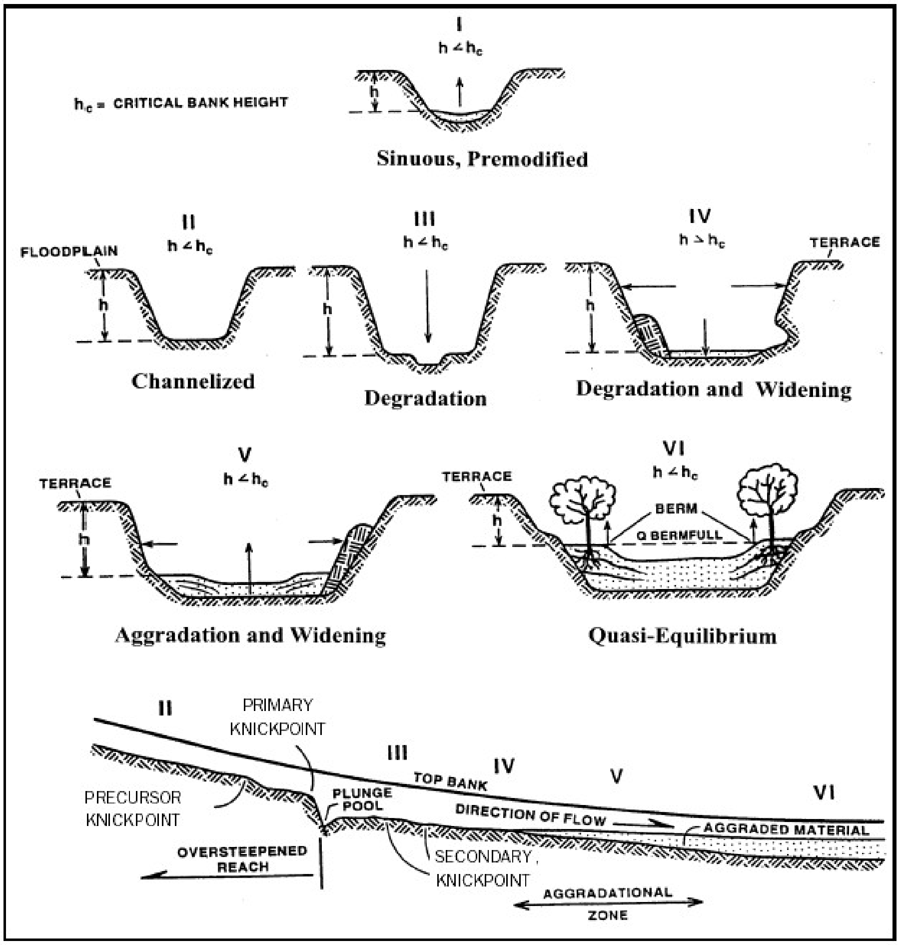
Figure 4B. Conceptual Channel Evolution Model
(Schumm, 1984)



SECTION 2. GEOMORPHIC ANALYSIS

This section of the Bank Stabilization Feasibility report presents (1) a review of watershed scale geomorphic processes and (2) a reach scale geomorphic analysis of Chimes Creek. The former describes large scale processes and patterns that may affect channel morphology in the Chimes Creek project reach, while the latter presents key reach scale processes illuminated through a topographic survey, geomorphic inventory, bankfull channel dimension, and plan and profile analysis of the entire project reach (STA 0+00 – 11+50). A geomorphic analysis investigates the relationship between hydrologic components of a watershed such as precipitation and slope and their effect on stream shape (profile, planform). Typical procedures of a geomorphic analysis include quantifying physical features of the watershed (slope, curvature) and reach scale characteristics such width, bank height, erosion sites, channel knickpoints, slope, bars, pools, and riffles. The main goal is to identify the key ongoing geomorphic processes and constraints that must be incorporated into restoration design alternatives.

Watershed Scale Geomorphology

Watershed scale geomorphic processes can dominate local processes of erosion, transport, and deposition. For example, tectonic uplift and weathering can expose resistant geologic controls like underlying bedrock or even redirect a stream channel to areas of lower resistance. These types of controls occur and evolve slowly over thousands of years and would be much more dominant in an undisturbed watershed. More typical of the Oakland Berkeley area is to see a drastic and geologically quick response in channel morphology to rapid urbanization of a watershed. This channel response can manifest itself immediately or can take several decades to change and adjust to new watershed conditions. Even though the project reach is located immediately adjacent to the active Hayward fault, it is the rapid historical urbanization of the watershed that is driving the present day condition of the channel and sediment transport dynamics of Chimes Creek.

Reach Scale Geomorphic Analysis

A site visit was conducted on February 20th, 2009 to delineate key geomorphic features of the site and to focus future topographic surveys. Initial field observations suggested that the primary erosion sites along Chimes Creek occur below the City of Oakland ROW at Hillmont Dr. and Edenvale Ave. A stable grade control consisting of concrete slabs, bricks, and rip-rap was observed at this location (STA 7+00). No bedrock control was observed throughout the project reach. Upstream of the grade control, the slope of the channel decreases and the entrenchment ratio increases. Entrenchment ratio is a geomorphic index that describes the degree to which a river can inundate its floodplain. It is calculated as the channel width at twice the bankfull depth divided by the bankfull width (Rosgen, 1996). Channels with high entrenchment ratios have well connected floodplains and those with low entrenchment ratios are vertically contained within adjacent channel banks and do not easily spill out into their floodplains. No major vertical incision was observed above STA 7+00, therefore subsequent topographic surveys focused on the project reach lying below the City of Oakland ROW to provide a highly detailed topographic map of the critical erosion areas.

<u>Topographic Survey and Basemap Generation</u>

As noted above, the entire study length of Chimes Creek can be broken into two distinct segments based on the magnitude of vertical incision. Those sections lying below the existing grade control (STA 7+00) on parcel # 037A277201400 have heavily vegetated and steep channel banks with extremely limited access (**Sheets 1 and 2**). This area is actively incising and poses the greatest risk to adjacent properties. Despite widespread vertical incision and bank failure, no structures were observed within 45 ft of the channel banks along the lower section. Numerous fencing were either already undercut or in danger of failure. The second channel segment (7+00-11+50) extends above the existing stable grade control for approximately 450 ft and contains a well connected floodplain. Extreme vertical incision was not observed however minor toe scour was apparent in some locations and numerous structures are located within 10 ft of the channel banks.

In order to maximize the quality of the project basemap in areas where construction is to have the greatest impact, a topographic survey of the lower section was completed on Feb 27th, March 4th, and March 6th, 2009. Elevations were referenced to the City of Oakland benchmark located at the intersection of Hillmont and Edenvale Drives (El. 261.36 ft). Features including channel flow lines, channel edges, top of bank, trees, fences, sewer/drain systems, and significant grade breaks were surveyed and imported to AutoCAD Civil 3D where a basemap and surface were created. Topography of the upstream section of Chimes Creek was obtained from a Light Detection and Ranging (LIDAR) survey conducted in 2004 for Alameda County. Contours of LIDAR data were shifted vertically to account for differences between the NAVD88 and City of Oakland datum. Vertically shifted contours were merged with data from the topographic survey and typical channel dimensions for the upstream section were interpolated based on field measurements obtained during the geomorphic inventory. The resulting basemap (**Sheets 1 and 2**) was used to depict major erosion sites, identify project constraints, and generate project alternatives. Cross sections from the entire surface (STA 0+00-11+50) were used in the hydraulic analyses.

Geomorphic Inventory

A geomorphic inventory was conducted by a staff hydrologist and geomorphologist walking along the stream line (center of flow in the channel) of the creek. The channel inventory consisted of identifying and marking all hydraulic structures, significant geomorphic features (grade controls, woody debris, waterfalls), and active erosion sites on the basemap. This included measuring average cross-section dimensions for the upstream section, identifying potential management problem areas, and taking digital photos to document overall channel morphology.

Detailed Description of Major Geomorphic Features

For identification of major feature locations, approximate distances in feet, termed river stations, are given for each identified feature along the streamline from *downstream to upstream* beginning at the ACFCD culvert near Nairobi Place. Banks are labeled left and right, facing the downstream direction of flow. Existing erosion conditions are shown on **Sheets 3 and 4**.

STA 0+70 to STA 0+80: Steep banks impinge the channel at a major left turn in the stream planform. Toe scour associated with flow deflection towards the outside bend of the channel has caused an active bank failure observed as fresh un-vegetated exposed soil. This suggests bank erosion and sediment delivery is active and ongoing. Additionally, a large rock exists within the channel and may have provided local grade control in the past. However, during the bank inventory, high velocity flow was observed moving around the rock suggesting the rock is currently not a major grade control for the lower stretch of Chimes Creek.

STA 0+83 to STA 1+40: Severely undercut banks exist along both sides of the channel. Existing riparian vegetation and large tree roots currently support banks along a deeply incised channel. Banks are vertical with heights ranging from 5 to 6 ft on the left and 6 to 9 feet on channel right. Bank undercutting is most severe on channel right and ranges from 1 to 3 ft.

STA 1+40: A significant waterfall feature exists in the narrow (< 1 ft) wide channel. Flow reaches the top of a knickpoint and plunges below into a deep (~3 ft) pool before transitioning into a moderately deep run.

STA 1+41 to STA 1+70: Toe scour and bank failure is evident along channel left near the previously described knickpoint. Channel side slopes are steep (> 100%) and may be adjusting to incision below the knickpoint. Channel slopes on river right are nearly vertical with stabilization provided by large trees and root structures (>16 inch diameter).

STA 1+55 to STA 1+60: Significant natural and anthropogenic woody debris currently blocks the active channel and causes a minor backwater effect.

STA 1+77 to STA 2+45: Despite extremely steep slopes ranging from 100% to nearly vertical on channel right, no major active erosion sites were documented. Overall the channel is severely incised but existing ivy, trees, and soil structure is providing slope stability.

STA 2+33 A 10-inch City of Oakland sewer line crosses the invert of the channel. The structure is supported with large concrete pilings and elevated off the surface with a steel support and clamp system. Elevation of the top of the pipe in reference to the channel invert is provided in the longitudinal analysis section of the report. Roughly 3 ft downstream of the active sewer line an abandoned 8-inch sewer line crosses the channel 6 feet above the invert.

STA 2+46 to STA 3+15: A bank failure zone on channel right was observed directly adjacent to the stream at the outside of a minor bend. Unprotected and exposed soil suggests recent sediment delivery from adjacent hillslopes. Major bank erosion on river right was observed 13 ft off the channel center for approximately 40 lineal feet. Existing fence near this erosion site is severely undercut and hanging without support.

STA 2+66 to STA 2+95: Existing rock revetment with driven posts supports a vertical bank on river left. Structure displays minor evidence of toe scour. Additionally a 4” PVC drainage pipe enters the channel at approximately 225 ft elevation (8 ft above channel invert) at STA 2+68.

STA 3+00. Significant natural and anthropogenic woody debris currently blocks the active channel and causes a minor backwater effect. The structure is composed mainly of cut tree rounds pinched against a minor turn in the channel.

STA 3+22 to STA 4+22: Steeply incised side slopes show minor toe erosion along both the river right and left. Existing vegetation on river right currently supports nearly vertical channel sides; however, river left has very little vegetation and major bank failure is evident. Fresh willow cuttings have been laid along existing contours by private land owners to support failing bank on river left.

STA 4+00 to STA 4+33: Rock toe protection has been installed to bolster existing bank failure zone parallel to active sewer line. Protection extends approximately 6 ft vertically to edge of exposed sewer line (~Elev. 227 ft). Vertical bank above sewer line suggests significant erosion occurred at this location prior to rock toe installation. On river left, a rotational slump caused a 2 ft diameter stump to obstruct the channel approximately 3 ft above the channel invert.

STA 4+50 to STA 4+75: Significant undercut bank present along river right with minor concrete rubble toe protection. Existing 4 ft diameter oak tree roots are undercut by 2-4 feet on the inside bend of the channel.

STA 4+45 to STA 5+00: Major bank failure zone on river left corresponding to the outside of a bend. Urban debris, including plywood, firewood rounds, and concrete rubble are scattered along the entire slope. Existing fence located at major slope break and in danger of eroding into channel.

STA 5+05 to STA 6+10: Nearly vertical channel walls border the channel on river right. Bank height ranges from 5-7 ft with significant vegetative stabilization. STA 5+05 through STA 5+45 show signs of recent bank failure denoted by exposed unprotected soil. STA 5+05 through STA 5+45 top of banks are stabilized by invasive blackberry species that drape laterally into the active channel.

STA 5+50: Corrugated metal pipe storm drain (12-inch) enters Chimes Creek at approximately 3.5 feet above the channel invert (Elev. 230 ft). Minor erosion at outfall is protected by blackberries and other invasive non-woody species.

STA 5+60 to STA 6+30: Major bank failure zones intermittently spaced along channel left. Some areas show sign of active sliding (fracture cracks near top of bank) while other areas are stabilized by thick riparian vegetation. Local residents reported a slide in February, 2008. Woody debris spans the channel in numerous locations suggesting bank adjustment to incision channel caused tree loss. Channel is severely incised with bank heights ranging from 5 to 8 ft.

STA 6+10 to STA 6+60: Vertical banks abut the active channel on river right with moderate toe erosion visible. Vegetation and major root structures stabilize the bank and support a flat elevated terrace to the North.

STA 6+68 to STA 7+00: Minor areas of rock toe protection exist along both banks. An existing failed concrete wall protrudes horizontally into the channel approximately 3 ft above invert with a major undercut bank below on river left. Bank height ranges from 6 to 9 ft.

STA 7+00: Major waterfall and plunge pool observed. Water cascades over 2 ft wide concrete slab into 2-3 ft deep pool with rock toe protection around edges. Waterfall composed of concrete bricks and rubble.

STA 7+00 to STA 11+50: Major waterfall provides backwater effect to upstream channel and prohibits vertical incision. Average slope is approximately 0.6 % to the mouth of the culvert outfall near Hillmont Dr. and Delmont Ave. Minor erosion associated with toe scour near channel bends was observed with bank heights ranging from 1 to 5 feet. Although some channel banks are steep and vary between 70% and 100% slope, major incision, toe scour, and bank failure was not observed. Unlike lower portions of Chimes Creek, structures exist within 10 ft of the top of bank.

TABLE 2

Summary of Erosion Features

Erosion Mechanism	Left Bank (lineal ft.)	Right Bank (lineal ft.)
Undercut Bank (Toe Scour)	120	229
Eroded/Exposed Bank	250	323
Total	370	552
Total (both banks)	922	

General Erosion Conditions and Mechanisms

The entire lower stretch (STA 0+00-7+00) of Chimes Creek is severely incised with bank heights ranging from 4 to 9 feet. Overall, top of bank widths currently range from 5 ft in the most narrow and incised stretches to over 20 feet where bank failures and, thus, channel widening have already occurred. The predominant erosion mechanism noted was bank failure due to toe scour and channel bed incision as represented in **Sheets 3 & 4** and **Table 2**. Typically this sort of geotechnical failure occurs following periods of high discharge and prolonged soil saturation when moderate to high velocity flows undercut the toe support of over-steepened bank slopes until the strength of the native soils are no longer sufficient to support the near-vertical banks. Channel bends are most susceptible to this sort of erosive failure as flows are accelerated towards the outside of channel bends; however, this was not observed on Chimes Creek channel bends. In some locations, channel edges are completely vertical with non-native vegetation and associated root structures providing the major component of bank stability. Tree slumping was observed at numerous locations and will continue to occur as the soil in the root matrix is winnowed away and the weight of the trunk becomes unsupported. Slumping can be a significant hazard because it can redirect high-velocity flow to other locations along the channel bank and initiate further bank erosion.

The future extent of bank erosion can be approximated for the Chimes Creek project reach. The future top of bank was predicted assuming the grade control at STA 7+00 fails. The extent of lateral erosion and location of the future top of bank depends on the equilibrium slope that adjacent channel banks establish. The final equilibrium slope or slope stability depends on local properties such as the size, orientation, cohesiveness, density, and conductivity of the soil. Overall, three different channel bank slope scenarios were completed (1.1:1, 1.25:1, and 1.5:1 (H:V)) and the total predicted area of erosion tabulated. The aforementioned slope values were used because they generally reflect worst case equilibrium slopes for soils similar to those found along Chimes Creek and do not consider the stabilization effects of vegetation. True equilibrium slopes may differ, however they provide a general starting point for predicting the possible extent of erosion. The predicted extent of erosion is shown in **Sheets 3 & 4** for two (1.1:1 and 1.25:1) scenarios and corresponding bank retreat in **Table 3**. These worst case scenarios provide a maximum estimate of future erosion patterns along Chimes Creek if no action is taken.

Table 3

Predicted Bank Retreat

Scenario	***Bank Slope***	***Grade (%)***	***Property Loss (ft^2)***	***Property Loss (Acres)***
1	1.1:1	91%	37500	0.9
2	1.25:1	80%	48200	1.1
3	1.5:1	67%	72600	1.7

<u>Bankfull Analysis</u>

Bankfull is the term used to describe the flow event that forms the overall morphology of a stream including average depth, width, cross-sectional area, and planform patterns. Bankfull discharge can be determined in a number of ways and is useful for reconstructing historical geomorphic development. In hydrology, bankfull flow events are determined with a flow frequency analysis whereby bankfull discharge is associated with the 50% probability event. Typically this event occurs every 1.5 to 2 years. The bankfull discharge for Chimes Creek was previously identified by Balance Hydrologics as 104.7 cfs (BH, 2003). As described in Section 2 "*Hydrology*," discharge values from the Balance Hydrologics Report were scaled up to reflect uncertainty in the storm drain performance in areas upstream of the Chimes Creek culvert. The scaled up 2-yr flow values were used to assess channel dimensions.

Channel Dimensions

Current bankfull channel dimensions (depth, width, cross-sectional area) can be compared against undeveloped historical values with the aid of regional geomorphic curves. Dunne and Leopold (1978) correlated channel dimensions and watershed area for San Francisco Bay Area streams. These curves were used to predict historical bankfull channel dimensions for Chimes Creek based on a drainage area of 0.6 square miles (387 Acres). Channel dimensions provided by regional geomorphic curves are best used as guides and do not necessarily reflect complex geomorphic phenomena (bedrock control, woody debris, anthropogenic controls, etc) that can alter channel dimensions at a local scale. Nevertheless, the predicted historical bankfull dimensions of Chimes Creek were found to be:

- Cross-sectional area = 17 ft^2
- Width = 14 ft
- Depth = 1.2 ft

We computed average channel dimensions utilizing a standard hydraulic modeling package (described in the following section) using the 2-yr flow event (120 cfs) and found Chimes Creek to have the following average geometric properties during bankfull flows:

- Cross-sectional area = 23 ft^2
- Width = 9.6 ft
- Depth = 2.4 ft

Current Chimes Creek channel dimensions deviate slightly from regional geomorphic curve predictions. For instance channel width is ~30% narrower and depth is ~100% deeper, while cross sectional flow area increased by ~35%. A portion of the observed discrepancy between predicted and observed values may be due to local effects as mentioned above; however, similar patterns of decreased bankfull width and increased depth have been documented in streams adjusting to urban development. For instance, actively incising channels cut deeper into the underlying substrate/bed and form steeply sloping banks that have a lower width to depth ratio during bankfull events. The geomorphic inventory verified that Chimes Creek is severely incised and has likely decreased its bankfull width and increased depth in response to reduced sediment input and increased bankfull discharges. Overall, predicted geomorphic channel dimensions should not be used as strict design constraints but instead as general guidelines during alternatives development.

Planform

The planform of a channel refers to its shape as seen from overhead or in plan view. Natural channels in alluvial valleys often have a meandering pattern, with the channel looping back and forth across the valley floor in a somewhat sinusoidal sequence. Channel meanders increase overall roughness of a stream and can be an important component to consider in bank stabilization or habitat restoration projects. Channels with low slopes (< 1%) have visible meander patterns evident in aerial photos or topographic maps. Because the average slope of Chimes Creek is well above 1% (see below), meander patterns were not considered to be a critical component of the feasibility analysis. However, numerous historical aerial photos (1946, 1958, 1968, 1980, 1987, and 2005 (HA, 2009)) and USGS topographic maps (Oakland East- 1947, 1959, 1968, 1973, and 1980) of the Chimes Creek project reach were analyzed for major changes in planform shape (UCB, 2009). A combination of dense canopy cover and limited image quality precluded any quantitative estimate of historical planform development with this methodology. However, in all images and topographic maps Chimes Creek is completely contained within the existing riparian zone between Hillmont Dr. and Delmont Ave and no major or significant changes in planform configuration were observed.

The historical evaluation of maps and imagery provided little quantifiable information, therefore a comparison of predicted and observed meander patterns of Chimes Creek project reach based on geomorphic curves that relate sinuosity to average bankfull channel dimensions was completed. Sinuosity, defined as stream length divided by valley length, was used to quantify the meandering pattern of Chimes Creek. A high sinuosity corresponds to channels with numerous bends and loops and a low sinuosity corresponds to straight channels. Sinuosity was predicted based on the bankfull channel dimensions from Dunne and Leopold's regional curves and Williams (1986) relationship between channel width, depth, and sinuosity. The predicted sinuosity of Chimes Creek was 2.5 and the observed value was 1.1. The large discrepancy in sinuosity doesn't necessarily mean Chimes Creek has significantly straightened over time or that stabilization design should focus on restoring a sinuosity of 2.5. Chimes Creek is near the geologically active Hayward fault and shouldn't necessarily conform to predicted values.

An aerial image and topographic map analysis shows the Chimes Creek project reach has not undergone major planform re-alignment as a result of urban development. Therefore, restoring channel sinuosity to predicted values is not a recommended as a significant design goal. However, as Chimes Creek adjusts to the new equilibrium grade, the degree of meander behavior will increase and lateral shifts within the confine channel should be expected. This suggests toe protection and establishment of vegetation along channel banks will become increasingly important after vertical incision stops.

<u>Longitudinal Profile Analysis</u>

Slope is one of the fundamental variables that controls geomorphic processes and will be considered here by analyzing the longitudinal profile of the channel bed through the study reach. A longitudinal profile of a creek shows the lowest channel bed elevation plotted against distance from a reference location. A longitudinal profile can provide information about sediment aggradation and degradation, delineate reaches of channel incision, and show anomalies, such as knick points (i.e. high slope areas that migrate upstream until an equilibrium slope or local grade control is reached), or points along the profile where a significant change in grade exists that may be more unstable than the rest of the reach. In addition, the longitudinal profile can be used to determine the presence of local controls on slope.

The lower section of Chimes Creek (STA 0+00-7+00) has an average slope of 3.6%; however, three major knickpoints separate regions of dissimilar slope (**Sheets 1 & 2**). The first knickpoint (STA 1+45) is a 4-ft vertical drop from ~213 ft to ~209 ft. Downstream of knickpoint #1 the channel slope is 0.6% and a region of sediment aggradation is apparent above the ACFCD culvert. The second knickpoint (STA 4+71) is a subtle 1-ft vertical drop upstream of a major undercut bank. Between knickpoint #1 and #2 channel slope averages 3.5%. The third knickpoint (STA 7+00) is a 6.5-ft drop over an existing concrete slab and block structure on parcel #037A277201400. Channel slope between knickpoint #2 and #3 averages 4.1%. The only grade control below STA 7+00 occurs at the ACFCD culvert entrance; no grade controls exist in the lower section to stop knickpoint migration.

The upper section of Chimes Creek (STA 7+00-11+50) has an average slope of 0.6% and no major knickpoints or vertical incision sites were observed. Knickpoints in the upper section or significant vertical incision would suggest the channel is actively adjusting to changes in sediment supply and run-off. The absence of these features, combined with the similarity in slope between the lowest section of the project reach (STA 0+00 to STA 1+45) suggests that with the current sediment and hydrologic inputs to Chimes Creek the equilibrium slope is somewhere near 0.5%.

The existing concrete slab and block structure near the City of Oakland ROW on parcel #037A277201400 provides a significant grade control that blocks vertical incision for the entire upstream section of Chimes Creek. During high flows, the grade control causes a backwater effect that decreases channel velocity, promotes sediment deposition (See Section 4 "Hydraulic Analysis"), and provides overall stability to the channel upstream.

Table 4

Observed Knickpoints

Station	***Elevation***	***Material***
1+45	213.4	Stream Substrate
4+71	224.9	Stream Substrate
7+00	234.6	Concrete Structure

Geomorphic Conclusions for Chimes Creek

As noted in Section 1, changes in discharge, sediment inputs, and overall channel equilibrium occur naturally in a watershed. For urban streams like Chimes Creek, the equilibrium is upset by land-use changes such as increased impervious surface areas, channel straightening, culverting, bank armoring, or changes in grade controls. Channel evolution models can be used to conceptualize how streams adjust to urban development (**Figure 4**). For example, "Urban equilibrium" is a term used to describe a channel that has deviated from its natural or original shape, but has finished adjusting to the urban influences (reduced sediment and increased discharge) affecting it so that it is relatively stable in its profile and planform dimensions. A channel in urban equilibrium, stage VI in **Figure 4** is neither excessively eroding nor depositing sediment and has a healthy riparian corridor established along its edges. From a geomorphic perspective, the channel has achieved a new balance in its bankfull width, depth, slope, and sediment composition in relation to discharge and sediment inputs. In general, the Chimes Creek appears to be between stages III and IV in the context of urban channel evolution.

Results from the geomorphic analysis suggest Chimes Creek has not reached "Urban Equilibrium" and will continue to incise unless modifications to the channel are made to control existing knickpoints and channel incision. Therefore each design alternative should target bank erosion and vertical channel stability. Overall, roughly 63% (STA 0+00 – 7+00) of Chimes Creek is actively incising while 37% is stable. Vertical incision via knickpoint migration has led to toe scour, geotechnical bank failure, and property loss along the entire lower section.

SECTION 3. BIOLOGICAL RECONNAISSANCE

Description of the Existing Biological and Physical Conditions

A Biological Reconnaissance Survey was performed on April 9, 2009 at which time habitat types and vegetation composition were mapped[1]. Ruderal/disturbed riparian woodland communities occur over the project area adjacent to individual homes, driveways, and along streets. These areas, if not landscaped, are dominated by a mixture of native and introduced or exotic plant species. The creek generally has little canopy coverage, with the exception of notable areas between stations 0+00 and 2+50[end point near Nairobi], as well as between 9+00 and 11+50 where a dense overstory of mature trees shades the creek. General garbage particles were observed throughout the project site affixed to concrete rubble, downed woody debris, and scattered within the low flow channel. Broken sewer lines and backed up sewer lines have caused numerous raw sewage spills in Chimes Creek, however no such observations were made. Sewage spills can carry pathogenic bacteria, nutrients, heavy metals, and can poison aquatic species such as frogs, salamanders, fish, and invertebrates that rely on clean water for survival.

Areas adjacent to the top of bank (mostly in the backyards of private residences) contain vegetation communities dominated by exotics and common landscaping species. Species observed include non-native grasses, such as wild oats (*Avena sativa*) and Bermuda grass (*Cynodon sp.*), ivy (*Hedera sp.*), Himalayan blackberry (*Rubus discolor*), cheeseweed (*Mallow sp.*), brislty ox-tongue (*Helminthotheca echioides*), Giant Reed (*Arundo gen.*). Some "backyard" areas were landscaped with a variety of ornamentals including non-native rose plants and a variety of fruit trees. Stands of fennel (*Foeniculum vulgare*) and bamboo were observed in patches along the reach. In most areas, the creek is severely incised, with no adjacent wetland band between the creek and upland areas.

As stated, most of the creek has little or no canopy coverage, and tree species generally include ornamentals associated with residential landscaping, including plums (*Prunus sp*.) and other fruit trees. There are, however, certain portions of the creek that run beneath a dense canopy of native trees, including willows (*Arroyo salix* and *Arroyo laevigata*), redwoods (*Sequoia sp.*), oaks (*Quercus spp*.), black walnuts (*Juglans californica*), and magnolias (*Magnolia sp.*). Other large non-native tree species were also observed, including eucalyptus (*Eucalyptus sp.*), acacias (*Acacia sp.*), and poplar (*Populus sp.).* One property owner at 3825 Delmont Ave. has recently planted native big leaf maple (*Acer macrophyllum*), buckeye (*Aesculus californica*), and dogwood saplings (*Cornus californica*) along the top of bank. The success or failure of

[1] Questa Engineering Corp., April 9, 2009. Biological Reconnaissance Survey of Chimes Creek.