5. Characterization and Evaluation of Channel Instability

Increasing urbanization of the Fountain Creek Watershed has led to problems and issues associated with the main streams draining the basin. Erosion, sedimentation and flooding problems have highlighted the need to understand the consequences of development activities in the watershed. A qualitative characterization and evaluation of channel stability problems in the main stream reaches has been conducted.

To better understand current and potential consequences of activity in the watershed, the Rosgen Classification method was used to broadly classify the main streams of the subwatersheds (Rosgen, 1996). Classification is largely based on observed channel patterns, topographic map data, limited stream geometry data, and limited sediment data. Confirmation and refinement of the stream classification will be completed when a comprehensive watershed dataset is developed.

5.1. Defining Stream Instability

Erosion and deposition in Fountain and Monument Creeks and their respective tributaries are the result of a balance of physical relationships presented in an illustration by Lane (1955) shown in Figure 5-1. A change in the relationships that make up the balance, such as a significant increase in sediment supply, will instigate geomorphologic change that attempts to reestablish equilibrium in the fluvial mechanics of the system. The following are the basic parameters that most affect channel changes and controlling erosion and sedimentation problems in the Fountain Creek Watershed, all of which are interrelated:

- Increased baseflow discharge
- Increased sediment supply
- Increased sediment transport
- Floodplain encroachment
- Floodplain and woodland expansion
- Channel realignment
- Channel bank protection and grade control

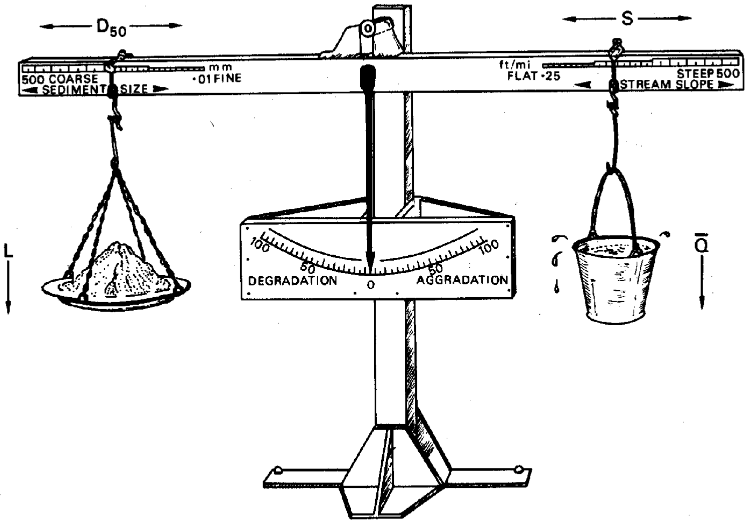

Figure 5-1: Lane's relationship for qualitative analysis of channel stability (Lane, 1955)

The stability class column in Appendix E designates a general rating of stream stability for each reach measured for this table, which is based on limited data and observations. A rating from 1 to 5 was given to each reach based on the available information. The class ratings are defined as follows:

5 = Maximum stability, no anthropogenic effects on channel morphology evident, channel in apparent equilibrium with watershed conditions, no recent dramatic hydrologic events have perturbed the system, structures in the stream corridor.

4 = Mostly stable, anthropogenic effects on channel morphology may be evident, channel mostly in apparent equilibrium with watershed conditions, some recent dramatic hydrologic events may have perturbed the system slightly, watershed has some developmental that may affect storm hydrology, there are scattered structures in the stream corridor.

3 = Stable reaches dominate with some unstable bank or channel areas, some anthropogenic effects on channel morphology are evident, channel appears mostly in good condition and is in equilibrium with watershed conditions, development or agricultural activities may affect bank areas locally, recent dramatic hydrologic events may have perturbed the system slightly, watershed has significant development that probably affects storm hydrology, structures may be common in the stream corridor.

2 = Unstable reaches dominate with some stable areas, anthropogenic effects on channel morphology are evident, channel banks are eroding on numerous reaches, channel bed may be degrading or aggrading to a degree above the natural state, some reaches are stable with engineered controls or are obtaining equilibrium after disturbance, dramatic hydrologic events may perturb the system, watershed has significant development that probably affects storm hydrology, structures may be common in the stream corridor.

1 = Mostly unstable, unstable reaches dominate, anthropogenic effects on channel morphology are evident, channel banks are eroding on numerous reaches, channel bed may be chronically degrading or aggrading, few reaches appear in equilibrium with watershed conditions and there is a lack of engineered channel and bank controls, dramatic hydrologic events will perturbed the channel system, watershed has significant development that probably affects storm hydrology, structures may be common in the stream corridor.

Interviews with various government personnel did not reveal any existing stability rating systems currently being used by officials within the watershed. The stream stability assigned to each reach was based on a cursory analysis of available data and as discussed in the Conclusions and Recommendations Section. A more definitive, quantitative based stability rating system should be developed in the future. General ratings were applied to each main stream segment according to the Rosgen Stream Type Classification in Table 5-1.

The primary causes for stream instability are watershed-wide problems, but each of the four subwatershed areas has particular geomorphic factors that are more applicable to the individual areas. The main factors controlling stream stability are discussed in Section 5.2.

5.2. Stream Channel Classification

Table 5-1 shows the Rosgen Classification scheme, which provides a detailed scheme for organizing stream channel types (Rosgen, 1996). The classification of stream segments within the watershed provides a baseline record from which changes in stream geomorphology arising from stream instability and channel change can be documented. Channel types also give an indication of the condition of the stream when considered in the context of upstream and downstream comparisons. Geomorphic parameters that are not in the range for a particular stream type can indicate problem areas or processes. In the last several years, Rosgen's Classification has become the most commonly used classification in the western United States, and it provides the most accurate way to communicate the classification of streams. Channel reaches are designated with a letter (A-G) that refers to the type of stream and a number subscript (1-6) that refers to the dominant channel bed material. Texture classification for all streams will be finalized when sediment grain size distributions are available.

Stream classification for the stream segments being discussed is possible at Level 1, geomorphic characterization, of the Rosgen Classification. Level 2, morphological description, is provided in some cases below, but final classification requires detailed survey, mapping and topographic data. Stream classifications presented below are based the channel alignment displayed on 1961 USGS Topographic DEM Quadrangles and aerial photography as described in Appendix C. As such, channel slopes and other channel geometry may not accurately depict current conditions. Grain size data is lacking within the watershed; therefore the probable classification range as affected by sediment texture is estimated and provided in Appendix E.

Table 5-1: Summary of Delineative Criteria for Broad-Level (Level 1 and 2) Classification (Rosgen, 1994)

Stream Type	Entrench-ment Ratio	Width/ Depth Ratio	Sinuosity	Slope	Meander Belt/ Bankfull Width	Dominant Bed Material*
Aa+	<1.4	<12	1.0 - 1.1	> 0.10	1.0 - 3.0	1,2,3,4,5,6
A	<1.4	<12	1.0 - 1.2	0.04 - 0.10	1.0 - 3.0	1,2,3,4,5,6
B	1.4 - 2.2	>12	>1.2	0.02 - 0.039	2.0 - 8.0	1,2,3,4,5,6
C	>2.2	>12	>1.4	< 0.02	4.0 - 20	1,2,3,4,5,6
D	n/a	>40	n/a	< 0.04	1.0 - 2.0	3,4,5,6
DA	>4.0	<40	variable	< 0.005	n/a	4,5,6
E	>2.2	<12	>1.5	< 0.02	20 - 40	3,4,5,6
F	<1.4	>12	>1.4	< 0.02	2.0 - 10	1,2,3,4,5,6
G	<1.4	<12	>1.4	0.02 - 0.039	2.0 - 8.0	1,2,3,4,5,6

*** Dominant Bed Material: 1 – Bedrock, 2 – Boulder, 3 – Cobble, 4 – Gravel, 5 – Sand, 6 - Silt/Clay**

5.2.1. Fountain Creek Headwaters

Upper Fountain Creek is primarily a Type B channel down through the City of Manitou Springs. A short reach of Type C4 channel is located in the area of reduced channel slope and high sediment transport directly below the City of Woodland Park. Below the City of Manitou Springs, a Type C channel dominates intermittently. Type A channels are found in the headwaters of the drainage basin.

5.2.2. Monument Creek

The uppermost reaches of the subwatershed above and through the Town of Palmer Lake are Type A and Type B channels. The mainstem of Monument Creek from Monument Lake down to the confluence with Fountain Creek is a Type C4 or C5 channel.

5.2.3. Colorado Springs Composite

Type C channels dominate the upper end of Monument Creek and Fountain Creek in this subwatershed; however much of the urban area channels have been altered either by realignment or erosion protection. Some reaches in Monument Creek have had problems with erosion to the extent that the channel has become incised.

5.2.4. Lower Fountain Creek

Mainstem channels of Fountain Creek are in the Type C4 or C5 range, with localized reaches of Type D4 or D5. This mixed classification may reflect the gradual change from more braided type streams to a more meandering channel. Most channels in the 1955 photos would be classified as Type D4 or D5 streams. Jimmy Camp Creek also displays these conditions, except in the most headward areas where Type A and B type channels are found. Changes in channel conditions are reflected in the channel classification comparison between the 1955 and 1999 aerial photographs.

5.3. Causes of Channel Instability

5.3.1. Drainage Basin Hydrology

The USGS analyzed trends in precipitation, streamflow and morphologic changes in Fountain Creek. Low streamflow statistics indicate that the low streamflow has increased significantly throughout most of the watershed, particularly since the early

1980s. The increase can be attributed to the modes of water management occurring in the basin, including 1) increases in wastewater effluent, 2) management of the Fountain Creek transbasin return flow decree, and 3) return flow from lawn watering and crop irrigation. Likewise, statistical analysis shows there have been minor increases in instantaneous peak flow of high return frequency-flow events. Increased flow peaks are likely the result of basin development and greater impermeable surface area in the watershed (USGS, 2000).

The increase in low streamflow may be a primary factor influencing channel morphology change, particularly in the mainstem of Fountain Creek and possibly in several of its larger tributaries. Water availability effects sediment movement and vegetation establishment, which in turn effect stream channel stability and geomorphology. Originally, the interaction of climate, geology and topography in the basin caused many streams to be ephemeral or intermittent sand bedded streams. Potential transmission losses in coarse sands are high, and in the dry periods of the year basin streams used to dry up completely. Now that low flows have increased, lower Fountain Creek, Cottonwood Creek and Kettle Creek flow continuously, whereas they previously dried up seasonally.

5.3.2. Sediment Transport

Sediment movement in the main channels of the Fountain Creek Watershed was previously intermittent in nature, similar to the intermittent nature of stream flow that used to exist in the tributaries. The sands composing the channel bed are now continually transported downstream due to channel discharge that is now perennial in many watershed stream reaches. If the sediment in the channel was composed of significant amounts of cohesive clays, or if coarse material such as gravel or cobbles dominated the channel, sediment transport during low flow conditions would be much lower. Sediment movement and production from the watershed today is likely much greater than it was in the past. The degradation of channel beds in the Colorado Springs area and the aggradation of sediment at the mouth of Fountain Creek in Pueblo are conditions that reflect the increased transport of sediment.

One study by the USGS (1989) indicated that the bedload part of sediment transport in Fountain Creek makes up 16 to 90 percent of the total sediment load during snowmelt events, whereas storm runoff events contribute only 6 to 30 percent. This conclusion is indicative of the fact that bedload accounts for most of the sediment moving during baseflow periods when water is mostly clear and free of suspended sediment but is still moving on the bottom of the stream in the form of rolling or saltating grains of sand.

Table 5-2 shows a qualitative accounting of the physical factors influencing sediment transport within a watershed (Williams, 1991). It will be used as a general guide to help explain the factors that contribute to the increased sediment transport in the Fountain Creek Watershed. A "plus" (+) indicates that a factor increases sediment transport and a "minus" (-) indicates that a factor decreases sediment transport. The number of plusses and minuses indicates the severity of that factor. Three of the twelve factors shown in Table 5-2 will be discussed in detail in this section.

Table 5-2: Factors Affecting Sediment Transport

Relative Effect	**Factors of Sediment Transport (Relative to pre-1980s)**	**Explanation**
+++	Increased baseflow (main channel)	Continuous flow, more channel forming events
+	Increased Highflow	Increased discharge in high flow events due to development
-	Increased Paving/Structures	Surface protection
+	Increasing Construction	Disturbed ground (short term)
-	More Reservoirs	Effective sediment traps
-	Increased Floodplain Vegetation Density	Tamarisk, Russian live invasive species, more water availability with increased baseflow
++	Increased Bank Erosion	Due to increasing sinuosity
+	Increased Bed Erosion	Due to reduced effective channel width
-	Decreased Grazing, Farming	Decreased acreage
++	Increased Baseflow in Tributaries	Kettle Creek, Cottonwood Creek, Sand Creek development
-	More Channel Stabilization Structures	Hard structures in urban corridor
+	Floodplain Encroachment	Development, encroachment in urban areas
+11 – 5 = +6	**Increased Sediment Production**	

Sediment yield from the drainage basin hillslopes may be similar to or even less than it was historically. Increased urban development creates larger areas of paved and protected surfaces, thereby reducing the amount of sediment available for transport while increasing developed run-off. Detention structures provide settling basins for entrained sediment, which also reduces sediment movement in the system.

5.3.2.1 Floodplain Encroachment

Urban expansion in all of the communities located near the main stream corridors of the Fountain Creek Watershed has caused floodplain areas to be developed. Fill has been placed to allow the use and development of areas that originally provided zones for natural floodwater storage and conveyance. As a result, channel floodway zones have become constrained. Flood passage through these areas results in higher than normal flow velocities and a shortage of flood attenuation potential. Therefore, flood waves may progress downstream faster and flood peaks may be higher than normal in some reaches. In other reaches, encroachment may impede the downstream progression of the floodwave such that backwater effects may cause high local flood levels.

Encroachment of floodplain areas may also be caused by vegetation or large trees that have been protected to enhance landscape and urban riparian zones. In some cases, dense stands of trees in the urban stream corridor are not the natural condition of the floodplain, as may be the case in Manitou Springs. Another important aspect of encroachment by vegetation is discussed in the following section.

5.3.2.2 Increased Floodplain Vegetation Density

Floodplain vegetation on Fountain Creek has changed dramatically in the last 50 years, due in part to changes in the Fountain Creek flow regime. A comparison of aerial photographs between 1955 and 1999 shows that vegetation density increased dramatically in that time period. The USGS (2000) has suggested that vegetation in the floodplain is mainly governed by the frequency of flooding, in that floods cause scouring and denuding of the floodplain. This process obviously occurs on Fountain Creek, but it is apparent from the limited work with aerial photographs that the density of floodplain vegetation has increased over the years. Conversation with local residents and officials confirm that this observation is correct (Alt, B., 2001, personal communication).

Water flowing in the drainage network year round due to return flow of irrigation and treatment plant discharges has increased the water availability to riparian vegetation. This results in a more continuous supply of shallow alluvial and surface water supply to vegetation near Fountain Creek and its tributaries.

The fact that invasive species now cover much of the riparian corridor is related to the increase in vegetation density. Tamarisk (also known as salt cedar) and Russian olive now compose a larger part of the riparian vegetation in 1999 compared to 1955. Tamarisk was brought from Asia in the late 1800s to aid in erosion control. Tamarisk is a phreatophyte that may tap water with long roots at depth, but thrives in riparian areas (Graf, 1978). Photographs taken in the late 1800s in southwestern streams compared to modern photos taken at similar places show how completely this plant can invade streamside areas. Such is also the case on the lower half of Fountain Creek. Tamarisk thrives in the understory of the larger cottonwood and elm trees that serve as canopy cover for floodplain vegetation. Tamarisk and Russian olive can act as sieves for floating debris when flood flow attempts to spread over the floodplain from the main channel. There were numerous accounts during the 1999 flood of log jams during the high flow events.

Riparian vegetation density in 1999 provides considerably more floodplain stabilization to overbank areas than it did in 1955. Dense vegetation effectively narrows an active channel by stabilizing the sandy bank. Flood flows are less likely to spread evenly over the floodplain with dense vegetation blocking the path of overbank flood flows.

In 1955, the floodplains in lower Fountain Creek mostly had sparse vegetation. Scour is evident over much of the width of the floodplain in the 1955 photos. The stream appears to have been more braided than meandering, and it probably frequently left the main channel zone during higher flow periods. With the lack of dense floodplain vegetation in 1955, overbank flows were not impeded from crosscutting the flat floodplain, which was the most direct path downslope. In this setting, the capacity of the floodplain areas to carry flood waters or even minor out-of-bank seasonal flows, was greatly enhanced due to lack of flow resistance relative to present day conditions where large trees and dense bushes occupy most parts of the floodplain.

The changes taking place on lower Fountain Creek are somewhat similar to those that have occurred on the Platte River east of Denver. As the discharge regime of the Platte River has become less flashy due to upstream reservoirs and increased low flow from stream inputs from the City of Denver, the channel character has changed from a wide, flat, sandy bed with sparse vegetation to a meandering channel with dense floodplain vegetation. The river is much less dynamic than it was in the 1800s, partly due to woodland/floodplain expansion (Naldler, C.T. and S.A. Schumm, 1981).

5.3.2.3 Increased Bank Erosion

In the lower end of the Colorado Springs Composite subwatershed and most of the Lower Fountain Creek subwatershed, the realignment of Fountain Creek from 1955 to 1999 is evident. Changes in watershed conditions are causing the channel to adjust to the new influencing factors. Most notably are an increase in channel sinuosity and an increase in the length of channel banks that are actively cutting into previously un-eroded bedrock. This increased activity in channel bank cutting likely provides additional sediment for transport through the basin.

5.3.3. Channel Bank Protection and Grade Control

In some cases, the construction of channel bank protection constrains the floodplain and floodway, thus reducing the storage available for out-of-bank flows and promoting the quick passage of stream flow downstream. Bank protection causes other problems in areas outside of the urban environment. Bridge abutments create permanent cross sections where streams must pass. Channel adjustments upstream and downstream may create a need for the river to naturally adjust to maintain equilibrium. If the stream cannot naturally adjust, the energy requiring adjustment will be transferred to another location upstream or downstream and channel changes (such as erosion or widening of the stream cross-section) will result, causing problems to transfer from one location to another.

Such is the case at Pinon, where the channel was naturally shifting a meander downstream. The migrating meander adjusted as far as possible until the road embankment stopped the downstream progression. The result was initially the loss of road embankment to stream erosion, and eventually the loss of a bridge span when the flow was directed into the bridge support system instead of in a downstream path as was originally intended. In another case, a highway bridge and a railroad bridge cross Fountain Creek at the Old Pueblo Road crossing downstream from the City Fountain. The railroad encroaches on the floodplain approximately one-quarter mile upstream. The stream is constrained at these two points, and its natural tendency to adjust over the full width of the floodplain is prevented by hard controls. The energy directed at the railroad embankment is transferred downstream to the next bend, where a very large meander is developing and eroding agricultural land. Other problems are occurring downstream of the bridge, where agricultural land is being lost to erosion and local channel widening as the stream dissipates energy.

Bank protection and channel grade controls line much of the main channel of Fountain and Monument Creeks as they wind through the developed areas of Colorado Springs. Stream reaches in the older areas of the city were altered many years earlier and these channel areas are mostly stable. The occasional flood may reveal or revive erosion in problem areas. Similar well-established bed and bank protection may be found in other older parts of communities within the watershed, such as the levee system in downtown Pueblo and hard bank erosion control measures in Manitou Springs. In general, the effects of the construction of the older, well-established structures have long since occurred and some sort of equilibrium within the fluvial system has been attained.