# City of Reminderville

## Clipper Cove Flooding Study

3007-21-0040

OCTOBER 2021

OHM Advancing Communities®

# Contents

## Tables

## Figures

## Appendices

# A. Introduction – Need for Project

The flooding that occurred in the City of Reminderville (City) on September 7, 2020 (Labor Day) revealed that the City's stormwater conveyance system needed to be evaluated based on its ability to provide a reasonable Level of Service (LOS) to the residents of Reminderville. The flooding that occurred on and around September 7, 2020 was the result of high river levels observed along the Pond Brook Creek; the high river levels resulted in significant area flooding, yard flooding, basement flooding, and private property damage.

The scope of work for this project consisted of modeling and preliminary design, focusing on the Clipper Cove crossing and the flood prone areas north of Nautilus Trail. Additional upstream and downstream analysis was used to quantify the impacts of any hydraulic improvements and to demonstrate no adverse impact. Several alternatives were considered, at various levels of service, to provide the City with the analysis needed to make informed decisions about stormwater management improvements. A general guiding definition of success, as expressed by the City, was to prevent homes in the City from being flooded, which would mean maintaining the flood level upstream of Clipper Cove culvert lower than 997 feet.

The hydrologic and hydraulic modeling program PCSWMM 7.3 was used to estimate peak flow rates and determine the hydraulic capacity of City's Clipper Cove culvert and downstream open channel network. PCSWMM is a physically-based storm event simulation program capable of simulating runoff from various land uses and soil types, combining sub-basin hydrographs, and routing flow through storage (detention ponds and/or surface flooding) and conveyance elements (sewers, open drainage channels, and roadway flow that occurs when the sewer system is surcharged).

The findings from this modeling effort, which quantify the impact of a variety of alternatives from which the City can choose which to pursue, are covered in the following sections of this report.

# B. Key Findings and Recommendations

A larger redesign and reconstruction of the entire drainage system would likely be required to fully address flooding issues for low-lying homes in the vicinity of Clipper Cove. Implementing hydraulic improvements with a sole focus on Clipper Cove or any one location will have very limited benefits. A combination of improvements may cumulatively reduce flooding to a more acceptable level of service. However, the exploration of all possible combinations of alternatives showed that it was likely not feasible to eliminate the flood risk for a 100-year recurrence interval without buying the lowest property.

Key findings of each flooding mitigation alternative are summarized in Table 1.

The combination of proposed projects that shows the most significant beneficial impact to alleviating flooding in the City is to replace the Clipper Cove culvert and implement a regional storage system upstream of the culvert.

The implementation of any hydraulic improvements at Clipper Cove culvert or other areas within the Pond Brook drainage system will trigger a permit to work within the floodplain, which could trigger a requirement to officially update the official (FEMA) floodplain within the City. If the floodplain is officially updated, it would likely bring additional properties within the regulatory floodplain boundary.

Property owners can also play a role in maintaining local drainage systems by removing lawn debris and other obstructions. See the Section *Drainage Maintenance on Individual Properties* for additional information.

*Table 1: Flooding Mitigation Alternatives and Key Findings*

| ID | Alternative | Impacts/Benefits |
|---|---|---|
| 1 | Replace Clipper Cove Culvert<br>*16 ft x 4 ft box culvert* | Reduces flooding at Clipper Cove by depth of 6 inches for 100-year storm. |
| | | Increases downstream peak flows by up to 25% for 100-year storm. |
| | | Will trigger state regulatory review and a potential FEMA floodplain study. |
| | | Preliminary estimate: $717,365. |
| | | Reduces maintenance requirements. |
| 2 | Regrade Pond Brook Downstream<br>*1,500 ft channelization* | No flood reduction at Clipper Cove. |
| | | Reduces flooding downstream of the City by 5 inches for 100-year storm. |
| | | Planning-level cost not calculated due to zero impact in area of concern. |
| 3 | Add Regional Storage Detention System Upstream of Clipper Cove<br>*6 detention ponds with total footprint of 5.3 acres* | Reduces flooding at Clipper Cove by depth of 1.4 ft for 100-year storm. |
| | | Reduces flooding north of Clipper Cove by depth of 2.1 ft for 100-year storm. |
| | | Requires tree removal, regulatory permits, land acquisition, significant excavation. |
| | | Planning-level cost: $1,900,000* |
| 1 + 3 | Combination:<br>Add Regional Storage Detention System Upstream of Clipper Cove and Replace Clipper Cove Culvert<br>*6 detention ponds with total footprint of 5.3 acres*<br>*16 ft x 4 ft box culvert* | Reduces flooding at Clipper Cove by depth of 1.6 ft for 100-year storm. |
| | | Reduces flooding north of Clipper Cove by depth of 2.3 ft for 100-year storm. |
| | | Requires tree removal, regulatory permits, land acquisition, significant excavation. |
| | | Planning-level cost: $2,600,000* |
| 4 | Add Regional Storage Detention System Upstream and Downstream of Clipper Cove<br>*8 detention ponds with total footprint of 8.1 acres* | Reduces flooding at Clipper Cove by depth of 1.4 ft for 100-year storm. |
| | | Reduces flooding north of Clipper Cove by depth of 2.1 ft for 100-year storm. |
| | | Requires tree removal, regulatory permits, land acquisition, significant excavation. |
| | | Planning-level cost: $2,400,000* |
| 1 + 4 | Add Regional Storage Detention System Upstream and Downstream of Clipper Cove and Replace Clipper Cove Culvert | Reduces flooding at Clipper Cove by depth of 1.7 ft for 100-year storm. |
| | | Reduces flooding north of Clipper Cove by depth of 2.3 ft for 100-year storm. |
| | | Requires tree removal, regulatory permits, land acquisition, significant excavation. |

| | | |
|---|---|---|
| | *8 detention ponds with total footprint of 8.1 acres*<br>*16 ft x 4 ft box culvert* | Planning-level cost: $3,100,000* |
| 5 | Divert Walmart runoff to Aurora Lake in the City of Aurora | No flood reduction at Clipper Cove. |
| | | No flood reduction north of Clipper Cove. |
| | | Requires modification to stormwater infrastructure, coordination with Bainbridge, Walmart, Homeowners Association. |
| | | Shall estimate cost if City decides to pursue this option. |
| 6 | Divert Signature of Solon runoff to Aurora Lake in the City of Aurora | Reduces flooding at Clipper Cove by depth of 0.4 ft for 100-year storm. |
| | | Reduces flooding north of Clipper Cove by depth of 0.3 ft for 100-year storm. |
| | | Requires modification to stormwater infrastructure, coordination with Solon, golf course, Homeowners Association. |
| | | Shall estimate cost if City decides to pursue this option. |
| 7 | Install Pump Station<br>*75 million gallon per day (MGD) pump station* | Reduces flooding at Clipper Cove by depth of 0.5 ft for 100-year storm. |
| | | Reduces flooding north of Clipper Cove by depth of 0.2 ft for 100-year storm. |
| | | Requires land acquisition, electrical service upgrades, and a pump station control facility. |
| | | Planning-level cost: $5,400,000* |
| 8 | Install Pump and Gate at Anchorage Cove<br>*35 MGD pump station*<br>*700-ft-long gate* | Reduces flooding at Clipper Cove by depth of 1.9 ft for 100-year storm. |
| | | Increases flooding north of Clipper Cove by depth of 3.9 ft for 100-year storm. |
| | | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Requires land acquisition, electrical service upgrades, and a pump station control facility. Increases flood levels north of Clipper Cove culvert. |
| | | Planning-level cost: $4,200,000* |
| 1 + 8 | Combination:<br>Replace Clipper Cove Culvert, Install Pump Station, and Install Gate at Anchorage Cove<br>*16 ft x 4 ft box culvert*<br>*35 MGD pump station*<br>*400-ft-long gate* | Reduces flooding at Clipper Cove by depth of 1.9 ft for 100-year storm. |
| | | Increases flooding north of Clipper Cove by depth of 0.9 ft for 100-year storm. |
| | | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Requires land acquisition, electrical service upgrades, and a pump station control facility. Increases flood levels north of Clipper Cove culvert. |
| | | Planning-level cost: $5,000,000* |
| 1 + | Combination:<br>Replace Clipper Cove Culvert, Install Small | Reduces flooding at Clipper Cove by depth of 1.4 ft for 100-year storm. |
| | | Increases flooding north of Clipper Cove by depth of 0.9 ft for 100-year storm. |

| | | |
|---|---|---|
| 8 S | Budget Pump Station Without Superstructure, and Install Gate at Anchorage Cove<br>*16 ft x 4 ft box culvert*<br>*10 MGD pump*<br>*400-ft-long gate* | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Requires land acquisition, electrical service upgrades, and a pump station control facility. Increases flood levels north of Clipper Cove culvert. Extra maintenance for unprotected pump station. |
| | | Planning-level cost: $2,900,000* |
| 1 + 8 XS | Combination:<br>Replace Clipper Cove Culvert, Install Tiny Budget Pump Station Without Superstructure, and Install Gate at Anchorage Cove<br>*16 ft x 4 ft box culvert*<br>*1 MGD pump*<br>*400-ft-long gate* | Reduces flooding at Clipper Cove by depth of 1.0 ft for 100-year storm. |
| | | Increases flooding north of Clipper Cove by depth of 0.9 ft for 100-year storm. |
| | | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Requires land acquisition, electrical service upgrades, and a pump station control facility. Increases flood levels north of Clipper Cove culvert. Extra maintenance for unprotected pump station. |
| | | Planning-level cost: $2,400,000* |
| 9 | Install Weir on Pirates Trail branch | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| | | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. |
| 10 | Install Weir at Liberty Ledges | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| | | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. |
| 11 | Install Weir at Crossings confluence | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| | | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. |
| 12 | Install Backflow Gate at Glenwood Blvd. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| | | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. |
| 13 | Modify Culvert at Glenwood Blvd. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |

| | | |
|---|---|---|
| | | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. |
| **14** | Modify Drainage at Glenwood Blvd. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| | | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. |
| **15** | Property Buy-Out<br>*Purchase 5 homes in low areas and regrade for floodplain storage* | Removes flood-prone homes |
| | | Requires purchase agreements with homeowners. |
| | | Planning-level cost: $1,200,000 |

*Planning-level costs exclude land acquisition costs and operations & maintenance costs. Further design needed for more refined cost opinions.

## C. Level of Service

The Level of Service (LOS) for a stormwater system is traditionally defined as the storm magnitude (i.e., annual exceedance interval) that the collection system can convey without causing surface flooding that may negatively impact residents, businesses, and institutions. This is often referred to in terms of inches of rainfall or annual recurrence interval, such as the 10-year storm (also known as the 10% storm, as it has a one-in-ten chance of being exceeded in any given year). For this analysis, the 2-year (50%), 10-year (10%), 25-year (4%), 50-year (2%), and 100-year (1%) recurrence interval events were analyzed, as they provide a wide range of LOS that can be used to evaluate different parts of the City's stormwater conveyance system.

***Based on our analysis of the City's open channel stormwater conveyance system, the LOS varies between different neighborhoods; however, in general, the system can adequately convey a 2-year storm (50% chance of being exceeded in any given year) without overbank flooding that would inundate private property, except the Anchorage Cove and Skippers Cove neighborhoods, which may experience flooding even during a 1-year storm.***

Upon discussion with City staff, it was determined that a 100-year storm (1% chance of being exceeded in any given year) should be used as the basis for evaluating the Clipper Cove culvert. A 10-year storm is the typical municipal standard, so each alternative was also evaluated at that LOS. The City also requested that each alternative be evaluated for a 1-year storm to better understand the minimum impact the alternative might have.

More specifically, stormwater infrastructure components were considered as not achieving the desired LOS if:

### 1. Culverts

- The headwater resulting from a 100-year storm exceeds the roadway surface elevation and results in roadway flooding (this increases the likelihood of a roadway washout).
- The headwater resulting from a 100-year storm creates a hydraulic surcharge that adversely impacts the upstream open channel conveyance system and causes flooding on private property.

# D. Summary of Alternatives Analysis

## 1. Quantitative Analysis

Table 2 presents a summary of the analysis of each of the alternatives that was analyzed quantitatively.

*Table 2: Summary of Quantitative Alternatives Analysis*

| ID | Alternative | Description | Challenges | Cost | Level of Service Upstream of Clipper Cove | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-year Flood Elevation (Flood Level Reduction) (ft) | | 10-year Flood Elevation (Flood Level Reduction) (ft) | | 100-year Flood Elevation (Flood Level Reduction) (ft) | | Labor Day 2020 Flood Elevation (Flood Level Reduction) (ft) | |
| | | | | | East Branch | North Branch | East Branch | North Branch | East Branch | North Branch | East Branch | North Branch |
| **Quantitative Analysis** | | | | | | | | | | | | |
| **Existing Conditions** | | | | | **995.2** | **995.3** | **997.0** | **997.2** | **998.4** | **999.1** | **998.9** | **998.9** |
| 1 | Replace Clipper Cove Culvert | Replace the existing Clipper Cover Culvert with a 16 ft x 4 ft box culvert. | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. | Preliminary estimate: $720,000 | 994.8 (0.4) | 995.2 (0.1) | 996.6 (0.4) | 997.1 (0.1) | 997.9 (0.5) | 998.9 (0.2) | 997.8 (1.1) | 998.5 (0.4) |
| 2 | Regrade Pond Brook Downstream | Straighten and widen the meandering Pond Brook Creek in Liberty Park, roughly 1,500 ft of channel. | Shall contact DNR to determine feasibility if City decides to pursue this option. | Shall estimate cost if City decides to pursue this option. | 995.2 (0) | 995.3 (0) | 997 (0) | 997.2 (0) | 998.4 (0) | 999.1 (0) | 998.8 (0.1) | 998.8 (0.1) |
| 3 | Regional Storage Detention System - Upstream of Clipper Cove (with no modifications to Clipper Cove culvert) | Add six regional detention ponds (Herrington, Maryland North, Illinois, Georgia, Maryland, Walmart) to reduce peak flow at Clipper Cove culvert. | Requires tree removal, regulatory permits, land acquisition, significant excavation. | Planning-level cost: $1,900,000* | 994.1 (1.1) | 994.1 (1.2) | 995.8 (1.2) | 995.8 (1.4) | 997 (1.4) | 997 (2.1) | 997 (1.9) | 997 (1.9) |
| Combination 1 + 3 | Regional Storage Detention System - Upstream of Clipper Cove (with Clipper Cove culvert replaced) | Add six regional detention ponds (#3) and replace the existing Clipper Cove culvert with a 16 ft X 4 ft box culvert (#1). | Requires tree removal, regulatory permits, land acquisition, significant excavation. | Planning-level cost: $2,600,000* | 993.9 (1.3) | 994 (1.3) | 995.4 (1.6) | 995.5 (1.7) | 996.8 (1.6) | 996.8 (2.3) | 996.5 (2.4) | 996.6 (2.3) |
| 4 | Regional Storage Detention System - Upstream and Downstream of Clipper Cove (with no modifications to Clipper Cove culvert) | Add the regional detention ponds above (#3) plus two detention ponds (Pirate and Windjammer) downstream of Clipper Cove to reduce peak flow at Clipper Cove culvert. | Requires tree removal, regulatory permits, land acquisition, significant excavation. | Planning-level cost: $2,400,000* | 994 (1.2) | 994.1 (1.2) | 995.7 (1.3) | 995.8 (1.4) | 997 (1.4) | 997 (2.1) | 996.9 (2) | 996.9 (2) |
| Combination 1 + 4 | Regional Storage Detention System - Upstream and Downstream of Clipper Cove (with Clipper Cove culvert replaced) | Add eight regional detention ponds (#5) and replace the existing Clipper Cove culvert with a 16 ft X 4 ft box culvert. | Requires tree removal, regulatory permits, land acquisition, significant excavation. | Planning-level cost: $3,100,000* | 993.9 (1.3) | 994 (1.3) | 995.4 (1.6) | 995.5 (1.7) | 996.7 (1.7) | 996.8 (2.3) | 996.5 (2.4) | 996.5 (2.4) |
| 5 | Divert Walmart runoff to Aurora Lake in the City of Aurora | Re-route all runoff from Walmart to Aurora Lake instead of ditch system. | Requires modification to stormwater infrastructure, coordination with Bainbridge, Walmart, Homeowners Association. | Shall estimate cost if City decides to pursue this option. | 995.2 (0) | 995.3 (0) | 997 (0) | 997.2 (0) | 998.4 (0) | 999.1 (0) | 998.8 (0.1) | 998.9 (0) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | Divert Signature of Solon runoff to Aurora Lake in the City of Aurora | Re-route all runoff from Signature of Solon golf course to Aurora Lake instead of ditch system. | Requires modification to stormwater infrastructure, coordination with Solon, golf course, Homeowners Association. | Shall estimate cost if City decides to pursue this option. | 995 (0.2) | 995.2 (0.1) | 996.8 (0.2) | 997 (0.2) | 998 (0.4) | 998.8 (0.3) | 998.3 (0.6) | 998.4 (0.5) |
| 7 | Install Pump Station | Install a new pump station instead of replacing Clipper Cove culvert. Pump station would be rated for 75 MGD. | Requires land acquisition, electrical service upgrades, and a pump station control facility. | Planning-level cost: $5,400,000* | 994.8 (0.4) | 995.2 (0.1) | 996.6 (0.4) | 997.1 (0.1) | 997.9 (0.5) | 998.9 (0.2) | 997.8 (1.1) | 998.5 (0.4) |
| 8 | Install Pump and Gate at Anchorage Cove | Install 35 MGD pump station and 700-ft-long gate (height at elevation 1004 ft) upstream of Clipper Cove culvert that pumps into Aurora Lake boating channel. | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Requires land acquisition, electrical service upgrades, and a pump station control facility. Increases flood levels north of Clipper Cove culvert. | Planning-level cost: $4,200,000* | 994.6 (0.6) | 995.3 (0) | 995.7 (1.3) | 999.5 (-2.3) | 996.5 (1.9) | 1003 (-3.9) | 996.6 (2.3) | 1002.3 (-3.4) |
| Combination 1 + 8 | Replace Clipper Cove Culvert, Install Pump Station, and Install Gate at Anchorage Cove | Replace the existing Clipper Cover Culvert with a 16 ft x 4 ft box culvert. Install a new 35 MGD pump station and 400-ft-long gate (height at elevation 1001 ft) upstream of Clipper Cove culvert that pumps into Aurora Lake boating channel. | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Requires land acquisition, electrical service upgrades, and a pump station control facility. Increases flood levels north of Clipper Cove culvert. | Planning-level cost: $5,000,000* | 994.6 (0.6) | 995.1 (0.2) | 995.7 (1.3) | 997.8 (-0.6) | 996.5 (1.9) | 1000 (-0.9) | 996.6 (2.3) | 999.4 (-0.5) |
| Combination 1 + 8, small version | Replace Clipper Cove Culvert, Install Small Budget Pump Station Without Superstructure, and Install Gate at Anchorage Cove | Replace the existing Clipper Cover Culvert with a 16 ft x 4 ft box culvert. Install a new 10 MGD pump station and 400-ft-long gate (height at elevation 1001 ft) upstream of Clipper Cove culvert that pumps into Aurora Lake boating channel. | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Requires land acquisition, electrical service upgrades, and a pump station control facility. Increases flood levels north of Clipper Cove culvert. Extra maintenance for unprotected pump station. | Planning-level cost: $2,900,000* | 995.3 (-0.1) | 995.1 (0.2) | 996.3 (0.7) | 997.8 (-0.6) | 997 (1.4) | 1000 (-0.9) | 997.5 (1.4) | 999.4 (-0.5) |
| Combination 1 + 8, tiny version | Replace Clipper Cove Culvert, Install Tiny Budget Pump Station Without Superstructure, and Install Gate at Anchorage Cove | Replace the existing Clipper Cover Culvert with a 16 ft x 4 ft box culvert. Install a new 1 MGD pump station and 400-ft-long gate (height at elevation 1001 ft) upstream of Clipper Cove culvert that pumps into Aurora Lake boating channel. | Shall follow state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Requires land acquisition, electrical service upgrades, and a pump station control facility. Increases flood levels north of Clipper Cove culvert. Extra maintenance for unprotected pump station. | Planning-level cost: $2,400,000* | 995.9 (-0.7) | 995.1 (0.2) | 996.8 (0.2) | 997.8 (-0.6) | 997.4 (1) | 1000 (-0.9) | 997.9 (1) | 999.4 (-0.5) |

## 2. Qualitative Analysis

Table 3 presents a summary of the analysis of each of the alternatives that was analyzed qualitatively.

*Table 3: Summary of Qualitative Alternatives Analysis*

| ID | Alternative | Description | Challenges | Cost | Level of Service |
|---|---|---|---|---|---|
| 9 | Install Weir on Pirates Trail branch | Install weir upstream of Pirates Trail branch junction. | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. | Not estimated. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| 10 | Install Weir at Liberty Ledges | Install weir in the stream between the shopping center and Liberty Ledges subdivision. | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. | Not estimated. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| 11 | Install Weir at Crossings confluence | Install weir downstream of the confluence of ditches from Crossings Dr. and Signature of Solon golf course. | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. | Not estimated. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| 12 | Install Backflow Gate at Glenwood Blvd. | Install a backflow gate upstream of the Crossings Dr. & Glenwood Blvd. culvert. | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. | Not estimated. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| 13 | Modify Culvert at Glenwood Blvd. | Modify the culverts along Glenwood Blvd. to divert to flow to the boat channel. | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. | Not estimated. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| 14 | Modify Drainage at Glenwood Blvd. | Modify drainage along Glenwood Blvd. to prevent backflow from boat channel. | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. | Not estimated. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| 15 | Property Buy-Out | Purchase five homes in the lowest area near Clipper Cove culvert and regrade the area into flood storage. | Requires purchase agreements with home owners. | Planning-level cost: about $1,200,000 to purchase 5 homes | Flood elevation not modeled because storage area determined by which homes are purchased. Removes those homes from flooding risk. |

*Planning-level costs exclude land acquisition costs and operations & maintenance costs.

## 3. Proposed Storage

Table 4 presents a summary of proposed storage locations that are combined for the analysis of the regional storage alternatives (Alternative 3, Combination 3 + 1, Alternative 4, and Combination 4 + 1).

*Table 4: Proposed Storage Options*

| ID | Location | Footprint ($ft^2$) | Storage Volume ($ft^3$) | Outlet Elevation (ft) | Excavation Volume ($yd^3$) | Tree Removal | Property Acquisition |
|---|---|---|---|---|---|---|---|
| **3a** | Herrington | 63,000 | 350,000 | 997 | 26,000 | Significant | No |
| **3b** | Maryland North | 24,000 | 100,000 | 1006 | 3,000 | Significant | Yes |
| **3c** | Illinois | 18,000 | 96,000 | 1007 | 4,000 | Minimal | Yes |
| **3d** | Georgia | 22,000 | 97,000 | 1006 | 4,000 | Moderate | Yes |
| **3e** | Maryland | 52,000 | 275,000 | 997 | 11,000 | Moderate | Yes |
| **3f** | WalmartNew | 52,000 | 148,000 | 1019 | 1,000 | Significant | * |
| **4a** | Windjammer | 93,000 | 181,000 | 992 | 6,000 | Significant | ** |
| **4b** | Pirates | 29,000 | 115,000 | 991.7 | 4,000 | Significant | Yes |

*Discuss stormwater options with Bainbridge Township

**Discuss stormwater options with City of Twinsburg

# E. Modeling Methodology: Hydraulics

PCSWMM integrates the hydrologic analysis with the hydraulic analysis, so stormwater storage resulting from detention ponds or surface flooding/ponding is taken into account in peak flow computations. Peak flows from the hydrologic analysis (see Section J and Section K) are used to compute a hydraulic grade line (HGL) for each component of the collection system (pipes, culverts, open channels).

An *Existing Conditions* PCSWMM model was developed to simulate the hydraulic characteristics of the collection system under existing land use conditions. The key findings of the *Existing Conditions* PCSWMM model are discussed in Section J: Existing Conditions: Key Findings. A PCSWMM model scenario for each of the proposed alternatives was developed to simulate the impacts of recommended hydraulic improvements. A summary of all modeling scenarios is provided in Section K: Proposed Conditions.

Channel cross sections of the Pond Brook Creek were modeled, as this drainage channel represents the major component of the City's drainage system. Channel cross sections tributary to Aurora Lake, known as Aurora Lake Channel Brook, were not modeled as this section does not impact the Clipper Cove culvert study. Culvert dimensions were based on field survey.

Hydraulic characteristics for the stormwater collection system were based on existing GIS data and supplemented with field survey to confirm channel depths, top of bank elevations, and culvert characteristics. The base assumption is that the open channel cross sections are structurally sound and clear of sediment or other debris.

## 1. Open Channels/Cross Sections

Twenty-six cross sections of the waterways were surveyed and spaced roughly between 100 to 300 feet. A map of the cross-section locations can be found in Figure A-1 in Appendix A. Additional cross sections were collected near culverts. The cross sections include low-lying or flat areas outside of the defined channel. This was done to more accurately model the floodplain during low-probability storms, allowing the flow which overtops the banks of the channel to spread over adjacent areas.

The channel and overbank roughness factor (Manning's n), was estimated based on the 2016 Flood Insurance Study for Pond Brook Creek as listed in Table 5:

*Table 5: Roughness Factor*

| Stream | Channel n | Overbank n |
|---|---|---|
| **Pond Brook Creek** | 0.032-0.038 | 0.034-0.064 |

Given that Pond Brook Creek is a weedy earth channel, the Manning's n value used for the channel is 0.032. The overbank generally consists of less heavy (woody) vegetation and was assigned a Manning's n value of 0.049.

The downstream portion of Pond Brook Creek through Liberty Park, which includes constructed meanders, was assigned a Manning's n value of 0.045 to account for the additional roughness resulting from the meanders.

Culvert dimensions were based on field survey. Entrance and exit loss coefficients were estimated based on hydraulic charts for culverts available from the Federal Highway Administration (FHWA) – Hydraulic Design of Highway Culverts Third Edition.

# F. Modeling Methodology: Hydrology

The 1,169-acre study area for the City's Pond Brook Creek tributary area was limited to areas draining through the Clipper Cove culvert. The tributary area was determined by examining the drainage system and the topography in and around the City. Areas that drain to Aurora Lake through the Aurora Lake Channel Brook are in a distinct tributary area separate from the Pond Brook Creek tributary area. The City hydrology is unusual in that two separate stormwater systems flow through the City and cross each other at Clipper Cove culvert before combining downstream of the City and the Aurora Lake dam, south of the City. Only the Pond Brook Creek stormwater system is modeled for this study. A topographical map is provided in Figure B-1 in Appendix B.

Special attention was devoted in the development of the hydrologic model to determine which areas should be included as part of the Pond Brook Creek tributary area and which should be excluded because they are part of the Aurora Lake Channel Brook tributary area. The construction drawings of the Bainbridge Walmart stormwater system (provided in Appendix C were reviewed to determine that the east side of the Walmart property drains to Aurora Lake, while the detention ponds on the west side drain to the Pond Brook Creek tributary area. The Signature of Solon and Sycamore Estates construction drawings were reviewed (provided in Appendix C) to determine that the detention ponds in these areas also drain to the Pond Brook Creek tributary area. The portions of Aurora, Solon, Bainbridge, and Twinsburg that drain through Pond Brook Creek were determined using topography and storm sewer system data.

The hydrologic model consists of 39 individual subcatchments to quantify the stormwater runoff contribution from individual portions of the studied watershed. Figure A-2 in Appendix A shows the subcatchments assigned by the existing delineated watershed. Subcatchment delineation was confirmed using 2-foot contours provided by Portage and Summit Counties.

Most of the City has soils classified as Type C, confirmed by our analysis of the United States Department of Agriculture (USDA) National Resources Conservation Service (NRCS) online soils map. Type C soils are generally classified as slow infiltration soils and usually consist of sandy loam (or silty clay loam mixtures) and have a relatively high runoff potential. All subcatchments were assigned a saturated soil conductivity rate (infiltration rate) reflective of sandy loam soils in an urban environment.

The Horton methodology was used to model infiltration for pervious areas. This is a standard tool to model the impacts of infiltration and depends on multiple variables to define the pervious surface and how quickly rainfall can soak into the soil, so it does not become runoff. Variables used in the City of Reminderville model are as follows for sandy loam conditions.

- Maximum Infiltration Rate (in/hour): 3 (typical for USDA-NRCS Type C soils)
- Minimum Infiltration Rate (in/hour): 0.1 (typical for USDA-NRCS Type C soils)
- Decay Constant (1/hour): 4
- Drying Time (days): 7

A key variable in urban stormwater models is ***percent impervious***, as the hard (impervious) surfaces in each drainage area create the majority of runoff and therefore place a greater demand on the stormwater system. The percent impervious value was estimated for each subcatchments based on actual measurements of impervious areas (using the Ohio Statewide Imagery Program (OSIP) 2017 aerial photography) for lower and higher density development areas. The impervious percentage ranged from 5 to 90 percent, depending on the land use.

Stormwater detention can impact peak flows and it is useful to model it where specific data (i.e. storage volume and outlet characteristics) are available. Our modeling effort focused on the detention ponds in the Herrington Place subdivision (off Glenwood Boulevard). There are seventeen (17) detention ponds in the subdivision. For modeling purposes, the total volumes of the detention ponds were combined into four larger detention ponds. The detention ponds were combined based on the location of the outlet to the open channel. Modeling this existing storage provides a more realistic flow scenario, as the existing detention ponds reduce peak flows in the conveyance system.

## G. Modeling Methodology: Design Storms

Design storms were used to predict peak flows throughout the watershed under existing conditions and to model proposed improvements. Peak flow rates were evaluated using the 10-, 25-, 50-, and 100-year recurrence interval events. The rainfall depths are based on the National Oceanic and Atmospheric Administration's (NOAA) Precipitation Frequency Data Server (PFDS), also known as NOAA Atlas 14. These values supersede previous rainfall depth/frequency tables, TP-40 and Bulletin 71, both of which are based on older rainfall statistics. The 24-hour rainfall distribution used is the SCS Type II, which is the most commonly used rainfall distribution in Ohio by local, county, and state regulatory agencies to estimate peak flows for design events. The design storm rainfall depths for each of these recurrence interval events are listed in **Table 6**.

*Table 6: Design Storm Rainfall Depths in Reminderville (NOAA Atlas 14)*

| Recurrence Interval | 24-hour Rainfall (inches) |
|---|---|
| **1-year** | 2.05 |
| **2-year** | 2.46 |
| **5-year** | 3.06 |
| **10-year** | 3.55 |
| **25-year** | 4.27 |
| **50-year** | 4.87 |
| **100-year** | 5.52 |

### 1. Labor Day Storm Event

In addition to looking at design storms (which are based on a synthetic rainfall distribution), OHM modeled the September 7, 2020 event (Labor Day rainfall event) using PCSWMM. Since this storm is recent and reflects an actual storm in the City of Reminderville, it is a useful benchmark against which to measure the effectiveness of the storm sewer system.

The nearest rain gauge from the City of Reminderville is at the Cleveland-Hopkins International Airport (CLE), which is roughly 28 miles from the City. The airport received roughly 13 inches of rainfall within 8 hours on Labor Day 2020. Based on residential rain gauges in Reminderville, roughly 6.5 inches of rain was observed during the same time period. The rainfall data pattern from CLE was adjusted to represent the total observed rainfall within the City. The observed intensity of the rainfall in CLE was used to distribute the 6.5 inches of rainfall observed in Reminderville. Figure 1 illustrates the estimated rainfall distribution of the Labor Day 2020 rainfall event. To better validate future rainfall events, a rain gage in the City of Reminderville that records rainfall depths every 5 to 60 minutes would be useful.

The modeled peak flows from the Labor Day rainfall event were compared to the 10-, 25-, 50-, and 100-year design storm peak flows. The modeled peak flows from the Labor Day rainfall event storm were nearly identical to those from the 50-year, 24-hour recurrence interval storm event.

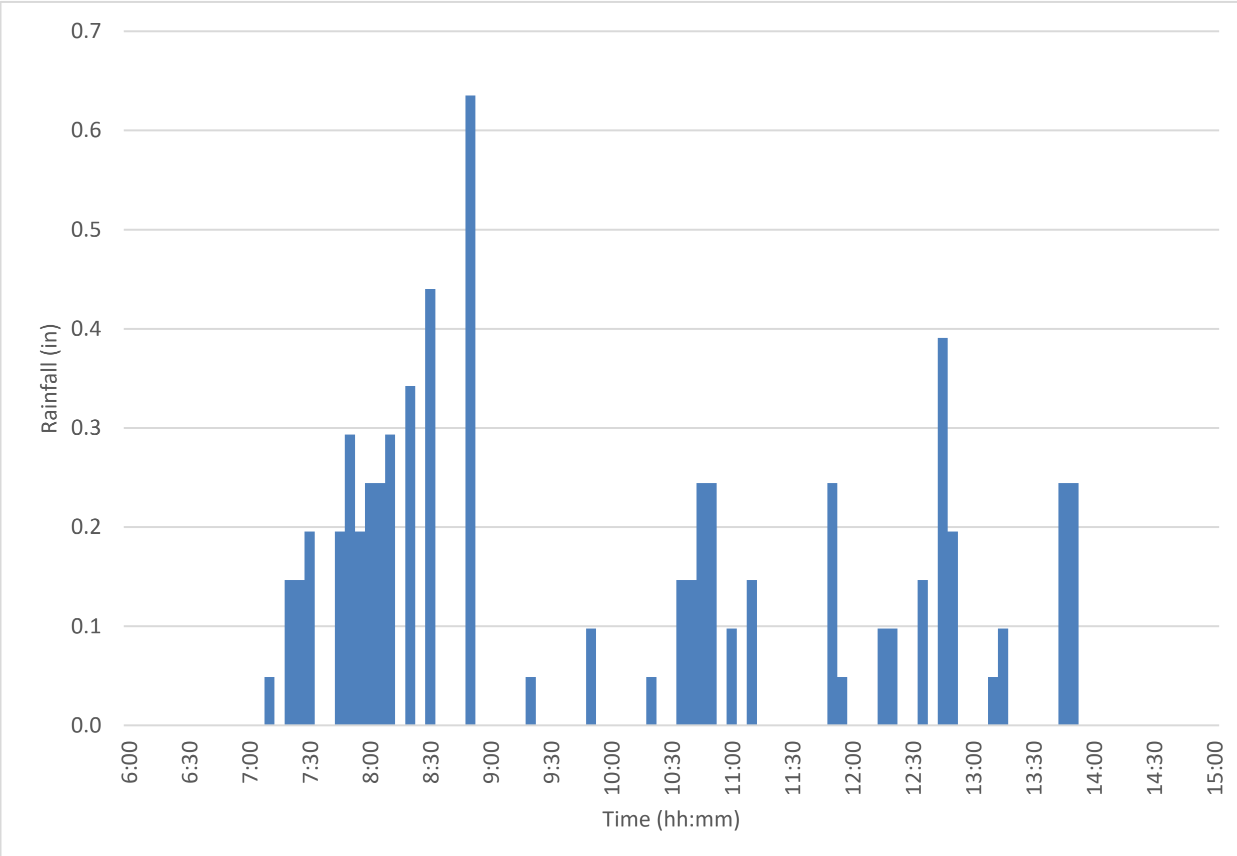


*Figure 1: Labor Day Rainfall Event: CLE Rainfall Pattern Adjusted for Reminderville*

## H. Previous Modeling Efforts

A report and model were produced for the City by Stantec. The Stantec report and model have limited usefulness this current analysis.

The Stantec report was based on a survey and analysis performed nearly 5 years ago and does not reflect current culvert dimensions; for example, the Tradewinds Cove is modeled as a triple pipe culvert, but it is now a box culvert. As a result of this difference, the Stantec model predicts a 100-year high water level about 1 ft higher than the current model just upstream of Tradewinds Cove.

The Stantec HEC-RAS model and the OHM SWMM model agree on the peak flow at Tradewinds (604 cfs in the OHM model and 670 cfs in the Stantec model). However, the Stantec model references much lower flows downstream (300 cfs about 1,600 ft downstream of Tradewinds Cove), but we have no information that would support such a reduction in the peak flow rate.

There is no documentation provided with the Stantec report that states the source of and assumptions made for their hydrologic modeling; the Stantec report appears to be primarily focused on hydraulics. The OHM SWMM model is based on current land use and topography, which lends greater confidence to the flow rates and hydraulic profiles in the OHM SWMM model.

As a result, the Stantec report or model will not be used to inform the findings and recommendations in this report.

## I. Model Calibration

The model results were compared to the observed flooding from the Labor Day rainfall event. The Labor Day event was well-documented with collected survey data from OHM and residential interviews. Photographs from the event also demonstrate the amount of flooding, such as the flooding on Nautilus Trail in Figure 2. Additional photographs can be found in Appendix D.

*Figure 2: Nautilus Trail Flooding on Labor Day 2020 Storm*

The Labor Day rainfall event was used as an initial calibration storm. Based on field investigation of surface flooding during this event, it appears that the PCSWMM hydraulic model accurately represented the magnitude of surface flooding at key locations where flooding was predicted, such as the flooded neighborhoods at Anchorage Cove and Skippers Cove and the flooded streets Nautilus Trail and Pirates Trail. Figure A-3 and Figure A-4 in Appendix A are flood maps created by OHM from the Labor Day rainfall event. The observed flood elevation reached 998.4 feet, and the model predicted roughly the same flood elevation for the event, as seen in Figure 3, which shows the cross section just upstream of Clipper Cove. The cross sections in Figure 4 show that the model predicts that the neighborhoods of Anchorage Cove and Skippers Cove were inundated during the Labor Day 2020 storm, as was observed, further validating the model. To better validate this model in future efforts, a rain gage installed in the City would be useful.

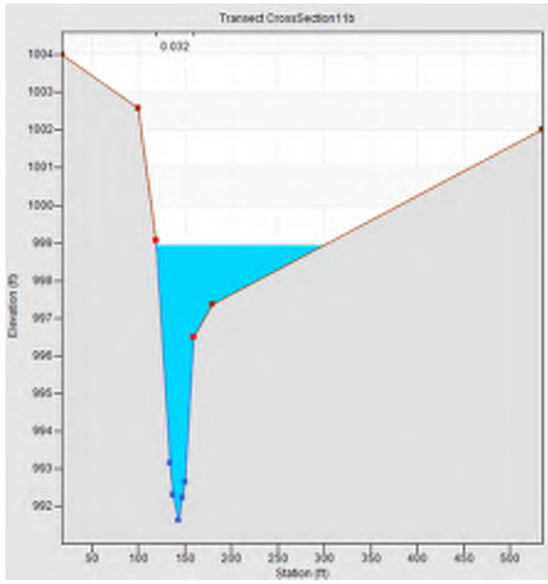

*Figure 3: Cross Section Flooding in Clipper Cove during Labor Day Event*

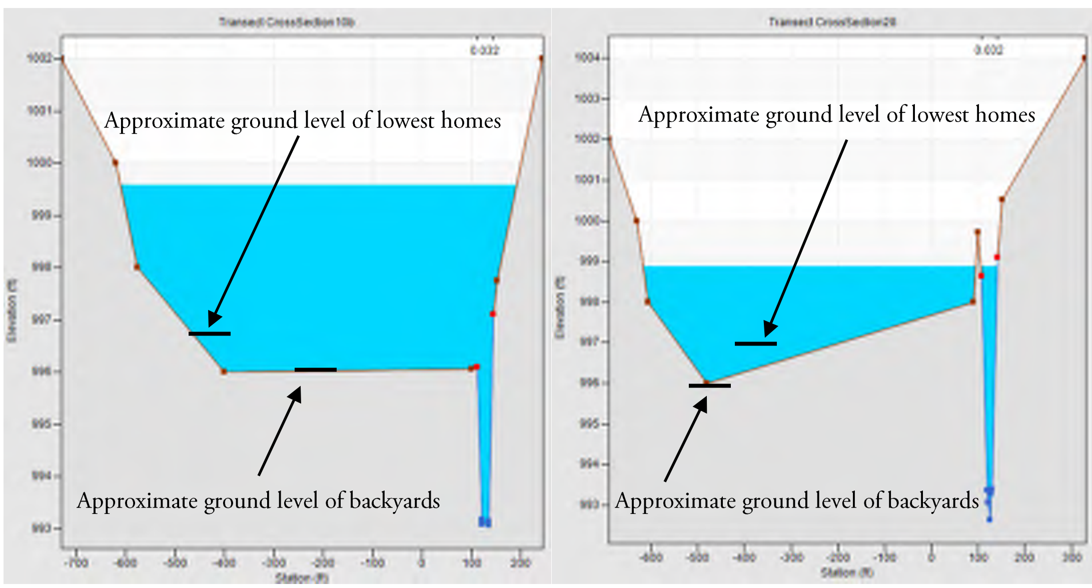


*Figure 4: Cross Section Flooding at Anchorage Cove (left) and Skippers Cove (right) during Labor Day Event*

***The observed flood levels from the Labor Day 2020 storm are roughly equivalent to a 100-year recurrence interval flood event.*** Although the total observed rainfall exceeded the 100-year recurrence interval, the peak rainfall intensities were closer to a 50-year recurrence interval storm. The model predicted similar flood levels for a 100-year recurrence interval flood event as was observed during the Labor Day 2020 storm. The flood level upstream of Clipper Cove is shown for the model for the Labor Day 2020 storm and the 100-year recurrence interval flood event in Figure 5.

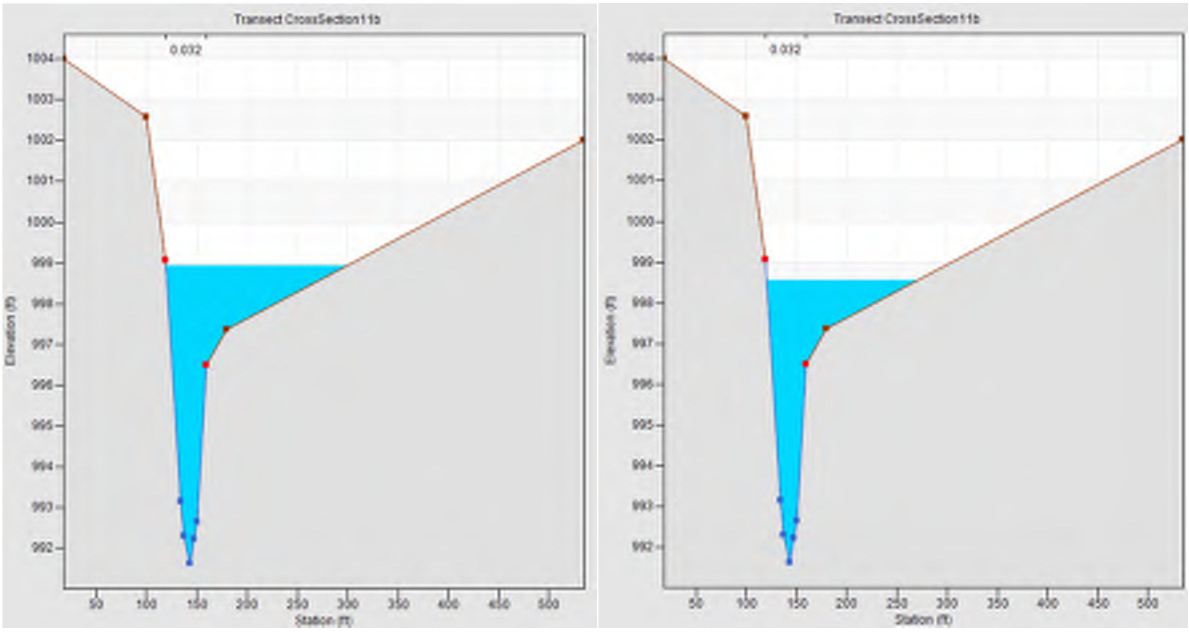


*Figure 5: Cross Section Flooding at Clipper Cove during Labor Day Event (left) and 100-Year Storm (right)*

## J. Existing Conditions: Key Findings

The *Existing Conditions* model was used to identify the open channel and culverts within the watershed that are undersized. Each section below identifies the level of service for each stormwater component.

### 1. Undersized Storm Sewers

Storm sewers were not modeled in this study (only culverts were modeled); therefore, no storm sewers were identified as undersized.

### 2. Undersized Culverts

In our analysis, culverts were analyzed under existing conditions for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year recurrence interval storm events.

Table 7 provides a summary of culverts along Pond Brook Creek (organized upstream to downstream). Table 8 provides a summary of model results for the Clipper Cove culvert.

*Table 7: Culvert Summary*

| Location | Length (ft) | Width (ft) | Height (ft) | Number of Barrels | Cross-Sectional Area ($ft^2$) | Structure Type | Structure Shape | Material |
|---|---|---|---|---|---|---|---|---|
| **Herrington Drive** | 59.2 | 8 | 5 | 1 | 40 | Flared Wingwalls (40 degree) | Rectangle | Concrete |
| **Clipper Cove** | 184.1 | 3 | - | 4 | 28 | Straight | Circular | PVC |
| **Nautilus Trail** | 66.7 | 16 | 4 | 1 | 64 | Wingwall Straight | Rectangle | Concrete |
| **Tradewinds Cove** | 72.1 | 16 | 6 | 1 | 96 | Flared Wingwall (45 degree) | Rectangle | Concrete |

A culvert is considered to be undersized if one of the following conditions occur:

- The headwater resulting from a 100-year storm exceeds the roadway surface elevation and results in roadway flooding (this increases the likelihood of a roadway washout).
- The headwater resulting from a 100-year storm creates a hydraulic surcharge that adversely impacts upstream storm sewer systems.

Per the scope of work, the Clipper Cove culvert was the only culvert analyzed for improvements.

*Table 8: Clipper Cove Culvert Model Results*

| | Existing Conditions - Clipper Cove Culvert | | |
|---|---|---|---|
| **Recurrence Interval** | **Max HGL (ft)** | **Velocity (ft/s)** | **Peak Flow (cfs)** |
| **1-year** | 995.9 | 6.1 | 171.1 |
| **10-year** | 997.5 | 7.9 | 224.4 |
| **100-year** | 998.8 | 9.9 | 280.3 |
| **Labor Day 2020** | 999.1 | 9.6 | 272.0 |

## *Federal Emergency Management Agency (FEMA) Study Analysis*

The City of Reminderville is part of a FEMA Flood Insurance Study (FIS) within Summit County. The initial countywide FIS effective date is July 2009 with some revisions in April 2016. It should be noted that the hydrologic and hydraulic analysis for the City of Reminderville was completed in July 1988 for this study and has not been updated since. This study has developed flood risk data for various areas of the County that have been used to establish actuarial flood insurance rates. The purpose of the study is for Summit County and local communities to update existing floodplain regulations as part of the regular phase of the National Flood Insurance Program and to promote sound land use and floodplain development.

The hydraulic grade line in the FIS for Pond Brook Creek indicates the culverts can convey the 100-year flow without excessive headwater. The official FEMA floodplain elevation through Clipper Cove culvert is roughly 995.5 feet.

The PCSWMM model developed for this study (based on 2020 data) indicates the culverts cannot handle the 100-year storm event. The model predicts the 100-year hydraulic grade line (HGL) at roughly 998.81 feet, which is 3.3 feet higher than the FEMA study. Figure 6 below illustrates the 100-year storm elevations. This discrepancy is largely because the official FIS floodplain is based on an analysis that was performed 33 years ago and does not reflect current land use, rainfall statistics, or current channel/culvert dimensions.

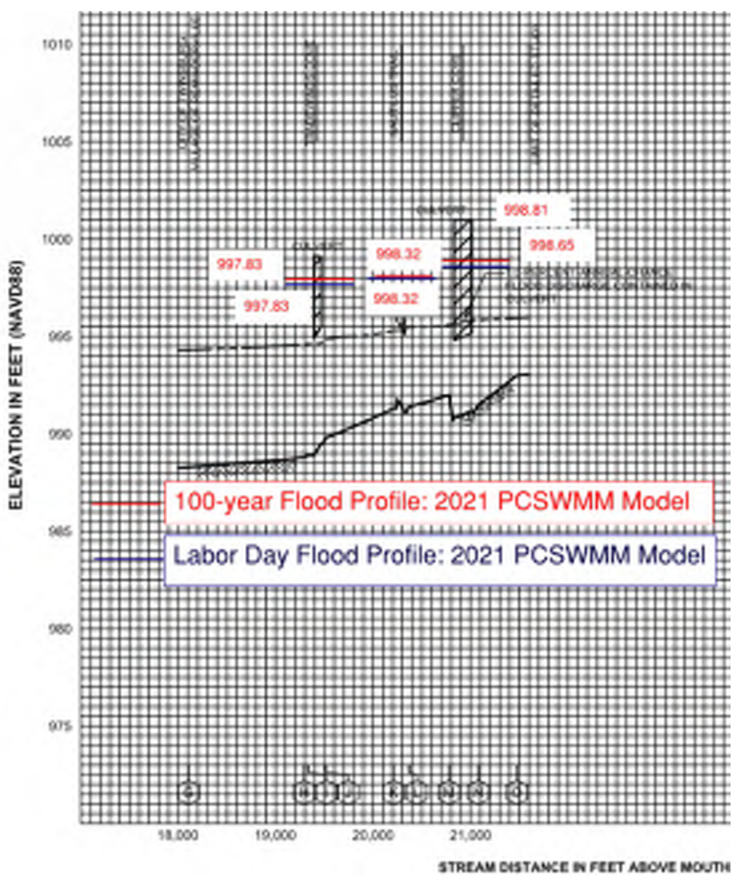


*Figure 6: Pond Brook Creek FEMA - FIS Profile vs. 2021 PCSWMM Model Flood Profile*

The implementation of any recommendations made for Clipper Cove culvert will trigger a permit to work within the floodplain, which will involve a study of the current floodplain within the City.

## 3. Open Channel

In general, the open channel north of Clipper Cove can handle the 2-year recurrence interval storm event without overtopping the channel. Model results upstream of Clipper Cove are provided in Table 9 and Figure 7. A system profile downstream of Clipper Cove for the 2-year recurrence interval storm event is provided in Figure 8, and a system profile for the 100-year recurrence interval storm event is provided in Figure 9.

*Table 9: Model Results for Cross Sections Upstream of Clipper Cove*

| Existing Conditions | Cross Section 11 (from east) | | | Cross Section 12 (from north) | | |
|---|---|---|---|---|---|---|
| **Recurrence Interval** | **Max HGL (ft)** | **Velocity (ft/s)** | **Peak Flow (cfs)** | **Max HGL (ft)** | **Velocity (ft/s)** | **Peak Flow (cfs)** |
| **1-year** | 995.2 | 1.5 | 42.8 | 995.3 | 2.9 | 175.7 |
| **2-year** | 995.9 | 1.5 | 70.1 | 996.0 | 3.2 | 253.6 |
| **10-year** | 997.0 | 2.5 | 249.0 | 997.2 | 3.9 | 467.8 |
| **100-year** | 998.4 | 3.6 | 601.4 | 999.1 | 4.2 | 871.9 |
| **Labor Day 2020** | 998.9 | 2.2 | 426.4 | 998.9 | 3.6 | 657.6 |

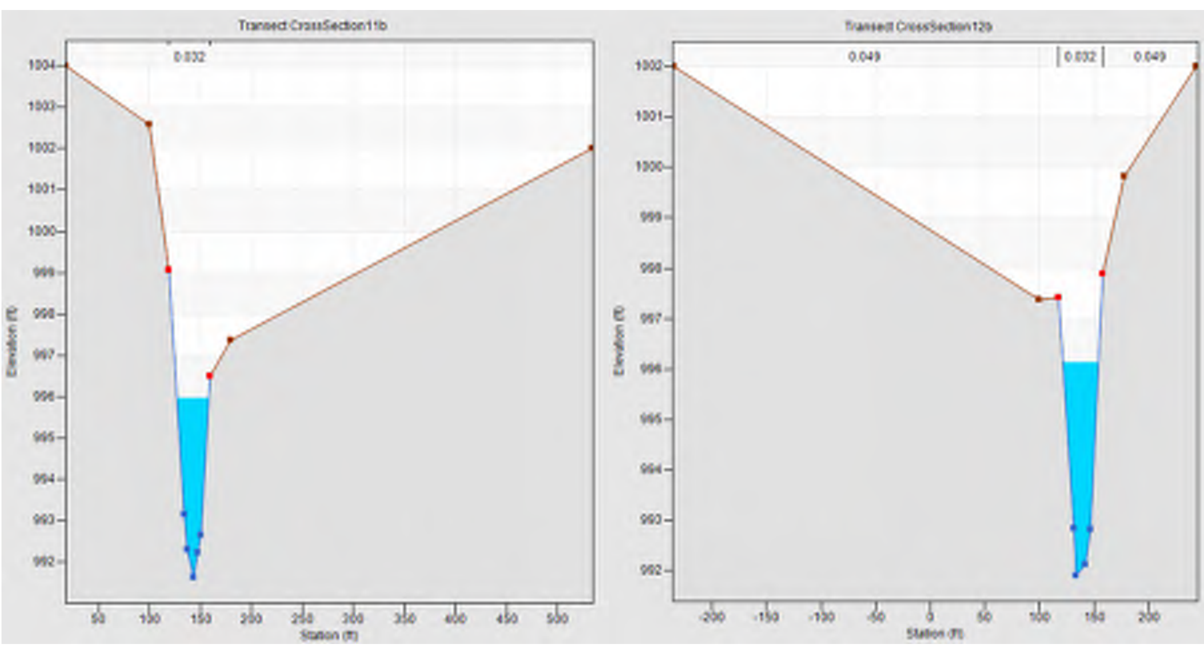

*Figure 7: Cross Sections Upstream of Clipper Cove, 2-year storm, 11 (left) and 12 (right)*

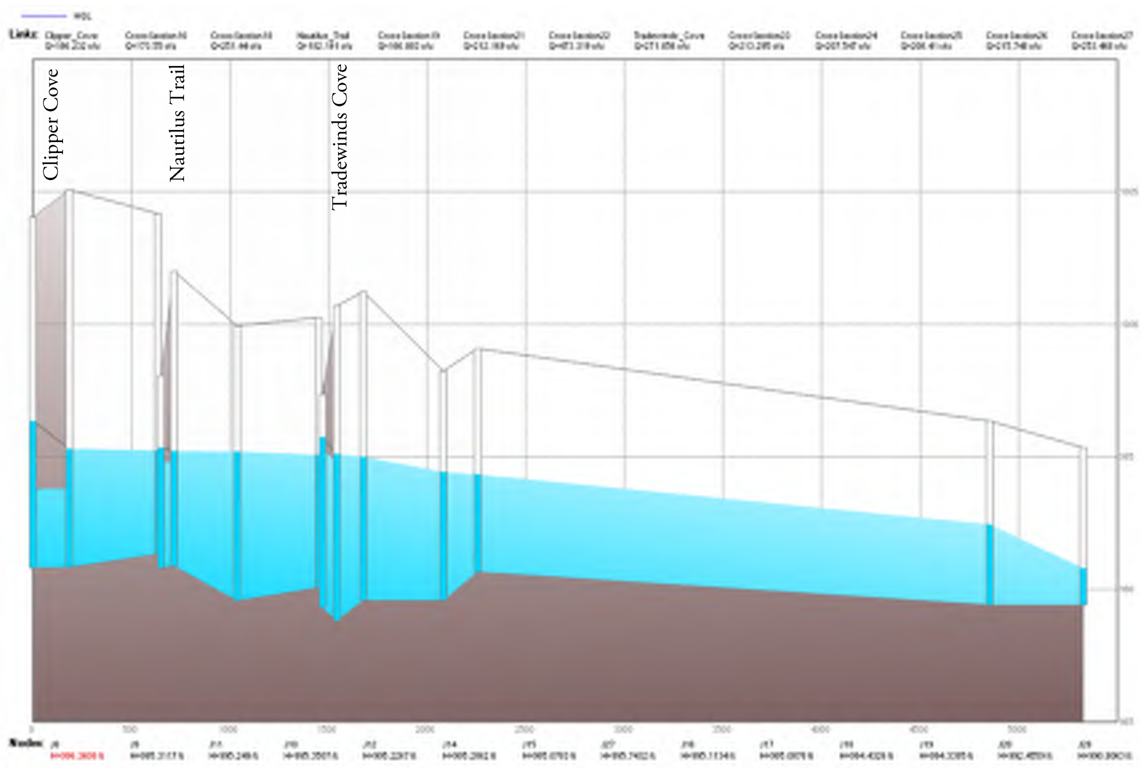


*Figure 8: System Profile from Clipper Cove to Pond Brook Creek Confluence for 2-year storm*

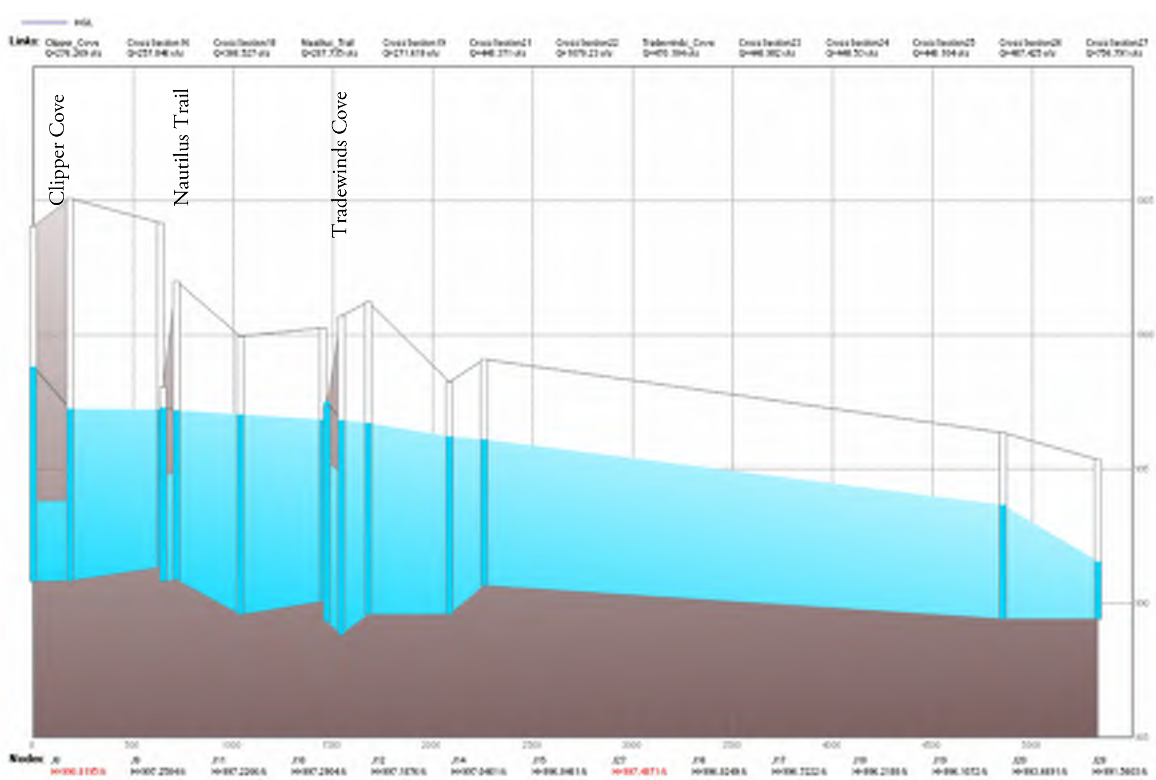


*Figure 9: System Profile from Clipper Cove to Pond Brook Creek Confluence for 100-year storm*

# K. Proposed Conditions: Quantitative Analysis

## *Modeling Scenarios*

Several proposed hydraulic model scenarios (listed in **Error! Reference source not found.**) were developed to e valuate the impacts of various improvements, focusing on hydraulic enhancements at the Clipper Cove culvert. The following potential improvements were identified to address the desired LOS and were evaluated quantitively:

1. **Replace Clipper Cove culvert***
2. Regrade Pond Brook downstream
3. **Regional storage system (upstream only)***
- **Combination 1 + 3: Regional storage system (upstream only) and replace Clipper Cove culvert***
4. Regional storage system (including downstream)
- Combination 1 + 4: Regional storage system (including downstream) and replace Clipper Cove culvert
5. Divert Walmart runoff to Aurora Lake in the City of Aurora
6. Divert Signature of Solon runoff to Aurora Lake in the City of Aurora
7. Install pump station (in lieu of culvert replacement)
8. Install pump and gate at Anchorage Cove
- Combination 1 + 7 + 8: Replace Clipper Cove culvert, install pump station, and install gate at Anchorage Cove
- Combination 1+ 7 + 8, small version: Replace Clipper Cove Culvert, Install Small Budget Pump Station Without Superstructure, and Install Gate at Anchorage Cove
- Combination 1+ 7 + 8, tiny version: Replace Clipper Cove Culvert, Install Tiny Budget Pump Station Without Superstructure, and Install Gate at Anchorage Cove

*Analyses of the scenarios in **bold** text, which provide the greatest impact and benefit to the City, are included in the body of this report. Analyses of the remaining scenarios are included in Appendix E.

## *Basis for Comparison*

For each of the model scenarios, OHM analyzed the cross section at the Clipper Cove culvert, as the center of the study area, the cross sections upstream from Clipper Cove culvert on the branch to the east and on the branch to the north, and two cross sections downstream of the Clipper Cove project area to determine if there would be any impact to the FEMA floodplain or if it would increase peak flow rates or the flood profile downstream of Clipper Cove.

Figure 100 identifies the locations of the cross sections that were used for the basis of comparison between the model scenarios.

System profiles that show peak water surface elevations for all storms for comparing the proposed model scenarios to the *Existing Conditions* scenario can be found in Appendix F.


*Figure 10: Location of Cross Section Results from Existing and Proposed Model*

## 1. Clipper Cove Culvert Improvements

### *Description*

For the *Proposed Conditions (Culvert)* model, Clipper Cove culvert was replaced with a 16-ft by 4-ft box culvert, similar to Nautilus Trail culvert. The size of the culvert is limited to the surrounding neighborhood and Aurora Lake Channel depth. Increasing the culvert size does not solve the high-water levels along the open channels or headwaters through the culvert for the 100-year recurrence interval event; it only reduces the flooding no more than 6 inches across the tributary area.

While replacing the Clipper Cove culvert would not provide the desired LOS, because it will not prevent homes from being flooded during a 100-year recurrence interval event, it may reduce the maintenance effort compared to the existing culvert. To determine the benefit this would provide to the City, an estimate of the current cost to maintain the culvert would need to be compared to an estimated cost of maintaining the proposed culvert.

The concept design for the replacement Clipper Cove culvert is shown in Figure 11.

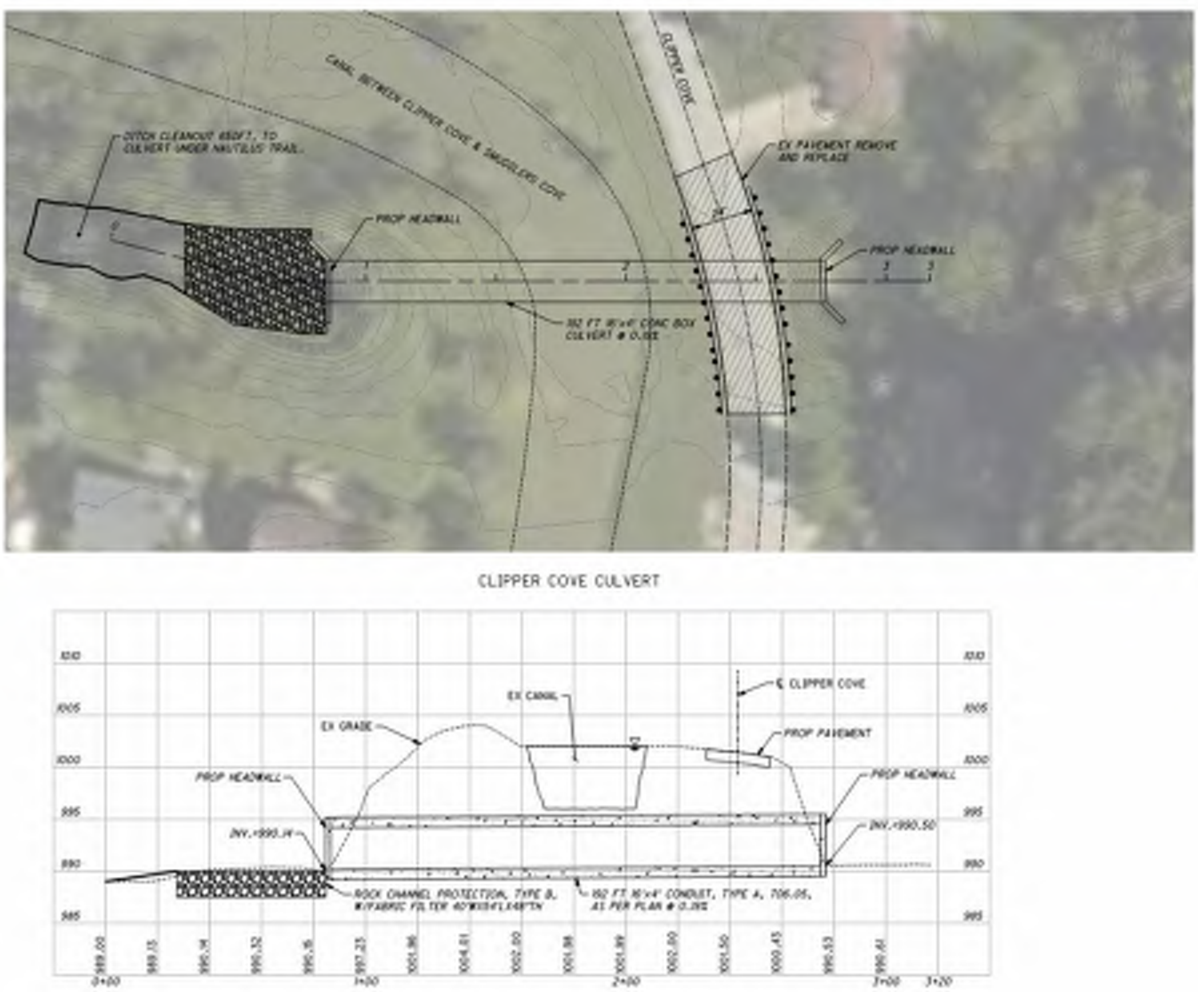


*Figure 11: Preliminary Design of Proposed Clipper Cove Culvert*

The preliminary cost opinion and preliminary design sheets are provided in Appendix G. The preliminary engineer's estimate is $717,365, as submitted to Ohio Public Works Commission - Small Government FY-22 Round 35.

## Level of Service

The proposed culvert model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table 10. Figure 12 compares the system profiles for the *Existing Conditions* model and the proposed conditions scenario during a 100-year recurrence interval event for the area just upstream and just downstream of Clipper Cove. Maximum velocity and peak flow data for the proposed scenario and the *Existing Conditions* model can be found in Appendix F.

The comparison of the *Existing Conditions* model and the proposed culvert scenario shows that the proposed culvert would provide a marginal improvement in headwater upstream of the culvert but would also cause a significant increase in peak flow and flood elevations downstream of the culvert. Essentially, the larger culvert allows more flow through the bottleneck, pushing the problems from large flows downstream.

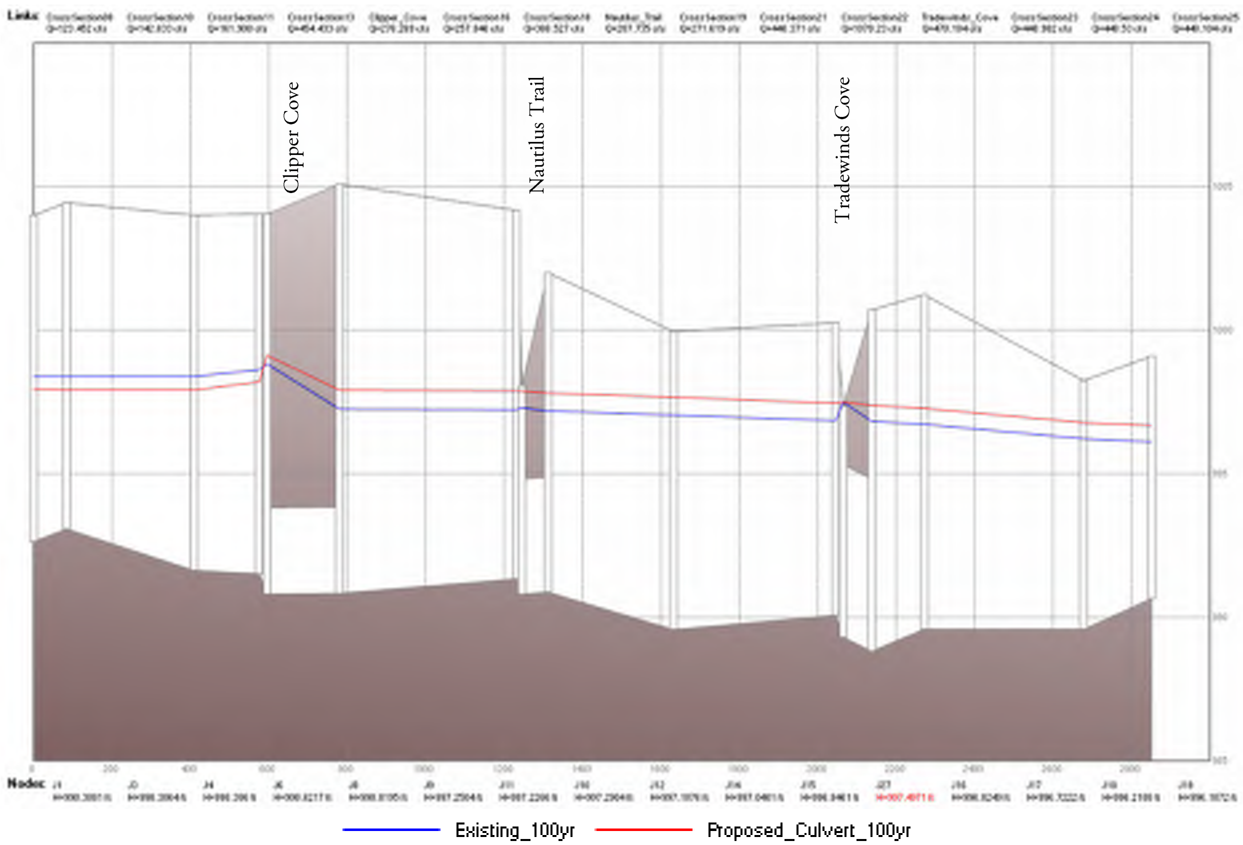


*Figure 12: Compare Existing Conditions and Proposed Culvert Scenario System Profiles for 100-year storm*

*Table 10: Compare Existing Conditions to Proposed Culvert Results*

| Clipper Cove Culvert | Existing | Proposed | Change |
|---|---|---|---|
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.9 | 995.8 | 0.1 |
| 10-year | 997.5 | 997.8 | -0.3 |
| 100-year | 998.8 | 999.2 | -0.4 |
| Labor Day 2020 | 999.1 | 998.9 | 0.2 |
| East Branch Upstream Cross Section 11 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.2 | 994.8 | 0.4 |
| 10-year | 997.0 | 996.6 | 0.4 |
| 100-year | 998.4 | 997.9 | 0.5 |
| Labor Day 2020 | 998.9 | 997.8 | 1.1 |
| North Branch Upstream Cross Section 12 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.3 | 995.2 | 0.1 |
| 10-year | 997.2 | 997.1 | 0.2 |
| 100-year | 999.1 | 998.9 | 0.2 |
| Labor Day 2020 | 998.9 | 998.5 | 0.4 |
| Immediately Downstream Cross Section 16 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 994.8 | 994.9 | -0.1 |
| 10-year | 996.0 | 996.6 | -0.6 |
| 100-year | 997.3 | 997.9 | -0.7 |
| Labor Day 2020 | 997.2 | 997.7 | -0.5 |
| Further Downstream Cross Section 25 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 993.9 | 994.0 | -0.1 |
| 10-year | 995.2 | 995.6 | -0.4 |
| 100-year | 996.2 | 996.8 | -0.5 |
| Labor Day 2020 | 996.1 | 996.6 | -0.4 |

### Challenges

The FEMA floodplain is out of date and inaccurate; any proposed improvements to the Clipper Cove culvert will require review by the Ohio Department of Natural Resources (ODNR), and that review may trigger a requirement for a Conditional Letter of Map Revision (CLOMR). If a CLOMR is pursued, the flood profile will likely increase, and the floodplain extents will impact a larger area. This would likely result in an increase in the number of homes requiring flood insurance; this would have a negative impact on area residents, as they would have to pay new or additional insurance premiums.

Replacing the Clipper Cove culvert will result in significant increases in downstream peak flows and increased flood elevations. This scenario may be rejected by ODNR, which would require upstream mitigation through additional flood storage. Any culvert replacement design should include a study of regional detention to offset the impacts of increased downstream flows. Obtaining a permit may depend on this additional detention volume. Alternatively, downstream channel improvements may need to be considered to further reduce the flood profile and increase flow capacity.

## 2. Regional Storage System (upstream only)

### *Description*

Since it was determined that hydraulic improvements would increase peak flow rates and flood elevations downstream of the Clipper Cove culvert, additional stormwater detention storage in the watershed upstream of the Clipper Cove culvert could be implemented to alleviate flooding at Clipper Cove culvert without pushing the problem downstream. Flood storage cannot be constructed in delineated wetlands, so that limits the potential areas for flood storage. Potential locations were identified as a desktop exercise by outlining areas not occupied by homes or wetlands, using aerial imagery and wetland delineation from the United States Environmental Protection Agency (EPA).

The potential storage locations are shown in Figure H-3 in Appendix H

### *Level of Service*

The proposed regional storage system (upstream) model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table 11. **Error! Reference source not found.** compares the system profiles for the *Existing Conditions* model and the proposed conditions scenario during a 100-year recurrence interval event for the area just upstream and just downstream of Clipper Cove. Maximum velocity and peak flow data for the proposed scenario and the *Existing Conditions* model can be found in Appendix F.

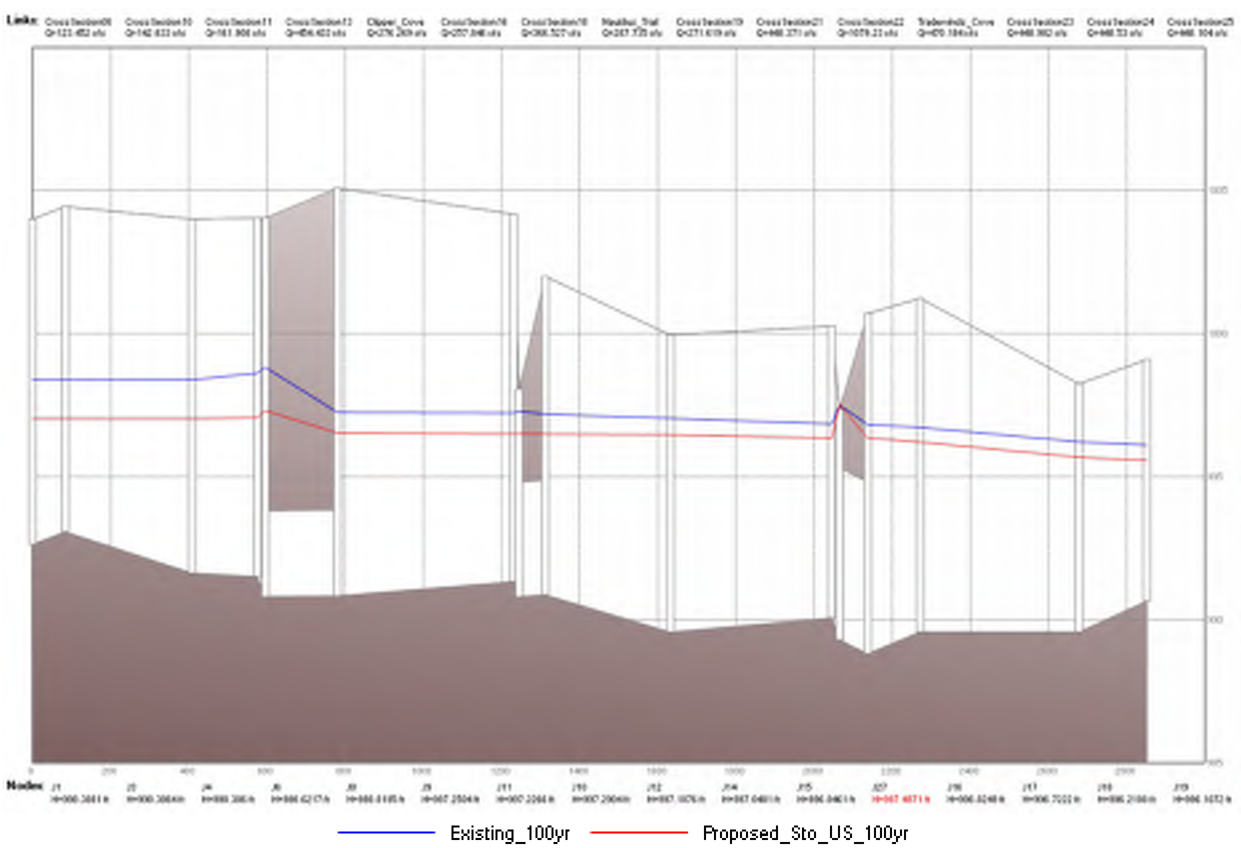


*Figure 13: Compare Existing Conditions and Proposed Regional Storage Upstream Scenario System Profiles for 100-year storm*

*Table 11: Compare Existing Conditions to Proposed Storage Upstream Results*

| Clipper Cove Culvert | Existing | Proposed | Change |
|---|---|---|---|
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.9 | 994.7 | 1.2 |
| 10-year | 997.5 | 996.3 | 1.3 |
| 100-year | 998.8 | 997.4 | 1.5 |
| Labor Day 2020 | 999.1 | 997.4 | 1.7 |
| East Branch Upstream Cross Section 11 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.2 | 994.1 | 1.1 |
| 10-year | 997.0 | 995.8 | 1.2 |
| 100-year | 998.4 | 997.0 | 1.4 |
| Labor Day 2020 | 998.9 | 997.0 | 1.9 |
| North Branch Upstream Cross Section 12 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.3 | 994.1 | 1.2 |
| 10-year | 997.2 | 995.8 | 1.4 |
| 100-year | 999.1 | 997.0 | 2.0 |
| Labor Day 2020 | 998.9 | 997.0 | 1.9 |
| Immediately Downstream Cross Section 16 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 994.8 | 994.0 | 0.8 |
| 10-year | 996.0 | 995.4 | 0.6 |
| 100-year | 997.3 | 996.5 | 0.8 |
| Labor Day 2020 | 997.2 | 996.4 | 0.9 |
| Further Downstream Cross Section 25 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 993.9 | 993.2 | 0.7 |
| 10-year | 995.2 | 994.6 | 0.6 |
| 100-year | 996.2 | 995.7 | 0.6 |
| Labor Day 2020 | 996.1 | 995.5 | 0.6 |

### Challenges

Construction of any of these detention ponds will require tree removal, regulatory permits, and land acquisition, as detailed in Figure H-4 in Appendix H.

## 3. Combination: Regional Storage (upstream only) with Modifications to Clipper Cove Culvert

### *Description*

An alternative was analyzed that combines the replacement of Clipper Cove culvert and the implementation of a regional storage system upstream of Clipper Cove culvert.

### *Level of Service*

The proposed regional storage system (upstream) with culvert model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table 12. **Error! Reference source not found.** compares the system profiles for the *Existing Conditions* model and the proposed conditions scenario both with and without the culvert during a 100-year recurrence interval event for the area just upstream and just downstream of Clipper Cove. Maximum velocity and peak flow data for the proposed scenario and the *Existing Conditions* model can be found in Appendix F.

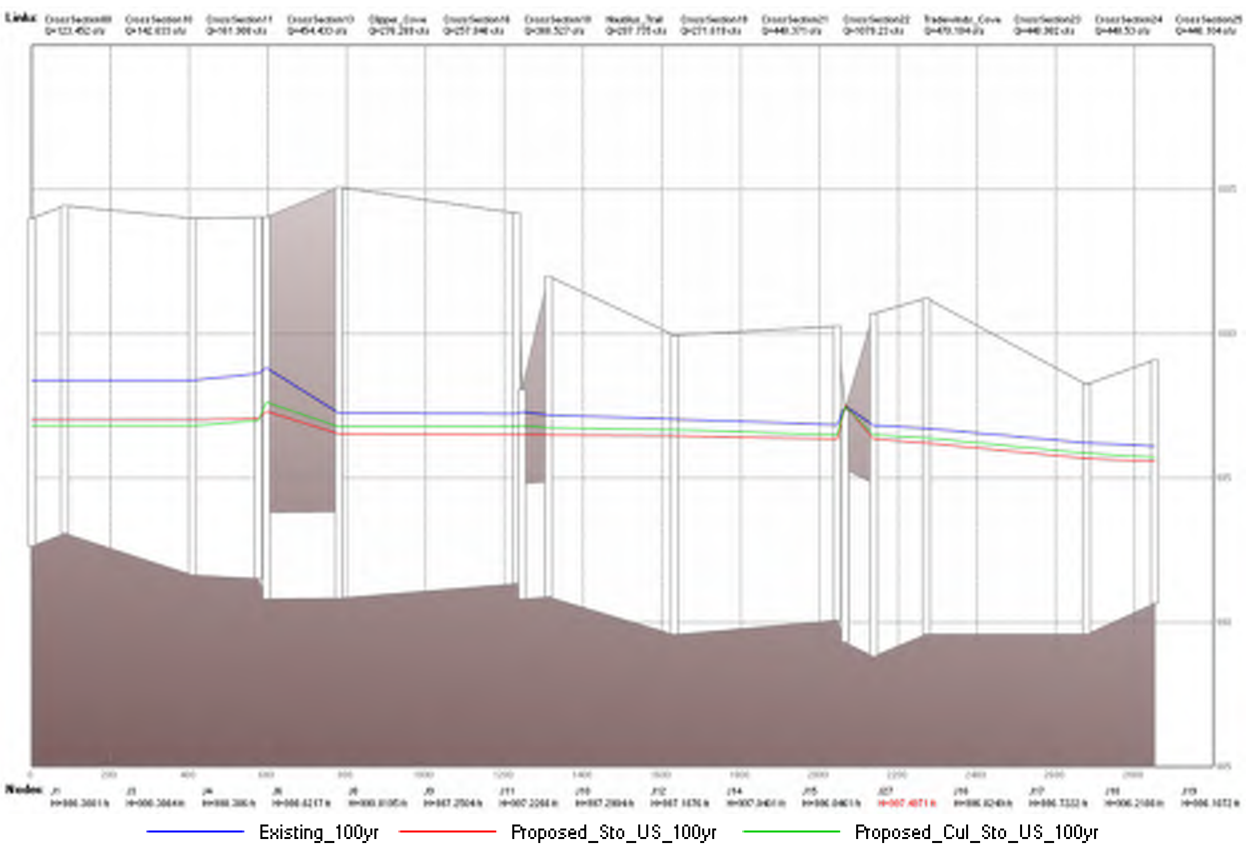


*Figure 14: Compare Existing Conditions and Proposed Regional Storage Upstream with Culvert Scenario System Profiles for 100-year storm*

*Table 12: Compare Existing Conditions to Proposed Storage Upstream with Culvert Results*

| Clipper Cove Culvert | Existing | Proposed | Change |
|---|---|---|---|
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.9 | 994.6 | 1.3 |
| 10-year | 997.5 | 996.5 | 1.0 |
| 100-year | 998.8 | 997.7 | 1.1 |
| Labor Day 2020 | 999.1 | 997.5 | 1.6 |
| East Branch Upstream Cross Section 11 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.2 | 993.9 | 1.3 |
| 10-year | 997.0 | 995.4 | 1.6 |
| 100-year | 998.4 | 996.8 | 1.6 |
| Labor Day 2020 | 998.9 | 996.5 | 2.3 |
| North Branch Upstream Cross Section 12 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 995.3 | 994.0 | 1.3 |
| 10-year | 997.2 | 995.5 | 1.7 |
| 100-year | 999.1 | 996.8 | 2.2 |
| Labor Day 2020 | 998.9 | 996.6 | 2.3 |
| Immediately Downstream Cross Section 16 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 994.8 | 994.0 | 0.8 |
| 10-year | 996.0 | 995.5 | 0.5 |
| 100-year | 997.3 | 996.8 | 0.5 |
| Labor Day 2020 | 997.2 | 996.5 | 0.7 |
| Further Downstream Cross Section 25 | Existing | Proposed | Change |
| Recurrence Interval | Max HGL (ft) | Max HGL (ft) | Reduce HGL (ft) |
| 1-year | 993.9 | 993.2 | 0.7 |
| 10-year | 995.2 | 994.7 | 0.5 |
| 100-year | 996.2 | 995.8 | 0.4 |
| Labor Day 2020 | 996.1 | 995.5 | 0.6 |

### Challenges

The same challenges for both the Clipper Cove culvert replacement scenario and the Regional Storage System scenario apply.

## L. Proposed Conditions: Qualitative Analysis

The following additional potential improvements were evaluated qualitatively:

9. Install weir on Pirates Trail branch
10. Install weir at Liberty Ledges
11. Install weir at Crossings confluence
12. Install backflow gate at Glenwood Blvd.
13. Modify culvert at Glenwood Blvd.
14. Modify drainage at Glenwood Blvd.
15. Property buy-out and regrading of flood-prone areas

A summary of the results of the qualitative analysis can be found in Table 13.

*Table 13: Qualitative analysis of additional alternatives*

| ID | Alternative | Description | Challenges | Cost | Level of Service |
|---|---|---|---|---|---|
| 9 | Install Weir on Pirates Trail branch | Install weir upstream of Pirates Trail branch junction. | The FEMA floodplain boundaries would be expanded causing additional homes to be required to obtain FEMA flood plain insurance. | Not estimated. | Impact on downstream peak flows is equivalent to recommended regional detention storage areas. Regional detention storage reduces peak flows without adverse impacts to floodplain elevations. |
| 10 | Install Weir at Liberty Ledges | Install weir in the stream between the shopping center and Liberty Ledges subdivision. | | | |
| 11 | Install Weir at Crossings confluence | Install weir downstream of the confluence of ditches from Crossings Dr. and Signature of Solon golf course. | | | |
| 12 | Install Backflow Gate at Glenwood Blvd. | Install a backflow gate upstream of the Crossings Dr. & Glenwood Blvd. culvert. | | | |
| 13 | Modify Culvert at Glenwood Blvd. | Modify the culverts along Glenwood Blvd. to divert to flow to the boat channel. | | | |
| 14 | Modify Drainage at Glenwood Blvd. | Modify drainage along Glenwood Blvd. to prevent backflow from boat channel. | | | |
| 15 | Property Buy-Out | Purchase five homes in the lowest area near Clipper Cove culvert and regrade the area into flood storage. | Requires purchase agreements with home-owners. | Planning-level cost: $1,200,000 to purchase 5 homes | Flood elevation not modeled because storage area determined by which homes are purchased. Removes those homes from flooding risk. |

## Property buy-out and regrading of flood-prone areas

Instead of implementing culvert or channel improvements, a more cost-effective approach to mitigating flooding at the most impacted homes may be to instead use available funding to buy the most flood-prone (lowest elevation) properties and regrade them to convert them to natural floodplain storage. Figure I-1 in Appendix I shows the contours in the Anchorage Cove and Skippers Cove neighborhoods, where the flooding has the greatest impact.

Source of property values: https://summitmaps.summitoh.net/ParcelViewer2.0/, http://fiscalweb.summitoh.net/clt/refintg2.opt?parcel=6600405

# M. Drainage Maintenance on Individual Properties

Managing an entire stormwater network begins with each individual property within the watershed. The City is responsible for improvements and maintenance of the storm conveyance system, however every part of the watershed requires stormwater management in order to reduce the potential for nuisance flooding and to minimize pollution. Therefore, as part of the recommended improvements throughout the City by OHM Advisors, residents (as well as Homeowners Associations) and any other property owner should perform basic maintenance on their own private properties; this maintenance generally includes the removal of debris that could impede the flow of stormwater from or through a property. This may include routine groundskeeping such as grass mowing, removal of trash, vegetation and debris. Owners should ensure that the drainage systems are kept free of yard waste (grass clippings, tree trimmings, and leaves) or other obstructions (trash, fencing, etc.) that may block the flow of water. This may also include the removal of trees that have fallen across a drainage swale or ditch.

The City is not responsible for the basic maintenance as described above. It is important to understand that performing this basic maintenance can reduce the potential for nuisance flooding and can help prevent downstream stormwater pollution. The City will continue to improve and maintain the public drainage systems, but it is the responsibility of all property owners and Homeowners Associations to perform regular maintenance as described above so that the local drainage systems function as originally designed.

The Codified Ordinances of Reminderville, Section 521.12 Removal of Watercourse Obstructions, is included in Appendix J for reference.

# N. Conclusions

Addressing the flooding at the Clipper Cove culvert will result in numerous economic, public safety, and regulatory hurdles. There is no easy solution to address flood control at this location, as doing so will have reverberations beyond the project area. The following considerations should be made when planning and designing flood control at Clipper Cove:

1. The FEMA floodplain is out of date and inaccurate; any proposed improvements to the Clipper Cove culvert will require review by the Ohio Department of Natural Resources (ODNR), and that review may trigger a requirement for a Conditional Letter of Map Revision (CLOMR). If a CLOMR is pursued, the flood profile will likely increase, and the floodplain extents will impact a larger area. This would likely result in an increase in the number of homes requiring flood insurance; this would