of land in the City of Lake Forest.

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BACKGROUND

There are nearly 13 miles of ravines in The City of Lake Forest. Almost all of the ravines are privately-owned. Most often, property lines run down the center of the ravine, at the bottom. There are 15 separate ravines in the City that range in length from approximately a tenth of a mile to just over a mile.

The City has approximately 3.5 miles of lake front. A bluff exists where the tableland meets the lake. In many cases, the bluff drops off steeply to the lake and beach below.

Along Lake Michigan, bluffs ranging from sheer drop offs, to more moderate slopes, provide the transition from land to water. Due to the force of the Lake, the bluffs take an extraordinary beating as seasons change and lake levels vary from year to year. Many properties at the edge of the Lake have lost, or are in danger of losing, some portion of their land as the slopes weaken and slough off to the beach below.

The natural process of erosion has carved and shaped the ravines and bluffs over many years. However, in many cases, the erosion process has been accelerated by development of the surrounding land, removal of vegetation, and development of land located away from the ravines and bluffs, but within the same watershed.

Over the years, the volume of storm water runoff has increased as prairies and wooded areas are replaced by driveways, buildings, swimming pools, and tennis courts. Development activity has changed the volume and rate of storm water runoff. An increase in the volume of storm water runoff speeds up the erosion process.

Left unchecked, erosion of ravines and bluffs can cause significant damage. Continued erosion can undermine buildings, roads, and bridges, damage sewer lines, and can result in the loss of yard areas. In extreme cases, erosion can cause a loss of land area resulting in a corresponding decrease in property value. Since the majority of the ravines and bluffs in Lake Forest are privately owned, property owners are responsible for taking erosion control measures and for maintaining ravines and bluffs.

RAVINE LOCATIONS

THE EROSION PROCESS

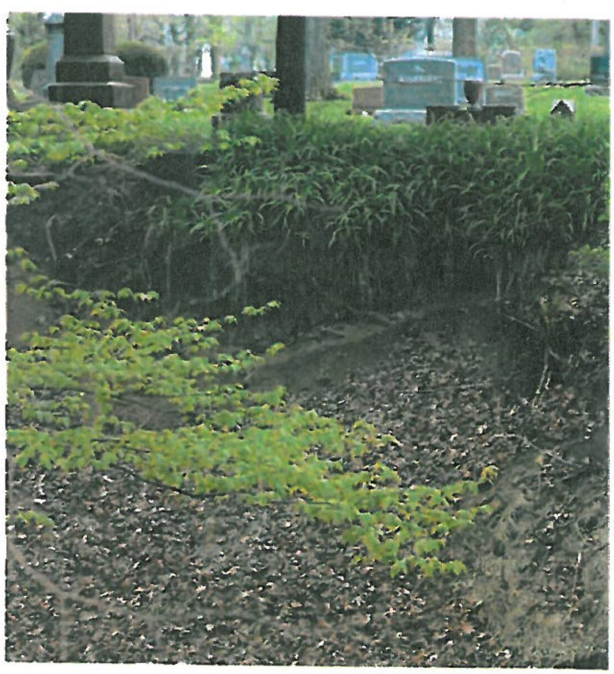
The erosion process is affected by many variables. Two variables are of particular significance:

1. The speed of the storm water runoff, and
2. The characteristics of the soils.

The geologic characteristics of the ravine system, the bluffs, and the characteristics of the soil were established many years ago. Conversely, the volume and velocity of storm water runoff are continually affected by human intervention and development activity.

As development occurs on land surrounding the ravines, the amount of storm water runoff and the speed of the water flow both increase. The increased volume and speed of the water causes erosion that deepens and widens the ravines causing slopes to fail. Ultimately, a ravine will become wider at the top as surrounding tableland falls into the ravine. This process will continue until the ravine channel has become large enough to carry the increased volume of storm water.

In some areas of the City, the erosion process is exposing storm and sanitary sewer pipes and undermining retaining structures located at the bottom of ravines. Structures at the top of the ravines can also be undermined as the erosion process continues.

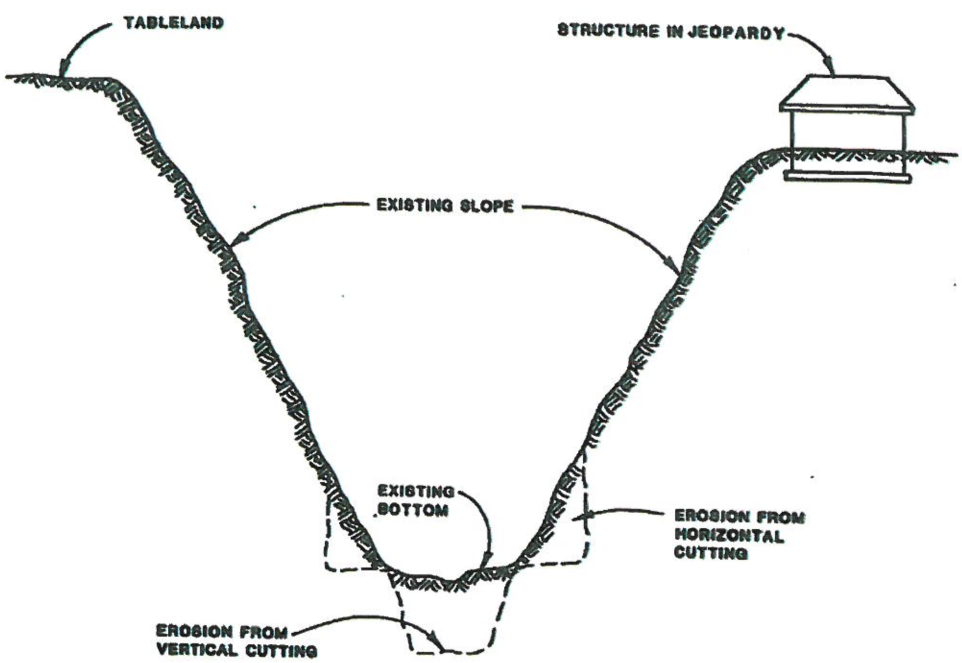


ERODING RAVINE

Three forms of erosion are prevalent in ravines.

Vertical cutting of the channel at the bottom of the ravine

Vertical cutting of the channel is the removal of soils at the bottom of the ravine. This process occurs naturally due to the existing channel on an upward or downward slope. Vertical cutting is more prevalent in ravines with steep channel slopes or gradients.



Slopes of 0.5 percent or less are recommended to provide stability at the bottom of the ravine and to minimize erosion of the clay in ravines. It is important to note that each ravine, and each section of a ravine, has its own optimum slope based on the channel width and the storm water discharge rates. Most of the existing channel gradients range from one percent to over five percent.

In ravines that convey storm sewer, the vertical cutting of the channel bottom is accelerated when the volume of storm water and the speed of the water increase. Logs and debris can create obstructions and reduce the width of the bottom of the ravine. Obstructions cause an increase in the speed of the flow of water creating even greater potential for vertical cutting. Slope failure from vertical cutting is common in smaller ravines where side slopes meet and the channel is narrow.

Horizontal cutting of the channel along the top of the ravine

Horizontal cutting of the channel is the removal of soils along the top of the ravine slope which occurs during periods of unusually high water when the flows exceed the carrying capacity of the channel at the bottom of the ravine. During periods of high water flows, soil is picked up and carried away by the water. Horizontal cutting is the process that causes meandering or a widening of the channel.

Horizontal cutting occurs in channels at the bottom of the ravines even during periods of normal water flows. During these times, water speeds at the bottom of the channel can be naturally accelerated around bends or as a result of blockages. As a result, water can be directed into the toe of the slope. Horizontal cutting that occurs at the base of trees eventually causes trees to fall. When a tree falls, more soil is exposed and there is increased potential for erosion and slope failure. Slope failure from horizontal cutting occurs more frequently in larger ravines with wider channels.

The vertical and horizontal cutting of the channel at the bottom of a ravine reduces support for the sides of the ravine. This in turn results in sloughing off of the slopes.

Sheet and rill erosion on ravine and bluff slopes
Storm water runoff from the adjacent land is a significant cause of erosion and slope instability. Storm water runoff on the slopes of ravines and bluffs cause rill erosion, a little stream or brook, and sheet erosion, a broad, flat, thin expanse of on a slope with the loss of vegetation. Although some rill and sheet erosion occurs naturally, these types of erosion are made worse by storm water that is directed to the edges of ravines and bluffs from roof drain downspouts, patios, driveways, storm sewer discharges, and failed storm sewers.

Rill erosion is widespread throughout the ravines in the City. Most often, this type of erosion is the result of small diameter, private storm water pipes at the sides of ravines and bluffs. The flow of storm water causes soils to erode at the point of the pipe outfall undermining the support for the storm sewer pipe. Eventually, the pipe breaks off. This erosion cycle continues up the ravine slope as the discharge point from the storm water pipe widens and deepens. Rill erosion can also be caused by fallen trees that lie up and down the slope, rather than across the slope. Storm water runoff creates a channel along the tree, and a rill erosion problem begins.

Sheet erosion and loss of vegetation can be caused by seepage. Seepage occurs when sand and silt layers prevent rainfall from reaching the ground water table and instead, conduct the water over the surface to the edge of a ravine or bluff.

Slope failure from seepage is common in ravines. The top portion of a ravine is weathered by rainfall and storm water runoff. "Weathered" soil conducts water to the bottom of the ravine. Weathered soil becomes saturated and the strength and stability of the soil is reduced. Eventually, the slope of the ravine or bluff, sloughs off and falls to the ground at the bottom of the ravine. Leaves, limbs, and other debris that is dumped on the slopes of the ravines and bluffs hold moisture in the weathered soil and accelerate the sloughing off process.

EROSION CONTROL TECHNIQUES

There are several erosion control measures available to property owners. Each has its own advantages and limitations. Each erosion situation requires its own solution. No single erosion control measure can be used to solve every erosion problem. Careful analysis is necessary to identify the best way to address each erosion problem. Using the wrong erosion control technique for particular situation can have negative impacts. Erosion control techniques are described below.

Storm Sewers
The installation of storm sewer pipes in ravines significantly reduces erosion of the channel bottom. However, it is important to note that storm sewer construction can be quite disruptive to ravines and surrounding neighborhoods. Staging areas for material and equipment are needed and temporary construction easements may be required to allow for construction access into the ravines. With proper consideration to construction access and methods, storm sewer installation at the bottom of ravines can be managed to protect ravines.

Over the long term, a storm sewer in a ravine will not harm the natural setting of the ravine. After installation of storm sewers, a ravine can be restored with native plants. After installation of storm sewers, minimal maintenance, including periodic inspections and removal of debris from inlets, is required on a continuing basis.

Residents surrounding a ravine need to work together to initiate, execute, and finance a storm sewer construction project.

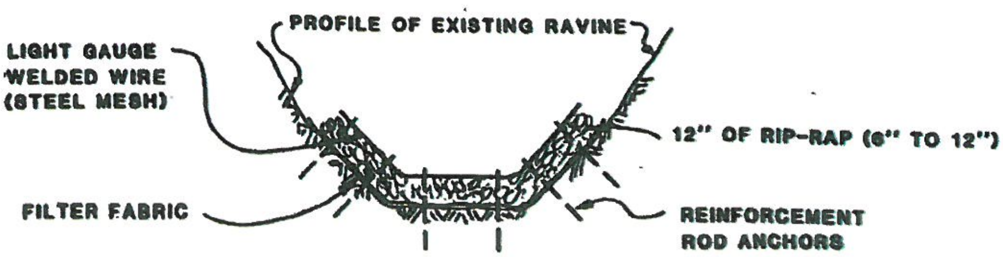
Channel Linings
Channel linings "armor plate" or protect the ravine. This erosion control technique is not as effective as storm sewers. However, channel linings provide satisfactory protection against vertical and horizontal cutting of the ravine channel when storm sewers are not appropriate or possible. The following lining methods are available:

1. Riprap - Layers of rock or chunks of concrete, and
2. Gabion Baskets - Steel baskets filled with rock

Riprap
Stone riprap, like concrete linings, is found throughout the ravine system, particularly below storm sewer outfalls. For successful riprap applications, the stone or concrete must be large enough to remain in place during times of peak water flows. Water flowing at two feet per second can move a stone weighing half a pound. Water flowing at ten feet per second can move a stone that weighs 150 pounds.

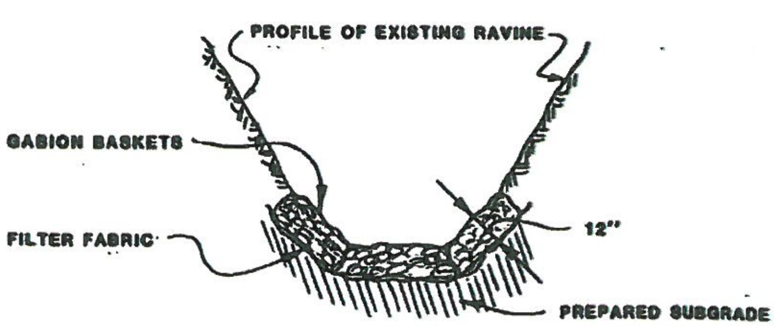
Unlike concrete, riprap lining is flexible and allows voids created by shifting soils to be filled. The rough surface of the riprap is effective in dissipating energy and reducing the speed of the water in the channel. Slower moving water causes less erosion.

To prevent displacement of the riprap as a result of the water flow the installation of welded-wire reinforcement may be necessary. The welded wire covering must be inspected frequently to ensure that the covering and riprap are secure. Very large rocks are required for riprap if a welded wire cover is not used. The cost of riprap increases with larger rocks.

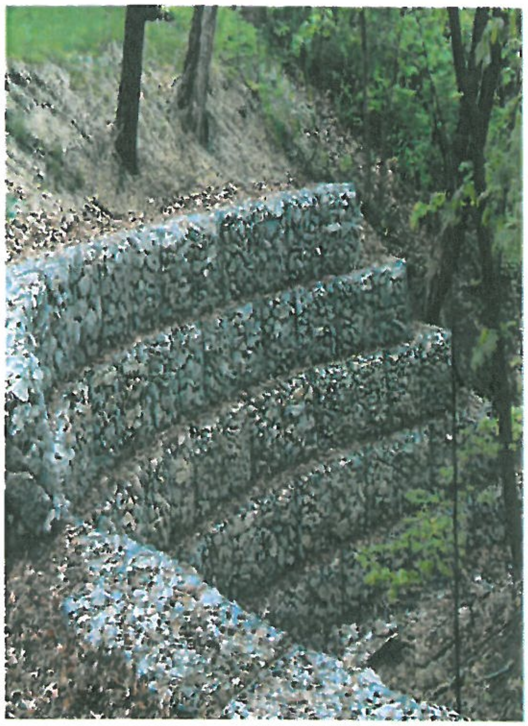


RIP RAP LINED CHANNEL

Gabion Baskets
Gabion Baskets offer both flexibility and the energy dissipating characteristics to slow the flow of water as riprap does. In addition, because the Gabion Baskets hold and secure the rock material, smaller rocks can be used. Gabion Baskets can be fitted to the irregular shape of ravine bottoms. Gabion Baskets require only periodic inspections primarily to check for debris that may divert water outside the lining.



GABION LINED CHANNEL



Gabion Baskets lining a steep slope for support

Water flow is slowed by Check Dam like the one pictured above. The rocks shown sit on top of a Gabion Basket buried in a ravine and covered with small stones

Check Dams

Check dams are used in ravines with reasonable success. Check dams decrease the speed of the flow of water and as a result, reduce erosion in channel bottoms. Although check dams control erosion from vertical cutting, they are not as effective in controlling erosion from horizontal cutting.

Check dams are appropriate for straight ravines with steep side slopes. Check dams are not as effective for meandering ravine channels. Dams may be constructed in a meandering section of a ravine, but special construction techniques including channel lining or bank armoring would be necessary to protect both the channel bottom and side slopes.

The following are critical to the effectiveness of Check Dams.

- Check dams should be aligned at right angles to the centerline of the channel;
- A gabion spillway should extend 10-12 feet below the dam to prevent both horizontal and vertical cutting of the channel bed; and
- Gabion baskets should be placed on the ravine slopes above the dam to prevent horizontal cutting and diversion of water around the dam.

The above information is based on the assumption that check dams are constructed of light gauge steel sheeting, wood planking, and gabion baskets.

Concrete check dams were not considered because of higher cost, susceptibility to deterioration from freezing and thawing, and inflexibility.

Steel and gabion basket check dams have the advantage of being stronger and longer lasting than wood. They also require infrequent maintenance; however, installation requires the use of heavy equipment to drive sheeting and to excavate for gabion baskets.

The amount of disruption to the ravines depends on the number of access points in to the ravines and the extent of work required. Construction of check dams is normally short-term and quite acceptable to the surrounding residents. Extensive cooperation among residents is not required for check dams.

Aesthetically, check dams can be consistent with the natural character of ravines. Check dam structures are buried and confined to small areas and for the most part, are not highly visible. A possible objection to check dams may be the formation of pools of water behind the dams which can provide a breeding habitat for mosquitoes. Alternatively, residents may find the pools desirable and complimentary to the natural setting of the ravines.

Series of Check Dams

Dewatering for Groundwater Control

Groundwater flow and seepage can destabilize ravine slopes. Dewatering the ravine slope can help to control erosion caused by destabilization. Dewatering can occur through planting and maintaining vegetation on the slope. The slope can also be mechanically dewatered using either a vertical well or a horizontal drain system.

A vertical well system involves a well located on the tableland adjacent to and above the eroding ravine slope. A pump is located in the well to remove water in and "behind" the eroding slope. The water is discharged at a location where the water will not impact the slope.

A horizontal drain system also uses a well to dewater the slope. The well is drilled horizontally into the slope and is cased with perforated pipe. Groundwater seeps into the encased well and drains away from the slope through a gravity pipe system to a location where the water will not negatively impact the slope.

These erosion control systems can be installed by individual ravine property owners. The cost of these systems varies greatly dependent upon groundwater and soil conditions, slope angle, and the size of the project.

Biotechnical Slope Protection

Structural solutions and vegetation can function together to provide slope protection.

Vegetation prevents surface erosion and shallow slides. Vegetation reduces rainfall erosion by slowing the speed of rainfall runoff and binding and holding soil particles in place. Deeply rooted woody vegetation prevents slumps and slides through stabilization from the root systems. Vegetation also depletes moisture in the soil.

Retaining walls protect and stabilize steep slopes at the base and flatten the slope near the wall. Rock breast walls, gabions, crib walls, and welded wire walls are all structures that can be used in the ravines. These structures are flexible, easily constructed, and cost-effective. Each of these types of construction can benefit from the incorporation of vegetation.

Gabion and crib walls can be constructed in many different design configurations and are not as limited in height as breast walls. A crib wall is a structure formed by joining a number of cells together and filling them with soil or rocks for strength and weight to form a gravity retaining wall.

Contour Wattling is the placement of bundles of plant materials in shallow, contoured trenches on either a cut or an area of fill. The bundles or "wattles" are staked in place on the down slope side of the trenches. Ideally, the bundles consist of woody live plant stems from a species that is in plentiful supply near the job site.

Contour wattling has been used to stabilize entire slopes and is particularly useful for gullies caused by seepage areas. These areas are moist enough to promote rooting and sprouting of the plant material. The plant material will draw the moisture from the soil once it is established. Contour wattling reduces the potential for slope erosion by:

- Stabilizing the surface layers of the slope;
- Slowing the movement of water down slope;
- Entrapping sediments in the wattles;
- Increasing infiltration into the slope; and
- Establishing vegetation.

Contour brush-layering may be used as a rehabilitation measure for seriously eroded and barren slopes. Green branches of shrubs and trees which will root easily are placed in successive rows on the contours on the face of a slope.

Brush-matting has been used successfully in stream bank erosion control. A mulch of hardwood brush is fastened to the ground with stakes and wire. The brush can withstand periods of inundation with water, but cannot withstand undercutting. This technique is best used in conjunction with construction of revetments.

Live-staking is a quick and effective way to provide plant cover. Unrooted cuttings from plants which root easily are planted in bare soil areas on slopes showing evidence of recent movement or active erosion. The cuttings, often Willow, will grow vigorously for several years while they stabilize the soil and serve as a "pioneer species" until other plants have an opportunity to get established. Bottoms and banks of small ravines, sediment fills behind check dams, and raw gully banks are well-suited to live staking. Live staking can also be implemented into contour wattling, revetments, and breast walls.

The choice of plant material is affected by many considerations. Climate, native vegetation, topography, and soil are environmental factors that must be considered. For the ravine application, consideration must be given to the amount of sunlight available to new vegetation. Some tree removal may be necessary to insure adequate lighting to the forest floor. A permit is required for tree removal. Lack of sunlight is a major problem when trying to establish new vegetation in ravines.

The most important plant characteristic for erosion control is the ability to adapt to the environment. The plants should be hardy and competitive against less desirable plants. Consideration should be given to the type of erosion and the type of rooting system desired to best control the erosion. Availability, planting, and seeding procedures, existing vegetation, and required site preparation must also be considered. A list of desirable plants is listed at the end of the report.

RESTORING RAVINE AND BLUFF SLOPES

Re-introducing native ravine plants is important in restoring the natural character of the ravines. Over the years, many non-native plants have been introduced into the ravine systems. Frequently, they are more aggressive than native species and take over sections of the ravine.

Non-native trees such as Buckthorn and Norway Maples create a dense canopy and heavy shade, eliminating growth on the slopes. This exposes the steep slopes to accelerated erosion from water runoff.

In closing, ravines and bluffs are fragile ecosystems that require care and maintenance. Without maintenance, erosion, natural or the result of development activity and tree failure will cause uncontrolled changes. Proper maintenance and a watchful eye planting will increase the changes of minimizing erosion, and early intervention when problem conditions arise. Keeping the banks of ravines and bluffs stable and will reduce the need for expensive repairs and prevent the loss of table land. Enjoy and protect your ravines and bluffs.

For more information, contact:

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BIBLIOGRAPHY

- "Controlling Erosion." N.p.: US Dept of Agriculture, 1970.
- "Erosion Problems on the Great Lakes." N.p.: US Army Corps of Engineers, 1978.
- "Stream Bank Protections Guidelines." N.p.: US Army Corps of Engineers, 1983.
- Highland Park Lakefront Task Force Pamphlet

A restored Ravine: Some vegetation removed to improve light. The banks have been replanted with native forbes that will send roots deep into the bank to help stabilize once the weather warms (photo taken in early May). Bottom channel lined with Gabions and Check Dams installed to slow water flow.

Ravine Before Restoration

Ravine After Restoration

Ravine Before Restoration

Ravine After Restoration