Ditch Function and Impacts of Ditch Alterations

Technical Memo #1

December 3, 2021

FINAL

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1.0 INTRODUCTION

1.1 Project Overview

Roadside ditches are critical infrastructure of the City of Ottawa's overall engineered drainage network along municipal streets that have a rural cross-section. They exist throughout the city in various urban, village, and rural contexts. Ditches provide an important stormwater management function within the drainage network via quantity collection and conveyance controls and in-line quality treatment. In addition to assisting in the collection and conveyance of run-off from adjacent lands, roadside ditches provide a roadway subbase drainage role which assists in preserving the longevity and integrity of the adjacent roadways which are themselves vitally important municipal infrastructure. However, the purpose and multiple benefits derived from a well-maintained, functioning municipal roadside ditch network is not widely understood by residents.

The City of Ottawa, through staff across a wide variety of services including Roads, Right of Way, Development Review and Asset Management, receive regular requests from property owners requesting to alter or fill in the ditch within the municipal right-of-way adjacent to their property. The rationale for such requests is typically either to reduce maintenance or to improve aesthetics along the street lot line. In some cases, improper ditch filling or alteration activities are completed by property owners, without municipal review and authorization. Improper ditch filling or alteration may cause an array of detrimental effects to private property or to City infrastructure, both locally as well as to the extended drainage system, and at times requiring remedial action by the City.

The City has retained Parsons to review the City research information and provide a professional and objective third-party review of the matter of ditch filling and alterations. The work includes preparing a series of memorandums focused on ditch function and impacts of ditch alterations, a ditch alteration policy consistency review, and a City of Ottawa alterations business process review.

Following the completion of research and dialogue held working group meetings of key City of Ottawa staff, it was recognized that the City's approach to Local Improvement and Ditch Alteration could be improved. There is an opportunity to increase consistency and transparency, and to serve to better educate property owners about the importance of ditches in protecting public and private property from damage and degradation.

1.2 Objective of this Technical Memorandum

The objective of this technical memorandum is to identify the functionality of roadside ditches, to document the important services they provide the City, and to provide informaton on how ditch alterations affects both their function and serviceability. As stated, ditches are part of an integrated stormwater management system that benefits the City through managing stormwater quantity and quality, protecting and supporting infrastructure, providing flood protection, and supporting climate change resiliency. These and many other services and benefits are further detailed within this memorandum.

This memorandum also considers the financial impacts to the operation and maintenance of the ditch systems that have been altered or infilled, without City approval.

1.3 What is Stormwater Management?

The components of a community's Stormwater Management (SWM) system can range in complexity, depending on its urban, village, or rural context. A detailing of all the applications, designs, and functions of SWM systems are outside of the scope of this memorandum, although the main key factor of SWM and how the function of ditches serves as part of the integrated SWM system have been highlighted below and in the following sections of the memorandum.

When it rains or snow melts the water runoff needs to go somewhere. SWM is the effort to safely convey and treat the runoff through quantity and quality controls. Land development increases impervious surfaces (roads, roofs, sidewalks, driveways, etc.) and decreases the amount of natural infiltration into the ground increasing the volume and velocity of the runoff. This increase in volume and velocity, when not properly managed, can potentially result in flooding, and erosion. Figure 1 below provides a simple illustration of pre-development and post-development increase in stormwater runoff.

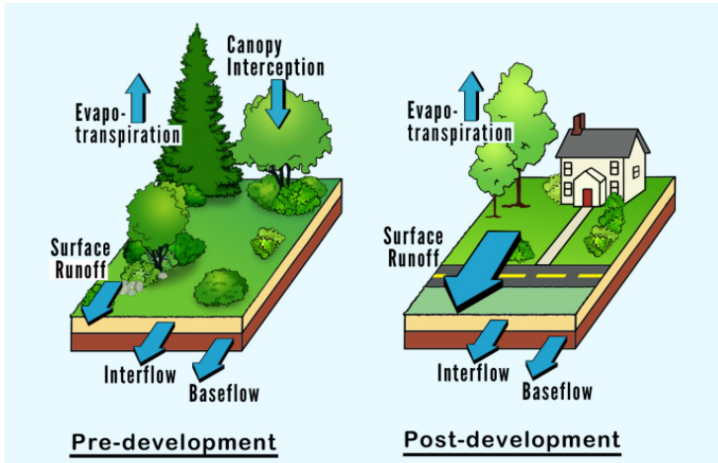


Figure 1: Increase Stormwater Runoff due to Land Development

This increase in flows associated with lot development is managed through SWM quantity control measures. Typical quantity conveyance controls range in level of complexity but may include lot level controls such as on-site storage, sewer pipes, reduced lot grading, infiltration trenches, swales, storm sewers, and ditches. The SWM systems often include end-of-pipe controls such as a wet pond, a dry pond, and basins, to name a few.

The second part of SWM is quality control. Rainfall and snow melt accumulate contaminants such as chemicals (fertilizers), bacteria (pet waste), organic matter (trash), oil and grease (cars, leaks, spills), salt (roads, winter salting), pesticides (yard and garden care), heat (increase in water temperature) and suspended solids/sediment (construction sites, roads). Large amounts of these items are detrimental to aquatic life and environment when carried, through stormwater management conveyance systems, to waterbodies. The implementation of SWM quality treatment measures improve the quality of the runoff. Quality measures include ditches, low impact development (LID) practices, infiltration trenches, pervious pipe system, vegetated filters strips, and ponds to name a few.

Stormwater quantity control and quality treatment is best implemented through an integrated treatment train which is a series of treatments that meet the stormwater management objectives as set out in the City of Ottawa design manuals and the Ministry of the Environment Stormwater Management Planning Design Manual (2003). Treatment trains provide a combination of quantity and quality controls from the lot level to the end-of-pipe system. These activities are Best Management Practices (BMPs) which are a combination of practices designed to prevent and/or reduce the release of pollutants to the receiving waterbodies. The design of BMPs focus on detaining stormwater runoff until pollutants and harmful contaminants are settled out and filter through the soils and the trapped pollutants are removed through maintenance. Ditches provide an important function and readily available opportunity to pursue the treatment train approach along municipal roadways.

The benefits of SWM integrated treatment trains include:

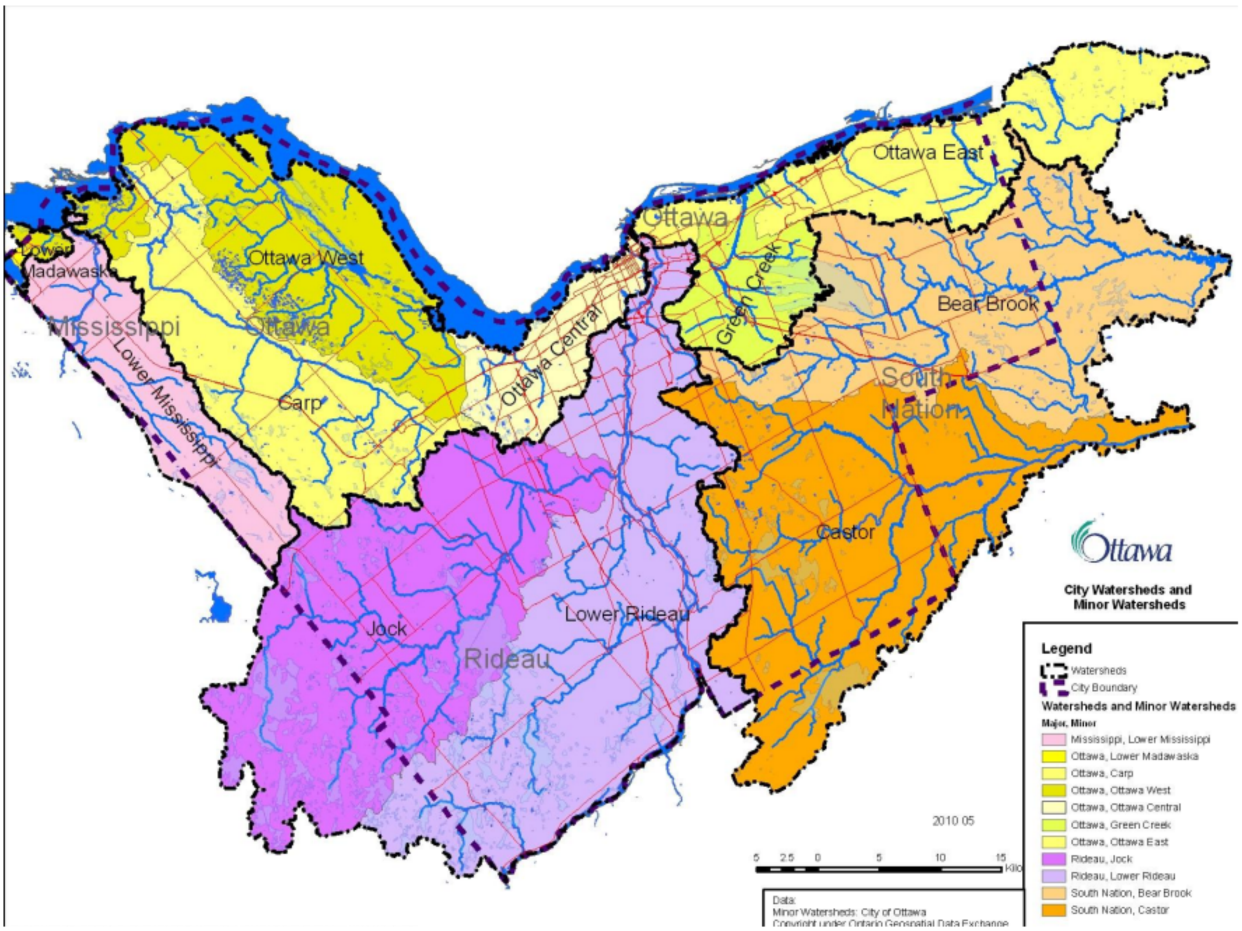
- More effective stormwater management, applying SWM through a combination of different controls and treatments;
- Reduction in land area required for end-of-pipe systems (ponds or basins);
- Enhanced quality treatment for removal of pollutants;
- Decrease in total cost when factoring land value; and
- Increase level of public awareness and involvement in the implementation and management of stormwater management initiatives.

It should also be mentioned that rear yard ditches and swales are used to convey storm drainage at the rear of private property and are designed to be used as a stormwater management conveyance system. Although not the focus of this technical review, it is noted that maintaining the design grading of rear yard drainage swales on private property is essential to preserving the stormwater management function of the system, as it was originally engineered.

From this review, it is clear that roadside ditches form a vitally important component of any SWM system, and that their effective management should be a notable objective of any municipality.

1.4 Subwatershed and Catchment area

The City of Ottawa (the city) is comprised of an extensive network of rivers and streams including portions of four major rivers (Rideau, South Nation, Mississippi, and the Ottawa River), four major tributaries (Carp, Jock and Castor Rivers, and Bear Brook), and hundreds of smaller creeks and streams. The health of these watercourses is important to the city and the city has been, and is, invested in improving the quality of these local rivers and streams. Figure 2 illustrates the City of Ottawa Watershed and Minor Watershed boundaries.



Source: Characterization of Ottawa's Watershed, 2011 March, An Environmental Foundation Document with Supporting Information Base

Figure 2: City of Ottawa Watershed and Minor Watershed Boundaries

Land use affects the environment and effective stormwater management is critical for the protection of the life, property, and aquatic habitat. Stormwater management is implemented to protect the natural systems, associated fish habitat as well as people living in the surrounding area.

Stormwater management watersheds and/or catchment areas are broken down into drainage areas. Each SWM system is comprised of drainage areas and the runoff from these areas are conveyed through drainage systems. Ditches form part of these drainage systems by conveying runoff from drainage areas upstream of its location. Although ditches play a small part of a larger picture, they are a critical part of the stormwater management system protecting the watershed, creeks, streams, and rivers, as they are often the first segment in the flow route between development-generated runoff and the eventual receiving watercourse.

2.0 FUNCTION AND BENEFITS OF A DITCH DRAINAGE SYSTEM

The City of Ottawa has approximately 5,650 km of roadside ditches which are critical to neighborhood drainage and stormwater management systems. This section provides a high-level overview of the functions and benefits that ditches provide to the SWM system.

Historically, the key objectives of ditches were to provide the quickest means of safely directing storm water runoff away from roadways and properties. This can especially be demonstrated through roadside ditches to prevent impact on the ability to travel safely. The introduction of stormwater management (major and minor drainage systems) emerged in the 1960s and 1970s and led the way to how engineer's now approach an integrated stormwater management design. Figure 3 shows the various types of drainage features (including the municipal road right-of-way) and how an integrated drainage system plays a role from a watershed perspective.

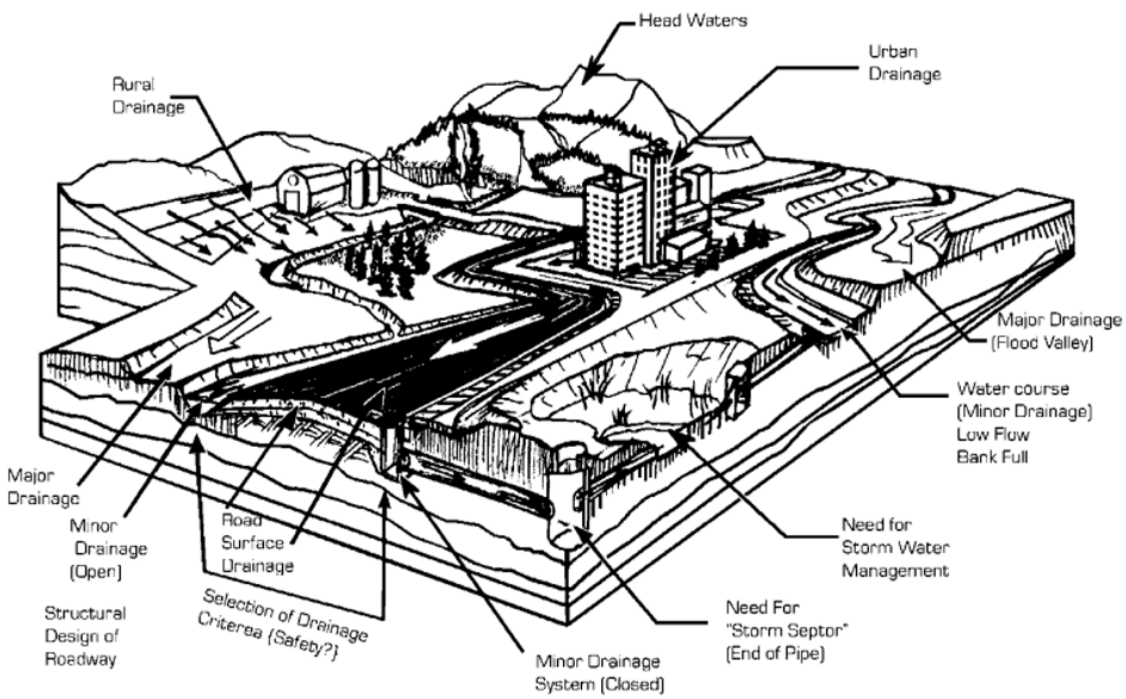


Figure 3: Watershed Drainage Features

Within this community context, in addition to serving developments, roadside ditches create a drainage outlet, collection and conveyance system for boulevard, sidewalk, cycle tracks, and roadway drainage, in turn protecting the integrity of the entirety of the right-of-way roads including the road subgrade and below-graded municipal services and utilities. Ditches are also more environmentally friendly when compared to closed sewer systems, as they allow for infiltration, water quality treatment, and reduction in peak flows, and playing a vital role in the treatment train approach discussed above. The benefits of ditch systems are detailed further below.

2.1 Stormwater Quantity and Quality Management

The primary purpose of SWM is to detain and collect stormwater to provide quantity control, and remove pollutants found in the runoff, providing quality control.

Land development increases impervious (hard) surfaces (asphalt, concrete, roofs) and decreases the natural absorption of precipitation into the ground. The decrease in infiltration and increase in hard surface, increases the volume of storm runoff which contributes to erosion, sedimentation, and/or flooding. To account for this decrease of natural infiltration and to ensure the stormwater runoff conveyed safely drainage systems are designed. These systems are design to direct stormwater runoff away from the development and into city roadside ditches and/or underground storm sewer systems.

The quantity control function of the ditch system is the reduction in peak flow rates. When rainfall stays close to where it falls there is less erosion and less pollutants carried downstream. Ditches help storm water managers pursue this objective. Flow within a ditch system is limited by the driveway culvert and crossroad culvert. The culverts will limit the flow rate of water, decreasing the potential for erosion and downstream flooding. In addition, vegetated ditches allow for the runoff to be absorbed by the vegetation located within the ditch, reducing the volume of storm runoff.

Land development activities also increase the risk of discharge of pollutants into the surface water system. These pollutants enter our streams and waterways through the storm drainage systems. In underground storm sewer systems, the road runoff is either directed to an underground storm sewer system that outlets directly to a waterbody, where no quality treatment is provided, or to a stormwater management treatment system which provides quality treatment of the runoff. Contrary to underground storm sewer systems, vegetated roadside ditches slow down the runoff, promote infiltration, and allow some pollutants to settle out. In addition, finer pollutants are also filtered through the mesh of plant roots.

Reasons to improve the quality of water runoff include:

- Healthy, clean water is fundamental to personal health and healthy communities;
- Many individual businesses (mainly agricultural) rely on natural sources of good clean water for farming, fishing, boating, water sports, wildlife viewing and hiking/waking beside the rivers;
- Improved water quality promotes a healthy aquatic ecosystem; and
- Pursuing healthy watercourses such as the Rideau River, which flows through the Nation’s Capital and is key to the identity and look of the city, is another important objective.

The City of Ottawa Sewer Design Guidelines section 8.3.13 states that for Best Management Practices to prevent or reduce the release of pollutants to receiving waters or streams roadway ditches should be used for quality treatment.

2.2 Flood Reducing Benefits

Ditches typically have more capacity than a sewer system and play a vitally important function in reducing downstream flooding during heavy rainfall events. In addition, during heavy storm events the driveway culverts or road crossing culverts will act as quantity controls allowing the ditches to become small detention basins creating a reduction in downstream peak flow rates and allowing for runoff to be stored until downstream capacity is available. By contrast, an underground stormwater sewer system does not have the capacity to store excess water.

Storm sewers are sized for small storm events which are more frequent and include the 2, 5, or 10-year events. Sewers will also have maximum capacities, which will depend on the material fabrication (roughness of the inside) of the sewer, the diameter of the sewer, and the slope of the sewer. During the larger storm events, including events over the 10-year storm, sewers will surcharge or back up and ponding of water will occur above catchbasins located at low points within the roadway. In these cases, within some older systems across the city, basement flooding may occur. In high rainfall events (100-year events), the roadways themselves will be used as a conveyance method and the underground sewers have the potential to surcharge creating the risk of flooding.

Figure 4 depicts a the hydraulic grade line in a storm sewer system during the 10-year design storm even and the 100-year storm event. The hydraulic grade line refers to the level of the water in the drainage system. In a sewer system when the pipe is flowing full the pipe is under pressure and the the hydraulic grade line is the level the water would rise to if a small vertical tube was connected to the pipe.

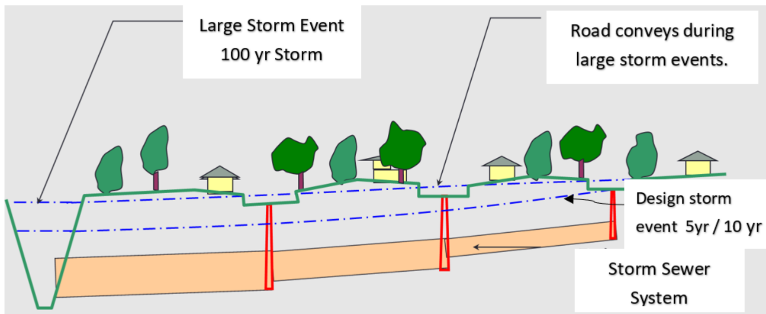


Figure 4: Storm Sewer System

In the Ottawa Sewer Design Guidelines, ditches are typically designed to convey at least the 5-year storm event, although some can be designed for a larger event (up to the 100-year storm). The design of the ditch is dependent upon the cross-sectional area, the wetted perimeter, the slope, and the roughness of the surface (grass, granular, etc.). Ditches are also required to be designed with freeboard, a water elevation above the design storm event, to accommodate higher than normal water levels. The freeboard for a 5-year storm event is to have the water elevation of the design storm set below the pavement structure. It should be noted that ditches do not have the same pressures as found within a pipe system and therefore the hydraulic grade line is the water elevation within the ditch. Figure 5 illustrates a typical trapazoidal ditch cross section with a low water quality storm event, a 2-year storm, and a 10-year storm, and it can be seen that the ditch has additional capacity above the 10-year water level (the freeboard).

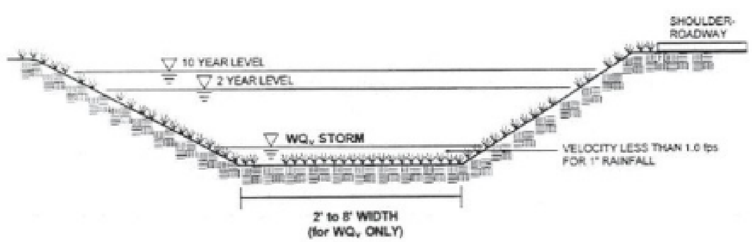


Figure 5: Trapezoidal Ditch

2.3 Climate Change Resiliency

In 2020 the City of Ottawa, in partnership with the National Capital Commission (NCC) completed a study to better understand future climate conditions to see how it might affect this region and how to take appropriate action to prepare for this change. This study concluded that the National Capital Region will become much warmer and wetter over the coming decades with a greater chance of extreme weather events. The rate and extent of climate change will depend on future global greenhouse gas emissions.

Ditch systems that are well-design and well-maintained can provide a buffer to the ongoing climate changes and associated risk that the City is expected to manage. As previously stated, ditches reduce flow rates, promote infiltration, reduce the risk of flooding, and decrease pollution transportation to downstream bodies of water. Considered in this manner, they are a small but important part of the City's climate change adaptation strategy.

2.4 Road Base Drainage

A service feature that ditches provide is drainage of the road base which protects the integrity of the road. The base of the roadway is the foundation that supports the traffic load. The base is made of granular material and although it provides a strong support for the traffic load the void in the granular creates a place for water to become trapped and weaken the structure of the roadway. The freezing and thawing of the trapped water also causes rapid deterioration of the pavement.

Figure 6 illustrates a road cross section and drainage of the roadbase. This assists in the understanding of the importance of maintaining effective roadside ditch drainage system, and mitigating the risk of costly infrastructure failure.

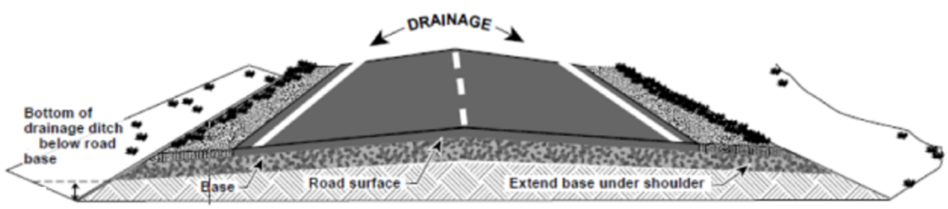


Figure 6: Road Base Drainage

2.5 Groundwater Recharge

Land development increases the amount of impervious surface area and as a result, decreases the amount of water infiltration. The City's local conservation authorities continue to monitor and study the local groundwater. The Rideau Valley Conservation Authority (RVCA) recognized groundwater as a vital natural resource and since 2005 RVCA has been coordinating source protection programs. The scope of these studies and programs are beyond the scope of this memorandum although it is important to understand that ditches play a role in achieving groundwater recharge. The SWM quantity characteristics of ditches allow for the water to pond within the ditches intern providing time for infiltration into the ground. It should be noted that the groundwater recharge function of the ditch is dependent upon the type of soils beneath the ditch systems and that infiltration will provide a benefit to the groundwater.

3.0 TYPES OF DITCH ALTERATIONS

Diligence should be taken when reviewing proposals to alter or fill in roadside ditches, and decisions need to have regard for the site-specific context. When altering a ditch, consideration must be given to the entire drainage catchment area to ensure no negative effects are created with respect to ditch conveyance capacity or public and private property. Unapproved alterations without proper technical analysis may result in upstream flooding, basement flooding, reduced network conveyance, missed water quality treatment, aggravated water quality issues, and local infrastructure maintenance problems, including reduced life expectancies of the stormwater management system.

When the City of Ottawa was comprised of individual municipalities, various inconsistent rules and approaches were applied to ditch alterations. In 2008 the City of Ottawa Council approved a Ditch Alteration Policy to establish an engineered approach to apply a consistent level of service to all ditches across the City.

This section of the memorandum will provide comments on the impacts that ditch alterations and in-fills have on ditch functions, services, and benefits.

3.1 City of Ottawa Ditch Alteration Policy

The current legal and procedural framework for the City to administer Local Improvements and Ditch Alteration is outline below:

- Provincial Municipal Act 2001
    - Ontario Regulation 586/06 – which identifies ditch alteration as a Local Improvement
- Provincial Environmental Compliance Approvals
- City of Ottawa
    - Local Improvement Policy (Updated Policy was approved by Council on November 24, 2021)
    - Ditch Alteration Policy
        - Drainage By-law, superseded with the Site Alteration By-law

The City established a Local Improvement Policy in 2006 under the governance of the Municipal Act (2001) and predicated on Ontario Regulation 586/06 (Local Improvement Charges – Priority Lien Status). An updated Policy was recently approved by Council on November 24, 2021. Ditch Alteration is categorized as a Local Improvement in Ontario Regulation 586/06 and the City's Local Improvement Policy and is also subject to Ministry of Environment Conservation and Parks (MECP) Environmental Compliance Approval (ECA) requirements for discharges to water.

In 2007, City Council passed the Drainage By-law, prohibiting the obstruction or alteration of ditches and detailed the related maintenance activities. Acknowledging circumstances where ditch alterations would be permissible, a Ditch Alteration Policy was subsequently approved in July 2008. The City has since approved an over-arching Site Alteration By-law that defers to Ditch Alteration Policy criteria where applicable.

3.2 Ditch Infill Alterations

The City understands the desire of some landowners to want to fill in or alter roadside ditches. Depending on the individual's values, the context, and the local condition, roadside ditches located along a property frontage are not always desirable to maintain nor are they aesthetically pleasing to the property owner. For example, if designed with steep side slopes, ditches can be difficult to mow, and can be a place for unwanted and unmanageable vegetation to grow. In other cases, ditches could have continuous standing water within them creating a location for the breeding of mosquitos. In addition, owners can see this as a loss of what they perceive to be usable property space, notwithstanding the fact the ditch is located within the municipal right-of-way.

This section highlights different ditch infill methods and their effects on the function and benefits of the ditch, listed in the previous section, on the integrated SWM system.

3.2.1 Pipe Installation Ditch Infill

A ditch is a quantity conveyance system that is part of an integrated stormwater management system. The ditch conveys more than the drainage from the property it is fronting. Ditches convey flow from a drainage area which is part of the larger watershed. When a ditch is altered through unregulated infill, the SWM system is disrupted. Alterations need to be analyzed to ensure no negative impacts occur to the SWM system.

A method of infill is to replace the ditch with a pipe and infilling the ditch. It may seem like a simple solution to determine the upstream culvert size, the downstream culvert size and replace the ditch with the same size pipe and infill the ditch. Although it is not that simple.

Below is a list of factors affecting the SWM conveyance system that need to be considered when replacing a ditch with a pipe and infilling:

- City of Ottawa Standards state that minimum driveway culvert sizing is 500mm. Driveway culverts are typically not sized for a specific storm event. However, the ditches are typically sized for specific storm events and designed as part of the overall SWM system;
- Since driveway culverts are not typically sized for a specific storm event, it is intended that stormwater will overflow the culvert and driveway during larger storm events from one ditch to the next;
- A new pipe installed within the ditch, that is the same size of the driveway culvert, will create a restriction in the system increasing the hydraulic grade line, which results in increased water elevations upstream of the infill location. This increase in water elevation can lead to upstream flooding of both roadways and private property; and
- The new pipe material (Concrete, CSP, HDPE, PVC) will affect the velocity of flow through the pipe. Increased flow velocity will potentially increase erosion if adequate measures are not installed. Runoff flowing at a faster velocity, will reach downstream drainage systems faster than expected and could potentially overload them and flood the surrounding area.

In addition, the ditch replaced by a pipe has removed the quality treatment function of the ditch system, the surface drainage has been altered, the road base drainage has been removed, and the groundwater recharge in this area has been removed.

It should also be noted that stormwater conveyance and storage volume are significantly decreased in a pipe system compared to a ditch system. **Figure 7** shows an oversimplification of the situation although it does demonstrate that the amount of storage volume is significantly reduced within a pipe. A 2500mm, diameter pipe, by 12m long sewer would provide approximately the same amount of volume, 58.9 cubic meters, as a trapezoidal ditch with a 0.5m bottom by 1.0m depth with 3:1 side slope, 6.5m top width and 12m length which provided 54.6 cubic meter volume. By this comparison, the ditch is more efficient in conveying flow than the sewer, as the sewer would extend 1.5m higher than the banks of the ditch.

The cost of the 2500mm sewer per meter is also approximately $3,000/m this is significantly greater than the $2,240 per linear meter for ditching. Although the sewer has a longer design life, the capital cost of the sewer is hard to justify against an existing system that adequately performs.

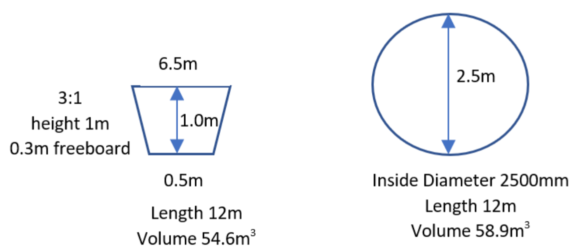


Figure 7: Ditch and Pipe Volume Comparison

3.2.2 Ditch Infill with No Pipe Installation

A second type of infill is when the ditch is filled with no pipe installed. This method creates a blockage in the SWM system. Due to the blockage the water level will continue to rise in the upstream ditches until the driveways and/or roadway are overtopped (flooded), and the runoff finds a new drainage route. It should also be noted that some properties are not graded with positive drainage away from the building. Therefore, in this instance overflow runoff from the ditch may flow towards the house and cause property damage.

When the storm event has subsided, the upstream ditches will remain filled with water until it can either infiltrate into the ground or evaporate.

A ditch infill with no pipe installation has removed all functions and benefits of the ditch at this location and has increased flooding and erosion upstream.

3.2.3 Ditch In-fill with Bio-Retention LID

Infilling the bottom of the ditch, as shown in Figure 8, with a bio-retention low impact development (LID) treatment system is a benefit to an existing SWM system although only if the quantity conveyance control of the system has been reviewed.

Source: SVR Design (left); Seattle Public Utilities (right)

Figure 8: Ditch In-Fill with Bio-Retention LID

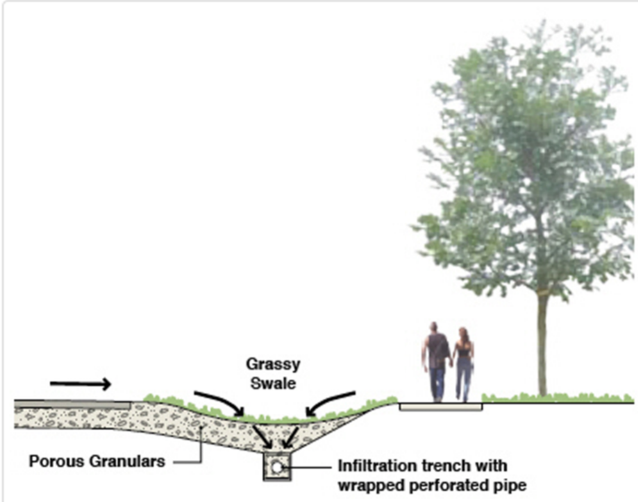
A bio-retention system is an enhanced grass swale that incorporates an engineered soil bed (filter media or growing media) and optional perforated pipe underdrain. These LIDs remain as ditches to convey, treat, and attenuate stormwater runoff although they vegetation or aggregate material is incorporated on the bottom of the ditch to slow the runoff in the smaller storm events and to allow additional sedimentation, filtration through the root zone and engineered soil bed, evapotranspiration, and infiltration into the underlying native materials. Bio-retention areas may be planted with grasses or have more elaborate landscaping.

The addition of an enhanced vegetated bottom to a ditch needs to be analyzed as part of the whole SWM system. The vegetated area removes storage volume from the ditch and slows down flows. The removal of storage volume and the slower flows could result in flooding upstream. It should also be noted that these areas may require additional maintenance due to the additional sedimentation accumulation at the bottom of the ditch.

3.2.4 Ditch In-fill with Perforated Pipe and Swale

This in-fill is when the ditch is replaced with a perforated pipe, a pipe with tiny holes to allow water to filter into the surrounding soil, and a swale is constructed above the pipe. The perforated pipe is used in combination with a filter sock and clear stone around the pipe to prevent sediment from blocking the tiny holes. This is also termed an infiltration system. This system promotes infiltration and settling of pollutants which is quality treatment within the SWM system. The type of native soil is an important factor to consider in this in-fill design since clay and bedrock is in many parts of Ottawa and you cannot infiltrate into clay. These systems are best suited for pervious soils. Figure 9 illustrated an in-fill perforated pipe and swale system.

As with the bio-retention LID the perforated pipe system can provide additional beneficial water quality treatment to the SWM system although the storage volumes typically provided within the ditch are removed. As stated within the Ministry of Environment Design Guidelines, section 4.9.4 the quality benefits of this system are also difficult to quantify because it is dependent upon many factors (pipe slope, number and size of perforations, depth of flow). It is also recommended that these systems be inspected for standing water 24 hr. hours after a storm event and standing water would suggest the need for flushing of the system.



Source: City of Ottawa website – The Basis for Sustainable Road Corridors

Figure 9: Ditch In-fill with Perforate Pipe and Swale

3.2.5 Ditch Bottom Treatments

The first flush of runoff, which is the runoff at the very beginning of the storm, conveys more pollutants then as the storm progresses. Altering the bottom of the ditch with granular, river stone or low-lying vegetation will improve the quality treatment within the SWM system. Enhancement of the ditch bottom will provide sediment filtration through low-lying vegetation, dense vegetation will help filter pollutants, and sedimentation will occur through granular slowing the flow and filtering the pollutants.

Key components to enhancing water quality treatment within the ditch system is to widen and flatten the ditch bottom as much as possible to spread out the flow. Quality treatment is achieved when the water is flowing through shallow low-lying vegetation. Select vegetation that is herbaceous and not woody. Herbaceous leaves will slow the water, promote sedimentation, and help filter the pollutants. If the existing soils do not promote infiltration a selection of appropriate vegetation will be required to ensure plant survival.

Steep side slopes or steep ditch bottoms are vulnerable to erosion. The side slopes and bottoms can be planted with vegetation to prevent erosion, or they can be reinforced with a soil stabilization system if the plant system does not provide adequate stabilization. Figure 10 illustrates the use of a vegetated retaining wall system for the ditch side slopes and a granular bottom to prevent erosion.

Figure 10: Roadside Ditch Enhancement Granular bottom and Vegetated Wall Side Slops

3.3 Cumulative Impacts Ditch In-fill Alterations

As previously stated, ditches are part of an integrated SWM treatment train within a drainage area. In the absence of a catchment-wide engineering design and/or review of the system as a whole, the implications of random ditch alterations can significantly decrease the benefits and functions of the SWM system. These decreases and loss of benefits translate into reduced infrastructure life expectancy (roads), uncontrolled surface flooding, basement flooding, network conveyance and capacity issued, and an increase in pollutants into our local streams and rivers.

As stated within the City Ditch Alteration Policy, approval of a one-off alteration without considering the effects to the whole catchment area and completing an engineered assessment has the potential to prevent approval of subsequent requests.

It should also be noted that ditch alteration (piping in excess of private approach extents) is required to comply with Ministry of the Environment, Conservation and Parks (MECP) Certificate of Approval (CofA) process.

4.0 FINANCIAL IMPLICATION

Operations and maintenance activities by the City of Ottawa are required to maintain the operation, longevity, and function of the municipal ditch system. The financial implications related to one-off ditch in-fill alteration adjacent to road networks is proportionate to the resulting effects of the in-fill. It can be assumed that the need for an increase in routine maintenance of the ditch system will be required. Although quantifying the quantity and cost of operation and maintenance needed will be depended on each individual situation.

The Ministry of the Environment SWM Planning, and Design Manual provides, within chapter 6.0, information on the Operation, Maintenance and Monitoring for SWM systems.

The following activities should be routinely completed on existing ditch systems and the importance of these items is more significant when an unapproved ditch in-fill alteration has been completed because the function of the SWM has altered without review of the effects on the system:

- Observations resulting from inspection:
    - Hydraulic operation (detention time, standing water, evidence, or occurrence of overflows);
    - Condition of vegetation in and around the area;
    - Occurrence of obstructions at the culverts or pipes (inlet and outlet);
    - Evidence of spills and oil/grease contaminations; and
    - Frequency of trash build up.
- Measurement of sediment depth (especially upstream of in-fill areas); and
- Recommendation for inspection and maintenance program for coming year.

Table 1 was obtained from the Ministry of the Environment SWM Planning, and Design Manual and depicts the operation and maintenance requirements for different stormwater management activities.

Table 1: 6.1 Stormwater Management Practices Operation and Maintenance Activities

Table 6.1: Stormwater Management Practices Operation and Maintenance Activities

Item No.	Operation or Maintenance Activity	Type of Stormwater Management Practice											
		Wet Pond	Wetland	Dry Pond	Infiltration Basin	Infiltration Trench	Filter Strip	Superpipe Storage	Filters	Oil/Grit Separator	Soakaway Pit	Pervious Pipe	Grassed Swales
1	Inspection	■	■	■	■	■	■	■	■	■	■	■	■
2	Grass cutting	□	□	■	■	■			■				■
3	Weed Control	■	■	■	■		■		□				■
4	Upland vegetation replanting	□	□	□	□	□	□		□				
5	Shoreline Fringe and Flood Fringe vegetation replanting	□	□										
6	Aquatic vegetation replanting	□	□										
7	Removal of accumulated sediments	■	■	■	■	■	■		■	■		■**	■
8	Outlet valve adjustment	□	□	□									
9	Roof leader filter cleaning/replacement										■		
10	Pervious pipe flushing											■	
11	Oil/Grit separator or Catchbasin cleaning									■		■	
12	Closing of infiltration facility inlet for winter months				■g	■g			■g			■g	
13	Trash removal	■	■	■	■	■	■	■	■	■*	■***	■	■
14	Infiltration basin floor tilling				■								

■ Normally Required □ May be Required

Source: Ministry of the Environment SWM Planning, and Design Manual

It is recommended that all roadside ditch in-fill alteration SWM systems be inspected after every significant storm event for the first two years to ensure proper functioning of the SWM system, increasing the maintenance requirements of the system. After the first two years and with no adverse effects the SWM can be inspected yearly.

4.1 Ditch In-fill Financial Implications

4.1.1 Road base Drainage Financial Implications

Ditch in-fill removes the ability for the road base to drain properly. This directly affects the road pavement structure and its lifespan which can have major effect on the city annual road rehabilitation cost. At ditch in-fill locations a road base subdrain can be added to the edge of the roadway to promote drainage of the road base. The City of Ottawa Spec Code list dated September 29, 2021 lists the cost of perforated pipe (F010.01) from $48/m to $58/m, dependent on the size of the pipe.

4.1.2 Flooding, Erosion, and Ponding Financial Implications

Ditch in-fill has the potential to increase flooding, erosion, and ponding water within the upstream ditch systems. Long term ponding within ditches could become a breeding location for insects such as mosquitos which could lead to the city having to spend additional funds to monitor and control the possible spread of the West Nile Virus. An announcement on the City of Ottawa website dated September 10, 2021, states: "*Ottawa Public Health has a proactive plan to address West Nile virus that includes weekly surveillance and, when necessary, mosquito larvicidal treatment of standing water on City property, such as ditches and storm water management ponds. Ottawa Public Health also regularly applies larvicide in City-owned roadside storm sewer catch-basins to reduce the mosquito population and the risk of West Nile virus.*"

In addition, increasing the length of time water ponding remains within the ditch bottom could lead, in the long term, to the ditch bottom being classified with "wetland" characteristics requiring modifications to the current ditch maintenance plan including increased cost.

A previously detailed unapproved ditch in-fill has the potential to increase flooding, erosion, and ponding and to mitigate the implication the ditches need to be routinely inspected and cleaned or additional financial implication will be placed upon the City. The City of Ottawa Spec Code list dated September 29, 2021 lists Earth Ditch Clean out at $42/m.

4.1.3 Perforated Pipe and Swale Financial Implications

Ditch in-fill with a perforated pipe and swale system will require additional inspection to determine if there is standing water within the system and the evidence of standing water would suggest the need for flushing of the system.

In the City of Ottawa when a perforated pipe and swale system is designed, the City of Ottawa Sewer Design Guidelines requires the designer to provide a cost benefit analysis to account for the additional maintenance costs associated with this system. Section 5.9, of the design guidelines, also states that this type of system, due to its complexity, is evaluated on a case-by-case basis. Therefore, a ditch that is in-filled with a perforated pipe and swale system without prior approval by the city will increase the maintenance an operation costs and these costs need be evaluated on a case-by-case basis.

The City of Ottawa Spec Code list dated September 29, 2021 lists the cost of a Flusher (Operated) (U020.25) as $141 per hour. Blockage or damage to the perforated pipe could require replacement of the system, which includes the perforated pipe, the filter sock, and the clear stone around the pipe.

4.1.4 City Provided Information

City staff from Asset Management Branch (AMB) provided the following illustrative dollar figures:

- Ditching maintenance costs = +/- $100/m; can be higher or lower depending on many variables. We have used the unit rate from the City's Unit Price Master Item List;
- A section of ditch gets filled in, and understandably, neither road operations or sewer maintenance are able to complete ditch or 'pipe' maintenance activities;
- If there are resulting surface drainage issues, residents and/or the Councillor's Office look for a remedy and the issue eventually gets deferred to Asset Management;
- Through the design, review, approve, procure, and construct process;
- Cost to reinstate ditch = +/- $1,000/m; and
- Cost to replace unauthorized and informal ditch infill with formal storm sewers on a street or neighbourhood = $1,000/m to $2,500/m or higher.

5.0 CONCLUSION

From the analyses completed to-date, it is clear that municipal roadside ditches provide invaluable, incalculable value to the land uses, communities, and watersheds that they are located in. Not only do they play a vitally important stormwater management role, but they also protect the adjacent lands and roadways from risk of flooding or failure, they play a role in mitigating risks associated with climate change and extreme weather events, they assist in groundwater recharge, and they contribute to green communities and healthy watersheds. Duty of care needs to be taken in decisions to authorize requests to alter roadside ditches.

6.0 GLOSSARY

The following definitions have been attained from technical literature associated with open channel drainage systems.

“Culverts” – Culverts form part of an open channel drainage system and are primarily used to convey flow from one open channel to another to overcome obstacles such as roadways or driveways.

“Ditches” – Ditches are small to moderate channel dug in the ground, often found adjacent to rural roads in urban setting used to convey storm runoff.

“Swales” – Swales are very shallow channels with gentle sloping sides used to help drain yards with excess water.

“Drainage”– Natural or artificial means of intercepting and removing surface or subsurface water (usually by gravity).

“Groundwater” – The water below the ground surface, and typically below the groundwater table.

“Infiltration” – The slow movement of surface water into or through a soil or subsurface drainage system.

“Integrated Stormwater Management” – An approach to stormwater management that integrates the land use planning, engineering, and environmental science functions with the goal of protecting property and wildlife habitat while accommodating land development.

“Major Storm Events” – The design storm with an average recurrence interval selected on the basis of satisfying requirements for flood control and safety. Design may vary in accordance with local authority guidelines. In Ottawa the major storm event is defined as the 100-year event.

“Major Storm Drainage System” – The major storm drainage system consists of natural streams, valleys, man-made street swales, channels, and ponds, that are designed to convey overland flows from larger storm events (above 100-years).

“Minor Storm Events” – The design storm with an average recurrence interval selected on the basis of satisfying requirements for convenience and safety of pedestrians and vehicles. Design may vary in accordance with local authority guidelines. In Ottawa the minor storm event is generally defined as the 5-year event.

“Minor Storm Drainage System” – The minor storm drainage systems are designed to direct minor storm events. The minor system consists of curb and gutters, inlets, sewers, and open channels (ditches).

“Outlet” – The point at which water discharges to a river, creek or stream, or artificial drain.

“Overland Flow Path” – Open space floodway channels, road reserves, pavement expenses, and other flow paths that convey flows typically more than the capacity of the minor drainage system.

“Runoff” – That portion of the water precipitated onto a catchment area, which flows as surface discharge from the catchment area past a specified point.

“Swale” – A shallow channel, often grassed-lined, which is used to transport storm water. They are generally characterized by a high-top width to depth ratio and gentle longitudinal grades.

“Watercourse” – A river, creek, or stream in which water flows permanently in a natural or artificial channel.

“Watershed/Catchment Area” - A watershed is all the land area that drains into a given body of water. Small watersheds combine to become big watersheds, sometimes called basins. When water from a few acres drains into a little stream, those few acres are its watershed. When that stream flows into a larger stream, and that larger stream flows into a bigger river, then the initial small watershed is now part of that river’s watershed. Watersheds are a logical way to think about the connection between the land and the quality of water we all benefit from. How we manage and treat the land has a direct impact on the ability of water to support several important public uses like swimming, fishing, aquatic species habitat and drinking water supply.

7.0 REFERENCES

1. City of Ottawa FACT SHEET - Roadside Drainage Systems – Request for Ditch Alteration
2. City of Ottawa Sewer Design Guidelines, October 2012
3. Credit Valley Conservation Authority and Toronto and Region Conservation Authority - Low Impact Development Stormwater Management Planning and Design Guide, 2010
4. City of Orillia website – Stormwater Management: Quantity and Quality Control
5. Ontario Ministry of Environment, Conservation and Parks website – Surface Water Quality Management
6. City of Ottawa Climate Change Master Plan, approved January 2020
7. City of Ottawa Climate Change Resiliency Strategy
8. City of Ottawa & NCC, FACT SHEET – What will the climate of Canada's Capital Region look like in the future?
9. Ottawa's Long-Term Risk Prevention & Mitigation Plan, 2012
10. National Guide to Sustainable Municipal Infrastructure – Road Drainage, Design Alternatives and Maintenance
11. The Toronto and Region Conservation Authority, Lake Simcoe Region Conservation Authority, Ryerson University and Ontario Ministry of the Environment – An Evaluation of Roadside Ditches and Other Related Stormwater Management Practices, J.F. Sabourin and Associates Inc. Second Edition February 2000
12. City of Ottawa, Ditch Alteration Policy, Public Works and Services Department, Approved by City Council, July 9, 2008
13. City of Ottawa, Low Impact Development Screening Tool for Municipal Right-of-Ways, Aquafor Beech Ltd., April 2020
14. City of Ottawa, Village Collector and Rural Arterial/Collector Road Design.
15. City of Ottawa Spec Code List, September 29, 2021
16. Ministry of the Environment, Design Guidelines for Sewage Works, 2008