TOWN OF LYONS

BOULDER COUNTY, COLORADO

DRAINAGE MASTER PLAN

FINAL REPORT

April 1998

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Project No. 35600-002-0701

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1.0 EXECUTIVE SUMMARY

The Town of Lyons has experienced significant growth during the 1990's. Development within Lyons has resulted in an increase in the magnitude and frequency of stormwater runoff and placed greater demands on current drainage systems. Much of the Town's drainage infrastructure is undersized and nearing the end of its safe service life. Consequently, this Master Drainage Plan has been commissioned to identify problem areas, formulate a strategy to cost effectively upgrade the Town's flood control facilities, and provide feasibility-level cost analyses to enable subsequent capital budgeting.

DRAINAGE ISSUES IDENTIFIED BY THE STUDY

During the course of this study, significant drainage issues were encountered that underscore the need for comprehensive stormwater management in the Town. The most critical issues relate to the following:

The Town's Role in Drainage Matters Needs to Be Defined. Lyons historically has not been active in the management of stormwater. Most recent drainage and flood control facilities have been constructed by developers as part of subdivision approvals or the Colorado Department of Transportation (CDOT) in association with roadway projects within Highway 36/66. Lyons' role relating to ownership, maintenance, and funding on drainage projects need to be considered in the context of liability, current Town public works staff capacity and public support for earmarking revenues toward flood control.

A Framework for Resolution of Minor and Major Drainage Problems Should be Developed. At present there are several active and pending lawsuits within the Town relating to drainage. Minor system problems typically are found where the "Common Enemy Doctrine" is practiced, whereby landowners manage stormwater for individual benefit without adequate regard for potential damage to adjacent properties. In addition to identifying the Town's role in these matters as discussed above, a concept for resolving these minor system needs to be incorporated in the master drainage strategy.

Funding Mechanisms need to be identified and implemented. Stormwater projects are problematic because of the significant capital investment costs required and mixed public support. Other infrastructure needs, such as roadways, water supply and wastewater treatment commonly receive higher priorities in communities because capacity limitations in these systems are more easily recognized. Drainage problems are manifested on a more infrequent basis, but can cause a far more significant negative fiscal impact. Additionally, residents that are less prone to flooding (on higher ground) feel less need to support projects than those adjacent to or within major drainageway floodplains although their development worsens drainage problems downstream. The Town should conduct a survey to determine the level of support for flood control projects to select the appropriate form of funding.

Core Areas of Town Need to Be Protected as Upland Development Patterns Continue. Development above the older portions of Town, including the Central Business District, will exacerbate drainage problems. Outfalls for stormwater need to be better defined with formalized channels, roadways, and storm sewers designed to covey developed flow rates. The challenge will be to select and implement the best combination of conveyance elements and stormwater detention in the developing areas.

MASTER PLANNING THEMES

Drainage problems tend to be ubiquitous in that they require comprehensive solutions. Piece-meal approaches frequently only shift the burden to other locations. Improvements generally must be phased to match available funds and therefore a master plan must be long-term focused. The Town of Lyons will be confronted with the advantage of growth relative to potential funding sources, but also with the disadvantage of an undersized drainage system that will be subject to damage if no improvements are made to accommodate the increased runoff generated by development. Cognizant of these factors, the following guiding principles have been adopted in this study:

Incorporate existing infrastructure to the maximum extent possible to solve ultimate system needs. The most cost-effective solutions will utilize and augment existing drainage facilities. In some instances this will entail using existing available capacity as part of a permanent solution to defray costs and in others will consist of integrating the system on an interim basis to defer capital expenditures.

Employ multi-purpose strategies that encourage open space amenities and recreational opportunities that are consistent with the Lyons Comprehensive Plan. Open channels associated with natural drainageways will represent a cost effective means of conveying drainage through the Town. Also, stormwater detention facilities can be designed to provide open space and recreational benefits such as parks within public lands or private development.

Create major Town outfalls using the highway, old railroad, and public right-of-way currently available. To minimize the cost of easement or right-of-way acquisition, the plans should take full advantage of the facilities and properties owned by the town to create improved outfalls to St. Vrain Creek. This will entail working with CDOT for upgrade of the system when future roadway improvements are made and incorporation of drainage facilities into future town roadway projects (such as the future paving of 4th Avenue).

Work with the development community to provide increased stormwater detention to enable the downsizing of conveyance facilities across developed portions of town or to completely obviate the need for capital improvements in these areas. In many cases stormwater detention facilities can be located to store stormwater and to regulate the discharge to the capacity of the current system. In these cases the cost of the detention facilities must be compared with the savings and downsizing or foregoing storm sewer costs across the existing town.

Key points of the recommended plan. Individual drainage improvements must be identified on a basin by basin basis. At this junction the overall program cost is estimated to be $2.57 million, which would be implemented over a multi-year capital improvement program. The most critical drainage improvement needs are enumerated below in order of priority.

- Make a determination on the ownership of the stormwater impoundment located on the Boone property and incorporate the facility into the overall drainage plan to protect existing properties in the area. This will require reconfiguration of the pond and outlet structure to maintain 5 acre-feet (AF) of active storage.
- Construction of a new 5.6 AF detention pond within the area of the Steamboat Valley and Sierra Roja Subdivisions.
- Construction of a new storm sewer outfall system within Fourth Avenue as part of planned roadway improvements in 1999.
- Work with CDOT to incorporate storm sewer upgrades in Highway 36/66 for inclusion in 5 year CIP.
- Construction of 3.7 AF detention pond west of the cemetery above the Upper Fourth Avenue drainage basin.
- Construction of a 3.0 AF detention pond east of the cemetery in the Upper Third Avenue drainage basin.
- Construction of a 3.0 AF detention pond in the eastern Lyons drainage basin.
- Install a 100-year diversion canal (900 LF) in the Ewald drainage.
- Install new cross-culverts along the existing Steamboat Valley drainageway through Town.
- Construct lower basin open channel and storm sewer improvements in the Upper Third Avenue drainage basins.
- Construct lower basin open channel and storm sewer improvements in the Second Avenue drainage basins.

2.0 HYDROLOGY

Climatological conditions in the vicinity of the town of Lyons produce relatively minor amounts of precipitation under normal conditions. However, when intense rainstorms stall over the region, stormwater runoff is rapid and fierce in the steep foothills surrounding the town. The semi-arid climate supports only sparse vegetation of grasses and a few pine trees. These conditions with relatively little plant cover and organic matter in the soil to store runoff and promote infiltration results in rapid generation of runoff during intense rainfall events. Further, the rocky soils and steep hillside slopes generate runoff quickly.

RAINFALL

Rainfall depths for Lyons have been obtained from the Urban Drainage & Flood Control District's Drainage Criteria Manual, Volume 1 Depth – Duration – Frequency map figures. Point data for the 1-hour duration are shown below:

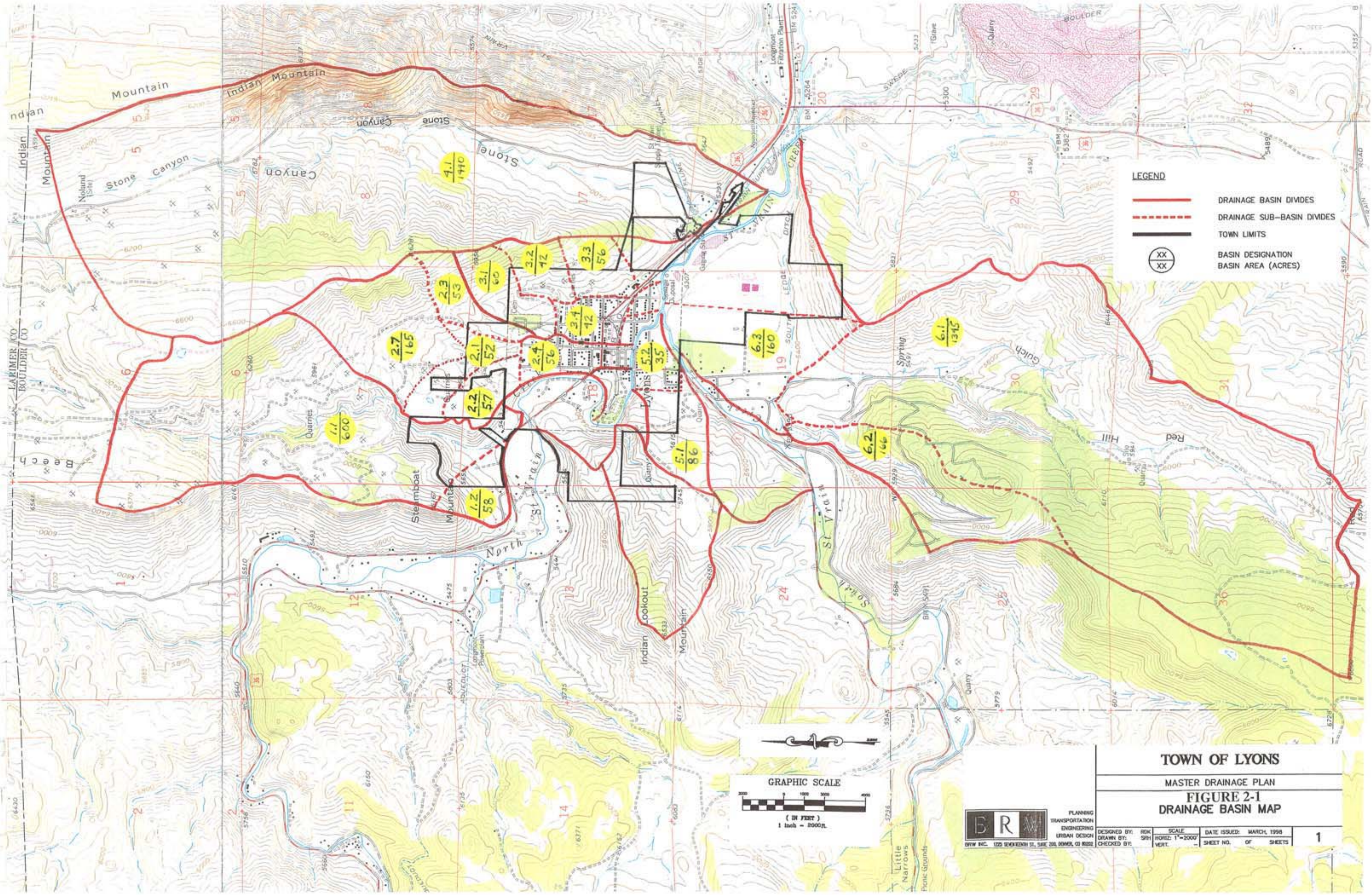
2-Year	1.04 inches
5-Year	1.45 inches
10-Year	1.72 inches
50-Year	2.40 inches
100-Year	2.70 inches

BASIN CHARACTERISTICS

The town of Lyons is located at the confluence of North and South St. Vrain Creeks and join to form the St. Vrain Creek. These three waterways are the receiving water bodies for stormwater drainage through the town. The hydrology of the St. Vrain Creek system is discussed in the **Floodplain Management**, Section 4.0, of this report. The smaller local basins directly affecting the town are shown on the **Drainage Basin Map, Figure 2-1** from the USGS 7½ minute quadrangle maps. There are six primary drainage basins through the town of Lyons as shown on the map and described below which necessitate a stormwater management program:

- Eagle Canyon basin,
- Steamboat Valley basin,
- Eastern Lyons basin,
- Stone Canyon basin,
- Ewald basin, and
- Red Hill Gulch basin.

Eagle Canyon basin is located northwest of the town center and is a north bank tributary to the North St. Vrain Creek. The Eagle Canyon watershed is approximately 650 acres, with a high point elevation at 6,680 feet and an outfall at approximately 5,400 feet. The average slope of the drainageway is over 7%. The majority of this basin is expected to remain undeveloped due to the steep cliffs in the upper reaches, although a new


LEGEND
DRAINAGE BASIN DIVIDES
DRAINAGE SUB-BASIN DIVIDES
TOWN LIMITS
BASIN DESIGNATION
BASIN AREA (ACRES)
GRAPHIC SCALE
(IN FEET)
1 inch = 2000ft.
TOWN OF LYONS
MASTER DRAINAGE PLAN
FIGURE 2-1
DRAINAGE BASIN MAP
PLANNING
TRANSPORTATION
ENGINEERING
URBAN DESIGN
DESIGNED BY: RDK
DRAWN BY: SRH
CHECKED BY:
SCALE
HORIZ: 1"=2000'
VERT. -
DATE ISSUED: MARCH, 1998
SHEET NO. OF SHEETS
1
Indian Mountain
Stone Canyon
Steamboat Mountain
Indian Lookout Mountain
Red Hill
Spring Gulch
North St Vrain
South St Vrain
Lyons
Beech
LARIMER CO
BOULDER CO
4.1
1440
3.3
56
3.2
42
3.1
60
2.3
53
3.4
42
2.7
165
2.1
52
2.4
56
5.2
35
6.3
160
6.1
1345
2.2
57
1.1
600
5.1
86
6.2
166
1.2
58

residential development is rapidly transforming the low-lying areas. The new subdivision of Eagle Canyon Estates is located in this basin, and a detention pond has recently been constructed to regulate stormwater runoff from this urbanization. There is currently a lawsuit pending concerning the discharge of the detention pond across Highway 36 onto an adjacent field.

Steamboat Valley basin has the greatest impact to Lyons and is located directly north of town through the heart of downtown. Drainage from this 383 acre basin flows through the center of Lyons and is conveyed primarily in an old stone box culvert between 4th and 5th Avenues. The upper reaches of this basin are being developed for the Sierra Roja and Steamboat Valley Subdivisions. The historic detention pond created by the old railroad embankment located on the Boone property is an issue of major concern and is discussed later in this report.

The drainage basin referred to as Eastern Lyons includes the west facing slopes of the hogback which drain into 2nd and 3rd Avenues. The watershed is approximately 200 acres with steep slopes of 30 – 40% in the upper reaches and 4 – 5% in the low reaches through town. As the community continues to rapidly grow, these hillsides are being developed with residences along Longs Peak Drive and Kelling Drive. Presently, no formal drainage system exists within this basin until Main Street where pipes convey the runoff under the highway to an open channel that discharges into the S. Vrain Creek.

Stone Canyon is a large undeveloped basin east of town with a 1,440 acres watershed. The elevation of the basin ranges from 6,591 feet at the ridgeline to 5,290 feet at the highway. A defined drainage channel exists at the base of the drainage although it is dry during most of the year except during storm events or snowmelt. A 71-unit subdivision is proposed in Stone Canyon, and a drainage report dated May 1997 was prepared by Drexel Barrell & Co. to address impacts from development. A detention pond created by a proposed roadway will limit discharges to historic levels.

The drainage above Ewald Avenue on the west side of town has proven to be a concern in the August 1994 flood. The 15% slopes of the 120-acre drainage produced a debris flow during the storm that washed out the residential streets in 1994. The upper two-thirds of the basin is undeveloped and the lower one-third is medium density residential development between the North and South St. Vrain Creeks. Constructing any detention facilities in the basin is impractical on the steep slopes since no defined drainage channel exists.

The Red Hill Gulch drainage is located south of the town and stormwater has primarily been managed with the use of irrigation ditches to route stormwater around development. The steep (10 – 20% sloped) upper reaches of this basin extending up to elevation 6,800 feet are largely undeveloped. Only the flat (1.6% average slope) lowlands at elevation 5,320 to 5,400 feet are being developed. This 1,670-acre drainage basin has the potential to concentrate a large volume of runoff onto development in an extreme event, but typically the South Ledge Ditch and network of laterals intercept nuisance flows. Experience has shown that using irrigation ditches to manage runoff can create problems by either importing additional stormwater runoff into the basin, or exporting it until a weak point in the ditch system is reached and the bank becomes breached.

CUHP / UD-SWM MODEL

Hydrologic models have been developed to simulate developed stormwater runoff rates and volumes using the Urban Drainage & Flood Control District CUHP (Colorado Urban Hydrograph Procedure) and UD-SWMM (Urban Drainage Storm Water Management Model) programs. Input data for CUHP (a synthetic hydrograph program) are presented in **Table 2-1**. Data for hydrograph routing through existing and proposed detention facilities in the UD-SWMM program is included in **Table 2-2**. **Figure 2-2** illustrates the routing diagram for computation of flood flow discharges.

TABLE 2-1
CUHP Input
Lyons Drainage Master Plan

Basin ID	Drainage Basin	Area (acres)	*Area (sq. mi.)*	Low Elevation (feet)	Upper Elevation (feet)	Length of Drainageway (feet)	*Length of Drainageway (miles)*	Length to Centroid (feet)	*Length to Centroid (miles)*	Slope of Catchment (ft/ft)	Imperv-iousness (%)	Ti (min)
1.1	Eagle Canyon	600	*0.938*	5400	6680	12600	*2.386*	6500	*1.231*	0.055	7%	
1.2	Lower Eagle Canyon	58.22	*0.091*	5420	6167	3300	*0.625*	1600	*0.303*	0.060	16.91%	28.3
	TOTAL	**658.22**										
2.7	Upper Steamboat Valley	165	*0.258*	5500	6540	4700	*0.890*	2100	*0.398*	0.068	6%	
2.1	Steamboat Valley	52	*0.081*	5440	5500	3500	*0.663*	1600	*0.303*	0.054	6%	29.4
2.2	Upper Fifth Avenue	57	*0.089*	5445	5705	2500	*0.473*	1350	*0.256*	0.060	30%	23.9
2.3	Upper Fourth Avenue	53	*0.083*	5460	6281	4200	*0.795*	1900	*0.360*	0.072	12%	33.3
2.4	Lower Steamboat Avenue	56	*0.088*	5330	5450	2700	*0.511*	1400	*0.265*	0.043	50%	25.0
	TOTAL	**383**										
3.1	Upper Third Avenue	60	*0.094*	5420	6160	3800	*0.720*	1700	*0.322*	0.065	10%	31.1
3.2	Upper Stickney Street	42	*0.066*	5420	6040	2800	*0.530*	1000	*0.189*	0.076	13%	25.6
3.3	Upper Main Street	56	*0.088*	5335	5840	2300	*0.436*	800	*0.152*	0.072	10%	22.8
3.4	Middle Third Avenue	42	*0.066*	5330	5420	1850	*0.350*	800	*0.152*	0.047	50%	20.3
	TOTAL	**200**										
	Lower Third Avenue	16	*0.025*	5320	5345	800	*0.152*	450	*0.085*	0.031	40%	14.4
	Lower Second Avenue	14	*0.022*	5320	5340	1250	*0.237*	600	*0.114*	0.016	40%	16.9
	TOTAL	**30**										
	Lower Railroad	**35**	*0.055*	5310	5640	1500	*0.284*	500	*0.095*	0.070	16%	18.3
4.1	Stone Canyon	**1440**	*2.250*	5290	6591	20100	*3.807*	9800	*1.856*	0.037	3%	
5.1	Ewald Drainage	86	*0.134*	5400	5740	2200	*0.417*	1400	*0.265*	0.065	7%	22.2
5.2	Lower Ewald	35	*0.055*	5320	5400	1815	*0.344*	1000	*0.189*	0.028	40%	20.1
	TOTAL	**121**										
6.1	Red Hill Gulch	1345	*2.102*	5385	6800	19100	*3.617*	8250	*1.563*	0.052	4%	
6.2	Olson Gulch	166	*0.259*	5400	6480	8750	*1.657*	4700	*0.890*	0.060	3%	
6.3	South Lyons	160	*0.250*	5320	5400	5100	*0.966*	2500	*0.473*	0.016	33%	
	TOTAL	**1671**										

TABLE 2-2
Detention Pond Storage
Lyons Drainage Master Plan

Eagle Canyon *(Element 100)*

Elev. (ft)	Area (sq. ft)	Area (acres)	Volume (ac-ft)	Cum. Vol. (ac-ft)	Pipe Dia. (inches)	Outflow (cfs)	Velocity (ft/sec)
5420.00	0	0.000	0.00	0.00	24	0.0	0.0
5421.00	1693	0.039	0.01	0.01	24	0.0	0.0
5422.00	5920	0.136	0.08	0.10	24	4.0	1.3
5423.00	6887	0.158	0.15	0.24	24	7.5	2.4
5424.00	8302	0.191	0.17	0.42	24	11.0	3.5
5425.79	11000	0.253	0.40	0.81	24	14.2	4.5
5426.00	14000	0.321	0.06	0.87	24	18.3	5.8
5427.00	19000	0.436	0.38	1.25	24	38.1	12.1
5427.49	25100	0.576	0.25	1.50	24	58.2	18.5

Steamboat Valley *(Element 200)*

Depth (ft)	Area (sq. ft)	Area (acres)	Volume (ac-ft)	Cum. Vol. (ac-ft)	Pipe Dia. (inches)	Outflow (cfs)	Velocity (ft/sec)
0.00	0	0.00	0.00	0.00	48	0.0	0.0
2.50	16553	0.38	0.32	0.32	48	46.4	3.7
5.00	22651	0.52	1.12	1.44	48	113.5	9.0
9.00	33759	0.78	2.57	4.01	48	173.4	13.8
10.00	37897	0.87	0.82	4.83	48	185.4	14.8
11.00	41382	0.95	0.91	5.74	48	196.6	15.6

Boone Property *(Element 201)*

Elev. (ft)	Area (sq. ft)	Area (acres)	Volume (ac-ft)	Cum. Vol. (ac-ft)	Box Width (inches)	Outflow (cfs)	Velocity (ft/sec)
5431.0	0	0.000	0.00	0.00	30	0.0	0.0
5432.0	120	0.003	0.00	0.00	30	8.7	0.3
5433.0	195	0.004	0.00	0.00	30	24.5	0.8
5434.0	460	0.011	0.01	0.01	30	45.0	1.4
5435.0	1230	0.028	0.02	0.03	30	60.0	1.7
5436.0	2480	0.057	0.04	0.07	30	96.8	7.7
5437.0	3735	0.086	0.07	0.14	30	114.5	9.2
5438.0	5000	0.115	0.10	0.24	30	129.8	10.4
5439.0	7500	0.172	0.14	0.39	30	143.5	11.5
5440.0	11200	0.257	0.21	0.60	30	156.0	12.5
5441.0	17600	0.404	0.33	0.93	30	167.6	13.4
5441.1	18600	0.427	0.04	0.97	30	168.7	13.5
5442.0	21900	0.503	0.42	1.39	30	178.4	14.3
5443.0	27450	0.630	0.57	1.95	30	188.6	15.1
5443.8	29760	0.683	0.53	2.48	30	196.4	15.7
5444.0	32000	0.735	0.14	2.62	30	198.3	15.9
5445.0	34000	0.781	0.76	3.38	30	207.5	16.6
5446.0	36300	0.833	0.81	4.18	30	216.3	17.3
5446.4	38000	0.872	0.34	4.52	30	219.8	17.6

TABLE 2-2
Detention Pond Storage
Lyons Drainage Master Plan

4th Avenue Drainage *(Element 202)*

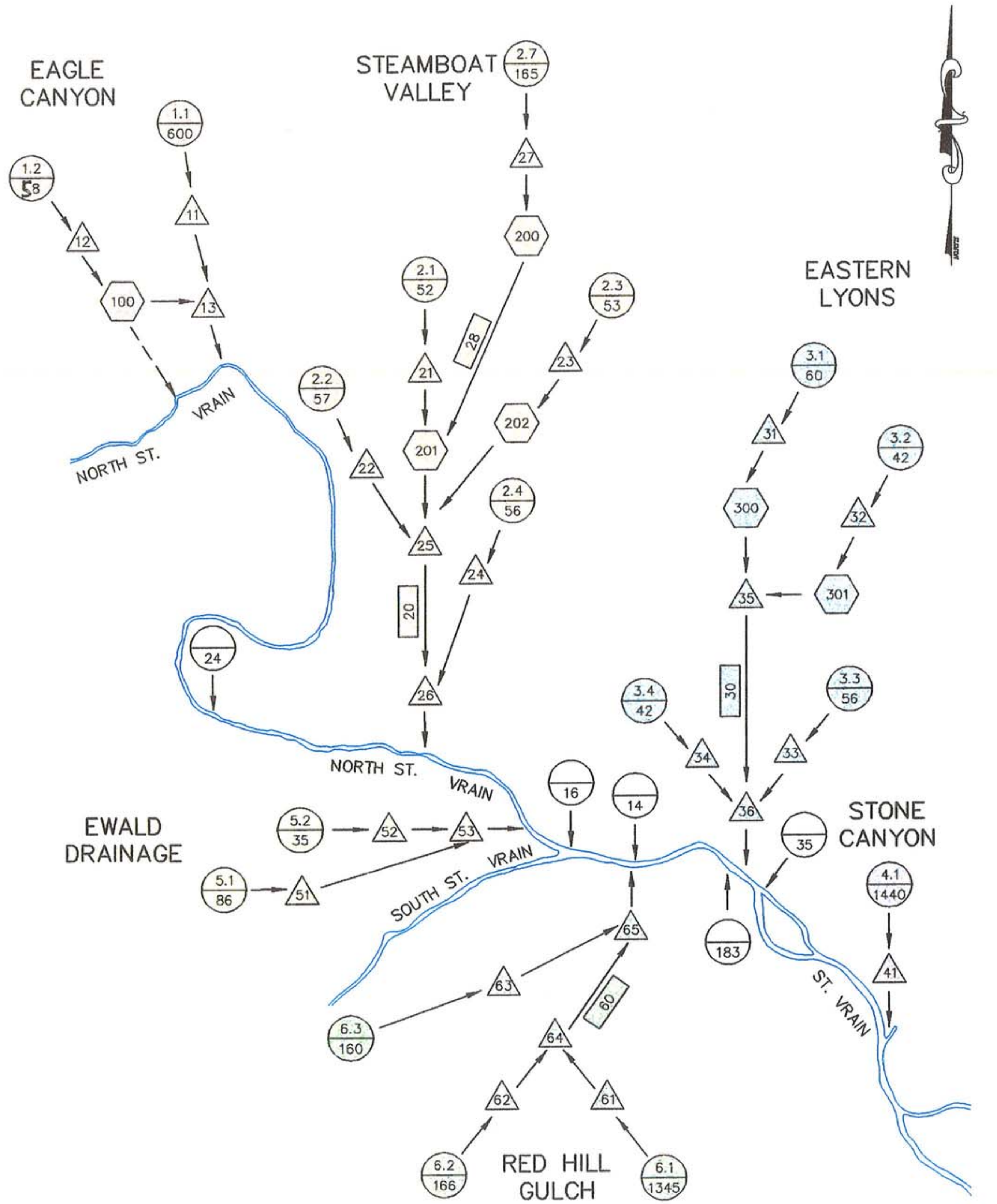
Depth (ft)	Area (sq. ft)	Area (acres)	Volume (ac-ft)	Cum. Vol. (ac-ft)	Pipe Dia. (inches)	Outflow (cfs)	Velocity (ft/sec)
0.00	0	0.000	0.00	0.00	24	0.0	0.0
2.50	10019	0.230	0.19	0.19	24	18.5	5.9
5.00	15246	0.350	0.72	0.91	24	30.3	9.6
9.00	23958	0.550	1.78	2.70	24	42.8	13.6
10.00	26136	0.600	0.57	3.27	24	45.4	14.4
11.00	29098	0.668	0.63	3.90	24	47.8	15.2

3rd Avenue Drainage *(Element 300)*

Depth (ft)	Area (sq. ft)	Area (acres)	Volume (ac-ft)	Cum. Vol. (ac-ft)	Pipe Dia. (inches)	Outflow (cfs)	Velocity (ft/sec)
0.00	0	0.000	0.00	0.00	30	0.0	0.0
2.50	7841	0.180	0.15	0.15	30	26.4	5.4
5.00	12197	0.280	0.57	0.72	30	45.8	9.3
9.00	15682	0.360	1.28	2.00	30	65.8	13.4
10.00	17424	0.400	0.38	2.38	30	69.9	14.2
12.00	19602	0.450	0.85	3.23	30	77.5	15.8

2nd Avenue Drainage *(Element 301)*

Depth (ft)	Area (sq. ft)	Area (acres)	Volume (ac-ft)	Cum. Vol. (ac-ft)	Pipe Dia. (inches)	Outflow (cfs)	Velocity (ft/sec)
0.00	0	0.000	0.00	0.00	24	0.0	0.0
2.50	6578	0.151	0.13	0.13	24	18.5	5.9
5.00	10672	0.245	0.49	0.62	24	30.3	9.6
9.00	19166	0.440	1.35	1.97	24	42.8	13.6
10.00	21780	0.500	0.47	2.44	24	45.4	14.4
12.00	27312	0.627	1.12	3.56	24	50.2	16.0



LYONS, COLORADO
DRAINAGE ROUTING DIAGRAM

LYONSR12

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PCP FILE: P:\PLTCFG\Colrhalf.PCP
DATE OF ISSUE: Mar 06, 1998 8:11am
THIS DRAWING IS CURRENT AS OF THE DATE OF ISSUE AND MAY BE SUBJECT TO CHANGE.

FIGURE 2-2

PLANNING
TRANSPORTATION
ENGINEERING
URBAN DESIGN
BRW INC. 1225 SEVENTEENTH ST., SUITE 200, DENVER, CO 80202

3.0 EXISTING CONDITIONS

HISTORY OF FLOODING

Lyons' residents have experienced floods since the area was first settled in the early 1860s. Although the construction of a town at the confluence of the North and South St. Vrain creeks provided a beautiful setting and quick access to water supplies, it has left the town vulnerable to periodic flooding. The semi-arid climate of the area can easily mislead residents into believing they are safe from flooding. The spare vegetation resulting from normally dry conditions combined with the steep mountain foothills makes Lyons subject to flash flooding during extreme precipitation events. The Town of Lyons is subject to flooding from two different sources: 1) flooding of the St. Vrain Creek, and 2) localized flash flooding within the drainages from intense rainstorms on the steep local basins around Lyons.

Flooding of the creek is usually the result of prolonged rainstorm activity in combination with rapid snowmelt. This type of flooding usually occurs in the late spring (May and June) when the riverbanks are flowing full due to spring runoff. North and South St. Vrain Creeks drain approximately 212 square miles of mountain area and join at Lyons to form the main stream of the St. Vrain Creek.

Flash flooding within the town results from heavy rainfall events in the summer (May through September) which overloads the storm drainpipes and channels. The foothills around Lyons act as cloud collection pockets for storm systems trapping and holding storms in the valley. Precipitation and temperature records are available for Longmont and Allenspark, Colorado. The average annual precipitation measured in nearby Longmont is 13 inches, with 9.4 inches of that falling in the months April through September. The maximum rainfall depth accumulated over a 24-hour period in Longmont was 4.04 inches, which occurred on May 9, 1957. The average annual precipitation at Allenspark is approximately 20.6 inches, with 17.5 inches occurring during April through September.

The relatively steep mountain drainages can funnel flash floods toward the town with little advanced warning. Preparing for inevitable future floods by regulating floodplains and constructing adequate drainage systems will help Lyons prevent major damage and potentially loss of life when the next extreme event occurs.

Significant floods occurred in Lyons in 1864, 1876, 1894, 1919, 1941, 1949, 1951, 1957, 1969 and 1994. The flood on May 31, 1894 was the largest on record and washed away 20 homes in the lower part of Lyons. A Longmont report described the situation saying, "...the entire lower portion of the town [Longmont] was washed away. Large houses and barns were swept away, as well as all bridges of the region." Heavy rains on July 30, 31 and August 3, 1919 washed out all bridges of North St. Vrain Creek and St. Vrain Creek, damaged the water transmission mains and washed out roads. A newspaper article in *The Boulder County Miner and Farmer* described a June 1921 flood of the St. Vrain Creek, stating "... a tremendous local rain storm ... turned the streets into rivers of rushing water." Flooding resulting from rains on September 2, 3 and 4, 1938 damaged homes and washed out two bridges. Three years later in June 22, 1941, floods took three homes away, damaged roads, flooded a half dozen houses in Lyons, and a resident of Longmont drowned at his cabin in South St. Vrain Canyon. Eight years later, a rainstorm on June 4, 1949 caused flooding which destroyed two bridges and damaged roadways and the Burlington Northern Railroad track to Lyons. On August 3, 1951, Lyons received 6.3 inches of rainfall which inundated businesses and destroyed several sections of road. On May 8 and 9, 1957, three to five inches of rain fell at night over the St. Vrain basin destroying two bridges. A newspaper report of the 1957 flood in the *Longmont Times-Call* showed a picture of roadways turned to rivers east of Lyons along the St. Vrain Creek. Heavy rainfall combined with snowmelt in May and June of 1969 caused extensive damage to property, roads and bridges.

More recently on August 10, 1994, an estimated three inches of rain fell in Lyons within 30 minutes. The town's drainage system was inadequate to convey to large amount of runoff, and overtopping of storm drainage pipes and channels caused urban flooding. The hardest hit area of town was the central area between Fourth and Fifth Street of the Steamboat Valley drainage. The primary drainage system, comprised of a historic open channel ditch and closed culvert built of sandstone, was overwhelmed and backed up water into businesses and residences. Although this old drain system conveys nuisance flows of minor storm events, it lacks capacity to handle the extreme runoff events beyond an approximate 5-year return period frequency. Development over the natural drainways, increased imperviousness of the land from urbanization, and lack of attention to drainage has severely limited the conveyance capacity of the towns' drainage system.

PHOTO INVENTORY

BRW, Inc. performed a cursory reconnaissance of important drainage facilities in the Town to identify problem areas and opportunities for remedial flood control construction. The following 10 photographs represent general conditions in the Town and highlight many of the more critical drainage needs requiring attention. **Figure 3-1** shows the location of the photos together with flow paths and major drainage culverts in the study area.

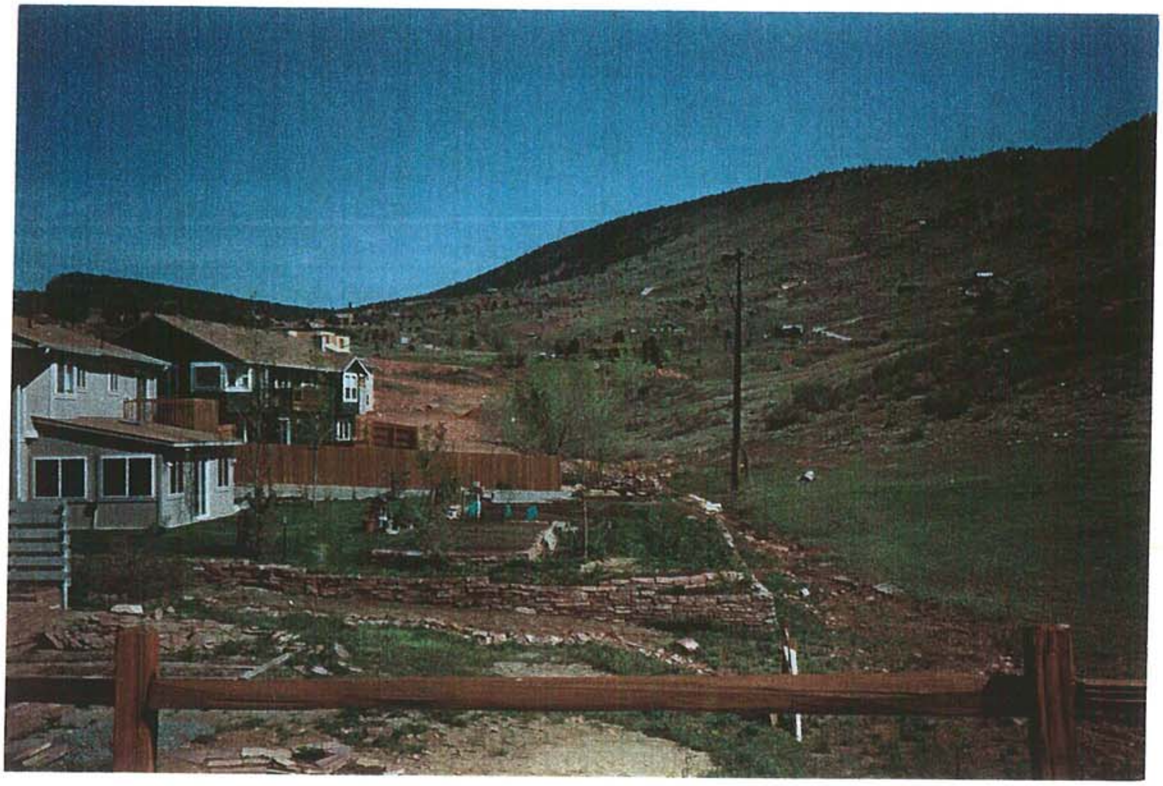


Photo 1: View of the upper Steamboat Valley drainage basin. Photo taken from the former railroad embankment (now a driveway) that has created a stormwater detention pond, which has historically served to protect downstream properties from peak runoff flows. Unfortunately, development has been allowed to occur within the high water mark of the pond. The built-up landscaping and walkout basements could be inundated in a major stormwater event.

Photo 2: This is the primary drainage ditch through the town of Lyons, between 4th and 5th Avenues on the Steamboat Valley drainage. The open channel seen here varies in width and depth, and is enclosed downstream to accommodate development over the ditch. The capacity of the ditch is approximately 150 cfs, but is inadequate to convey a major storm event as evident in the 1994 flooding.

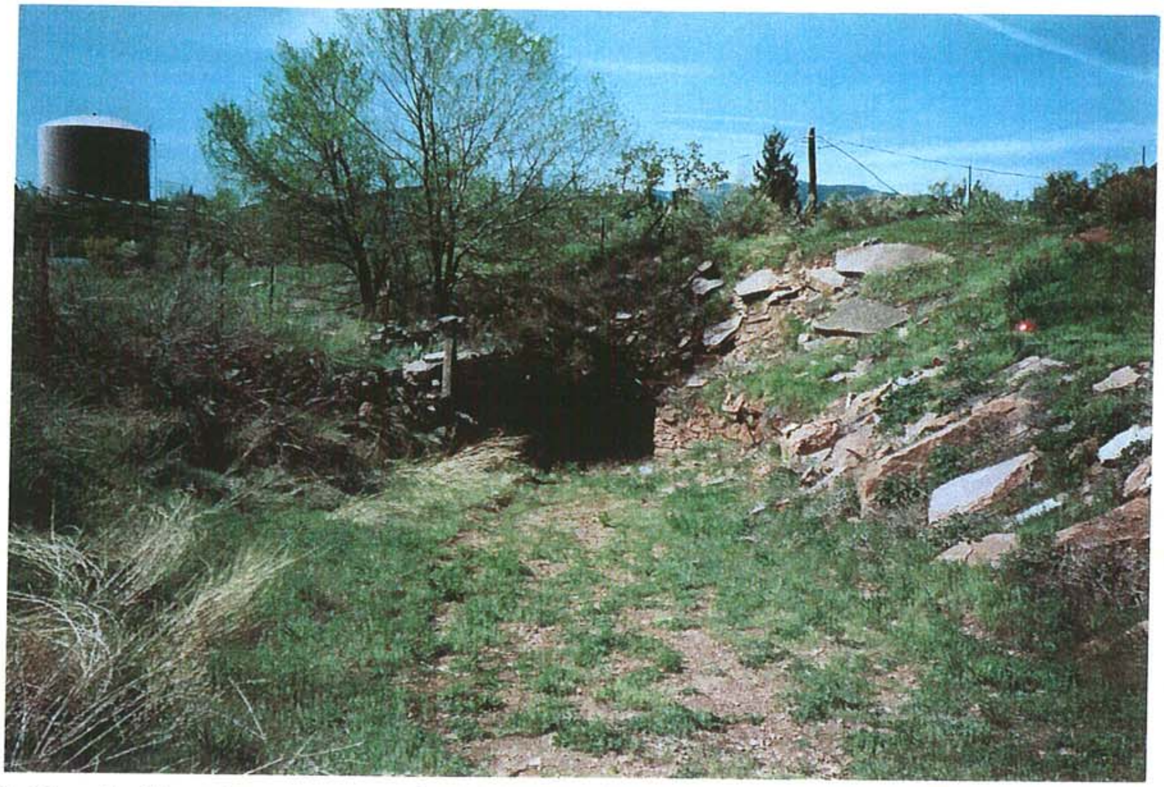


Photo 3: View looking downstream at the 3'-9" x 3'-6" flagstone box culvert under the historic railroad embankment on the upper 4th Avenue drainage basin. This culvert had become plugged and was recently opened which lead to flooding of a downstream property. This stone culvert is similar to the other culvert also under the railroad embankment and is located immediately east of the pond described in Photo 1.

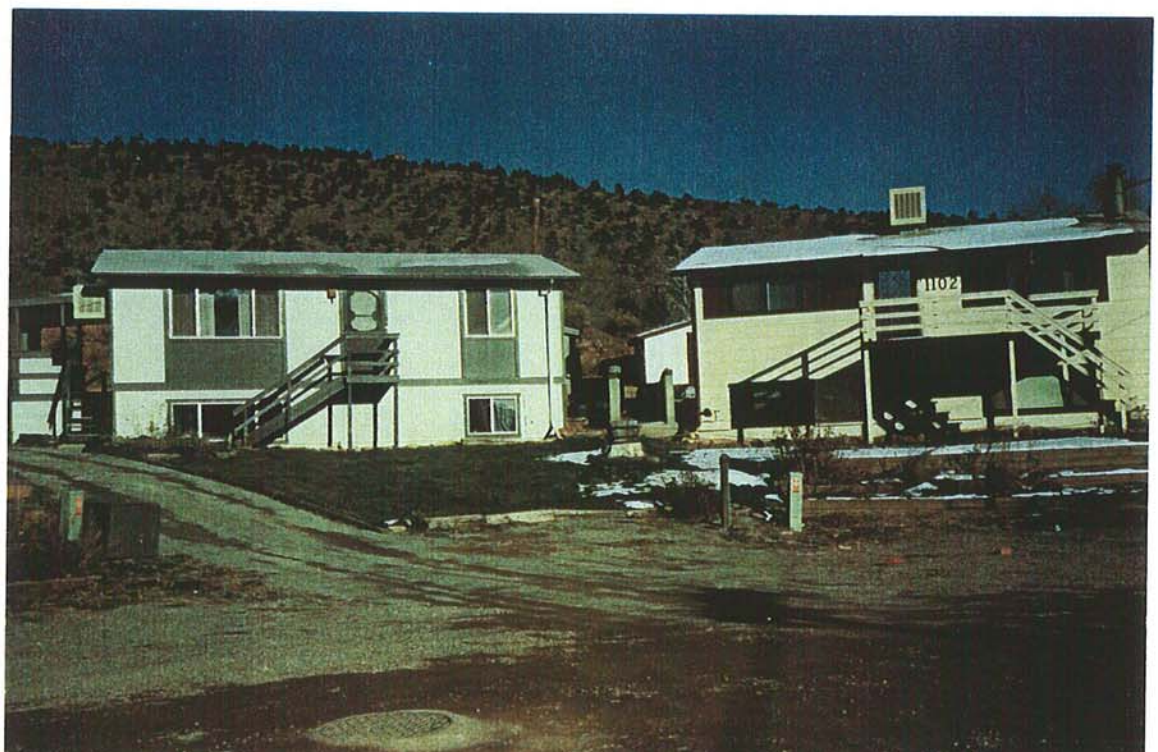


Photo 4: This is the downstream outlet of the culvert shown in Photo 3. Between these two houses is a concrete chute constructed to prevent the flooding which was caused by unplugging the upstream culvert. This chute, however, does not mitigate, and could potentially make worse, flood damage that could occur to downstream properties. A new storm sewer constructed in 4th Avenue could be constructed to convey the discharge from this chute through town.

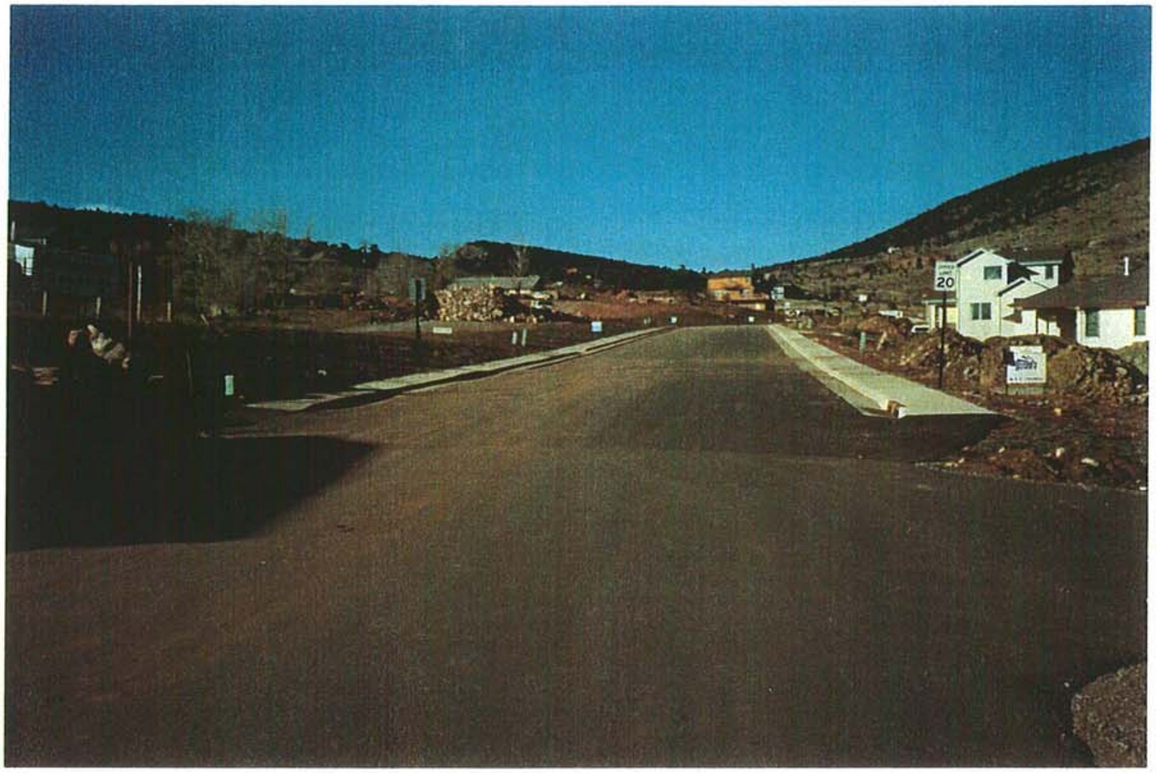


Photo 5: View upstream of new development in the upper Steamboat Valley drainage basin. This basin is rapidly becoming urbanized, and attention must be given to protect downstream properties from increased flooding that could result from upstream development. The curb and gutter will allow the streets to be used for conveyance of stormwater runoff. The curb grate inlet shown on the right will intercept only a small portion of the total runoff in a major event due to the steepness of the street. When using streets to convey runoff, it is important that houses be constructed to avoid flood damage if flow in the streets overtops the curbs (flowline depth greater than 6-inches in a major event).

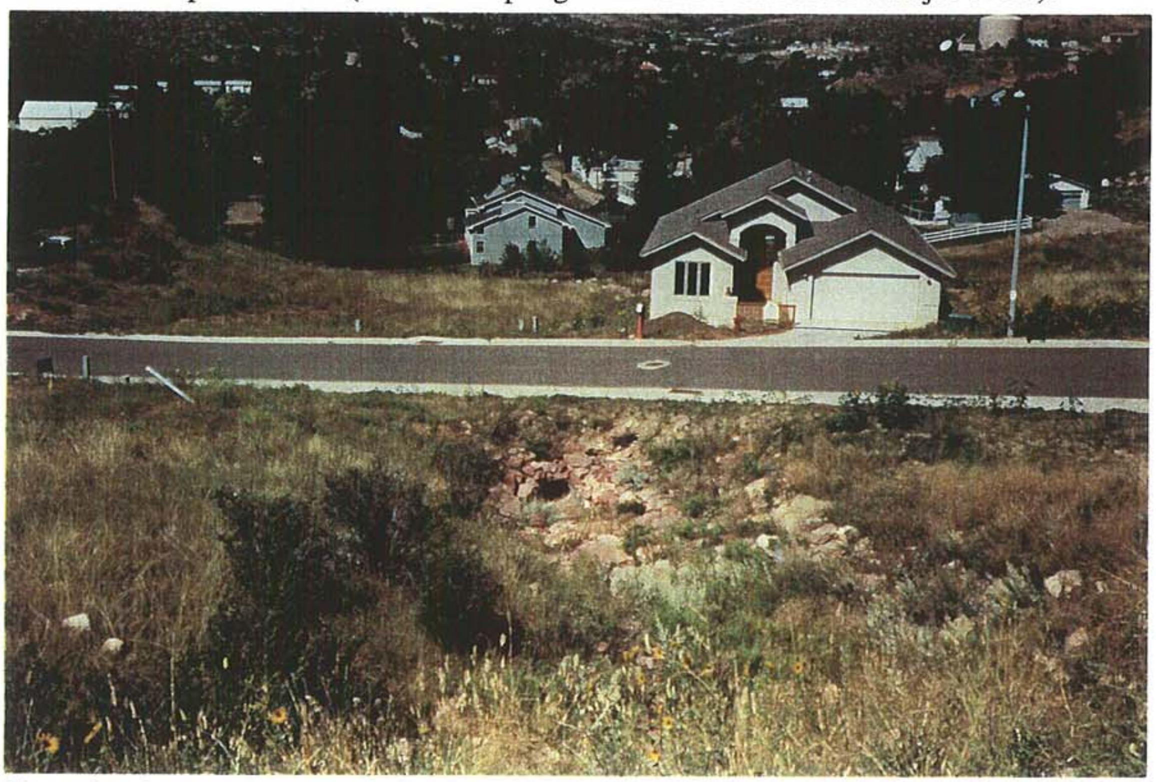


Photo 6: New development must not restrict historic drainage corridors. The roadway may be overtopped in a major storm event. The blue/gray house in the background was constructed on a natural drainageway and could become flooded if drainage ditches and pipes are not maintained. Debris flow is a potential threat in a major storm event.

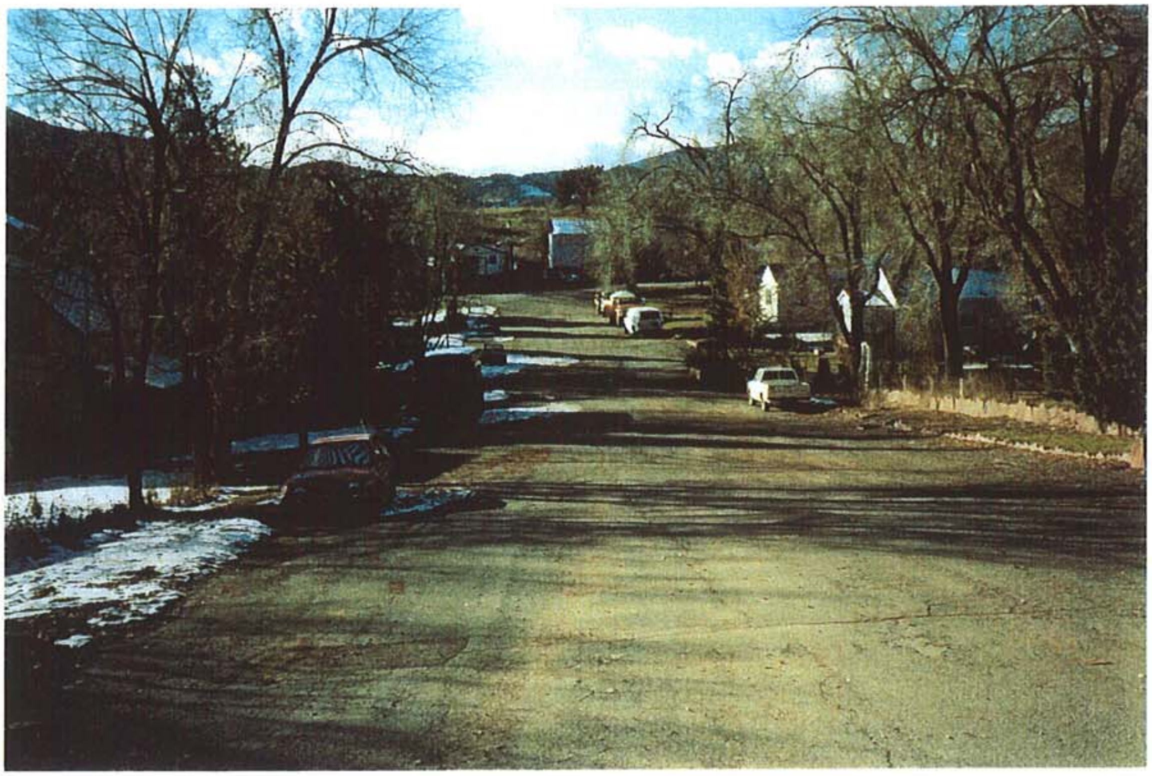


Photo 7: Many of the roads in the old section of town have a sag between intersections. Streets constructed in this manner cannot help to convey stormwater through town. Also, the absence of curb and gutter further prevents containment of stormwater runoff. Homes in these areas are subject to flooding in a significant storm event.

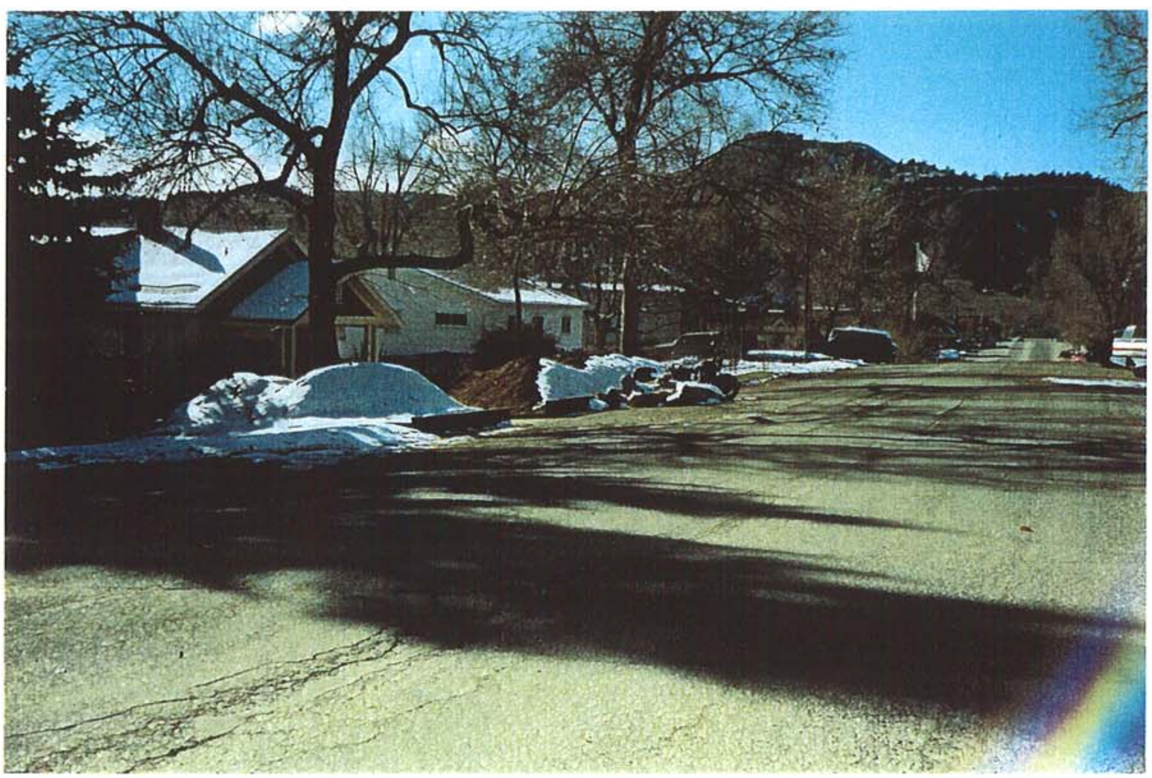


Photo 8: As described above, older streets in Lyons cannot contain or convey stormwater runoff. Homeowners have been forced to construct their own curbs to prevent water in the street from flowing into their property. Sandbags are readily available here to close the walkway gap in the makeshift curb during a storm event.

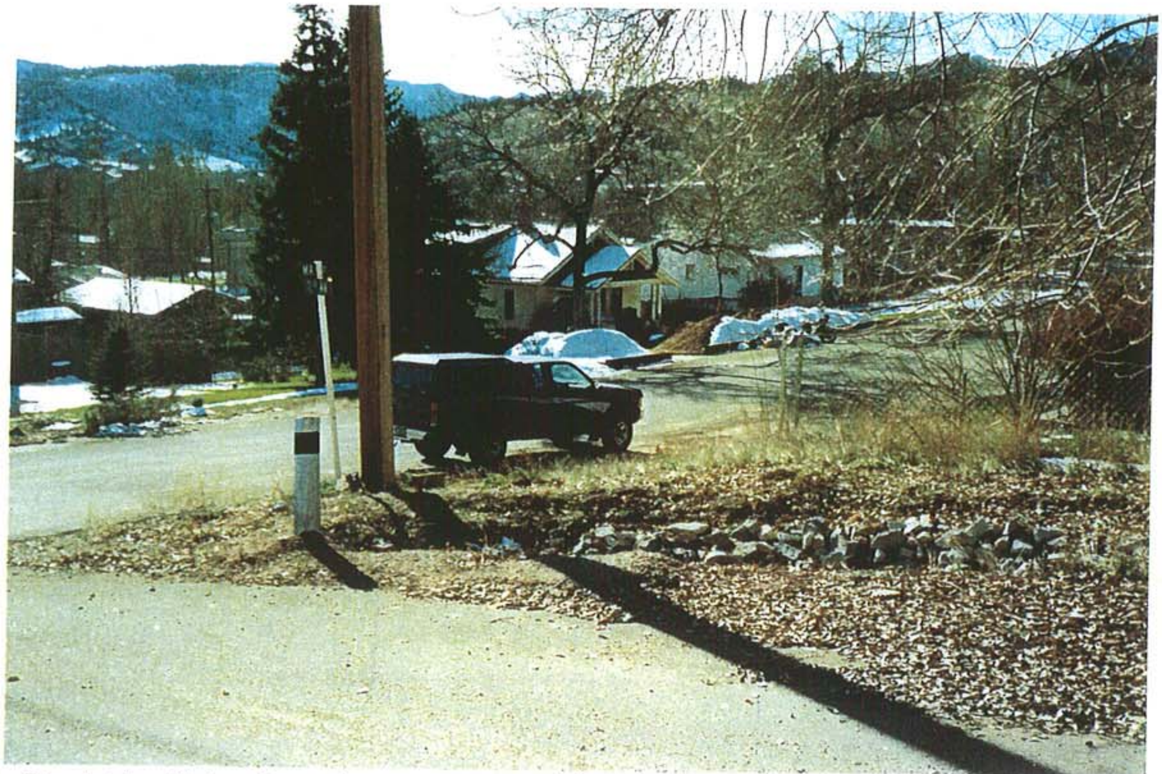


Photo 9: Roadside ditches have been constructed in some areas to convey drainage. However, at intersections, the stormwater must be conveyed in culverts or crosspans across the roadways. At this intersection at 2nd and Main Street, the culvert is inadequate to convey even a minor storm event and roadway overtopping will occur. The problem here is that when runoff overtops the roadway, it flows in an uncontrolled direction toward residences.

Photo 10: Drainage is often a forgotten issue until a large storm event occurs. Drainage swales and culverts must be maintained to convey runoff. Many of the culverts in Lyons do not have headwalls, and the ends have been crushed or the pipes have filled with silt and debris. This picture shows a culvert paved nearly closed.

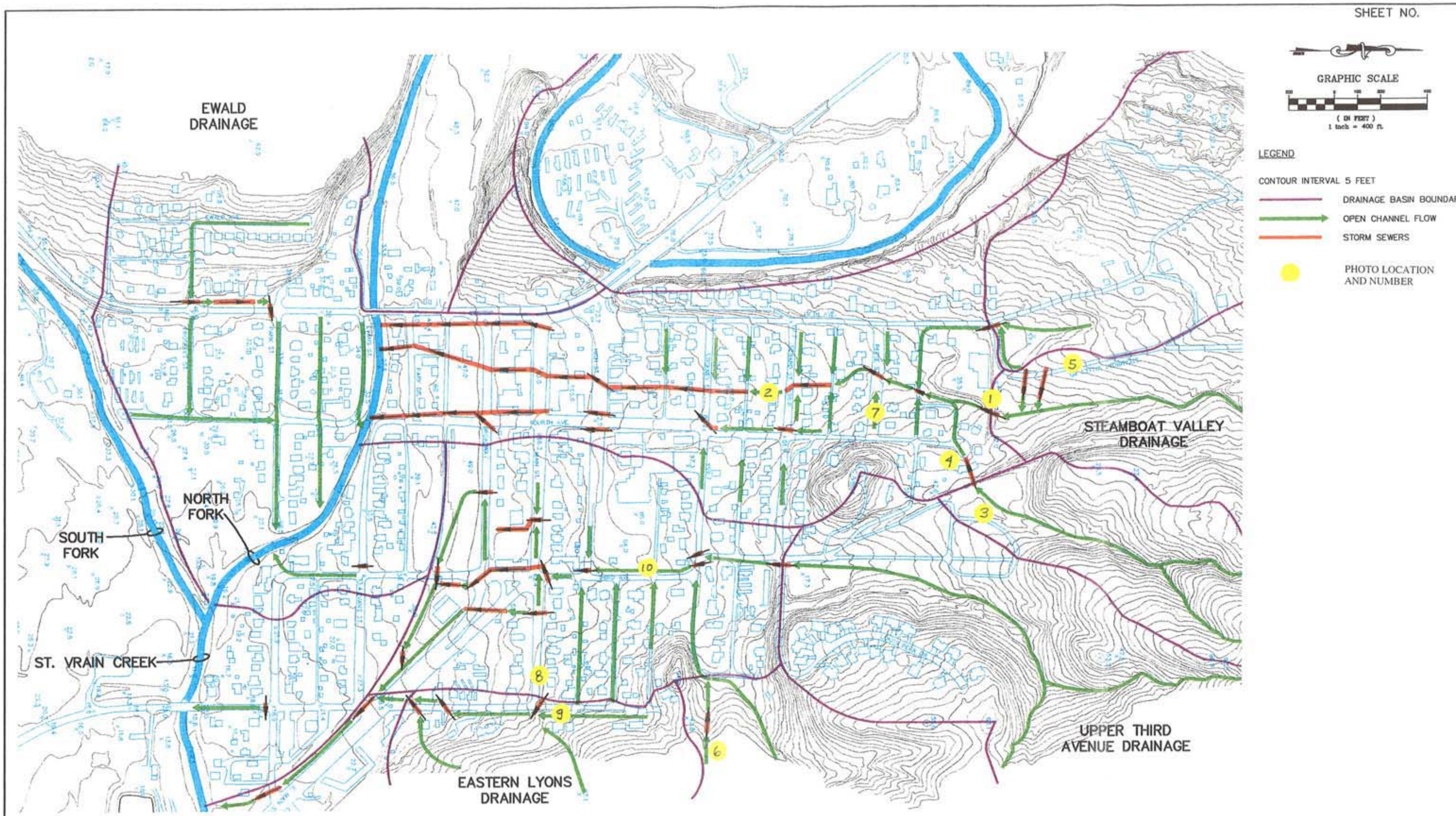


FIGURE 3-1

TOWN OF LYONS

MASTER DRAINAGE PLAN

MAJOR CENTRAL TOWN DRAINAGEWAYS

BASIN PLAN

REFERENCE DRAWINGS
3560BRPL
LOO2RFA1

NO.	DATE	DESCRIPTION	BY

REVISIONS

COMPUTER FILE MANAGEMENT
DISK FILE NAME: R:\35600\CADD\EXHIBITS\3560MSD1.DWG
PCP FILE: COLRHALF.PCP
DATE OF ISSUE: Mar 11, 1998 9:22am
THIS DRAWING IS CURRENT AS OF THE DATE OF ISSUE AND MAY BE SUBJECT TO CHANGE

BRW
PLANNING
TRANSPORTATION
ENGINEERING
URBAN DESIGN
BRW INC. 1225 SEVENTEENTH ST., SUITE 200, DENVER, CO 80202

DESIGNED BY: RDK
DRAWN BY: SRH
CHECKED BY:
SCALE HORIZ: 1" = 400'
VERT. -
DATE ISSUED: MARCH, 1998
SHEET NO. OF SHEETS
MD1

4.0 FLOODPLAIN MANAGEMENT

Floodplain management is understanding and defining where flooding will likely occur for a given frequency runoff event. Stormwater management and floodplain management are go hand-in-hand since floodplains are the manifestation of stormwater drainage. Although floodplains are generally considered to be FEMA regulatory floodplains for river corridors such as those defined for the St. Vrain Creeks in Lyons, they can also include upland areas that are regularly inundated during large storm events. Typically, these urban floodplains are defined by municipalities to warn citizens of zones where flooding has been known to occur, often resulting from encroachment on drainage corridors which has reduced conveyance capacity.

The purpose of floodplain regulation is to manage, not prevent, development within a defined floodplain so as to preclude or mitigate future flood damages. Development which has occurred within floodplain areas can be monetarily protected if local governments are pro-active in floodplain management. The federal government sponsored National Flood Insurance Program (NFIP) makes flood insurance available to individuals within communities that meet eligibility requirements by adopting and enforcing measures to reduce flood risks in defined flood hazard areas.

Currently, the FEMA regulated floodplains of South St. Vrain, North St. Vrain and St. Vrain Creeks within the corporate limits of Lyons are determined by the Flood Insurance Study for Lyons, Colorado, prepared by the Federal Insurance Administration (February 1980). The hydraulic and hydrologic analyses of these major drainages were completed by Howard, Needles, Tammen and Bergendoff (HNTB, October, 1977). Generally, the hydrologic data used by HNTB was that generated by the Army Corps of Engineers (ACOE) for the 1972 studies of the St. Vrain Creek basin (100-year flow of 10,200 cfs at the confluence of the North and South St. Vrain Creeks). The 1980 Flood Insurance Study is currently used by regulatory agencies, lending institutions, and planners for administration of the St. Vrain floodplain.

The hydraulic methods, hydrologic data and topographic information used in the 1987 floodplain study are considered to be more current. The hydrologic data utilized in the revised study were taken from a 1981 report by the Corps of Engineers, "St. Vrain Creek Hydrology, Boulder and Weld Counties". The 100-year flow at the confluence of the North and South St. Vrain Creeks was reduced to 8,880 cfs based on additional years of stream gauge data and revised hydrologic analysis methods. Floodplain characteristics were determined using the Corps of Engineers HEC-RAS computer program and 2-foot contour topographic mapping (based on 1981 aerial photography). In 1992, the 1987 study was revised by Love & Associates to correct hydraulic modeling errors in the original study and updating the study to include new bridge and culvert information.

FLOODPLAIN DELINEATION UPDATE

Updating the 1980 floodplain maps for the St. Vrain Creek through Lyons is important because of the anticipated land use changes and urbanization expected to occur in the

Lyons area over the next several years. Revised maps will form the basis for administration of activities in the floodplain and will be used by residents, town and county officials, CWCB, and FEMA for regulating activities and administering the National Flood Insurance Program (NFIP). Objectives of the updated plan include:

- Reflect changes posed by the newly adopted ACOE hydrologic study, which reduced discharges by over 1,000 cfs.

- Model river hydraulics associated with man-made and natural channel modifications occurring since 1987.

- Provide the basis for subsequent modeling of floodplain encroachments and floodplain activities within such as construction of the McConnell Drive Bridge, and

- Provide the framework for comprehensive planning and related parks and recreational planning along the St. Vrain Creek riparian corridor.

FLOODPLAIN RECOMMENDATIONS

The following elements of floodplain management are recommended to be improved or amended in order to best utilize the information obtained by this floodplain study:

- Review the Town of Lyons administrative process to regulate activities in the floodplain and discuss the best manner in which reviews can be conducted to ensure that facilities are not constructed within the floodplain or floodway resulting in excessive impacts within riparian areas.

- Improve building department review and permitting such that Elevation Certificates, Letter of Map Revisions, Letter of Map Amendment applications are properly interpreted and processed.

- Notify homeowners subject to flooding impacts by the St. Vrain Creek to suggest consideration of the purchase of insurance. This would also include distribution of the floodplain maps to local lenders.

- Distribute an accepted HEC-RAS model to the developers of Lyons Valley Park such that it can be updated in accordance with FEMA guidelines and submitted to the Town to demonstrate that base flood elevations will not increase by more than 1 foot by construction of the proposed McConnell Drive Bridge.

- Work with Boulder County and the CWCB for proper incorporation of the model results into an updated flood insurance study. This work would likely be sponsored by Boulder and the CWCB for formal acceptance by FEMA during the summer and early fall of 1998.

5.0 RECOMMENDED PLAN

Table 5-1 is the summary runoff table for all subcatchments, detention ponds and design points. This table should be used in conjunction with **Figure 5-1, Drainage Capital Improvements Plan**, to identify the modeled peak discharge values for the 2-year, 5-year, 10-year, 50-year and 100-year storm events. Development and drainage capital improvement projects should utilize these hydrology values as the basis for design.

Different types of drainage capital improvements are described below. The specific capital improvements proposed for the Town of Lyons are detailed at the end of this section and described by drainage basin. Existing drainage facilities were utilized to the extent possible. The anticipated costs for additional recommended drainage capital improvements are detailed in **Table 5-2, Feasibility Level Opinion of Probable Costs**.

STORM SEWERS

Storm sewers are typically designed for the "minor" storm event, which is an event with a 2 or 5 year recurrence interval (depending upon land use). The goal of drainage improvements is to protect people and property from reoccurring damage. The minor event is important because it often causes the most damage over time. For example, if a 10-year event causes $100,000 in damage every occurrence, the resulting damage in 100 years is $1,000,000. A 100-year event may cause $500,000 damage; therefore, planning for the 10-year event has a greater economic impact.

While the minor event is important, a community should also plan for the 100-year event to warn citizens and businesses of the potential danger. The 100-year river floodplain is designated by FEMA to notify people of the potential flooding risk. Likewise, communities should be aware of flooding that may occur from drainage in the 100-year event. Assuming the storm sewers convey the 5-year discharge, additional runoff in a major event (that amount beyond the 5-year discharge) will be conveyed by streets and open channels. Lyons, however, must retro-fit the community with a drainage system, and the opportunities to utilize drainage corridors to convey a major event is limited. Therefore, where surface overflow cannot occur without damage, storm sewers must be upsized to convey the major event.

Building has encroached on the natural drainageways over time due to a false sense of security about flooding as a result of the dry climate typically experienced in Lyons. Since the natural open channel drainages through town are not now available for flood conveyance, Lyons must plan to utilize larger storm sewers to convey more of a major storm event, or alternatively, notify residents of the risks associated with urban flooding.

STREET DRAINAGE

Streets are an integral part of the urban drainage system and may be used for transporting storm runoff up to design limits. However, it must be understood the primary purpose of streets is for traffic, and therefore the use of streets for drainage must be limited. Too

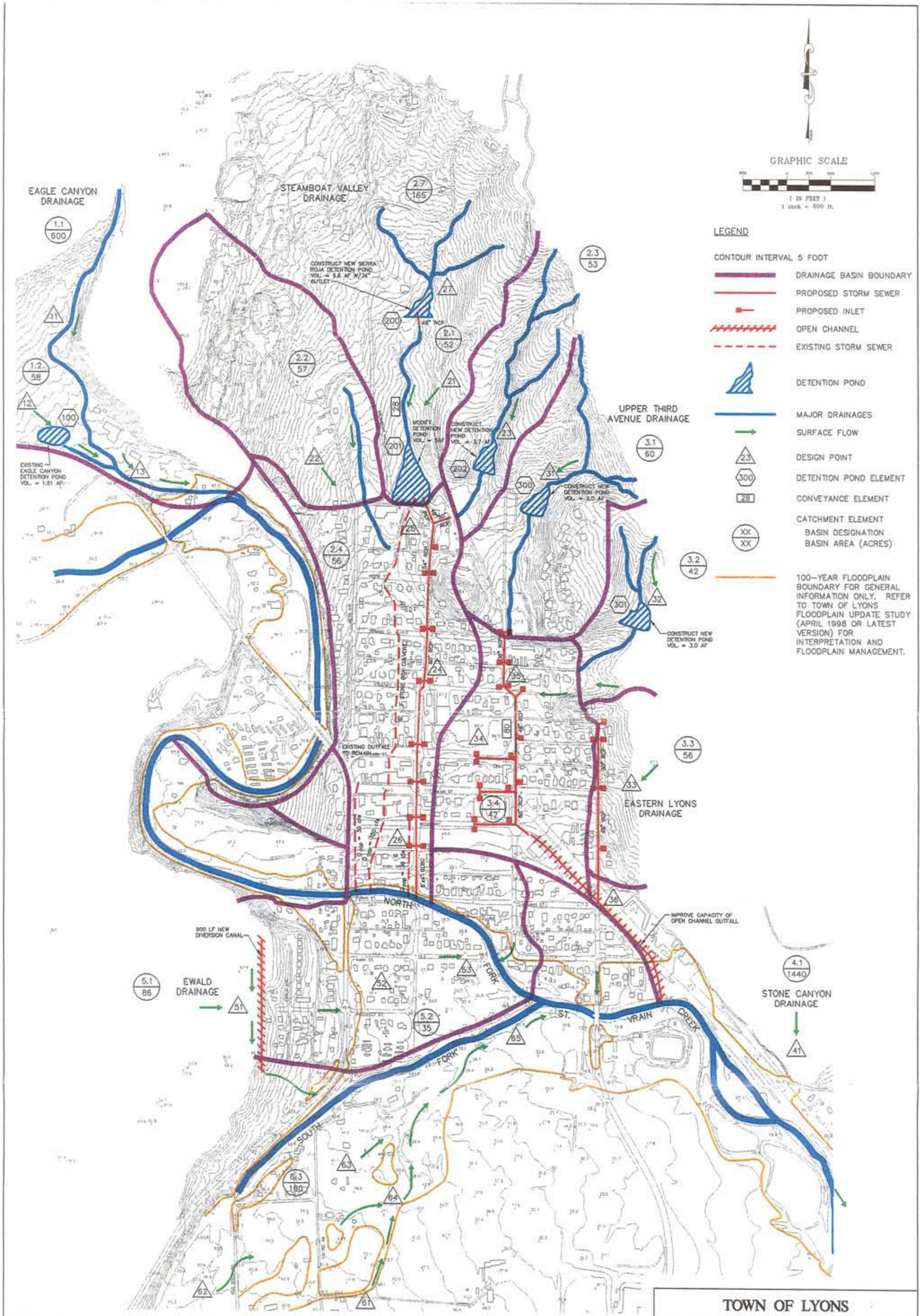

GRAPHIC SCALE
(IN FEET)
1 inch = 600 ft.
LEGEND
CONTOUR INTERVAL 5 FOOT
DRAINAGE BASIN BOUNDARY
PROPOSED STORM SEWER
PROPOSED INLET
OPEN CHANNEL
EXISTING STORM SEWER
DETENTION POND
MAJOR DRAINAGES
SURFACE FLOW
DESIGN POINT
DETENTION POND ELEMENT
CONVEYANCE ELEMENT
CATCHMENT ELEMENT
BASIN DESIGNATION
BASIN AREA (ACRES)
100-YEAR FLOODPLAIN BOUNDARY FOR GENERAL INFORMATION ONLY. REFER TO TOWN OF LYONS FLOODPLAIN UPDATE STUDY (APRIL 1998 OR LATEST VERSION) FOR INTERPRETATION AND FLOODPLAIN MANAGEMENT.
EAGLE CANYON DRAINAGE
STEAMBOAT VALLEY DRAINAGE
UPPER THIRD AVENUE DRAINAGE
EASTERN LYONS DRAINAGE
EWALD DRAINAGE
STONE CANYON DRAINAGE
RED HILL GULCH DRAINAGE
CONSTRUCT NEW SIERRA ROJA DETENTION POND VOL. = 5.6 AF W/36" OUTLET
EXISTING EAGLE CANYON DETENTION POND VOL. = 1.51 AF
MODIFY DETENTION POND
CONSTRUCT NEW DETENTION POND VOL. = 5.7 AF
CONSTRUCT NEW DETENTION POND VOL. = 3.0 AF
EXISTING OUTFALL TO REMAIN
900 LF NEW DIVERSION CANAL
IMPROVE CAPACITY OF OPEN CHANNEL OUTFALL
NORTH
FORK
SOUTH
ST. VRAIN CREEK
DISK FILE NAME: R:\35600\CADD\EXHIBITS\3560CI01.DWG
PLOT DATE: Apr 29, 1998 9:16am
BRW
PLANNING
TRANSPORTATION
ENGINEERING
URBAN DESIGN
BRW INC. 1225 SEVENTEENTH ST, SUITE 200, DENVER, CO 80202
TOWN OF LYONS
MASTER DRAINAGE PLAN
FIGURE 5-1
CAPITAL IMPROVEMENTS PLAN
DATE ISSUED APRIL, 1998
SHEET NO. 1 OF 1 SHEETS
1

TABLE 5-1: RUNOFF SUMMARY TABLE
TOWN OF LYONS - DRAINAGE MASTER PLAN

CONVEYANCE ELEMENT	CONTRIBUTING AREA (acres)	2-YEAR PEAK DISCHARGE (cfs)	2-YEAR DETENTION VOLUME (ac-ft)	5-YEAR PEAK DISCHARGE (cfs)	5-YEAR DETENTION VOLUME (ac-ft)	10-YEAR PEAK DISCHARGE (cfs)	10-YEAR DETENTION VOLUME (ac-ft)	50-YEAR PEAK DISCHARGE (cfs)	50-YEAR DETENTION VOLUME (ac-ft)	100-YEAR PEAK DISCHARGE (cfs)	100-YEAR DETENTION VOLUME (ac-ft)
11	600	23		126		191		446		567	
12	58	18		49		68		131		158	
13	658	33		152		229		531		671	
20		37		142		189		322		365	
21	52	4		31		45		100		124	
22	57	25		57		78		148		178	
23	53	7		32		45		96		118	
24	56	44		77		95		161		191	
25	327	38		145		189		322		366	
26	383	74		202		269		471		548	
27	165	10		69		101		229		285	
28		10		59		86		167		195	
30		13		51		66		108		122	
31	60	7		37		53		115		141	
32	42	7		30		43		90		111	
33	56	8		42		62		130		161	
34	42	36		65		84		140		163	
35	102	14		52		67		109		122	
36	200	51		139		182		331		392	
41	1440	22		195		320		760		984	
51	86	9		66		99		212		262	
52	35	24		48		62		108		128	
53	121	33		114		162		320		390	
60		29		242		392		940		1216	
61	1345	29		220		351		835		1078	
62	166	4		36		55		131		165	
63	160	65		135		177		323		385	
64	1511	32		250		400		951		1230	
65	1671	67		294		466		1074		1382	
100	58	10	0.4	26	1.0	40	1.3	100	2.0	125	2.3
200	165	10	0.1	59	0.5	86	1.0	167	3.7	195	5.6
201	217	13	0.0	79	0.1	114	0.1	195	2.4	217	4.3
202	53	7	0.1	22	0.4	27	0.7	42	2.6	47	3.7
300	60	7	0.0	30	0.3	39	0.5	66	2.0	76	3.0
301	42	7	0.0	22	0.3	28	0.5	42	1.9	47	2.8

TABLE 5-2
FEASIBILITY LEVEL OPINION OF PROBABLE COST
LYONS DRAINAGE CAPITAL IMPROVEMENTS PLAN

Bid Item	Quantity	Unit	Unit Cost	Item Total	Subtotal Cost	Total Cost
STEAMBOAT VALLEY IMPROVEMENTS						
Construct Sierra Roja Detention Pond	5.6	AF			$81,335	
Riprap on Embankment	350	CY	$50	$17,500		
48" RCP Outlet Pipe	105	LF	$168	$17,640		
Embankment Material	3230	CY	$7.00	$22,610		
Excavate/Shape Pond	650	CY	$1.50	$975		
Outlet Structure with Trash Rack	1	EA	$8,000	$8,000		
Revegetate Site	0.87	AC	$3,000	$2,610		
Baffled Pipe Outlet	1.00	EA	$12,000	$12,000		
Reconstruct Boone Detention Pond	5.0	AF			$116,685	
Riprap on Embankment	110	CY	$50	$5,500		
Remove Driveway	3750	SF	$0.25	$938		
Remove Embankment	3150	CY	$2.00	$6,300		
Temp. Maintain Existing Outlet - Plug	1	LS	$5,000	$5,000		
New 48" RCP Outlet Pipe	200	LF	$168	$33,600		
Embankment Material	3600	CY	$7.00	$25,200		
Excavate/Shape Pond	1800	CY	$1.50	$2,700		
Outlet Structure	1	EA	$10,000	$10,000		
Replace Utilities	1	LS	$8,000	$8,000		
Rebuild Driveway	3750	SF	$1.25	$4,688		
Revegetate Site	0.92	AC	$3,000	$2,760		
Baffled Pipe Outlet/Energy Dissipator	1.00	EA	$12,000	$12,000		
Construct Upper 4th Ave Detention Pond	3.7	AF			$51,730	
Riprap on Embankment	100	CY	$50	$5,000		
24" RCP Outlet Pipe	75	LF	$84	$6,300		
Embankment Material	3100	CY	$7.00	$21,700		
Excavate/Shape Pond	620	CY	$1.50	$930		
Outlet Structure	1	EA	$8,000	$8,000		
Revegetate Site	0.60	AC	$3,000	$1,800		
Baffled Pipe Outlet/Energy Dissipator	1.00	EA	$8,000	$8,000		
Storm Drain System (Lyons)					$571,000	
18" RCP	225	LF	$63	$14,175		
30" RCP	200	LF	$105	$21,000		
54" RCP	750	LF	$189	$141,750		
60" RCP	800	LF	$210	$168,000		
6' x 4' RCBC	650	LF	$306	$198,575		
Inlets	11	EA	$2,500	$27,500		
Storm Drain System (CDOT)					$132,200	
6' x 4' RCBC	400	LF	$306	$122,200		
Inlets	4	EA	$2,500	$10,000		
Subtotal Steamboat Valley Improvements						$952,950

TABLE 5-2
FEASIBILITY LEVEL OPINION OF PROBABLE COST
LYONS DRAINAGE CAPITAL IMPROVEMENTS PLAN

Bid Item	Quantity	Unit	Unit Cost	Item Total	Subtotal Cost	Total Cost
3rd AVENUE IMPROVEMENTS						
Construct Cemetery Detention Pond	3.0	AF			$37,600	
Riprap on Embankment	55	CY	$50	$2,750		
24" RCP Outlet Pipe	75	LF	$84	$6,300		
Embankment Material	1800	CY	$7.00	$12,600		
Excavate/Shape Pond	500	CY	$1.50	$750		
Outlet Structure	1	EA	$8,000	$8,000		
Revegetate Site	0.40	AC	$3,000	$1,200		
Baffled Pipe Outlet/Energy Dissipator	1.00	EA	$6,000	$6,000		
Storm Drain System (Lyons)					$240,545	
18" RCP	165	LF	$63	$10,395		
24" RCP	280	LF	$84	$23,520		
36" RCP	520	LF	$126	$65,520		
48" RCP	440	LF	$168	$73,920		
54" RCP	210	LF	$189	$39,690		
Inlets	11	EA	$2,500	$27,500		
Storm Drain System (CDOT)					$211,815	
18" RCP	105	LF	$63	$6,615		
24" RCP	550	LF	$84	$46,200		
60" RCP	350	LF	$210	$73,500		
Inlets	7	EA	$2,500	$17,500		
Improve Open Channel	680	LF	$100	$68,000		
Subtotal 3rd Avenue Improvements					$489,960	$489,960
2nd AVENUE IMPROVEMENTS						
Construct Upper 2nd Ave Detention Pond	3.0	AF			$45,310	
Riprap on Embankment	85	CY	$50	$4,250		
24" RCP Outlet Pipe	75	LF	$84	$6,300		
Embankment Material	2700	CY	$7.00	$18,900		
Excavate/Shape Pond	540	CY	$1.50	$810		
Outlet Structure	1	EA	$8,000	$8,000		
Revegetate Site	0.35	AC	$3,000	$1,050		
Baffled Pipe Outlet/Energy Dissipator	1.00	EA	$6,000	$6,000		
Storm Drain System (Lyons)					$179,885	
18" RCP	90	LF	$63	$5,670		
24" RCP	110	LF	$84	$9,240		
30" RCP	335	LF	$105	$35,175		
48" RCP	600	LF	$168	$100,800		
Inlets	6	EA	$2,500	$15,000		
Improve Open Channel	280	LF	$50	$14,000		
Storm Drain System (CDOT)					$88,600	
48" RCP	200	LF	$168	$33,600		
Improve Open Channel	550	LF	$100	$55,000		
Subtotal 2nd Avenue Improvements						$313,795

TABLE 5-2
FEASIBILITY LEVEL OPINION OF PROBABLE COST
LYONS DRAINAGE CAPITAL IMPROVEMENTS PLAN

Bid Item	Quantity	Unit	Unit Cost	Item Total	Subtotal Cost	Total Cost
EWALD DRAINAGE IMPROVEMENTS						
Diversion Canal	900	LF	$100	$90,000		
Outfall Improvements	1	LS	$10,000	$10,000		
Highway Culvert (48" RCP)	100	LF	$168	$16,800		
Subtotal Ewald Drainage Improvements						$116,800
;ubtotal						$1,873,505
;ontengency (25%)						$468,376
Engineering/ Survey (12%)						$224,821
'OTAL						$2,566,702

much flow in the streets is a threat to cars and pedestrian traffic. During a large storm event, emergency vehicles must be able to drive on the streets, and flow depths in the streets must be limited to one foot of depth or less. To utilize the streets in this manner, the right-of-ways must be regraded and curb & gutter installed to contain a full one-foot flow depth without overtopping and damaging adjacent property. Lyons is fortunate that the streets are relatively steep and can convey a considerable flow without exceeding depth limits. Although installing curb and gutter to use the streets for drainage will help convey some drainage, this will not solve the drainage problems alone, and additional improvements will be necessary.

Flow during the minor event should not overtop the top of curb, and therefore drainage capacity is expected to be less than 20 cfs (cubic feet per second) (less than 10 cfs per side for a center crowned road) on the collector streets. Allowable street flow in Lyons during a major event will likely not exceed 100 cfs.

DETENTION PONDS

Detention ponds act to limit the peak discharges and are designed to hold back runoff until after the peak of the storm has passed. The volume of runoff is held nearly constant, but increasing the duration of runoff limits the peak discharge. By limiting the peak discharge, the conveyance facilities downstream can be down-sized at a significant cost savings.

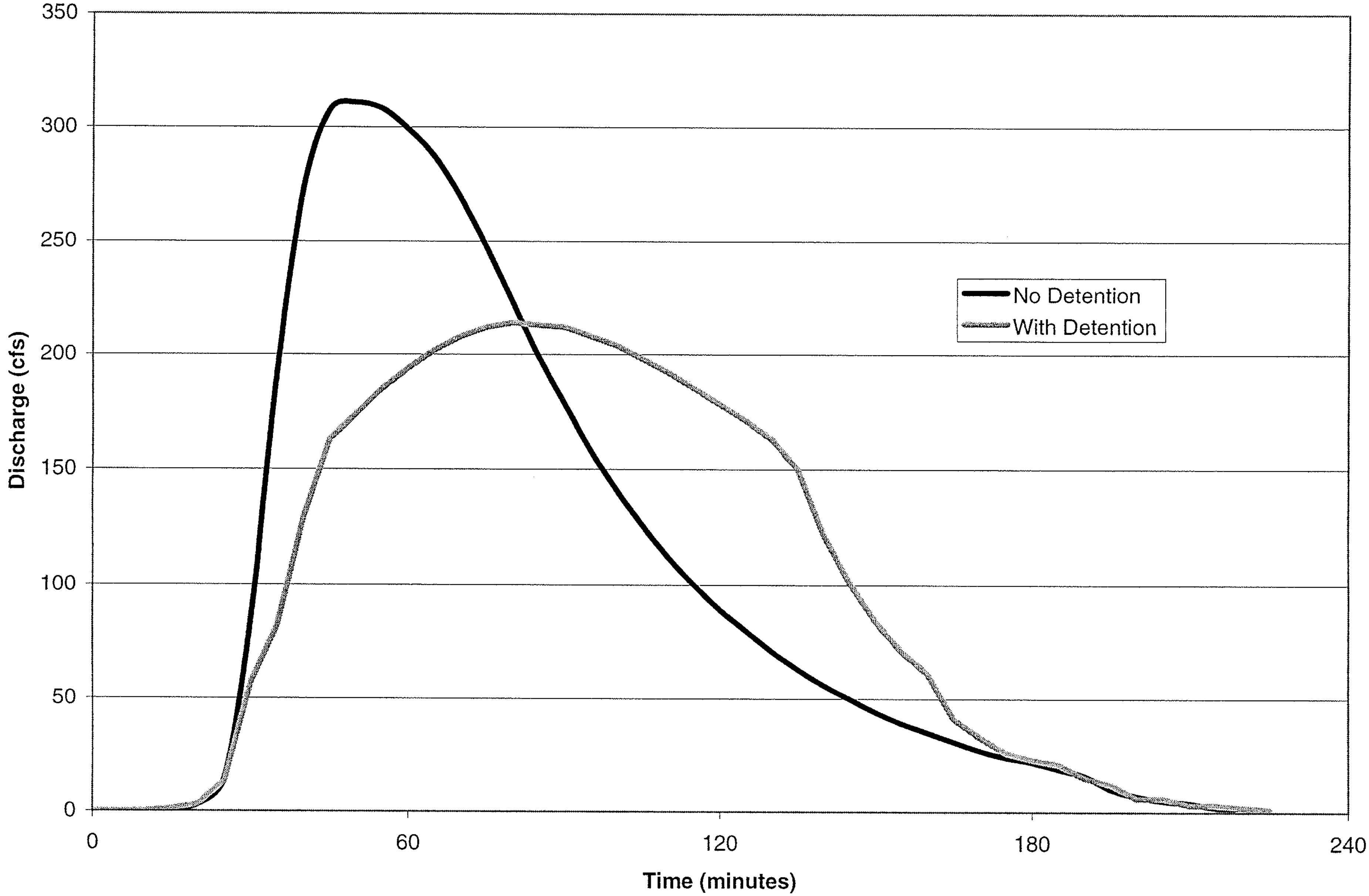
The hydrology of Lyons was modeled using hydrographs. A hydrograph shows the relationship of discharge over time for a storm event. **Figure 5-2** is a hydrograph depicting 100-year runoff from the Steamboat Valley drainage into the town of Lyons. The black curve is the hydrograph for the basin without any detention. The gray curve is the hydrograph with a detention pond acting to reduce the peak discharge. The cost savings achieved by down-sizing conveyance facilities must be considered against the cost of detention structures. Since the length of conveyance facilities through the town of Lyons is considerable (over 2,000 feet for Steamboat Valley), detention ponds are a very cost-effective solution for managing the town's drainage.

Benefits of detention ponds include:

1. Erosion protection in the downstream channel,
2. Peak discharge control, and
3. Sediment and debris control in regularly occurring storm events.

The ponds shown on **Figure 5-1** are for information and planning purposes. Preliminary and final designs must incorporate detailed survey to analyze stage (depth) verses storage to develop outlet configurations that control discharges for multiple storm events (e.g., 2-year, 10-year and 100-year events). Designs should include an emergency spillway to prevent breaching of the dam in the event of overtopping, trash racks and debris protection, access for maintenance, drainage easements and rights-of-ways.

FIGURE 5-2
Steamboat Valley Hydrographs at Boone Property
100-Year Storm Event



R:\35600\Drainage MP\Report\Hydrographs.xls DETENTION GRAPH

4/29/98 11:27 AM

EAGLE CANYON DRAINAGE

The development of Eagle Canyon Estates has included a detention pond to offset the increased runoff associated with the development. The 1.5 acre-foot pond will limit peak discharges to historic flow rates. The minimum design criteria, consistent with Boulder County criteria, were used to calculate the runoff into the ponds. The CUHP model for this master plan predicts a higher runoff into the pond, and consequently, the model results show overtopping of the detention pond in a 100-year storm event. **Table 5-3** compares the minimum parameters considered in the design for Eagle Canyon. Although the design hydrology is debatable, the significance of this discrepancy is the understanding that major storm events can and do exceed design parameters, thereby requiring attention to an emergency overflow design to minimize damage in such an event.

The bulk of the Eagle Canyon drainage is expected to remain undeveloped, and runoff will follow historic patterns. The hydrology completed for this study should be utilized as a planning tool to maintain adequately sized open channel drainageways without encroachment by new development.

STEAMBOAT VALLEY

Steamboat Valley is an important drainage that discharges stormwater through the heart of downtown. The Steamboat Valley watershed lying directly north of Lyons is a 217-acre drainage basin at the point where it enters the main town development. The natural channel was located between 4th and 5th Avenues, and now a 6-foot wide by 3-foot deep stone culvert in this low-lying area is nearly all that remains to convey the drainage. The potential for damage from flooding is significant if flows exceed the capacity of this channel. Development upstream will compound the problem by increasing the peak runoff. Therefore, drainage improvements must:

1. maximize the capacity of the existing channel,
2. limit the peak flow from this drainage through town, and
3. take the burden off the historic channel.

The stone box culvert was built many years ago and is the main drainage facility in the town. When the highway was rebuilt in 1973, the downstream end of this stone box was replaced by CDOT with a 60" x 38" elliptical concrete pipe to discharge the Steamboat Valley runoff to the St. Vrain Creek. In addition, a 36" pipe in 4th Avenue also conveyed some stormwater across Main and Broadway streets to the creek. These storm drain pipes have been shown to have only enough capacity to convey approximately a 5-year recurrence interval event without backing water up and overtopping. Three culverts on this channel at Reese Street and two adjacent alleys have further reduced the conveyance capacity of this channel and should be replaced with larger culverts.

A historic detention pond, presently owned by Robert Boone, has provided some attenuation of the peak discharges from extreme runoff events in this basin (model

TABLE 5-3
DETENTION POND DESIGN

EAGLE CANYON SUBDIVISION:

Basin Area = 58.22 acres
Imperviousness = 16.91 %

Minimum Parameters According to Boulder County Design Criteria:

K_{10}	0.01416	V_{10}	0.82 acre-feet	Q_{10}	17 cfs
K_{100}	0.02597	V_{100}	1.51 acre-feet	Q_{100}	58 cfs

Minimum Parameters According to CUHP Model:

K_{10}		V_{10}	1.30 acre-feet	Q_{10}	40 cfs
K_{100}		V_{100}	2.30 acre-feet	Q_{100}	125 cfs

SIERRA ROJA SUBDIVISION:

Basin Area = 165 acres
Imperviousness = 6 %

Minimum Parameters According to Design Criteria:

K_{10}	0.00380	V_{10}	0.63 acre-feet	Q_{10}	50 cfs
K_{100}	0.00705	V_{100}	1.16 acre-feet	Q_{100}	165 cfs

Minimum Parameters According to CUHP Model:

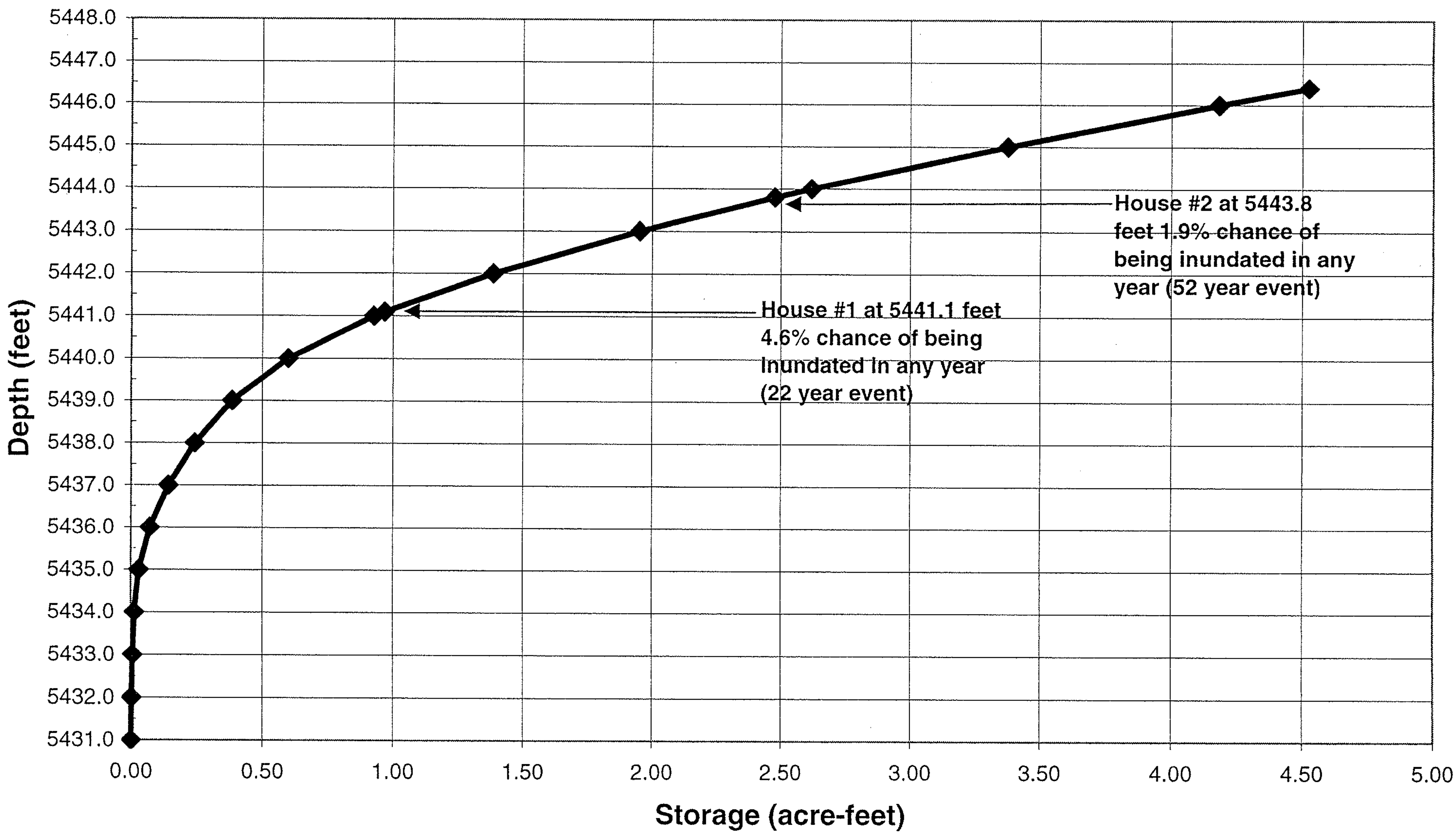
K_{10}		V_{10}	1.00 acre-feet	Q_{10}	86 cfs
K_{100}		V_{100}	5.60 acre-feet	Q_{100}	195 cfs

element 201). Residents downstream from this detention facility have built reliance upon it to limit peak discharges. Because of this reliance, any attempt to remove the embankment could result in injury to downstream property owners in a major storm event. However, leaving the embankment alone in its present condition posses safety concern due to the possibility of dam failure by overtopping or breaching. The inherent liability associated with ownership and maintenance of this detention pond must be cautiously addressed. Because of the importance of this detention facility, one of the first drainage improvements in the Steamboat Valley should be to rebuild this embankment and pond area. The embankment should be kept less than 10 feet high to avoid complicating permits and restrictions required by the State Engineer's Dam Safety Office for jurisdictional dams. The dam embankment should be recompacted to improve the safety and integrity of the structure. The area behind the dam should be excavated to match the historic detention volume that was available with the historic structure having a greater dam height. Finally, the outlet box should be improved to match historic release rates and reliability. This drainage report provides information on a new dam and outlet pipe for planning and budgeting purposes, and a more detailed design will be required with additional survey and geotechnical information prior to reconstruction.

Figure 5-3 is a Stage-Capacity Curve for the Boone detention pond as it exists now without any additional detention upstream, which based upon available mapping. The diagram shows how storage volume in the pond changes with the depth of water in the pond. Three residential properties would potentially be inundated if the pond filled full. An efforts to take these properties partially out of the zone of inundation would include additional excavation in the pond area to maintain the same storage volume at a lower pond depth. Figure 5-3 shows the calculated chance of inundation of these buildings within the pond high water level, and the storage volume at which it would occur. Due to the potential of flooding, it is recommended that these homeowners maintain flood insurance and floodproof their homes and valuables.

Additional detention upstream if designed correctly would benefit the Steamboat Valley drainage. Existing and post-development hydrology conditions of the Steamboat Valley drainage basin have been modeled to understand the effects of development in the basin above town. The analysis considered potential impacts from the recent developments of Sierra Roja and Steamboat Valley Subdivisions located immediately upstream of the Boone detention pond. A stormwater analysis for these subdivisions by Park Engineering of Longmont, Colorado showed minimal impact on drainage, and therefore, no additional detention was required as a condition of development. Our studies concur that the impact is minimal in a major event. However, runoff in a minor event is significantly altered due to the increased imperviousness of the land, and the resultant discharge has the potential to noticeably increase channel erosion. The town should work with Sierra Roja and Steamboat Valley Subdivisions to include some detention for both the minor and major storm events to minimize channel erosion, limit runoff volume which could overtop the Boone embankment, and improve water quality of stormwater runoff. The hydrology model for this report includes a new detention pond (element 200) upstream from the existing detention pond (element 201). **Table 5-3** includes the minimum and CUHP model design parameters for a detention pond in this location.

Figure 5-3
Boone Detention Pond
Stage-Capacity Curve
(without Upstream Detention)



R:\35600\Drainage MP\Report\Lyons.xls Stage Curve

BRW, Inc. 4/29/98

An opportunity also exists to construct a detention pond west of the cemetery. A pond at this location could be fit into existing topography relatively easily and provide attenuation of peak flows from this drainage into the 4th Avenue drainage corridor. A 3.7 acre-foot detention pond would reduce the 100-year peak discharge from approximately 118 cfs to 47 cfs. This would help to reduce the size of conveyance structures downstream.

The 100-year peak flow downstream of the Boone embankment near Reese Street is calculated to be 366 cfs with two upstream detention facilities. The flow is calculated to be 548 cfs at the outfall into the St. Vrain Creek with the additional runoff from within the town. The existing open channel and stone box drainageway has a capacity of approximately 150 cfs. Additional conveyance capacity is therefore necessary to safely convey the 100-year event through town. Rebuilding the existing stone box is impractical and would require condemning land and easements. Utilizing the right-of-way easements in 4th and 5th Avenues for drainage appears to be the best solution for Lyons. Curb and gutter on these two avenues would provide some drainage conveyance in the streets (allowable capacity calculated to be approximately 105 cfs). Therefore, to provide protection in the 100-year event, a new storm sewer would need to convey approximately 111 cfs in the upper reaches of town, and 293 cfs in the lower reaches.

A new storm sewer system in 4th Avenue is the most practical location and would take the burden off the low-lying residences and provide the existing system the added capacity to capture local drainage. Understandably, a new large storm sewer retro-fit into an existing roadway corridor will be costly. The potential for conflicts with existing utilities will require careful design. Phasing this storm drain system over time and coordinating with the Highway Department will ease the financial impact of such a system. As streets are planned to be paved, the storm sewer can be included in the designs. Additionally, when CDOT rebuilds the highway through town, these drainage improvements should be coordinated into their designs.

UPPER THIRD AVENUE DRAINAGE

There are presently few drainage improvements in the 3rd Avenue corridor. Periodic flooding of properties has been a problem without formal drainage facilities. The most cost-effective drainage improvement is a detention pond east of the cemetery. A 3.0 acre-foot detention pond would reduce the 100-year peak discharge into 3rd Avenue from 141 cfs to an estimated 76 cfs, and capture sediment and debris flowing in the drainage.

Additionally, a new detention pond in the natural drainage north of 2nd Avenue which discharges into the 3rd Avenue drainage corridor will further reduce the peak flow. A 3.0 acre-foot detention pond is expected to reduce the 100-year peak discharge in this drainage from 111 cfs to 47 cfs.

A new storm drain pipe constructed in the 3rd Avenue right-of-way would protect existing development from flooding. Additionally, curb and gutter would provide conveyance in the street. Again, phasing these improvements with town and CDOT road reconstruction and paving plans is the realistic approach to financing and implementing a drainage improvement plan in 3rd Avenue.

SECOND AVENUE DRAINAGE

Stormwater runoff into 2nd Avenue has been a problem that will be further compounded by additional development on the hillside. There is very little, if any, opportunity to construct a detention pond in this area due to the steep topography. Additional development will therefore increase the runoff burden on the existing houses near 2nd Avenue and should be expected to contribute to the storm drain system in 2nd Avenue. Also, curb and gutter on the streets could provide drainage conveyance to reduce the size of the storm drains. This relatively short section of storm drain will discharge to the open channel along the highway and eventually discharge into St. Vrain Creek.

EWALD DRAINAGE

The hillside above Ewald Avenue is composed of sandstone rock near the surface. The geology in this area relating to the dip of the rock layer has a profound impact on stormwater runoff. Runoff is rapid once the thin surface soil layer becomes saturated. Heavy runoff conveys loose soil and rock into the development in the lower reaches of this drainage as observed in the storm of August 10, 1994.

Conveying runoff though this development into the North St. Vrain Creek will be costly due to the length of pipe required. A more practical solution appears to construct a diversion channel above existing development to concentrate runoff and direct it around existing houses. A sump area along the highway exists to collect runoff before discharging through a culvert into the South St. Vrain Creek. Increasing the discharge into this sump area with a diversion channel will require negotiation with the highway department for potential improvements to the sump area and culvert pipe to prevent roadway overtopping.

RED HILL GULCH DRAINAGE

This drainage has been modeled for this master plan to include the hydrology for future planning purposes. Since much of the lower reaches are either outside the town limits, in the floodplain or undeveloped, no specific drainage improvements have been identified. New development should plan to convey the peak flows identified in this report in the historic drainageways to the St. Vrain Creek. Preserving open space for these natural drainages is the least costly drainage solution.

PHASING PRIORITIES

Construction of the proposed detention ponds provides the most benefit for the least cost. Further improvements as proposed can be constructed under a phased capital improvement plan. The following priority list should be used as a guideline by the town to develop drainage improvements:

1. Incorporate the Boone detention pond facility into the overall drainage plan to protect existing properties in the area. This will require reconfiguration of the pond and outlet structure to maintain 5 acre-feet (AF) of active storage. The dam could be reconstructed to improve safety and provide a new outlet into 4th Avenue.

2. Construction of a new detention pond within the area of the Steamboat Valley and Sierra Roja Subdivisions. The roadway embankment could be utilized as a detention pond dam. Instead of the proposed twin 60-inch pipes to convey the 100-year runoff, the pipe size could be reduced and runoff could be slowed down in a pond. Improvements beyond the proposed roadway embankment in lieu of the twin pipes would include a multi-stage outlet structure and riprap on the downstream face to protect against stormwater overtopping the roadway.

3. Install three new cross-culverts along the existing Steamboat Valley drainageway through Town. A 36-inch culvert at Reese Street, an upstream 42-inch culvert and a downstream 43" x 28" elliptical culvert have less capacity than the 6' x 3' stone culvert thereby limiting the conveyance capacity, and should be replaced with larger culverts.

4. Install a 100-year capacity diversion canal approximately 900 feet long in the Ewald drainage.

5. Construct a new storm sewer outfall system within Fourth Avenue as part of planned roadway improvements in 1999 where the dirt streets will be paved.

6. Work with CDOT to incorporate storm sewer upgrades in Highway 36 for inclusion in 5 year CIP.

7. Reconstruct the drainage open channel along the highway from 3rd Avenue discharging to St. Vrain Creek with a conveyance capacity for the 100-year event.

8. Construct a 3.7 AF detention pond west of the cemetery above the Upper Fourth Avenue drainage basin.

9. Construct a 3.0 AF detention pond east of the cemetery in the Upper Third Avenue drainage basin.

10. Construct a 3.0 AF detention pond in the eastern Lyons drainage basin.

11. Install storm sewer pipe and curb & gutter improvements in 3rd Avenue.

12. Install storm sewer pipe and curb & gutter improvements in 2nd Avenue.

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TECHNICAL APPENDIX

CUHP INPUT FILE FOR 2-YEAR STORM

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CUHP INPUT FILE FOR 5-YEAR STORM

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CUHP INPUT FILE FOR 10-YEAR STORM

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CUHP INPUT FILE FOR 50-YEAR STORM

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\80 1 15.0 4.1  041STONE CANYON
2.2503.8071.856 3.000.037     0.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 5.1  051EWALD DRAINAGE
0.1340.4170.265 7.000.065 22.20.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 5.2  052LOWER EWALD
0.0550.3440.18940.000.028 20.10.350 0.10 3.0 .0018 0.50 0.0 0
\80 1 15.0 6.1  061RED HILL GULCH
2.1023.6171.563 4.000.052     0.400 0.10 3.0 .0018 0.50 0.0 0
\80 1 15.0 6.2  062OLSON GULCH
0.2591.6570.890 3.000.060     0.400 0.10 3.0 .0018 0.50 0.0 0
\80 1 15.0 6.3  063SOUTH LYONS
0.2500.9660.47333.000.016     0.350 0.10 3.0 .0018 0.50 0.0 0
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CUHP INPUT FILE FOR 100-YEAR STORM

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\2      LYONS DRAINAGE MASTER PLAN  3/11/98
01  100-YEAR100 2.70                                                   0.000.000.000.00

\80 1 15.0 1.1  011EAGLE CANYON
0.9382.3861.231 7.000.055     0.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 1.2  012LOWER EAGLE CANYON
0.0910.6250.30316.910.060 28.30.350 0.10 3.0 .0018 0.50 0.0 0
\80 1 15.0 2.7  027UPPER STEAMBOAT VALLEY
0.2580.8900.398 6.000.068     0.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 2.1  021STEAMBOAT VALLEY
0.0810.6630.303 6.000.054 29.40.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 2.2  022UPPER FIFTH AVENUE
0.0890.4730.25630.000.060 23.90.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 2.3  023UPPER FOURTH AVENUE
0.0830.7950.36012.000.071 33.30.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 2.4  024LOWER STEAMBOAT VALLEY
0.0880.5110.26550.000.043 25.00.350 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 3.1  031UPPER THIRD AVENUE
0.0940.7200.32210.000.065 31.10.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 3.2  032UPPER STICKNEY STREET
0.0660.5300.18913.000.076 25.60.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 3.3  033UPPER MAIN STREET
0.0880.4360.15210.000.072 22.80.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 3.4  034MIDDLE THIRD AVENUE
0.0660.3500.15250.000.047 20.30.350 0.10 3.0 .0018 0.50 0.0 0
\80 1 15.0 4.1  041STONE CANYON
2.2503.8071.856 3.000.037     0.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 5.1  051EWALD DRAINAGE
0.1340.4170.265 7.000.065 22.20.400 0.10 3.0 .0018 0.50 0.0 0
\81 1 15.0 5.2  052LOWER EWALD
0.0550.3440.18940.000.028 20.10.350 0.10 3.0 .0018 0.50 0.0 0
\80 1 15.0 6.1  061RED HILL GULCH
2.1023.6171.563 4.000.052     0.400 0.10 3.0 .0018 0.50 0.0 0
\80 1 15.0 6.2  062OLSON GULCH
0.2591.6570.890 3.000.060     0.400 0.10 3.0 .0018 0.50 0.0 0
\80 1 15.0 6.3  063SOUTH LYONS
0.2500.9660.47333.000.016     0.350 0.10 3.0 .0018 0.50 0.0 0
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CUHP OUTPUT FILE FOR 100-STORM

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE AT TIME

CUHPE/PC VERSION MODIFIED IN JANUARY 1985

PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 8

LYONS DRAINAGE MASTER PLAN 3/11/98

BASIN ID: 1.1 -- BASIN COMMENT: EAGLE CANYON

AREA OF BASIN (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERVIOUS AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
.94	2.39	1.23	7.00	.0550	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
.137	.298

TIME (MIN.)	STORM HYDROGRAPH	TIME (MIN.)	STORM HYDROGRAPH	TIME (MIN.)	STORM HYDROGRAPH
5.	0.	135.	274.	265.	48.
10.	0.	140.	256.	270.	44.
15.	0.	145.	240.	275.	42.
20.	2.	150.	224.	280.	39.
25.	10.	155.	209.	285.	36.
30.	54.	160.	196.	290.	34.
35.	146.	165.	183.	295.	32.
40.	261.	170.	171.	300.	30.
45.	372.	175.	160.	305.	28.
50.	461.	180.	150.	310.	26.
55.	522.	185.	140.	315.	24.
60.	555.	190.	131.	320.	23.
65.	567.	195.	122.	325.	21.
70.	563.	200.	114.	330.	20.
75.	551.	205.	107.	335.	19.
80.	536.	210.	100.	340.	17.
85.	516.	215.	93.	345.	16.
90.	492.	220.	87.	350.	14.
95.	465.	225.	82.	355.	9.
100.	437.	230.	76.	360.	6.
105.	408.	235.	71.	365.	4.
110.	381.	240.	67.	370.	3.
115.	357.	245.	62.	375.	2.
120.	334.	250.	58.	380.	2.
125.	313.	255.	54.	385.	1.
130.	293.	260.	51.	390.	0.

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXECESS PRECIP. = 1.736 INCHES
VOLUME OF EXCESS PRECIP = 87. ACRE-FEET
PEAK Q = 567. CFS TIME OF PEAK = 65. MIN.
INFILT.= 3.00 IN/HR DECAY = .00180 FNINF = .50 IN/HR
MAX.PERV.RET.= .40 IN. MAX.IMP.RET.= .10 IN.

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE AT TIME

CUHPE/PC VERSION MODIFIED IN JANUARY 1985

PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 8

LYONS DRAINAGE MASTER PLAN 3/11/98

BASIN ID: 1.2 -- BASIN COMMENT: LOWER EAGLE CANYON

AREA OF BASIN (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERVIOUS AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
.09	.63	.30	16.91	.0600	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
.115	.213

TIME (MIN.)	STORM ' HYDROGRAPH	*	TIME (MIN.)	STORM ' HYDROGRAPH	*	TIME (MIN.)	STORM ' HYDROGRAPH	*
5.	0.	*	50.	126.	*	95.	15.	*
10.	0.	*	55.	110.	*	100.	11.	*
15.	3.	*	60.	96.	*	105.	9.	*
20.	8.	*	65.	86.	*	110.	7.	*
25.	32.	*	70.	71.	*	115.	6.	*
30.	118.	*	75.	57.	*	120.	5.	*
35.	158.	*	80.	45.	*	125.	3.	*
40.	157.	*	85.	34.	*	130.	2.	*
45.	142.	*	90.	22.	*	135.	2.	*

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXECESS PRECIP. = 1.898 INCHES
VOLUME OF EXCESS PRECIP = 9. ACRE-FEET
PEAK Q = 158. CFS TIME OF PEAK = 35. MIN.
INFILT.= 3.00 IN/HR DECAY = .00180 FNINF = .50 IN/HR
MAX.PERV.RET.= .35 IN. MAX.IMP.RET.= .10 IN.

RATIONAL FORMULA C = .61
I = 4.4 INCHES/HOUR
A = 58.2 ACRES
Q = 155. CFS

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE AT TIME

CUHPE/PC VERSION MODIFIED IN JANUARY 1985

PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 8

LYONS DRAINAGE MASTER PLAN 3/11/98

BASIN ID: 2.7 -- BASIN COMMENT: UPPER STEAMBOAT VALLEY

AREA OF BASIN (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERVIOUS AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
.26	.89	.40	6.00	.0680	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
.141	.250

TIME (MIN.)	STORM HYDROGRAPH	*	TIME (MIN.)	STORM HYDROGRAPH	*	TIME (MIN.)	STORM HYDROGRAPH	*
5.	0.	*	65.	233.	*	125.	43.	*
10.	0.	*	70.	212.	*	130.	37.	*
15.	1.	*	75.	188.	*	135.	32.	*
20.	3.	*	80.	163.	*	140.	27.	*
25.	18.	*	85.	141.	*	145.	23.	*
30.	111.	*	90.	121.	*	150.	19.	*
35.	224.	*	95.	104.	*	155.	12.	*
40.	279.	*	100.	90.	*	160.	8.	*
45.	285.	*	105.	77.	*	165.	6.	*
50.	282.	*	110.	67.	*	170.	4.	*
55.	268.	*	115.	58.	*	175.	3.	*
60.	249.	*	120.	50.	*	180.	2.	*

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXECESS PRECIP. = 1.724 INCHES
VOLUME OF EXCESS PRECIP = 24. ACRE-FEET
PEAK Q = 285. CFS TIME OF PEAK = 45. MIN.
INFILT.= 3.00 IN/HR DECAY = .00180 FNINF = .50 IN/HR
MAX.PERV.RET.= .40 IN. MAX.IMP.RET.= .10 IN.

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1     U.D.F.C.D. CUHP RUNOFF ANALYSIS     EXECUTED ON DATE                AT TIME

      CUHPE/PC VERSION MODIFIED IN JANUARY 1985

      PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS  8

      LYONS DRAINAGE MASTER PLAN  3/11/98


      BASIN ID:    2.1    --  BASIN COMMENT:  STEAMBOAT VALLEY

        AREA OF BASIN  LENGTH OF BASIN  DIST TO CENTROID  IMPERVIOUS AREA  SLOPE  UNIT DURATION
           (SQMI)           (MI)             (MI)              (PCT)       (FT/FT)     (MIN)

            .08              .66              .30               6.00        .0540       5.00

                    COEFFICIENT                        COEFFICIENT
               (REFLECTING TIME TO PEAK)    (RELATED TO PEAK RATE OF RUNOFF)

                          .141                              .210


       TIME       STORM      '     TIME       STORM      '     TIME       STORM      '
      (MIN.)   HYDROGRAPH    *    (MIN.)   HYDROGRAPH    *    (MIN.)   HYDROGRAPH    *
                             *                           *                           *
        5.          0.       *     50.        105.       *     95.         16.       *
       10.          0.       *     55.         93.       *    100.         11.       *
       15.          1.       *     60.         83.       *    105.          8.       *
       20.          2.       *     65.         75.       *    110.          6.       *
       25.         13.       *     70.         63.       *    115.          4.       *
       30.         80.       *     75.         52.       *    120.          3.       *
       35.        120.       *     80.         42.       *    125.          2.       *
       40.        124.       *     85.         33.       *    130.          1.       *
       45.        116.       *     90.         26.       *    135.          1.       *

           TOTAL PRECIP. =  3.12 (1-HOUR RAIN =  2.70)      EXECESS PRECIP. = 1.724  INCHES
           VOLUME OF EXCESS PRECIP =      7.  ACRE-FEET
           PEAK Q =  124. CFS       TIME OF PEAK =  40. MIN.
           INFILT.= 3.00 IN/HR     DECAY = .00180     FNINF =  .50 IN/HR
           MAX.PERV.RET.= .40 IN.      MAX.IMP.RET.= .10 IN.

           RATIONAL FORMULA C =        .55
                            I =       4.3 INCHES/HOUR
                            A =      51.8 ACRES
                            Q =      122. CFS
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1   U.D.F.C.D. CUHP RUNOFF ANALYSIS     EXECUTED ON DATE               AT TIME

    CUHPE/PC VERSION MODIFIED IN JANUARY 1985

    PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS  8

    LYONS DRAINAGE MASTER PLAN  3/11/98


    BASIN ID:   2.2    --  BASIN COMMENT:  UPPER FIFTH AVENUE

      AREA OF BASIN  LENGTH OF BASIN  DIST TO CENTROID  IMPERVIOUS AREA  SLOPE  UNIT DURATION
         (SQMI)           (MI)             (MI)              (PCT)       (FT/FT)     (MIN)

          .09              .47              .26              30.00        .0600       5.00

                     COEFFICIENT                        COEFFICIENT
              (REFLECTING TIME TO PEAK)   (RELATED TO PEAK RATE OF RUNOFF)

                          .099                              .277

     TIME       STORM     '     TIME      STORM      '     TIME      STORM     '
    (MIN.)   HYDROGRAPH   *    (MIN.)   HYDROGRAPH   *    (MIN.)   HYDROGRAPH  *
                          *                          *                         *
      5.          0.      *      55.       111.      *     105.        10.     *
     10.          0.      *      60.        96.      *     110.         8.     *
     15.          5.      *      65.        85.      *     115.         7.     *
     20.         15.      *      70.        69.      *     120.         7.     *
     25.         39.      *      75.        54.      *     125.         5.     *
     30.        128.      *      80.        41.      *     130.         4.     *
     35.        178.      *      85.        27.      *     135.         3.     *
     40.        171.      *      90.        20.      *     140.         2.     *
     45.        151.      *      95.        15.      *     145.         1.     *
     50.        131.      *     100.        12.      *     150.         1.     *


        TOTAL PRECIP. =  3.12 (1-HOUR RAIN =  2.70)     EXECESS PRECIP. = 2.016  INCHES
        VOLUME OF EXCESS PRECIP =     10.  ACRE-FEET
        PEAK Q =  178. CFS       TIME OF PEAK =  35. MIN.
        INFILT.= 3.00 IN/HR     DECAY = .00180     FNINF =  .50 IN/HR
        MAX.PERV.RET.= .40 IN.      MAX.IMP.RET.= .10 IN.

        RATIONAL FORMULA C =         .65
                         I =        4.8 INCHES/HOUR
                         A =       57.0 ACRES
                         Q =       177. CFS
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1    U.D.F.C.D. CUHP RUNOFF ANALYSIS      EXECUTED ON DATE                    AT TIME

     CUHPE/PC VERSION MODIFIED IN JANUARY 1985

     PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS  8

     LYONS DRAINAGE MASTER PLAN  3/11/98


     BASIN ID:    2.3     --  BASIN COMMENT:  UPPER FOURTH AVENUE

       AREA OF BASIN  LENGTH OF BASIN  DIST TO CENTROID  IMPERVIOUS AREA  SLOPE  UNIT DURATION
          (SQMI)           (MI)             (MI)               (PCT)       (FT/FT)    (MIN)

           .08              .80              .36               12.00        .0710      5.00

                       COEFFICIENT                        COEFFICIENT
                 (REFLECTING TIME TO PEAK)   (RELATED TO PEAK RATE OF RUNOFF)

                           .122                              .200


      TIME        STORM      '     TIME        STORM      '     TIME        STORM      '
     (MIN.)    HYDROGRAPH    *    (MIN.)    HYDROGRAPH    *    (MIN.)    HYDROGRAPH    *
                             *                            *                            *
       5.           0.       *      50.        105.       *      95.         27.       *
      10.           0.       *      55.         95.       *     100.         22.       *
      15.           1.       *      60.         86.       *     105.         14.       *
      20.           4.       *      65.         79.       *     110.         10.       *
      25.          15.       *      70.         68.       *     115.          8.       *
      30.          76.       *      75.         58.       *     120.          6.       *
      35.         113.       *      80.         48.       *     125.          4.       *
      40.         118.       *      85.         40.       *     130.          3.       *
      45.         114.       *      90.         33.       *     135.          2.       *


          TOTAL PRECIP. =  3.12 (1-HOUR RAIN =  2.70)      EXECESS PRECIP. = 1.797  INCHES
          VOLUME OF EXCESS PRECIP =       8.  ACRE-FEET
          PEAK Q =  118. CFS       TIME OF PEAK =  40. MIN.
          INFILT.= 3.00 IN/HR     DECAY = .00180     FNINF =  .50 IN/HR
          MAX.PERV.RET.= .40 IN.     MAX.IMP.RET.= .10 IN.

          RATIONAL FORMULA C =         .58
                           I =       4.0 INCHES/HOUR
                           A =      53.1 ACRES
                           Q =      121. CFS
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1    U.D.F.C.D. CUHP RUNOFF ANALYSIS      EXECUTED ON DATE                AT TIME

     CUHPE/PC VERSION MODIFIED IN JANUARY 1985

     PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS  8

     LYONS DRAINAGE MASTER PLAN  3/11/98


     BASIN ID:   2.4    --  BASIN COMMENT:  LOWER STEAMBOAT VALLEY

       AREA OF BASIN  LENGTH OF BASIN  DIST TO CENTROID  IMPERVIOUS AREA  SLOPE  UNIT DURATION
          (SQMI)           (MI)              (MI)             (PCT)       (FT/FT)     (MIN)

           .09              .51               .26             50.00        .0430       5.00

                    COEFFICIENT                        COEFFICIENT
              (REFLECTING TIME TO PEAK)   (RELATED TO PEAK RATE OF RUNOFF)

                          .088                             .433

      TIME      STORM      '     TIME      STORM      '     TIME      STORM      '
     (MIN.)   HYDROGRAPH   *    (MIN.)   HYDROGRAPH   *    (MIN.)   HYDROGRAPH   *
                           *                          *                          *
       5.          0.      *      55.       125.      *     105.        14.      *
      10.          0.      *      60.       106.      *     110.        13.      *
      15.          5.      *      65.        92.      *     115.        12.      *
      20.         19.      *      70.        78.      *     120.        11.      *
      25.         45.      *      75.        62.      *     125.         9.      *
      30.        110.      *      80.        48.      *     130.         7.      *
      35.        183.      *      85.        33.      *     135.         5.      *
      40.        191.      *      90.        25.      *     140.         3.      *
      45.        171.      *      95.        19.      *     145.         2.      *
      50.        147.      *     100.        16.      *     150.         1.      *


        TOTAL PRECIP. =   3.12 (1-HOUR RAIN =   2.70)      EXECESS PRECIP. = 2.285  INCHES
        VOLUME OF EXCESS PRECIP =     11.  ACRE-FEET
        PEAK Q =  191. CFS       TIME OF PEAK =  40. MIN.
        INFILT.= 3.00 IN/HR     DECAY = .00180     FNINF =  .50 IN/HR
        MAX.PERV.RET.= .35 IN.      MAX.IMP.RET.= .10 IN.

        RATIONAL FORMULA C =          .73
                         I =         4.7 INCHES/HOUR
                         A =        56.3 ACRES
                         Q =        194. CFS
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1     U.D.F.C.D. CUHP RUNOFF ANALYSIS     EXECUTED ON DATE                 AT TIME

      CUHPE/PC VERSION MODIFIED IN JANUARY 1985

      PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS  8

      LYONS DRAINAGE MASTER PLAN  3/11/98


      BASIN ID:   3.1     --  BASIN COMMENT:  UPPER THIRD AVENUE

        AREA OF BASIN  LENGTH OF BASIN  DIST TO CENTROID  IMPERVIOUS AREA  SLOPE  UNIT DURATION
           (SQMI)           (MI)              (MI)              (PCT)      (FT/FT)    (MIN)

            .09              .72               .32              10.00       .0650      5.00

                      COEFFICIENT                           COEFFICIENT
                (REFLECTING TIME TO PEAK)    (RELATED TO PEAK RATE OF RUNOFF)

                          .126                                  .202

TIME        STORM     '      TIME        STORM     '      TIME        STORM     '
     (MIN.)   HYDROGRAPH  *    (MIN.)   HYDROGRAPH  *    (MIN.)   HYDROGRAPH  *
                          *                         *                         *
      5.           0.     *      50.        122.    *      95.          26.   *
     10.           0.     *      55.        108.    *     100.          17.   *
     15.           1.     *      60.         97.    *     105.          12.   *
     20.           4.     *      65.         88.    *     110.           9.   *
     25.          18.     *      70.         75.    *     115.           7.   *
     30.          92.     *      75.         63.    *     120.           5.   *
     35.         135.     *      80.         51.    *     125.           4.   *
     40.         141.     *      85.         41.    *     130.           2.   *
     45.         134.     *      90.         33.    *     135.           1.   *


          TOTAL PRECIP. =  3.12 (1-HOUR RAIN =  2.70)      EXECESS PRECIP. = 1.773  INCHES
          VOLUME OF EXCESS PRECIP =      9.  ACRE-FEET
          PEAK Q =  141. CFS      TIME OF PEAK =  40. MIN.
          INFILT.= 3.00 IN/HR     DECAY = .00180     FNINF =  .50 IN/HR
          MAX.PERV.RET.= .40 IN.      MAX.IMP.RET.= .10 IN.

          RATIONAL FORMULA C =         .57
                           I =        4.1 INCHES/HOUR
                           A =       60.2 ACRES
                           Q =       141. CFS
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1     U.D.F.C.D. CUHP RUNOFF ANALYSIS      EXECUTED ON DATE                AT TIME

      CUHPE/PC VERSION MODIFIED IN JANUARY 1985

      PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS  8

      LYONS DRAINAGE MASTER PLAN  3/11/98


      BASIN ID:    3.2     --  BASIN COMMENT:  UPPER STICKNEY STREET

        AREA OF BASIN  LENGTH OF BASIN  DIST TO CENTROID  IMPERVIOUS AREA  SLOPE  UNIT DURATION
           (SQMI)           (MI)             (MI)               (PCT)       (FT/FT)    (MIN)

            .07             .53              .19               13.00        .0760      5.00

                         COEFFICIENT                         COEFFICIENT
                   (REFLECTING TIME TO PEAK)    (RELATED TO PEAK RATE OF RUNOFF)

                             .121                               .194

TIME       STORM     '     TIME        STORM     '     TIME        STORM     '
     (MIN.)   HYDROGRAPH  *    (MIN.)   HYDROGRAPH  *    (MIN.)   HYDROGRAPH  *
                          *                         *                         *
       5.           0.    *     50.          89.    *     95.          10.    *
      10.           0.    *     55.          78.    *    100.           7.    *
      15.           2.    *     60.          69.    *    105.           5.    *
      20.           5.    *     65.          62.    *    110.           4.    *
      25.          17.    *     70.          50.    *    115.           3.    *
      30.          84.    *     75.          41.    *    120.           2.    *
      35.         111.    *     80.          31.    *    125.           2.    *
      40.         110.    *     85.          20.    *    130.           1.    *
      45.         100.    *     90.          13.    *    135.           1.    *

         TOTAL PRECIP. =  3.12 (1-HOUR RAIN =  2.70)      EXECESS PRECIP. = 1.809  INCHES
         VOLUME OF EXCESS PRECIP =      6.  ACRE-FEET
         PEAK Q =  111. CFS       TIME OF PEAK =  35. MIN.
         INFILT.= 3.00 IN/HR     DECAY = .00180     FNINF =  .50 IN/HR
         MAX.PERV.RET.= .40 IN.      MAX.IMP.RET.= .10 IN.

         RATIONAL FORMULA C =         .58
                          I =        4.6 INCHES/HOUR
                          A =       42.2 ACRES
                          Q =       113. CFS
```

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE AT TIME

CUHPE/PC VERSION MODIFIED IN JANUARY 1985

PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 8

LYONS DRAINAGE MASTER PLAN 3/11/98

BASIN ID: 3.4 -- BASIN COMMENT: MIDDLE THIRD AVENUE

AREA OF BASIN (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERVIOUS AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
.07	.35	.15	50.00	.0470	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
.088	.414

TIME (MIN.)	STORM HYDROGRAPH	' * *	TIME (MIN.)	STORM HYDROGRAPH	' * *	TIME (MIN.)	STORM HYDROGRAPH	' * *
5.	0.	*	55.	88.	*	105.	9.	*
10.	0.	*	60.	73.	*	110.	8.	*
15.	6.	*	65.	62.	*	115.	8.	*
20.	19.	*	70.	50.	*	120.	8.	*
25.	44.	*	75.	35.	*	125.	7.	*
30.	109.	*	80.	26.	*	130.	4.	*
35.	163.	*	85.	19.	*	135.	3.	*
40.	155.	*	90.	14.	*	140.	2.	*
45.	130.	*	95.	12.	*	145.	1.	*
50.	108.	*	100.	10.	*	150.	1.	*

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXECESS PRECIP. = 2.285 INCHES
VOLUME OF EXCESS PRECIP = 8. ACRE-FEET
PEAK Q = 163. CFS TIME OF PEAK = 35. MIN.
INFILT.= 3.00 IN/HR DECAY = .00180 FNINF = .50 IN/HR
MAX.PERV.RET.= .35 IN. MAX.IMP.RET.= .10 IN.

RATIONAL FORMULA C = .73
I = 5.3 INCHES/HOUR
A = 42.2 ACRES
Q = 163. CFS

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE AT TIME

CUHPE/PC VERSION MODIFIED IN JANUARY 1985

PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 8

LYONS DRAINAGE MASTER PLAN 3/11/98

BASIN ID: 4.1 -- BASIN COMMENT: STONE CANYON

AREA OF BASIN (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERVIOUS AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
2.25	3.81	1.86	3.00	.0370	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
.152	.368

TIME (MIN.)	STORM HYDROGRAPH	*	TIME (MIN.)	STORM HYDROGRAPH	*	TIME (MIN.)	STORM HYDROGRAPH	*
5.	0.	*	200.	375.	*	395.	60.	*
10.	0.	*	205.	358.	*	400.	57.	*
15.	0.	*	210.	342.	*	405.	55.	*
20.	1.	*	215.	326.	*	410.	52.	*
25.	5.	*	220.	311.	*	415.	50.	*
30.	32.	*	225.	297.	*	420.	48.	*
35.	93.	*	230.	283.	*	425.	45.	*
40.	184.	*	235.	270.	*	430.	43.	*
45.	297.	*	240.	258.	*	435.	41.	*
50.	421.	*	245.	246.	*	440.	39.	*
55.	543.	*	250.	235.	*	445.	38.	*
60.	658.	*	255.	224.	*	450.	36.	*
65.	760.	*	260.	214.	*	455.	34.	*
70.	844.	*	265.	204.	*	460.	33.	*
75.	909.	*	270.	195.	*	465.	31.	*
80.	954.	*	275.	186.	*	470.	30.	*
85.	978.	*	280.	177.	*	475.	28.	*
90.	984.	*	285.	169.	*	480.	27.	*
95.	974.	*	290.	161.	*	485.	26.	*
100.	951.	*	295.	154.	*	490.	25.	*
105.	917.	*	300.	147.	*	495.	24.	*
110.	878.	*	305.	140.	*	500.	22.	*
115.	840.	*	310.	134.	*	505.	21.	*
120.	804.	*	315.	128.	*	510.	20.	*
125.	770.	*	320.	122.	*	515.	20.	*
130.	736.	*	325.	116.	*	520.	19.	*
135.	703.	*	330.	111.	*	525.	18.	*
140.	671.	*	335.	106.	*	530.	17.	*
145.	639.	*	340.	101.	*	535.	16.	*
150.	608.	*	345.	96.	*	540.	15.	*
155.	578.	*	350.	92.	*	545.	15.	*
160.	550.	*	355.	88.	*	550.	13.	*
165.	524.	*	360.	84.	*	555.	8.	*
170.	499.	*	365.	80.	*	560.	5.	*
175.	476.	*	370.	76.	*	565.	4.	*
180.	454.	*	375.	73.	*	570.	3.	*
185.	433.	*	380.	69.	*	575.	2.	*
190.	412.	*	385.	66.	*	580.	1.	*
195.	393.	*	390.	63.	*	585.	1.	*

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXECESS PRECIP. = 1.687 INCHES
VOLUME OF EXCESS PRECIP = 202. ACRE-FEET
PEAK Q = 984. CFS TIME OF PEAK = 90. MIN.
INFILT.= 3.00 IN/HR DECAY = .00180 FNINF = .50 IN/HR
MAX.PERV.RET.= .40 IN. MAX.IMP.RET.= .10 IN.

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE AT TIME

CUHPE/PC VERSION MODIFIED IN JANUARY 1985

PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 8

LYONS DRAINAGE MASTER PLAN 3/11/98

BASIN ID: 5.1 -- BASIN COMMENT: EWALD DRAINAGE

AREA OF BASIN (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERVIOUS AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
.13	.42	.26	7.00	.0650	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
.137	.223

TIME (MIN.)	STORM HYDROGRAPH	*	TIME (MIN.)	STORM HYDROGRAPH	*	TIME (MIN.)	STORM HYDROGRAPH	*
5.	0.	*	50.	177.	*	95.	12.	*
10.	0.	*	55.	146.	*	100.	8.	*
15.	2.	*	60.	124.	*	105.	6.	*
20.	6.	*	65.	108.	*	110.	4.	*
25.	36.	*	70.	82.	*	115.	3.	*
30.	206.	*	75.	62.	*	120.	3.	*
35.	262.	*	80.	43.	*	125.	2.	*
40.	243.	*	85.	27.	*	130.	1.	*
45.	210.	*	90.	17.	*	135.	1.	*

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXECESS PRECIP. = 1.736 INCHES
VOLUME OF EXCESS PRECIP = 12. ACRE-FEET
PEAK Q = 262. CFS TIME OF PEAK = 35. MIN.
INFILT.= 3.00 IN/HR DECAY = .00180 FNINF = .50 IN/HR
MAX.PERV.RET.= .40 IN. MAX.IMP.RET.= .10 IN.

RATIONAL FORMULA C = .56
I = 5.0 INCHES/HOUR
A = 85.8 ACRES
Q = 239. CFS

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE AT TIME

CUHPE/PC VERSION MODIFIED IN JANUARY 1985

PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 8

LYONS DRAINAGE MASTER PLAN 3/11/98

BASIN ID: 6.1 -- BASIN COMMENT: RED HILL GULCH

AREA OF BASIN (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERVIOUS AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
2.10	3.62	1.56	4.00	.0520	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
.148	.356

TIME (MIN.)	STORM HYDROGRAPH	TIME (MIN.)	STORM HYDROGRAPH	TIME (MIN.)	STORM HYDROGRAPH
5.	0.	175.	412.	345.	61.
10.	0.	180.	389.	350.	58.
15.	0.	185.	368.	355.	55.
20.	1.	190.	348.	360.	52.
25.	8.	195.	329.	365.	49.
30.	51.	200.	311.	370.	46.
35.	145.	205.	294.	375.	44.
40.	280.	210.	278.	380.	41.
45.	438.	215.	263.	385.	39.
50.	595.	220.	249.	390.	37.
55.	742.	225.	235.	395.	35.
60.	865.	230.	222.	400.	33.
65.	962.	235.	210.	405.	31.
70.	1029.	240.	199.	410.	30.
75.	1067.	245.	188.	415.	28.
80.	1078.	250.	178.	420.	26.
85.	1065.	255.	168.	425.	25.
90.	1034.	260.	159.	430.	24.
95.	991.	265.	150.	435.	22.
100.	946.	270.	142.	440.	21.
105.	903.	275.	134.	445.	20.
110.	859.	280.	127.	450.	19.
115.	816.	285.	120.	455.	18.
120.	773.	290.	113.	460.	17.
125.	730.	295.	107.	465.	16.
130.	688.	300.	101.	470.	15.
135.	649.	305.	96.	475.	13.
140.	612.	310.	91.	480.	8.
145.	579.	315.	86.	485.	5.
150.	547.	320.	81.	490.	4.
155.	517.	325.	77.	495.	3.
160.	488.	330.	72.	500.	2.
165.	461.	335.	68.	505.	1.
170.	436.	340.	65.	510.	1.

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXECESS PRECIP. = 1.699 INCHES
VOLUME OF EXCESS PRECIP = 191. ACRE-FEET
PEAK Q = 1078. CFS TIME OF PEAK = 80. MIN.
INFILT.= 3.00 IN/HR DECAY = .00180 FNINF = .50 IN/HR
MAX.PERV.RET.= .40 IN. MAX.IMP.RET.= .10 IN.

1 U.D.F.C.D. CUHP RUNOFF ANALYSIS EXECUTED ON DATE AT TIME

CUHPE/PC VERSION MODIFIED IN JANUARY 1985

PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS 8

LYONS DRAINAGE MASTER PLAN 3/11/98

BASIN ID: 6.2 -- BASIN COMMENT: OLSON GULCH

AREA OF BASIN (SQMI)	LENGTH OF BASIN (MI)	DIST TO CENTROID (MI)	IMPERVIOUS AREA (PCT)	SLOPE (FT/FT)	UNIT DURATION (MIN)
.26	1.66	.89	3.00	.0600	5.00

COEFFICIENT (REFLECTING TIME TO PEAK)	COEFFICIENT (RELATED TO PEAK RATE OF RUNOFF)
.152	.266

TIME (MIN.)	STORM HYDROGRAPH	*	TIME (MIN.)	STORM HYDROGRAPH	*	TIME (MIN.)	STORM HYDROGRAPH	*
5.	0.	*	100.	116.	*	195.	31.	*
10.	0.	*	105.	108.	*	200.	29.	*
15.	0.	*	110.	101.	*	205.	27.	*
20.	0.	*	115.	94.	*	210.	25.	*
25.	3.	*	120.	87.	*	215.	23.	*
30.	22.	*	125.	82.	*	220.	22.	*
35.	59.	*	130.	76.	*	225.	20.	*
40.	100.	*	135.	71.	*	230.	19.	*
45.	134.	*	140.	66.	*	235.	18.	*
50.	155.	*	145.	62.	*	240.	17.	*
55.	165.	*	150.	58.	*	245.	15.	*
60.	165.	*	155.	54.	*	250.	14.	*
65.	163.	*	160.	50.	*	255.	8.	*
70.	161.	*	165.	47.	*	260.	6.	*
75.	158.	*	170.	44.	*	265.	4.	*
80.	152.	*	175.	41.	*	270.	3.	*
85.	144.	*	180.	38.	*	275.	2.	*
90.	135.	*	185.	36.	*	280.	1.	*
95.	125.	*	190.	33.	*	285.	1.	*

TOTAL PRECIP. = 3.12 (1-HOUR RAIN = 2.70) EXECESS PRECIP. = 1.687 INCHES
VOLUME OF EXCESS PRECIP = 23. ACRE-FEET
PEAK Q = 165. CFS TIME OF PEAK = 60. MIN.
INFILT.= 3.00 IN/HR DECAY = .00180 FNINF = .50 IN/HR
MAX.PERV.RET.= .40 IN. MAX.IMP.RET.= .10 IN.

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1      U.D.F.C.D. CUHP RUNOFF ANALYSIS      EXECUTED ON DATE                 AT TIME

       CUHPE/PC VERSION MODIFIED IN JANUARY 1985

       PRINT OPTION NUMBER SELECTED FOR THIS BASIN IS  8

       LYONS DRAINAGE MASTER PLAN  3/11/98


       BASIN ID:    6.3    --  BASIN COMMENT:  SOUTH LYONS

         AREA OF BASIN  LENGTH OF BASIN  DIST TO CENTROID  IMPERVIOUS AREA  SLOPE  UNIT DURATION
            (SQMI)           (MI)             (MI)              (PCT)       (FT/FT)    (MIN)

             .25             .97              .47              33.00        .0160      5.00

                        COEFFICIENT                        COEFFICIENT
                  (REFLECTING TIME TO PEAK)   (RELATED TO PEAK RATE OF RUNOFF)

                              .097                              .350

TIME        STORM     '     TIME        STORM     '     TIME        STORM     '
     (MIN.)   HYDROGRAPH  *    (MIN.)  HYDROGRAPH  *    (MIN.)  HYDROGRAPH  *
                          *                        *                        *
      5.           0.     *     65.        265.    *     125.        40.    *
     10.           0.     *     70.        236.    *     130.        29.    *
     15.           6.     *     75.        204.    *     135.        21.    *
     20.          22.     *     80.        172.    *     140.        16.    *
     25.          62.     *     85.        144.    *     145.        12.    *
     30.         181.     *     90.        120.    *     150.         9.    *
     35.         317.     *     95.        101.    *     155.         7.    *
     40.         385.     *    100.         86.    *     160.         5.    *
     45.         380.     *    105.         74.    *     165.         3.    *
     50.         356.     *    110.         64.    *     170.         3.    *
     55.         323.     *    115.         55.    *     175.         2.    *
     60.         291.     *    120.         48.    *     180.         2.    *

         TOTAL PRECIP. =  3.12 (1-HOUR RAIN =  2.70)     EXECESS PRECIP. = 2.087  INCHES
         VOLUME OF EXCESS PRECIP =     28.  ACRE-FEET
         PEAK Q =  385. CFS      TIME OF PEAK =  40. MIN.
         INFILT.= 3.00 IN/HR     DECAY = .00180     FNINF =  .50 IN/HR
         MAX.PERV.RET.= .35 IN.       MAX.IMP.RET.= .10 IN.
```

SWMM INPUT FILE

```
2    1    1    2
   3    4
WATERSHED    1
LYONS DRAINAGE MASTER PLAN
ROUTE ALL DRAINAGES THROUGH TOWN
        40   0 0   5.0                                                         1
        11    11
        12    12
        21    21
        22    22
        23    23
        24    24
        27    27
        31    31
        32    32
        33    33
        34    34
        41    41
        51    51
        52    52
        61    61
        62    62
        63    63
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SWMM INPUT FILE, continued

```
0   11   13  0 3              1.
0   12  100  0 3              1.
0  100   13  9 2   0.1       50.   0.010                    0.013    7.5
    0.0      0.0    0.01       0.0     0.10      4.0       0.24       7.5
   0.42     11.0    0.81      14.2     0.87     18.3       1.25      38.1
   1.50     58.2
0   13           0 3              1.
0   27  200  0 3              1.
0  200   28  6 2   0.1      105.   0.010                    0.013   10.0
    0.0      0.0    0.32      46.4     1.44    113.5       4.00     173.4
   4.83    185.4    5.74     196.6
0   28  201  0 1   4.0     1275.   0.045     4.0      4.0   0.030    5.0
0   21  201  0 3              1.
0  201   25 17 2   0.1      100.   0.010                    0.025   10.0
   0.00      0.0    0.01      45.0     0.03     60.0       0.07      96.8
   0.14    114.5    0.24     129.8     0.39    143.5       0.60     156.0
   0.93    167.6    0.97     168.7     1.39    178.4       1.95     188.6
   2.48    196.4    2.62     198.3     3.38    207.5       4.18     216.3
   4.52    219.8
0   22   25  0 3              1.
0   23  202  0 3              1.
0  202   25  6 2   0.1       50.   0.040                    0.013    2.0
   0.00      0.0    0.19      18.5     0.91     30.3       2.70      42.8
   3.27     45.4    3.90      47.8
0   25   20  0 3              1.
0   20   26  0 1   30.     2400.   0.043     5.0      5.0   0.022    4.0
0   24   26  0 3              1.
0   26           0 3              1.
0   31  300  0 3              1.
0   32  301  0 3              1.
0  300   35  6 2   0.1       50.   0.010                    0.013    2.0
   0.00      0.0    0.15      26.4     0.72     45.8       2.00      65.8
   2.38     69.9    3.23      77.5
0  301   35  6 2   0.1       50.   0.010                    0.013    2.0
   0.00      0.0    0.13      18.5     0.62     30.3       1.97      42.8
   2.44     45.4    3.56      50.2
0   35   30  0 3              1.
0   30   36  0 1  30.0     2000.   0.047     5.0      5.0   0.022    4.0
0   34   36  0 3              1.
0   33   36  0 3              1.
0   36           0 3              1.
0   41           0 3              1.
0   51   53  0 3              1.
0   52   53  0 3              1.
0   53           0 3              1.
0   61   64  0 3              1.
0   62   64  0 3              1.
0   64   60  0 3              1.
0   60   65  0 1  30.0     5100.   0.016     6.0      6.0   0.022    4.0
0   63   65  0 3              1.
0   65           0 3              1.

0
6    1
 100  200  201  202  300  301
ENDPROGRAM
```

2-YEAR SWMM OUTPUT SUMMARY TABLE

LYONS DRAINAGE MASTER PLAN
ROUTE ALL DRAINAGES THROUGH TOWN

*** PEAK FLOWS, STAGES AND STORAGES OF GUTTERS AND DETENSION DAMS ***

CONVEYANCE ELEMENT	PEAK (CFS)	STAGE (FT)	STORAGE (AC-FT)	TIME (HR/MIN)	
27	10.	(DIRECT FLOW)		0	45.
200	10.	.1	.1	0	50.
32	7.	(DIRECT FLOW)		0	30.
31	7.	(DIRECT FLOW)		0	40.
23	7.	(DIRECT FLOW)		0	40.
21	4.	(DIRECT FLOW)		0	40.
28	10.	.4		0	50.
62	4.	(DIRECT FLOW)		0	55.
61	29.	(DIRECT FLOW)		1	15.
301	7.	.1	.0	0	40.
300	7.	.1	.0	0	40.
202	7.	.1	.1	0	45.
22	25.	(DIRECT FLOW)		0	30.
201	13.	.1	.0	0	50.
64	32.	(DIRECT FLOW)		1	15.
35	14.	(DIRECT FLOW)		0	40.
25	38.	(DIRECT FLOW)		0	40.
12	18.	(DIRECT FLOW)		0	35.
63	65.	(DIRECT FLOW)		0	40.
60	29.	.3		1	40.
52	24.	(DIRECT FLOW)		0	30.
51	9.	(DIRECT FLOW)		0	40.
33	8.	(DIRECT FLOW)		0	30.
34	36.	(DIRECT FLOW)		0	30.
30	13.	.1		0	50.
24	44.	(DIRECT FLOW)		0	35.
20	37.	.2		0	45.
100	10.	.1	.4	0	55.
11	23.	(DIRECT FLOW)		1	0.
65	67.	(DIRECT FLOW)		0	40.
53	33.	(DIRECT FLOW)		0	30.
41	22.	(DIRECT FLOW)		1	25.
36	51.	(DIRECT FLOW)		0	35.
26	74.	(DIRECT FLOW)		0	40.
13	33.	(DIRECT FLOW)		1	0.

5-YEAR SWMM OUTPUT SUMMARY TABLE

LYONS DRAINAGE MASTER PLAN
ROUTE ALL DRAINAGES THROUGH TOWN

*** PEAK FLOWS, STAGES AND STORAGES OF GUTTERS AND DETENSION DAMS ***

CONVEYANCE ELEMENT	PEAK (CFS)	STAGE (FT)	STORAGE (AC-FT)	TIME (HR/MIN)	
27	69.	(DIRECT FLOW)		0	40.
200	59.	.1	.5	0	50.
32	30.	(DIRECT FLOW)		0	30.
31	37.	(DIRECT FLOW)		0	35.
23	32.	(DIRECT FLOW)		0	35.
21	31.	(DIRECT FLOW)		0	35.
28	59.	1.0		0	50.
62	36.	(DIRECT FLOW)		0	50.
61	220.	(DIRECT FLOW)		1	10.
301	22.	.1	.3	0	45.
300	30.	.1	.3	0	45.
202	22.	.1	.4	0	50.
22	57.	(DIRECT FLOW)		0	30.
201	79.	.1	.1	0	45.
64	250.	(DIRECT FLOW)		1	10.
35	52.	(DIRECT FLOW)		0	45.
25	145.	(DIRECT FLOW)		0	40.
12	49.	(DIRECT FLOW)		0	30.
63	135.	(DIRECT FLOW)		0	35.
60	242.	.9		1	20.
52	48.	(DIRECT FLOW)		0	30.
51	66.	(DIRECT FLOW)		0	30.
33	42.	(DIRECT FLOW)		0	30.
34	65.	(DIRECT FLOW)		0	30.
30	51.	.3		0	50.
24	77.	(DIRECT FLOW)		0	35.
20	142.	.5		0	45.
100	26.	.1	1.0	0	55.
11	126.	(DIRECT FLOW)		1	0.
65	294.	(DIRECT FLOW)		1	15.
53	114.	(DIRECT FLOW)		0	30.
41	195.	(DIRECT FLOW)		1	20.
36	139.	(DIRECT FLOW)		0	35.
26	202.	(DIRECT FLOW)		0	40.
13	152.	(DIRECT FLOW)		0	55.

10-YEAR SWMM OUTPUT SUMMARY TABLE

LYONS DRAINAGE MASTER PLAN
ROUTE ALL DRAINAGES THROUGH TOWN

*** PEAK FLOWS, ST.GES AND STORAGES OF GUTTERS AND DETENSION DAMS ***

CONVEYANCE ELEMENT	PEAK (CFS)	STAGE (FT)	STORAGE (AC-FT)	TIME (HR/MIN)
27	101.	(DIRECT FLOW)		0 40.
200	86.	.1	1.0	0 50.
32	43.	(DIRECT FLOW)		0 30.
31	53.	(DIRECT FLOW)		0 35.
23	45.	(DIRECT FLOW)		0 35.
21	45.	(DIRECT FLOW)		0 35.
28	86.	1.2		0 55.
62	55.	(DIRECT FLOW)		0 50.
61	351.	(DIRECT FLOW)		1 15.
301	28.	.1	.5	0 50.
300	39.	.1	.5	0 50.
202	27.	.1	.7	0 55.
22	78.	(DIRECT FLOW)		0 30.
201	114.	.1	.1	0 50.
64	400.	(DIRECT FLOW)		1 15.
35	67.	(DIRECT FLOW)		0 50.
25	189.	(DIRECT FLOW)		0 40.
12	68.	(DIRECT FLOW)		0 30.
63	177.	(DIRECT FLOW)		0 35.
60	392.	1.2		1 20.
52	62.	(DIRECT FLOW)		0 30.
51	99.	(DIRECT FLOW)		0 30.
33	62.	(DIRECT FLOW)		0 30.
34	84.	(DIRECT FLOW)		0 30.
30	66.	.3		0 50.
24	95.	(DIRECT FLOW)		0 35.
20	189.	.6		0 45.
100	40.	.1	1.3	0 50.
11	191.	(DIRECT FLOW)		1 0.
65	466.	(DIRECT FLOW)		1 15.
53	162.	(DIRECT FLOW)		0 30.
41	320.	(DIRECT FLOW)		1 25.
36	182.	(DIRECT FLOW)		0 35.
26	269.	(DIRECT FLOW)		0 40.
13	229.	(DIRECT FLOW)		0 55.

50-YEAR SWMM OUTPUT SUMMARY TABLE

LYONS DRAINAGE MASTER PLAN
ROUTE ALL DRAINAGES THROUGH TOWN

*** PEAK FLOWS, STAGES AND STORAGES OF GUTTERS AND DETENSION DAMS ***

CONVEYANCE ELEMENT	PEAK (CFS)	STAGE (FT)	STORAGE (AC-FT)	TIME (HR/MIN)	
27	229.	(DIRECT FLOW)		0	45.
200	167.	.1	3.7	1	5.
32	90.	(DIRECT FLOW)		0	40.
31	115.	(DIRECT FLOW)		0	40.
23	96.	(DIRECT FLOW)		0	40.
21	100.	(DIRECT FLOW)		0	40.
28	167.	1.6		1	10.
62	131.	(DIRECT FLOW)		0	55.
61	835.	(DIRECT FLOW)		1	20.
301	42.	.1	1.9	1	5.
300	66.	.1	2.0	1	5.
202	42.	.1	2.6	1	15.
22	148.	(DIRECT FLOW)		0	35.
201	195.	.1	2.4	1	20.
64	951.	(DIRECT FLOW)		1	15.
35	109.	(DIRECT FLOW)		1	5.
25	322.	(DIRECT FLOW)		0	40.
12	131.	(DIRECT FLOW)		0	35.
63	323.	(DIRECT FLOW)		0	40.
60	940.	2.0		1	25.
52	108.	(DIRECT FLOW)		0	35.
51	212.	(DIRECT FLOW)		0	35.
33	130.	(DIRECT FLOW)		0	35.
34	140.	(DIRECT FLOW)		0	35.
30	108.	.4		1	10.
24	161.	(DIRECT FLOW)		0	40.
20	322.	.8		0	45.
100	100.	.1	2.0	0	50.
11	446.	(DIRECT FLOW)		1	5.
65	1074.	(DIRECT FLOW)		1	20.
53	320.	(DIRECT FLOW)		0	35.
41	760.	(DIRECT FLOW)		1	30.
36	331.	(DIRECT FLOW)		0	40.
26	471.	(DIRECT FLOW)		0	40.
13	531.	(DIRECT FLOW)		1	0.

100-YEAR SWMM OUTPUT SUMMARY TABLE

LYONS DRAINAGE MASTER PLAN
ROUTE ALL DRAINAGES THROUGH TOWN

*** PEAK FLOWS, STAGES AND STORAGES OF GUTTERS AND DETENSION DAMS ***

CONVEYANCE ELEMENT	PEAK (CFS)	STAGE (FT)	STORAGE (AC-FT)	TIME (HR/MIN)
27	285.	(DIRECT FLOW)		0 45.
200	195.	.1	5.6	1 15.
32	111.	(DIRECT FLOW)		0 35.
31	141.	(DIRECT FLOW)		0 40.
23	118.	(DIRECT FLOW)		0 40.
21	124.	(DIRECT FLOW)		0 40.
28	195.	1.7		1 15.
62	165.	(DIRECT FLOW)		1 0.
61	1078.	(DIRECT FLOW)		1 20.
301	47.	.1	2.8	1 10.
300	76.	.1	3.0	1 10.
202	47.	.1	3.7	1 20.
22	178.	(DIRECT FLOW)		0 35.
201	217.	.1	4.3	1 30.
64	1230.	(DIRECT FLOW)		1 20.
35	122.	(DIRECT FLOW)		1 10.
25	366.	(DIRECT FLOW)		0 40.
12	158.	(DIRECT FLOW)		0 35.
63	385.	(DIRECT FLOW)		0 40.
60	1216.	2.3		1 25.
52	128.	(DIRECT FLOW)		0 35.
51	262.	(DIRECT FLOW)		0 35.
33	161.	(DIRECT FLOW)		0 35.
34	163.	(DIRECT FLOW)		0 35.
30	122.	.5		1 15.
24	191.	(DIRECT FLOW)		0 40.
20	365.	.9		0 45.
100	125.	.1	2.3	0 50.
11	567.	(DIRECT FLOW)		1 5.
65	1382.	(DIRECT FLOW)		1 20.
53	390.	(DIRECT FLOW)		0 35.
41	984.	(DIRECT FLOW)		1 30.
36	392.	(DIRECT FLOW)		0 40.
26	548.	(DIRECT FLOW)		0 40.
13	671.	(DIRECT FLOW)		1 5.