CITY OF BOZEMAN

STORMWATER FACILITY INSPECTION PROPOSAL

MAY 2020

Produced By Montana State University
EENV 436 Stormwater Management Course

TABLE OF CONTENTS

The report was prepared by:
Michael Barene, Devin de Jong, Embla Hagensen, Caroline Requa, and Eric Wegren

INTRODUCTION

The current stormwater facility inspection tool that the City of Bozeman utilizes is entirely qualitative. In order to more effectively make and enforce decisions regarding stormwater facility maintenance (particularly for private and HOA-owned facilities), the City of Bozeman has asked Montana State University Students enrolled in EENV 436 Stormwater Management and Engineering, to develop a quantitative assessment tool to aid in stormwater facility inspections. The tool that has been developed consists of a tiered rating system. After stormwater facilities are inspected, they are placed in a tier that helps show the required level of maintenance required for that facility at that point in time. The tiers are determined by the quantitative information that is measured or collected by the inspector. The assessment tool aims to provide a user-friendly method to gather mensurable information about stormwater facilities, and thus allow the City of Bozeman to make decisions regarding maintenance.

GOALS AND OBJECTIVES

Develop a quantitative condition assessment protocol and rating system for private and HOA-owned stormwater facilities. With an analysis of the City of Bozeman's current Stormwater Facility Inspection Form, the team will create an efficient and accurate decentralized stormwater facility assessment tool. Along with the tool, an implementation plan will be drafted for both the City of Bozeman stormwater facility inspectors and the HOA for easy instructions on the facility inspections.

BACKGROUND & RESEARCH

The stormwater facilities referenced for this project are located in the Cattail Subdivision on the Northwest side of town. Cattail Subdivision contains 7 detention ponds used for stormwater runoff. In 2019, the City of Bozeman conducted a Stormwater Facility Audit that found that only 25% of stormwater facilities are currently receiving adequate maintenance. Many of the stormwater facilities are struggling with unwanted debris and vegetation, clogged inlet pipes, and no water movement. Currently, the City of Bozeman has been assessing these facilities through a qualitative condition assessment. These assessments are mostly based on a visual inspection and previous knowledge of the staff.

Information from other cities with developed stormwater management plans was used to discern which criteria were crucial to the function of detention ponds. Most other cities of similar population size to Bozeman assess items of detention ponds that appeared to fall into five general categories: blockage or deterioration of flow paths within ponds, vegetation condition, side slope condition, condition of the main storage bay, and overall condition of the facility. In order to create a quantitative, easy-to-use, and relatively quick assessment tool, the team picked five items that capture the essence of these categories. Items were picked/developed based on the criteria that they gather some form of quantitative

measurement, and that each measurement is relatively easy to obtain and monitor over time. The inspection items are described below.

INSPECTION ITEM DESCRIPTIONS

The following section outlines the tiered maintenance system and the grading criteria from the Stormwater Facility Inspection Form (Appendix A). There are different protocols for assessing each of the five grading criteria. This can serve as a walkthrough of what the inspection for inlet/outlet clogging, sediment, vegetation, and structure condition would resemble. As staffing allows, stormwater facilities inspections should occur annually. It is estimated that each inspection should take no more than 30 minutes.

A tiered maintenance system developed by the *ASCE* in their *Inspection and Maintenance of Stormwater Control Measures* will be used to help inform HOA's and the City of Bozeman of the level of maintenance required at a point in time at each detention pond. There are three tiers, starting with low or no maintenance required and ending with serious maintenance required immediately. Following is a description of the tiers.

- **Tier 1:** A Tier 1 maintenance level means that all parts of the detention pond are functioning properly and little to no maintenance is required. Routine procedures such as clearing trash and debris, trimming grass and vegetation, and other aesthetics-pleasing may be completed as needed or desired. Tier 1 means the pond poses little to no risk of overflowing or other failures.
- **Tier 2:** A maintenance level of Tier 2 means that the pond is still functioning well, but some pond items are beginning to impede the function of the pond. Routine procedures are recommended as soon as possible, and more procedures are likely required in the near future to prevent malfunction of the pond. Tier 2 means the pond is at medium risk to overflowing or other failures.
- **Tier 3:** A Tier 3 maintenance level means that the pond is not functioning properly and maintenance is required immediately to return the pond to a functioning state. Serious procedures are likely required. Tier 3 means that the pond is currently overflowing or failing, or that the pond is at high risk to overflows or other failures.

Detention ponds will be placed into maintenance tiers based on composite scores assigned by the inspector. A minimum score of 5 places a pond in Tier 1; a score of 6-14 places a pond in Tier 2; and a score of 15 or greater places a pond in Tier 3.

Composite scores are obtained from totaling subscores. Facility items are subscored as Good (1), Fair (2), Poor (3), and Extreme (11). Subscores between 3 and 11 (i.e. 4-10) may not be given. The purpose of an Extreme score of 11 is to automatically place the detention pond into a Tier 3 maintenance level if any one or more item is in failing condition. For instance, if four of the five inspection items are in working condition (subscores of 1), but the fifth item is failing (subscore of 11), the pond will still be marked as needing maintenance immediately. This scoring system aims to eliminate score averaging, which often misrepresents extreme conditions. It also helps to eliminate the need to add weight to items for weighted averages. The team found little information as to which items are more severe than others, so weighted averages were determined to be potentially misrepresentative.

Descriptions

A subscore of 1-3, or 11 must be assigned to each item. A subscore of 11 means that that individual item requires immediate maintenance and automatically places the pond in a tier 3 maintenance level. Subscores between 3 and 11 may not be assigned.

Total Score	Maintenance Tier
5	1
6-14	2
15 or greater	3

	Subscore Description			
	Good	Fair	Poor	Extreme
Item	1	2	3	11
Inlet Clogging	Inlet structure is 0-10% clogged. No maintenance required, item is performing as designed.	Inlet structure is 11-33% clogged. Maintenance will be likely be needed in the near future, but item is still performing well.	Inlet is 34-66% clogged. Item is still functioning, but maintenance is required at the earliest convenience.	Inlet is more than 66% clogged. Item is not functioning and requires maintenance immediately.
Outlet Clogging	Outlet structure is 0-10% clogged. No maintenance required, item is performing as designed.	Outlet structure is 11-33% clogged. Maintenance will be likely be needed in the near future, but item is still performing well.	Outlet is 34-66% clogged. Item is still functioning, but maintenance is required at the earliest convenience.	Outlet is more than 66% clogged. Item is not functioning and requires maintenance immediately.
Sediment	Pond volume has been reduced by 0-10% due to sediment accumulation. No maintenance required, function of pond is not impeded.	Pond volume has been reduced by 11-33% due to sediment accumulation. Function of pond is not impeded but it likely will be in near future. Maintenance not required but needed in near future.	Pond volume has been reduced by 34-66% due to sediment accumulation. Function of pond is beginning to be impeded. Requires maintenance at earliest convenience.	Pond volume has been reduced by more than 66% due to sediment accumulation. Function of the pond is impeded. Requires maintenance immediately.
Vegetation Height	Vegetation height is between 4 and 9 inches. It is not impeding function of the ponds and no maintenance is required.	Vegetation height is between 2- 4 inches or 9-12 inches. Function of pond is not impeded but likely will be in near future. Maintenance may be needed in near future.	Vegetation height is less than 2 inches or between 12-24 inches. Function of pond is beginning to be impeded. Requires maintenance at earliest convenience.	Vegetation height is bare or greater than 2ft. Function of pond is being impeded. Requires maintenance immediately.
Structure Condition	All stormwater structures including catch basins, inlet and outlet pipes, and embankments are in good condition and show no signs of cracking, erosion, or degradation that would impact the hydraulic performance of the structure.	Stormwater structures show minor signs of cracking and erosion but does not impact the hydraulic function of the structure. Deficiencies should be noted and watched to determine if maintenance is needed.	Stormwater structures show significant damage and may potentially fail in the near future. Maintenance should be scheduled for the earliest convenience.	Damage to stormwater structures are impacting the hydraulic function of the facility. Maintenance should be scheduled immediately.

Pond name: _____

Inspector: _____

Date: _____

Item	Subscore* (1, 2, 3, or 11*)	Notes
Inlet Clogging	1	
Outlet Clogging	1	
Sediment	1	
Vegetation Height	1	
Inlet/Outlet Structures	11	

*See 'Score Desctiptions' or 'Stormwater Facility Inspection Proposal' for detailed subscore explanations.

TOTAL for Pond:	15
Maintenance Tier:	3

FOR SEDIMENT:

Pond Surface Area=	100
Distance in 1st Inspection=	1
1st Inspection Volume=	100
% Reduction=	25

Distance in Current Inspection=	0.75
Current Volume=	75

Figure 1 - Stormwater Facility Inspection Form (Workable spreadsheet available in Appendix A)

INLET CLOGGING

Before runoff from a development can access a stormwater facility it must be collected and transferred through an inlet structure. An inlet structure could be a hydraulically designed pipe or a simple series of berms to direct water. Either way, they were designed to convey a calculated peak flow rate. Inlets can become impeded by trash, sediment, and vegetation which can greatly alter the amount of flow that can pass through. When a structure becomes too clogged, like the photo to the right, it may start to erode and flood areas around the inlet causing significant damage.

Figure 2: Probable Rating: Extreme (11)
Sediment buildup over 66%

Frequency:

A visual inspection of inlet structures should be performed regularly. Maintenance should be scheduled before peak flow rates due to snowmelt and before the first snowfall in the Fall. Maintaining during these critical times can positively affect the function of the stormwater facility over the summer and into the winter months.

Guidelines and Equipment:

Special attention to the condition of the surrounding areas for evidence of erosion is critical in determining performance. Some inlet structures involve the use of coarse aggregate as a filter media and if these rocks are not present the entire functionality of the facility can be impeded. Other methods include: gravel verge, turf fringe, rock-lined basin, or sediment box. Pretreatment strategies mentioned are of high importance in the overall design of the stormwater facility.

A representative from the City of Bozeman can perform an inspection fast and easy with a few pieces of equipment. A visual inspection and a photograph can be a useful tool when analyzing circular pipes. If a pipe is short and can be seen from one side it can be passed or failed quickly. When a pipe is longer it could be harder to analyze the level of clogging. Visually inspecting both sides and the use of flexible probes may be necessary for determining the severity of the clogging. For alternate inlet structures like pretreatment, a visual inspection of the area should suffice. In more complex designs, an inspection of the underlining of a filtration method used may be necessary. A shovel and a hand compaction tool should be carried by the inspector. After inspecting the area, compaction of the media should be completed to its original level. A photograph of the site should be required as documentation.

Rating System:

A simple survey shown below can be used by the City of Bozeman to analyze the condition of the facility. Once a facility has over one third (33%) of its inlet clogged it can seriously affect the hydraulic function it was originally designed to perform. A poor or extreme rating needs to be addressed immediately and the HOA needs to be alerted. The image to the right shows an example of some sediment and vegetation buildup.

Figure 3: Probable Rating: Fair (2)
Some sediment and vegetation

Table 1: Inlet Clogging Subscore Descriptions

Good	Fair	Poor	Extreme
1	2	3	11
Inlet structure is 0-10% clogged. No maintenance required, item is performing as designed.	Inlet structure is 11-33% clogged. Maintenance will likely be needed in the near future, but the item is still performing well.	Inlet is 34-66% clogged. Items are still functioning, but maintenance is required at the earliest convenience.	Inlet is more than 66% clogged. Item is not functioning and requires maintenance immediately.

OUTLET CLOGGING

Outlet structures are crucial to the performance of stormwater facilities. Outlet structures are carefully sized for each specific facility based on the storage capacity. Therefore, clogging or obstruction of the outlet can drastically affect the functionality of a stormwater pond. The best-designed pond cannot work properly if the outlet structure does not work as intended. Detention ponds can sometimes be an effective way to remove pollutants and trash that accumulate during storm events before the water enters waterways. However, trash sediment and other debris like excess leaves, overgrown grass or rocks can then clog the outlet structure which can impact the effectiveness of the detention pond. Inadequate drainage can result in severe flooding in residential areas.

Frequency:

Similar to the inlet clogging protocol, visual inspections of the outlet structure should be performed on the same schedule. These inspections should be conducted annually when there is limited snow accumulation to ensure that the outlet structure is visible. If staffing allows, the outlet structures of ponds should be inspected after large storm events as well.

Guidelines and Equipment:
Outlet structures can vary based on the construction of the wetland. Therefore, it can often be difficult to assess clogging of an outlet pipe aside from the initial inspection of the opening. It is recommended that the grate to the outlet structure is removed if applicable. If the outlet pipe is in a favorable location, a flashlight can be used to inspect the inside of the outlet piping. Estimate the percent of the outlet opening that is covered or clogged using a tape measure or measuring stick and performing basic percentage calculations. Images of the outlet pipe opening should be included in the final documentation. It is also important to ensure that the structural integrity of the outlet structure is not compromised.

Rating System:
The outlet structure for the applicable detention ponds inspections should be rated using the "Outlet Clogging" criteria shown in the table below. The estimated percentage covered should be recorded and assigned a value of Good (1), Fair (2), Poor (3), or Extreme (11). See the full workable Stormwater Facility Inspection Form in Appendix A.

Table 2: Outlet Clogging Subscore Description

Good	Fair	Poor	Extreme
1	2	3	11
Outlet structure is 0-10% clogged. No maintenance required, item is performing as designed.	Outlet structure is 11-33% clogged. Maintenance will be likely be needed in the near future, but item is still performing well.	Outlet is 34-66% clogged. Item is still functioning, but maintenance is required at the earliest convenience.	Outlet is more than 66% clogged. Item is not functioning and requires maintenance immediately.

Pipe Clogging Examples - Outlet Structures

Figure 4: Probable Rating: Good (1)
Slight debris in outlet structure, easily accessible, opening is not covered

Figure 5: Probable Rating: Poor (3)
Surrounding vegetation would likely impede pond function

Figure 6: Probable Rating: Poor (3)
Erosion around outlet structure

Figure 7: Probable Rating: Fair (2)
Large obstruction near opening

Figure 8: Probable Rating: Fair (2)
Sediment build up in basin, structure degrading

SEDIMENT

As stormwater enters a detention pond, it often carries sediment from the streets, ditches, and/or storm drains. This sediment accumulates in the pond, and over time reduces the volume of water that the pond can store. A decrease in detention pond storage volume can lead to overflows and flooding. It is important to monitor the amount of sediment building up in each pond so that it can be removed before overflows occur.

Guidelines:
To measure the reduction in storage caused by sediment buildup in an individual pond, the distance from a benchmark to accumulated sediments needs to be measured and multiplied by the surface area of the pond. For the purpose of this assessment tool, this calculation will be an estimate only and not an exact number.

To approximate the distance to accumulated sediment, a single measurement is needed. The measurement should be taken at the inlet structure of each pond where the most sediment is likely to accumulate. A benchmark location on each inlet structure, determined during the first inspection utilizing this assessment tool, shall be marked. Marking locations can be done with a permanent marker or etching a recognizable symbol to establish a benchmark. If there is no surface on an inlet structure (for instance, if the inlet is simply a pipe), the benchmark shall be the top of the structure (i.e. the top of the pipe). Measure the vertical distance from the benchmark directly downward to the top of the sediment.

To find the surface area of each pond, find as-built drawings and note the surface area. If drawings are not available, pond area can be approximated using the Polygon Measuring Tool in Google Earth.

Multiply the distance measured from the benchmark to the sediment by the pond area. This results in an approximate volume of water. By recording the results of this calculation during each inspection of an individual pond, approximated changes in storage volume can be monitored.

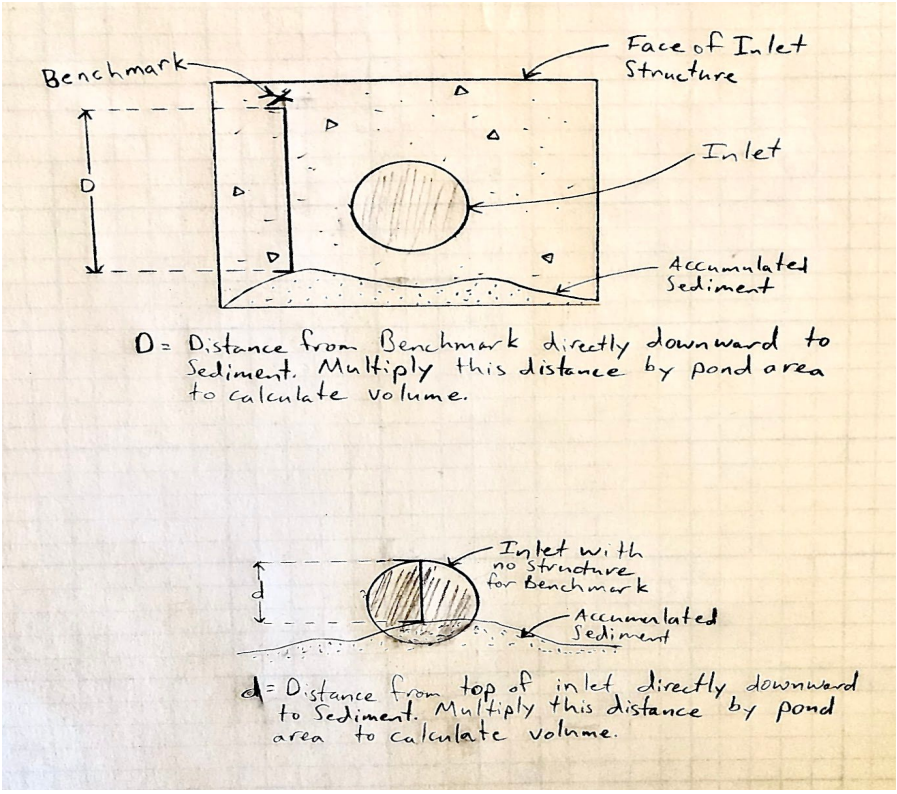

Figure 9: Example of measuring distance to sediment, with (top) and without (bottom) structure.

Equipment:

A permanent marker or hard, sharp object (such as a nail) is needed to mark the Benchmark on the inlet structure at each detention pond, if the structure has a surface or available area to mark (see above if there is no surface). While this is only required for the first inspection of an individual pond, it may be necessary to re-mark the benchmark in case of fading or deterioration of the original mark.

A tape measure, ruler, yardstick, or similar measuring tool is required to measure the distance from the benchmark to the sediment. As-built drawings of the detention pond being inspected are required in order to calculate the area of the pond. If as-builts are not available to the inspector, Google Earth's Polygon Measuring Tool can be used. Although not required, a calculator may be useful to aid in the multiplication of distance to sediment and pond area.

Rating system:

If the calculated volume of water (distance from datum to sediment multiplied by pond area) is 0-10% less than the volume calculated during the first inspection, the pond receives a subscore of "1" in the "Sediment" category. A subscore of "1" means that no maintenance is required, and the function of the pond is not being impeded by sediment accumulation.

If the calculated volume of water is 11-33% less than the volume calculated during the first inspection, the pond receives a subscore of "2" in the "Sediment" category. A subscore of "2" means that the function

of the pond is not being impeded by sediment accumulation but it likely will be in the near future. Maintenance is not required currently but will be soon.

If the calculated volume of water is 34-66% less than the volume calculated during the first inspection, the pond receives a subscore of "3" in the "Sediment" category. A subscore of "3" means that the function of the pond is beginning to be impeded by sediment accumulation. Maintenance is required at the earliest convenience.

If the calculated volume of water is 67-100% less than the volume calculated during the first inspection, the pond receives a subscore of "11" in the "Sediment" category. A subscore of "11" means that the function of the pond is completely impeded by sediment accumulation. Maintenance is required immediately.

Table 3: Sediment Subscore Description

Good	Fair	Poor	Extreme
1	2	3	11
Pond volume has been reduced by 0-10% due to sediment accumulation. No maintenance required, function of pond is not impeded.	Pond volume has been reduced by 11-33% due to sediment accumulation. Function of pond is not impeded but it likely will be in near future. Maintenance not required but needed in near future.	Pond volume has been reduced by 34-66% due to sediment accumulation. Function of pond is beginning to be impeded. Requires maintenance at earliest convenience.	Pond volume has been reduced by more than 66% due to sediment accumulation. Function of the pond is impeded. Requires maintenance immediately.

VEGETATION

Plants and vegetation are important factors that help improve water quality in stormwater facilities. Plants are responsible for absorbing water and nutrients, and the roots of the plants help in stabilizing banks and reducing erosion (Stormwater 2015). Vegetation also helps in trapping trash and pollution and provides a habitat for wildlife. Management of vegetation helps reduce stormwater facility problems and makes maintenance easier to assess. Cattail Creek Subdivision Facilities are dry ponds, which means that the pond dewaters between storm events. The following information was collected from the City of Portland's, *Stormwater Facility Inspection and Maintenance Manual,* and ASCE's *Inspection and Maintenance of Stormwater Control Measures*.

Figure 10: Probable Rating: Good (1)
Short grass with no bare ground

Frequency:
According to the City of Portland, the inspection of vegetation should be done at least once a year. These inspections should review the side and bottom vegetation of the pond. If accessible, it can be helpful to have the landscape plan of the stormwater facility to assess whether the plants that were initially planted are still present in the area. It is best to check the conditions of the vegetation when the pond is dry. It is acceptable if the bottom of the pond does not have vegetation, but the side of the pond should have vegetation unless it is a newly developed pond.

Guidelines and Equipment:

Figure 11: Probable Rating: Fair (2)
Pond bottom is clear but pond sides have overgrown vegetation

Pond Walls and Bottom: To ensure that proper vegetation management is maintained, the pond walls need to be mowed between 4 to 9 inches, and the clippings need to be removed. Bring a measuring stick to record the average length of the grass in the area. The recorded data provides an idea of when the next grass clipping should proceed. The pond wall needs to be reseeded if bare. Check what type of grass is currently planted or find seeds for a native grass that is located in the area. For best growth, plant the seeds during the late spring, so the grass has a chance to grow before the cold weather in the Fall arrives.

Around the Pond: Remove trees and shrubs that may cause issues to the pipes and structures for the pond. If trees are shading areas that reduce vegetation growth, consider removing these trees. Visual inspection is needed for this type of inspection. Describe the current state of the trees and shrubs and whether there are any issues with roots or shading. Pictures can help future inspectors analyze changes in the area. Check the surrounding area for invasive or poisonous plants. Either carry a book with known native and invasive vegetation in the area or provide a sheet with an overview of the main invasive species that can be found in the area.

Rating System:
The City of Portland suggests that the vegetation on the sides of the pond and pond bottom "should be mowed during the dry season to keep it 4" to 9 `` tall". If the grass is too tall, it can lead to problems in evaluating the conditions of the stormwater facility. After the grass is cut, the grass clippings should be removed from the pond area to avoid clogging issues. If areas of the pond are bare, reseed the area as soon as possible.

Figure 12: Probable Rating: Poor (3)
Overgrown vegetation prevents drainage

Table 4: Vegetation Height Subscore Descriptions

Good	Fair	Poor	Extreme
1	2	3	11
Vegetation height is between 4 and 9 inches. It is not an impending function of the ponds and no maintenance is required.	Vegetation height is between 2- 4 inches or 9-12 inches. Function of pond is not impeded but likely will be in near future. Maintenance may be needed in near future.	Vegetation height is less than 2 inches or between 12-24 inches. Function of pond is beginning to be impeded. Requires maintenance at earliest convenience.	Vegetation height is bare or greater than 2ft. Function of pond is being impeded. Requires maintenance immediately.

Trees and shrubs can also be located in the stormwater facilities. Be observant of whether the roots of the trees are causing issues to the slopes and if the trees block the sun from areas where the grass should grow. The trees should also not be blocking the path of flow or the inlets or outlets. Taking pictures during each inspection will help determine the growth of the vegetation in the area.

STRUCTURE CONDITION

The condition of the physical structures that are part of the stormwater system are critical to the function of the system. Some examples of these structures are inlet pipes, bank protection, and outlet structures. The elevations of outlet weirs and orifices were intentionally designed and if damaged, they may function in a way that does not meet local runoff requirements. If these structures completely fail, the chance of damage to the surrounding property and infrastructure increases significantly.

Guidelines and Equipment

A visual inspection of the physical structures is adequate to determine the condition of the structures. All pipes coming into or out of the stormwater facility should be checked for cracking. Any concrete structures, such as catch basins or curb chases should be checked for cracks or deficiencies in the concrete. Any screens or grates should be checked for deficiencies. Maintenance should be conducted on an as-needed basis for repairs.

Boots should be brought for if there are any structures located in wet areas of the facility. A flashlight to check the inside of the structures. A probe should be used to check the depth of sediment or the water level within a structure. Confined spaces within structures should not be entered unless the proper OSHA certifications are obtained.

Rating system

The rating system is based on a visual inspection of concrete and pipe materials. The inspector should have an understanding of visual material inspection or have reference materials available.

Table 5: Structure Condition Subscore Descriptions

Good	Fair	Poor	Extreme
1	2	3	11
All stormwater structures including catch basins, inlet and outlet pipes, and embankments are in good condition and show no signs of cracking, erosion, or degradation that would impact the hydraulic performance of the structure.	Stormwater structures show minor signs of cracking and erosion but do not impact the hydraulic function of the structure. Deficiencies should be noted and watched to determine if maintenance is needed.	Stormwater structures show significant damage and may potentially fail in the near future. Maintenance should be scheduled for the earliest convenience.	Damage to stormwater structures is impacting the hydraulic function of the facility. Maintenance should be scheduled immediately.

Figure 13: An outlet structure in poor condition. Significant cracking and rebar showing.

Figure 14: An outlet structure in good condition. No noticeable cracking.

INSPECTION RESPONSIBILITIES

A City of Bozeman employee who has been trained on the use of the *Stormwater Facility Inspection Form* (Appendix A) is recommended to perform the detention pond inspections. However, landscapers, adjacent homeowners, and Homeowners Association (HOA) members are encouraged to share if they notice potential problems with the surrounding ponds.

For reference, the table below outlines the skill level for diagnosing problems during the inspection. The facility inspections in Bozeman will be conducted by city employee personnel with a skill level of either 1 or 2 and on rare occasions, level 3. Citizens with level 0 experience can share concerns about local ponds with the HOA if the information is provided in a hand out to the community. This information is then shared with the respective HOA and maintenance can be mandated.

Table 6: EPA Stormwater Wet Pond and Wetland Management Guidebook

Table 2.1: Inspection Skill Level Descriptions	
Skill Level	**Description**
0	No special skills or prior experience required, but some basic training via manual, video, or other materials is necessary.
1	Inspector, maintenance crew member or citizen with prior experience with ponds and wetlands
2	Inspector or contractor with extensive experience with pond and wetland maintenance issues
3	Professional engineering consultant

The *Stormwater Facility Inspection Form* is predicted to take approximately 30 minutes to complete. To perform the inspection, it is recommended that the inspector will have access to a tablet that can take photos and run the program used by the City of Bozeman. Photographs of the grading criteria and any abnormal pond properties should be uploaded with the inspection form. Spray paint should be used to make discrete markings of areas that need maintenance.

The following list summarizes the recommended materials that the inspector will use during each inspection:

- Tablet with a camera
- Tape Measure
- Spray Paint
- Measuring Stick
- Sediment Estimation Kit
    - Tape Measure, ruler, yardstick, or similar measuring tool
    - Permanent marker and hard, sharp object (like a nail)
    - As-Built Drawings and/or Google Earth
    - Calculator (optional)
- Flashlight
- Paper and Pen

The inspections are suggested to be completed at least once a year unless otherwise noted. The inspections should occur during the late spring or summer. This assures that there is no water in the facility so all inspections can be determined.

CONCLUSION

Studies have shown that poor operation and maintenance is the leading reason for pond failure. Bozeman has around 600 stormwater facilities with very few of these receiving acceptable maintenance. As Bozeman continues to grow, the number of stormwater facilities will also continue to rise. The Stormwater Facility Inspection Form has been provided to help reduce the time each inspection takes while providing quantitative (rather than qualitative) values that will help the City of Bozeman evaluate their stormwater facilities and enforce needed maintenance. This number can be of great use for the City's records and an HOA's understanding of why their detention pond is or is not performing well. The corresponding tiered system for maintenance will allow these HOA's to develop short and long term comprehensive plans, including a budget, inspection frequency, and record-keeping processes.

REFERENCES

Inspection and Maintenance of Stormwater Control Measures. (2019, August 7). Retrieved April 20, 2020, from https://ascelibrary.org/doi/book/10.1061/9780784415436

Maintaining Your Detention Basin - Clermont SWCD. (2016, August 23). Retrieved April 22, 2020, from https://clermontswcd.org/wp-content/uploads/sites/23/2016/08/clermontswcdbasinmanual.pdf

Stormwater Drainage Infrastructure Maintenance Guidelines and FAQ: New Braunfels, TX - Official Website. (n.d.). Retrieved April 29, 2020, from https://www.nbtexas.org/2366/Stormwater-Drainage-Infrastructure-Maint

Stormwater Facility Inspection and Maintenance Manual. (2015, October). Retrieved April 19, 2020, from http://www.co.whatcom.wa.us/DocumentCenter/View/34229/Private-Stormwater-Facility-Inspection-and-Maintenance-Manual

Stormwater Wet Pond and Wetland Management Guidebook. (2009, February). Retrieved April 22, 2020, from https://www3.epa.gov/npdes/pubs/pondmgmtguide.pdf