APPENDIX C – EXCERPTS FROM OTHER REPORTS

Drainage Master Plan

Town of Mead, Colorado

July 1998

THE
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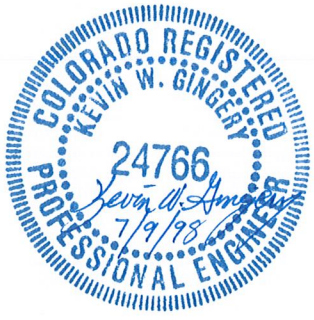
Drainage Master Plan

Town of Mead, Colorado

July 1998



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Note: Due to its size, the Technical Appendix, which contains all computations, is contained in a separate document.

DRAINAGE MASTER PLAN
TOWN OF MEAD, COLORADO

I. INTRODUCTION

This report examines existing and future fully developed drainage conditions in and around the Town of Mead, Colorado. The Drainage Master Plan is intended to be used as a planning tool by the town and developers as the town and the surrounding area become developed. Proposed system improvements, guidelines for future development, cost-estimates and time lines have been investigated and are discussed in the report.

The study area is presently rural in character and largely undeveloped. Over the last few years, several sub-divisions have been constructed in and around the town. Many future developments are currently proposed. In response to the growth, this report will present the Town of Mead a drainage master plan which will ensure that drainage issues are properly addressed during development. In addition, proposed improvements to the existing drainage systems are presented to provide better drainage conditions for the current town residents.

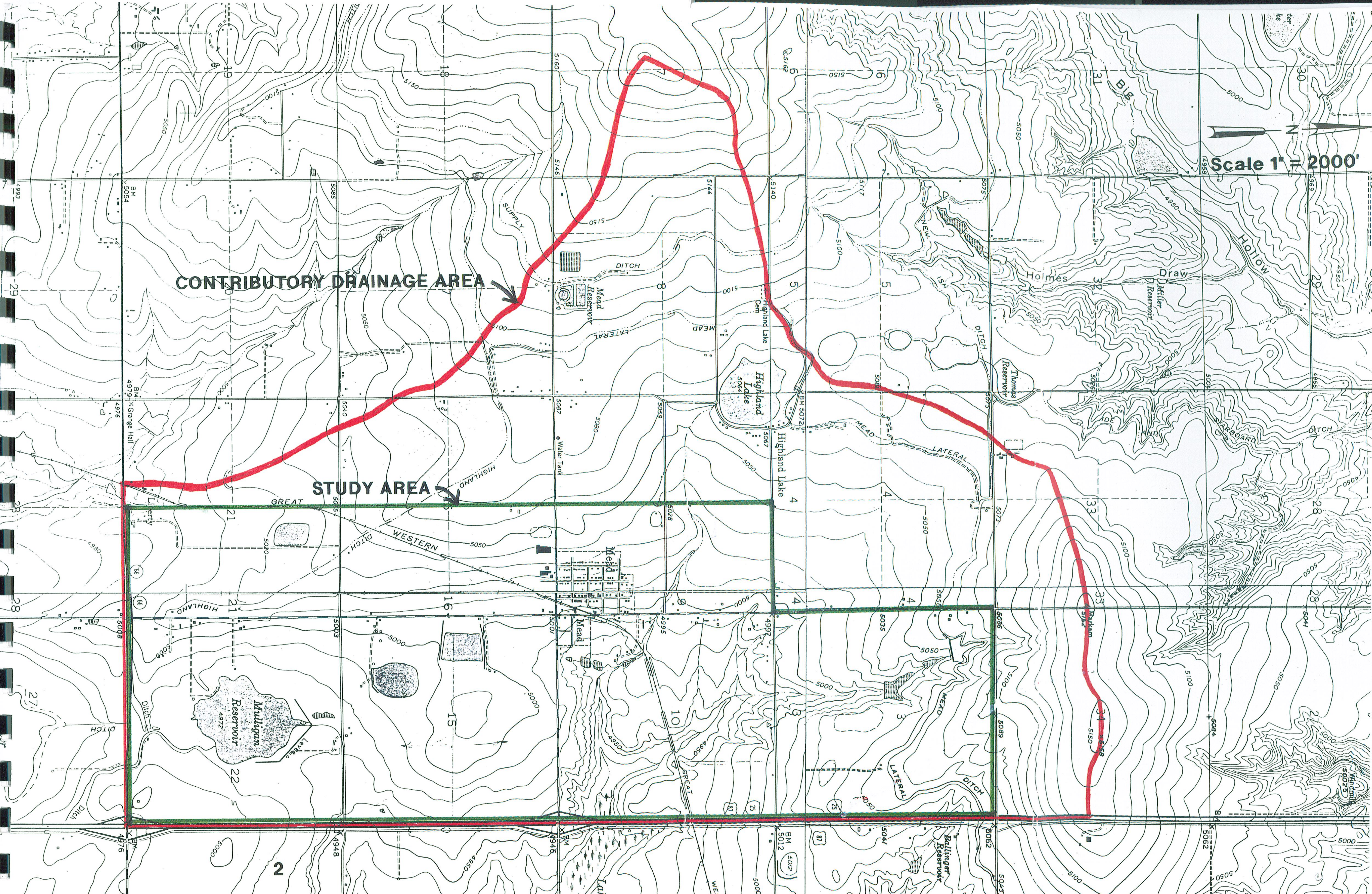
II. EVALUATION OF EXISTING STORM DRAINAGE SYSTEM

The location of the study area incorporates much of the area immediately surrounding the Town of Mead proper. The study area boundaries were chosen to incorporate newly developed residential areas as well as many of the proposed subdivisions. The study area is bounded by Interstate 25 on the east, Highway 66 on the south, Weld County Road 38 on the north, and generally ½ mile west of Weld County Road 7 on the west. The study area incorporates 5½ square miles and is shown in Figure 1 on the following page.

A. Data Collection and Interpretation

Data for the analyses were collected from several sources. The main mapping source was the Town of Mead 1"=200' ortho-photo maps, which were created in the Spring of 1997, and were available within the study area boundaries . Electronic versions of the photography was used as a base map for the attached exhibits. USGS 7.5' quadrangle maps were used for upstream basin delineations in areas not contained within the study area. Because the 2' contours on the ortho-photo maps are not accurate enough for some specific hydrologic and hydraulic analyses, approximately 4 days of ground surveying was completed, during which major culverts, minor channels and downtown street cross-sections were surveyed.

Drainage characteristics of soils were obtained from the SCS soil survey maps (SCS, 1980). This data was transferred onto the USGS maps. The Town of Mead Storm Drainage Criteria and Construction Standards manual was used as a base for a majority of drainage methodologies and graphs. This manual generally follows concepts suggested by the Urban Drainage and Flood Control District (UDFCD), which has developed region-wide drainage standards for use specifically in the Denver Metro area. Where information was not


CONTRIBUTORY DRAINAGE AREA
STUDY AREA
N
Scale 1" = 2000'
2

available in the Town's Storm Drainage Criteria Manual, the UDFCD Urban Storm Drainage Criteria Manual was used (UDFCD, 1991). These practices have been adopted by most municipalities along the Colorado Front Range.

Basin Delineation

To better facilitate discussions of the existing and proposed drainage systems, the study area has been divided into four primary basins: the Foster Reservoir Basin, the Mulligan Lake Basin, the North Creek Basin and the North I-25 Basin, as shown in Figure 1.

The Foster Reservoir Basin includes all of the lands at the southern end of the study area which flow south under Highway 66. The basins are bounded by Interstate 25 and Highland Canal on the east, Highway 66 on the south, Highland Canal on the North and a ridge line on the west. Water crosses Highway 66 at two locations east of County Road 7 and one location west of County Road 7. The Foster Reservoir Basin flows to Foster and Sanborn Reservoirs approximately one-half mile south of the highway.

The Mulligan Lake Basin includes all of the lands surrounding Mulligan Lake and Mulligan Reservoir. Much of the basin is presently developed with 3-5 acre homesites. The basin is bounded by I-25 on the East, a ridge separating basins on the north and south, and Highland Ditch on the west. The basin outlets under Interstate 25 at the County Road 32 overpass. The southern portion of the basin flows into an existing ditch (outlet of Mulligan Reservoir) along the south side of County Road 32 which flows east and crosses under Interstate 25. The northern portion of the basin flows into a small wetland area near County Road 32, which outlets under Interstate 25. The Mulligan Lake Basin eventually flows into Lake Thomas approximately one mile east of the Interstate.

The North Creek Basin incorporates the central portion of the study area. The southern edge of the North Creek Basin is approximately one-half mile south of CR34 at the northern edge of the Mulligan Lake subdivision. The northern and western boundary extends along the ridge line separating the Little Thompson River Basin (off-site). The eastern boundary is the North I-25 Basin and I-25 itself. The North Creek Basin flows under Interstate 25 north of the CR 34 interchange. The North Creek Basin includes the downtown area, which includes the area within Mead proper, and is generally bounded by Welker on the south, 7th Street on the north, the town sewage lagoons on the east, and the edge of town on the north. Drainage west of CR7 primarily drains into North Creek immediately north of downtown along CR7. Drainage east of CR7 primarily drains into North Creek immediately east of the town sewage lagoons. Many of the streets in town are unpaved without formal drainage channels. Several buildings in town, including the Town Hall, have experienced flooding in recent storms. The North Creek Basin flows into Lake Thomas approximately one mile east of Interstate 25.

The North I-25 Basin includes all of the lands north of the North Creek Basin within and tributary to the study area. The area is generally bounded by the ridge line the north, Interstate 25 on the east, and the divide between the North Creek Basin on the west and south. The North I-25 Basin flows under Interstate 25 in two separate culverts. The northern

culvert crossing of Interstate 25 flows into Ballinger Reservoir. The southern culvert crossing of Interstate 25 flows into Lake Marie and Lake Thomas.

Major Drainage Features

North Creek is the only perennial stream within the study area. The stream originates at Highland Lake and flows east in an undefined channel towards the North Creek subdivision. As the creek enters the North Creek subdivision, a channel becomes well defined and continues to flow east. It passes under Interstate 25 approximately ¼-mile north of the County Road 34 interchange. North Creek contains several small tributaries. Base flows in North Creek are relatively small, originating primarily from irrigation return flows.

The remainder of runoff in the study area occurs as overland flow, with some drainage entering formalized man-made drainage channels. Recently completed sub-divisions all have drainage facilities within their boundaries. Agricultural areas generally are drained by farm ditches, which may change dimensions and locations from year to year.

There are two main irrigation canals within the study area. The Highland Ditch flows from northwest to southeast through the southwestern corner of the study area. A portion of the flows in the Highland Ditch eventually flow into Mulligan Reservoir. The canal does not appear to have formalized inlet structures to receive agricultural return flows, but the ditch is incised in many places, and collects surface and sub-surface flows.

The Mead Lateral (Farmers Extension Ditch) flows from west to east through the far northern portion of the study area. The Mead Lateral currently is a concrete lined irrigation ditch, with inlet structures to receive agricultural surface return flows. Only 160 acres of the study area lie above the canal.

The Great Western Railroad tracks run from the eastern portion of the study area towards the southwestern portion of the study area. The tracks form borders of many of the sub-basins, as they tend to direct sheet flow runoff towards culverts under the tracks.

B. Hydrologic Analysis of Existing System Methodology

Minor basins were delineated both within the study area and in the tributary area. A total of 42 sub-basins were delineated, with 32 sub-basins within the study area and 10 sub-basins outside the study area. Sub-basins were generally numbered from south to north, with the 100-series sub-basins either entirely or partially within the study area, and the 200-series sub-basins outside the study area. Sub-basins were not numbered consecutively to allow further sub-division of sub-basins as areas develop, especially outside the study area.

Hydrologic calculations were conducted for existing drainage paths to provide baseline flows. As development continues in the Mead area, more of the land surface will become impervious. The degree of imperviousness indicates how well water can seep through the soil and into groundwater. Impervious land uses include: asphalt and concrete roadways, parking lots, building roofs and other hard surfaces. More pervious land uses include:

agriculture, lawns and pastures. Impervious land uses result in increase surface flows and higher peak discharges.

The Colorado Urban Hydrograph Procedure was used to develop 10-year and 100-year rainfall/runoff relationships for each of the sub-basins in accordance with the Town of Mead Storm Drainage Criteria and Construction Standards. The Town's Storm Drainage Criteria was also used to develop storm hyetographs and to determine inputs for runoff routing calculations. Soil types were taken from the Soil Survey of Weld County, Colorado (SCS, 1980).

The Environmental Protection Agency Storm Water Management Model version PC.1 (MODSWMM) was used to model surface runoff for the existing and improved drainage system. MODSWMM takes runoff hydrographs from each sub-basins and routes them through a system of channels, pipelines and detention areas.

Flow depths in the existing irrigation main canals and laterals continually vary. During storm events, upstream off-site runoff will fill most irrigation canals and laterals. In the hydrologic model routing, it was assumed for the existing system evaluation that storm water runoff may sheet flow directly over the irrigation canals and laterals as if they were full. This is a conservative approach, and it is realized that during an actual storm event some storm water runoff may enter the ditches. In addition, Colorado law dictates that storm water runoff shall not be diverted from one basin to another (cross basin diversion). Cross basin diversion of storm water runoff causes downstream erosion, sedimentation and mitigation impacts. Therefore, any storm water runoff originating in one basin must remain in that same basin, and irrigation canals and laterals shall not convey drainage problems to a different basin.

Using the SWMM computer model, flows were computed for the major conveyance elements at 5 minute time intervals. The resulting peak flows computed for each element in both the 10-year and 100-year storm event are presented in the SWMM output in Technical Appendix A.

C. Hydraulic Analysis of Existing System Methodologies

Hydraulic analyses were performed on several natural and man-made channels within the study area to determine if the channels have adequate capacity to convey expected storm flows. For North Creek and its tributaries, a HEC-2 analysis was performed. For smaller man-made channels, normal depth calculations were performed. Storage-discharge relationships were developed for the major culverts in the area using a combination of methods.

HEC-2 Floodplain Analysis

Hydraulic analysis of the 100-year floodplain for North Creek was conducted using the BOSS HEC-2 for AutoCAD software package. HEC-2 is a computer program developed by

the Army Corps of Engineers for computing water surface profiles for one-dimensional, cross-section averaged, open channel flow. The BOSS version of HEC-2 allows analysis to be conducted using graphical topographic information, such as the Town of Mead ortho-photo contour maps.

The purpose of this HEC-2 analysis is to determine water surface elevations during a 100-year flood event. The 100-year floodplain analysis was conducted on the North Creek main stem, the north branch of North Creek, and two tributaries which flow into the north branch. Once the extent of the North Creek floodplain is known, the Town can use this information to guide future development adjacent to the inundated areas.

The Town of Mead computerized digital version of the aerial photography was used in the HEC-2 analysis in conjunction with surveyed field information. Manning's 'n' roughness values were taken from standard tables for natural channels and floodplains (Chow, 1988).

Normal Depth Calculations

Normal depth calculations were used to determine flow depths on reaches of man-made channels and roads where normal depth conditions exist. Normal depth occurs when flow is uniform, which occurs when a channel is straight and without change in slope or cross section along the length of channel, and when there are no backwater effects of culverts, bridges or other flow restrictions. This was assumed to occur on many residential streets in downtown, in road borrow ditches, in irrigation laterals, and in certain drainage channels.

Normal depth was calculated using Manning's equation, which is a function of channel roughness, slope and cross-section. Standard Manning's 'n' values for roughness were selected for use in the calculations. Surveyed data was used to generate cross-sectional data. Channel slopes were determined from the aerial photo contour maps. The FlowMaster software package was used to perform normal depth calculations.

Culvert Analysis

To properly develop basin runoff using the SWMM model, storage-discharge relationships were developed for all culverts in and affecting the study area. As a culvert reaches its maximum discharge capacity, water begins to be stored upstream of the culvert in a detained area (or temporary pond). When the level of water reaches the top of the roadway or other overflow section, water begins to flow through the overflow section. The relationship between the quantity of water being stored, to the discharging from the system through the culvert and over the road, is called a storage-discharge relationship.

To develop the storage-discharge relationship, a head-discharge relationship is required for the culvert and overflow section, and a stage-area-volume relationship is required for the detained area. Each relationship is generated using different methodology. The head-discharge relationship is developed using the Federal Highway Administration's (FHWA) HY8 software program. This program utilizes standard FHWA procedures for calculating

flows through culverts. The stage-area-volume relationships were calculated by determining areas for each stage from the aerial photo contour maps, and using the equation:

$$V=(d/3)*(A_a+A_b+\sqrt{A_aA_b})$$

where: A = Area of incremental contours
d = depth between contours

Once the individual relationships are determined, a storage discharge curve can be constructed by relating stage/depth values to equate storage and discharge.

D. Determination of Facilities Subject to Flood Damage Methodology

Two methods were employed to determine which structures and facilities may be subject to flood damage. The primary and more accurate method incorporates the use of the HEC-2 model. Any structure which is affected by the floodplain produced by the HEC-2 analysis has been indicated with an 'X' on Figure 3. In some portions of the HEC-2 model, especially at road overtoppings and where flows begin to be entangled within the housing developments, the assumptions of steady and gradually varied flow are violated, and a more concise 2-dimensional model could be used to accurately develop flow paths and water surface elevations. Two-dimensional modeling is outside the scope of this drainage master plan.

In the downtown area, normal depth methods and contour maps were used to develop flow inundation areas. Normal flow depths were calculated for each east-west street at several different locations. Using these flow depths, an approximate water surface elevation is estimated and an approximate floodplain designated. Once the floodplain was plotted on the ortho-photo maps, structures within the inundation areas were marked with an 'X' on the exhibits. All flow depths are less than one foot. As with the previous method, inaccuracies are inherent, and a 2-dimensional model could be used to more accurately develop flow paths and water surface elevations.

E. Analysis Results of Existing Drainage System

Using flows determined in the CUHP/SWMM analysis along with the flow characteristics of culverts, channels, streets, and other conveyance elements, an evaluation of the existing storm drainage system was conducted. From the analysis, it was determined where problems exist with existing drainage facilities which are undersized, where flood waters may cause damaging effects on roads and structures, and where improvements should be made within the study area. The following is a summary of the findings for each sub-basin within the study area.

Foster Reservoir Basin

The Foster Reservoir Basin contains sub-basins 100 and 102 within the study area, and sub-basin 200 and 202 outside the study area. Flow from sub-basins 200 and 202 is tributary to

sub-basin 100, and generally occurs as overland flow through irrigated and non-irrigated farmland. The Highland Ditch flows along the northeast boundaries of the basin. Sub-basin 102 has no off-site tributary area. The Foster Reservoir Basin outlets under Highway 66, where it flows south to Foster Reservoir and the St. Vrain Creek. Historic flows from each sub-basin, as well as combined flows at critical locations are presented in Table 1.

Table 1 Foster Reservoir Basin - Existing Discharges

Sub-basin /Node	Description	Existing Discharge (cfs)	
		10-year	100-year
100	Sub-basin 100	126	433
102	Sub-basin 102	18	64
200	Sub-basin 200	70	269
500	Culvert under Highway 66	11	29
505	Culvert overtopping of Highway 66	38	379

Sub-basin 100

Sub-basin 100 is comprised mostly of agricultural lands and associated buildings. Highway 66 is the existing collection point for runoff from sub-basin 100 and its tributary area. Currently, there is a 24" reinforced concrete pipe (RCP) under Highway 66 which conveys runoff under the road. The existing culvert overflows during both the 10-year and 100-year storm events, with overflow depths across Highway 66 of less than one foot. Overtopping of Highway 66 does not impact existing buildings within the basin, but may impact traffic flow on the highway.

Sub-basin 102

Sub-basin 102 is a long narrow strip along Highway 66 south of Mulligan Reservoir. The basin contains agricultural land and associated buildings. A 28"x18" horizontal elliptical corrugated metal pipe (HECMP) and a 24" RCP convey runoff under Highway 66. These culverts are adequately sized to convey the 100-year storm event runoff without road overtopping.

Mulligan Lake Basin

The Mulligan Lake Basin consists of sub-basins 101, 103, 104, 105, 106, 110, 111 and 119. There is no tributary runoff from outside the study area. The basin outlets under I-25 and flows east to Lake Thomas and the St. Vrain Creek. Historic flows from each sub-basin, as well as combined flows at critical locations are presented in Table 2.

Table 2 Mulligan Lake Basin - Existing Discharges

Sub-basin /Node	Description	Existing Discharge (cfs)	
		10-year	100-year
101	Sub-basin 101	16	55
103	Sub-basin 103	414	943
104	Sub-basin 104	39	110
105	Sub-basin 105	48	173
106	Sub-basin 106	29	102
110	Sub-basin 110	112	301
111	Sub-basin 111	69	245
119	Sub-basin 119	47	168
550	Detention area north of CR32, west of I-25. *	63	199

* County Road 32 overtopping occurs at 80 cfs.

Sub-basin 101

Sub-basin 101 is composed primarily of the Hunters Ridge development, which contains 2-5 acre home tracts. A small southern portion of the sub-basin is currently undeveloped agricultural land. A low point at County Road 7 and County Road 32 is the collection point for storm water runoff. The two 20" CMP culverts under CR7 are inadequate to convey 100-year discharges, at which time, County Road 7 is overtopped. Existing culverts and roadside ditches in the development were designed to transport the 100 year storm event runoff to the sub-basin low point. The roadside ditch along CR7 is currently not well defined, and has not received adequate maintenance to carry storm flows.

Sub-basin 103

Sub-basin 103 is the area surrounding the southern portion of Mulligan Reservoir, including the reservoir. The area is primarily agricultural lands and associated buildings. Mulligan Reservoir is the collection point for stormwater runoff from the sub-basin. The existing reservoir is adequate to receive a 100-year storm event, although no formal agreement is in place with the owners of the Reservoir for detention of storm water runoff. The reservoir outlets into a ditch which flows north and east along the south side of County Road 32. Consistent with modeling in other portions of the study area, the MODSWMM model

assumes that the reservoir is completely full during a 100-year storm event, and all runoff spills out of the reservoir.

Sub-basin 104

Sub-basin 104 is comprised of the Hunters Cove development, which contains 2-5 acre home tracts. An existing detention pond adjacent to Mulligan Reservoir within lots 2, 3 and 4 of the development is the collection point for stormwater runoff. The underdrains installed in the detention pond to drain detained storage are currently clogged and being rehabilitated by the developer of Hunters Cove.

The existing culverts and roadside ditches in the development were designed to transport the 100-year storm event runoff to the detention pond (McKissack, 1993). The existing roadside ditch along the south side of County Road 32 is currently not well defined. The existing culvert at County Road 32 and Hunters Cover Road is partially clogged, resulting in reduced flow capacity.

Sub-basin 105

Sub-basin 105 is currently comprised of agricultural lands and associated buildings. The sub-basin drains primarily to the intersection of Interstate 25 and County Road 32. At the intersection, stormwater overtops the Baugh Lateral ditch and flows east on County Road 32 under Interstate 25 via the underpass.

Sub-basin 106

Sub-basin 106 is currently comprised of agricultural lands and associated buildings. Stormwater drains to the east towards two culverts under County Road 7 immediately north of County Road 32. Storm water is then conveyed downstream in an undefined ditch along the north side of County Road 32. The two 20" CMP culverts under County Road 7 are undersized for the 100-year storm event. When stormwater runoff exceeds the existing culvert capacities, stormwater overtops County Road 7 and proceeds east along the north side of County Road 32, impacting the rears of residential lost within Mulligan Lakes Estates.

Sub-basin 110

Sub-basin 110 is comprised of the Mulligan Lake Estates development, which contains 2-5 acre homesites. Mulligan Lake is a stormwater collection point for the northern portion of this sub-basin. Mulligan Lake outlets into a ditch which flows south to the existing ditch along the north side of County Road 32. Existing culverts, roadside ditches and street overtoppings in the development were designed to transport the 100-year storm event runoff to either Mulligan Lake or the north roadside ditch along County Road 32 (Swift, 1992a; Swift, 1992b; Swift, 1993b; Wheeler, 1996). The sub-basin continues to flow east in the roadside ditch to a 30" RCP under Interstate 25. Flows which exceed the capacity of the I-25 culvert flow onto County Road 32 and then east under I-25 through the underpass. This system is in accordance with historic flow paths. This basin is minorly impacted by 100-year storm runoff from sub-basin 106. The existing culvert at Silo Court and Mulligan Lake Drive is currently partially plugged, which reduces the culvert capacity. The roadside ditch

along the north side of County Road 32 between County Road 7 and the Mulligan Lake outfall channel, which conveys water from sub-basin 106, is not well defined.

Sub-basin 111

Sub-basin 111 contains the Singletree Estates development, which is currently under construction. The development will contain 2-5 acre home tracts. The basin drains into the County Road 32 northerly roadside ditch, then east to the culvert and underpass under Interstate 25 in accordance with historic flow paths. The proposed culverts and roadside ditches in the development were designed to convey the 100-year storm event runoff to the County Road 32 roadside ditch (Swift, 1993a).

Sub-basin 119

Sub-basin 119 contains agricultural lands, which drains to an existing 24" RCP under Interstate 25 immediately south of County Road 34. This culvert is undersized for the 100-year storm event, at which time, storm water overtops Interstate 25 and proceeds east.

North Creek Basin

The North Creek Basin is the largest basin within the study area. The basin contains sub-basins 107, 108, 109, 112, 113, 114, 115, 116, 117, 118, 120, 122, 123, 124, 126, 128, 130, 132 and 133 within the study area, and sub-basins 204, 206, 210, 212, 214, 216, 218 and 220 outside the study area. All sub-basins discharge into North Creek which then flows through a 6' x 10' reinforced concrete box culvert (RCBC) under I-25. North Creek then flows east to Lake Thomas and the St. Vrain Creek. Historic flows from each sub-basin, as well as combined flows at critical locations are presented in Table 3.

The sub-basins outside the study area are all comprised of undeveloped agricultural land and associated farmsteads/buildings. Sub-basins 204, 206 and 210 are tributary to North Creek west of sub-basin 120. Sub-basin 214 is tributary to sub-basin 128 through a 42"x60" HECMP under CR7. This culvert is undersized to convey 100-year stormwater runoff. Runoff overflows the banks of the culvert inlet channel and travels south along the west side of County Road 7. This runoff is combined with sub-basin 212 runoff, which eventually overtops an 18" CMP under CR36, and flows into sub-basin 122. The 18" CMP is partially plugged and incapable of handling storm runoff. Sub-basin 216 is tributary to sub-basin 133 through two 20"x28" HECMPs under County Road 36. Sub-basin 218 is tributary to sub-basin 132 through an 18" CMP under County Road 36.

North Creek flows from west to east through the basin, with smaller tributaries entering the creek primarily from the north. During the 100-year storm event, flows in the main stem exceed 2,100 cfs, and flows in the main tributary from the north exceed 1,500 cfs. The Great Western Railroad tracks and Interstate 25 provide two major detention areas which pond and reduce downstream flows. Nearly all culverts under county roads are overtopped during the 100-year storm event, and many are overtopped during the 10-year storm event. The culvert for the main stem of North Creek under the Great Western Railroad tracks is severely undersized and causes storm water flows to overtop the railroad tracks.

Table 3 North Creek Basin - Existing Discharges

Sub-basin /Node	Description	Existing Discharge (cfs)	
		10-year	100-year
107	Sub-basin 107	37	104
108	Sub-basin 108	68	251
109	Sub-basin 109	22	49
112	Sub-basin 112	66	250
113	Sub-basin 113	38	77
114	Sub-basin 114	73	150
115	Sub-basin 115	93	203
116	Sub-basin 116	92	274
117	Sub-basin 117	30	103
118	Sub-basin 118	14	50
120	Sub-basin 120	56	166
122	Sub-basin 122	18	68
123	Sub-basin 123	57	147
124	Sub-basin 124	68	240
125	Sub-basin 125	27	94
126	Sub-basin 126	44	162
128	Sub-basin 128	53	153
130	Sub-basin 130	80	295
132	Sub-basin 132	85	252
133	Sub-basin 133	43	110
600	North Creek culvert under I-25	947	1,885
615	North Creek culvert under CR 7	487	1,540
915	North Creek upstream of I-25 culvert	1,010	2,991

Sub-basin 107

Sub-basin 107 is currently comprised of agricultural land and associated buildings. The basin drains generally northeast towards the intersection of County Road 7 and County Road 34. Storm flows overtop the roads and intersection during 10-year and 100-year events, and significantly impact sub-basin 115.

Sub-basin 108

Sub-basin 108 is comprised of agricultural land and associated farm buildings. The sub-basin drains towards the northeast. Runoff from the southern portion of the sub-basin is intercepted by the Great Western Railroad track embankment, which redirects flows along the west side of the tracks towards County Road 34. Runoff from the northern portion of the sub-basin sheet flows across the school property (sub-basin 113), then towards the intersection of County Road 34 and the railroad tracks in roadside ditches. Existing culverts under County Road 34 are plugged and incapable of conveying storm water flows. Therefore, stormwater runoff overtops County Road 34 and continues along the railroad tracks into sub-basin 114.

Sub-basin 109

Sub-basin 109 contains residential homes within the downtown portion of the Town (refer to Figure 3 for an enlargement of this sub-basin area). The sub-basin drains north via paved streets onto agricultural lands in sub-basin 112. During 100-year storm events, conveyance channels along the northern portion of the sub-basin are inadequate to convey water around the perimeter of the town, and contributes to runoff which inundates numerous properties and structures within sub-basin 114.

Sub-basin 112

Sub-basin 112 lies directly west of the downtown area and is currently comprised of agricultural land and associated farm structures (refer to Figure 3 for an enlargement of this sub-basin area). The main stem of North Creek enters sub-basin 112 from sub-basin 120, and flows across the extreme northeastern corner of sub-basin 112 towards the 60" CMP culvert under County Road 7. Sub-basin 112 drains east, with the southern portion of the sub-basin draining into the downtown portion of the Town, affecting sub-basins 109 and 114. All runoff eventually flows to the culvert under County Road 7. The culvert is undersized for the 100-year storm event and overtops the road. Overtopping produces shallow flooding affecting structures in sub-basins 115 and 117. No structures in sub-basin 112 are affected by the flooding or overtopping.

Sub-basin 113

Sub-basin 113 encompasses the schools and athletic facilities immediately south of the downtown area (refer to Figure 3 for an enlargement of this sub-basin area). During the 100-year storm event, the sub-basin drains across County Road 34 and into the downtown portion of Town, impacting sub-basin 114. Sub-basin 113 also receives sheet flow from sub-basin 108 during 100-year events. Runoff is carried through the sub-basin via drainage swales and culverts throughout the schoolyards.

Sub-basin 114

Sub-basin 114 contains residential homes and businesses within the downtown portion of the Town (refer to Figure 3 for an enlargement of this sub-basin area). Drainage is normally from west to east, then south to north, eventually flowing to the North Creek culvert under County Road 7 via roadside ditches. County Road 7 is overtopped during 100-year storm events, which impacts structures in sub-basin 115 and 117. Numerous properties and structures are inundated during the 100-year storm event from on-site and off-site stormwater runoff. There is a lack of on-site stormwater conveyance facilities, such as roadside ditches, culvert and storm sewers to convey runoff along drainage paths and away from structures.

Normal depth calculations were performed for each of the street sections to determine the extent of storm water flows during the 100-year storm event. Structures marked with an 'X' on Figure 3 indicate structures which may potentially be affected during the 100-year storm event. The following summarizes conditions in the downtown area:

- Because there is no defined channel on the north side of the Welker Street, residences on the north side of the street will experience shallow flooding. Hydraulic analysis shows that some properties will be inundated less than 0.1 feet deep.

- Storm water on Fairbairn street generally does not endanger structures during the 100-year storm event. Storm waters can generally be retained in street channels without reaching a depth to flood buildings.

- Sixth and seventh streets are paved with curb and gutter. Storm water from the southern portion of the streets is directed to Dillingham Street with valley pans which flow east. Because of this, Dillingham Street must convey more water than any other street in the downtown area. Hydrologic analysis shows that Dillingham must convey approximately 46 cfs during the 100-year storm event. Hydraulic analysis shows that the current street drainage system is unable to handle these flows, and will inundate adjacent properties approximately 0.2 feet deep.

- Although Martin Street is required to convey less storm water flow than Dillingham, grading on the shoulders is inadequate and directs flow towards property on the north side of the street. Hydraulic analysis shows that water may reach depths up to 0.5 feet deep along fence lines on the north side.

- Two hydraulic analyses were performed for Palmer Street. Under normal conditions, Palmer is only required to route storm water runoff from areas east of 6th Street. During these conditions, adjacent properties will be inundated to a depth of approximately 0.2 feet. But, recent history has shown that drainage ditches designed to carry runoff from 6th and 7th Streets is sometimes blocked off, and this flow must be carried by Palmer. During these conditions, adjacent properties will be inundated to a depth of 0.3 feet.

- Most runoff from sixth and seventh streets are directed north towards drainage ditches on the north side of Palmer Street. One ditch was originally constructed to carry the sub-division runoff, and the other ditch was pulled by the farmer to carry return flow from the adjacent field. The ditch constructed from the sub-division is inadequate to convey 100-year storm flows. This water must then be conveyed by the field ditches. Under non-design condition, such as blockage of the ditch, inadequate maintenance, or full ditch conditions due to irrigation, this ditch is inadequate to convey flows and water overflows onto Palmer.

- Storm water is conveyed to North Creek via the Great Western Railroad tracks and Third Street. No conveyance facilities are present along the railroad tracks, resulting in flooding of low areas, such as the grain elevators and town hall. Once storm water reaches the north side of town, drainage ditches are inadequate to convey flows to North Creek, and flooding occurs along County Road 7.

Erosion will occur along downtown streets during the 100-year flood event because of the high velocities in and along streets. Velocities range from 3.5 to 4.5 feet per second. Maximum permissible design velocities for fine gravel channels is 2.50 feet per second (Chow, 1988). Velocities greater than this can cause erosion. Past flood events in the town have shown that erosion occurs along these roads. No drainage ditches have been constructed along the downtown streets to direct storm water off of driving surfaces and into concentrated channels. In addition, the lack of culverts under north-south streets will cause erosion on these streets as water flows over the street crowns.

Sub-basin 115

Sub-basin 115 contains residential homes, industrial businesses, agricultural lands, and the Town's Wastewater Treatment Plant. Runoff from the sub-basin generally occurs as sheet flow, and drains into North Creek via sub-basin 117. The Great Western Railroad tracks run through the western portion of the sub-basin, directing runoff towards North Creek. Numerous properties and structures will be inundated during the 100-year storm event from on-site and off-site storm water runoff and because there is a lack of on-site stormwater conveyance facilities to adequately convey water to the major runoff channels. Normal depth calculations were performed for each of the street sections to determine the extent of flows during the 100-year storm event. Structures marked with and 'X' on Figure 3 indicate structures which may potentially be affected during this storm event

Sub-basin 116

Sub-basin 116 contains agricultural land and a small lake. Runoff drains north towards an 18" culvert under County Road 34. The culvert is undersized for 100-year storm events, and runoff overtops County Road 34 affecting sub-basin 117. Minor runoff conveyance is made via farm ditches and roadside ditches along County Road 7 and County Road 34.

Sub-basin 117

Sub-basin 117 is comprised of agricultural land, associated farm buildings and a few homesites. The sub-basin contains the main stem of North Creek, and subsequently, all runoff drains directly into North Creek. North Creek enters the sub-basin at the northwest corner at County Road 7. The road is overtopped during the 100-year storm event, affecting several structures in this area. The Great Western Railroad tracks intersect North Creek in the northwestern limb of the sub-basin. The tracks contain a 24" steel pipe to convey the flow of North Creek beneath the track. This culvert is too small to handle both the 10-year and 100-year storm events. Significant railroad overtopping occurs during both storm events.

In addition, a small in-line stockpond is located just downstream of the Great Western Railroad tracks. This pond is also overtopped during the 100-year storm event. However, neither of these overtopping situations affect residential homes or property. Overtopping of County Road 34 occurs at the southwestern portion of the sub-basin, affecting homesites in the area. These structures are marked on Figure 3. The HEC-2 model was used to develop the North Creek 100-year floodplain through the area. The floodplain affects only the structures previously mentioned during road overtopping of County Road 7.

Sub-basin 118

Sub-basin 118 is comprised of agricultural land. Runoff drains to the north to County Road 34. There is currently no culvert to convey runoff under the road. Therefore, the road is overtopped during both the 10-year and 100-year storm events, and impacts sub-basin 125.

Sub-basin 120

Sub-basin 120 contains the residential community of North Creek, miscellaneous buildings, as well as agricultural land. This basin is impacted by upstream off-site storm water runoff from North Creek which collects along the western boundary of the basin. This basin contains the existing main stem of North Creek that conveys off-site upstream storm water runoff through the basin. On Friday June 6, 1997, the North Creek development experienced a 25-year recurrence interval rain storm event which caused localized flooding. This rain storm event took place during the preparation of this Drainage Master Plan document.

The existing streets within the North Creek development were designed to transport 100 year storm water runoff directly to North Creek and directly onto private property lying east of the North Creek development. This occurs via a network of street center cross pans and culverts with inlets. In the event the inlets plug with debris, storm water will pond up over the inlets and may ultimately impact existing residential homes adjacent to the inlets. During the rain storm of June 6, 1997, the existing inlet on Meadow Lane plugged with debris and began to pond water in the street according to Mr. Mike Bean who was called to unplugged the inlet during that flooding event. Serena Drive collects storm water runoff and transports the runoff east directly onto private property owned by Mr. Walt Logsdon. Meadow Lane also collects storm water runoff in an existing inlet and 15" outlet pipe which discharge east directly onto private property owned by Mr. Walt Logsdon. According to Mr. Walt Logsdon, during the rain storm of June 6, 1997 his property experienced erosion caused by storm water

runoff from Serena Drive and from the storm sewer in Meadow Lane discharging directly onto his property.

At the southwest corner of the North Creek development at County Road 34 ½, an existing culvert is currently plugged and covered with earthen soil according to Mr. Mike Bean. In addition, the existing culvert used to drain via a swale along the westerly property line of the North Creek development, north to North Creek according to Mr. Mike Bean. The swale has since been filled in with earthen soil as a result of the North Creek development according to Mr. Mike Bean. Therefore storm water runoff collecting at this low point in County Road 34 ½ can no longer drain to North Creek as it historically did according to Mr. Mike Bean. During the rain storm of June 6, 1997, Mr. Mike Bean observed storm water runoff ponding on the south side of County Road 34 ½, at the subject location, and overflowing over the road centerline as water attempted to drain northerly.

Basin 120 outlets via North Creek across County Road 34 ½. When storm water runoff exceeds the existing culvert capacities under County Road 34 ½, storm water then over tops the road and travels into Basin 112. Storm water runoff from the subject basin impacts basin 112 at County Road 34 ½ and County Road 7.

The HEC-2 computer model (one dimensional hydraulic model), used to evaluate the 100 year existing condition floodplain of North Creek, is based on the Saint-Venant equations for one- dimensional, cross-section averaged, open channel flow with the following limitations:

1. The equations are valid in a main channel only.
2. The equations are not valid for a floodplain that contains trees, fences, and houses. In this case a two dimensional hydraulic model is required to analyze the water surface elevations.

A two dimensional hydraulic model is outside the scope of the Town of Mead Drainage Master Plan project due to its extreme expense. Therefore the floodplain delineation shown along the western portion of the North Creek development is "approximate only" and is shown within this document only as a planning tool for "future condition" proposed improvements. The nine houses marked with an "X" on Figure 3 are so noted because they could possibly be inundated with storm water runoff during a 100 year "existing condition" storm event, but confirmation of this can only be accomplished with a two dimensional hydraulic model. During the rain storm of June 6, 1997, one of the nine houses, marked with an "X", was flooded and damaged.

Sub-basin 122

Sub-basin 122 lies directly north of sub-basin 120. The sub-basin contains agricultural land and associated farm buildings. The sub-basin drains northeast to a culvert in a swale under County Road 7. This culvert also receives overflow from sub-basin 214, and all runoff from sub-basin 212. The culvert is undersized to adequately convey the 100-year storm event

runoff, and subsequently County Road 7 is overtopped, which impacts flows in sub-basin 124.

Sub-basin 123

Sub-basin 123 contains the Feather Ridge Estates residential development, as well as undeveloped farmland to the south. Runoff drains primarily to the east into the north branch of North Creek. The existing streets and storm sewer/inlet system was designed to collect and transport the 100-year storm event runoff into the on-site detention pond (MCS, 1995a; MCS, 1995b). The detention pond releases at the 100-year historic rate into the north branch of North Creek in accordance with historic flow paths. The undeveloped portion generally drains along the railroad tracks, and enters the north branch just upstream of the culvert under the Great Western railroad tracks.

Sub-basin 124

Sub-basin 124 contains agricultural land and associated farm buildings. The north branch of North Creek flows from west to southeast through the sub-basin. In addition, two smaller tributaries drain to the north branch of North Creek, entering from the north. Subsequently, all drainage flows directly into the north branch. The sub-basin is impacted by flows from upstream off-site runoff from sub-basins 122, 128 and 130. The existing 9'x6' RCBC culvert under the Great Western railroad tracks is adequate in size to prevent overtopping of the railroad tracks. In addition, the culvert serves as an outlet to a large detention area created by the railroad tracks, which reduces flows in the north branch downstream of the railroad tracks. Storage in the detention area during the 100-year existing condition storm event is approximately 74 acre-feet, encompassing a surface area of approximately 14.3 acres. The HEC-2 model was used to develop the north branch of North Creek floodplain through the area. The floodplain does not affect any structures in the sub-basin.

Sub-basin 125

Sub-basin 125 is currently comprised of undeveloped agricultural land. The land drains north directly into North Creek. The sub-basin is affected by road overtopping flows from sub-basin 118.

Sub-basin 126

Sub-basin 126 contains agricultural land and associated farm buildings. The sub-basin encompasses the confluence of the north branch of North Creek and the main stem of North Creek. The main stem flows from west to east towards a dual 6'x10' reinforced concrete box culverts (RCBC) under Interstate 25. The north branch flows into the main stem just upstream of the culvert. The culvert is adequately sized to convey 100-year storm events without overtopping of I-25. In addition, the culvert provides detention storage for North Creek. Storage upstream of the I-25 culvert during the 100-year existing condition storm event is 102 acre-feet. All runoff drains directly into either the main stem or north branch of North Creek. The HEC-2 model was used to develop the north branch of North Creek floodplain through the area as well as the main stem of North Creek. The floodplain does not affect any structures in the sub-basin.

Sub-basin 128

Sub-basin 128 contains agricultural land, associated farm buildings, and large lot home tracts within a portion of the Lake Hollow Estates development. Stormwater runoff drains east in a small swale to a 24" CMP under County Road 36. The culvert is undersized to convey the 100-year storm event runoff, and consequently, County Road 36 is overtopped. This flow is tributary to the north branch of North Creek in sub-basin 124. The HEC-2 model was used to develop the north branch of North Creek floodplain through the area. The floodplain does not affect any structures in the sub-basin. The drainage system within Lake Hollow Estates was designed with existing roadside ditches and a 24-inch culvert to transport the 100-year storm event runoff west to County Road 7 (Carroll, 1994).

Sub-basin 130

Sub-basin 130 contains agricultural land and associated farm buildings. Runoff drains southwest to a 24" CMP under County Road 36. The sub-basin also contains a swale tributary to the north branch of North Creek which conveys off-site upstream stormwater runoff through the sub-basin. The HEC-2 model was used to develop the north branch of North Creek floodplain through the area. The floodplain does not affect any structures in the sub-basin. The culvert under County Road 36 is undersized to convey the 100-year storm event runoff, and consequently, is overtopped.

Sub-basin 132

Sub-basin 132 contains portions of the Highland Estates and Lake Hollow Estates developments, which contain large lot home tracts. The existing culverts, roadside ditches and street overtoppings were designed to convey the 100-year storm event runoff to the drainage system, which consists of the large drainage channel through the central portion of the sub-basin and two ponds (Carroll, 1994). Any overtopping of the Mead Lateral ditch within sub-basin 133 and this basin would continue downstream into the existing drainage system. The drainage system conveys off-site upstream storm water runoff through the sub-basin and impacts sub-basin 130 downstream. The HEC-2 model was used to develop the north branch of North Creek floodplain through the area. The floodplain does not affect any structures in the sub-basin.

Sub-basin 133

Sub-basin 133 contains large lot residential tracts in a portion of the Highland Estates development. Runoff drains generally south towards an existing culvert and swale within the central portion of the sub-basin. The existing culvert and roadside ditches in the Highland Estates development were designed to convey the 100-year storm event through the basin and into the downstream conveyance system. Any overtopping of the Mead Lateral ditch within this sub-basin would continue downstream into an existing lake south of the ditch. The HEC-2 model was used to develop the north branch of North Creek floodplain through the area. The floodplain does not affect any structures in the sub-basin. On-site and off-site storm water from this area impact sub-basin 132.

North I-25 Basin

The North I-25 Basin contains sub-basins 127 and 134 within the study area, and sub-basin 220 outside the study area. Flow from sub-basin 220 is tributary to sub-basin 134, and generally occurs as overland flow through irrigated and non-irrigated farmland. Runoff enters sub-basin 134 through a 48" CMP under County Road 38. This culvert is inadequate to convey 100-year stormwater, and consequently overtops. The Mead Lateral ditch flows from southwest to northeast through the Basin. The basin outlets under Interstate 25, where it flows east through several small ponds and the St. Vrain Creek. Historic flows from each sub-basin, as well as combined flows at critical locations are presented in Table 4.

Table 4 North I-25 Basin - Existing Discharges

Sub-basin /Node	Description	Existing Discharge (cfs)	
		10-year	100-year
127	Sub-basin 127	26	101
134	Sub-basin 134	54	185
220	Sub-basin 220 *	108	371
580	Culvert under I-25	54	296

* Flows presented are basin runoff before the effects of detention at the County Road 38 culvert.

Sub-basin 127

Sub-basin 127 is comprised of agricultural land. Runoff drains south to a 4'x8' RCBC under Interstate 25. Culverts under the Great Western Railroad tracks are inadequate to convey 100-year stormwater flow, and consequently, the railroad tracks are overtopped. The culvert under Interstate 25 is adequate to convey 100-year storm flows without overtopping.

Sub-basin 134

Sub-basin 134 contains agricultural land. Runoff generally drains southeast towards a 60" RCP under Interstate 25. The Mead Lateral ditch flows from southwest to northeast through the sub-basin. Facilities are present to allow irrigation return flows to enter the ditch and be conveyed out of the sub-basin. The culvert under Interstate 25 is adequate to convey the 100-year flood event without overtopping Interstate 25. In addition, it provides a small amount of detention storage to reduce discharge out of the culvert.

III. DRAINAGE MASTER PLAN FORMULATION

The ultimate goal of drainage improvements within the study area and areas within their upstream drainage basins is to protect the Town of Mead from damaging effects of flood

events. There are several methods commonly used along the front range to control storm drainage runoff, including detention ponds, open-channel systems, and storm-sewer systems. A combination of these methods is proposed for the Mead area. The following summarizes the conceptual design process for these elements and the location and size of these elements.

A. Hydraulic/Hydrologic Analysis Methodology

Several structural improvements to the existing storm drainage systems should be implemented. These improvements include detention ponds, culverts, open-channels, storm sewer systems and streets (curb and gutter). Many of the improvements are concentrated in the existing core area. As development continues within the study area, developers will be responsible for constructing these facilities on individual sites.

Methodology for Improvements

Urban development results in increased runoff from historic rates. Because the existing farmland and pastures are pervious mediums, a portion of the rain water infiltrates into the soil. Therefore, not all of the rain water runs off the land surface. When an area is developed, much of the surface is covered with impervious materials, such as parking lots, roads, roofs, etc. Therefore, water is not able to infiltrate, and a greater portion of the rain-water becomes surface runoff. In addition, peak runoff rates occur earlier and higher than historical rates because water usually travels faster over impervious materials than pervious materials. These conditions result in peak runoff rates for developed conditions much greater than peak runoff rates for undeveloped lands.

The degree of imperviousness depends upon the type of development. Low density residential areas, parks, golf courses and open-spaces have a low degree of imperviousness, and runoff increases only slightly over historical conditions. High density residential areas, commercial areas and industrial areas have a higher percentage of impervious areas, and runoff increases greatly over historical conditions. Developed conditions were simulated using zoning guidelines as set forth in the Town of Mead Comprehensive Development Plan (Brown, 1996). The plan contains a Land Use Map, on which land use categories for various residential densities, commercial, industrial and public areas are outlined. For areas outside the land use map (primarily upstream in tributary basins), proposed land uses were discussed with the Town Administrator and/or based on adjacent land uses. Any variation from these land uses will require changes in the modeling.

Most municipalities along the front range have design criteria which require developers to release storm water from their development at a rate no greater than selected historical conditions. Often, regulations state that the 100-year developed runoff rates should be released from the development at no greater than 2-year, 5-year, 10-year, 50-year or 100-year historical rates. Therefore, this guarantees that flood conditions for developed areas either match or are greatly improved over historic conditions.

Proposed Detention Pond Release Rates

Typically, in areas where existing development has proceeded with little regard for matching or improving drainage releases, 2-year or 5-year historic drainage releases are often required for new development to bring the drainage system into balance. Because of the Town's advanced planning and because development in the Mead area has not progressed uncontrollably, it is not necessary to require these more strict requirements within or surrounding the town.

The proposed drainage system is designed to adequately protect and drain the Town and study area. These facilities are designed not only to prevent future development from changing historical drainage flows, but also to improve drainage within the study area and alleviate some of the problem areas as identified with the existing system analysis. Design flows for conveyance facilities will be for the 100-year developed conditions. Release rates proposed herein from detention facilities, for developed 100-year storm runoff conditions will not exceed the 10-year historic release rate from the sub-basin, in accordance with the Town of Mead Storm Drainage Criteria and Construction Requirements.

Detention ponds have not been limited to sub-basins within the study area. To fairly distribute improvements through the basin, sub-basins outside of the study area which are upstream of those within the study area have been included in the proposed detention system.

Required detention pond volumes and proposed release rates have been noted on Figure 4. Although the detention sites have been marked on the exhibit at a single site, this is not necessarily the location of the pond. A combination of detention facilities can be used as development progresses. Each development will be required to detain their portion of increased runoff from each sub-basin.

Structural Improvements

Structural improvements include culverts, storm sewers and drainage channels. All structural facilities have been designed to convey 100-year developed flows with all facilities in place. Therefore, until an area is fully developed, the proposed facilities may be undersized for existing conditions. All proposed facilities have been noted on the Figure 4.

Culverts were sized using the same methodology as with existing culverts. Road overflow elevations were taken from survey data or estimated from the 2' contour maps. One foot of freeboard was allowed below the overtopping elevation for the 100-year fully developed flows. Storm sewers and channels have been sized using normal depth calculations. One foot of freeboard was allowed in all channel designs. All facilities, especially storm sewers and culverts, will need further engineering analysis during final design to verify conceptual design calculations.

Use of Irrigation Canals for Storm Water Conveyance

Use of irrigation canals for storm water conveyance is not encouraged. Colorado State law prohibits the transfer of storm water runoff between basins (cross basin diversion). This prevents drainage waters from creating off-site problems such as erosion and sedimentation and encourages drainage to be dealt with within the basin from which it originates. For this reason, it has been assumed for the proposed drainage system improvements that storm water runoff will sheet flow directly over the irrigation canals and laterals as if they were full.

B. Cost Estimation

Budget-level cost estimates were developed for all facilities in which the Town will be fully or partially responsible for costs. These facilities include culverts, storm sewers and drainage channels which serve existing developments.

Cost information was taken from the Means Cost Estimating book, Colorado Department of Transportation, and from previous bid submittals for work in the Northern Colorado area (Means, 1995; CDOT, 1995). Capital costs were developed for all construction work which may be involved in the project, including materials, labor, reseeding and mulching, utility relocation and traffic control. In addition, an engineering fee of 7% of construction costs for less technically demanding projects and 10% for more technically demanding projects, and a contingency fee of 10% for maintenance items to 25% for design items was added to the capital construction cost to develop an estimated project total cost.

Because the cost of labor, materials, equipment, services furnished by others, or competitive bidding or market conditions may vary, actual project costs may vary. Estimates are intended to be budget-level estimates only. Refer to the Technical Appendix for detailed quantity developments for proposed improvements and budget level cost estimate calculations. A summary of all proposed budget level cost estimates are presented in Table 9 at the end of Section C.

C. Proposed Drainage System Improvements

Using flows from the modified SWMM analysis, proposed culverts, channels, storm sewers, detention ponds and other drainage system components are proposed herein. The improvements are not only intended to solve current drainage problems, but to help prevent future drainage problems as a result of future development. The following is a summary of the proposed improvements for each sub-basin within the study area. Refer to Figure 4 for locations of each of the improvements.

Foster Reservoir Basin

Because the Foster Reservoir Basin is largely undeveloped, the problems in the basin are relatively minor, and the proposed drainage system will be easy to implement. All cost associated with the proposed improvements within this basin will be incurred by developers.

Fully developed discharges from each sub-basin as well as discharges at key locations are shown in Table 5.

Sub-basin 100

Sub-basin 100, as well as upstream sub-basins 200 and 202 are classified by the Comprehensive Development Plan as low-density, medium low density, and medium density residential development. The primary problem within this sub-basin is overtopping of Highway 66. It is proposed herein that all development within this sub-basin and upstream sub-basins 200 and 202 be detained and release at a rate which does not exceed the capacity of the existing culvert under Highway 66 to prevent overtopping and downstream mitigation measures. To detain enough runoff so that the upstream water surface elevation of the culvert has 1 foot of freeboard below the road crest, approximately 108 acre-feet of storage is anticipated to be distributed upstream of the culvert and throughout the developments in these three sub-basins. All costs should be incurred by future developers.

Table 5 Foster Reservoir Basin - Fully Developed Discharges

Sub-basin /Node	Description	Fully Developed Discharge (cfs)	
		10-year	100-year
100	Sub-basin 100	310	791
102	Sub-basin 102	106	193
200	Sub-basin 200	173	464
500	Culvert under Highway 66	17	27
505	Culvert under Highway 66	7	17

Sub-basin 102

Sub-basin 102 is categorized by the Comprehensive Development Plan as low-density and commercial/retail development, although plans are currently underway for high-density and commercial development with the sub-basin. Therefore, the more conservative high-density developments were assumed for the sub-basin. Currently, the culverts under Highway 66 which drain sub-basin 102 are adequately sized to convey the 100-year existing peak discharge without overtopping. Under developed conditions, a upstream water surface elevation of one-foot below the road crest is desired. Because of this, and increase peak discharge due to developed conditions, a total of eight acre-feet of detention is anticipated. Currently, approximately four acre-feet of detention is available directly upstream of the culvert. Therefore, an additional four acre-feet is anticipated within developments. If the area immediately upstream of the culvert is disturbed, then more detention will be required

within the developments. All costs for this detention should be incurred by future developers.

Mulligan Lake Basin

A large portion of the Mulligan Lake Basin is currently developed. Most of the developments have addressed drainage in some manner. Therefore, existing release rates should be allowed to continue for existing developments. No improvements are being proposed herein to convey storm water under Interstate 25 to relieve flooding in the underpass but rather it will continue in historic flow paths. Anticipated fully developed discharges from each sub-basin as well as discharges at key locations are shown in Table 6.

Table 6 Mulligan Lake Basin - Fully Developed Discharges

Sub-basin /Node	Description	Fully Developed Discharge (cfs)	
		10-year	100-year
101	Sub-basin 101	17	54
104	Sub-basin 104	39	110
105	Sub-basin 105	66	201
106	Sub-basin 106	59	171
110	Sub-basin 110	112	301
111	Sub-basin 111	75	250
119	Sub-basin 119	287	560
550	Detention area north of CR32, west of I-25. *	101	736
902	Channel south of CR 32, west of I-25	116	764

* County Road 32 overtopping occurs at 80 cfs.

Sub-basin 101

The existing drainage system within the Hunters Ridge development and the culverts under County Road 7 are inadequate to convey 100-year flows. It is proposed that the channel "J" along the west side of County Road be rehabilitated to a cross-section which is adequate to convey 100-year fully developed flows. In addition, all driveway/street culverts along County Road 7 and the culverts under County Road 7 will need to be replaced to accommodate the flows. It is estimated that dual 30" culverts will be needed across County

Road 7 at County Road 32. Because the development is existing, the Town should incur the total cost of the project, which is estimated at $86,000.

Sub-basin 103

Sub-basin 103 is categorized by the Comprehensive Development Plan primarily as low density residential development with a small amount of commercial/retail development in the far southeastern portion of the sub-basin. Because sub-basin 103 is currently undeveloped, the proposed system within the sub-basin will be incorporated within future developments and all costs should be incurred by future developers. Approximately 33 acre-feet of detention storage is anticipated to release 100-year future fully developed flow rates at existing 10-year release rates. It may be possible for future developers to make an agreement with the Owners of Mulligan Reservoir to store fully developed storm water runoff in the reservoir during storm events.

Sub-basin 104

The Hunters Cove development was adequately designed with a detention pond for the 100-year fully developed runoff. The detention pond is currently being repaired by the developer to adequately drain the pond. But, flows from the Hunters Ridge development exceed channel and culvert capacities in the roadside ditch along the south side of County Road 32 and across Hunters Cove Road. Therefore, it is proposed that channel "J" and the driveway culverts be enlarged to adequately convey 100-year fully developed flows from sub-basin 101 downstream. Because the development is existing, the developer should incur the total cost of the project, which is estimated at $78,000.

Sub-basin 105

Sub-basin 105 is categorized by the Comprehensive Development Plan as low density residential development, with a very small amount of commercial/retail development in the far southeastern corner of the sub-basin. Because the sub-basin is undeveloped, detention ponds should be incorporated within future developments to decrease future discharge from the sub-basin. Approximately 13 acre-feet of detention storage is anticipated with a release rate from the sub-basin of 48 cfs. This sub-basin will continue to outlet into the roadside channel along County Road 36 consistent with historic drainage patterns.

Sub-basin 106

Sub-basin 106 is currently undeveloped agricultural land. The Comprehensive Development Plan categorizes the sub-basin as low-density residential. Because the sub-basin is currently undeveloped, detention ponds should be incorporated within future developments to decrease peak discharges from the sub-basin. Approximately 8 acre-feet of storage is anticipated within developments to release at the 10-year historic discharge rate of 29 cfs. The existing culverts under County Road 7 should be removed and replaced with a 30" diameter RCP to accommodate runoff with 1' of freeboard below the existing road surface. Future developers should incur the full cost of improvements.

Sub-basin 110

The current drainage system in the Mulligan Lake Estates requires minor maintenance to an existing culvert under Silo Court. The culvert has become plugged and requires cleaning by maintenance personnel. In addition, channel "K" along the north side of County Road 32 from County Road 7 to the Mulligan Lake outfall channel requires regrading to raise the ditch capacity to accommodate runoff flows from sub-basin 106. The home owner's association should incur the full costs for both of these projects, which is estimated at $16,000.

Sub-basin 111

The Singletree Estates development within sub-basin 111 is currently under construction. All drainage components were designed to accommodate 100-year stormwater runoff. Runoff will enter the wetlands/detention area between the development and I-25. No improvements are required at this time.

Sub-basin 119

Sub-basin 119 is currently undeveloped. The Comprehensive Development Plan classifies the sub-basin as a mixture of medium low density and high density residential development, and commercial/retail development. The existing 24" RCP under Interstate 25 is undersized to accommodate 10-year historic release rates. Therefore, future fully developed runoff will need to be detained at a lesser rate to avoid overtopping Interstate 25. The capacity of the culvert with one foot freeboard below the road surface is 28 cfs. This will require approximately 20 acre-feet of detention storage within future developments. Future developers should incur all expenses with the improvements.

North Creek Basin

Several sub-basins west of the study area are tributary to streams within the study area. These basins include sub-basins 204, 206, 210, 212, 214, 216 and 218. Although these sub-basins are outside the study area, the MODSWMM methodology has assumed that each of these sub-basins will be detained in the future so that they release storm water no greater than the 10-year historic rate. If this does not turn out to be the case in the future, downstream drainage infrastructure sizes will need to be increased to accommodate larger storm water flows. Anticipated fully developed discharges from each sub-basin (without detention effects) along with flows at key points are presented in Table 7.

Most of the area outside the study limits has been categorized by the development plan as low-density and medium density residential development. North of County Road 36, the zoning was changed from low-density to medium and high density residential and commercial development in accordance with current plans for the area. The development plan does not classify any lands West of County Road 9. Therefore, a mixture of low density, medium density and high density residential and commercial lands were assumed for the area (this area is directly west of the proposed high-school grounds, which usually attract high density and commercial development).

In addition to detention requirements for sub-basins outside the study area, two culverts will need to be modified as the exterior sub-basins enter the study area. The culvert under County Road 36 just west of County Road 7 is overtopped by both the 10-year and 100-year historic flow rates. To accommodate anticipated fully developed flows from sub-basins 212 and 214, a 54" diameter culvert should be installed across County Road 36. In addition, drainage channel "E" should be constructed along the west side of County Road 7 for overflow from the culvert for sub-basin 214 under County Road 7, to the proposed culvert under County Road 36. Costs for these improvements should be paid by future developers.

The western portions of sub-basins 108 and 112 are outside the study area. This comprises about 40% of the total area of each. It is anticipated that these parcels will be developed in conjunction with parcels to the east, which lie within the study area. Improved facilities for these areas are described with their associated sub-basins below.

To discourage development in the 100-year floodplain of North Creek, the Town should elect to create a floodplain buffer along North Creek. The buffer strip could be used to maintain existing floodplain vegetation and aquatic habitat. The buffer could be placed at the limits of the historic 100-year floodplain, or a minimum of 50' on either side of the North Creek thalweg. No residential, commercial, industrial or other development should be allowed within the buffer strip.

Sub-basin 107

Sub-basin 107 is currently undeveloped. The Comprehensive Development Plan categorizes this area as low density residential development in the southern portion of the sub-basin to high density and downtown commercial/retail development in the northern portion of the sub-basin. The 10-year historic release rate from the sub-basin is 37 cfs. Approximately 13 acre-feet of detention storage is anticipated within developments in the sub-basin. To alleviate flooding problems downstream of the sub-basin, drainage should enter storm sewer "BB" at the southwest corner of County Road 7 and County Road 34. The storm-sewer system would convey storm water east along County Road 34 to swale "C" which is tributary to North Creek. Future developers should be responsible for 100% of the cost.

Sub-basin 108

Sub-basin 108 is currently undeveloped agricultural land. The Comprehensive Development Plan has classified this area low and medium density residential development. The 10-year historic release rate for the sub-basin is 68 cfs. Approximately 24 acre-feet of detention storage is anticipated in developments to accommodate this release rate. Existing drainage patterns in the sub-basin cause minor flooding of the school grounds. To divert runoff away from the schools, a drainage channel "B" is proposed which flows around the perimeter of the school grounds from the northwest corner to the southeast corner. To help alleviate drainage problems in the downtown area, all drainage from the sub-basin will enter a lateral of the downtown storm sewer system "AA". Future developers should be responsible for all drainage within the sub-basin, the lateral from the sub-basin to the downtown storm sewer, and approximately 42% of the cost of the downtown storm-sewer system.

Table 7 North Creek Basin - Fully Developed Discharges

Sub-basin /Node	Description	Fully Developed Discharge	
		10-year	100-year
107	Sub-basin 107	117	252
108	Sub-basin 108	231	545
109	Sub-basin 109	20	44
112	Sub-basin 112	308	697
113	Sub-basin 113	38	78
114	Sub-basin 114	73	150
115	Sub-basin 115	121	243
116	Sub-basin 116	283	611
117	Sub-basin 117	47	134
118	Sub-basin 118	100	206
119	Sub-basin 119	287	560
120	Sub-basin 120	83	218
122	Sub-basin 122	58	166
123	Sub-basin 123	60	150
124	Sub-basin 124	92	276
125	Sub-basin 125	150	281
126	Sub-basin 126	184	410
127	Sub-basin 127	35	111
128	Sub-basin 128	61	166
130	Sub-basin 130	88	297
132	Sub-basin 132	85	252
133	Sub-basin 133	43	110
600	North Creek culvert under I-25	508	1,382
615	North Creek culvert under CR 7	477	771
915	North Creek upstream of I-25 culvert	515	1,579

Sub-basin 109

Sub-basin 109 is the developed western portion of the downtown area. Drainage from this sub-basin flows north to a small return flow ditch in the agricultural field. The ditch is informal and its existence often depends upon the time of year and the type of agriculture being performed. In addition, this sub-basin receives runoff from sub-basin 112 west of the downtown area. For these reasons, drainage channel "A" around the western and northern portion of the downtown area is proposed. This channel should convey storm water from sub-basin 112 away from the downtown area. In addition, the channel should convey storm drainage from sub-basin 109, and aide in keeping the northern portions of the downtown areas from future flooding. Because of the importance in keeping the Town safe during storm events, the Town should be responsible for 100% of the cost of the drainage channel. The estimated cost of the channel is $114,000.

Sub-basin 112

Sub-basin 112 is currently undeveloped agricultural lands. The Comprehensive Development Plan indicates that this sub-basin will be a combination of medium density residential development and school grounds. Approximately 43 acre-feet of detention storage is anticipated within future developments to release runoff at the historic 10-year rate of 66 cfs. In addition, drainage channel "A", as described in the sub-basin 109 narrative, should be constructed within the sub-basin to eliminate flooding in the downtown area. Future developers should not be responsible for initial construction of the channel, but should consider the ditch and any necessary improvements during design. Drainage from the developed portions of sub-basins 109, 112 and 114 drain to a culvert under County Road 7. This culvert is undersized to convey 100-year storm water flows. Four 60-inch RCP's should be added to the existing 60-inch CMP to adequately convey anticipated future fully developed flows. The Town should be responsible for 18 percent of the cost, or approximately $27,800, and the school district should be responsible for 5 percent, or $7,492.

Sub-basin 113

Sub-basin 113 is comprised of the existing school yards. In order to increase safety at the interface of the school yards and County Road 34, storm sewer "AA" is proposed. The storm sewer should eliminate the need for roadside ditches within the school yards. Two to three inlets should be placed along the south side of County Road 34 and should flow through lateral pipes to the main line along the south side of the road. The school district should continue along the storm sewer route as described in the sub-basin 114 narrative. The sub-basin will be responsible for 24% of the storm sewer total cost, or approximately $141,000.

Sub-basin 114

Sub-basin 114 is comprised of the eastern portion of the downtown area west of County Road 7 and the Great Western Railroad tracks. The downtown area has several sources of flooding, including upstream sub-basins 108, 109, 112 and 113. Improvements are proposed for these sub-basins which will help alleviate existing drainage problems. But, runoff from sub-basin 114 itself will continue to cause problems if no measures within the sub-basin are taken. Most urban settings use a combination of curb and gutter and storm sewers to drain storm flows from streets and lots. Currently, the downtown area has few paved roads, and

no storm sewer system. This results in erosion of streets, and general flooding of low-lying areas during flood events.

The most urgent need in the downtown area at this time is a storm sewer system. The system should convey runoff from the downtown area north to North Creek and be designed to convey peak 10-year storm water runoff. The proposed storm sewer "AA" should begin on Welker near the school, run east to Fourth Street, then north and east towards North Creek. The storm sewer should outlet in North Creek near the proposed detention pond at the intersection of County Roads 7 and 34 ½. Pipe sizes should range from 18" at the upper end of the system to 60" at the lower end of the system. Inlets to the system should be placed at two to three points along Welker, and at the ends of all east/west streets in town. The storm sewer should reduce flooding between Third and Fourth Streets near the bean warehouse, and along Third Street approaching North Creek. In addition, roadside ditches south of Welker in the school grounds should be eliminated to improve pedestrian/traffic safety along the road.

Because a storm sewer system to convey the 100-year storm event runoff would be too cost prohibitive to construct, the downtown area will still need other drainage improvements to safely convey 100-year peak discharges. Channel "F" is proposed for the area immediately west of the Great Western Railroad tracks between Welker and Third Street. This channel should convey 100-year discharges from the school and the areas south of Martin. A culvert should be placed under Third Street and should outfall along historic flow paths adjacent to the Great Western Railroad tracks. In addition, downtown streets should eventually be paved with curb and gutter. Paved streets would eliminate erosion of the gravel streets during storm events. In addition, curb and gutter would provide effective means of conveying storm water from the upper portions of the downtown basin to the storm sewer inlets at the lower portions of the basin. All 100-year storm runoff could be contained within the gutter system to keep water from damaging structures and be routed to North Creek.

The Town should be fully responsible for the $34,000 estimated cost of the drainage channel "F" west of the Great Western Railroad tracks. The total estimated cost of storm sewer "AA" is $596,000. The Town should be responsible for approximately 34%, or approximately $204,000, of this cost. Street paving and curb and gutter have not been estimated as part of this study.

Sub-basin 115

Sub-basin 115 incorporates the downtown area east of the Great Western Railroad tracks. A majority of the sub-basin is currently developed. The small area which is not developed is categorized by the Comprehensive Development Plan as downtown commercial/retail and parks. Much of the runoff from this basin is overland flow to North Creek. Drainage is somewhat channelized along the railroad tracks, which also outfalls into North Creek. The existing residential development at the northeast corner of Welker and Third Street should be protected from storm water runoff from the south and west by the proposed detention pond and storm sewer as described in sub-basin 107. But, flooding from localized runoff will remain a problem. It is proposed that this area eventually be paved with curb and gutter

similar to sub-basin 114. Storm water runoff should be routed away from houses and structures into storm sewer "CC", which would outfall into drainage channel "C". The Town should incur 100% of the cost of the storm sewer and 18% of the cost of the channel, approximately $46,000 and $6,000 respectively. Paving and curb and gutter costs have not been estimated as a part of this study.

Sub-basin 116

Sub-basin 116 is currently undeveloped agricultural lands. The Comprehensive Development Plan currently indicates a mix of medium-low density and high density development and downtown commercial/retail development. But, current proposals for the area show more medium density residential development and less commercial/retail development. This development scenario was used in the modeling. Runoff from this sub-basin currently causes flooding problems in sub-basins 115 and 117. During development, many of these problems will be rectified. In addition, future development should be required to detain a total of approximately 18 acre-feet of storm water in order to release at the 10-year historic rate of 92 cfs. Drainage facilities within the basin should discharge into storm sewer "BB" described in the sub-basin 107 narrative, which then outfalls into drainage channel "C" to North Creek. Future developers should be responsible for 100% of the cost of the storm sewer.

Sub-basin 117

Sub-basin 117 is currently undeveloped agricultural land. The Comprehensive Development Plan classifies the area within the sub-basin as a mixture of parks and medium density residential lands. The primary improvement proposed for this sub-basin is enlargement of the current culvert under the Great Western railroad to two reinforced concrete box culverts capable of conveying the 100-year fully developed discharge in North Creek under the tracks with one foot of upstream freeboard. This will keep the tracks from overtopping and possible failure. This sub-basin also contains a significant amount of land within the existing 100-year floodplain of North Creek. Detention for the sub-basin is currently provided at the culvert for North Creek under Interstate 25.

Sub-basin 118

Sub-basin 118 is currently undeveloped agricultural land. The Comprehensive Development Plan classifies the sub-basin as primarily medium density residential with a small amount of medium-low density residential and commercial/retail. Approximately 7 acre-feet of detention storage is anticipated within future developments to release storm water runoff at the historic 10-year release rate of 14 cfs. In addition, a 24" culvert should be constructed under County Road 34 to adequately convey storm water runoff without overtopping the road. Channel "G" will be required to convey storm water from the culvert under County Road 34 to North Creek. Developers will be responsible for all improvements.

Sub-basin 120

Due to the possibility of nine houses marked with an "X" being inundated with storm water during a 100 year "existing condition" storm event, and the rain storm event of June 6, 1997, we recommend the following measures be under taken immediately by the Town of Mead:

A. The Town of Mead notify the Developer of the North Creek development that the potential exists for nine houses marked with an "X" to be inundated with storm water during a 100 year "existing condition" storm event.

B. The Town of Mead require the Developer of the North Creek development to hydraulically prove with a two dimensional hydraulic model that the nine houses marked with an "X" will not be inundated with storm water during a 100 year "existing condition" storm event.

and/or

The Town of Mead require the Developer of the North Creek development to engineer, submit for review and approval, and construct the necessary berming or channelization or piping to prevent the nine houses marked with an "X" from being inundated with storm water during a 100 year "existing condition" storm event. Permission from private property owners to construct any improvements will need to be obtained before construction.

Due to the existing drainage outlets associated with Serena Drive and Meadow Lane and the rain storm event of June 6, 1997, Mr. Walt Logsdon has indicated that historically his property did not receive storm water runoff in this manner, he does not want to continue to receive storm water runoff in this manner, and he wants these existing drainage problems fixed as soon as possible, we recommend the following measures be under taken immediately by the Town of Mead:

A. The Town of Mead notify the Developer of the North Creek development that Serena Drive storm water runoff be redirected south along the east property line of the North Creek development, to North Creek. This can be accomplished within the existing 10 foot utility easement along the east property line of Lot 7 within Block 3. The Town of Mead require the Developer of the North Creek development to engineer, submit for review and approval, and construct the necessary improvements,

B. The Town of Mead notify the Developer of the North Creek development that Meadow Lane storm water runoff be redirected north along the east property line of the North Creek development, to North Creek. This can be accomplished within the existing 10 foot utility easement along the east property line of Lot 7 within Block 8. The Town of Mead require the Developer of the North Creek development to engineer, submit for review and approval, and construct the necessary improvements,

Due to the existing drainage situation on County Road 34 ½ at the southwest corner of the North Creek development, the rain storm event of June 6, 1997, and the need to prevent future drainage problems at this location, we recommend the following measure be under taken immediately by the Town of Mead:

A. The Town of Mead notify the Developer of the North Creek development that the existing culvert under County Road 34 ½ be uncovered, cleaned out and a drainage swale restored from the culvert outlet, north to North Creek. The swale will need to be located on private property west of Lots 1-9 of Block 9 of the North Creek development due to recent development of Lots 1-9 and related fencing and landscape improvements. Permission from the private property owner to construct a swale will need to be obtained before construction,

The existing culverts for North Creek under County Road 34 ½ are inadequate to convey fully developed storm water runoff. The existing culverts should be replaced with a 16' x 4' reinforced concrete box culvert as development warrants. The Town should be responsible for 18 percent of the cost, or approximately $26,600.

Sub-basin 122

Sub-basin 122 is currently undeveloped agricultural land. The Comprehensive Development Plan classifies this land as low density residential development. Approximately 7 ac-ft of detention storage is anticipated to release fully developed runoff at the historic 10-year runoff rate of 18 cfs. The existing culvert under County Road 7 is incapable of conveying fully developed flows. Therefore, 2-48" RCP culverts should replace the existing culvert. Future developers should be responsible for all improvements.

Sub-basin 123

Sub-basin 123 is comprised of existing Feather Ridge Estates development in the northern portion of the development, and undeveloped agricultural land in the southern portion. The Feather Ridge Estates development was designed to convey and detain 100-year fully developed flows and release at the 100-year historic rate. Therefore, no drainage improvements are required for this portion. The undeveloped portion of the sub-basin is classified as medium low density residential development by the Comprehensive Development Plan. Approximately 3.5 acre-feet of detention storage is anticipated so that the sub-basin releases at the 10-year historic rate. Future developers should be responsible for all improvements.

Sub-basin 124

Sub-basin 124 is currently comprised of undeveloped agricultural land, as well as the north branch of North Creek. The Comprehensive Development Plan indicates that this area is classified as low-density residential development. Detention for the sub-basin is currently provided at the culvert for the north branch of North Creek under the Great Western railroad tracks. The ponding area upstream of the culvert is included within the floodplain boundaries. It is not recommended that the culvert under the Great Western railroad tracks be enlarged. Colorado law dictates that conditions are defined as historic if the condition has been in place for 18 years or more. Therefore, the culvert under the tracks is defined as historic. Enlargement of the culvert would increase peak discharge and volume of water released into the main stem of North Creek thus causing downstream erosion and sedimentation impacts. The FEMA Approximate Floodplain was based on "historic"

conditions with the existing culvert size under the Great Western Railroad tracks. No structural improvements are proposed for this sub-basin.

Sub-basin 125

Sub-basin 125 is comprised of undeveloped agricultural lands. The Comprehensive Development Plan indicates that the area will be a mixture of commercial/retail development and parks. Detention for the sub-basin is currently provided at the culvert for North Creek under Interstate 25. The ponding area upstream of the culvert is included within the floodplain boundaries. Drainage channel "G" which conveys flows from sub-basin 118 to North Creek will flow through the sub-basin.

Sub-basin 126

Sub-basin 126 lies downstream of sub-basin 124 along the north branch of North Creek. The land is currently undeveloped agricultural land. The Comprehensive Development Plan indicates that this area is classified as low and medium density residential development. Detention for the sub-basin is currently provided at the culvert for North Creek under Interstate 25. The ponding area upstream of the culvert is included within the floodplain boundaries. No structural improvements are proposed for this sub-basin.

Sub-basin 128

Sub-basin 128 is currently comprised of undeveloped agricultural land as well as a tributary to the north branch of North Creek. The Comprehensive Development Plan classifies this land as low and very low density residential development. Approximately 11.8 acre-feet of detention storage is anticipated to release fully developed runoff at the 10-year historic rate of 53 cfs. Currently, the culvert under County Road 36 is inadequate to convey this release rate plus upstream off-site runoff. Two 48-inch diameter RCPs, in addition to the 24" CMP are anticipated to adequately convey this discharge. Future developers should be responsible for this improvement.

Sub-basin 130

Sub-basin 130 is currently comprised of undeveloped agricultural land as well as a tributary to the north branch of North Creek. The Comprehensive Development Plan classifies the sub-basin as very low and low density residential development. Approximately 19 acre-feet of detention storage is anticipated to release fully developed runoff at the 10-year historic rate of 80 cfs. Currently, the culvert under County Road 36 is inadequate to convey storm water discharges. A 17'x4' RCBC is anticipated to convey stormwater under County Road 36. Because a portion of the discharge through this culvert is a result of current developments upstream, both the Town and the County should be responsible for a portion of the improvement cost of the culvert. Based on percent of flow contributions, the Town should be responsible for 49 %, or $65,800, of the total cost and the County should be responsible for 21%, or $28,000, of the total cost. The future developer should be responsible for all remaining improvement costs.

Sub-basin 132

Sub-basin 132 is currently comprised of portions of Highland Estates and Lake Hollow Estates developments as well as a small undeveloped parcel of agricultural land. All facilities were designed to convey the 100-year fully developed flows, and no improvements are proposed within the development. A tributary to the north branch of North Creek also flows through the sub-basin. When the small parcel of agricultural land is developed, its storm water runoff should be directed into the tributary to the north branch of North Creek.

Sub-basin 133

Sub-basin 133 is currently comprised of portions of the Highland Estates developments. All facilities were designed to convey the 100-year fully developed flows, and no improvements are proposed within the development. A tributary to the north branch of North Creek also flows through the sub-basin.

North I-25 Basin

The north I-25 basins generally require little improvement. Sub-basin 220 is north of the study area. Proposed development is primarily commercial and high-density residential. Approximately 30 acre-feet of storage is anticipated in sub-basin 220 to release fully developed runoff at the 10-year historic rate of 109 cfs. One 24" RCP will need to be added to the existing 48"' CMP to adequately convey this discharge under County Road 38. Table 8 summarizes fully developed flows from each sub-basin as well as discharges at key locations. Cost of these improvements will be the responsibility of future developers.

Table 8 North I-25 Basin - Fully Developed Discharges

Sub-basin /Node	Description	Fully Developed Discharge (cfs)	
		10-year	100-year
127	Sub-basin 127	35	111
134	Sub-basin 134	74	215
220	Sub-basin 220	616	1064
580	Culvert under I-25	104	249

Sub-basin 127

Sub-basin 127 covers the far eastern portion of the basin. The Comprehensive Development Plan classifies the sub-basin as very low, low and medium density development. The existing culvert under I-25 is adequate to detain and convey existing, as well as developed storm water flows. Therefore, no modifications will be needed to the existing culvert under

Interstate 25. Approximately one acre-foot of detention storage is anticipated within the sub-basin to ensure that flows through the culvert do not exceed existing 100-year discharges of 101 cfs. Culverts under CR 36 and the Great Western Railroad tracks should be installed as the area is developed to handle storm water. Developers should be responsible for these improvements.

Sub-basin 134

Sub-basin 134 is currently comprised of undeveloped agricultural land. The Comprehensive Development Plan classifies the land as low-density residential development. The existing culvert under Interstate 25 is adequate to convey existing as well as developed storm water flows. But, approximately 1.6 acre-feet of detention storage will be required to ensure that fully developed discharges do not exceed 100-year existing discharge through the culvert. Portions of the runoff from sub-basins 220 and 134 currently drain into the Mead Lateral irrigation ditch. It has been recommended that irrigation canals not be used for storm water runoff. Therefore, a cross-drainage structure should be constructed across the ditch to convey upstream 100-year historic storm flows. Future developers should be responsible for these improvements.

D. North Creek FEMA Approximate Floodplain

North Creek from Interstate 25 through the North Creek residential development is classified as a Zone A Federal Emergency Management Agency (FEMA) floodplain. This designation indicates the approximate area of the 100-year flood, but base flood elevations and flood hazard factors have not been determined by FEMA. The Town of Mead currently is not in the National Flood Insurance Program (NFIP), although Weld County is in the program. For communities which are in the NFIP, processes for proposed developments are stated within an ordinance, and a community floodplain administrator then applies provisions within the ordinance. Weld County has a "Flood Hazard Submittal Checklist" which must be filled out prior to approval of developments within Floodways of Floodprone Districts. A Flood Hazard Development Permit is then issued pending review of the application.

FEMA is not involved in local assessments of impacts within A zone areas (Metzler, 1997). However, for communities which are in the NFIP, development proposals within any A zone area would need to be submitted to the floodplain administrator with plans showing dimensions and elevations of existing and proposed structures, drainage facilities, etc. The floodplain administrator would then make a decision as to whether the structures "adversely affects" the flood carrying capacity of the area of special flood hazard. This implies that base flow and developed flow conditions should be modeled. If a map revision is being requested, the applicant is required to apply to FEMA. Future drainage design shall consider all applicable FEMA regulations and requirements related to North Creek.

VI. CONCLUSIONS

The proposed improvements are intended to improve storm drainage handling within the Town of Mead as the Town develops and expands. Proposed detention facilities should be

Table 9 - Summary of Cost Estimates

Cost Summary

Basin Number	Description	Estimated Cost	Town Share Percent	Town Share Cost	School Share Percent	School Share Cost	Developer Share Percent	Developer Share Cost	County Share Percent	County Share Cost	HOA Share Percent	HOA Share Cost
101	Chan. J (Rch. 1 & 2) - Clvt. 568	$86,000	100%	$86,000	0%	$0	0%	$0	0%	$0	0%	$0
104	Channel J (Reach 3)	$78,000	0%	$0	0%	$0	100%	$78,000	0%	$0	0%	$0
110	Channel K (Reach 1)	$16,000	0%	$0	0%	$0	0%	$0	0%	$0	100%	$16,000
115	Storm Sewer CC	$46,000	100%	$46,000	0%	$0	0%	$0	0%	$0	0%	$0
112	Channel A	$114,000	100%	$114,000	0%	$0	0%	$0	0%	$0	0%	$0
108	Channel B	$60,000	100%	$60,000	0%	$0	0%	$0	0%	$0	0%	$0
114	Channel F	$28,000	100%	$28,000	0%	$0	0%	$0	0%	$0	0%	$0
108, 109, 113, 114	Storm Sewer AA	$596,000	34%	$203,602	24%	$140,671	42%	$251,727	0%	$0	0%	$0
112	Culvert 615	$152,000	18%	$27,798	5%	$7,492	67%	$101,136	0%	$0	0%	$0
120	Culvert 618	$144,000	18%	$26,517	0%	$0	82%	$117,483	0%	$0	0%	$0
130	Culvert 742	$134,000	49%	$65,756	0%	$0	30%	$40,164	21%	$28,080	0%	$0
117	Channel C	$34,000	18%	$6,064	0%	$0	82%	$27,936	0%	$0	0%	$0
Total		$1,488,000		~~$663,737~~		~~$226,162~~		$538,446		$28,080		$16,000

741,737 148,163 746,263

Cost Division Worksheet

Basin Number	Description	Total Flow	Town Share Flow	Town Share Percent	School Share Flow	School Share Percent	Developer Share Flow	Developer Share Percent	County Share Flow	County Share Percent
108, 109, 113, 114	Storm Sewer AA	161	55	34.16%	38	23.60%	68	42.24%	0	0.00%
112	Culvert 615	771	141	18.29%	38	4.93%	513	66.54%	0	0.00%
120	Culvert 618	429	79	18.41%	0	0.00%	350	81.59%	0	0.00%
130	Culvert 742	377	185	49.07%	0	0.00%	113	29.97%	79	20.95%
117	Channel C	157	28	17.83%	0	0.00%	129	82.17%	0	0.00%

Notes:

(1) The "Developer Share" of the costs are not all inclusive. Only costs which will be shared with the town have been included. Developers will be responsible for all costs not included in the cost estimate.

(2) Costs were divided on a pro-ration of the total flow at the improvement between each of the contributors. Flows used for division are fully developed flows with improvements in place

(3) Total costs rounded up to the nearest $2,000 increment.

(4) Because the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others, or over competitive bidding or market conditions, his opinions of probable Project Cost and Construction Cost provided herein are to be made on the basis of his experience and qualifications, and represent his best judgement as an experienced and qualified professional engineer familiar with the construction industry; but ENGINEER cannot and does not guarantee that proposals, bids or actual Project or Construction Cost will not vary from opinions of probable cost prepared by him. If prior to the Bidding or Negotiating phase, OWNER wishes greater assurance as to Project or Construction Cost, he should employ an independent cost estimator.

incorporated into individual developments, and therefore, should be built as each development is built. All proposed facilities should be considered high priority. But, many of the proposed facilities will be undersized until full build-out because the proposed detention ponds are designed to lessen the impacts of 100-year storm events on the system. Therefore, priority should be placed on facilities which are currently faced with full build out conditions, such as the storm sewers in the downtown area and some of the small channels proposed in the Mulligan Lake area.

The Town should be responsible for all or part of many of the proposed improvements, including storm-sewers, channel construction and rehabilitation, and culvert replacement. The total current 1998 estimated cost of the Town's contributions is $664,000. This cost is for facilities or a portion of facilities which serve existing development with the study area. In addition, three of the proposed projects should require joint funding from the school district and Weld County. Negotiations should be undertaken with these entities to develop a plan for cost-sharing these projects.

This report is intended to be a planning tool used by the Town and developers to adequately plan developments and facilities to meet storm drainage criteria. As developments and facilities are designed and constructed, the CUHP/MODSWMM computer modeling should be updated by the Town Engineer to reflect changes from the original assumptions and verify that proposed developments will work from a storm drainage standpoint.

IX. REFERENCES

Brown, Lisa, et. al. 1996. Town of Mead Comprehensive Development Plan.

Carroll and Lange Inc. (Carroll). 1994. Lake Hollow Estates design drawings. February 17.

Chow, Ven Te. 1988. Open-Channel Hydraulics. McGraw-Hill Book Company, New York.

Colorado Department of Transportation (CDOT). 1996. 1995 Cost Data. Cost Estimate Unit of the Staff Design Branch. January 1.

McKissack, Willey. 1993. Hunters Cove Subdivision design drawings. October 28.

MCS Inc. 1995a. Feather Ridge Estates design drawings. August 14.

MCS Inc. 1995b. Drainage Report for Feather Ridge Estates. November 2.

Metzler, Fred. 1997. Personal Communication. Federal Emergency Management Agency, Denver, Colorado. November 12.

R.S. Means Company (Means). 1995. Site Work & Landscape Cost Data. 15th Annual Edition. Kingston, MA.

Soil Conservation Service (SCS). 1980. Soil Survey of Weld County, Colorado Southern Part. United States Department of Agriculture, Colorado Agriculture Experiment Station.

Swift and Associates (Swift). 1992a. Drainage Report for Mulligan Lakes Estates Phase 1. December 10.

Swift and Associates (Swift). 1992b. Drainage Report for Mulligan Lakes Estates Phase 2. December 12.

Swift and Associates (Swift). 1993a. Singletree Estates design drawings. February.

Swift and Associates (Swift). 1993b. Mulligan Lake Estates Phase 1 and 2 design drawings. September.

Swift and Associates (Swift). 1994. North Creek at Mead design drawings. May 23.

Swift and Associates (Swift). Date Unknown. North Creek at Mead Final Drainage Report.

W.W. Wheeler and Associates, Inc. (Wheeler). 1996. Mulligan Lake Estates Storm water Hydrology. September 30.

Urban Drainage and Flood Control District (UDFCD). 1991. Urban Storm Drainage Criteria Manual. Volumes 1 and 2.

ADDENDUM TO
DRAINAGE MASTER PLAN
TOWN OF MEAD

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May 4, 2007

Job Number 39241.47

CERTIFICATION

ENGINEER

I hereby certify that this report for the Addendum to the Drainage Master Plan for the Town of Mead, Colorado was prepared under my direct supervision in accordance with the provisions of the Storm Drainage Criteria and Construction Standards for the Town of Mead.

Respectfully Submitted,

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1. INTRODUCTION

This is an addendum to the Drainage Master Plan, Town of Mead, Colorado, prepared by The Sear-Brown Group dated July 1998. This addendum is intended to update existing drainage conditions, proposed system improvements and guidelines for future development for the Town of Mead detailed in the Drainage Master Plan, Town of Mead (MMP).

Several drainage reports and utility plans were referenced in the preparation of this document to provide design information for detention ponds and conveyance facilities within future developments.

The scope of this project includes the following:

a) perform a review and evaluation of previous studies in the area
b) clarify release rates for each sub-basin
c) update the existing storm system
d) update cost contributions for future storm systems

The next step to further update the MMP would be to use the updated information in this Addendum to rerun the Stormwater Management Model (SWMM) to obtain updated existing drainage conditions, proposed system improvements and guidelines for future development for the Town of Mead.

2. UPDATE TO EXISTING DRAINAGE SYSTEM

Several sub-divisions have been constructed in and around town since the MMP was first approved. In response to the growth in the study area, the sub-basins containing these new developments have been updated. Forty-two (42) sub-basins were delineated in the study area. Several of the 42 sub-basins that were undeveloped during the MMP analysis now contain developments.

The following is a summary of the findings for each updated sub-basin within the study area.

Foster Reservoir Basin

The Foster Reservoir Basin contains 4 sub-basins (100, 102, 200 and 202) and has not seen any new development since the approval of the MMP. Historic parameters and flows, as generated from the MMP, from each sub-basin are presented in Table 1.

Table 1. Foster Reservoir Basin—Existing Parameters and Flows.

Sub-basin	Description	Existing Parameters			Existing Flow (cfs)	
		Area (Ac)	C_5	%I	10-year	100-year
100	Sub-basin 100	373.92	0.15	7	126	433
102	Sub-basin 102	48.09	0.10	2	18	64
200	Offsite sub-basin 200	278.44	0.10	2	70	269
202	Offsite sub-basin 202	92.00	0.20	4	47	133

Mulligan Lake Basin

The Mulligan Lake Basin contains 8 sub-basins (101, 103, 104, 105, 106, 110, 111, and 119). Sub-basin 111 now contains the Singletree Estates development. Historic parameters and flows from each sub-basin are presented in Table 2. Sub-basins that incurred changes to existing conditions are listed in bold italics and changes are explained following the table.

Table 2. Mulligan Lake Basin—Existing Parameters and Flows.

Sub-basin	Description	Existing Parameters			Existing Flow (cfs)	
		Area (Ac)	C_5	%I	10-year	100-year
101	Hunters Ridge	59.46	0.25	6	16	55
103	Mulligan Reservoir	329.12	0.46	41	414	943
104	Hunters Cove	96.69	0.35	8	39	110
105	Sub-basin 105	126.53	0.10	2	48	173
106	Sub-basin 106	72.38	0.10	2	29	102
110	Mulligan Lake Estates	147.25	0.35	22	112	257
111	Singletree Estates	154.90	0.12	7	75	250
119	Sub-basin 119	122.24	0.10	2	47	168

Sub-basin ***104***

Sub-basin 104 is comprised of the Hunters Cove development. The developers of Hunters Cove rehabilitated the detention pond outlet in 2006, constructing an outlet structure that discharges to an irrigation box on the north side of Mulligan Reservoir. The previous outlet was connected to an irrigation sub-drain and failed.

Sub-basin ***111***

Sub-basin 111 contains Singletree Estates development. The ditch along the northerly side of County Road 32 has been sized to convey the 100-yr developed flow of this development, flows from the Mulligan Lake outlet and flows from the roadside ditch that will be constructed along the north side of Adams Avenue when it is paved.

North Creek Basin

The North Creek Basin contains 26 sub-basins (107, 108, 109, 112, 113, 114, 115, 116, 117, 118, 120, 122, 123, 124, 126, 128, 130, 132, 133, 204, 206, 210, 212, 214, 216 and 218). Historic parameters and flows from each sub-basin are presented in Table 3. Sub-basins that incurred changes to existing conditions are listed in bold italics and changes are explained following the table.

Table 3. North Creek Basin—Existing Parameters and Flows.

Sub-basin	Description	Existing Parameters			Existing Flow (cfs)	
		Area (Ac)	C_5	%I	10-year	100-year
107	Sub-basin 107	96.63	0.14	7	37	104
108	Sub-basin 108	186.77	0.10	2	68	251
109	Sub-basin 109	13.08	0.50	45	22	49
112	Western Meadows	264.45	0.24	29	57	92
113	Sub-basin 113	23.88	0.50	50	37	77
114	Sub-basin 114	44.85	0.57	55	73	150
115	Prairie Hills	55.07	0.48	46	93	203
116	Sub-basin 116	142.95	0.19	12	92	274
117	Sub-basin 117	101.08	0.14	7	30	103
118	Sub-basin 118	50.40	0.10	2	14	50
120	Sub-basin 120	99.79	0.24	15	56	166
122	Sub-basin 122	62.37	0.10	2	18	68
123	Sub-basin 123	46.83	0.31	22	56	147
124	Coyote Run	181.58	0.21	21	123	340
125	Sub-basin 125	59.30	0.10	2	27	94
126	Sub-basin 126	126.45	0.10	2	44	162
128	Vale View II	114.69	0.13	9	61	158
130	Vale View I, Margil Farms 2nd Filing	213.01	0.10	5	88	223
132	Sub-basin 132	103.04	0.37	12	85	252
133	Sub-basin 133	35.10	0.35	8	43	110
204	Offsite sub-basin 204	619.59	0.15	7	215	628
206	Offsite sub-basin 206	213.94	0.32	25	167	404
210	Offsite sub-basin 210	127.62	0.12	4	73	244
212	Offsite sub-basin 212	213.94	0.10	2	75	227
214	Offsite sub-basin 214	558.15	0.10	2	205	624
216	Margil Farms 1st Filing	50.66	0.12	3	87	184
218	Margil Farms 1st Filing	27.37	0.13	4	56	112

Sub-basin *112*

Sub-basin 112 contains Western Meadows I and II subdivisions. Western Meadows subdivisions generate 189 cfs during the major (100-yr) storm event. These flows are detained to 78 cfs during the 100-yr event. The 10-yr and 100-yr flows, C_5 and percent impervious values were obtained from Mead Western Meadows Filing I Final Drainage Study Addendum I, June 2005 and Mead Western Meadows Filing II Final Drainage Study, September 2005.

Sub-basin *115*

Sub-basin 115 contains Prairie Hills subdivision, which has been platted but not constructed, residential homes, industrial businesses, agricultural lands and the Town's Wastewater Treatment Plant. A swale has been proposed to intercept and convey runoff from sub-basin 114 to Evans Gulch.

Sub-basin *124*

Sub-basin 124 contains Coyote Run subdivision. This subdivision generates 224 cfs during the major (100-yr) storm event. These flows are detained at the existing 6'x7' concrete box culvert crossing the Great Western Railroad. The flows and percent impervious values were obtained from Coyote Run Filing No. 1 Final Drainage Report prepared by Rocky Mountain Consultants, Inc., December 2001.

Sub-basin *128*

Sub-basin 128 contains Vale View Second Phase subdivision. This subdivision generates 91 cfs during the major (100-yr) storm event. The 100-yr flow and percent impervious values were obtained from Final Drainage Report for Vale View and Vale View Second Phase prepared by Park Engineering, May 1999 and March 2005, respectively. The C_5 value was interpolated based on the percent imperviousness of the sub-basin and the major soil group using Table RO-5 of Urban Storm Drainage Criteria Manual. The 10-yr flow was obtained from MMP.

Sub-basin *130*

Sub-basin 130 contains Vale View and Margil Farms Second Filing subdivisions. Vale View subdivision generates 159 cfs during the major (100-yr) storm event. The 100-yr flow and percent impervious values were obtained from Final Drainage Report for Vale View prepared by Park Engineering, May 1999. The C_5 value was interpolated based on the percent imperviousness of the sub-basin and the major soil group using Table RO-5 of Urban Storm Drainage Criteria Manual. The 10-yr flow was obtained from MMP. Margil Farms Second Filing contributes 30 cfs during the 100-yr major storm. This information was obtained from

Drainage Report Margil Farms, Second Filing prepared by Park Engineering Consultants, October 2001.

Sub-basin ***216***

Sub-basin 216 contains Margil Farms First Filing subdivision. Margil Farms First Filing subdivision generates 141 cfs during the major (100-yr) storm event. The 100-yr flow, C_5 and percent impervious values were obtained from Technical Addendum to the Final Drainage Report for Margil Farms 1st Filing prepared by Drexel Barrell & Co., August 1999. The 10-yr flow was obtained from MMP.

Sub-basin ***218***

Sub-basin 218 contains Margil Farms First Filing subdivision. Margil Farms First Filing subdivision generates 42 cfs during the major (100-yr) storm event. The 100-yr flow, C_5 and percent impervious values were obtained from Technical Addendum to the Final Drainage Report for Margil Farms 1st Filing prepared by Drexel Barrell & Co., August 1999. The 10-yr flow was obtained from MMP.

North I-25 Basin

The North I-25 Basin contains 3 sub-basins (127, 134 and 220). Historic parameters and flows from each sub-basin are presented in Table 4. Sub-basins that incurred changes to existing conditions are listed in bold italics and changes are explained following the table.

Table 4. North I-25 Basin—Existing Parameters and Flows.

Sub-basin	Description	Existing Parameters			Existing Flow (cfs)	
		Area (Ac)	C_5	%I	10-year	100-year
127	Vale View I	96.63	0.15	12	37	101
134	Margil Farms 2nd Filing	186.77	0.10	2	68	251
220	Margil Farms 1st Filing	264.45	0.12	3	66	371

Sub-basin ***127***

Sub-basin 127 contains Vale View I subdivision. Vale View I subdivision generates 76 cfs during the major (100-yr) storm event. The 100-yr flow and percent impervious values were obtained from Final Drainage Report for Vale View prepared by Park Engineering, May 1999. The C_5 value was interpolated based on the percent imperviousness of the sub-basin and the major soil group using Table RO-5 of Urban Storm Drainage Criteria Manual. The 10-yr flow was obtained from MMP.

Sub-basin ***134***

Sub-basin 134 contains Margil Farms Second Filing subdivision. Margil Farms Second Filing subdivision generates 101 cfs during the major (100-yr) storm event. The 100-yr flow and percent impervious values were obtained from Final Drainage Report for Vale View prepared by Park Engineering, May 1999. The C_5 value was interpolated based on the percent imperviousness of the sub-basin and the major soil group using Table RO-5 of Urban Storm Drainage Criteria Manual. The 10-yr flow was obtained from MMP.

Sub-basin ***220***

Sub-basin 220 contains Margil Farms First Filing subdivision. Margil Farms First Filing subdivision generates 137 cfs during the major (100-yr) storm event. The 100-yr flow, C_5 and percent impervious values were obtained from Technical Addendum to the Final Drainage Report for Margil Farms 1st Filing prepared by Drexel Barrell & Co., August 1999. The 10-yr flow was obtained from MMP.

3. UPDATE TO PROPOSED DRAINAGE SYSTEM IMPROVEMENTS

Using flows from the MMP and new development's drainage reports SWMM analysis, proposed culverts, channels, storm sewers, detention ponds and other drainage system components are detailed herein. The following is a summary of the findings for each updated sub-basin within the study area.

Foster Reservoir Basin

The Foster Reservoir Basin is still largely undeveloped. All cost associated with the proposed improvements within this basin will be incurred by developers. Fully developed discharges from each sub-basin as well as release rates are shown in Table 5.

Table 5. Foster Reservoir Basin—Fully Developed Parameters, Flows and Release Rates.

Sub-basin	Description	Fully Developed Parameters		Fully Developed Flow (cfs)		Fully Developed Release Rate (cfs)
		C_5	%I	10-year	100-year	
100	Sub-basin 100	0.36	30	310	791	0.023 cfs/ac
102	Sub-basin 102	0.76	82	106	193	27 cfs
200	Offsite sub-basin 200	0.33	27	173	464	0.023 cfs/ac
202	Offsite sub-basin 202	0.25	14	58	152	0.023 cfs/ac

Sub-basins 100, 200 and 202

It is proposed herein that all developments with in these sub-basins be detained and released at a rate that does not exceed the capacity of the existing culvert (24" RCP) under Highway 66 to prevent overtopping and downstream mitigation measures. The upstream water surface elevation of the culvert must have 1 foot of freeboard below the road crest. The rate associated with this capacity has been calculated to be 0.023 cfs/ac. The storage anticipated with this release rate shall be distributed upstream of the culvert and throughout the future developments in these three sub-basins. Future developers should incur all costs involved with this.

Sub-basin 102

It is proposed herein that all developments with in this sub-basin be detained and released at a rate that does not exceed the capacity of the existing culverts (28"X18" HECMP and 24" RCP) under Highway 66 and maintains an upstream water surface elevation of 1 foot below the road

crest. The rate associated with this capacity has been calculated to be 27 cfs. Currently, approximately four acre-feet of detention is available directly upstream of the culvert. However, more detention is required to achieve this release rate and future developers should incur all costs for this detention.

Mulligan Lake Basin

The Mulligan Lake Basin is largely developed. Fully developed discharges from each sub-basin as well as release rates are shown in Table 6.

Table 6. Mulligan Lake Basin—Fully Developed Parameters, Flows and Release Rates.

Sub-basin	Description	Fully Developed Parameters		Fully Developed Flow (cfs)		Fully Developed Release Rate (cfs)
		C_5	%I	10-year	100-year	
101	Hunters Ridge	0.25	6	16	55	55
103	Mulligan Reservoir	0.66	62	665	1312	414
104	Hunters Cove	0.35	8	39	110	48
105	Sub-basin 105	0.25	14	66	201	48
106	Sub-basin 106	0.25	14	59	171	29
110	Mulligan Lake Estates	0.35	22	112	301	301
111	Singletree Estates	0.12	7	75	250	250
119	Sub-basin 119	0.61	63	287	560	0.23 cfs/ac

Sub-basin 101

Most of this sub-basin is developed. A small portion to the south of Hunters Ridge remains undeveloped. This area must be analyzed in order to determine the 10-yr historic flow, which will be the developed runoff rate released from the proposed development. Runoff from sub-basin 101 will enter Swale "A" along the west side of CR 7. This swale is inadequate to convey 100-year fully developed flows and the culverts under CR 7 at CR 32 will not convey 100-yr fully developed flows. The Town, in conjunction with Range View Estates developer, will construct a regional detention pond to detain basin 101 and 106 at the northwest corner of CR 7 and CR 32. All existing and proposed conveyance will accommodate runoff associated with this sub-basin. Storm water from this sub-basin will flow under CR 32 to the proposed detention pond, then under CR 7 from the pond outlet, and finally along CR 32 in swale C to be constructed by the Town and then into the Singletree drainage channel. Future developers will incur 100% of the cost of the improvements to Swale "A", reach 1. The town will incur 100% of the cost to improve Swale "A", reach 2, and to construct the regional detention pond at the northwest corner of CR 7 and CR 32. Rangeview Estates will participate in the detention pond by enlarging it to detain basin 106 when Rangeview goes to construction.

Sub-basin 103

Most of sub-basin 103 is currently undeveloped. The 10-year historic release rate from the sub-basin is 414 cfs. Any undeveloped areas must be analyzed in order to determine the 10-yr historic flow, which will be the developed runoff rate released from the proposed development. Future developers may make an agreement with the Owner of Mulligan Reservoir to store fully developed stormwater runoff in the reservoir during storm events. All existing and proposed conveyance will accommodate runoff associated with this sub-basin.

Sub-basin 104

This sub-basin is fully developed. Runoff from sub-basin 104 goes to the detention pond on the south side of CR 32.

Sub-basin 105

Most of sub-basin 105 is currently undeveloped. The 10-year historic release rate from the sub-basin is 48 cfs. This sub-basin will outlet into the roadside channel, which is the Baugh Lateral Irrigation Channel, along the south side of CR 32. This channel will accommodate 100-yr developed flow runoff. Future developers will incur any costs associated with upgrading this channel and will coordinate with the irrigation company or will construct a different conveyance alternative.

Sub-basin 106

Most of sub-basin 106 is currently undeveloped, but is in the process of being platted as Range View Estates. The 10-year historic release rate from the sub-basin is 29 cfs. This sub-basin currently outlets into the roadside channel along the west side of CR 7. A regional detention pond is proposed at the NW corner of CR 32 and CR 7, that will intercept this basin. The existing culverts under CR 7 at the intersection with CR 32 should be analyzed and determined if replacement is necessary in order to convey 100-yr developed flows after the detention pond is constructed. Also, Swale "C" must accommodate 100-yr developed flow runoff. Future developers may incur 9% of the costs associated with upgrading this swale, but at this time Swale "C" is slated for construction in the summer of 2007 with construction of Adams Avenue and the regional detention pond in sub-basin 106.

Sub-basins 110 and 111

Runoff from these sub-basins will enter the wetlands/detention area at the culvert under I-25. The existing Mulligan Lake drainage channel along the north side of CR 32 requires re-grading in order to raise the capacity to accommodate runoff from sub-basin 110. The homeowner's

association of Mulligan Lake Estates should incur 100% of the cost of this project. The Town will construct Swale "C" as a roadside ditch. The two, Mulligan Lake drainage channel and Swale "C", will combine at the west end of the Singletree swale.

Sub-basin 119

It is proposed herein that all developments with in this sub-basin be detained and released at a rate that does not exceed the capacity of the existing culverts under I-25 and maintains an upstream water surface elevation of 1 foot below the road crest. The rate associated with this capacity has been calculated to be 0.23 cfs/ac. Approximately 20 acre-feet of detention is required to achieve this release rate and future developers should incur all costs for this detention.

North Creek Basin

Fully developed discharges from each sub-basin as well as release rates are shown in Table 7.

Table 7. North Creek Basin—Fully Developed Parameters, Flows and Release Rates.

Sub-basin	Description	Fully Developed Parameters		Fully Developed Flow (cfs)		Fully Developed Release Rate (cfs)
		C_5	%I	10-year	100-year	
107	Sub-basin 107	0.44	40	117	252	37
108	Sub-basin 108	0.40	36	231	545	68
109	Sub-basin 109	0.50	45	20	44	44
112	Western Meadows	0.46	44	308	697	92
113	Sub-basin 113	0.50	50	38	78	78
114	Sub-basin 114	0.57	55	73	150	150
115	Prairie Hills	0.58	57	121	243	242
116	Sub-basin 116	0.50	47	283	611	92
117	Sub-basin 117	0.25	19	47	134	1.03 cfs/ac
118	Sub-basin 118	0.53	53	100	206	14
120	Sub-basin 120	0.31	24	83	218	56
122	Sub-basin 122	0.25	14	58	166	18
123	Sub-basin 123	0.34	28	60	150	19
124	Coyote Run	0.25	14	92	276	340
125	Sub-basin 125	0.66	70	150	281	1.59 cfs/ac
126	Sub-basin 126	0.45	43	184	410	1.28 cfs/ac
128	Vale View II	0.20	10	61	166	130
130	Vale View I, Margil Farms 2nd Filing, Coyote Run	0.12	6	88	436	255
132	Sub-basin 132	0.37	12	85	252	252
133	Sub-basin 133	0.35	8	43	110	43
204	Offsite sub-basin 204	0.38	32	509	1191	0.47 cfs/ac
206	Offsite sub-basin 206	0.40	32	214	495	0.47 cfs/ac
210	Offsite sub-basin 210	0.36	32	186	450	0.47 cfs/ac
212	Offsite sub-basin 212	0.24	14	96	257	75
214	Offsite sub-basin 214	0.31	23	368	917	205
216	Margil Farms 1st Filing	0.50	50	87	184	40
218	Margil Farms 1st Filing	0.56	57	56	112	12

Sub-basins 107

Sub-basin 107 is currently undeveloped. The 10-year historic release rate from the sub-basin is 37 cfs. To alleviate flooding problems downstream of the sub-basin, drainage should enter the existing storm system located at the intersection of CR 7 and CR 34. The storm system should then convey storm water east to proposed Swale "E" located along CR 34 to 2-36" culverts under CR 34. Storm water will then enter the drainage ditch, which is tributary to North Creek. All existing and proposed conveyance will accommodate runoff associated with this sub-basin. Future developers will incur 14% of the cost of improvements to Swale "E". Future developers will incur the cost of any other storm system improvements.

Sub-basins 108

Sub-basin 108 is currently undeveloped. The 10-year historic release rate from the sub-basin is 68 cfs. To prevent minor flooding of the school grounds, drainage should be diverted from the schools to proposed Swale "D" which flows around the perimeter of the school grounds. The stormwater should then enter the existing storm system located at the intersection of CR 7 and CR 34, which conveys storm water to Swale "E" along CR 34 to 2-36" culverts under CR 34. Storm water will then enter the drainage ditch, which is tributary to North Creek. All existing and proposed conveyance will accommodate runoff associated with this sub-basin. Future developers will incur 25% of the cost of improvements to Swale "E". Future developers will incur 100% of the cost of improvements to Swale "D". Future developers will incur the cost of any other storm system improvements.

Sub-basin 109

A small portion of the runoff from this sub-basin enters the existing storm system located at the intersection of CR 7 and CR 34 via swales along CR 34. Another small portion of the runoff from this sub-basin enters the Western Meadows storm system along the west side of 7th Street. The rest of the runoff from this sub-basin should flow into proposed storm system B-B. It currently flows along 6th Street and across Palmer Avenue to an existing swale. The existing swale runs into a field/irrigation tailwater ditch, and should be improved to ensure capacity and directed to proposed system B-B. This system should be designed to convey peak 10-yr storm water runoff at a minimum. The Town should be fully responsible for the estimated cost of this storm system.

Sub-basin 112

Sub-basin 112 is comprised of Western Meadows I and II subdivisions. Drainage from this sub-basin and future and current developed portions of sub-basins 204, 206, 210 and 120 drain

to a culvert under CR 7. This culvert is currently undersized to convey 100-year storm water flows. Three 60-inch RCPs should be added to the existing 60-inch CMP in order to adequately convey anticipated future fully developed flows. The homeowner's association of Western Meadows subdivision will be responsible for 12% of the cost of this upgrade.

Sub-basin 114

Run-off from sub-basin 114 should flow into proposed storm-systems A-A and B-B, which together will drain most of the Old Town area. System A-A has been designed but not constructed. It will convey drainage between Welker and Martin Avenues across 3rd Street at Martin, and into the existing culverts under the railroad. System B-B will convey drainage from Martin to Palmer, along 3rd Street to North Creek. These systems should be designed to convey peak 10-yr storm water runoff. The Town should be fully responsible for the estimated cost of these storm systems.

Sub-basin 115

Most of this sub-basin is developed. The Prairie Hills development is to be constructed soon. All drainage components were designed to accommodate 100-year stormwater runoff. The Coop constructed a new building and a detention pond in 2006 that may enable the Prairie Hills offsite channel to be reduced in size.

Sub-basin 116

Sub-basin 116 is currently undeveloped. The 10-year historic release rate from the sub-basin is 92 cfs. Drainage facilities within the sub-basin should discharge to Swale "E". The stormwater should then enter 2-36" culverts under CR 34. Storm water will then enter the drainage ditch, which is tributary to North Creek. All existing and proposed conveyance will accommodate runoff associated with this sub-basin. Future developers will incur 17% of the cost of improvements to Swale "E" while the town will incur 44%.

Sub-basin 120

A portion of sub-basin 120 is comprised of North Creek subdivision. Drainage from this subdivision and future developed portions of this sub-basin and sub-basins 204, 206, 210 drain to a culvert under CR 34-1/2 and a culvert under CR 7. The culvert under CR 34-1/2 is undersized to convey 100-year storm water flows. A 16'x4' RCB should replace the existing culverts in order to adequately convey anticipated future fully developed flows. The homeowner's association of North Creek subdivision will be responsible for 5% of the cost of this upgrade. The developers of the remaining, undeveloped portion of this sub-basin will be

responsible for 6% of the cost of this upgrade. The culvert under CR 7 is currently undersized to convey 100-year storm water flows. Three 60-inch RCPs should be added to the existing 60-inch CMP in order to adequately convey anticipated future fully developed flows. The homeowner's association of North Creek subdivision will be responsible for 4% of the cost of this upgrade. The developers of the remaining, undeveloped portion of this sub-basin will be responsible for 6% of the cost of this upgrade.

Sub-basin 124

Sub-basin 124 is currently comprised of undeveloped land and Coyote Run subdivision. Detention for the sub-basin is currently provided at the culvert for the north branch of North Creek under the Great Western railroad tracks. No structural improvements are proposed for this sub-basin. The 100-yr water surface elevation of this detention should be maintained. Therefore, any future developments are responsible for the analysis of this detention and storm systems that will maintain the discharge and volume of water released into the main stem of North Creek.

Sub-basin 128

Fully developed sub-basin 128 contains a portion of the Vale View Phase II and Lake Hollow Estates developments. All drainage components were designed to accommodate 100-year stormwater runoff.

Sub-basins 130

Sub-basin 130 consists of Coyote Run, Vale View I, and Margil Farms 2nd Filing subdivisions. Most of this sub-basin is developed. A small portion to the east and southeast of Coyote Run remains undeveloped. This area must be analyzed in order to determine the 10-yr historic flow, which will be the developed runoff rate released from the proposed development. All existing and proposed conveyance will accommodate runoff associated with this sub-basin. Future developers will incur the cost of any improvements.

North I-25 Basin

The North I-25 Basin is largely developed. All cost associated with the proposed improvements within this basin will be incurred by developers. Fully developed discharges from each sub-basin as well as release rates are shown in Table 8.

Table 8. North I-25 Basin—Fully Developed Parameters, Flows and Release Rates.

Sub-basin	Description	Fully Developed Parameters		Fully Developed Flow (cfs)		Fully Developed Release Rate (cfs)
		C_5	%I	10-year	100-year	
127	Vale View I	0.36	30	310	791	76 cfs
134	Margil Farms 2nd Filing	0.76	82	106	193	43 cfs
220	Margil Farms 1st Filing	0.33	27	173	464	1.0 cfs/ac

Sub-basins 127

Sub-basin 127 consists of a portion of Vale View I subdivision. Most of this sub-basin is developed. A small portion to the south of Vale View I remains undeveloped. This area must be analyzed in order to determine the 10-yr historic flow, which will be the developed runoff rate released from the proposed development. A culvert under the Great Western Railroad tracks should be installed as this area is developed to handle the storm water. Future developers will incur the cost of this improvement.

Sub-basins 134

Sub-basin 134 consists of a portion of Margil Farms 2nd Filing. Most of this sub-basin is developed. A small portion to the northeast of the 2nd Filing remains undeveloped. This area must be analyzed in order to determine the 10-yr historic flow, which will be the developed runoff rate released from the proposed development.

Sub-basins 220

Sub-basin 220 consists of a portion of Margil Farms 1st Filing. Most of this sub-basin is undeveloped. The 100-yr developed release rate associated with this sub-basin has been calculated to be 1 cfs/Ac. All existing and proposed conveyance will accommodate runoff associated with this sub-basin with costs for improvement incurred by the developer.

4. CONCLUSIONS

This report is an addendum to the Drainage Master Plan for the Town of Mead, Colorado, 1998. This report is intended to be a planning tool used by the Town and developers to adequately plan developments and facilities to meet storm drainage criteria. As developments and facilities are designed and constructed, the CUHP/SWMM computer modeling should be updated by the developer and submitted to the Town Engineer and should reflect changes from the original assumptions and verify that proposed developments will work from a storm drainage standpoint.

Table 9. Summary of Cost Estimates.

Basin Number	Description	Estimated Flow, cfs	Town Share		Developer Share		Off-site Developer Share		HOA Share	
			Flow, cfs	Percent	Flow, cfs	Percent	Flow, cfs	Percent	Flow, cfs	Percent
101	Swale "A" reach 2	55	55	100	0	0	0	0	0	0
	Culvert 568	55	55	100	0	0	0	0	0	0
104	Swale "B"	103	103	100	0	0	0	0	0	0
106	Swale "C"	330	0	0	29	9	0	0	0	0
110	Swale "C"	330	0	0	0	0	0	0	301	91
107	Swale "E"	270	0	0	37	14	0	0	0	0
108	Swale "D"	68	00	0	68	100	0	0	0	0
	Swale "E"	270	0	0	68	25	0	0	0	0
109, 114	Storm System A-A	52	52	100	0	0	0	0	0	0
112	Culvert 615	511	0	0	0	0	0	0	73	12
116	Swale "E"	270	119	44	46	17	0	0	0	0
120	Culvert 618	511	0	0	32	6	455	89	24	5
	Culvert 615	577	0	0	32	5	455	79	24	4

5. REFERENCES

1. Armfield Engineering, Inc. 2005. Final Drainage Report Prairie Hills Subdivision Filing 1. September.

2. Drexel Barrell & Co. 1999. "Final Drainage and Erosion Control Report for Margil Farms 1st Filing. August 25.

3. Management & Consulting Services, Inc. 1995. Drainage Report for Feather Ridge Estates. November 2.

4. Park Engineering Consultants. 1999. Final Drainage Report Vale View. May 12.

5. Park Engineering Consultants. 2000. Addendum to Drainage Report Margil Farms, Second Filing. September 28.

6. Park Engineering Consultants. 2000. Drainage Report Margil Farms, Second Filing. October 26.

7. Pickett Engineering, Inc. 2005. Mead Western Meadows Filing II Final Drainage Study. September.

8. Pickett Engineering, Inc. 2005. Mead Western Meadows Filing I Final Drainage Study Addendum I. June.

9. Rocky Mountain Consultants, Inc. 2001. Coyote Run Filing No. 1 Final Drainage Report. December.

10. The Sear-Brown Group. 1998. Storm Drainage Criteria and Construction Standards Town of Mead. January.

11. The Sear-Brown Group. 1998. Drainage Master Plan Town of Mead (MMP). July.

12. Swift and Associates. Date Unknown. North Creek at Mead Final Drainage Report.

13. Swift and Associates. 1992. Drainage Report for Singletree Estates. December 21.

14. Urban Drainage and Flood Control District, "Urban Storm Drainage Criteria Manual", Volumes 1 and 2, dated June 2001, and Volume 3, dated September 1992.

15. Welsch Design Consultants, Inc. 2002. Mead Western Meadows Subdivision Filing No. 1 Final Drainage Report. August 6.