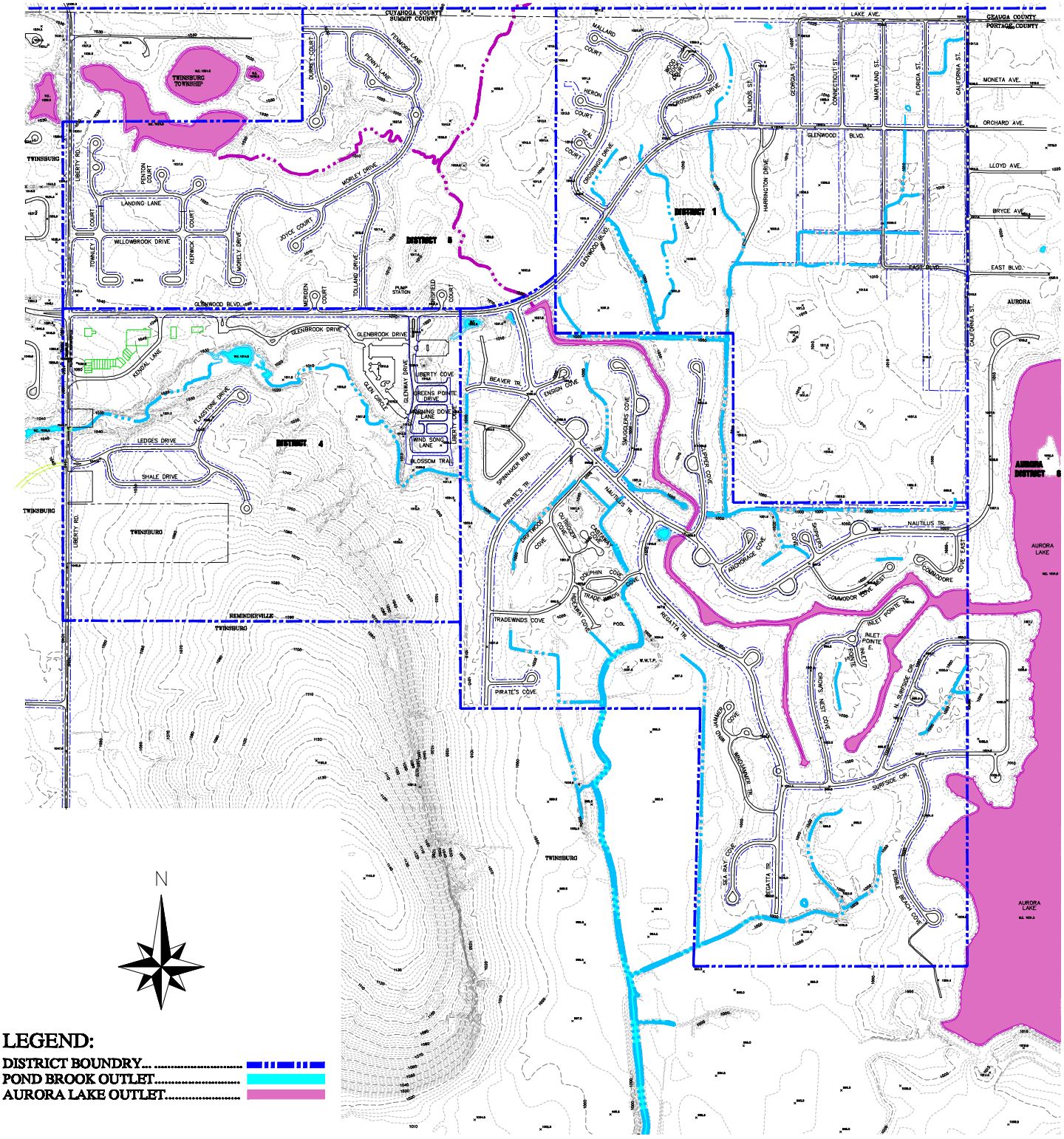
VILLAGE OF REMINDERVILLE



N

LEGEND:

DISTRICT BOUNDRY.....
POND BROOK OUTLET.....
AURORA LAKE OUTLET.....

DRAINAGE MAP

Village of Reminderville, Ohio

Krock Esser Engineering, Inc.
Providing "KEE" Solutions
6138 Riverview Road, Suite B
Peninsula, Ohio 44264
PH: (330) 657-2145

Appendix D

Labor Day Flood Photos

North California Street Looking East

North California Street Looking West

Florida Street

Nautilus Trail

Nautilus Trail

Regatta Trail

Regatta Trail

Appendix E

Alternative Projects

Contents

Tables

Figures

1. Regrade Pond Brook Downstream

Description

The Village requested that channel improvements downstream be considered for reducing flood levels. For the proposed channel scenario, the existing Pond Brook downstream of the Village through Liberty Park (Cross Section 26) was changed from a meandering natural channel, with the surveyed cross section and a Manning's n of 0.045, to an engineered straightened channel with a Manning's n of 0.035 and a trapezoidal shape 6 ft deep, 25 ft wide, and a 4 to 1 slope.

Figure E-1 shows the existing channel in the *Existing Conditions* model and the proposed engineered channel in the proposed channel scenario.

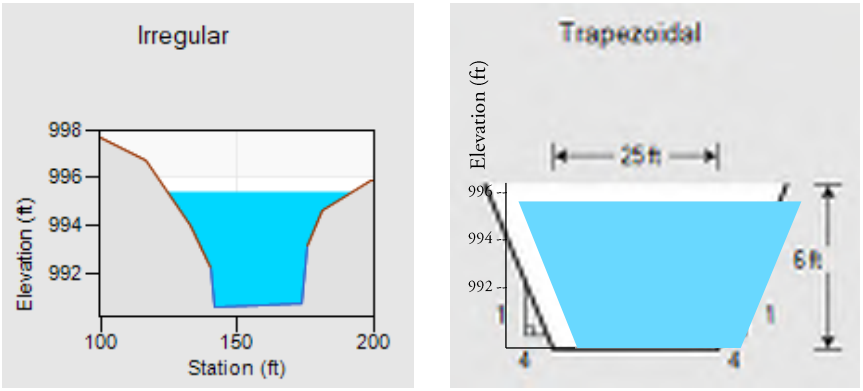


Figure E-1*: Pond Brook (Cross Section 26) in Existing Conditions model (left) and proposed channel scenario (right) for the 100-year recurrence interval*

Level of Service

The proposed channel scenario was compared to the *Existing Conditions* model for its impact on flood levels. If the Pond Brook channel were modified as shown in **Error! Reference source not found.**, the 100-year flood levels would only be reduced by approximately 5 inches compared to the *Existing Conditions* model. However, this downstream improvement would have a negligible impact at the Clipper Cove culvert and areas upstream of the culvert. Straightening and widening the Pond Brook channel through Liberty Park would have little to no impact on the flooding of the homes in the Anchorage Cove and Skippers Cove neighborhoods. The profile in *Figure E-2* compares the 100-year peak flood levels in each of the three modeling scenarios. The regrade Pond Brook downstream model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-1.

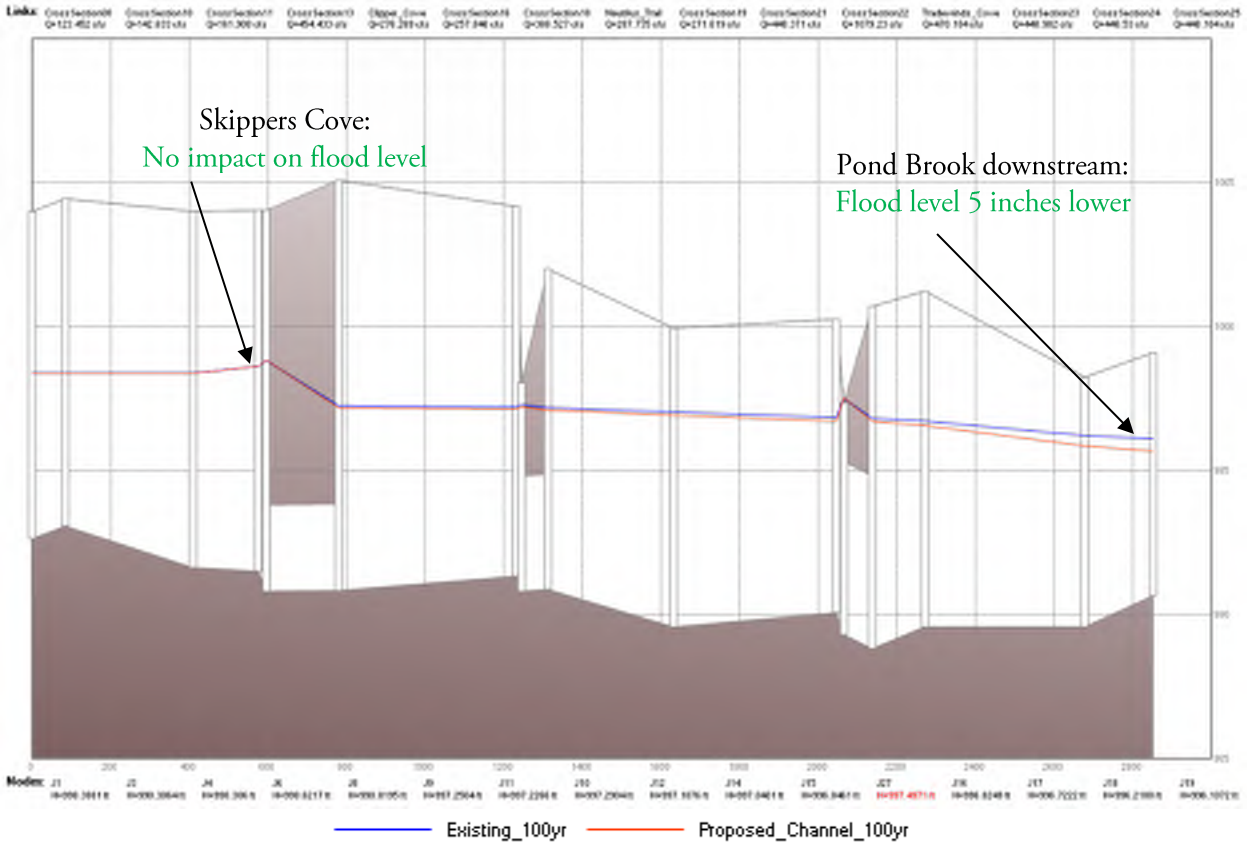


Figure E-2*: Profile of peak flood levels from Skippers Cove to the confluence*

Table E-1: Compare Existing Conditions to Proposed Regrade Pond Brook Downstream Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	995.9	0.0	6.1	6.1	171.1	171.4
10-year	997.5	997.5	0.0	7.9	8.0	224.4	225.0
100-year	998.8	998.9	0.0	9.9	10.0	280.3	282.9
Labor Day 2020	999.1	999.0	0.1	9.6	9.8	272.0	277.8
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	995.2	0.0	1.5	1.5	42.8	42.8
10-year	997.0	997.0	0.0	2.5	2.5	249.0	247.8
100-year	998.4	998.4	0.0	3.6	3.5	601.4	599.2
Labor Day 2020	998.9	998.8	0.1	2.2	2.2	426.4	419.0
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	995.3	0.0	2.9	2.9	175.7	175.7
10-year	997.2	997.2	0.0	3.9	3.9	467.8	466.6
100-year	999.1	999.1	0.0	4.2	4.2	871.9	872.5
Labor Day 2020	998.9	998.8	0.1	3.6	3.6	657.6	658.1
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.8	0.0	2.1	2.1	154.9	155.4
10-year	996.0	995.9	0.1	1.8	1.8	213.5	216.2
100-year	997.3	997.2	0.1	1.5	1.6	258.6	262.3
Labor Day 2020	997.2	997.1	0.2	2.3	2.3	272.4	279.6
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	993.7	0.2	1.8	2.0	158.3	161.7
10-year	995.2	994.8	0.4	2.0	2.3	302.3	304.7
100-year	996.2	995.8	0.4	2.2	2.5	448.1	463.0
Labor Day 2020	996.1	995.7	0.4	2.2	2.5	437.5	444.3

Challenges

Contacting ODNR would be necessary to determine the feasibility of this alternative if Village decides to pursue this option. It seems unlikely that ODNR would permit the channelization of the natural creek.

2. Regional Storage System (include downstream)

Description

Additional potential storage locations were identified downstream of Clipper Cove culvert by the same process as the upstream locations. The potential storage locations are shown in Figure H-3 in Appendix H.

Level of Service

The proposed regional storage system (include downstream) model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-2. *Figure E-3* compares the system profiles for the *Existing Conditions* model, the regional storage system (upstream only) scenario, and the regional storage system (include downstream) scenario during a 100-year recurrence interval event for the area just upstream and just downstream of Clipper Cove.

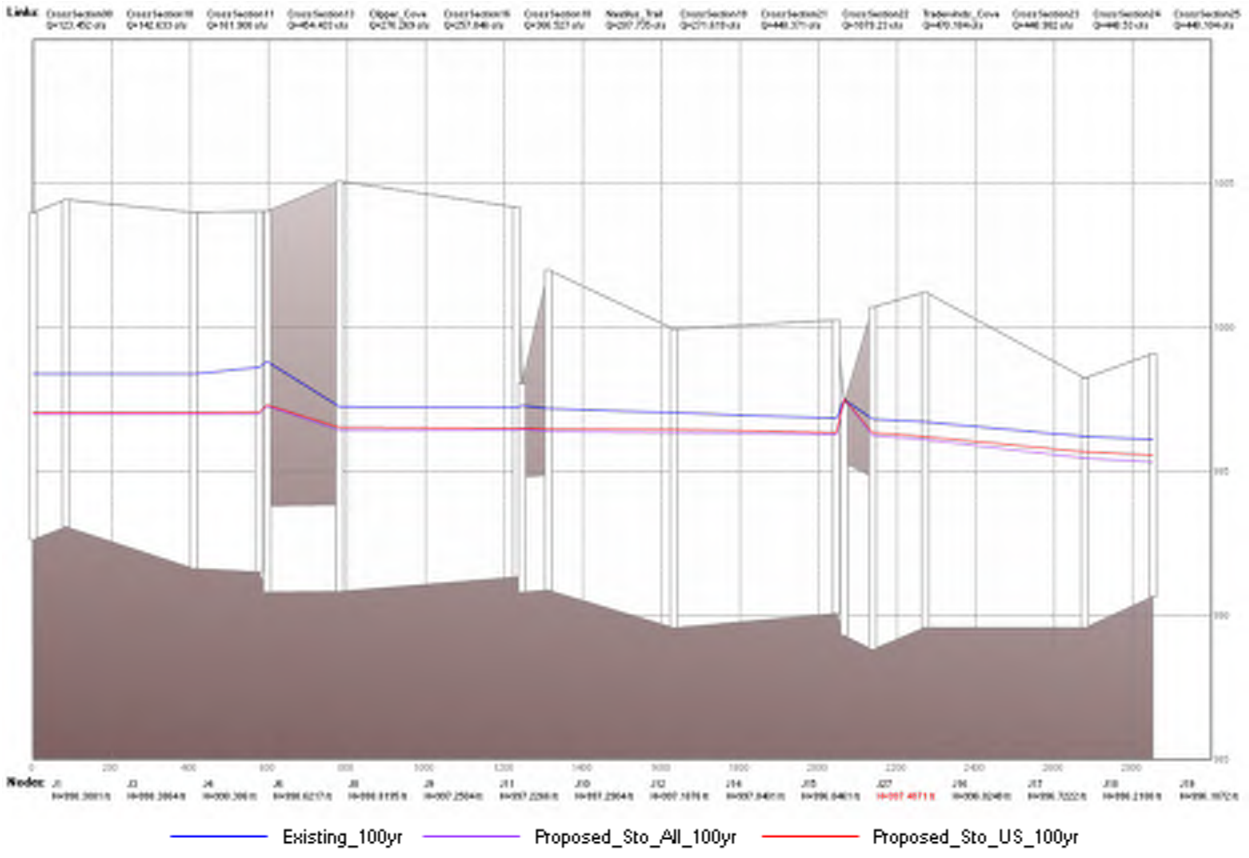


Figure E-3*: Compare Existing Conditions and Proposed Regional Storage Including Downstream Scenario System Profiles for 100-year storm*

Table E-2: Compare Existing Conditions to Proposed Regional Storage System (including downstream) Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	994.6	1.3	6.1	3.8	171.1	100.3
10-year	997.5	996.3	1.3	7.9	5.4	224.4	153.3
100-year	998.8	997.4	1.5	9.9	6.5	280.3	184.4
Labor Day 2020	999.1	997.3	1.8	9.6	6.5	272.0	184.7
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	994.0	1.2	1.5	2.0	42.8	43.2
10-year	997.0	995.7	1.3	2.5	2.0	249.0	72.3
100-year	998.4	997.0	1.4	3.6	1.5	601.4	140.5
Labor Day 2020	998.9	996.9	2.0	2.2	2.0	426.4	100.2
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	994.1	1.2	2.9	1.9	175.7	47.6
10-year	997.2	995.8	1.5	3.9	1.9	467.8	133.8
100-year	999.1	997.0	2.1	4.2	2.6	871.9	275.7
Labor Day 2020	998.9	996.9	2.0	3.6	2.1	657.6	223.2
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.0	0.8	2.1	1.7	154.9	80.6
10-year	996.0	995.3	0.7	1.8	1.7	213.5	133.9
100-year	997.3	996.4	0.8	1.5	1.2	258.6	185.3
Labor Day 2020	997.2	996.3	0.9	2.3	1.9	272.4	184.9
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	993.1	0.8	1.8	1.4	158.3	94.1
10-year	995.2	994.4	0.8	2.0	1.8	302.3	223.8
100-year	996.2	995.4	0.8	2.2	2.3	448.1	371.7
Labor Day 2020	996.1	995.3	0.8	2.2	2.3	437.5	354.5

Challenges

The same challenges for the Regional Storage System (upstream only) scenario apply.

3. Combination: Regional Storage (include downstream) 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 with storage both upstream and downstream of Clipper Cove culvert.

Level of Service

The proposed regional storage system (include downstream) model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-3. **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.

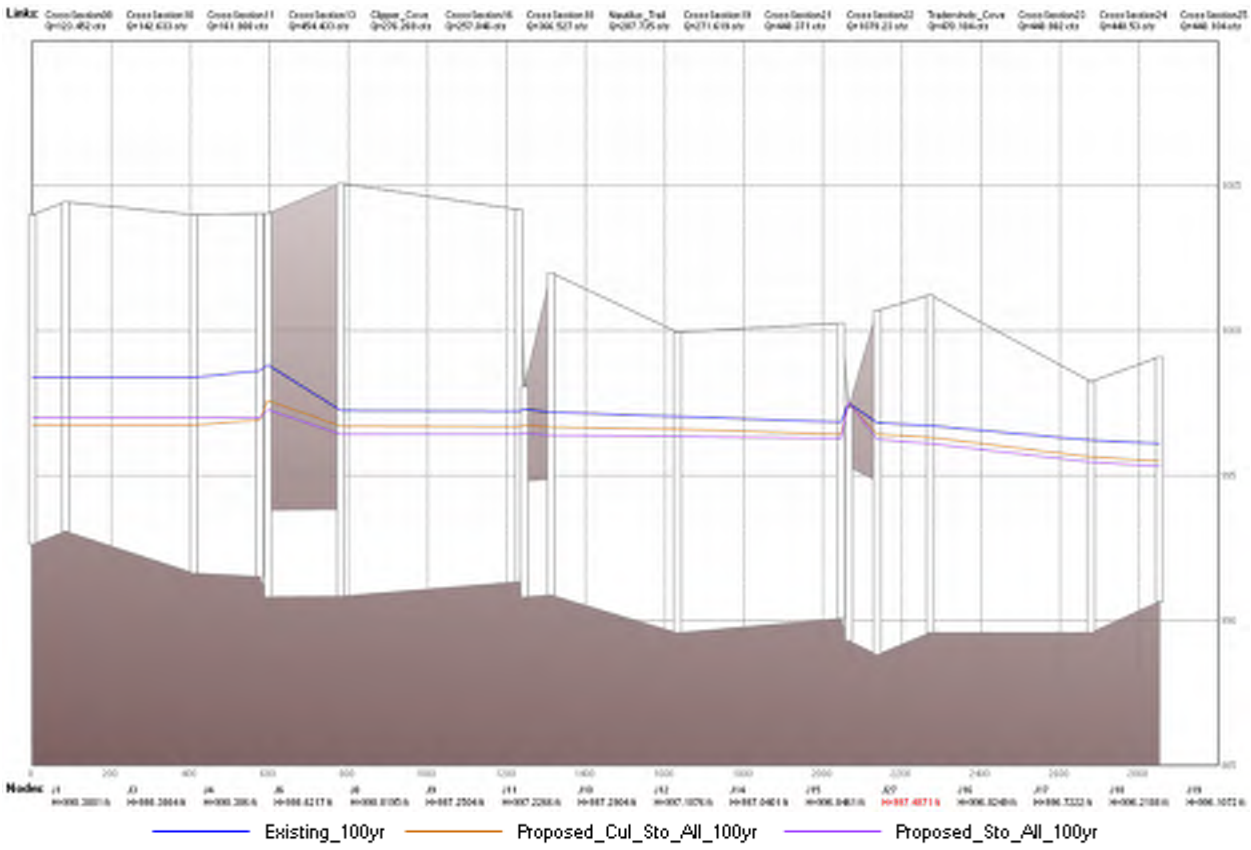


Figure E-4: Compare Existing Conditions and Proposed Regional Storage Including Downstream with Culvert Scenario System Profiles for 100-year storm

Table E-3: Combination 1 + 4: Compare Existing Conditions to Proposed Regional Storage System (including downstream) and Replace Clipper Cove Culvert Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	994.5	1.4	6.1	2.5	171.1	96.7
10-year	997.5	996.5	1.0	7.9	3.4	224.4	204.3
100-year	998.8	997.7	1.2	9.9	4.0	280.3	255.3
Labor Day 2020	999.1	997.5	1.6	9.6	3.5	272.0	225.6
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	993.9	1.3	1.5	2.2	42.8	44.9
10-year	997.0	995.4	1.7	2.5	2.3	249.0	88.9
100-year	998.4	996.7	1.7	3.6	1.8	601.4	126.4
Labor Day 2020	998.9	996.5	2.4	2.2	2.3	426.4	112.5
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	994.0	1.3	2.9	2.1	175.7	50.9
10-year	997.2	995.5	1.8	3.9	2.3	467.8	148.3
100-year	999.1	996.8	2.3	4.2	3.0	871.9	294.2
Labor Day 2020	998.9	996.5	2.4	3.6	2.6	657.6	242.4
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.0	0.8	2.1	1.7	154.9	79.0
10-year	996.0	995.4	0.6	1.8	1.8	213.5	157.9
100-year	997.3	996.7	0.5	1.5	1.6	258.6	217.6
Labor Day 2020	997.2	996.5	0.7	2.3	1.9	272.4	200.0
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	993.1	0.8	1.8	1.4	158.3	94.1
10-year	995.2	994.5	0.7	2.0	1.9	302.3	235.1
100-year	996.2	995.6	0.6	2.2	2.4	448.1	402.4
Labor Day 2020	996.1	995.5	0.6	2.2	2.3	437.5	386.8

Challenges

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

4. Divert Walmart

Description

It was proposed that runoff from the west side of the Bainbridge Walmart property could be redirected down California Street into Aurora Lake. An alternative was analyzed that eliminated the Walmart subcatchment from the model.

Level of Service

The proposed divert Walmart model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-4. Figure E-5compares 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.

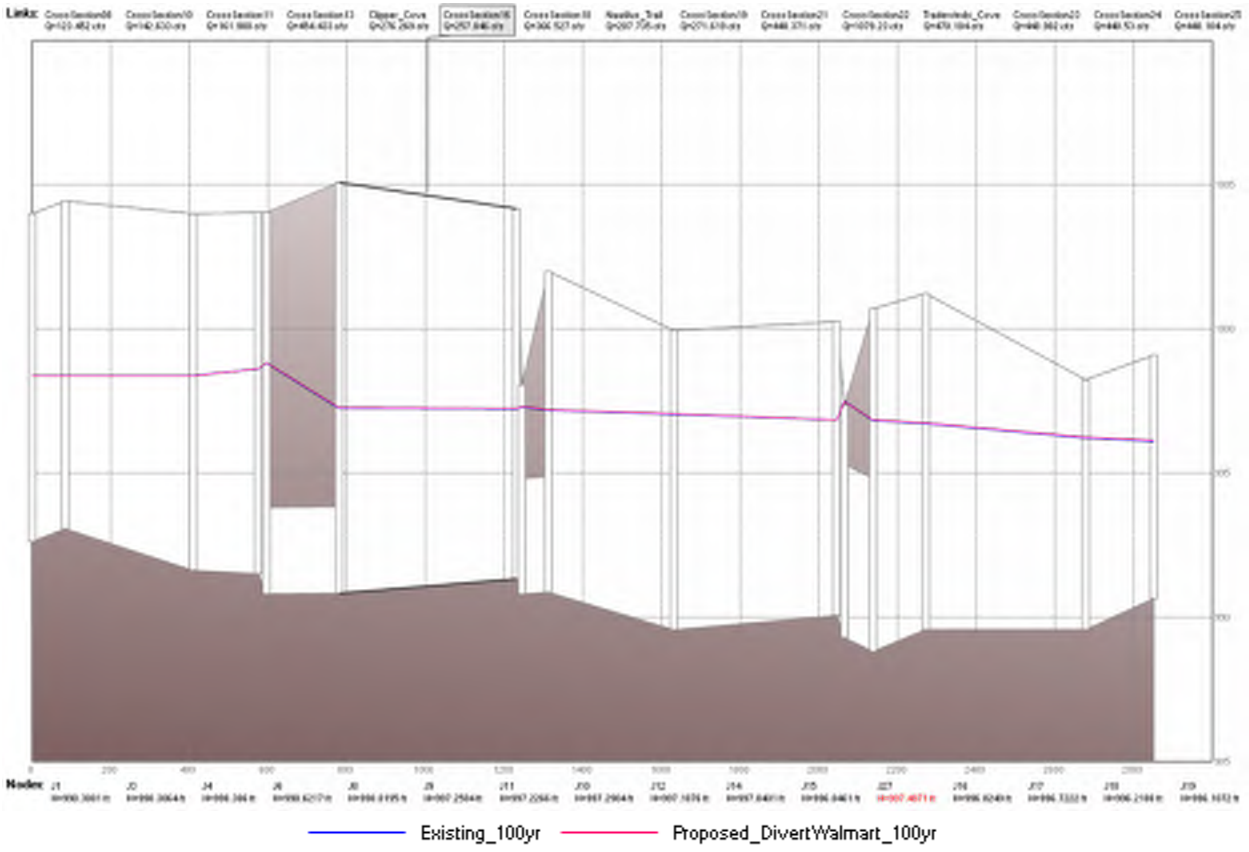


Figure E-5: Compare Existing Conditions and Divert Walmart Scenario System Profiles for 100-year storm

Table E-4: Compare Existing Conditions to Proposed Divert Walmart Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	995.9	0.0	6.1	6.0	171.1	170.5
10-year	997.5	997.5	0.0	7.9	7.9	224.4	224.2
100-year	998.8	998.8	0.0	9.9	9.9	280.3	279.5
Labor Day 2020	999.1	999.1	0.0	9.6	9.5	272.0	269.4
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	995.2	0.0	1.5	1.5	42.8	43.8
10-year	997.0	997.0	0.0	2.5	2.5	249.0	248.5
100-year	998.4	998.4	0.0	3.6	3.5	601.4	599.7
Labor Day 2020	998.9	998.8	0.0	2.2	2.2	426.4	422.8
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	995.3	0.0	2.9	2.9	175.7	175.3
10-year	997.2	997.2	0.0	3.9	3.9	467.8	467.0
100-year	999.1	999.1	0.0	4.2	4.2	871.9	868.7
Labor Day 2020	998.9	998.9	0.0	3.6	3.6	657.6	653.5
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.8	0.0	2.1	2.1	154.9	155.1
10-year	996.0	996.0	0.0	1.8	1.8	213.5	214.3
100-year	997.3	997.3	0.0	1.5	1.5	258.6	257.9
Labor Day 2020	997.2	997.2	0.0	2.3	2.3	272.4	270.0
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	993.9	0.0	1.8	1.8	158.3	157.2
10-year	995.2	995.2	0.0	2.0	2.0	302.3	308.3
100-year	996.2	996.2	0.0	2.2	2.2	448.1	448.1
Labor Day 2020	996.1	996.1	0.0	2.2	2.2	437.5	435.8

Challenges

Diverting the runoff from Walmart would require modification to the existing stormwater infrastructure and coordination with Bainbridge Township, Walmart, and the Aurora Shores Homeowners Association.

5. Divert Signature of Solon

Description

It was proposed that runoff from the Signature of Solon golf course property could be redirected into Aurora Lake. An alternative was analyzed that eliminated the Signature of Solon subcatchment from the model.

Level of Service

The proposed divert Signature of Solon model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-5. Figure E-6 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.

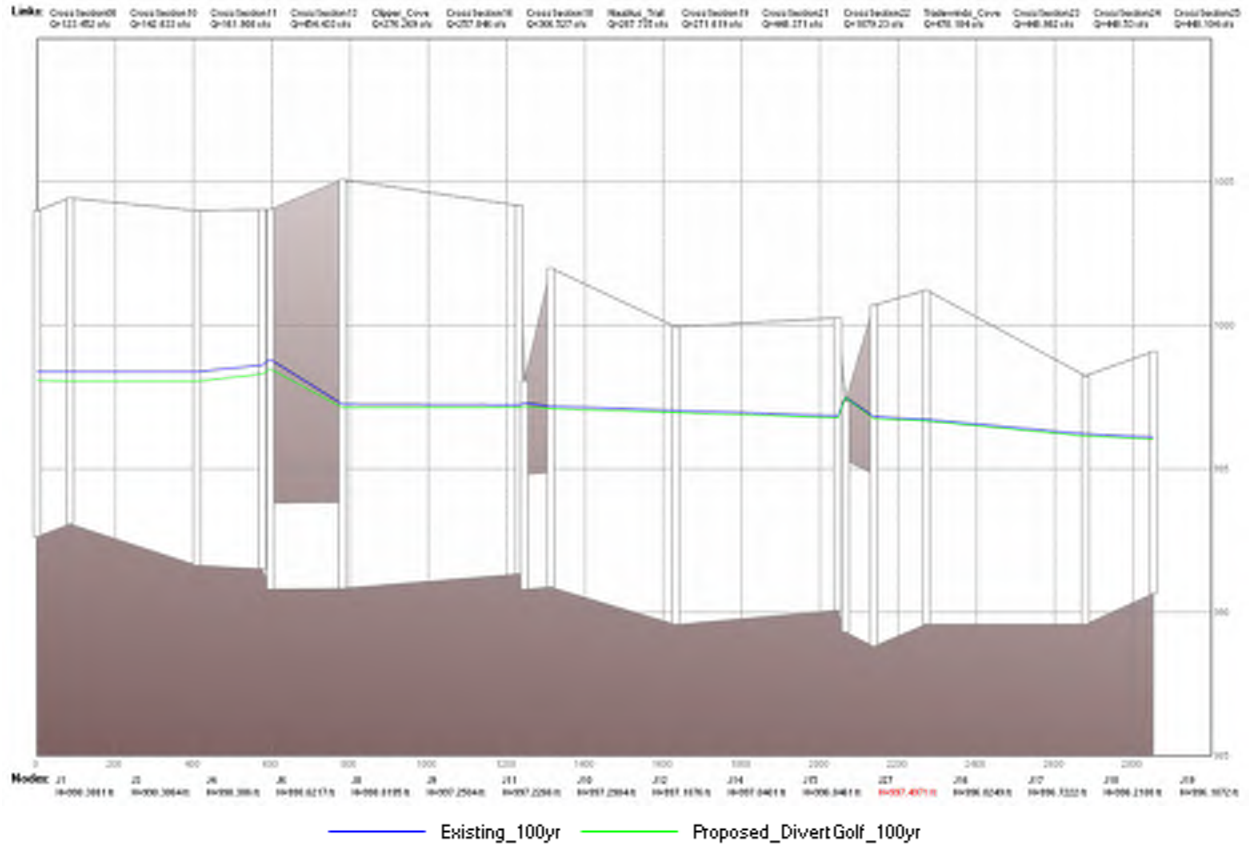


Figure E-6: Compare Existing Conditions and Divert Signature of Solon Scenario System Profiles for 100-year storm

Table E-5: Compare Existing Conditions to Divert Signature of Solon Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	995.8	0.1	6.1	5.9	171.1	166.8
10-year	997.5	997.3	0.2	7.9	7.5	224.4	213.0
100-year	998.8	998.6	0.3	9.9	9.3	280.3	262.1
Labor Day 2020	999.1	998.6	0.5	9.6	8.7	272.0	244.8
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	995.0	0.1	1.5	1.5	42.8	44.7
10-year	997.0	996.8	0.2	2.5	2.2	249.0	199.4
100-year	998.4	998.1	0.3	3.6	3.4	601.4	509.7
Labor Day 2020	998.9	998.3	0.6	2.2	2.0	426.4	325.8
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	995.2	0.2	2.9	2.7	175.7	155.0
10-year	997.2	997.0	0.3	3.9	3.7	467.8	410.1
100-year	999.1	998.8	0.3	4.2	4.1	871.9	772.5
Labor Day 2020	998.9	998.4	0.5	3.6	3.4	657.6	537.9
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.7	0.1	2.1	2.1	154.9	151.3
10-year	996.0	995.9	0.1	1.8	1.8	213.5	201.3
100-year	997.3	997.1	0.1	1.5	1.5	258.6	242.1
Labor Day 2020	997.2	997.0	0.2	2.3	2.3	272.4	247.2
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	993.8	0.1	1.8	1.8	158.3	149.1
10-year	995.2	995.1	0.1	2.0	2.0	302.3	294.3
100-year	996.2	996.1	0.1	2.2	2.2	448.1	430.3
Labor Day 2020	996.1	996.0	0.1	2.2	2.2	437.5	414.2

Challenges

The diversion would require modification to the existing stormwater infrastructure and coordination with the City of Solon, Signature of Solon, and the Aurora Shores Homeowners Association.

6. Pump Station

Description

If the Village opted to forego the culvert replacement, a pump station could be installed to provide a similar level of protection at the Clipper Cove culvert crossing. A stormwater pump station was modeled on the equivalent level of protection that the proposed Clipper Cove 16-ft by 4-ft box culvert would provide. It was determined that the pump station would need to be sized for a flow rate of approximately 75 MGD (113 cfs) to provide the same level of service as the box culvert. This is because the proposed culvert replacement increases the flow capacity at Clipper Cove by a similar amount. The planning-level cost for a pump station of this size is roughly $5,400,000. The cost opinion can be found in Appendix K.

Level of Service

Since this scenario was developed to provide the equivalent level of protection that the proposed Clipper Cove 16-ft by 4-ft box culvert would provide, the Level of Service results are equal to those in the Clipper Cove Culvert Improvements section, which is reproduced in Table E-6.

Challenges

In general, it is very expensive to use pumping for flood control purposes; this is because stormwater runoff results in very high flow rates, which require large and expensive pumps. Furthermore, these systems must include backup power systems to ensure they function during a thunderstorm; this requires large and expensive generator equipment and fuel storage. These facilities take up significant space and would likely not integrate well in a residential subdivision. Due to the high cost and facility footprint needs of the pump station, we do not recommend pumping as an option.

Table E-6: Compare Existing Conditions to Proposed Replace Clipper Cove Culvert Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	995.8	0.1	6.1	3.9	171.1	230.7
10-year	997.5	997.8	-0.3	7.9	5.6	224.4	360.3
100-year	998.8	999.2	-0.4	9.9	7.5	280.3	480.1
Labor Day 2020	999.1	998.9	0.2	9.6	6.0	272.0	382.6
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	994.8	0.4	1.5	1.8	42.8	55.6
10-year	997.0	996.6	0.4	2.5	1.8	249.0	157.5
100-year	998.4	997.9	0.5	3.6	3.2	601.4	456.0
Labor Day 2020	998.9	997.8	1.1	2.2	2.1	426.4	312.7
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	995.2	0.1	2.9	3.3	175.7	189.0
10-year	997.2	997.1	0.2	3.9	4.6	467.8	507.6
100-year	999.1	998.9	0.2	4.2	5.2	871.9	915.8
Labor Day 2020	998.9	998.5	0.4	3.6	4.5	657.6	678.5
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.9	-0.1	2.1	2.3	154.9	187.0
10-year	996.0	996.6	-0.6	1.8	2.3	213.5	317.2
100-year	997.3	997.9	-0.7	1.5	2.1	258.6	420.3
Labor Day 2020	997.2	997.7	-0.5	2.3	2.5	272.4	354.4
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	994.0	-0.1	1.8	1.9	158.3	164.8
10-year	995.2	995.6	-0.4	2.0	2.2	302.3	350.4
100-year	996.2	996.8	-0.5	2.2	2.4	448.1	559.1
Labor Day 2020	996.1	996.6	-0.4	2.2	2.4	437.5	527.7

7. Pump Station and Gate

Description

An alternative was modeled for a 35-MGD stormwater pump station upstream of Clipper Cove culvert that pumps into Aurora Lake boating channel. A 700-ft-long gate (height at elevation 1004 ft) would be installed at Anchorage Cove to isolate the stormwater on the east branch upstream of the Clipper Cove culvert. The gate would separate the stormwater from the east branch, which would be pumped by the pump station, from the stormwater on the north branch, which would flow through the Clipper Cove culvert.

Level of Service

The proposed pump station and gate model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-7. Figure E-7 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.

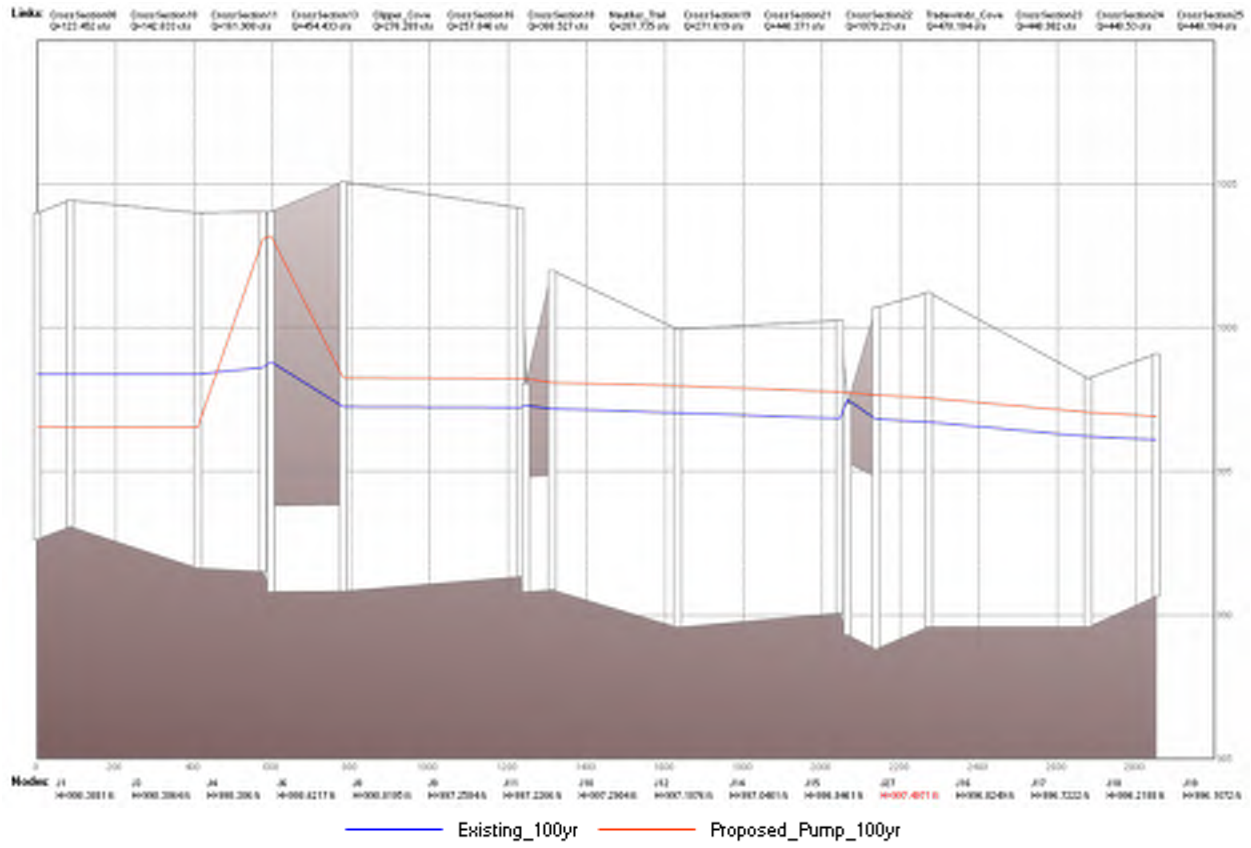


Figure E-7: Compare Existing Conditions and Pump Station and Gate Scenario System Profiles for 100-year storm

Table E-7: Compare Existing Conditions to Proposed Pump and Gate Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	995.6	0.3	6.1	6.0	171.1	168.6
10-year	997.5	999.8	-2.2	7.9	12.4	224.4	350.7
100-year	998.8	1003.2	-4.4	9.9	15.5	280.3	437.9
Labor Day 2020	999.1	1002.4	-3.3	9.6	14.4	272.0	406.9
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	994.6	0.6	1.5	1.7	42.8	41.4
10-year	997.0	995.7	1.3	2.5	1.7	249.0	52.2
100-year	998.4	996.5	1.9	3.6	1.7	601.4	57.2
Labor Day 2020	998.9	996.6	2.3	2.2	1.7	426.4	54.1
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	995.3	0.0	2.9	3.3	175.7	179.3
10-year	997.2	999.5	-2.3	3.9	3.1	467.8	372.0
100-year	999.1	1003.1	-4.0	4.2	2.5	871.9	500.9
Labor Day 2020	998.9	1002.3	-3.4	3.6	3.3	657.6	439.4
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.6	0.2	2.1	2.1	154.9	155.6
10-year	996.0	996.9	-0.9	1.8	2.3	213.5	340.6
100-year	997.3	998.3	-1.0	1.5	2.0	258.6	434.0
Labor Day 2020	997.2	998.1	-0.9	2.3	2.3	272.4	403.4
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	993.8	0.2	1.8	1.8	158.3	144.2
10-year	995.2	995.8	-0.6	2.0	2.3	302.3	392.0
100-year	996.2	997.1	-0.8	2.2	2.5	448.1	632.3
Labor Day 2020	996.1	996.9	-0.8	2.2	2.5	437.5	590.7

Challenges

The same challenges for the pump station scenario apply to this alternative. In addition, construction of the gate will require following the state regulatory review, potential FEMA floodplain study, and permitting process, as necessary. Since the stormwater from the north branch be blocked from flooding the east branch as

it does under existing conditions, and no additional storage would be added upstream of Clipper Cove culvert, installing the gate would increase flood levels north of Clipper Cove culvert.

8. Combination: Replace Culvert, Pump Station and Gate

Description

An alternative was analyzed that combined replacing Clipper Cove culvert with installing the 35-MGD stormwater pump station and a 400-ft-long gate (height at 1001 ft). The height of the gate would be shorter than the alternative for the pump station without the upsized culvert because the flood levels on the north branch would be lower. The shorter gate would also not need to be as long.

Level of Service

The proposed culvert with pump station and gate model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-8. Figure E-8 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.

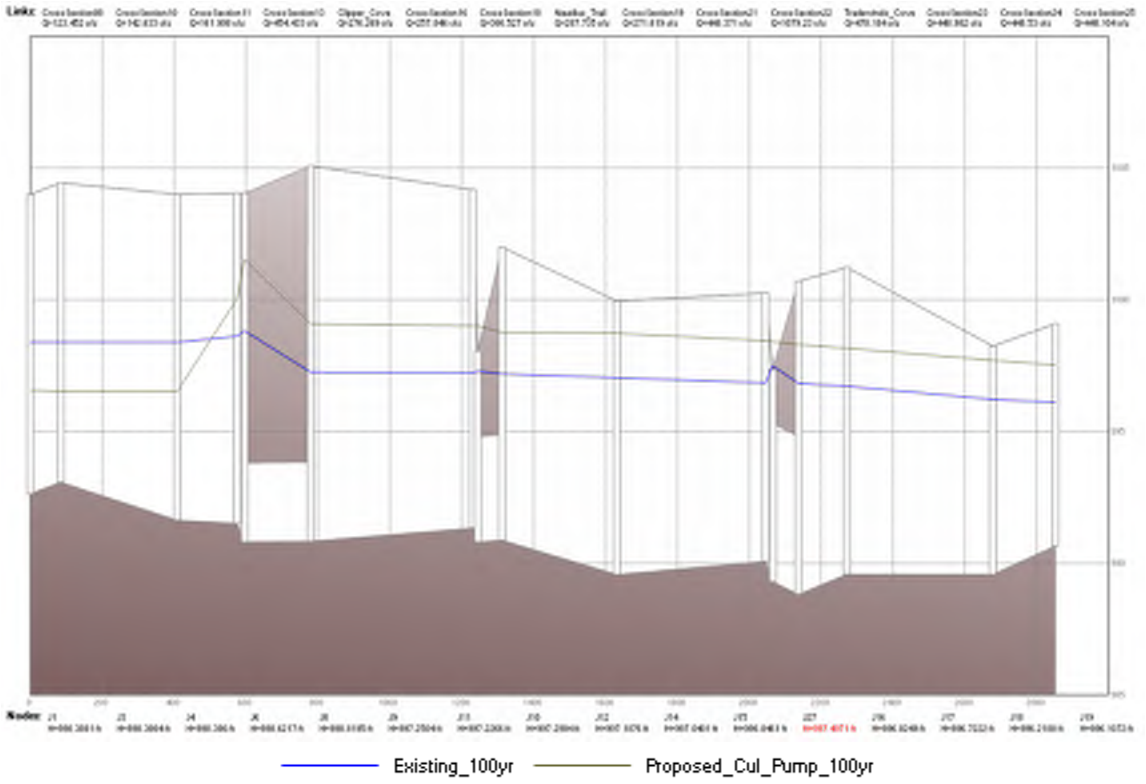


Figure E-8: Compare Existing Conditions and Culvert with Pump Station and Gate Scenario System Profiles for 100-year storm

Table E-8: Compare Existing Conditions to Combination 1 + 8: Replace Clipper Cove Culvert, Install Pump Station and Gate Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	995.3	0.6	6.1	3.5	171.1	193.2
10-year	997.5	998.3	-0.8	7.9	7.5	224.4	479.2
100-year	998.8	1001.6	-2.7	9.9	12.9	280.3	823.4
Labor Day 2020	999.1	1000.7	-1.6	9.6	10.3	272.0	657.4
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	994.6	0.6	1.5	1.7	42.8	40.7
10-year	997.0	995.7	1.3	2.5	1.7	249.0	52.4
100-year	998.4	996.5	1.9	3.6	1.7	601.4	57.2
Labor Day 2020	998.9	996.6	2.3	2.2	1.7	426.4	53.9
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	995.1	0.2	2.9	3.8	175.7	197.7
10-year	997.2	997.8	-0.5	3.9	4.8	467.8	580.9
100-year	999.1	1000.0	-1.0	4.2	4.6	871.9	850.9
Labor Day 2020	998.9	999.4	-0.5	3.6	4.5	657.6	673.3
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.6	0.2	2.1	2.1	154.9	158.8
10-year	996.0	997.1	-1.1	1.8	2.6	213.5	438.1
100-year	997.3	999.1	-1.8	1.5	2.7	258.6	781.4
Labor Day 2020	997.2	998.7	-1.5	2.3	2.5	272.4	621.5
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	993.7	0.2	1.8	1.8	158.3	143.6
10-year	995.2	995.9	-0.7	2.0	2.5	302.3	411.6
100-year	996.2	997.7	-1.5	2.2	2.9	448.1	791.6
Labor Day 2020	996.1	997.4	-1.3	2.2	2.7	437.5	718.9

Challenges

The same challenges of replacing the culvert and installing the pump station and gate apply to this alternative.

9. Combination: Replace Culvert, Pump Station and Gate, small version

Description

An alternative was analyzed in which the Clipper Cove culvert is replaced, a gate installed at Anchorage Cove, and a small, 10-MGD pump station is constructed with a minimalist design without a superstructure.

Level of Service

The proposed culvert with small pump station and gate model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-9. Figure E-9 compares the system profiles for the *Existing Conditions* model, the 35-MGD pump station scenario, and the 10-MGD pump station scenario during a 100-year recurrence interval event for the area just upstream and just downstream of Clipper Cove.

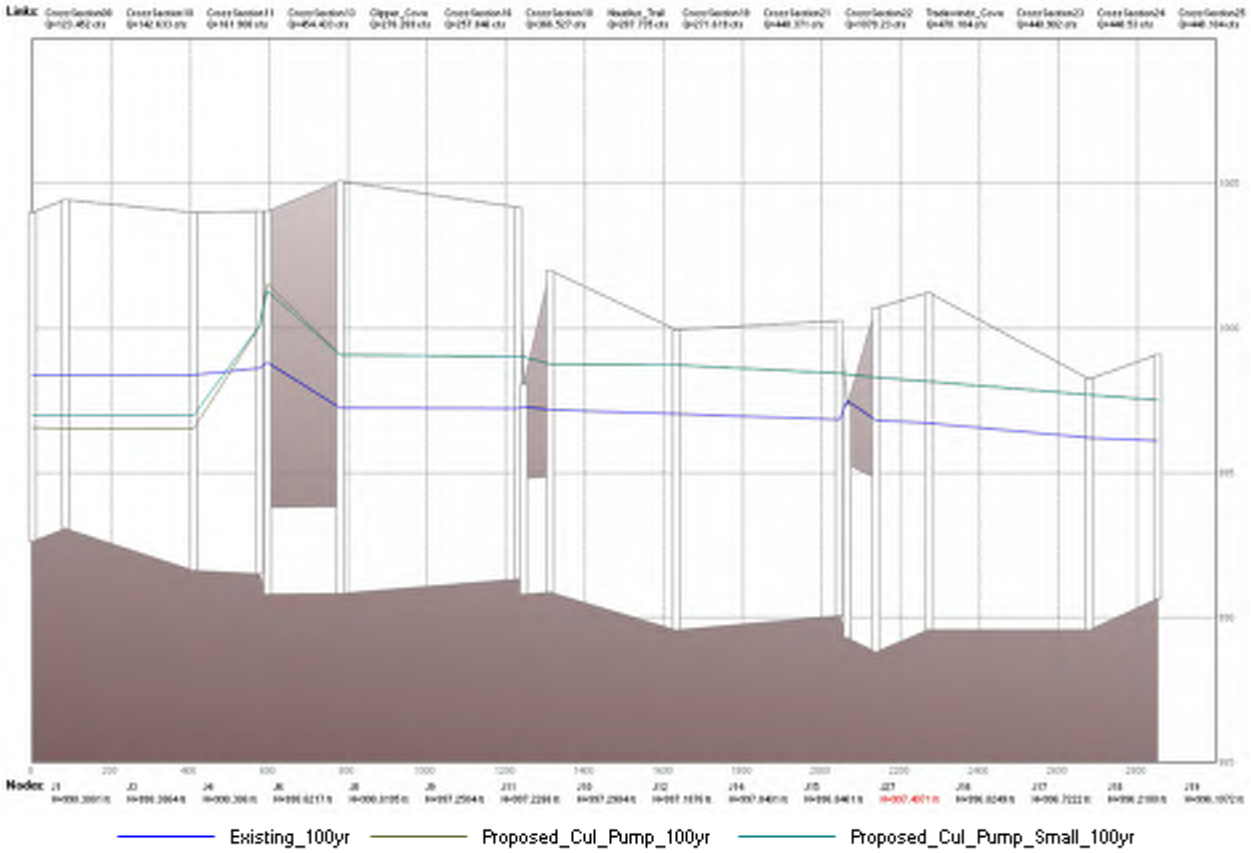


Figure E-9: Compare Existing Conditions and Culvert with Small Pump Station and Gate Scenario System Profiles for 100-year storm

Table E-9: Compare Existing Conditions to Proposed Combination 1+ 8, Small Version: Replace Clipper Cove Culvert, Install Pump Station and Gate Results

Clipper Cove Culvert	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.9	995.3	0.6	6.1	3.6	171.1	188.9
10-year	997.5	998.2	-0.7	7.9	7.5	224.4	479.7
100-year	998.8	1001.6	-2.8	9.9	12.9	280.3	823.6
Labor Day 2020	999.1	1000.7	-1.6	9.6	10.3	272.0	657.2
East Branch Upstream Cross Section 11	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.2	995.3	-0.1	1.5	0.8	42.8	14.2
10-year	997.0	996.3	0.7	2.5	0.8	249.0	19.5
100-year	998.4	997.0	1.4	3.6	0.8	601.4	21.0
Labor Day 2020	998.9	997.5	1.4	2.2	1.0	426.4	19.7
North Branch Upstream Cross Section 12	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	995.3	995.1	0.2	2.9	3.8	175.7	198.7
10-year	997.2	997.8	-0.5	3.9	4.8	467.8	580.4
100-year	999.1	1000.0	-1.0	4.2	4.6	871.9	851.5
Labor Day 2020	998.9	999.4	-0.5	3.6	4.5	657.6	673.4
Immediately Downstream Cross Section 16	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	994.8	994.6	0.2	2.1	2.1	154.9	158.0
10-year	996.0	997.1	-1.1	1.8	2.6	213.5	439.9
100-year	997.3	999.1	-1.8	1.5	2.7	258.6	781.5
Labor Day 2020	997.2	998.7	-1.5	2.3	2.5	272.4	621.5
Further Downstream Cross Section 25	Existing	Proposed	Change	Existing	Proposed	Existing	Proposed
Recurrence Interval	Max HGL (ft)	Max HGL (ft)	Reduce HGL (ft)	Velocity (ft/s)	Velocity (ft/s)	Peak Flow (cfs)	Peak Flow (cfs)
1-year	993.9	993.7	0.2	1.8	1.8	158.3	143.4
10-year	995.2	995.9	-0.7	2.0	2.5	302.3	412.1
100-year	996.2	997.7	-1.5	2.2	2.9	448.1	791.7
Labor Day 2020	996.1	997.4	-1.3	2.2	2.7	437.5	719.4

Challenges

The same challenges for replacing the culvert and installing the gate and larger pump station apply to this alternative. In addition, extra maintenance would be required for the unprotected pump station.

10. Combination: Replace Culvert, Pump Station and Gate, tiny version

Description

An alternative was analyzed, for the sake of comparison by order of magnitude, in which the Clipper Cove culvert is replaced, a gate installed at Anchorage Cove, and a tiny, 1-MGD pump station is constructed with a minimalist design without a superstructure.

Level of Service

The proposed culvert with small pump station and gate model scenario results for cross sections upstream and downstream of Clipper Cove are listed in Table E-10. Figure E-10 compares the system profiles for the *Existing Conditions* model, the 35-MGD pump station scenario, the 10-MGD pump station scenario, and the 1-MGD pump station scenario during a 100-year recurrence interval event for the area just upstream and just downstream of Clipper Cove.

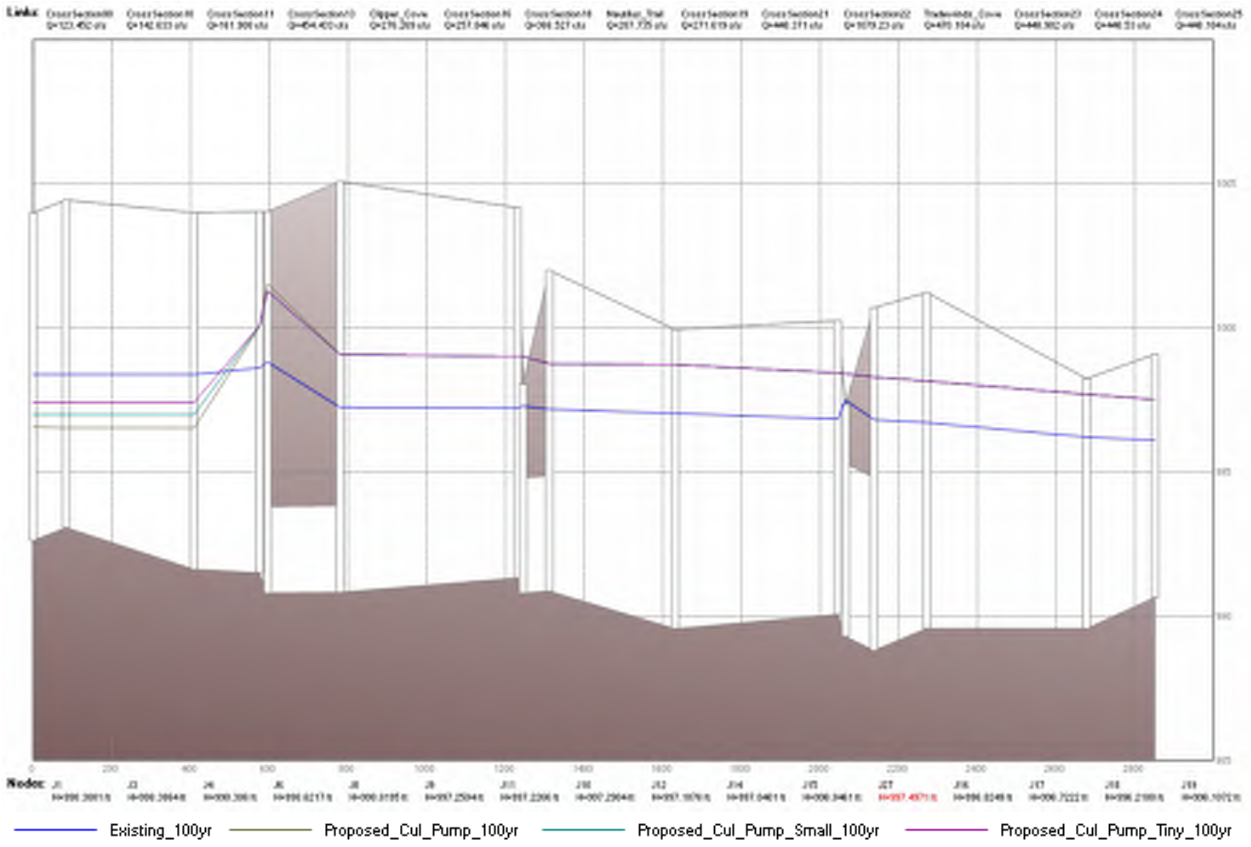


Figure E-10: Compare Existing Conditions and Culvert with Tiny Pump Station and Gate Scenario System Profiles for 100-year storm