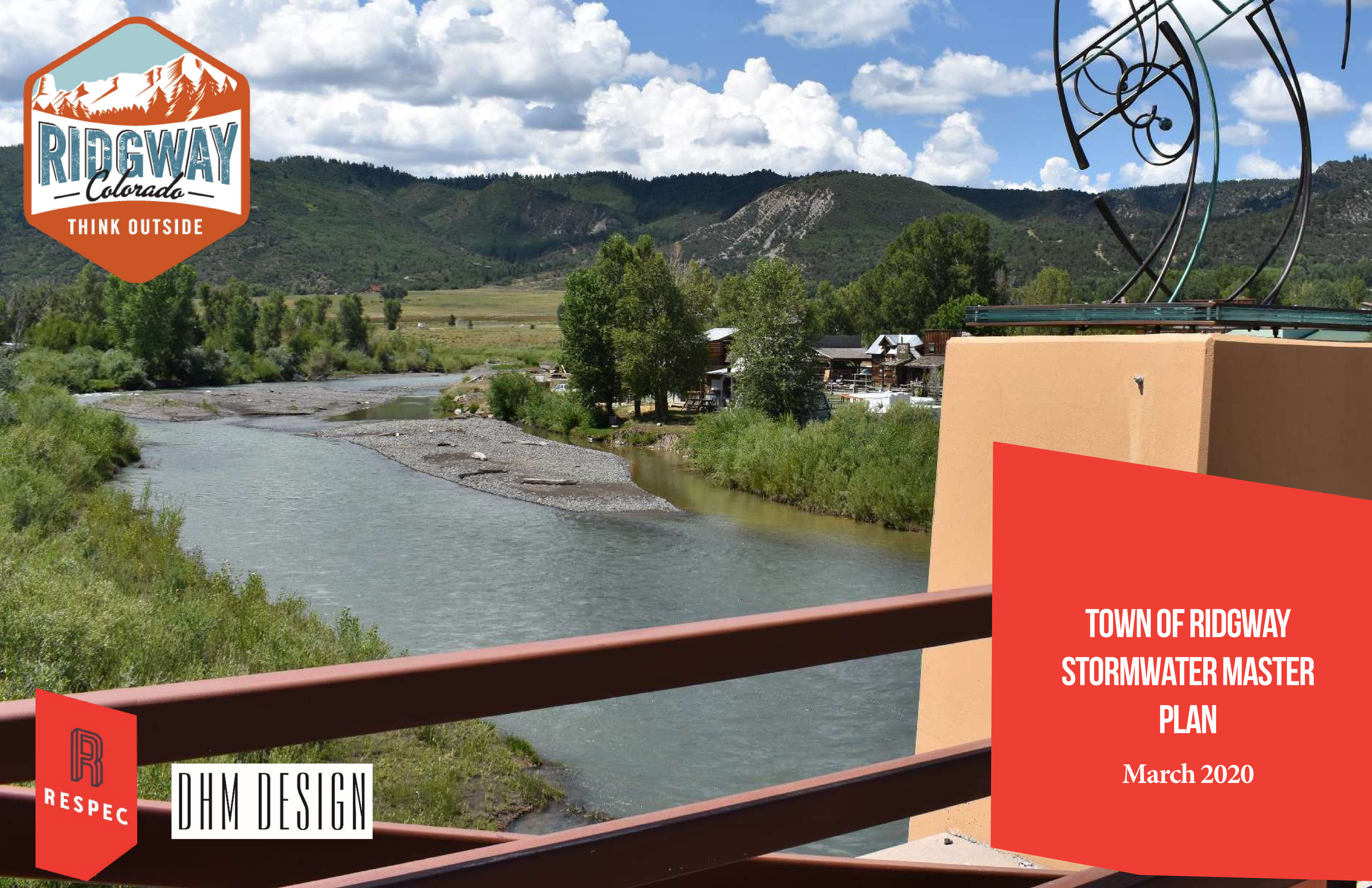


TOWN OF RIDGWAY STORMWATER MASTER PLAN

March 2020

This Page Intentionally Left Blank

TABLE OF CONTENTS

APPENDICES

I INTRODUCTION

I.1 PURPOSE AND GOALS

On May 1, 2019, the Town of Ridgway (Town) contracted with RESPEC Consulting Services (with subcontract to DHM Design) for the delivery of engineering services for a Stormwater Master Plan for the Town. The goals of the master plan included establishing a baseline hydrologic study and providing stormwater solutions that addressed both water quantity and quality to guide future development.

Eight specific project goals were identified by the Town prior to beginning the project:

1. Determine a Ridgway specific design storm for use in modeling and design calculations with consideration given towards changing weather patterns.
2. Understand the limitations and identify potential problems of the existing and proposed stormwater drainage infrastructure through an electronic modeling program.
3. Develop a comprehensive design and plan for managing stormwater within the study area, while considering impacts above and below the study area.
4. Create standard design criteria and specifications for use by current and future development to address and mitigate upstream, onsite and downstream stormwater management issues. Issues may include; flooding, erosion, maintenance needs and water quality concerns.
5. Identify and draft policy and regulatory changes necessary for the Town to implement the stormwater plan (e.g.: municipal code updates).
6. Determine cost estimates and priority recommendations for implementing the improvements while ensuring downstream infrastructure is in place and can accept the water.
7. Engage the public and incorporate community concerns into stormwater management solutions while decreasing stormwater issues in years to come.
8. Deliver a comprehensive, usable and implementable stormwater management plan to the Town of Ridgway.

With the exceptions of Goals #4 and #5 above, the project goals have been addressed in the following master plan and provide the Town with a comprehensive and usable guide to manage existing and future stormwater. Goals #4 and #5 have been addressed in the parallel update to the Town's Stormwater Design Standards and Specifications also performed by RESPEC under the same contract. In addition to this report, all supporting hydrologic modeling files have been provided by RESPEC to the Town. Digital files included the input and output files for the Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) and supporting stormwater infrastructure information in ArcGIS format.

I.2 PLANNING PROCESS

During the preparation of this master plan, RESPEC met with the Town and DHM on a consistent basis to discuss project goals and outcomes. Seven project meetings (Appendix M for Meeting Minutes) and two public meetings were held at the following dates and times:

- June 6, 2019: Project Kickoff Meeting
- June 26, 2019: Progress Meeting 1
- July 9, 2019: Public Meeting 1 and Progress Meeting 2
- August 7, 2019: Progress Meeting 3
- September 23, 2019: Progress Meeting 4
- October 21, 2019: Public Meeting 2 and Progress Meeting 5
- November 11, 2019: Progress Meeting 6
- November 21, 2019: Progress Meeting 7

I.3 ACKNOWLEDGEMENTS

The following individuals contributed to this study:

- Jennifer Coates (Town Manager)
- Chase Jones (Town Public Works)
- Joanne Fagan (Town Engineer)
- Mike Jenkins (Town Streets and Fleet Supervisor)
- Alan Leak (RESPEC)
- Jen Winters (RESPEC)
- Jessie Nolle (RESPEC)
- Mike Bannister (RESPEC)
- Rachel Grafman (RESPEC)
- Walker Christensen (DHM)
- Stephen Ellsperman (DHM)
- Susan Chism (DHM)

1 HYDROLOGIC ANALYSIS

1.1 OVERVIEW

The purpose of the hydrologic analysis was to determine the baseline hydrology to serve as the basis for the Town of Ridgway (Town) Stormwater Master Plan. The baseline hydrology provides the existing and future stormwater peak flows and runoff volumes in the Town. The storm runoff hydrographs and routing for the Town were generated using PCSWMM a proprietary software program developed by Computational Hydraulics International (CHI) that uses the Environmental Protection Agency Stormwater Management Model (EPA SWMM) (version 5.1, Release 5.1.010) as the model engine. Input files from PCSWMM can be directly input into the EPA SWMM software program. EPA SWMM was chosen as the hydrologic modeling methodology for the Town's master plan due to its ability to route complicated storm sewer networks along with its ability to model the hydrologic impacts of Low Impact Development (LID) and green stormwater infrastructure.

Peak discharges for the 2-, 5-, 10-, 25-, 50-, and 100-year return periods were analyzed for the watershed. The model was run using the dynamic wave routing method. This method was selected in order to best represent weir flow for overtopping street intersections and to account for small amounts of storage and hydrograph attenuation in features such as Cottonwood Creek.

Two model scenarios were run for each return period: existing conditions and future conditions. Descriptions of both scenarios are as follows:

Existing Conditions: Represents the existing peak flows and volumes within the Town.

Future Conditions: Represents the worst case future peak flows and volumes given the level of anticipated development that will occur within the Town. Future development was obtained from the "Town-wide Master Plan Land Use Map", dated June 2019. The period of future development presented is from 2019 through approximately 2050.

Detailed hydrologic input and output are described in the following sections.

1.2 DESIGN STORM

The Soil Conservation Service (SCS) Type II, 6-hour storm distribution was used to generate the hypothetical storm. The SCS Type II storm represents a temporal distribution of rainfall over the contributing drainage area to the Town. The benefit of using the SCS hypothetical storm distribution is that it is developed to include smaller storm events in a single distribution. For example, the 5-year, 6-hour storm distribution also includes the 5-year, 2-hour rainfall, the 5-year, 1-hour rainfall, etc., down to the 5-year, 1-minute rainfall imbedded in a single distribution (National Engineering Handbook, Part 630.0403).

One of the principles of hydrology is that the peak discharge and volume are determined primarily by rain falling in a duration that is equal to the time of concentration for the watershed. By far the largest watershed within the Town of Ridgway is the Cottonwood Creek basin. The time of concentration for the Cottonwood Creek watershed is much less than 6-hours; therefore, the 6-hour SCS storm distribution was selected for this study. It was assumed that the SCS 24-hour storm distribution could provide unrealistically high runoff volumes for the Town.

The 6-hour rainfall depths for the 2-, 5-, 10-, 25-, 50-, and 100-year return periods were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8 – Midwestern States, Point Precipitation-Frequency Estimates (Appendix B – Hydrologic Analysis- Design Storm) for the centroid of the Town. The incremental rainfall depths were input into PCSWMM to model each design storm. The Point Rainfall Depths are shown in Table 1-1 and the storm hyetographs are available in Appendix B - Hydrologic Analysis- Design Storm.

Table 1-1. NOAA Atlas 14 Point Rainfall Depth (inches)

Return Period	6-hour
2-year	0.787
5-year	0.960
10-year	1.12
25-year	1.37
50-year	1.58
100-year	1.82

The Town has reported storms with rainfall in exceedance of 1-inch in less than 1-hour in recent years. Statistically, such a storm would be equivalent to the 1-hour, 25-year event and have an approximately 4-percent chance of occurring in any given year. RESPEC evaluated local rainfall gages to determine if a 1-inch in less than 1-hour storm appeared to be statistically more likely to happen than the 25-year event suggested by NOAA. Rain gages were analyzed from the surrounding area and included stations in Ouray, Telluride, Norwood, Montrose, and Sanborn Park. The gages varied in years of record with the longest spanning 126 years and the shortest spanning 22 years (Table 1-2).

Table 1-2. 60-min Rainfall Data at Local Gages

Gage Info				60-min Rainfall (inches)					
Station	#	Years Record	Duration	1-year	2-year	5-year	10-year	25-year	50-year
Ouray	05-6203	1948-2006	1 day	0.416	0.468	0.583	0.705	0.912	1.1
		1949-2010	1 hour						
		1984-2006	15 min						
Telluride 4WNW	05-8204	1900 - 2008	1 day	0.459	0.517	0.641	0.773	0.998	1.21
		1948 - 2008	1 hour						
		1973-2008	15 min						
Norwood	05-6012	1924 - 2008	1 day	0.465	0.577	0.773	0.949	1.21	1.42
Montrose #2	05-5722	1885 - 2011	1 day	0.325	0.402	0.541	0.669	0.862	1.02
Sanborn Park	60-0045	1985 - 2011	1 hour	0.508	0.6	0.775	0.945	1.22	1.45

Three of the five gages (Telluride, Ouray, and Sanborn Park) include data for 1-hour duration storm events. Reviewing the rain depths for 1-hour storms at those gages provided 135 total data points with 6 of those points exceeding 1 inch. Notably, the 6 instances of storms exceeding 1-inch in 1-hour occurred mostly in recent history. This could be due many reasons - better and more complete gage data; changes in climate; statistical anomalies; or various other reasons. Regardless of the reason, it can be inferred that storms exceeding 1-inch in 1-hour have occurred more frequently in recent history and that those types of storms will likely continue into the future. Statistically this number of storms represents 4% of the total points exceeding 1-inch, or approximately the 25-year storm event. In other words, review of the regional rain gage data supports the statistical equivalent of 1-inch in 1-hour is equivalent to an approximately 25-year storm event. Rain gage information and supporting calculations are attached in Appendix B – Hydrologic Analysis of Design Storm.

It was decided for the purposes of this master plan, that a variety of storm events would be analyzed to determine the sizes of proposed infrastructure. The 2-year, 5-year, and 25-year storms were selected as the baseline design storms and are discussed more in in Section 3 – Alternatives Analysis.

1.3 SUBCATCHMENT CHARACTERISTICS

1.3.1 Subcatchment Delineation

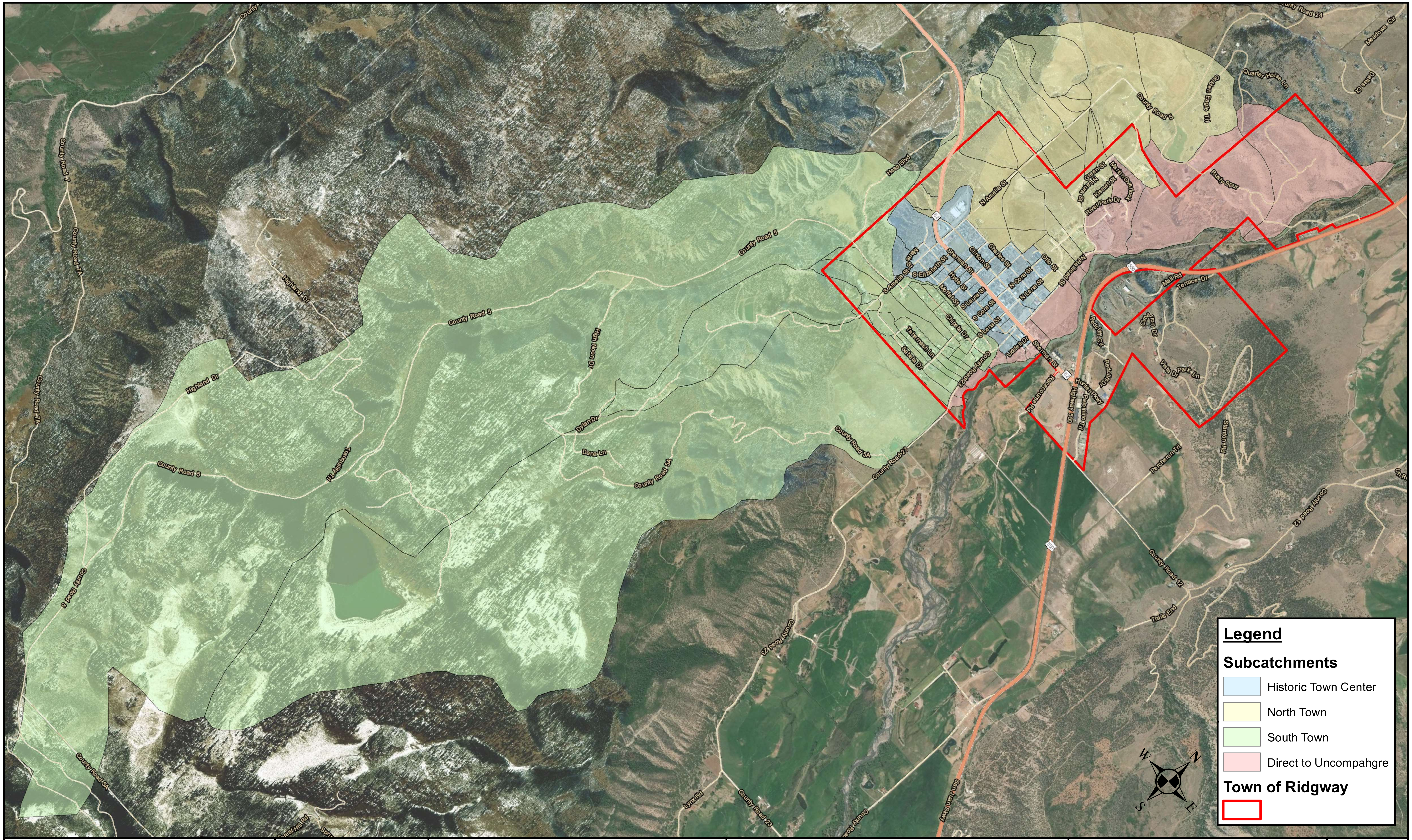
Subcatchment boundaries for the Town were delineated using two-foot contours provided by the Town. For the areas outside of the coverage of the 2-foot contours, the United States Geological Survey (USGS) National Map Digital Elevation Model (DEM) was used to estimate subcatchment boundaries. This is most relevant in the areas to the south and the north of the Historic Town Core. Subcatchment delineations were performed in ArcMap (version 10.6).

A total of 146 subcatchments were delineated in the Town. The subcatchments were categorized as follows:

- Historic Town Core (HTC): Subcatchments that are in or directly contribute to the Historic Town Core. 56 total subcatchments were identified as HTC.
- South Town (ST): Subcatchments located south of the HTC, notably including the Cottonwood Creek watershed and the areas to the south of Cottonwood Creek. 39 total subcatchments were identified as ST.
- North Town (NT): Subcatchments located north of the HTC. 40 total subcatchments were identified as NT.
- Direct drainage to the Uncompahgre River (U): Include areas located along the western bank of the Uncompahgre River that directly drain into the river. 13 total subcatchments were identified as U.

The subcatchment identifications, areas, and locations are displayed in Appendix A – Figure A1 - Subcatchment Map and Figure A2- Interactive Hydrology Map. Additionally, an overview of subcatchment categorizations are shown in Figure 1 on the following page.

It should be noted that actual subcatchment boundaries may vary from what was delineated. For example, site specific surveys or developments have the potential to modify identified subcatchment boundaries or even create a new catchment all together. These changes have the potential to alter the hydraulic analysis and should be addressed individually. For the scope and scale of this plan, the 2-foot contours and USGS data was assumed to be adequate and that a finer level of detail would have had little effect on largescale planning.



RESPEC

720 S. Colorado Blvd.
Suite 410 S
Denver, CO 80246
(303) 757-3655
www.respec.com

Created by: Mike Bannister
Date: 6/24/2019

Town of Ridgway
Stormwater Master Plan

0 0.5 1 Miles

Hydrologic Subcatchments

Figure
1

1.3.2 Watershed Imperviousness

Land use data was collected from the Town. Due to plans for future development in the Town, land use and corresponding imperviousness values were created for both existing conditions and anticipated future conditions. The following is a list of land use and impervious surface sources:

1. USGS National Land Cover Database (NLCD) Impervious Surface (30 meter, 2011)
2. GIS and PDF municipal land use and zoning plans:
   - Town-wide Master Plan Land Use Map (July 2019)
   - Town of Ridgway Zoning Map (May 2018)
3. Proposed land development master plans and drainage reports, notably for "Alpenglow CoHousing" and "Lena Street Commons" developments
4. Discussions with the Town Staff

The above sources were utilized to develop the existing and future imperviousness values. The foundation of the Town existing land use is the USGS NLCD Imperviousness (2011), which was verified and modified as needed by visual inspection using aerial imagery and site visits. The USGS NLCD imperviousness values are provided on Figure C-1 in Appendix C - Hydrologic Analysis- Imperviousness. Additionally, the NLCD was updated to reflect a minimum imperviousness of 2% (rather than 0%).

The future land use was developed by altering the imperviousness values for subcatchments with planned future development. See Appendix A – Hydrology Map for future land use maps for the Town of Ridgway. Ten types of future land use were identified as impacting the hydrologic modeling. Table 1-3 provides the imperviousness values assigned to each type.

Table 1-3. Future Land Use Imperviousness

Land Use Type	Imperviousness (%)
Undeveloped Land	2
Parks and Open Space	10
Rural Neighborhoods	20
Institutional	50
Residential Neighborhoods	50
Town Core Neighborhoods	50
Commercial	60
Mixed Use Residential	60
Mixed Use Business	70
Town Core	90

1.3.3 Soils Information

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) classifies soils into four hydrologic groups: A, B, C, and D. Type A soils have a low runoff potential, Type B soils have a moderate runoff potential, Type C soils have a moderately high runoff potential, and Type D soils have a high runoff potential.

Soil information for the Town was collected from the USDA NRCS Web Soil Survey (WSS), dated June 18, 2019. The soils report for the Town can be found in Appendix D – Hydrologic Analysis- Soils Information. The Town is predominately composed of Type C soils. Horton's equation was used in the SWMM model to represent infiltration within the watershed. Horton's equation represents infiltration as beginning at a constant rate and decreasing exponentially with time as the soil becomes saturated. Horton's equation is represented as follows:

$$f_t = f_c + (f_0 - f_c)e^{-kt}$$

Where

f_t = infiltration rate at time t

f_o = initial infiltration rate after the soil has been saturated

f_c = maximum infiltration rate

k = decay coefficient

Infiltration parameters selected to represent the Type C soils within the Town are as follows:

- Initial Infiltration (f_o): 3.0 inches per hour
- Final Infiltration (f_c): 0.15 inches per hour
- Decay Coefficient (k): 0.0018 per second

1.4 PREVIOUS STUDIES

The following three hydrologic studies were recently performed within the Town:

1. *Hydraulic Design Report – SH 62 Ridgway FOR Submittal*, prepared by RESPEC, dated July 2015
2. *Ridgway Business District Hydraulic Report (FOR)*, prepared by Russell Planning and Engineering, dated July 8, 2015
3. *Cottonwood Creek Flood Analysis - Gary Dick Property*, prepared by Del-Mont Consultants, Inc., dated March 10, 2014

The results of the above three studies were used for comparison with the results of the existing peak flows calculated in this analysis to compare relative reasonability. Table 1-4 below provides a comparison of relative discharge per acre for each study. Note that the intent of this comparison was not to calibrate the SWMM model, but to compare the results relative to previous studies prepared for the Town. The results shown in Table 1-4 present the peak flow per acre of land for the Historic Town Core area only and were obtained from the SWMM results (2020 Master Plan) and from Final Drainage Reports (SH 62 Hydrology and Russell Hydrology).

Table 1-4. Comparison of Peak Runoff Results

	Historic Town Core (cfs/acre)				
	2-year	**5-year**	**10-year**	**50-year**	**100-year**
SH 62 Hydrology	0.32	0.55	0.84	1.96	2.59
Russell Hydrology	1.09	1.47	1.94	3.64	4.55
2020 Master Plan	0.67	0.82	1.06	2.08	2.65
	Cottonwood Creek (cfs/acre)				
Gary Dick LOMR	---	---	---	---	0.15
2020 Master Plan	---	---	---	---	0.134

It should be noted that the Russell hydrology only included the business district portion of the HTC associated with the RAMP project. When comparing the results from this study with the Russell engineering peak flows to the subcatchments located exclusively within the business district, the results from this study are within approximately 10%.

1.5 RESULTS OF ANALYSIS

The existing and future 2-, 5-, 10-, 25-, 50- and 100-year peak flows are presented in Table 1-5 for the existing and future conditions. In the areas where development is anticipated, the resulting future conditions peak flows are an average of approximately 57% greater than the existing conditions peak. SWMM output files for the 5-year existing conditions model run is included as an example in Appendix E – Hydraulic Analysis- Existing Conditions SWMM Results.

Table 1-5. Peak Runoff from SWMM Subcatchments

Subcatchment	Existing Land Use - Peak Flows (cfs)						Future Land Use - Peak Flows (cfs)						Difference in Existing and Future Peak Flows (cfs)					
	2-year	5-year	10-year	25-year	50-year	100-year	2-year	5-year	10-year	25-year	50-year	100-year	2-year	5-year	10-year	25-year	50-year	100-year
HTC000	2.34	3.35	11.2	17.82	26.54	33.24	2.34	3.35	11.2	17.82	26.54	33.24	0	0	0	0	0	0
HTC001	2.2	2.69	4.35	9.27	13.67	18.43	3.67	4.48	5.76	10.75	15.06	19.66	1.47	1.79	1.41	1.48	1.39	1.23
HTC002	0.72	0.88	1.03	1.47	1.91	2.37	0.72	0.88	1.03	1.47	1.91	2.37	0	0	0	0	0	0
HTC003	4.09	4.99	6.02	10.28	13.65	18.54	4.09	4.99	6.02	10.28	13.65	18.54	0	0	0	0	0	0
HTC004	3	3.67	4.56	6.44	7.99	9.6	3	3.67	4.56	6.44	7.99	9.6	0	0	0	0	0	0
HTC005	10.47	12.9	15.56	20.92	25.98	31.8	10.47	12.9	15.56	20.92	25.98	31.8	0	0	0	0	0	0
HTC007	1.36	1.66	2.12	3.38	4.51	5.95	1.91	2.34	2.89	4.21	5.51	6.97	0.55	0.68	0.77	0.83	1	1.02
HTC008	0.98	1.2	1.8	2.8	3.89	5.06	1.4	1.71	2.2	3.43	4.51	5.62	0.42	0.51	0.4	0.63	0.62	0.56
HTC009	1.71	2.09	2.76	4.39	5.89	7.76	2.44	2.98	3.71	5.47	7.16	9.03	0.73	0.89	0.95	1.08	1.27	1.27
HTC010	1.35	1.64	2.18	3.47	4.65	6.13	1.91	2.34	2.92	4.31	5.65	7.12	0.56	0.7	0.74	0.84	1	0.99
HTC011	3.52	4.31	5.33	7.87	10.5	13.74	4.97	6.1	7.43	10.38	13.33	16.79	1.45	1.79	2.1	2.51	2.83	3.05
HTC012	3.33	4.07	5.02	7.37	9.85	12.87	4.69	5.76	7.01	9.76	12.52	15.77	1.36	1.69	1.99	2.39	2.67	2.9
HTC013	0.96	1.17	1.47	2.21	2.93	3.72	1.02	1.25	1.56	2.31	3.03	3.82	0.06	0.08	0.09	0.1	0.1	0.1
HTC014	0.77	0.94	1.31	2.07	2.81	3.69	1.09	1.33	1.69	2.54	3.34	4.21	0.32	0.39	0.38	0.47	0.53	0.52
HTC015	0.86	1.05	1.42	2.25	3.03	3.99	1.23	1.5	1.88	2.79	3.65	4.61	0.37	0.45	0.46	0.54	0.62	0.62
HTC016	0.83	1.02	1.45	2.28	3.11	4.08	1.19	1.45	1.84	2.8	3.68	4.62	0.36	0.43	0.39	0.52	0.57	0.54
HTC017	1.67	2.04	2.71	4.31	5.78	7.61	2.35	2.87	3.58	5.3	6.96	8.8	0.68	0.83	0.87	0.99	1.18	1.19
HTC018	0.8	0.98	1.31	2.08	2.79	3.68	1.14	1.39	1.74	2.58	3.38	4.26	0.34	0.41	0.43	0.5	0.59	0.58
HTC019	0.87	1.06	1.41	2.24	3.01	3.96	1.24	1.52	1.89	2.79	3.65	4.61	0.37	0.46	0.48	0.55	0.64	0.65
HTC020	1.72	2.1	2.75	4.38	5.85	7.71	2.45	2.99	3.72	5.46	7.14	9.02	0.73	0.89	0.97	1.08	1.29	1.31
HTC021	1.62	1.98	2.63	4.19	5.62	7.4	2.31	2.82	3.52	5.2	6.81	8.6	0.69	0.84	0.89	1.01	1.19	1.2
HTC022	1.61	1.96	2.58	4.11	5.5	7.25	2.27	2.78	3.46	5.09	6.67	8.43	0.66	0.82	0.88	0.98	1.17	1.18
HTC023	0.74	0.9	1.19	1.9	2.55	3.36	1.05	1.29	1.61	2.36	3.1	3.91	0.31	0.39	0.42	0.46	0.55	0.55
HTC024	0.86	1.05	1.38	2.2	2.94	3.88	1.22	1.5	1.86	2.74	3.58	4.52	0.36	0.45	0.48	0.54	0.64	0.64
HTC025	1.61	1.96	2.55	4.06	5.42	7.15	2.28	2.79	3.47	5.07	6.63	8.37	0.67	0.83	0.92	1.01	1.21	1.22
HTC026	1.72	2.1	2.74	4.36	5.84	7.69	2.44	2.99	3.71	5.45	7.12	9	0.72	0.89	0.97	1.09	1.28	1.31
HTC027	1.91	2.33	2.93	4.63	6.17	8.13	2.71	3.31	4.08	5.88	7.65	9.66	0.8	0.98	1.15	1.25	1.48	1.53
HTC028	1.59	1.94	2.51	4	5.35	7.05	2.26	2.76	3.42	5	6.54	8.26	0.67	0.82	0.91	1	1.19	1.21
HTC029	0.73	0.9	1.18	1.87	2.51	3.3	1.4	1.71	2.1	2.91	3.63	4.4	0.67	0.81	0.92	1.04	1.12	1.1
HTC030	1.38	1.7	2.08	2.9	3.66	4.48	1.52	1.86	2.27	3.12	3.87	4.68	0.14	0.16	0.19	0.22	0.21	0.2
HTC031	0.36	0.44	0.55	0.81	1.02	1.24	0.51	0.62	0.76	0.99	1.16	1.34	0.15	0.18	0.21	0.18	0.14	0.1
HTC032	2.65	3.25	3.99	5.63	7.16	8.83	3.85	4.73	5.71	7.4	8.72	10.16	1.2	1.48	1.72	1.77	1.56	1.33
HTC033	2.25	2.75	3.41	4.99	6.52	8.23	3.12	3.82	4.67	6.41	7.94	9.58	0.87	1.07	1.26	1.42	1.42	1.35
HTC034	1.68	2.05	2.67	4.25	5.68	7.49	2.39	2.92	3.63	5.31	6.95	8.77	0.71	0.87	0.96	1.06	1.27	1.28
HTC035	1.66	2.03	2.56	4.08	5.44	7.16	2.36	2.88	3.56	5.15	6.71	8.47	0.7	0.85	1	1.07	1.27	1.31
HTC036	1.65	2.01	2.58	4.11	5.48	7.22	3.27	4.01	4.89	6.68	8.27	9.97	1.62	2	2.31	2.57	2.79	2.75
HTC037	0.98	1.2	1.49	2.2	2.89	3.67	1.4	1.72	2.1	2.89	3.58	4.33	0.42	0.52	0.61	0.69	0.69	0.66
HTC038	1.2	1.47	1.82	2.63	3.42	4.3	2.02	2.48	2.99	3.86	4.55	5.29	0.82	1.01	1.17	1.23	1.13	0.99
HTC039	0.48	0.59	0.72	0.96	1.13	1.31	0.51	0.63	0.77	0.98	1.14	1.32	0.03	0.04	0.05	0.02	0.01	0.01
HTC040	2.68	3.28	4.04	5.71	7.24	8.9	3.83	4.7	5.68	7.37	8.68	10.1	1.15	1.42	1.64	1.66	1.44	1.2
HTC041	2.09	2.55	3.22	4.93	6.66	8.61	3.92	4.81	5.85	7.87	9.53	11.29	1.83	2.26	2.63	2.94	2.87	2.68
HTC042	3.18	3.9	4.76	6.69	8.74	11.27	4.86	5.99	7.22	9.72	12.17	15.1	1.68	2.09	2.46	3.03	3.43	3.83
HTC043	3.11	3.89	5.7	8.77	11.28	14.11	6.6	8.26	10.34	13.91	16.81	20.01	3.49	4.37	4.64	5.14	5.53	5.9
HTC044	1.12	1.37	1.69	2.35	2.88	3.43	1.38	1.69	2.06	2.64	3.09	3.58	0.26	0.32	0.37	0.29	0.21	0.15
HTC045	1.64	2.01	2.44	3.25	3.92	4.64	1.83	2.25	2.71	3.49	4.1	4.77	0.19	0.24	0.27	0.24	0.18	0.13

Table 1-5. Peak Runoff from SWMM Subcatchments (Cont…)

Subcatchment	Existing Land Use - Peak Flows (cfs)						Future Land Use - Peak Flows (cfs)						Difference in Existing and Future Peak Flows (cfs)					
	2-year	5-year	10-year	25-year	50-year	100-year	2-year	5-year	10-year	25-year	50-year	100-year	2-year	5-year	10-year	25-year	50-year	100-year
HTC046	1.43	1.76	2.16	3.06	3.89	4.79	2.12	2.6	3.14	4.04	4.74	5.51	0.69	0.84	0.98	0.98	0.85	0.72
HTC047	0.13	0.18	0.33	0.53	0.73	0.97	0.17	0.21	0.36	0.56	0.79	1.02	0.04	0.03	0.03	0.03	0.06	0.05
HTC048	2.48	3.03	3.76	5.64	7.57	9.83	2.48	3.03	3.76	5.64	7.57	9.83	0	0	0	0	0	0
HTC049	1.69	2.07	2.59	4.07	5.42	7.14	1.69	2.07	2.59	4.07	5.42	7.14	0	0	0	0	0	0
HTC050	1.36	1.66	2.08	3.22	4.29	5.63	2.08	2.55	3.12	4.4	5.64	7.05	0.72	0.89	1.04	1.18	1.35	1.42
HTC053	0.4	0.49	0.62	0.92	1.15	1.38	0.45	0.55	0.69	0.97	1.19	1.42	0.05	0.06	0.07	0.05	0.04	0.04
HTC054	1.06	1.3	1.67	2.67	3.56	4.7	2.12	2.59	3.16	4.33	5.35	6.45	1.06	1.29	1.49	1.66	1.79	1.75
HTC055	0.26	0.31	0.39	0.53	0.64	0.75	0.26	0.31	0.39	0.53	0.64	0.75	0	0	0	0	0	0
HTC056	0.62	0.76	0.95	1.41	1.85	2.34	0.86	1.05	1.29	1.79	2.22	2.67	0.24	0.29	0.34	0.38	0.37	0.33
NT001	0.51	0.62	1.31	2.75	3.83	4.92	0.51	0.62	1.31	2.75	3.83	4.92	0	0	0	0	0	0
NT002	2.92	3.57	5.25	11.03	16.48	22.58	2.92	3.57	5.25	11.03	16.48	22.58	0	0	0	0	0	0
NT003	1.89	2.3	4.6	9.72	13.74	17.8	1.89	2.3	4.6	9.72	13.74	17.8	0	0	0	0	0	0
NT004	0.28	0.34	0.7	1.46	2.05	2.63	0.28	0.34	0.7	1.46	2.05	2.63	0	0	0	0	0	0
NT005	4.27	5.21	8.17	18.43	28.82	41.08	20.02	24.53	28.76	39.36	51.11	65.48	15.75	19.32	20.59	20.93	22.29	24.4
NT006	2.79	3.41	6.47	16.43	27.23	40.63	10.95	13.38	15.68	26.02	37.75	51.92	8.16	9.97	9.21	9.59	10.52	11.29
NT007	0.5	0.6	1.59	4.23	6.85	9.89	4.48	5.47	6.42	9	11.92	15.45	3.98	4.87	4.83	4.77	5.07	5.56
NT008	1.43	1.74	3.34	8.51	14.09	21.01	6.43	7.86	9.21	14.39	20.53	27.89	5	6.12	5.87	5.88	6.44	6.88
NT009	2.55	3.11	5.37	13.28	22.02	33.04	9.07	11.09	13	21.04	30.65	42.48	6.52	7.98	7.63	7.76	8.63	9.44
NT010	1.06	1.29	3.09	8.16	13.36	19.5	2.66	3.25	4.66	9.98	15.28	21.47	1.6	1.96	1.57	1.82	1.92	1.97
NT011	2.57	3.14	7.08	18.58	30.54	44.86	2.57	3.14	7.08	18.58	30.54	44.86	0	0	0	0	0	0
NT012	0.36	0.44	1.19	3.16	5.1	7.33	0.69	0.84	1.5	3.52	5.47	7.7	0.33	0.4	0.31	0.36	0.37	0.37
NT013	0.29	0.35	1.21	3.19	4.99	6.94	0.29	0.35	1.21	3.19	4.99	6.94	0	0	0	0	0	0
NT014	6.68	8.15	10.11	21.16	33.9	50.75	30.48	37.59	44.23	58.16	73.17	92.57	23.8	29.44	34.12	37	39.27	41.82
NT015	8.1	9.89	12.69	27.22	43.93	65.94	9.63	11.76	14.22	29.07	46.04	68.34	1.53	1.87	1.53	1.85	2.11	2.4
NT016	0.48	0.59	1.19	3.06	5.07	7.52	4.64	5.7	6.69	8.95	11.39	14.41	4.16	5.11	5.5	5.89	6.32	6.89
NT017	0.8	0.97	1.83	4.64	7.69	11.48	7.71	9.48	11.14	14.77	19.04	23.44	6.91	8.51	9.31	10.13	11.35	11.96
NT018	0.52	0.63	1.32	3.43	5.66	8.37	5.03	6.17	7.24	9.72	12.42	15.72	4.51	5.54	5.92	6.29	6.76	7.35
NT019	1.65	2.01	2.68	5.9	9.59	14.42	15.85	19.75	23.4	30.19	36.85	45.02	14.2	17.74	20.72	24.29	27.26	30.6
NT020	1.05	1.29	2.44	6.18	10.25	15.29	10.17	12.51	14.69	19.5	24.64	30.99	9.12	11.22	12.25	13.32	14.39	15.7
NT021	0.46	0.83	2.16	4.78	7.24	10.03	4.54	5.55	6.82	9.73	12.61	15.93	4.08	4.72	4.66	4.95	5.37	5.9
NT022_2	3.79	4.65	5.49	7.4	9.6	12.89	11.23	14.12	16.87	21.8	26.46	32.11	7.44	9.47	11.38	14.4	16.86	19.22
NT023_2	1.28	1.56	1.88	3.75	5.8	8.39	5.78	7.13	8.4	11	13.7	17.06	4.5	5.57	6.52	7.25	7.9	8.67
NT024	0.71	0.86	1.67	4.26	7.06	10.51	6.75	8.3	9.75	12.98	16.45	20.75	6.04	7.44	8.08	8.72	9.39	10.24
NT026	2.42	2.97	3.58	5.32	7.33	9.74	5.44	6.73	8.02	10.64	13.2	16.26	3.02	3.76	4.44	5.32	5.87	6.52
NT026_2	3.16	3.88	4.65	6.48	8.72	11.54	5.98	7.4	8.82	11.67	14.5	17.96	2.82	3.52	4.17	5.19	5.78	6.42
NT026_4	0.74	0.9	1.41	2.47	3.33	4.31	1.7	2.08	2.53	3.68	4.76	5.91	0.96	1.18	1.12	1.21	1.43	1.6
NT027_1	2.71	3.32	3.92	5.51	7.7	10.43	7.38	9.17	10.88	14.15	17.33	21.19	4.67	5.85	6.96	8.64	9.63	10.76
NT027_2	0.39	0.47	0.88	1.66	2.25	2.94	1.16	1.41	1.69	2.53	3.29	4.06	0.77	0.94	0.81	0.87	1.04	1.12
NT028	0.51	0.62	1.26	3.24	5.36	7.95	5.3	6.52	7.66	10.18	12.86	16.13	4.79	5.9	6.4	6.94	7.5	8.18
NT029	0.58	0.73	1.49	3.01	4.47	6.14	3.04	3.73	4.53	6.3	8.04	10.07	2.46	3	3.04	3.29	3.57	3.93
NT030_2	0.43	0.52	0.88	1.41	1.92	2.53	0.66	0.81	1.06	1.7	2.26	2.84	0.23	0.29	0.18	0.29	0.34	0.31
NT030_3	2.86	3.52	4.26	5.84	7.5	9.59	4.5	5.58	6.71	8.89	11.04	13.64	1.64	2.06	2.45	3.05	3.54	4.05
NT031	0.22	0.27	0.42	0.83	1.24	1.74	0.89	1.1	1.31	1.79	2.28	2.87	0.67	0.83	0.89	0.96	1.04	1.13
NT031_2	1.46	1.79	2.23	3.97	5.67	7.66	2.44	2.98	3.58	5.12	6.85	8.94	0.98	1.19	1.35	1.15	1.18	1.28
NT033_1	4.88	5.95	10.04	16.02	21.8	28.78	8	9.76	12.71	20.01	26.37	32.86	3.12	3.81	2.67	3.99	4.57	4.08

Table 1-5. Peak Runoff from SWMM Subcatchments (Cont…)

Subcatchment	Existing Land Use - Peak Flows (cfs)						Future Land Use - Peak Flows (cfs)						Difference in Existing and Future Peak Flows (cfs)					
	2-year	5-year	10-year	25-year	50-year	100-year	2-year	5-year	10-year	25-year	50-year	100-year	2-year	5-year	10-year	25-year	50-year	100-year
NT033_2	0.82	1	1.51	2.48	3.27	4.37	0.89	1.08	1.57	2.53	3.39	4.49	0.07	0.08	0.06	0.05	0.12	0.12
NT033_3	1.6	2.6	4.22	6.99	9.3	11.37	2.43	3.18	4.59	7.82	9.83	11.72	0.83	0.58	0.37	0.83	0.53	0.35
NT034	3.07	3.74	5.09	8.4	11.19	14.6	3.55	4.33	5.54	8.84	11.78	15.54	0.48	0.59	0.45	0.44	0.59	0.94
NT035	7.75	9.48	11.72	17.92	24.2	31.36	12.34	15.15	18.39	25.45	32.56	41.02	4.59	5.67	6.67	7.53	8.36	9.66
ST001	168.91	206.96	242.13	304.13	372.5	462.71	168.91	206.96	242.13	304.13	372.5	462.71	0	0	0	0	0	0
ST003	1.02	1.24	1.77	5.6	9.97	15.4	1.84	2.24	2.62	6.56	11.03	16.53	0.82	1	0.85	0.96	1.06	1.13
ST004	1.09	1.33	1.89	5.97	10.64	16.43	1.84	2.25	2.63	6.86	11.61	17.47	0.75	0.92	0.74	0.89	0.97	1.04
ST005	98.8	120.76	141.06	178.79	224.36	295.1	98.8	120.76	141.06	178.79	224.36	295.1	0	0	0	0	0	0
ST006	0.66	0.81	1.18	3.76	6.69	10.31	0.85	1.04	1.36	3.97	6.93	10.56	0.19	0.23	0.18	0.21	0.24	0.25
ST007	10.97	13.38	15.61	26.49	43.21	66.04	10.97	13.38	15.61	26.49	43.21	66.04	0	0	0	0	0	0
ST008	0.34	0.42	0.99	2.29	3.4	4.55	1.09	1.34	1.69	2.98	3.99	5.34	0.75	0.92	0.7	0.69	0.59	0.79
ST009	1.08	1.31	2.98	7.82	12.84	18.85	4.58	5.59	6.56	11.81	17.08	23.22	3.5	4.28	3.58	3.99	4.24	4.37
ST010_1	0.77	1.11	3.1	7.75	12.23	17.39	2.15	2.63	4.89	9.94	14.49	19.66	1.38	1.52	1.79	2.19	2.26	2.27
ST010_2	1.06	1.29	2.24	3.59	5.13	6.43	1.51	1.84	2.5	4.17	5.51	6.66	0.45	0.55	0.26	0.58	0.38	0.23
ST011	0.9	1.1	2	4.28	6.17	8.14	2.85	3.48	4.08	6.16	8.43	10.95	1.95	2.38	2.08	1.88	2.26	2.81
ST012	0.37	0.45	1.18	2.7	3.92	5.15	1.59	1.95	2.3	3.68	5.16	6.79	1.22	1.5	1.12	0.98	1.24	1.64
ST013	1.21	1.47	1.75	2.78	3.72	4.94	1.65	2.02	2.39	3.43	4.53	5.82	0.44	0.55	0.64	0.65	0.81	0.88
ST014	1.45	1.77	2.06	2.73	3.52	4.56	2.03	2.48	2.9	3.75	4.69	5.88	0.58	0.71	0.84	1.02	1.17	1.32
ST015	2.27	2.77	4.03	6.33	8.67	11.35	3.18	3.88	4.97	7.66	10.11	12.68	0.91	1.11	0.94	1.33	1.44	1.33
ST016_2	0.28	0.72	1.99	4.14	5.9	7.73	0.57	0.96	2.25	4.38	6.11	7.9	0.29	0.24	0.26	0.24	0.21	0.17
ST016_3	1.31	1.6	2.76	5.43	7.87	10.57	3.64	4.45	5.38	7.94	10.66	13.87	2.33	2.85	2.62	2.51	2.79	3.3
ST016_4	0.41	0.52	0.91	1.48	2.03	2.51	0.58	0.71	0.99	1.68	2.16	2.59	0.17	0.19	0.08	0.2	0.13	0.08
ST016_5	0.63	0.77	1.58	2.84	3.78	5.02	1.43	1.75	2.24	3.56	4.85	6.19	0.8	0.98	0.66	0.72	1.07	1.17
ST016_6	0.8	0.98	1.33	2.23	2.88	3.49	0.8	0.98	1.33	2.23	2.88	3.49	0	0	0	0	0	0
ST016_7	0.76	0.93	1.23	2.04	2.67	3.27	0.76	0.93	1.23	2.04	2.67	3.27	0	0	0	0	0	0
ST017	1.31	1.6	2.01	3.14	4.19	5.51	1.83	2.24	2.76	3.96	5.15	6.52	0.52	0.64	0.75	0.82	0.96	1.01
ST018	1.81	2.22	2.76	4.17	5.56	7.3	2.2	2.69	3.31	4.78	6.3	8.09	0.39	0.47	0.55	0.61	0.74	0.79
ST019	1.47	1.8	2.47	3.91	5.28	6.95	2.06	2.52	3.17	4.77	6.28	7.93	0.59	0.72	0.7	0.86	1	0.98
ST020_1	1.59	1.94	2.63	4.18	5.63	7.41	2.23	2.72	3.41	5.1	6.71	8.48	0.64	0.78	0.78	0.92	1.08	1.07
ST021	1.55	1.89	2.63	4.16	5.63	7.4	1.91	2.33	2.98	4.64	6.25	8	0.36	0.44	0.35	0.48	0.62	0.6
ST022	0.3	0.36	0.42	0.99	1.71	2.67	1.8	2.2	2.57	3.26	4.09	5.19	1.5	1.84	2.15	2.27	2.38	2.52
ST023	0.55	0.67	0.85	1.59	2.2	3.03	0.78	0.95	1.11	1.71	2.54	3.28	0.23	0.28	0.26	0.12	0.34	0.25
ST024	0.28	0.35	1.12	2.97	4.68	6.56	0.57	0.69	1.4	3.26	4.97	6.83	0.29	0.34	0.28	0.29	0.29	0.27
ST025	0.33	0.41	0.92	2.42	3.98	5.84	0.67	0.81	1.25	2.8	4.39	6.27	0.34	0.4	0.33	0.38	0.41	0.43
ST026	1.63	1.98	2.31	4.45	6.78	9.39	1.79	2.18	2.54	4.63	6.96	9.56	0.16	0.2	0.23	0.18	0.18	0.17
ST027	0.71	0.86	1.43	2.24	3.11	3.97	0.92	1.13	1.57	2.55	3.38	4.19	0.21	0.27	0.14	0.31	0.27	0.22
ST028	0.38	0.6	1.18	1.93	2.62	3.49	0.58	0.76	1.32	2.04	2.89	3.73	0.2	0.16	0.14	0.11	0.27	0.24
ST029	1.05	1.28	2.02	3.12	4.37	5.64	1.05	1.28	2.02	3.12	4.37	5.64	0	0	0	0	0	0
ST030	0.98	1.2	1.4	1.78	2.22	2.8	1.37	1.68	1.96	2.46	3.01	3.7	0.39	0.48	0.56	0.68	0.79	0.9
ST032	0.3	0.36	1.14	3.03	4.8	6.76	0.6	0.73	1.43	3.34	5.11	7.05	0.3	0.37	0.29	0.31	0.31	0.29
ST033	1.43	1.75	2.86	4.46	6.21	7.95	1.43	1.75	2.86	4.46	6.21	7.95	0	0	0	0	0	0
ST034	1.3	1.58	2.32	3.63	4.98	6.52	1.9	2.32	2.96	4.51	5.91	7.38	0.6	0.74	0.64	0.88	0.93	0.86
ST035	1.15	1.41	1.64	2.84	4.32	6.06	3.95	4.82	5.63	7.17	8.95	11.07	2.8	3.41	3.99	4.33	4.63	5.01
U001	8.21	10.01	15.25	35.95	59.28	89.33	21.32	26.04	30.54	51.71	77.06	109.14	13.11	16.03	15.29	15.76	17.78	19.81
U002	10.63	12.97	16.28	34.37	55.21	82.74	52.56	64.85	76.34	100.16	125.6	158.32	41.93	51.88	60.06	65.79	70.39	75.58

Table 1-5. Peak Runoff from SWMM Subcatchments (Cont…)

Subcatchment	Existing Land Use - Peak Flows (cfs)						Future Land Use - Peak Flows (cfs)						Difference in Existing and Future Peak Flows (cfs)					
	2-year	5-year	10-year	25-year	50-year	100-year	2-year	5-year	10-year	25-year	50-year	100-year	2-year	5-year	10-year	25-year	50-year	100-year
U003	7.94	9.72	11.99	17.32	22.56	28.5	7.94	9.72	11.99	17.32	22.56	28.5	0	0	0	0	0	0
U004	0.5	0.61	0.84	1.74	2.61	3.61	1.86	2.29	2.68	3.64	4.66	5.87	1.36	1.68	1.84	1.9	2.05	2.26
U005	0.74	0.91	1.27	2.63	3.95	5.46	2.81	3.44	4.04	5.49	7.04	8.86	2.07	2.53	2.77	2.86	3.09	3.4
U006_2	1.77	2.16	2.84	6.18	10.01	15.04	16.87	21.04	24.94	32.17	39.22	47.88	15.1	18.88	22.1	25.99	29.21	32.84
U007	5.44	6.73	8.08	10.66	13.01	15.68	5.44	6.73	8.08	10.66	13.01	15.68	0	0	0	0	0	0
U008	1.55	1.89	2.21	2.82	3.56	4.5	2.16	2.64	3.09	3.89	4.77	5.84	0.61	0.75	0.88	1.07	1.21	1.34
U009	2.28	2.79	3.26	4.11	5.08	6.32	3.15	3.87	4.53	5.67	6.87	8.33	0.87	1.08	1.27	1.56	1.79	2.01
U010	0.63	0.77	0.9	1.43	2.17	3.05	2.2	2.69	3.14	3.98	4.9	6.02	1.57	1.92	2.24	2.55	2.73	2.97
U011	1.1	1.34	1.61	3.04	4.44	6.05	2.56	3.14	3.68	5.05	6.58	8.46	1.46	1.8	2.07	2.01	2.14	2.41
U012	0.51	0.62	1.03	2.05	2.84	3.64	1.11	1.35	1.59	2.52	3.54	4.64	0.6	0.73	0.56	0.47	0.7	1
U013	0.67	0.82	1.17	2.31	3.32	4.39	1.39	1.69	1.99	3	4.1	5.44	0.72	0.87	0.82	0.69	0.78	1.05

2 HYDRAULIC ANALYSIS

2.1 OVERVIEW

The purpose of the hydraulic analysis was twofold: to determine stormwater flow paths for modeling flows through and adjacent to the Town and to identify areas with existing and future drainage issues. The SWMM model reflects existing flow paths taken from the subcatchments (presented in Section 1.0 – Hydrologic Analysis) into roadside ditches, culverts, pipes, swales, and ultimately discharging into the Uncompahgre River. Hydrographs for the hydraulic analysis were generated using SWMM and were used to evaluate the capacity of the drainage features to convey existing and future storm events (2-, 5-, 10-, 25-, 50-, 100- year).

2.2 CONVEYANCE

Stormwater Conveyance is the flow or movement of stormwater from one location to another, transferring the water from where it falls through the stormwater system to the final receiving body. Stormwater conveyance happens in four ways in the study area:

1. **Open Ditches** - This is the most common manner in which drainage travels through Ridgway. The benefits of the open ditches are that they are accessible for maintenance and they allow for some infiltration. There are ditches in the gravel roadways between the drive lanes and parking (Figure 2-1) and ditches with flatter profiles that are good for infiltration. The ditches are confined to edges of the roadway predominantly with steep side slopes (Figure 2-2). In steeper profile areas, such as along Hyde St., open ditches can start to erode and cause increased maintenance.

Figure 2-1. Unpaved road in Ridgway

Figure 2-2. Roadside ditch on Sherman St.

2. **Pipes** – There are all types of pipe throughout the study area both in material, including reinforced concrete pipe (RCP) and corrugated metal pipe (CMP), and in placement, including storm sewers, small road culverts, and standalone large culverts. A common problem with gravel streets is the inverts becoming clogged with sediment (Figure 2-3).

Figure 2-3. Culvert with accumulated sediment

3. **Curb and Gutter** - The improvements that were completed in the HTC in 2017 included paving some streets and adding curb and gutter (Figure 2-4). These areas have functioned well for conveyance. There is still the issue of sediment load in the gutter as material is tracked in from surrounding areas and during winter sanding.

Figure 2-4. Curb and gutter in the HTC

4. **Urban Water Quality Swales** – There are several areas where the Town has tested some informal urban water quality treatment in the landscape strips between the roadway and the sidewalk (Figure 2-5). These areas include N. Laura St. between SH 62 and Clinton St. and Charles St. between N. Lena St. and N. Railroad St. There has been variable success in these areas depending on the vegetation and ground cover. Areas with

daylilies, low growing red-twig dogwood, and switchgrass have filled in well and have stabilized. Other vegetation used that was not as hardy or did not provide full ground coverage has left loose mulch that can be washed out in storm events. Swales lined with cobble instead of mulch have not washed out; however, the cobbles are prone to be filled with sediment.

2-5. Urban swale along Charles St.

Each conveyance method is used to route stormwater in the SWMM model and are discussed in more depth in Sections 2.4 – Hydrograph Routing and Section 3 – Alternative Analysis.

2.3 STORMWATER FLOW PATHS

The following sections present the current stormwater flow paths through the Town.

2.3.1 South Town

In general, stormwater naturally flows from the southwest to the northeast in the South Town area. The area is bounded by Cottonwood Creek to the north and the Uncompahgre River to the east. Development has created the need for culverts across Sabeta Dr. and inlets, borrow ditches and valley pans at the intersection of Chipeta Dr. and S. Lena St. The drainage area extends to the south and west beyond the Town boundary to approximately Lake Otonawanda. The watershed south of the Town boundary consists largely of wooded and grassed areas covering approximately 3,700 acres between roughly County Road 5A and the southwest Town boundary. The remaining areas within the South Town are bound by roads or swales and comprised of low-density residential housing or open recreational areas.

West of the Town boundary, the Dallas Ditch diverts irrigation water from Cottonwood Creek near County Road 5 (CR 5) (Figure 2-6). Storms less than the 1-year event are diverted into the ditch and greater than 1-year are assumed to bypass the ditch and continue downstream in the Cottonwood Creek channel. The results of the hydraulic analysis indicate that although the existing culvert crossings at S. Amelia St. and S. Lena St. would overtop during the 100-year storm, the Creek channel itself can contain the 100-year peak flow due to channel degradation and incision. The existing degradation of Cottonwood Creek has caused concern for lowered groundwater levels and future tree health along the banks.

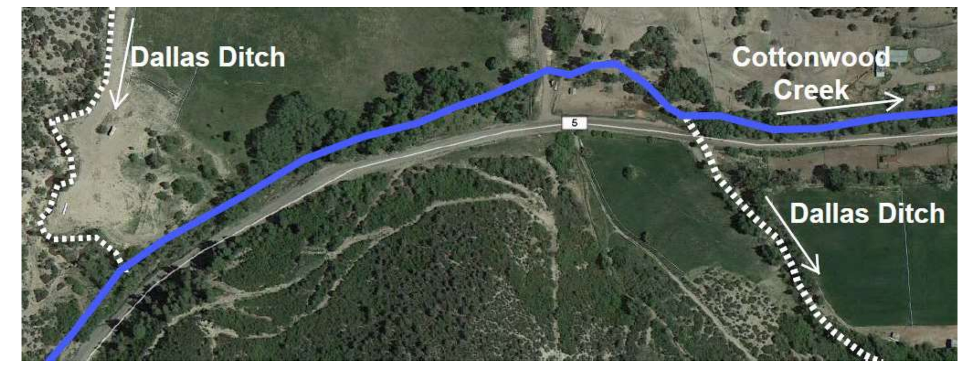


Figure 2-6. Dallas Ditch diversion at Cottonwood Creek

South of the Town boundary is the Cuddigan Gulch watershed which is largely unaffected by development. The gulch conveys open channel flow from an area covering approximately 1,500 acres of land cover at the southern end of the project area to County Road 23 (CR 23) (Figure 2-7). The gulch is conveyed under CR 23 via a 4-foot diameter reinforced concrete pipe (RCP) and ultimately discharges into the Uncompahgre River.

Figure 2-7. Location of Cuddigan Gulch

The development along Le Ranch Boulevard, Amy Way, and Amy Court drains in two directions. The northern area along Amy Way discharges directly into Cottonwood Creek; conversely, stormwater from the southern area along Amy Court flows to the southeast through an existing inlet and empties into the adjacent open field (Figure 2-8).

Figure 2-8. Stormwater flow paths from Amy Way and Amy Court

South of CR 5, stormwater leading to and crossing S. Amelia St. is represented by sheet flow in the model. Small irrigation ditches capture water along S. Amelia St. and convey irrigation water to the east throughout the South Town area. Beginning at the intersection of S. Amelia St. and Sabeta Dr. stormwater flows remain in shallow roadside paths, converging as they run east along Tabernash Lane and Sabeta Dr. as well as through a ditch behind the houses between the two streets. At the cul-de-sac located at the southeast corner of Sabeta Dr., it was assumed that stormwater overtops Sabeta Dr. and heads east until reaching the north/south drainage ditch along the western edge of the Ridgway Athletic Park. All other stormwater flows that reach Sabeta Dr. from the west, go through five existing culverts, returning to open channel flow on the east side of the road, and continue towards the north/south drainage ditch located west of the athletic park. See Figure 2-9 for the stormwater routing used in SWMM.

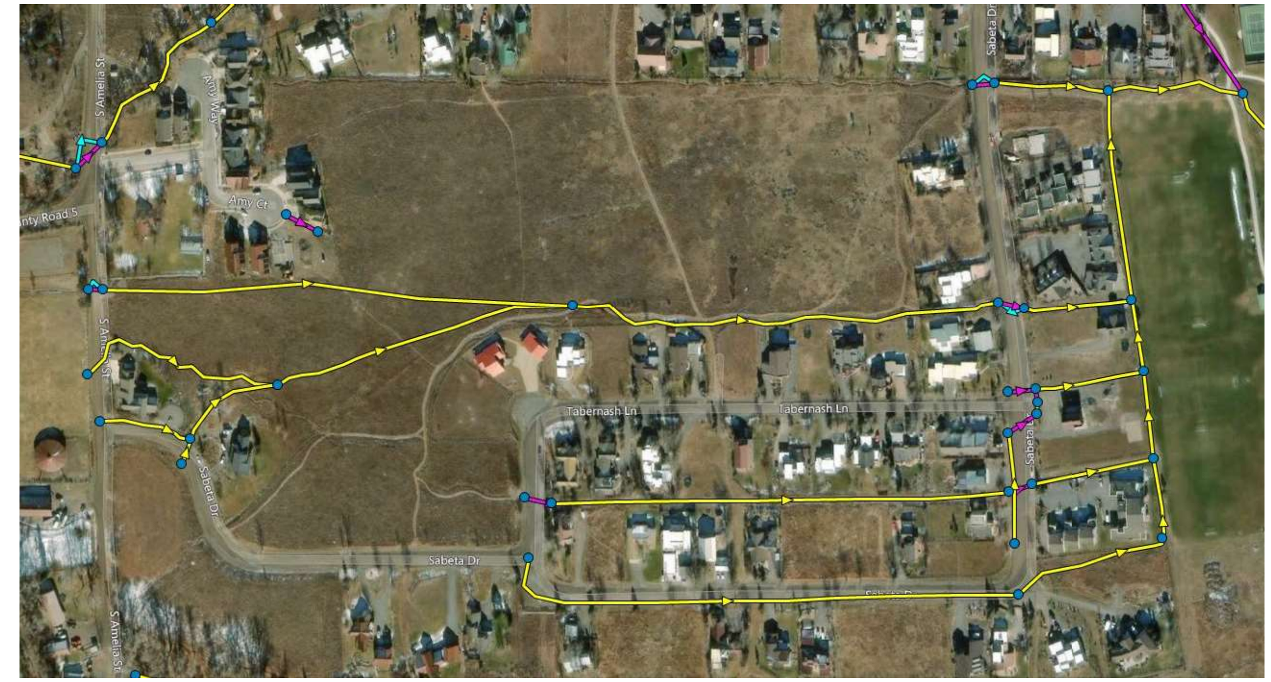


Figure 2-9. Stormwater paths across Tabernash Ln. and Sabeta Dr.

Similar eastward flow occurs along Chipeta Dr. and behind the houses between Chipeta Dr. and Cottonwood Creek. Stormwater conveyed across the open field north of Chipeta Dr. flows northeast towards S. Lena St. and into Cottonwood Creek (Figure 2-10). There is no existing curb or gutter along roads in the South Town area except for a curb along S. Lena St. and a valley pan at the intersection of Sabeta Dr. and Chipeta Dr.; therefore, roadside flow is mostly conveyed along the gravel at the edge of the road surface.

Figure 2-10. Stormwater flow paths across Chipeta Dr.

Stormwater from the soccer fields consolidates at the Ridgway Athletic Park at CR 23 in a large roadside swale. To mitigate existing issues with high groundwater at Ridgway Athletic Park, stormwater heading towards the park from the west is sent north in a north/south drainage ditch that runs along the western edge of the Park before joining with another ditch and heading east towards CR 23. While the park naturally has a high infiltration rate, the soils below may not, and the existing ditches divert additional flow around the field, its proximity to local irrigation and high groundwater table causes the area to regularly experience issues with saturated ground which reduces the functionality of drainages through the Park as well as the functionality of the fields. Most stormwater crosses CR 23 through three culverts. Once on the east side of CR 23, flow from the Ridgway Athletic Park discharges into Cottonwood Creek north of Chipeta Dr. and outlets to the Uncompahgre River.

Between S. Lena St. and the Uncompahgre River, Cottonwood Creek travels parallel to CR 23 as it first heads east before turning south into a steep and heavily grassed area. Unlike upstream along the Creek, trees give way to cattails and large brush which provide stormwater storage and potential water quality benefits in the riparian vegetation.

2.3.2 Historic Town Core

Recent improvements along SH 62 were completed by CDOT as part of the Town's RAMP project. Improvements included the construction of an approximately 2,100 feet long segment of reinforced concrete pipe (RCP) storm sewer running west to east along Sherman Street. The storm sewer increases in size as it approaches the Uncompahgre River from a 2-foot diameter west of Laura St. to a 4-foot diameter near the outfall. Additional improvements associated with the RAMP project include road and drainage improvements on Charles St., Clinton St., N. Cora St., N. Laura St., N. Lena St., and N. Railroad St. Drainage improvements included new sections of inlets, storm pipes, curb and gutter, concrete pans, and grass lined swales.

In the HTC, there are two characteristic stormwater routes: (a.) water flows along the west side of north-south roads that go north or (b) water flows along the south side of east-west roads that go east. Stormwater carried away from the business district transported along the roadside and through pipes routes up to Charles St. before turning north up N. Cora St., north up N. Lena St., or to N. Railroad St. on its way to the large ditch running West to East along N. railroad (i.e. the Big Ditch) and/or the Uncompahgre River.

To the west of the Town, SH 62 heads northwest parallel to Knife Edge Ridge. In this area, there are two culverts that capture stormwater from the steep ridgeline on the west side of the road towards CR 5. At both culverts the SWMM model includes a roadside weir and ditch to convey flows north under CR 5 that exceed the capacity of the culverts. Stormwater then runs parallel to SH 62 and downhill towards Amelia St. (Figure 2-11).

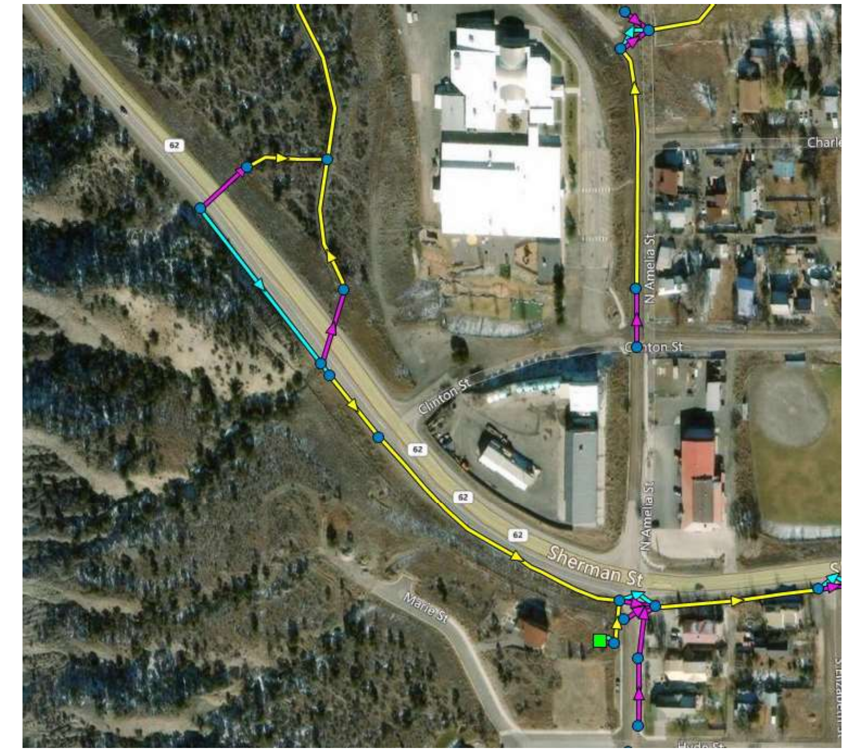


Figure 2-11. Stormwater flow paths at SH 62 west of Amelia St.

Between SH 62 and Marie St. there is a small existing detention pond. The pond is owned by a small Home Owners Association (HOA) and receives runoff from approximately 10 acres. The pond storage and peak flow attenuation are modeled in the existing and future conditions SWMM.

The CDOT facility and Ridgway Elementary School on N. Amelia St. discharge north along the west side of N. Amelia St., crossing culverts at multiple roads and ultimately conveying to the Uncompahgre River through the "Big Ditch" on the north side of Town.

In the area surrounded by S. Amelia St. to the west, Moffat St. to the south, S. Lena St. to the east and Hyde St. to the north, stormwater flows toward the northeast and enters a roadside ditch along Hyde St. or goes through a culvert when crossing Elizabeth, Charlotte, Mary, Laura, and Cora St. (Figure 2-12). In general, stormwater stays along Hyde St. with some water splitting to the north along S. Mary St., S. Cora St., and S. Lena St. Any stormwater that crosses over S. Lena St. flows to the north along S. Railroad St. and enters the SH 62 storm sewer.

Figure 2-12. Stormwater flow paths along Hyde St.

In the area surrounded by S. Amelia St. to the west, Hyde St. to the south, S. Lena St. to the east and Sherman St. to the north stormwater flows toward the northeast and enters either a roadside ditch, culvert or storm sewer along Sherman St. The RAMP improvement increased the capacity and condition of the culverts and storm sewers project along Sherman St. The culverts convey stormwater north to circumnavigate the business district in Town and the storm sewer conveys water beneath Sherman St. to outlet at the Uncompahgre River. Stormwater is routed to avoid heading north on Cora or Lena St. between Sherman and Clinton St.

Runoff from the undeveloped field between S. Railroad St. and Liddell Dr. is conveyed either east to the inlet located in the alley west of Campbell Lane or to the south to Cottonwood Creek. The stormwater is conveyed east down Campbell Ln., then through private property to the Uncompahgre River. Stormwater routing in this area will be impacted by the upcoming Alpenglow CoHousing development, located in the open area between Liddell Dr., CR 23, S. Railroad St. and SH 62. The proposed development will re-route runoff to the storm sewer under Sherman St. or to Cottonwood Creek.

North of Sherman St. the majority runoff from the HTC is conveyed to the Uncompahgre River by flowing north to Charles St. At the intersection of Charles St. and N. Cora St., most of the stormwater is conveyed north along Cora to a storm sewer and ultimately into the "Big Ditch" in the north part of Town. At the intersection of N. Railroad St. and Charles St. stormwater follows two possible paths: (1.) travels north along N. Railroad St. in an approximately 2-foot-deep roadside ditch before crossing Railroad just south of the Big Ditch and San Miguel Power Association (SMPA) and outletting to the Uncompahgre River or (2.) during major storm events crosses east under N. Railroad St. via a 24" RCP and flows east through the adjacent open field (Figure 2-13)

Figure 2-13. Stormwater flow paths at intersection of N. Railroad St. and Charles St.

2.3.3 North Town

The majority of stormwater in the North Town area is conveyed to the Uncompahgre River through the "Big Ditch", which runs parallel to the east/west section of N. Railroad St. between Ridgway Public Works (RPW) and SMPA to the west. Channelized flow begins with one natural and one irrigation ditch conveying flow from SH 62 on the western edge of the project area to CR 5. Stormwater crosses under CR 5 through four existing culverts or sheet flows over the road at low-lying locations that do not have a culvert (Figure 2-14). North of the River Park and Parkside developments routing is less influenced by improvements or infrastructure and predominantly traverses natural routes to reach the river.

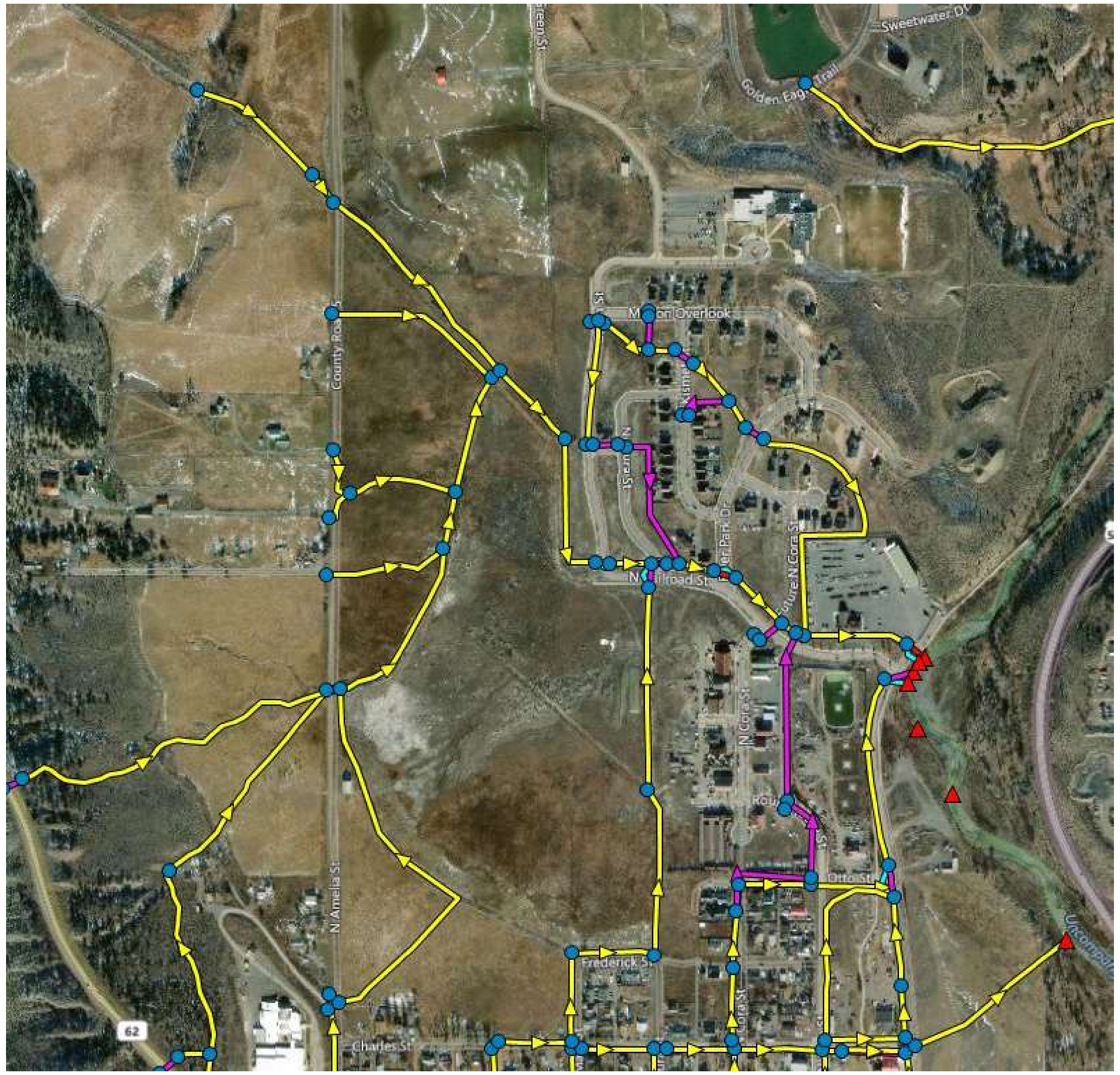


Figure 2-14. Stormwater flow paths in North Town area

An irrigation ditch begins at the end of a culvert crossing below SH 62 west of Amelia St. and the CDOT facility. This irrigation ditch, along with a natural ditch and a roadside ditch converge and cross N. Amelia St. through a culvert approximately 1/3 mile north of Charles St. Together, stormwater continues northeast and picks up flows heading east before turning 90-degrees and heading southeast (Figure 2-15). This flow path is the origin of the Big Ditch that runs adjacent to N. Railroad St. through the River Park and Parkside developments.

Figure 2-15. Stormwater flow paths between SH 62, CR 5, and the upper reach of Big Ditch

Another irrigation ditch is located in the field just north of Frederick St. The ditch has a high point located approximately 700 feet west of the intersection of Frederick St. and N. Mary St. Water on the west side of the high point flows northwest through the ditch system and conversely, water located on the east side, flows towards the east. The irrigation ditch ultimately discharges into the Big Ditch from both sides of the high point.

All the stormwater runoff generated from the River Park and Parkside developments ultimately ends up in the Big Ditch. Subcatchments were created around the development's inlets and a ditch that conveys water southeast through the development to the Big Ditch. Flow conveyed along this channel hugs the boundary of the SMPA property and reaches the Big Ditch east of Cora St.

2.4 HYDROGRAPH ROUTING

Within the SWMM model, the flow paths presented in Section 2.3 – Stormwater Flow Paths are modeled through a drainage network of design points, storm sewers, culverts, open channels, and storage units. The schematic in Appendix A – Hydrologic Analysis- Hydrology Maps illustrates the drainage system elements. It illustrates where the subcatchments presented in Section 1 – Hydrologic Analysis connect into the drainage system and the specific design points defined at these locations. In addition, the routing elements illustrate where the runoff is connected to the next downstream design points.

The main routing elements within this model are sheet flow, roadside flow, pipes, and open channels. Within EPA SWMM, the routing was defined according to channel shape, maximum depth, length, and roughness as estimated by contours, aerial photography, survey, and site visits.

The SWMM model includes four major routing elements:

1. Sheet flow:
    - The smallest overland flows were modeled through a sheet flow cross section. Areas such as the open field between Tabernash Ln. and Chipeta Dr. were assigned a sheet flow cross section.
    - Larger, but similarly wide flows, were modeled using a conveyance cross section. This cross section was made for both overland and roadside flows to reflect areas where stormwater is concentrated but not coming into contact with distinct physical barriers.
2. Roadside flow:
    - Cross sections extend from the road crown through the ditch. Two sizes were made to best present smaller roadside ditches such as those found along Hyde St. and larger ones such as the one on N. Mary St. between Sherman and Clinton St. Each size was modeled specifically to whether it was on the east/west or north/south side of the road.
3. Pipes:
    - Includes existing culverts and storm sewer pipes.
4. Open channel flow:
    - A small and a large cross section were generated to emulate how stormwater flows across open areas along the periphery of the project area as well as through irrigation and diversion ditches.

A summarized input file and example output files from the EPA SWMM model are included in Appendix E – Hydraulic Analysis- Existing Conditions SWMM Results, which includes the physical attributes assigned to each conveyance element used in the EPA SWMM model.

2.5 RESULTS OF ANALYSIS

2.5.1 General Drainage Concerns

In general, stormwater runoff within Town flows from the southwest to the northeast and eventually into the Uncompahgre River. Because the street grid system of the HTC is aligned in a north/south orientation, splits in stormwater paths occur at several street intersections with a portion of the stormwater flowing to the north and the remainder flowing to the east. The street orientation paired with the orientation of the natural contours creates areas where the residents adjacent to the street are at a lower elevation than the street crown. This can cause water in driveways and private property during rain events or snow melt. There are several locations in the model where stormwater runoff flowing adjacent to the street and at driveway entrances has very high velocities and the potential to create erosion problems for the Town. This is notable along Hyde St., as well as a number of other locations, where the Town has experienced erosion to the existing driveways due to high runoff peak flows and velocities (Figure 2-16).

Figure 2-16. Erosion along driveways on Hyde St.

The Town is largely comprised of gravel streets, drainage ditches, and small (average 18-inch) diameter corrugated metal pipes (CMPs). There are several areas where the SWMM model indicates that the ditch and/or CMP is exceeded during a storm event. An example is at the intersection of N. Cora St. and Charles St. where the existing 12-inch CMP is often overtopped and ponding occurs in the roadside ditch (Figure 2-17).

Figure 2-17. Intersection of N. Cora St. and Charles St. during a storm event

2.5.2 Peak Flows and Runoff Volumes

Peak flows and volumes for the existing and future conditions 2-, 5- and 25-year storm events were determined throughout the Town. Peak flows and volumes at major design points are provided in Table 2-1. Major design points are defined as locations of outfalls into the Uncompahgre River and locations of ditch or stream flow at select road crossings. Figure 2-18 provides the locations of the design points presented in Table 2-1. A full list of peak flows and volumes is presented in Appendix E - Hydraulic Analysis- Existing Conditions SWMM Results.

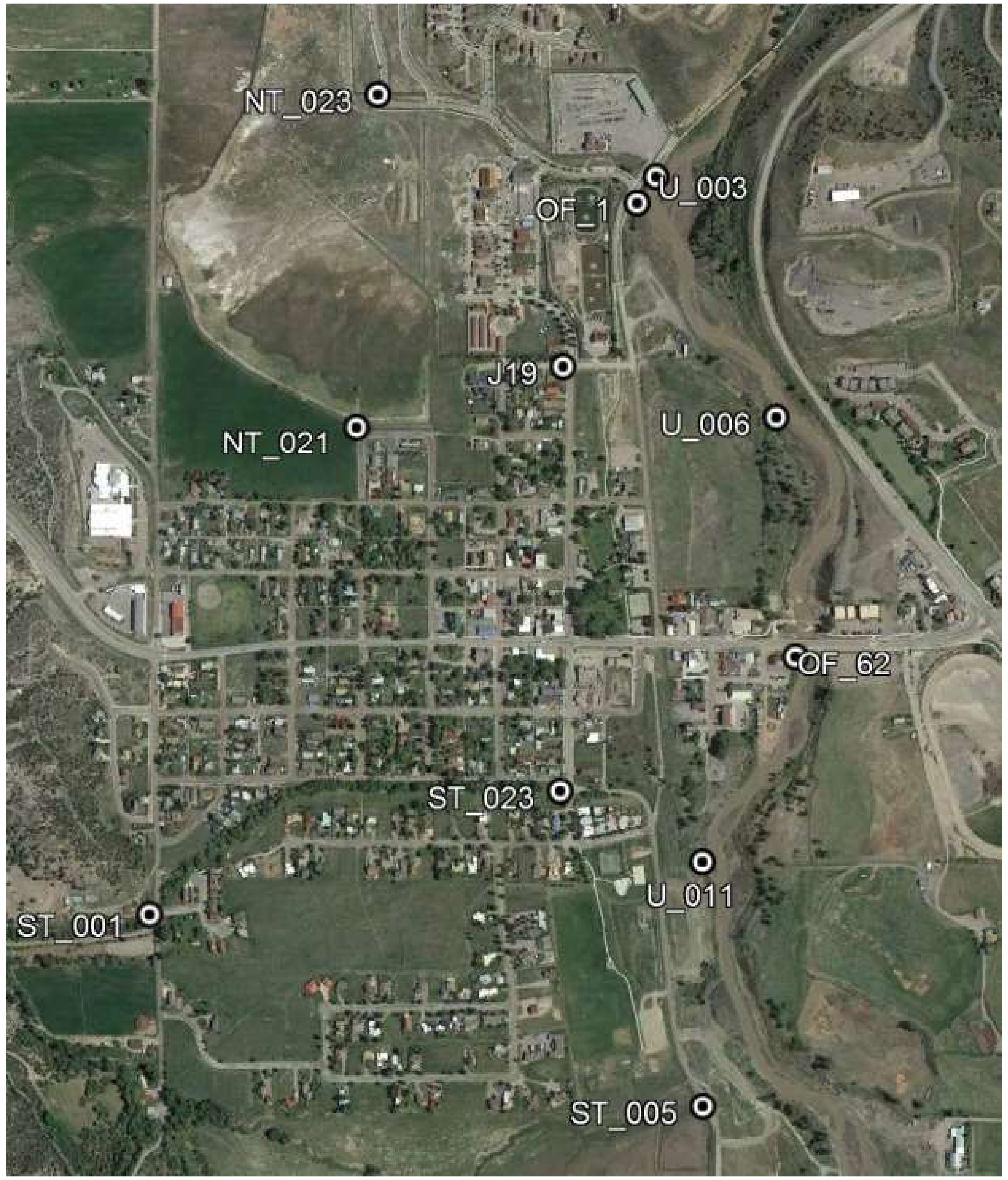


Figure 2-18. Location of Major Design Points (refer to Table 2-1 for SWMM Results)

Table 2-1. Peak Flows and Runoff Volumes at Major Design Points

Design Point	Location Description	Existing Peak Flow (cfs)			Future Peak Flow (cfs)			Existing Volume (AF)			Future Volume (AF)		
		2-year	5-year	25-year	2-year	5-year	25-year	2-year	5-year	25-year	2-year	5-year	25-year
ST_023	Cottonwood Creek at S. Lena St.	157	194	289	159	197	288	7.5	9.2	22.8	7.6	9.4	22.9
ST_001	Cottonwood Creek at S. Amelia St.	169	207	277	169	207	304	7.3	8.9	22.0	7.3	8.9	22.2
ST_005	Cuddigan Gulch at CR-23	108	132	127	108	132	194	4.7	5.7	17.2	4.7	5.7	17.2
U_011	Outfall - Cottonwood Creek into Uncompahgre River	177	220	345	196	241	371	8.9	11.0	28	10.0	12.4	29.5
OF_62	Outfall - SH 62 Storm Sewer into Uncompahgre River	18	22	41	25	30	50	0.8	1.1	2.1	1.2	1.5	2.6
U_006	Outfall - N. Railroad Street at Railroad Museum into Uncompahgre River	2	2	6	17	21	32	0.1	0.1	0.5	0.8	1.0	1.7
OF1	Outfall - N. Railroad Street at Public Works into Uncompahgre River	14	23	30	30	30	30	0.9	1.3	2.7	1.6	2.1	3.1
U_003	Outfall - Big Ditch into Uncompahgre River	54	68	180	122	158	313	5.3	6.9	19.5	12.7	15.7	29.4
NT_021	Corner of Frederick St. and N. Mary St. - discharge into Cattle Ditch	9	15	44	19	27	53	0.4	0.5	1.7	0.7	1.0	2.2
J19	Corner of Otto St. and N Lena St. - inlet into storm sewer system	8	8	7	7	7	7	1.1	1.2	1.6	1.3	1.5	1.9
NT_023	Big Ditch at Green St.	21	26	109	73	97	213	1.7	2.2	8.7	5.1	6.3	13.5

2.5.3 Infrastructure Deficiencies

In general, the existing drainage issues in Town are largely due to undersized or non-existent pipes and drainage ditches. Table 2-2 provides the total ditches, culverts, and storm sewers with capacities that are exceeded during the existing and future conditions 2-year, 5-year, and 25-year storm events. Additionally, Figure A2 in Appendix A provides a graphical depiction of the exceedances.

Table 2-2. Existing Structures with Capacities Exceeded

Structure	# Total Structures	Exceedances - Existing Conditions			Exceedances - Future Conditions		
		2-yr	5-yr	25-year	2-yr	5-yr	25-year
Ditches	138	20	29	42	32	36	46
*Pipes	101	**22**	**25**	**45**	**27**	**31**	**52**

* Pipes refer to both storm sewers and culverts

Additional water quality and maintenance issues could occur due to the large amount of gravel and sediment transported from the existing gravel streets. Water quality and sediment issues are discussed in Section 3.3 – Water Quality Alternative of this report.

As discussed in Section 1.0 – Hydrologic Analysis, the future conditions peak flows and volumes are significantly higher than the existing conditions. The future conditions model represents a worst-case possible scenario assuming that the Town is completely "built-out" by the year 2050 per the land use identified in the current master plan. The peak flows and runoff volumes associated with the future conditions model were used to inform the recommended alternatives and final conceptual plan presented in Sections 3 – Alternative Analysis and 4– Conceptual Design of this report.

Both the existing conditions and future conditions SWMM model, mapping, and output files are found in Appendices A and E.

3 ALTERNATIVE ANALYSIS

3.1 ALTERNATIVE DEVELOPMENT PROCESS

The goal of the alternatives analysis is to provide multiple possible solutions to existing and future stormwater issues within the Town. Alternatives proposed in this section are intended to address infrastructure deficiencies (as presented in Section 2.5 – Results of Analysis) as well as erosion and water quality issues. Town representatives have been consulted during the development of alternatives and provided valuable input into identifying issues and potential solutions.

As discussed in Section 1.2 – Design Storm, the 2-, 5-, and 25-year storm events were selected as potential design storms for conveyance alternatives in the master plan alternatives. Additionally, a smaller, more frequent 1.25-year storm was selected as the representative water quality storm event for the master plan. The intention of selecting those storm events are as follows:

- 1.25-year storm: Was analyzed as the approximate water quality event for the purposes of sizing water quality alternatives.
- 2-year storm: Given the lack of available right-of-way, the 2-year storm was analyzed as a potential smaller storm that would provide additional drainage protection for the Town but would not be the full 5-year event.
- 5-year storm: Represents a typical storm event for urban infrastructure design.
- 25-year storm: Represents a storm that produces 1-inch of rainfall in 1-hour. This design storm is conservatively high and represents the potential for storms of increased intensity due to climate change.

The following sections present the stormwater alternatives for this master plan. Refer to Figure H-1 in Appendix H for locations of proposed alternatives discussed in this section.

3.2 WATER QUANTITY AND DRAINAGE ALTERNATIVES

3.2.1 Road Crossings

As presented in Section 2.5.3 - Results of Analysis, there are currently several culverts that are undersized throughout the Town. These culverts, sometimes impeded by sediment build up, can cause flooding that extends into roadways and private property. Future development will increase impervious coverage and runoff throughout Town, causing further strain on existing infrastructure. To increase capacity throughout Town, improving and expanding infrastructure was explored.

The future conditions 2-, 5-, and 25-year storm events were modeled to assess the capacity of existing ditches and pipes. The deficient culverts presented in Section 2.5.3 – Infrastructure Deficiencies and shown in Figure A-2 were upsized to carry the future conditions 2-, 5-, and 25-year storm events. Manning's Equation was used to estimate the proposed culvert sizes:

$$Q = \frac{1.49AR^{2/3}\sqrt{S}}{n}$$

Where

Q = Flow Rate (cfs)

A = Flow Area (ft^2)

R = Hydraulic Radius (ft)

S = Channel slope (ft/ft)

n = Manning's n

All proposed culverts are reinforced concrete pipes (RCP) with a manning's n roughness coefficient of 0.015 and size ranging from 18"-72". Other pipe materials that may be suitable for use in these culverts include high-density polyethylene (HDPE) and polyvinyl chloride (PVC), both of which have a lower manning's n roughness coefficient, which could impact flow rate if used instead of RCP. All pipes were sized assuming 80% capacity.

This modeling process was used to address deficient pipes during the various storm events. All pipes were increased in size until they successfully conveyed the appropriate storm. Appendix F – Alternatives Analysis – Hydraulic Calculations provides results for each pipe throughout Town. The proposed costs for updated culverts are presented below in Table 3-1.

Table 3-1. Projected Cost for RCP Culvert Improvements at Road Crossings

2-year	5-year	25-year
$ 714,000	$ 902,000	$ 1,571,000

Refer to Figure H-1 in Appendix H for locations of proposed alternatives discussed in this section.

3.2.2 Pipes and Ditches

As presented in Section 2.5.3 – Infrastructure Deficiencies, there are currently several ditches and existing storm sewers that are undersized throughout the Town. For locations with undersized ditches, a new pipe that would be parallel to the existing ditch was proposed. The intention was for the new pipe to fully contain the design storm event (2-, 5-, 25-year) and that any storm event greater than that would then engage the existing ditch. The total system conveyance (pipe + ditch) would be dependent upon the capacity of the existing ditch.

It was assumed in these models that ditches would be regularly maintained but not enlarged. Ditches are also limited in potential for expansion due to right of way, slope, and size constraints. Ditches are already maintained by the Town and even though they would require lower upfront costs to improve, in many cases are already strained by high flow rates and sediment. Table 3-2 displays the projected costs for pipe and ditch improvements, excluding road crossings discussed in 3.2.1.

As in Section 3.2.1., all proposed pipes are assumed to be RCP with a manning's n roughness coefficient of 0.015 and size ranging from 18"-72". Manning's Equation was used assuming 80% pipe capacity.

Table 3-2. Projected Cost for Improvements to Pipes and Ditches

2-year	5-year	25-year
$ 4,336,000	$ 5,316,000	$ 7,652,000

Refer to Figure H-1 in Appendix H for locations of proposed alternatives discussed in this section.

3.2.3 Regional Detention

The possibility of regional detention was explored to mitigate the impact future development and increases in impervious surfaces have on runoff quantities. However, it was decided that regional detention was not a practical option for the Town at this time. There is very little available land that would be suitable for regional detention and the concept was deemed unfeasible. If conditions change in the future, the Town could explore the option of Regional Detention again. Smaller site-specific detention can be considered as future development occurs in Town. Updates to the Town's Standards and Specifications will address potential site-specific detention requirements.

3.2.4 General Drainage Issues

The following sections discuss smaller general drainage issues in Town. Refer to Figure H-1 in Appendix H for locations of proposed alternatives discussed in this section.

Post Office

The Post Office parking circle often experiences freezing issues in the winter months due to a combination of tree coverage and an undersized trench drain that conveys surface flows east towards Hartwell Park. The contributing drainage area to the parking lot is small (approximately 18,000 square feet or 0.4 acres) and consists of the parking lot itself and the eastern half of N. Lena St. between SH 62 and the entrance to the Post Office driveway. Stormwater only flows into the Post Office parking circle off of N. Lena St. when the concrete pan (running north along N. Lena St.) is obstructed with snow or other debris or in larger storm events.

Two possible solutions would involve re-grading the parking circle or to install a storm sewer and piping into Hartwell Park to prevent icing in the area. A grading project would prevent storm water from entering the parking lot off N. Lena St. and would prevent water from ponding in the existing low point within the parking lot. Installing a storm sewer would utilize the existing grade and direct the water off of the lot. Regrading would involve removing the existing asphalt, re-grading the area, and re-asphalting the area. Installing a storm sewer and pipe would effectively decrease the risk of flooding at the parking circle by improving conveyance compared to the existing trench drain. Both proposed solutions to this problem would decrease winter hazards. An undesirable factor related to installing an inlet and pipe is that sand and salt from the parking area will potentially impact the grass at the pipe outlet. There is potential to add water quality treatment to the inlet (similar to the BMPs recommended for SH 62 – Section 3.3) which could capture sediment and/or to the outlet which could promote infiltration of salt in an aesthetically pleasing solution.

Campbell Lane

Beginning in the alley west of Campbell Ln., an inlet conveys some stormwater flows to the east. From the alley, a 160-foot-long, 12-inch diameter corrugated metal pipe (CMP) runs directly east and outfalls to the road. Field review and reports from the Town indicate that this area has issues with sediment at the inlet and drainage issues at the outlet.

Improving conditions in this area can be accomplished by extending the pipe east and outfalling directly to the Uncompahgre River. This pipe extension would be located on private property and would need to be coordinated with the private owners.

Hyde Street

Erosion along Hyde St. is impacting driveways from S. Amelia St to S. Lena St. The Town has expressed interest in developing a solution to route stormwater flows off Hyde St to the north or south. A feasibility study for a possible pipe or series of pipes to the south connecting Hyde St. and Cottonwood Creek determined that the grade was inadequate to tie into the creek and utilities would also inhibit any potential solutions. Looking to the north, two additional feasibility studies examined the impact of storm sewers connecting Hyde St with SH 62 would have on decreasing infrastructure deficiencies and reducing stress on driveways.

The first study modeled the impact that a potential pipe running north along S. Amelia St. to SH 62 would have on downgradient flows and infrastructure. An 18-inch pipe would reroute all stormwater flows from subcatchment HTC003, the 7.6-acre subcatchment between Marie St. and Amelia St. and tie into the existing 18-inch storm sewer located on the east side of Amelia St.

The second study modeled the impact that potential pipes along both S. Amelia St. and S. Elizabeth St. north to SH 62 would have on downstream flows and infrastructure. This model rerouted stormwater flows from both HTC003 and HTC009, the 3.2-acre subcatchment immediately east of HTC003 between S. Amelia St. and S. Elizabeth St., north in 18-inch pipes. This analysis resulted in greater impact to pipe sizes to the east along Hyde and would result in the greater cost-benefit for the Town. Therefore, this master plan recommends a pipe on both S. Amelia St. and S. Elizabeth St. (Figure H-1 in Appendix H).

Solar Ranch

During rainstorms, Chipeta Dr. experiences erosion along driveways and the road. To help mitigate this and to promote flows to Cottonwood Creek, an 18-inch pipes can be installed following both of the foot paths between Chipeta Dr and the Creek as shown in Figure H-1 in Appendix H. Diverting water off the road would be beneficial to the Creek and also decrease the strain on infrastructure at the Ridgway Athletic Field and elsewhere downgrade.

Roadside erosion is also taking place along Sabeta Dr. and Tabernash Ln. in the South Town area. The Town has expressed concern specifically at the T-intersection just to the east of 860 Sabeta Dr where there are visible signs of erosion. Two possible solutions to improving conditions include constructing a valley pan to convey flows east and protect from further erosion and installing pipes to get smaller storm events out of the streets all together.

Both suggested alternatives would still convey flow to the Ridgway Athletic Field ditch. Existing drainage issues at the Athletic Field could be impacted by a change in flow rate though total volume of stormwater conveyed to this area would remain the same.

Ridgway Athletic Field

The Athletic Field experiences standing water, likely due to irrigation and a high groundwater table. There is an existing drainage ditch that runs from the south to the north behind the houses located on Sabeta Dr. and currently has a difficult time draining given its lack of adequate slope. An alternative is to replace the existing ditch with a storm sewer system. The pipes would need to be designed appropriately with underdrains to address the high groundwater table. See Figure H-1 in Appendix H for pipe sizes for the 2-, 5-, and 25-year design storms.

3.3 WATER QUALITY ALTERNATIVES

The purpose of the water quality alternatives analysis is to explore Low Impact Development (LID) and green stormwater infrastructure improvements that could be incorporated over time throughout the study area. There are three methods or locations utilized for providing water quality - outfalls, intermediate areas and conveyance. Water quality opportunities have been identified throughout the study area (Figure 3-1). Addtionally, Refer to Figure H-1 in Appendix H for locations of proposed alternatives discussed in this section.

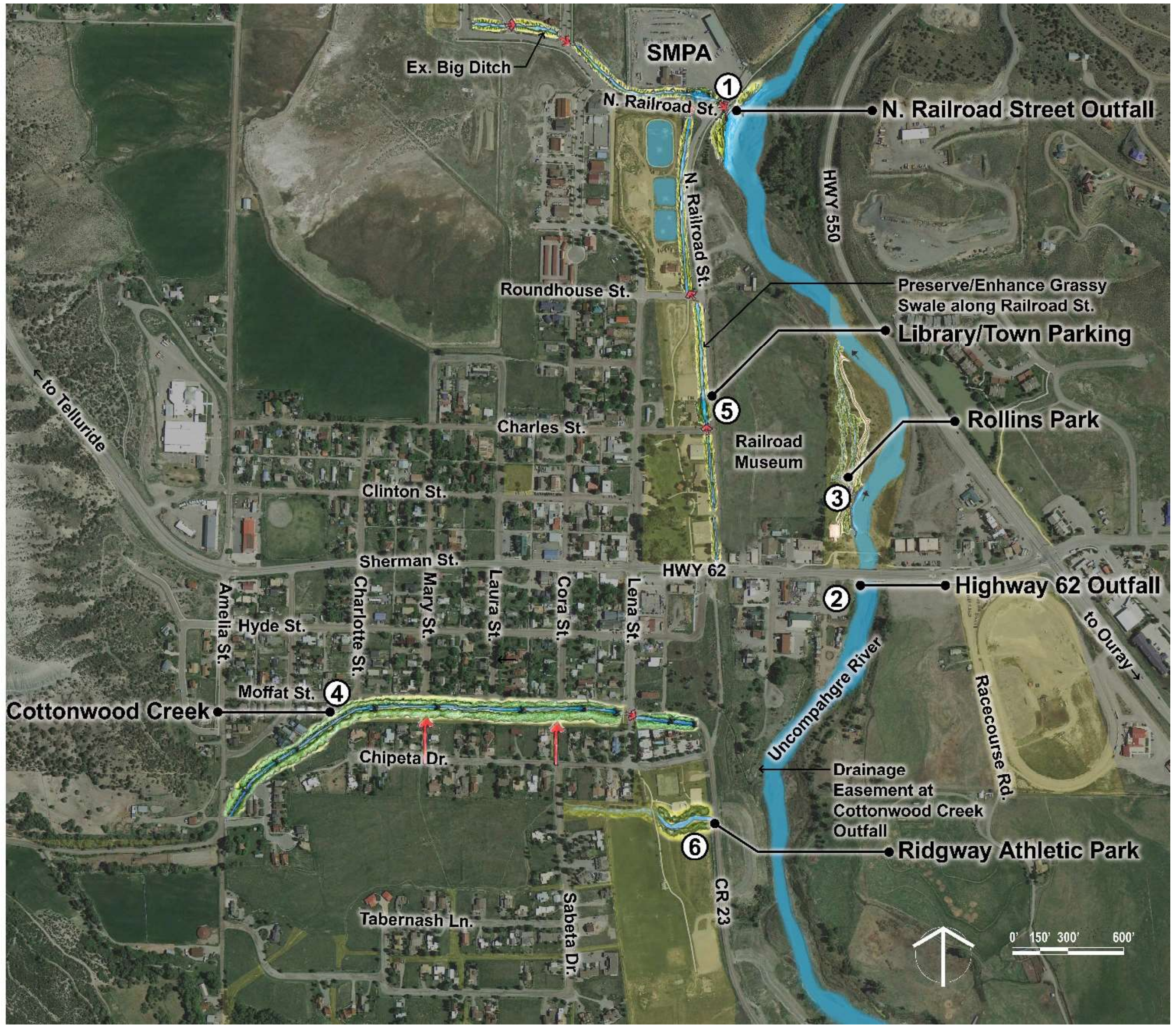


Figure 3-1. Water Quality Opportunities– Town owned properties are shown shaded

The potential improvement areas have been identified as follows:

1. North Railroad Street Outfall
2. Highway 62 Outfall
3. Rollins Park
4. Cottonwood Creek
5. Library/Town Parking Lot Along Railroad Street
6. Ridgway Athletic Park

3.3.1 Outfalls

Outfalls are a crucial piece of the existing system to be addressed because of their proximity to the Uncompahgre River. They are also critical because they are the portion of the drainage system that is carrying the most sediment and pollutants. Ideally water quality treatment areas would be spread throughout the overall drainage system. However, in some cases the outfall may be the area that is owned by the Town. Therefore, they may be more easily remediated and with the most impact to the system overall. There are three major outfalls that would contribute over a million gallons of stormwater during a 6-hour, 1.25-year event (Table 3-3). The three outfalls are North Railroad, Cottonwood Creek, and Cuddigan Ditch. SH 62 at the Uncompahgre River is a fourth outfall, that while not as large, would be an important area to treat because it serves the downtown area that drains to SH 62. Due to the fact that the Cottonwood Creek outfall is on private property and not available for public improvement projects, this report focuses on improvements possible along Cottonwood Creek instead of at the outfall (Section 3.3.2).

Table 3-3. Volume Required for Water Quality Treatment (1.25-year Event)

Outfall Location	Gallons	Acre-Feet
North Railroad	3,640,000	11.2
SH 62 at Uncompahgre	340,000	1.0
Cottonwood Creek	2,920,000	9.0
Cuddigan Ditch	1,400,000	4.3

North Railroad Outfall

North Railroad is a major outfall (Figure 3-2) into the river and a prime location for improving water quality prior to discharge. The outfall includes the irrigation wastewater ditch from the west and the roadside ditches from the north and south. The existing headwall and bank vegetation at the outfall are beginning to fail (Figure 3-2). Design alternatives will include improving the existing outfall into the river. Major collaboration would be needed with the San Miguel Power Association (SMPA) as they own the property, Figures 3-4 and 3-5 show how proposed improvements could impact their property and Figures 3-6 and 3-7 show examples of potential improvements. The North Railroad outfall is also utilized as an irrigation wastewater ditch (Figure 3-3) which ensures flowing water is present for the majority of the year. This continuous flow could help sustain permanent water quality wetlands as long as water rights allow. If this alternative is implemented, water rights would need to be investigated to understand the dependence of the irrigation wastewater flow.

Figure 3-2. Outfall at N. Railroad St.

Figure 3-3. Big Ditch at SMPA property

N. Railroad Street Proposed Improvements

Enlargement Plan - Option A (Maximum Proposed Improvements)

Existing Condition

- Lowest spot in town
- Currently has a public picnic area
- Existing large ditch runs west to east through the SMPA site to the river
- River is cutting behind existing headwall; headwall is unstable
- River is undercutting cottonwood trees; destabilizing the bank and causing them to fall down

Proposed Improvement

- Realign drop-off area for SMPA to create more room for water quality improvements
- Enhance grass swales draining to water quality area
- Create wetland that connects to the river to improve water quality
- Move trailhead parking; combine with SMPA drop-off area

Figure 3-4. Option A at SMPA

Enlargement Plan - Option B (Minimum Proposed Improvements)

Existing Condition

- Lowest spot in town
- Currently has a public picnic area
- Existing large ditch runs west to east through the SMPA site to the river
- River is cutting behind existing headwall; headwall is unstable
- River is undercutting cottonwood trees; destabilizing the bank and causing them to fall down

Proposed Improvement

- Relocate headwall up against trail
- Add guardrail to trail section abutting headwall

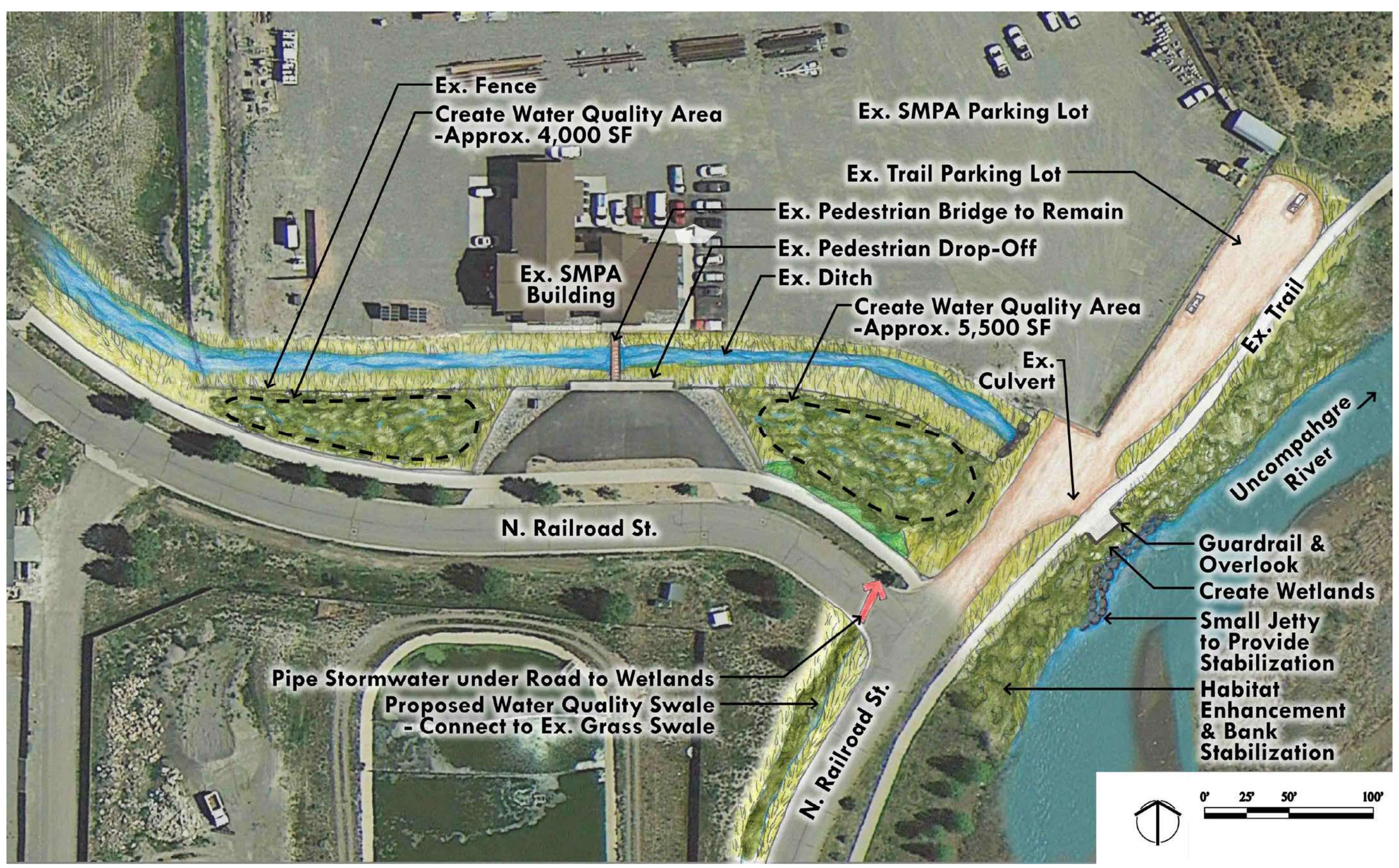


Figure 3-5. Option B at SMPA

Figure 3-6. Example of created wetlands

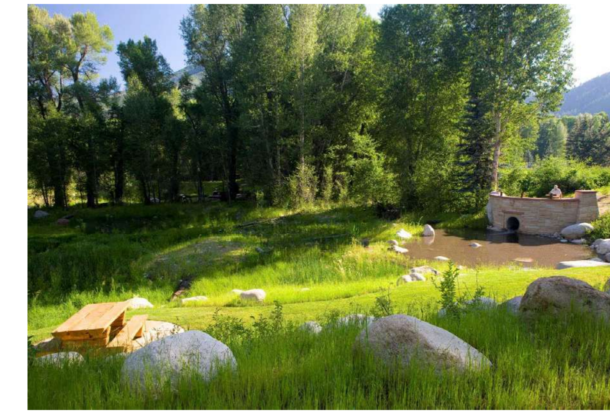


Figure 3-7. Example of ditch outfall and overlook

SH 62 *Outfall*

During the public process and discussions with the Town, SH 62 was identified as an important outfall to address (Figure 3-8). Water quality was removed from the CDOT SH 62 project due to several design and funding constraints. Vegetation improvements below the outfall could be added for water quality purposes, however addressing the water quality upstream from the outfall is more critical. A review of various Best Management Practices (BMPs) was conducted and some were found suitable for improving water quality by retrofitting existing inlets along Sherman Street are provided in Table 3-4. The risk to the current health of the river is most impacted by sediment and trash so these pollutants were established as the priority target for removal but others such as hydrocarbons and metals were also considered. The need to be able to maintain the feature easily is critical as the Town does not currently own a vacuum truck or have the necessary staff or equipment to manage proper upkeep of other BMPs.

Figure 3-8. View of the 48" pipe at the existing SH 62 outfall

Table 3-4. SH 62 BMP Matrix

BMP	Config.	Targeted Pollutants	Max Treatment	Maint. Req.	Easy to Retrofit	$$	Required Sump Depth	Other Constraints
Frog Creek’s Gutter Bins	Grate, curb or drop inlet with filter	Trash, sediment, hydrocarbons, metals	NA	Replace/ clean filters	Yes	Low $700-$4300/unit	NA	NA
Suntree's Curb Inlet Basket	Shallow catch basin	Trash, sediment	NA	Clean filters	Okay	Low	NA	NA
Snout	Vented hood over MH outlet pipe	Floatables, trash, oils, sediment (BMP snout with bioskirt captures hydrocarbons)	NA	Vac truck	Yes	Low <$1000 /unit	36" min, 2.5 to 3 times dia. outlet pipe	Smallest size 18" flat box or 24" round MH
SAFL Baffle	Rectangular baffle in center of MH	Sediment	NA	Vac truck	Yes	Low $5000/unit	36” min	Min 24” MH
Carlsonator Vault	Rectangular vault with 3 MH cover access points	Sediment	NA	Vac truck	Okay	Medium Approx. 10% of the cost of proprietary structures	Unknown	Unknown
AquaShield's "Aqua Swirl"	Single MH with tangential inlet pipe and arched baffle	Suspended solids, debris, floatables, oil	29.6 cfs	Vac truck	Okay	High	38”- 68” min	Needs cover for roadway situation
Environment 21's "V2B1"	Inlet manhole with tangential inlet pipe, elbow exit pipe and outlet manhole with baffle wall	TSS (removal of sandy sediment), floatable debris	24 cfs	Vac truck	Okay	High	3.5' to 6' min	Needs cover for roadway situation
Inlet Grate Filters	Filter insert in inlet or new catch basin with filter	Trash, sediment, hydrocarbons, metals	5.5 cfs	Replace/ clean filters	Yes	Low Approx. $500 for insert, $5000 for catch basin	NA	NA

There were three defining characteristics that defined the review of potential BMPs. First, space limitations eliminated the possibility of recommending many popular BMPs like detention ponds or vegetative BMPs. Second, ability to retrofit an inlet to install a potential BMP was an important aspect considered as some BMP designs are so large that they must be incorporated into the original design to be effective. Finally, due to maintenance constraints, BMPs that can be manually maintained were preferred.

As presented in Table 3-4, eight different BMPs were considered for this evaluation. Frog Creek’s Gutter Bins, Suntree’s Curb Inlet Basket, and inlet grate filters are BMPs that met all three constraints. The Gutter Bins design includes collecting sediment and fine debris while the Curb Inlet Basket and Inlet Grate Filters target trash and larger debris, but all can be maintained manually. The other five BMPs require a vacuum truck but can be retrofitted into the existing infrastructure. The Gutter Bins, Curb Inlet Basket, snout, SAFL baffle, and grate filters all provide the Town with low cost options. The higher priced BMPs are able to treat higher flow rates and can capture small particle pollutants including suspended solids. Fact Sheets for each of the BMPs in Table 3-4 are provided in Appendix J.

Another potential alternative would be to divert water to Rollins Park for water quality (Figures 3-9, 3-10 and 3-11). This could be beneficial to maintaining and enhancing existing native vegetation in the park as well as protecting the water quality of the river from highway runoff. Currently the park is not receiving a significant amount of storm water and a major design issue would be determining how to get water to that location. It has been determined at a very preliminary level that piping water to the park is possible (Figure 3-9); however, it would come with significant costs.

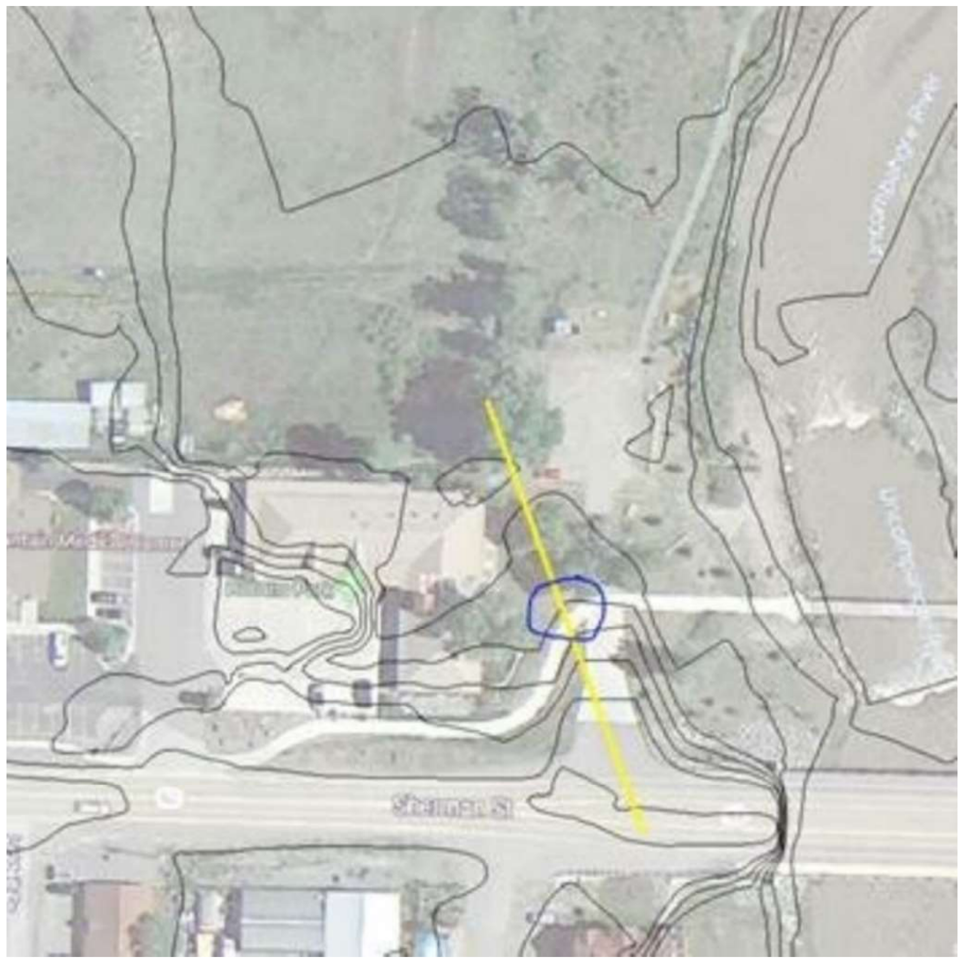


Figure 3-9. Preliminary routing of piped stormwater to Rollins Park. Routing to the park would come with significant costs.

Figure 3-10. Example of how redirecting water into Rollins Park could improve diversity in vegetation as well as providing water quality for the SH 62 outfall. Vegetation would be native that can survive inundation and drought.

Enlargement Plan - Rollins Park

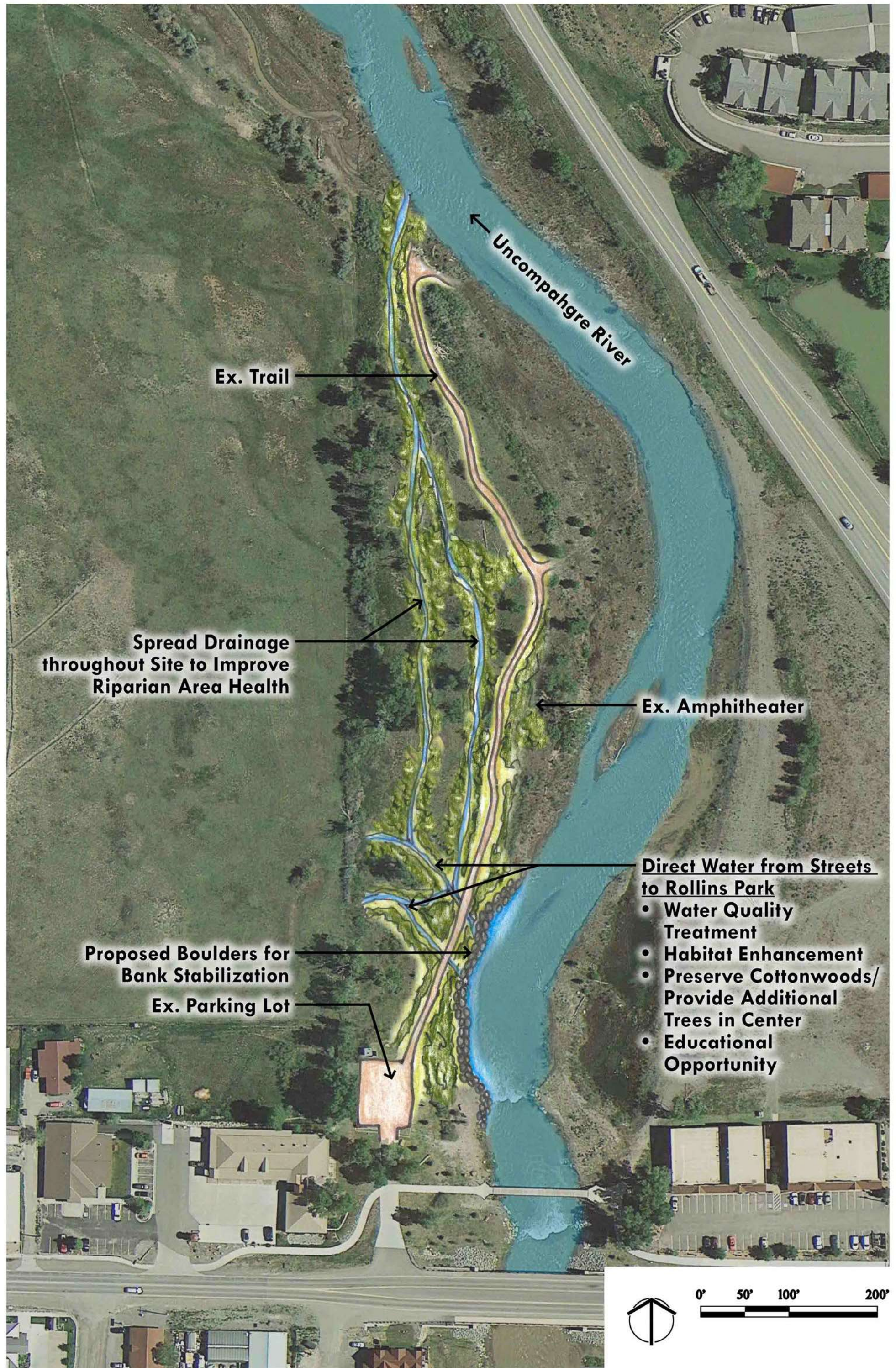


Figure 3-11. Rollins Park improvements

Rollins Park is also suffering from major bank erosion downstream of the in-stream boulder/whitewater features. This is a project in itself and is noted for information in this report. Figure 3-12 shows how terraced boulders can be used as a park feature that prevents erosion, provides an eddy for whitewater play features, and provides safer access to the river for park users.

Figure 3-12. Example bank stabilization with recreation access

Cuddigan Ditch Outfall:

This area is an undeveloped agricultural land use currently. Although not currently identified as a potential improvement location, it is recommended to stay as is until any future development occurs. If this area is developed in the future, the property owner would be required to provide applicable water quality improvements per the Town's anticipated Land Use Codes and Stormwater Standards.

3.3.2 Intermediate Treatment Areas

Intermediate treatment areas provide an opportunity to capture sediment and pollutants, as well as debris, in locations before the storm water reaches the outfall locations and the river. The intermediate treatment zones provide significant benefit to water quality as they provide a filtration mechanism before the final outfall locations. Three locations where intermediate treatment methods are suggested are Cottonwood Creek, Ridgway Athletic Park and Library/Town Parking.

Cottonwood Creek

The area along Cottonwood Creek has been classified as a potential intermediate treatment area. There is room along the creek and in the park where drainage and water quality treatment can occur that is not limited by the ROW. The Cottonwood Creek corridor has a number of issues:

- The creek is downcutting, the channel bottom is degrading and the banks are severely eroded.
- The invert of the channel has dropped and has separated the water table from the native vegetation, mostly mature cottonwood trees (Figure 3-13).
- Irrigation water is diverted from Cottonwood Creek before it goes through Town. The creek currently does not hold a perennial flow or receive much storm water.

Figure 3-13. Cottonwood Creek from Moffat St. This photo illustrates the issues of downcutting and lowering of the water table leaving the mature cottonwoods high and dry.

Water quality could be accomplished along the entire creek corridor through Town using a combination of the below-mentioned improvements.

Recommendations (Figure 3-14):

1. Divert water from Chipeta Dr., sending additional storm water to Cottonwood Creek.
2. Add a series of small boulder drop/check structures (Figure 3-17) to help flatten out and stabilize the channel. This could also help to raise the invert of the channel, bringing the water table up to help support the existing cottonwood trees. In areas of the park where there is room, side slopes could be laid back to help control erosion and create a safer interface to the creek for park users. If this alternative is pursued a more detailed design would need to be developed to determine the ideal location for the check structures and any potential grading along the channel. This design would also include native riparian planting and restoration and protection for the existing pedestrian bridges. Refer to Figures 3-15 to 3-18 for examples.
3. If the slope of the channel was flattened this would provide water quality for drainage that enters Cottonwood Creek. This provides better conditions for plants to grow which in turn improves diversity, habitat and ecological function of the corridor.

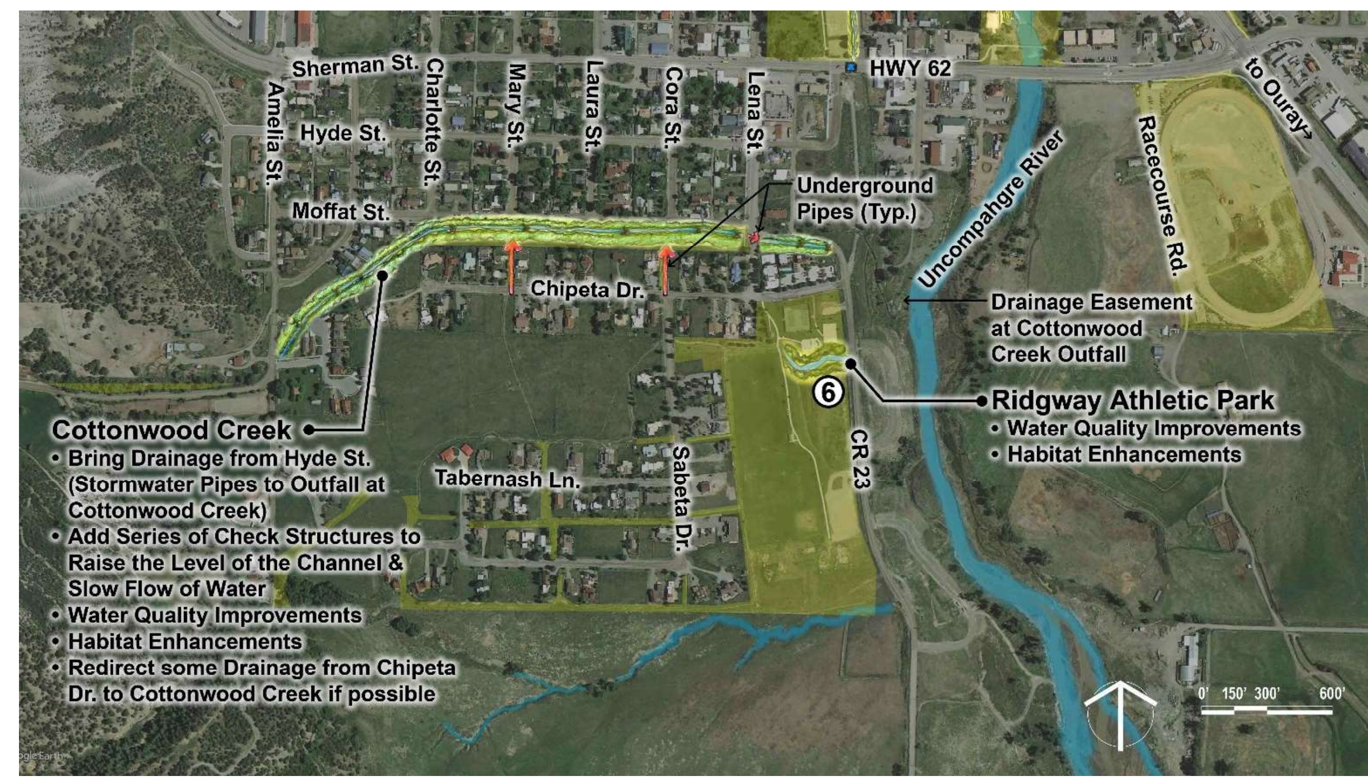


Figure 3-14. Water quality opportunities in South Town area

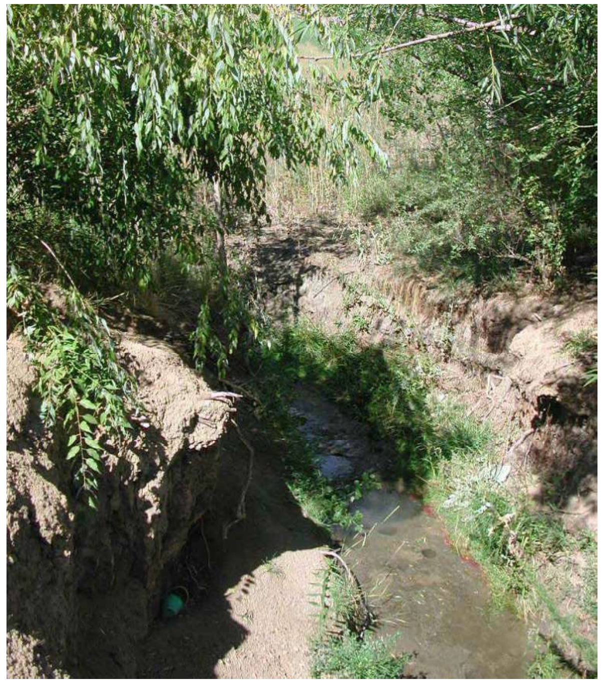


Figure 3-15. Lilley Gulch before improvements

Figure 3-16. Lilley Gulch after improvements

Example of an urban creek downcutting at Lilley Gulch (above left). A photo from the same location where a boulder drop structure was used to raise the channel invert, reduce the slope of the channel, and provide a safer way for park users to interact with the water (above right).

Figure 3-17. Example check structure

Figure 3-18. Example of bank stabilization and seeding

Small boulder check structure with bioengineering techniques used to stabilize the toe of the channel and provide protection for native revegetation (above left). A stabilized bank and seeding (above right).

Ridgway Athletic Park

The Ridgway Athletic Park is another intermediate area that could be improved. Some drainage is intercepted off of Chipeta Drive and sent into the park, outfalling south of the tennis courts (Figure 3-19). Currently the drainage channel that carries this water (Figure 3-20) is a cobble swale bordered by turf that helps to stabilize the drainage. This area is a stormwater resource with a fairly consistent flow that could be improved by restoring the channel with native riparian vegetation. Plants such as willows, cottonwoods, sedges and rushes could be incorporated. Once established, the area would not need to be mowed or weed wacked, allowing the vegetation to grow freely through the cobble. This planting would improve habitat and diversity in an important area where the drainage is closely connected to the river. The native plants would provide additional filtration and water quality as compared to the existing cobble alone. This improvement is low priority as the current channel does provide some water quality treatment. However, it is also an easily attainable and low-cost improvement as it falls under Town ownership and is a simple construction project.

Figure 3-19. Outfall from Chipeta Dr. into park

Figure 3-20. Existing drainage channel

Library/Town Parking Lot Along Railroad Street

Another area that is an intermediate opportunity in the system is the east side of the Library. There is an existing isolated landscape zone between the building and Railroad Street that is not used for the outdoor functions of the Library. The area would be ideal to create a shallow water quality basin that accepts water from the upstream inlet at Charles St. The inlet at Charles St. captures a substantial amount of water from the paved area in the HTC, making the location ideally suited for water quality improvement. An outfall control structure could be installed to capture the smaller storms while allowing the larger flows to pass through the system more quickly (Figure 3-21).

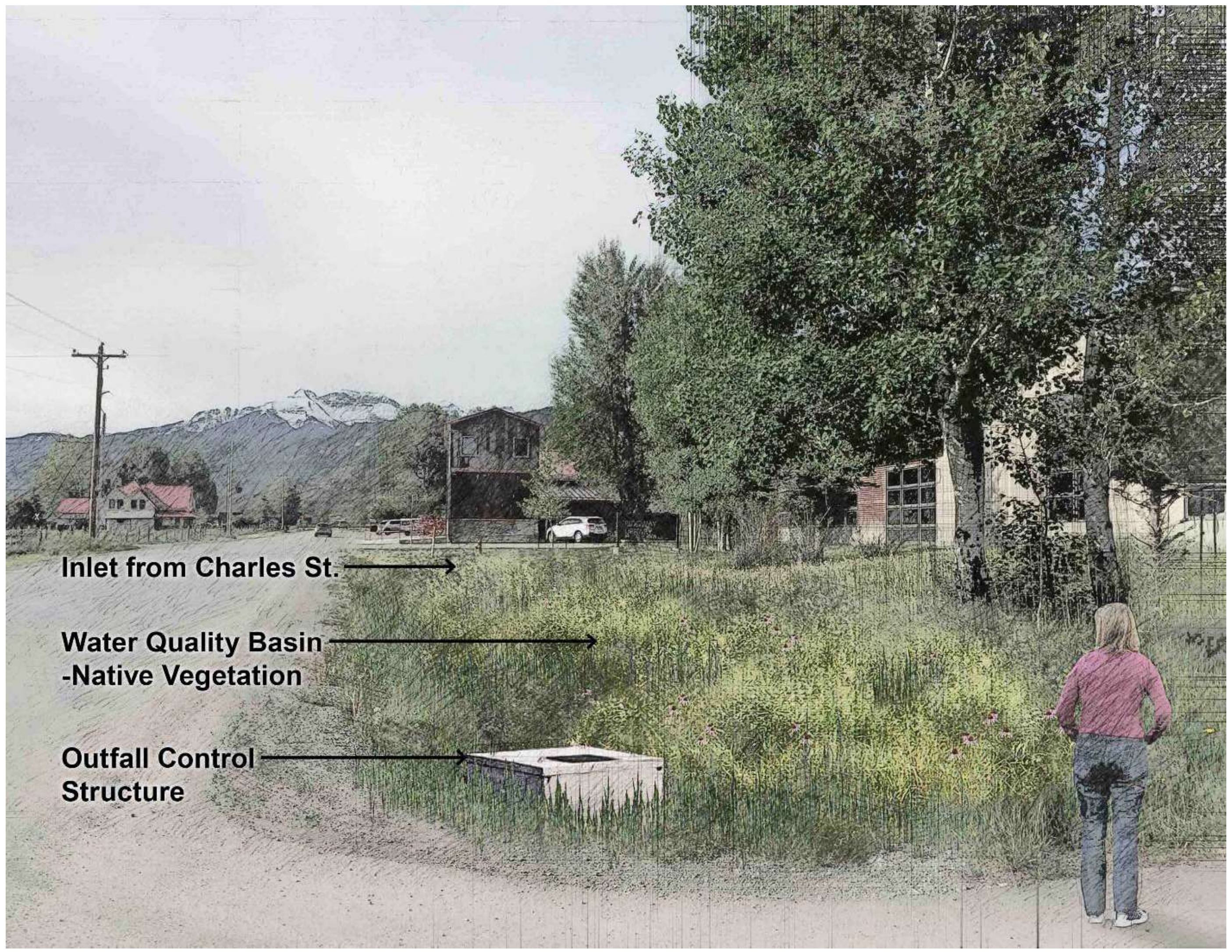


Figure 3-21. Photo simulation of potential water quality basin at the corner of Charles and Railroad, on the east side of the Library

3.4 EDUCATION

All of the outfall and intermediate locations discussed above would be ideal educational opportunities for how stormwater and water quality treatment are a critical piece of every town's infrastructure. There can be a combination of pipes, low-impact development, surface stormwater treatment, bioengineering, water quality, and habitat enhancement weaved into the Town's drainage system. It is important for the general public to understand more about flood control vs. water quality and how these functional pieces of the community can be woven into the Town's recreational infrastructure and fabric as an amenity.

Figure 3-22. Example of interpretive education signage

3.5 ALTERNATIVE COST SUMMARY

Costs were developed for the alternatives presented in the above sections. A cost estimate was prepared for all three design storms (2-, 5-, and 25-year) under future conditions. Water quality and general drainage improvements have only one cost associated with all storm events and are therefore identical in all three tables. As is shown in the tables, the total master plan costs range from approximately $7M for the 2-year design storm to approximately $12M for the 25-year design storm.

The costs were estimated using unit prices from the Mile High Flood District (MHFD) and the Colorado Department of Transportation (CDOT). A multiplier of 1.5 was applied to the raw capital costs for the increased cost of supplies and construction in the Town of Ridgway as compared to the Front Range. The multiplier was determined by comparing CDOT construction costs for southwestern Colorado to those for the Front Range.

Costs were estimated using the following breakdown of the Total Capital Cost:

- Capital: 45% - includes the costs of materials and construction
- Engineering: 15% - includes preparation of construction plans, specifications, and all associated administrative services from notice-to proceed to bidding assistance.
- Legal/Admin: 5% - covers the costs of legal fees for land acquisition, general contracting administration, and other support services.
- Contract Admin/CM: 10% - includes all professional services required for construction observation, review of shop drawings and technical submittals, request for information, preparation of pay estimates, etc.
- Contingency: 25% - meant to cover the additional items and unknowns.

Total costs for the 2-, 5-, and 25-year design storms are shown on Tables 3-5, 3-6, and 3-7 on the following pages. Detailed quantities and costs breakdowns are provided in Appendix G.

Table 3-5. Estimated Summary of Alternative Costs for the 2-year Storm Event

Alternative	Report Section	2-Year Storm Event					
		Capital	Engineering	Legal/Administrative	Contract Admin/CM	Contingency	Total Capital Cost
Road Crossings	3.2.1	$ 321,300.00	$ 107,100.00	$ 35,700.00	$ 71,400.00	$ 178,500.00	$ 714,000.00
Pipes and Ditches	3.2.2	$ 1,645,200.00	$ 548,400.00	$ 182,800.00	$ 365,600.00	$ 914,000.00	$ 3,656,000.00
[1]Solar Ranches	3.2.2	$ 100,547.70	$ 33,515.90	$ 11,171.97	$ 22,343.93	$ 55,859.83	$ 223,439.33
Post Office - Option A	3.2.4	$ 76,860.00	$ 25,620.00	$ 8,540.00	$ 17,080.00	$ 42,700.00	$ 170,800.00
[3]Post Office - Option B	3.2.4	$ 15,750.00	$ 5,250.00	$ 1,750.00	$ 3,500.00	$ 8,750.00	$ 35,000.00
Campbell Lane Pipes	3.2.4	$ 38,700.00	$ 12,900.00	$ 4,300.00	$ 8,600.00	$ 21,500.00	$ 86,000.00
Hyde Street Pipes	3.2.4	$ 116,100.00	$ 38,700.00	$ 129,000.00	$ 25,800.00	$ 64,500.00	$ 258,000.00
Ridgway Athletic Field Pipes	3.2.4	$ 430,200.00	$ 143,400.00	$ 47,800.00	$ 95,600.00	$ 239,000.00	$ 956,000.00
N. Railroad St. - Option A	3.3.2	$ 310,360.00	$ 103,453.33	$ 34,484.44	$ 68,968.89	$ 172,422.22	$ 689,688.89
[3]N. Railroad St. - Option B	3.3.2	$ 64,425.00	$ 21,475.00	$ 7,158.33	$ 14,316.67	$ 35,791.67	$ 143,166.67
Cottonwood Creek Treatment	3.3.1	$ 295,000.00	$ 98,333.33	$ 32,777.78	$ 65,555.56	$ 163,888.89	$ 655,555.56
[2]SH 62 BMPs	3.3.2	$ 15,000.00	$ 5,000.00	$ 1,666.67	$ 3,333.33	$ 8,333.33	$ 33,333.33
Library Parking	3.3.2	$ 9,320.00	$ 3,106.67	$ 1,035.56	$ 2,071.11	$ 5,177.78	$ 20,711.11
Rollins Park Water Quality	3.3.2	$ 67,730.00	$ 22,576.67	$ 7,525.56	$ 15,051.11	$ 37,627.78	$ 150,511.11
Ridgway Athletic Park Water Quality	3.3.1	$ 34,545.00	$ 11,515.00	$ 3,838.33	$ 7,676.67	$ 19,191.67	$ 76,766.67
TOTAL		**$ 3,214,927.70**	**$ 1,071,642.57**	**$ 473,314.19**	**$ 714,428.38**	**$ 1,786,070.94**	**$ 7,144,283.78**

[1] Solar Ranches cost is the sum of (18" Cottonwood Creek Diversion Pipes)+(Tabernash Concrete Pan)+(Chipeta Inlet)

[2] SH 62 BMP costs are average of potential options; assumed applied to 3 total inlets

[3] Total Project Costs assume selection of Post Office Option A and N. Railroad St. Option B

Table 3-6. Estimated Summary of Alternative Costs for the 5-year Storm Event

Alternative	Report Section	5-Year Storm Event					
		Capital	Engineering	Legal/Administrative	Contract Admin/CM	Contingency	Total Capital Cost
Road Crossings	3.2.1	$ 405,900.00	$ 135,300.00	$ 45,100.00	$ 90,200.00	$ 225,500.00	$ 902,000.00
Pipes and Ditches	3.2.2	$ 2,079,000.00	$ 693,000.00	$ 231,000.00	$ 462,000.00	$ 1,155,000.00	$ 4,620,000.00
[1]Solar Ranches	3.2.2	$ 100,547.70	$ 33,515.90	$ 11,171.97	$ 22,343.93	$ 55,859.83	$ 223,439.33
Post Office - Option A	3.2.4	$ 76,860.00	$ 25,620.00	$ 8,540.00	$ 17,080.00	$ 42,700.00	$ 170,800.00
[3]Post Office - Option B	3.2.4	$ 15,750.00	$ 5,250.00	$ 1,750.00	$ 3,500.00	$ 8,750.00	$ 35,000.00
Campbell Lane Pipes	3.2.4	$ 38,700.00	$ 12,900.00	$ 4,300.00	$ 8,600.00	$ 21,500.00	$ 86,000.00
Hyde Street Pipes	3.2.4	$ 137,700.00	$ 45,900.00	$ 15,300.00	$ 30,600.00	$ 76,500.00	$ 306,000.00
Ridgway Athletic Field Pipes	3.2.4	$ 430,200.00	$ 143,400.00	$ 47,800.00	$ 95,600.00	$ 239,000.00	$ 956,000.00
N. Railroad St. - Option A	3.3.2	$ 310,360.00	$ 103,453.33	$ 34,484.44	$ 68,968.89	$ 172,422.22	$ 689,688.89
[3]N. Railroad St. - Option B	3.3.2	$ 64,425.00	$ 21,475.00	$ 7,158.33	$ 14,316.67	$ 35,791.67	$ 143,166.67
Cottonwood Creek Treatment	3.3.1	$ 295,000.00	$ 98,333.33	$ 32,777.78	$ 65,555.56	$ 163,888.89	$ 655,555.56
[2]SH 62 BMPs	3.3.2	$ 15,000.00	$ 5,000.00	$ 1,666.67	$ 3,333.33	$ 8,333.33	$ 33,333.33
Library Parking	3.3.2	$ 9,320.00	$ 3,106.67	$ 1,035.56	$ 2,071.11	$ 5,177.78	$ 20,711.11
Rollins Park Water Quality	3.3.2	$ 67,730.00	$ 22,576.67	$ 7,525.56	$ 15,051.11	$ 37,627.78	$ 150,511.11
Ridgway Athletic Park Water Quality	3.3.1	$ 34,545.00	$ 11,515.00	$ 3,838.33	$ 7,676.67	$ 19,191.67	$ 76,766.67
TOTAL		**$ 3,754,927.70**	**$ 1,251,642.57**	**$ 417,214.19**	**$ 834,428.38**	**$ 2,086,070.94**	**$ 8,344,283.78**

[1] Solar Ranches cost is the sum of (18" Cottonwood Creek Diversion Pipes)+(Tabernash Concrete Pan)+(Chipeta Inlet)

[2] SH 62 BMP costs are average of potential options; assumed applied to 3 total inlets

[3] Total Project Costs assume selection of Post Office Option A and N. Railroad St. Option B

Table 3-7. Estimated Summary of Alternative Costs for the 25-year Storm Event

Alternative	Report Section	25-Year Storm Event					
		Capital	Engineering	Legal/Administrative	Contract Admin/CM	Contingency	Total Capital Cost
Road Crossings	3.2.1	$ 706,950.00	$ 235,650.00	$ 78,550.00	$ 157,100.00	$ 392,750.00	$ 1,571,000.00
Pipes and Ditches	3.2.2	$ 2,711,700.00	$ 903,900.00	$ 301,300.00	$ 602,600.00	$ 1,506,500.00	$ 6,026,000.00
[1]Solar Ranches	3.2.2	$ 100,547.70	$ 33,515.90	$ 11,171.97	$ 22,343.93	$ 55,859.83	$ 223,439.33
Post Office - Option A	3.2.4	$ 76,860.00	$ 25,620.00	$ 8,540.00	$ 17,080.00	$ 42,700.00	$ 170,800.00
[3]Post Office - Option B	3.2.4	$ 15,750.00	$ 5,250.00	$ 1,750.00	$ 3,500.00	$ 8,750.00	$ 35,000.00
Campbell Lane Pipes	3.2.4	$ 38,700.00	$ 12,900.00	$ 4,300.00	$ 8,600.00	$ 21,500.00	$ 86,000.00
Hyde Street Pipes	3.2.4	$ 148,500.00	$ 49,500.00	$ 16,500.00	$ 33,000.00	$ 82,500.00	$ 330,000.00
Ridgway Athletic Field Pipes	3.2.4	$ 547,650.00	$ 182,550.00	$ 60,850.00	$ 121,700.00	$ 304,250.00	$ 1,217,000.00
N. Railroad St. - Option A	3.3.2	$ 310,360.00	$ 103,453.33	$ 34,484.44	$ 68,968.89	$ 172,422.22	$ 689,688.89
[3]N. Railroad St. - Option B	3.3.2	$ 64,425.00	$ 21,475.00	$ 7,158.33	$ 14,316.67	$ 35,791.67	$ 143,166.67
Cottonwood Creek Treatment	3.3.1	$ 295,000.00	$ 98,333.33	$ 32,777.78	$ 65,555.56	$ 163,888.89	$ 655,555.56
[2]SH 62 BMPs	3.3.2	$ 15,000.00	$ 5,000.00	$ 1,666.67	$ 3,333.33	$ 8,333.33	$ 33,333.33
Library Parking	3.3.2	$ 9,320.00	$ 3,106.67	$ 1,035.56	$ 2,071.11	$ 5,177.78	$ 20,711.11
Rollins Park Water Quality	3.3.2	$ 67,730.00	$ 22,576.67	$ 7,525.56	$ 15,051.11	$ 37,627.78	$ 150,511.11
Ridgway Athletic Park Water Quality	3.3.1	$ 34,545.00	$ 11,515.00	$ 3,838.33	$ 7,676.67	$ 19,191.67	$ 76,766.67
TOTAL		**$ 4,816,927.70**	**$ 1,605,642.57**	**$ 535,214.19**	**$ 1,070,428.38**	**$ 2,676,070.94**	**$ 10,704,283.78**

[1] Solar Ranches cost is the sum of (18" Cottonwood Creek Diversion Pipes)+(Tabernash Concrete Pan)+(Chipeta Inlet)

[2] SH 62 BMP costs are average of potential options; assumed applied to 3 total inlets

[3] Total Project Costs assume selection of Post Office Option A and N. Railroad St. Option B

3.6 ALTERNATIVES CONCLUSION

Alternatives presented in this report were developed with regular input from the Town. Town representatives presented issues that currently impact residents and combined with issues presented as the result of modeling efforts, provide a variety of potential opportunities for further action. The presented water quantity solutions focus on increasing capacity throughout Town, primarily through improving infrastructure to meet the needs for the 2-, 5-, and 25-year storm events. Water quality solutions focus on decreasing peak flow rates to prevent further erosion and provide recreational opportunities throughout Town. The Town's final selected stormwater alternative for the master plan is presented in Section 4 – Conceptual Design.

4 CONCEPTUAL DESIGN

4.1 OVERVIEW

The alternatives presented in Section 3 – Alternatives Analysis were reviewed and discussed with Town Staff. Alternatives that were deemed undesirable or infeasible were removed from consideration and were not included in the conceptual design. The conceptual design represents a preliminary design of proposed master planned stormwater improvements for the Town.

The final proposed improvements for this master plan are as follows:

Conveyance and Drainage Improvements

- Culverts at Road Crossings
- Stormwater Pipes
- General Drainage Improvements – Post Office, Campbell Lane, Hyde Street, Solar Ranches, and Athletic Field Pipes

Water Quality Improvements:

- North Railroad Street – Alternative B was selected for the Conceptual Plan
- Cottonwood Creek Treatment
- SH 62 BMPs
- Library Parking
- Athletic Field Channel

Section 4.2 below provides conceptual level design for each of the items described. Additionally, the remainder of the section provides prioritization of the recommended improvements and a total estimated cost. All conceptual design elements can be found on the map in Appendix K – Final Master Plan Maps.

Click Here to View Final Master Plan Map (Figure K-1)

4.2 CONCEPTUAL DESIGN

The following subsections present conceptual designs for the final selected alternatives discussed above. The first three subsections present conveyance and drainage issues and the subsequent six subsections present water quality improvements.

4.2.1 Conveyance- Road Crossings, Pipes, and Ditches

As presented in Section 3 – Alternative Development Process, there are currently several existing culverts, ditches, and storm sewers that are undersized throughout the Town. These conveyance elements, sometimes impeded by sediment build up, can cause flooding that extends into roadways and private property. Future development will increase impervious coverage and runoff throughout Town, causing further strain on existing infrastructure.

The future conditions 2-, 5-, and 25-year design storm events were analyzed in Section 3 – Alternative Development Process to determine the selected design storm for infrastructure in the Town. After review of the analysis, the Town selected the 25-year design storm for sizing stormwater infrastructure in the Town of Ridgway; however, in some locations designing infrastructure to convey the 25-year storm may be impractical. If the designer feels that there are site specific challenges that prohibit conveyance of the 25-year storm, the designer shall prepare and submit a report to the Town explaining the challenges and proposing an alternate peak design for the location specific challenges with the rationale for that selection. The Town will review the request for deviation and work with the designer to determine the storm to be accommodated. Such deviations from the 25-year storm will be determined on a site-specific basis rather than project wide basis. New street designs shall incorporate a combination of storm piping, ditches and/or curb and gutter to convey the 25-year event.

For purposes of the analysis, all proposed culverts and storm sewers were assumed to be reinforced concrete pipes (RCP) with a manning's n roughness coefficient of 0.015 and 80% capacity. However, the Town prefers the use of corrugated metal pipes (CMPs) for most culvert crossings and high-density polyethylene (HDPE) or polyvinyl chloride (PVC) for storm sewers. The Town should be consulted prior to selecting a final material for design. Sizing may vary dependent on final material and slope.

There are three potential design layouts for storm pipes within the Town.

1. Parallel to Existing Ditch: As illustrated in Figure 4-1, one option is to construct a storm sewer pipe within the existing road right-of-way parallel to the existing roadside ditch. The proposed storm sewer would convey the design storm (25-year) with the existing ditch providing additional capacity. This option would limit construction within the existing ditch and would provide capacity above the design storm. This is important

in the areas of Town with existing gravel streets and therefore no additional stormwater capacity from a curb and gutter.

2. Below Ditch: Similar to layout #1, but with the pipe aligned below the ditch. This option would cause more impacts to the existing ditch, but would also provide conveyance that exceeds the design storm.
3. Pipe Only: In some locations in Town there is not an existing ditch or it may not be practical to utilize the existing ditch. In those locations, a stand-alone pipe could be designed.

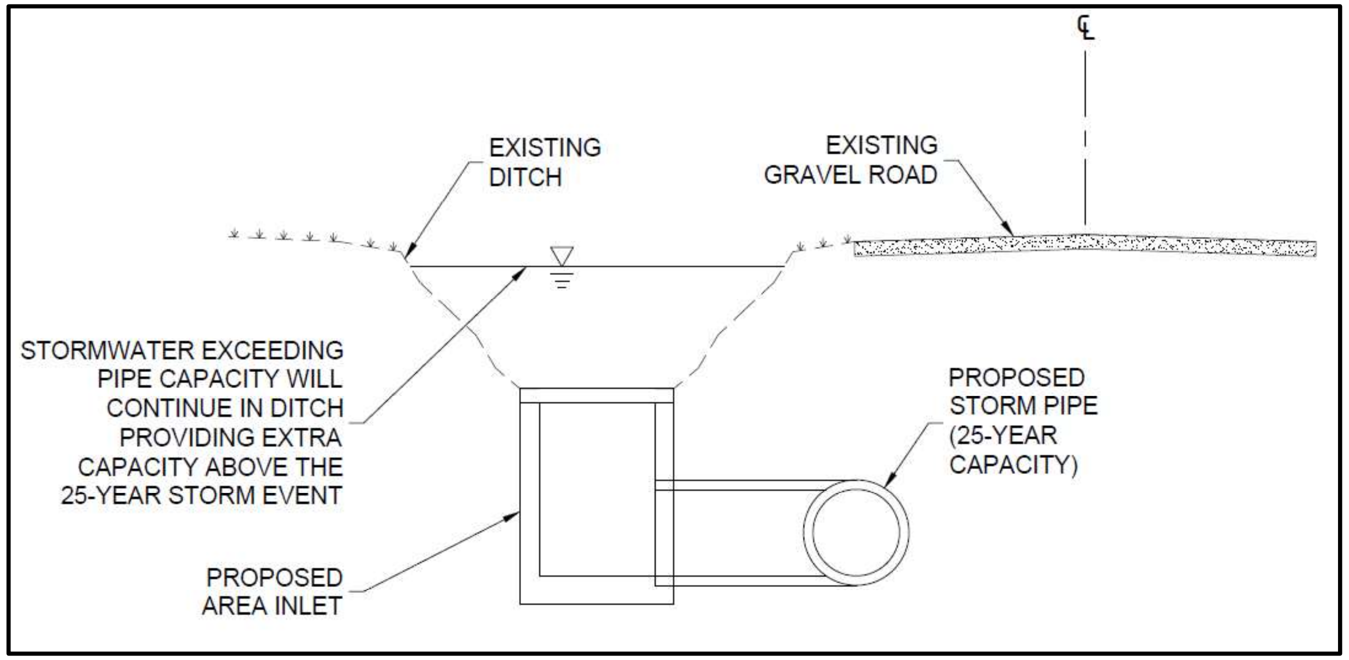


Figure 4-1. Conceptual storm pipe and ditch alignment

Click Here to View Final Master Plan Map (Figure K-1)

4.2.2 Conveyance- General Drainage Issues

Post Office

As presented in Section 3 – Alternative Development Process, the Post Office parking circle often experiences freezing issues in the winter months due to a combination of tree coverage and an undersized trench drain that conveys surface flows east towards Hartwell Park. The final selected alternative for the Post Office is to install a larger sidewalk chase to replace the existing drain. The chase must be located at the low point in the parking lot to properly convey surface flows away and reduce standing water.

Campbell Lane

Beginning in the alley west of Campbell Ln. and Liddell Dr., an inlet conveys some stormwater flows to the east along Campbell Ln. A 160' long, 12" diameter corrugated metal pipe (CMP) runs directly east and outfalls into the road. Field review and reports from the Town indicate that this area has issues with sediment at the inlet and drainage issues at the outlet.

Improving conditions in this area can be accomplished by extending the pipe east and outfalling directly to the Uncompahgre River. The pipe extension would consist of 24" diameter CMP and the outfall into the river would need riprap armoring to prevent erosion of the bank. This pipe extension would be located on private property and a drainage easement would need to be secured with the private property owners.

Hyde Street

Erosion along Hyde St is impacting driveways from Amelia St. to Lena St. The Town has expressed interest in developing a solution to route stormwater flows off Hyde St to the north or south. A feasibility study for a possible pipe or series of pipes to the south connecting Hyde St. and Cottonwood Creek determined that the grade was inadequate to tie into the creek and utilities would also inhibit any potential solutions. Looking to the north, two additional feasibility studies examined the impact of storm sewers connecting Hyde St with SH 62 would have on decreasing infrastructure deficiencies and reducing stress on driveways. As discussed in Section 3 – Alternative Development Process, the hydraulically and fiscally best solution is to construct storm sewers along both Amelia St. and Elizabeth St. to route water off of Hyde to SH 62. All future designs will take care to ensure surcharging or clogged inlets don't result in private property flooding along either road.

Solar Ranch

During rainstorms, Chipeta Dr. experiences erosion along driveways and the road. To help mitigate this and to promote flows to Cottonwood Creek, an 18-inch pipe can be installed following both of the foot paths between Chipeta Dr and the Creek. Diverting water off the road would be beneficial to the Creek and also decrease the strain on proposed stormwater infrastructure to the east.

Roadside erosion is also taking place along Sabeta Dr. and Tabernash Ln. in the South Town area. The Town has expressed concern specifically at the T-intersection just to the east of 860 Sabeta Dr where there are visible signs of erosion. The final selected alternative is to construct a concrete valley pan along the length of Sabeta to prevent erosion.

Ridgway Athletic Field

The Athletic Field experiences standing water, likely due to irrigation and a high groundwater table. There is an existing drainage ditch that runs from the south to the north behind the houses located on Sabeta Dr. and currently has a difficult time draining given its lack of adequate slope. An alternative is to replace the existing ditch with a storm sewer system. The pipes would need to be designed appropriately with underdrains to address the high groundwater table.

Click Here to View Final Master Plan Map (Figure K-1)

4.2.3 Water Quality – North Railroad Street Outfall

The intersection at North Railroad St. is a vital piece of Ridgway's stormwater system. It is the low point within the system where the stormwater from the Historic Town Core outfalls into the Uncompahgre River. There is an existing large ditch that runs west to east through SMPA property to the river that has the potential to provide a continuous water source to support created water quality wetlands. The water source, open space and proximity to the river - provide a unique opportunity to create valuable habitat, sediment control and water quality treatment for the existing conditions. This could be created through grading, a controlled outfall structure and revegetation. There may also be room to provide maintenance access to a forebay area where sediment could be cleaned out as needed. The Town would need to work with SMPA to implement these improvements, which are mutually beneficial to the community and protecting SMPA access. See Figure 4-2 for a conceptual plan of the improvements.

Existing Outfall

The existing outfall to the river is being undercut and is failing. This area could be improved with a new headwall that incorporates sturdier materials and bank protection. The area could incorporate an overlook and educational signage about the importance of water quality and protecting the river (Figure 4-3). Stabilizing the bank along this bend of the river is needed to protect access to the trail head parking (Figure 4-4). Stabilizing the bank will improve habitat and protect existing vegetation from eroding away (Figure 4-5).

Potential Benefits

- River Protection (Water Quality and Bank Stabilization)
- Habitat Enhancement and Connection to River
- Ease of Maintenance – Native revegetation and basins can be accessed from roadway for intermittent sediment cleaning
- Educational Opportunities

Figure 4-2. Plan View of Conceptual Improvements

Figure 4-3. Example of a headwall incorporating an over- look with educational signage. Created wetlands are below the outfall.

Figure 4-4. Example of river's edge improvements. Rock jetties were constructed to provide stabilization, creating wetlands which enhance habitat.

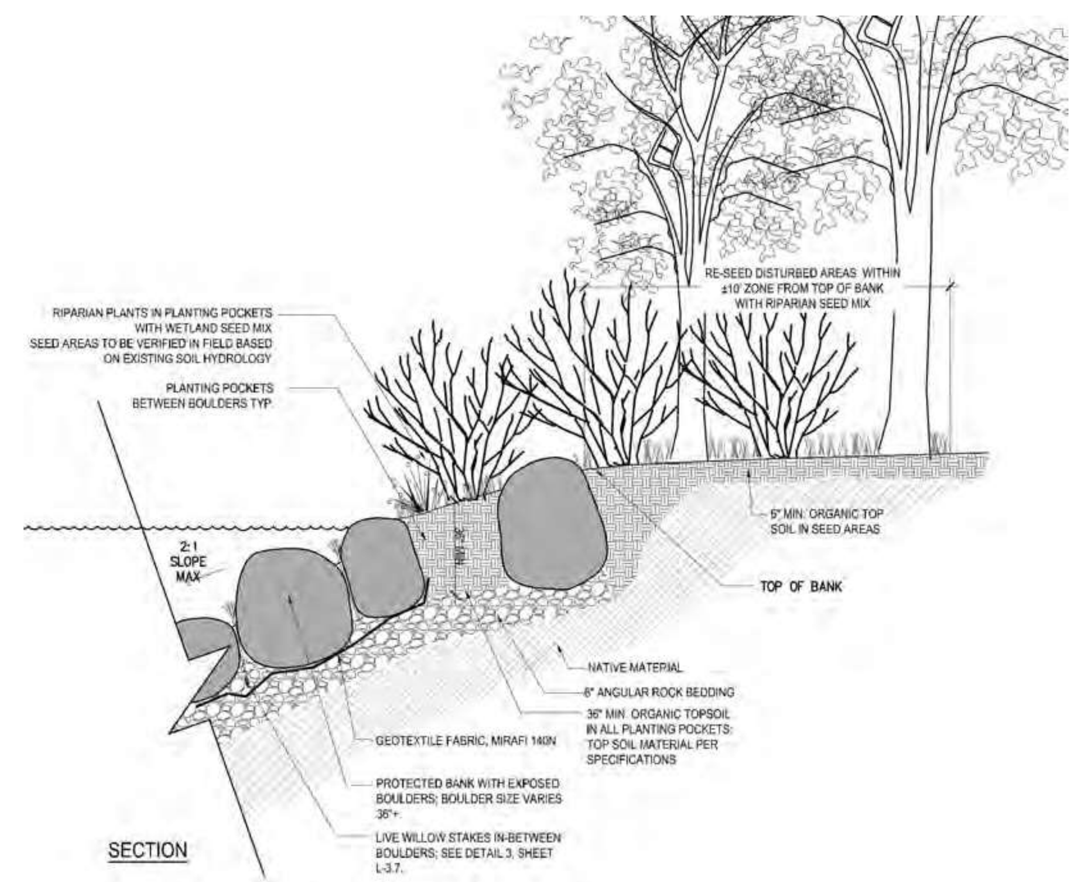


Figure 4-5. Typical Detail of Bank Stabilization

4.2.4 Water Quality- Cottonwood Creek Treatment

At Cottonwood Creek there is downcutting due to channelization of the creek which is causing the natural water table to be detached from the mature cottonwood trees. There are two potential improvements that could improve the health and long-term sustainability of the ecological features within the park's drainage. See Figure 4-6 for the plan. First, a series of natural boulder check structures could be added along profile of the channel (Figures 4-7, 4-8 and 4-9). This can help to raise the water table for the existing trees and flatten out the slope of the channel to decrease erosion/downcutting. The channel is directly adjacent to the road, so stabilizing the drainage is important to protect the Town's existing infrastructure. By allowing the stormwater to move through the Cottonwood Creek system slower in small events, infiltration and water quality will be increased.

The second improvement that could be incorporated is rerouting stormwater from Chipeta Dr. into Cottonwood Creek from the south. More water would be added to the natural system to improve health of the existing cottonwoods and riparian vegetation along the corridor. The rerouting of stormwater at two locations disburses the drainage and decreases erosional along the gravel roadway surface at Chipeta Dr.

Potential Benefits

- River Protection (Water Quality)
- Habitat Enhancement and Connection to River
- Ease of Maintenance – Native revegetation. Preventing future maintenance issues along Moffat St.
- Protecting existing Town resources (Cottonwood Park, mature cottonwood trees, protecting infrastructure)
- Educational Opportunity
- Reducing flows on Chipeta Dr.

Figure 4-6. Plan View of Conceptual Improvements

Figure 4-7. Smaller scale boulder drop structure incorporated with bank stabilization.

Figure 4-8. Boulder drop structure at Lilley Gulch, Jefferson County, provides channel stabilization, energy dissipation, habitat improvement and an easy way for park users to access the creek.

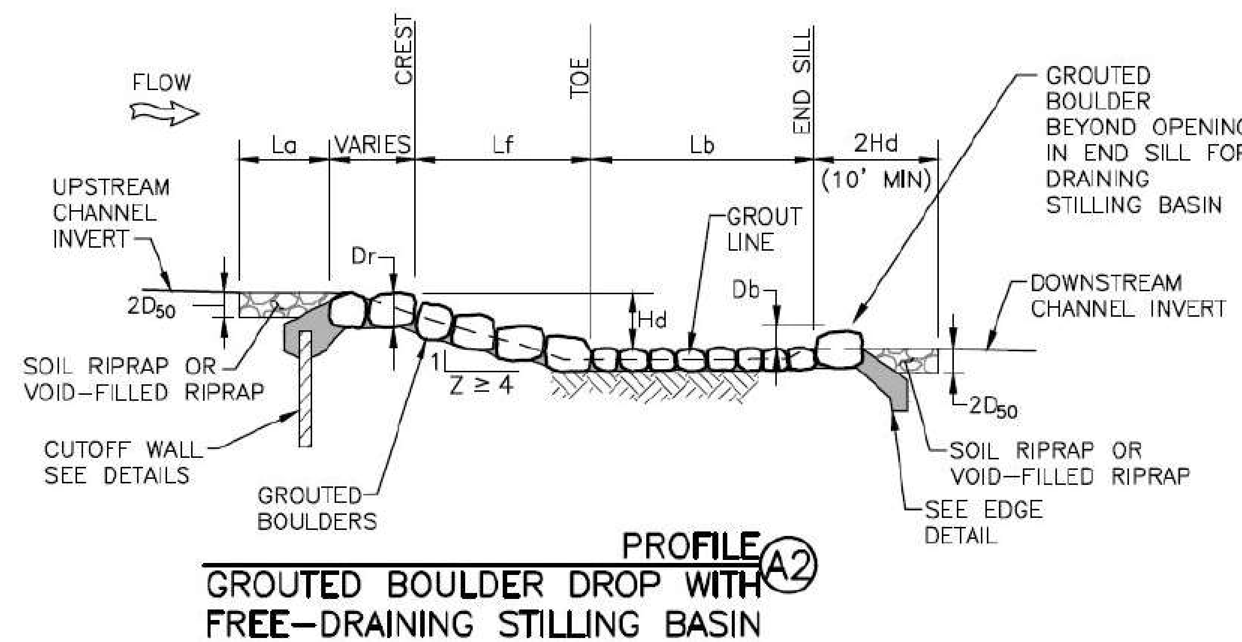


Figure 4-9. Boulder Drop Structure Detail

4.2.5 Water Quality – SH 62 BMPs

During the public process and discussions with the Town, SH 62 was identified as an important outfall to address. Water quality was removed from the CDOT SH 62 project due to several design and funding constraints. As presented in Section 3 – Alternatives Analysis, a review of various Best Management Practices (BMPs) was conducted and some that were suitable for improving water quality by retrofitting existing inlets along Sherman Street were provided. After discussions with the Town, it is recommended that the Town moves forward exploring BMPs that are inlet specific and do not require buying or renting a vac truck. The original matrix presented in Section 3 – Alternatives Analysis, contains eight total BMPs. Five BMPs were eliminated from the list and the below three are remaining for the final master plan.

Table 4-1. SH 62 BMP Matrix

BMP	Config.	Targeted Pollutants	Max Treatment	Maint. Req.	Easy to Retrofit	$$
Frog Creek's Gutter Bins	Grate, curb or drop inlet with filter	Trash, sediment, hydrocarbons, metals	NA	Replace/ clean filters	Yes	Low $700-$4300/unit
Sun tree's Curb Inlet Basket	Shallow catch basin	Trash, sediment	NA	Clean filters	Okay	Low
Inlet Grate Filters	Filter insert in inlet or new catch basin with filter	Trash, sediment, hydrocarbons, metals	5.5 cfs	Replace/ clean filters	Yes	Low Approx. $500 for insert, $5000 for catch basin

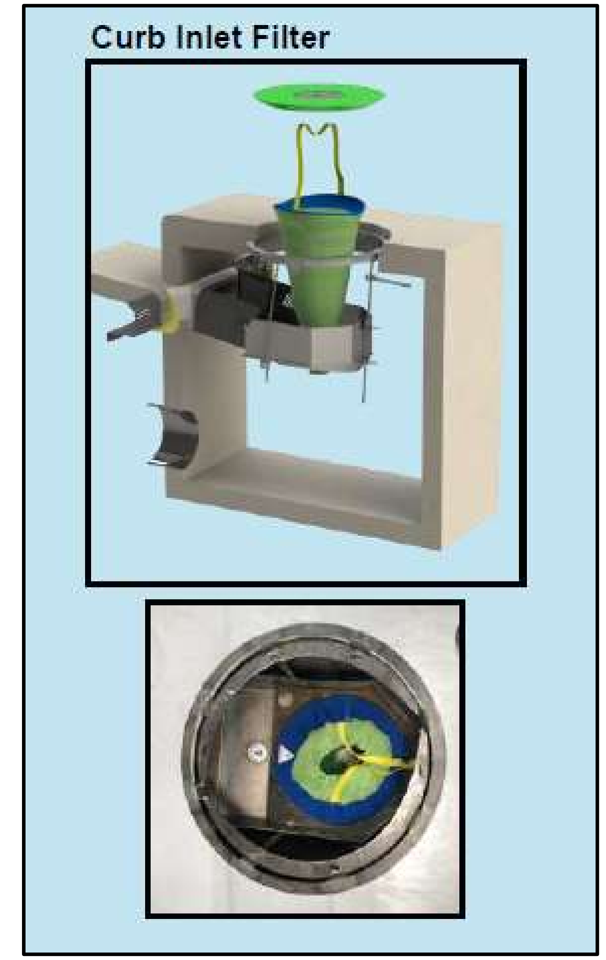


Figure 4-10. Example SH 62 Inlet BMP (Frog Creek's Gutter Bin)

Click Here to View Final Master Plan Map (Figure K-1)

All three of the above BMPs are intended to be placed at existing inlets along SH 62. It is recommended that the Town conduct a pilot study for three inlets along SH 62 and determine if the BMPs are working as intended, can handle the contributing sediment load, and are easy to maintain. Fact Sheets for each of the above BMPs are located in Appendix J. Figure 4-10 is an example of one potential inlet BMP – Frog Creek's Gutter Bin.

Potential Benefits

- River Protection (Water Quality)
- Ease of Maintenance – Does not require special equipment or vac trucks.
- Educational Opportunity

4.2.6 Water Quality- Library

The existing isolated landscape zone between the library building and Railroad Street is an easily implemented water quality improvement area (Figure 4-11). The area would be ideal to create a shallow water quality basin that accepts water from the upstream inlet at Charles St. The inlet at Charles St. captures a substantial amount of water from the paved area in the HTC area, making the location ideally suited for water quality improvement. An outfall control structure could be installed to capture the smaller storms while allowing the larger flows to pass through the system more quickly (Figures 4-12 and 4-13).

Potential Benefits:

- River Protection (Water Quality) Habitat Enhancement
- Ease of Maintenance – Native revegetation, easily accessed from roadway.
- Educational Opportunity at new library patio

Figure 4-11. Plan of Proposed Improvements

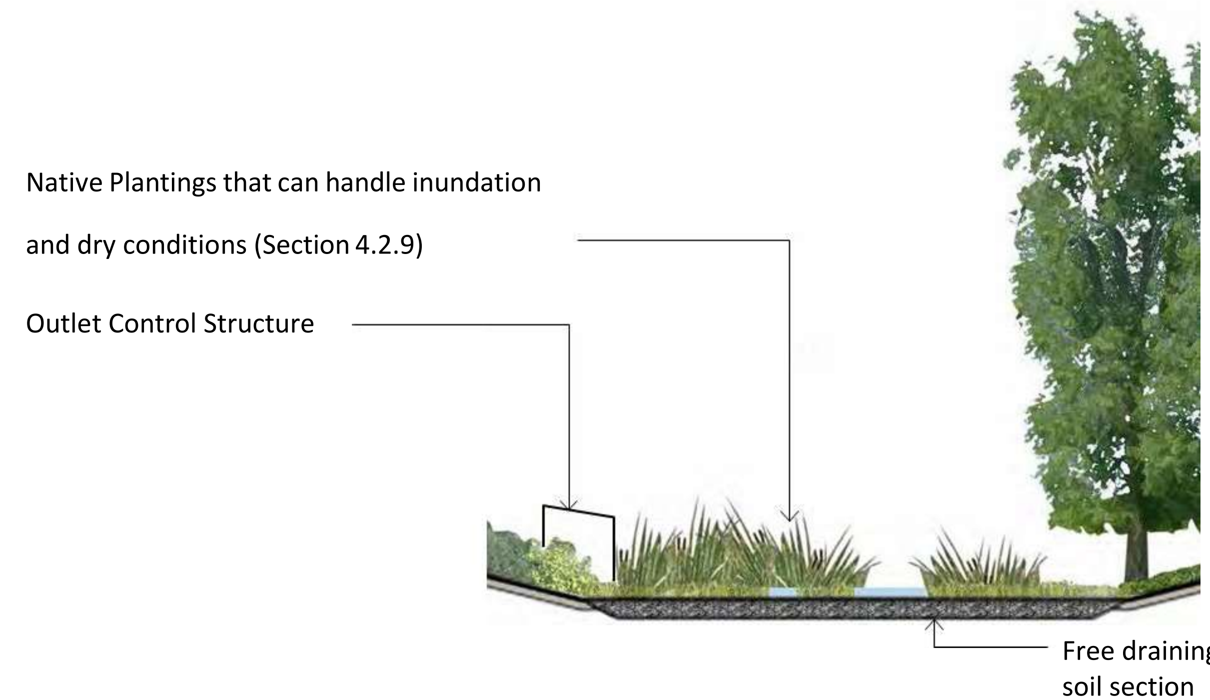


Figure 4-12. Typical Water Quality Basin Section

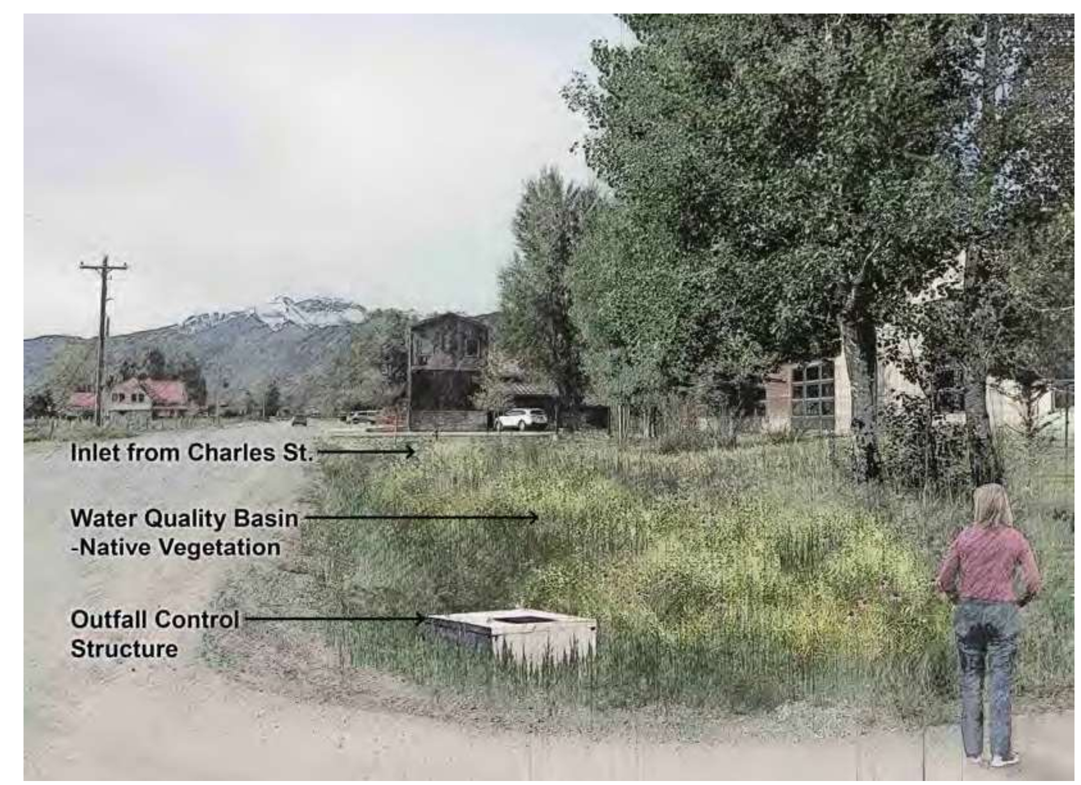


Figure 4-13. Water Quality Basin Rendering looking south

4.2.7 Water Quality- Ridgway Athletic Park

The Ridgway Athletic Park accommodates an existing drainage from Sabeta Dr. to CR 23. Some drainage is also intercepted off of Chipeta Drive and sent into the park, outfalling south of the tennis courts (Figure 4-14). Currently the drainage channel that carries this water is a cobble swale bordered by turf that helps to stabilize the drainage. This area is a stormwater resource with a fairly consistent flow that could be improved by grading to lay back the slopes and restoring the channel with native riparian vegetation (Figures 4-15 and 4-16). Plants such as willows, cottonwoods, sedges and rushes could be incorporated; refer to section 4.2.9 for plant lists. Once established, the area would need minimal maintenance. This planting would improve habitat and diversity in an important area where the drainage is closely connected to the river. The native plants would provide additional filtration and water quality as compared to the existing cobble alone. This improvement is low priority but should be considered in future phases of Ridgway Athletic Complex improvements because it is very visible and a good educational opportunity.

Potential Benefits

- River Protection (Water Quality)
- Habitat Enhancement
- Ease of Maintenance – Native revegetation, easily accessed from roadway, on Town property.
- Educational Opportunity
- Recreational Trail

Figure 4-14. Plan of Proposed Improvements

Figure 4-15. Low flow channel with native vegetation. The existing drainage in Ridgway Athletic Complex could be enhanced with native vegetation and a soft surface trail. This adds an element of interest in the park while also creating a pedestrian connection from west to east.

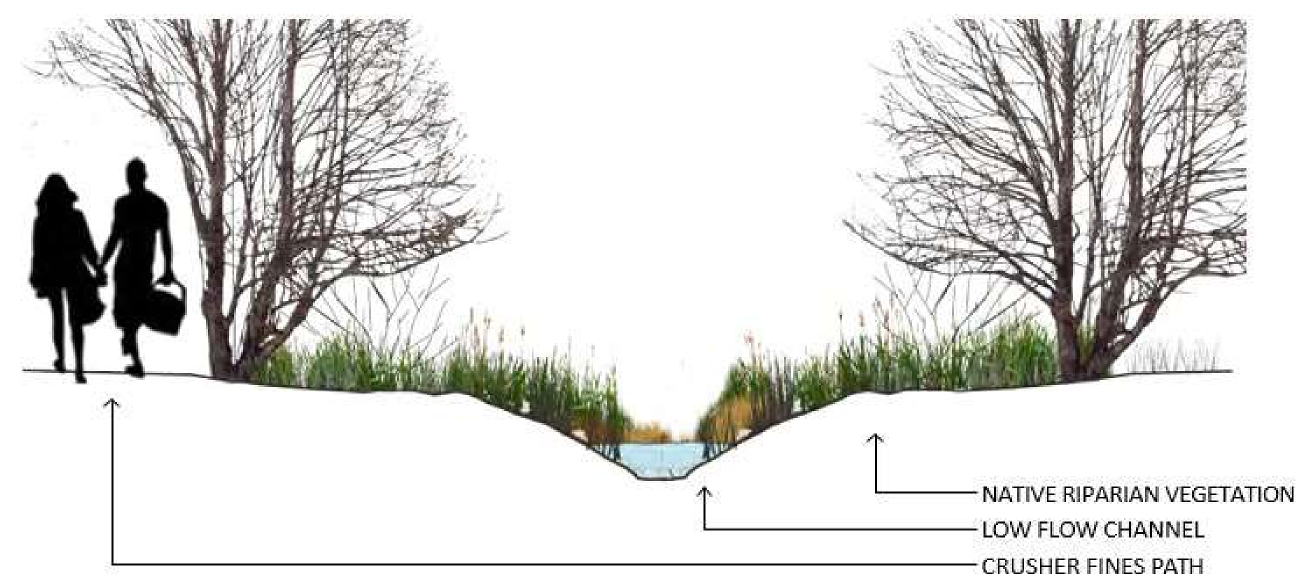


Figure 4-16. Cross Section of swale with soft surface trail

4.2.8 Water Quality- Suggested Vegetation

Vegetation for water quality areas should be able to withstand Colorado's dry conditions but also be able to be inundated for periods of the time during storm events. Plant material listed here is native to the Ridgway area.

Figure 4-17. Wetland Herbaceous Plants

Figure 4-18. Wetland Restoration Plantings

Seed Mixes

Refer to Table 4-2 below for typical seed mixes for the Town.

Table 4-2. Seed Mixes for Ridgway.

	WETLAND SEED MIX	
MIX %	*Botanic Name*	*Common Name*
30%	"Sodar" Elymus lanceolatus	Sodar' Streambank Wheatgrass
30%	"Peru Creek" Deschampsia caes.	" Peru Creek" Tufted Hairgrass
10%	Juncus arcticus	Arctic Rush
5%	Calamagrosstis canadensis	Bluejoint Reedgrass
25%	Poa palustris	Fowl Bluegrass
	RIPARIAN SEED MIX	
% Mix	*Botanic Name*	*Common Name*
10%	Juncus articus	Arctic Rush
10%	Calamagrostis canadensis	Bluejoint Reedgrass
10%	Poa secunda	Cany Bluegrass
10%	Glyceria striata	Fowl Mannagrass
20%	Elymus trachycaulus	Slender Wheatgrass
20%	Deschampsia Caespitosa	Tufted Hairgrass
20%	Pascopyrum smithii	Westem Wheatgrass

Plant Lists

Woody Plants - All of the woody plants below are valuable for aesthetics, wildlife habitat and forage, and erosion control for proposed wetland creation or riparian restoration projects. Woody plants are planted in hydrologic zone 4, which is 12" above water level and higher. This zone is also referred to as the wetland edge or transition zone, where soil is dry except for during large storm or flood events.

Alnus tenuifolia - Thin Leaf Alder, medium statured tree Betula occidentalis - River Birch, medium statured tree Cornus sericea - Red Osier Dogwood, large shrub

Crategeus erythopoda - Red Haw Hawthorne, small statured tree Lonicera involucrata - Twinberry Honeysuckle, large shrub

Populus angustifolia - Narrowleaf Cottonwood, large statured tree* Salix bebbiana - Bebb's Willow, large shrub*

Salix drummondiana - Drummond's Willow, large shrub*

Salix lasiandra - Whiplash Willow, large shrub/small statured tree* Salix geyeriana - Geyer's Willow, large shrub/small statured tree*

Salix monticola - Rocky Mountain Willow, large shrub/small statured tree* Shepherdia argentea - Silver Buffaloberry, large shrub/small statured tree

*Plants that can be planted as live stakes.

Herbaceous Plants - The specific design of each wetland creation or riparian restoration project and the number of different hydrologic zones will need to be taken into consideration when creating a final herbaceous plant list for a proposed project. Below are suggested native herbaceous plants that can withstand different levels of soil saturation and standing water. All of these plants provide for wildlife habitat, erosion control at the water's edge and aesthetics through the creation of a planted bank condition.

<u>Zone 1 - 4" Below Water Level</u>

Carex aquatalis - Water Sedge

Carex nebrascensis - Nebraska Sedge Carex utriculata - Beaked Sedge

<u>Zone 2 - 0"-4" Above Water Level</u>

Carex microptera - Small Wing Sedge Juncus arcticus - Artic Rush

Juncus confuses - Colorado Rush Juncus ensifolius - Sword Leaf Sedge

<u>Zone 3 - 4"-12" Above Water Level</u>

Calamagrostis canadensis - Blue Joint Reed Grass Glyceria striara - Manna Grass

Festuca thurberii - Thuber's Fescue

4.3 FINAL MASTER PLAN COSTS

Table 4-3 below presents the final estimated costs for the proposed master plan. The costs were estimated using unit prices from the Mile-High Flood District (MHFD) and the Colorado Department of Transportation (CDOT). A multiplier of 1.5 was applied to the raw capital costs for the increased cost of supplies and construction in the Town of Ridgway as compared to the Front Range. The multiplier was determined by comparing CDOT construction costs for southwestern Colorado to those for the Front Range.

Additional costs were added to estimate assuming the following breakdown of the Total Capital Cost:

- Capital: 45% - includes the costs of materials and construction. All pipe costs are based on RCP. Final costs may vary depending on material.
- Engineering: 15% - includes preparation of construction plans, specifications, and all associated administrative services from notice-to proceed to bidding assistance.
- Legal/Admin: 5% - covers the costs of legal fees for land acquisition, general contracting administration, and other support services.
- Contract Admin/CM: 10% - includes all professional services required for construction observation, review of shop drawings and technical submittals, request for information, preparation of pay estimates, etc.
- Contingency: 25% - meant to cover the additional items and unknowns.

Table 4-3. Estimated Summary of Costs for the 25-year Storm Event

Alternative	Report Section	25-Year Storm Event					
		Capital	Engineering	Legal/Administrative	Contract Admin/CM	Contingency	Total Capital Cost
[1]Road Crossings	4.2.1	$ 760,050	$ 253,350	$ 84,450	$ 168,900	$ 422,250	$ 1,689,000
[1]Pipes and Ditches	4.2.2	$ 1,872,000	$ 624,000	$ 208,000	$ 416,000	$ 1,040,000	$ 4,160,000
[2]Solar Ranches	4.2.3	$ 110,250	$ 36,750	$ 12,250	$ 24,500	$ 61,250	$ 245,000
Post Office	4.2.3	$ 10,000	$ 3,333	$ 1,111	$ 2,222	$ 5,556	$ 22,000
Campbell Lane Pipes	4.2.3	$ 37,350	$ 12,450	$ 4,150	$ 8,300	$ 20,750	$ 83,000
[3]Hyde Street Pipes	4.2.3	$ 186,300	$ 62,100	$ 20,700	$ 41,400	$ 103,500	$ 414,000
Ridgway Athletic Field Pipes	4.2.3	$ 160,200	$ 53,400	$ 17,800	$ 35,600	$ 89,000	$ 356,000
N. Railroad St.	4.2.4	$ 64,425	$ 21,475	$ 7,158	$ 14,317	$ 35,792	$ 143,000
Cottonwood Creek Treatment	4.2.5	$ 295,000	$ 98,333	$ 32,778	$ 65,556	$ 163,889	$ 656,000
[4]SH 62 BMPs	4.2.6	$ 15,000	$ 5,000	$ 1,667	$ 3,333	$ 8,333	$ 33,000
Library Parking	4.2.7	$ 9,320	$ 3,107	$ 1,036	$ 2,071	$ 5,178	$ 21,000
Ridgway Athletic Park Water Quality	4.2.8	$ 126,135	$ 42,045	$ 14,015	$ 28,030	$ 70,075	$ 280,000
TOTAL		$ 3,646,030	$ 1,215,343	$ 405,114	$ 810,229	$ 2,025,572	$ 8,102,000

[1] Pipe costs are based on use of RCP
[2] Solar Ranches cost is the sum of (18" Cottonwood Creek Diversion Pipes)+(Sabeta Concrete Pan)+(Chipeta Inlet)
[3] Hyde Street Pipes is the sum of (18" Pipe at Amelia) + (18" Pipe at Elizabeth) + (18" Pipe from Mary to Elizabeth) + (18" Culvert at Laura) + (24" Culvert at Cora)
[4] SH 62 BMP costs are average of potential options; assumed applied to 3 total inlets

Detailed quantities and costs breakdowns are provided in Appendix L.

4.4 PRIORITIZATION

The stormwater infrastructure recommended in this Master Plan consist of stormwater quantity (conveyance) and quality improvements. Table 4-4 below provides a ranking matrix of stormwater infrastructure, severity, and need. Regardless of the final order or implementation of the projects identified within this report, it is recommended that construction and completion of at least one project be done within the first few years creation of a stormwater fee for the Town residents. This will provide a visible, tangible example of how the funds are being used to benefit the Town.

Table 4-4. Town of Ridgway Stormwater Priority Matrix

Problem #	Problem	Solution	Description	Severity # (higher more severe)	Priority (lower #, higher priority)	Cost
1	Flooding/Capacity	Stormwater Pipes and Ditches	Updates to the storm sewer system should be done as funding becomes available and in association with upcoming development. Individual locations may vary in severity and priority	3	2	$ 4,160,000
2	Flooding/Capacity	Culverts at Road Crossings	Updates to culverts at road crossings should be done as funding becomes available and in association with road work.	5	1	$ 1,689,000
3	Drainage	Post Office Improvements	The Post Office receives high volumes of traffic from the Town residents and therefore should be addressed as soon as possible.	3	3	$ 22,000
4	Erosion/Capacity	Hyde Street Pipes	The proposed pipes along Amelia St. and Elizabeth St. can be constructed independently of other projects downgradient and should be implemented when possible.	3	2	$ 414,000
5	Drainage	Other general drainage projects (i.e. Campbell Pipes, Solar Ranches)	Should be addressed as they can be incorporated into other Town projects or as needed.	2	4	$ 328,000
6	Water Quality	SH 62 BMPs	SH 62 receives a large drainage area from the south and west part of Town. Implementing a pilot program to study the impacts of inlet BMPs on the outfall water quality could provide a large benefit for a relatively small cost.	1	4	$ 33,000
7	Water Quality	Cottonwood Creek Treatment	The health of the existing trees is at an immediate risk along the creek. Diverting additional water into the creek via Chipeta Drive is a relatively inexpensive project. The proposed grade control structures could be moved lower into the priority list.	3	2	$ 656,000
8	Water Quality	North Railroad Street	Receives the largest drainage area of any outfall in Town. Improvements would address a large quantity of water coming from both North Town and the Historic Town Core.	2	2	$ 118,000
9	Erosion/Water Quality	North Railroad Street Outlet	Repair to river bank at the outfall will prevent further erosion and protect the headwall.	4	1	$ 25,000
10	Water Quality	Library Parking	The Library is a very public location that can be used for educational purposes to the general public.	2	4	$ 21,000
11	Water Quality	Ridgway Athletic Field Channel	Is a potentially easy improvement that will improve water quality within the park.	1	5	$ 280,000
12	Drainage	Ridgway Athletic Field Ditch	Installing a series of pipes along the western edge of the Athletic Field will help reduce flooding.	3	3	$ 356,000

5 FUNDING SOURCES

The following sub-sections present potential funding sources for construction of stormwater infrastructure in Town.

5.1 GRANT OPPORTUNITIES

The Town can apply for a variety of grants to help fund their stormwater infrastructure projects. The majority of the grants herein pertain to water quality and riparian health, both of which are portions of the proposed stormwater projects. It is suggested that, if allowed, some of the funds also be used for quantity infrastructure as well because such projects protect the environment and downstream areas from flooding and scour. As a local government, the Town should be eligible for the following grants:

- **Fisheries and Riparian Restoration Program** from the *BLM-CO Water Resources* - The current funding expired August 16, 2019, but it may be renewed in 2020; it is therefore suggested that this grant be researched next year for its availability. The stormwater projects meet much of the criteria, such as improving “water quality, aquatic habitat… restoration… and downstream uses.” According to the grant, “Eligible projects under this Funding Opportunity Announcement (FOA) may include, but are not limited to: - Improving stream channel structure and complexity… Improving channel/floodplain connectivity; - Protecting and stabilizing stream and river banks; - Reducing erosion; - Installing and/or constructing of culverts and/or diversion structures; - Improving hydraulic and geomorphic conditions in streams.”
- **Water Plan Grant** from the *Colorado Water Conservation Board* - Stormwater infrastructure projects should fall within the Environmental & Recreational Projects category as they “promote watershed health, environmental health, and recreation.”
- **Colorado Watershed Restoration Grant** from the *Colorado Water Conservation Board* - The projects meet the focus of the grant as the “grant money may be used for planning and engineering studies, including implementation measures, to address technical needs for watershed restoration and flood mitigation projects throughout the state. Special consideration is reserved for planning and project efforts that integrate multi-objectives in restoration and flood mitigation.”
- **World Trout Grants Program** from *Patagonia* - The grant program funds work that “restores native river, coastal, and saltwater habitats,” the firsts of which is recommended in this project.
- **Water & Waste Disposal Loan & Grant Program** from the *USDA* - The grant should be applicable to these projects because they will promote “healthy watersheds.”
- **Healthy Watersheds Consortium Grant Program** from the *USEPA* - The grant is to be used to “protect healthy, aquatic ecosystems and their watersheds.” These projects will “achieve large-scale, measurable outcomes” and “develop and/or implement large-scale green infrastructure projects.”
- **Colorado Department of Local Affairs (DOLA) –** Administers multiple grants opportunities for various types of projects.

5.2 STORMWATER FEE

Enacting a stormwater utility fee on parcels within the Town boundary is another method of securing funding for selected projects or operations and maintenance costs. Unlike grant funding, collecting a stormwater fee would be predictable and consistent, providing a reliable source of capital for the future. The stormwater fee could be implemented in two mechanisms: existing residential, commercial and industrial use fees and new development fees. Residential, commercial and industrial fees would be implemented as a monthly utility fee for each private parcel in Town. New development fees could consist of a fee per acre of new development or based on new impervious area. The Town policy should strike a balance between equitably funding the stormwater enterprise through both new development and existing residents.

The EPA has outlined several methods for calculating residential stormwater utility fees. Two of the most popular methods include the following:

- Equivalent Residential Unit (ERU): Also known as the Equivalent Service Unit (ESU) method, the ERU method bills an amount proportional to the impervious area on a parcel regardless of the parcel’s total area.
- Intensity of Development (ID): Bills a percentage of impervious area relative to an entire parcel’s size. All parcels, including vacant/undeveloped parcels, are charged a fee.

For the purposes of this study, the ID method was used to calculate preliminary rates for a residential stormwater utility fee in the Town. The following assumptions were made with the ID calculations:

- The weighted fee assumes 30% weight on parcel area and 70% weight on percent impervious.
- The impervious percentage for each parcel was estimated using the future land use for the Town of Ridgway. Refer to Section 1.3.2 – Watershed Imperviousness for a discussion of future land use.
- The average parcel size in Town was assumed to be 15,000 sf. Actual rates would be parcel-by-parcel and would be dependent upon the parcel’s impervious area.
- The total master planned cost presented in Section 4.3 – Final Master Planned Costs was used to establish the fee. The 25-year design storm was used as the basis for the final master planned costs.

Using this method, the total cost incurred on the average 15,000 square foot residential parcel to fund the stormwater improvements outlined in this report is $3,483. The costs per square foot for pervious and impervious area are $0.07 and $0.45, respectively. The stormwater fee is largely dependent upon the timeframe upon which the Town intends to construct and implement the proposed infrastructure outlined in this master plan. Table 5-1 shows the average monthly costs assuming the master plan is fully implemented across different timelines:

Table 5-1. Monthly Stormwater Utility Fee for Average Parcel

Implementation Schedule	Monthly Fee
10 Year	$ 29.03
15 Year	$ 19.35
20 Year	$ 14.51
30 Year	$ 9.68
40 Year	$ 7.26
50 Year	$ 5.81

It should be noted that the above fees do not include additional annual Operations and Maintenance (O&M) costs for the proposed infrastructure outlined in this master plan. Additional O&M costs for the Town are estimated to be approximately $40,000 per year and would need to be funded through either increased utility fees or other mechanisms.

Stormwater utility fees for communities in Colorado vary drastically depending on location and need. Some small communities have no additional fees for stormwater funding (e.g. Town of Steamboat Springs) while others have a robust stormwater enterprise with fees as high as $20 per month (e.g. City of Boulder). The utility fee which the Town would need to implement is largely dependent upon the schedule for upcoming development, existing rates for other utilities, ability to obtain grant funding, and other Town-specific factors. A table of monthly fees by community can be found in Appendix M – Funding Sources.

The second source of utility fee funding is through new development stormwater fees. New development fees are paid on a per Acre of development basis. Town policy for establishing the stormwater enterprise should assume a balanced split between new development and current residents. A sliding scale of existing user fees and new development fees is shown in Figure 5-1. Additional background data is included in Appendix M – Funding Sources.

It should be noted that the scope of this study was to prepare a preliminary review of potential funding sources for a stormwater enterprise. Setting up a stormwater enterprise can be a large and complex task. If desired the Town can perform detailed Fee Assessment Study under a separate scope or as needed in the future. However, although the fee assessment prepared in support of the rates shown in Figure 5-1 is a preliminary calculation, it is a good starting point for the Town to begin to make funding decisions and to be utilized until such time that the Town feels an update is necessary.

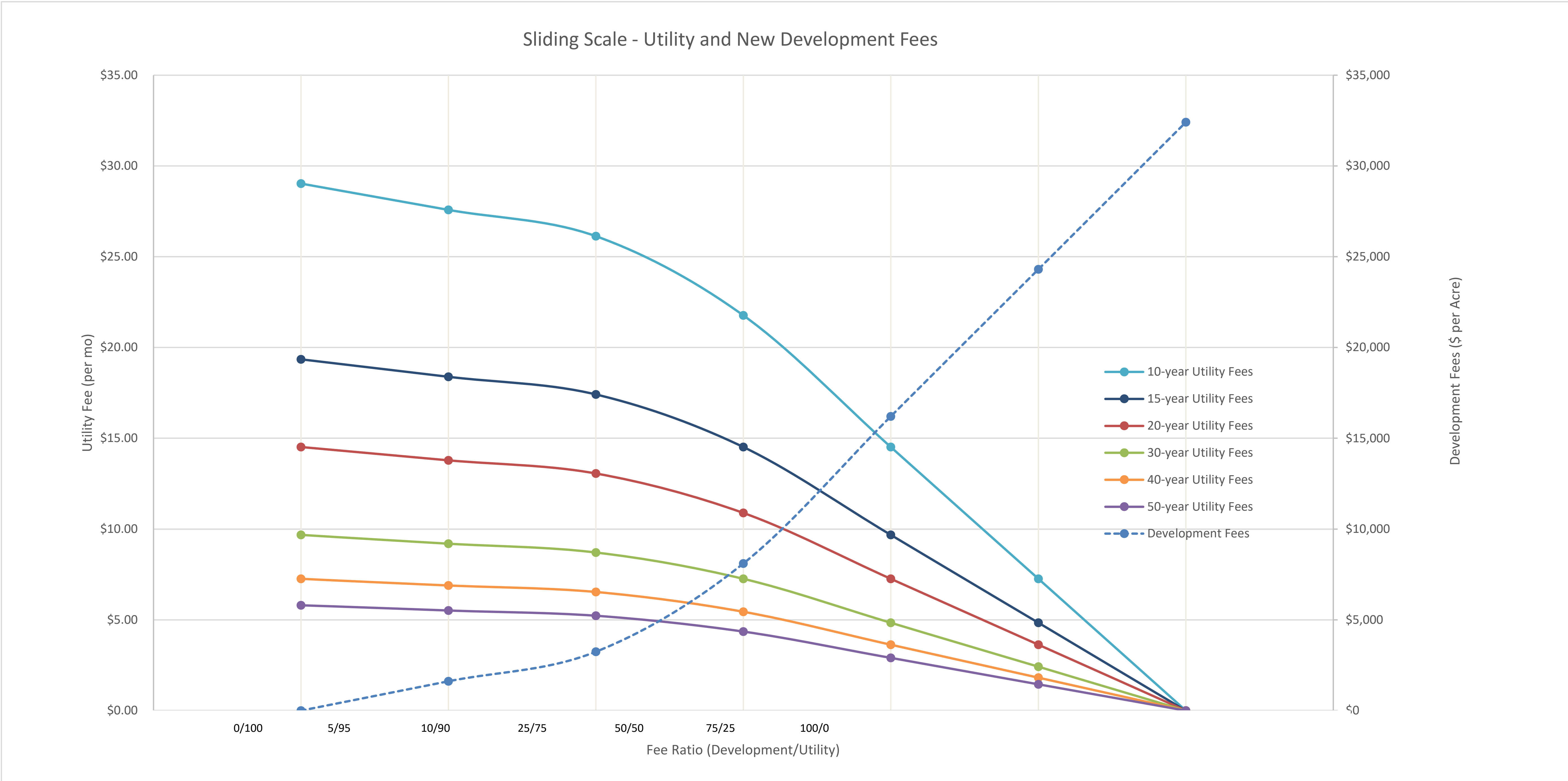


Figure 5-1. Potential Stormwater Fees

6 MASTER PLAN CONCLUSION

The report herein addresses the stormwater goals and priorities of the Town of Ridgway as outlined in the Section I – Introduction. In order to minimize the impacts of flooding and to improve water quality, this master plan lays out strategies for drainage, conveyance, and water quality improvements within the Town. The recommendations improve the conveyance efficiency, address general drainage issues, prevent erosion, and reduce the discharge of sediment and other potential pollutants into the Uncompahgre River. The master plan provides conceptual level cost estimates for implementing the improvements recommended in this report. It also provides a preliminary review of possible funding sources for the Town to implement the recommended improvements. This master plan report serves as tool for efficient and proactive stormwater planning for the use of Town funds and resources into the future.

RESPEC and DHM Design would like to acknowledge the invaluable help and support in preparation of this report that was furnished by the Town of Ridgway staff, residents, and business owners.

7 REFERENCES

Atlas 14, Volume 8 – Midwestern States - Point Precipitation-Frequency Estimates [Internet Download], National Oceanic and Atmospheric Administration, June 2019.

ArcMap [Software Program], ESRI, v10.6.1.

Cottonwood Creek Flood Analysis – Gary Dick Property, Del-Mont Consultants, Inc., March 10, 2014.

Drainage Report – AlpenGlow CoHousing, SGM, May 2019.

Funding Stormwater Programs, Environmental Protection Agency – Region 1, April 2009.

Hydraulic Design Report – SH 62 FOR Submittal, RESPEC, July 2015.

Lena Street Commons – Civil Construction Plans, Del-Mont Consultants, Inc., 2017.

National Engineering Handbook – Part 630 - Chapter 4: Storm Rainfall Depth and Distribution, United States Department of Agriculture – Natural Resources Conservation Service, September 2015.

National Land Cover Database (NLCD) Impervious Surface (30 meter, 2011) [Internet Download], United States Geological Survey, June 2019.

National Map – Digital Elevation Model [Internet Download], United States Geological Survey, June 2019.

Parkside Subdivision – As Built Plan Set, November 14, 2007.

PCSWMM [Software Program], Computational Hydraulics International, 2018.

Ridgway Business District Hydraulic Report (FOR), Russell Planning and Engineering, July 8, 2015.

Stormwater Utility Fees – Considerations and Options for Interlocal Stormwater Working Group (ISWG), New England Environmental Finance Center, May 2005.

SWMM [Software Program], Environmental Protection Agency, v5.1.

Town-wide Master Plan - Draft Land Use Map, July 11, 2019.

Town of Ridgway Zoning Map, May 2018.

UD-MP COST User's Guide – V1.1, Mile High Flood District, December 2010.