From Prairie Creek Channel Migration Study, conducted by GeoEngineers for Pierce County, funded through FCAAP

REACH-SCALE GEOMORPHIC PROCESSES

Introduction

Reach scale channel forming processes include erosion, transport and deposition of sediment and debris within a channel, and flow dynamics through each reach. The extent to which these processes influence channel development are generally determined by one of more of the following controls that can change both spatially (from one reach to the next) and temporally (over time). The relationships between factors that control channel form and channel forming processes can be explained in the following example.

In upstream channel reaches where gradients are steepest, the hydraulic action of fast flowing water results in the net erosion of the streambed, which in turn forms a straight, V-shaped valley wherein the stream channel occupies all or most of the valley floor. In contrast, as the channel gradient decreases and the valley becomes wider, a point is eventually reached where the stream behavior changes from one dominated by streambed erosion (vertical down cutting), to more complex behavior including deposition, bank erosion, channel widening, and development of bends, bars and floodplains. Below we review the types of migration we observed and major factors that control channel forming processes for South Prairie Creek, which include the following; a) the composition of bank and bed material, b) the supply of sediment and woody debris, c) the transport capacity (the ability of the stream to move sediment), and d) the regional and local topography.

Composition of Bank and Bed Material

Relative rates of lateral migration are controlled to some extent by the composition of bank and bed soils. As described in the Regional Geology section above, the Orting formation, White River boulders and Osceola Mudflow are relatively resistance to erosion by South Prairie Creek. In contrast, younger alluvium is composed of sediment that was previously transported and deposited by the stream and is therefore susceptible to erosion, transport and re-deposition. The erodibility of the bank material plays an important role in the channel pattern (straight or meandering) that we observed.

Supply of Sediment and Woody Debris

The volume of sediment and woody debris entering the stream from external source areas can greatly influence channel forming processes and, ultimately, channel pattern and behavior. Changes in land use within the South Prairie Creek Basin, particularly mining and logging, significantly increased the volume of sediment in transport compared to pre- development conditions. After mining activity ceased, the volume of sediment entering the main stem channel, and moving through the system, decreased with time.

One result of the abrupt increase and then decrease in sediment influx is the change in channel behavior following the change in sediment flux. For example, as a large slug of sediment enters a stream reach, the typical channel response is channel aggradation coupled with braiding and multi-channel development, widening of the high flow corridor, and active migration. As more sediment is received, rates of migration typically increase. As sediment influx decreases a main channel develops, migration rates decrease, braid bars stabilize and become vegetated, and the main channel becomes more stable.

Another important influence on local and reach-scale fluvial processes is the relative abundance of woody debris in active channels, especially large-diameter wood. The presence of large woody debris (LWD) within the active corridor will typically increase the complexity of local flow dynamics by diverting and/or splitting the flow, which in turn, creates chutes, eddies and scour pools, and alters the incidence and character of channel erosion, bar development and, subsequently, channel pattern and behavior. In streams with relatively low channel gradients, bedload sediments accumulate as bars in the immediate vicinity of LWD. Historically, stream reaches subject to high incoming sediment discharge and abundant in-channel LWD tended to aggrade, widen and develop braided channels from bedload deposition, which further contributed to the complexity of in-stream flow and morphology.

Early logging and agriculture within the South Prairie Creek basin reduced or eliminated the historic riparian zone, and thus depleted a large percentage of the large wood available for stream recruitment. As the floodplain was further developed, flood control strategies included the removal of existing large woody material from within the channel as a means of increasing flow velocities, which improved transport capacity (see next section) and subsequently, eroded bars and channel floor sediment causing channel incision and loss of flow and morphologic complexity. New conservation regulations will likely increase the amount of riparian wood available for recruitment by South Prairie Creek.

Transport Capacity

The ability of a stream to transport sediment is referred to its “transport capacity”. The transport capacity of a stream is determined by discharge, and channel gradient. Channel gradient is typically used to describe the difference in transport capacity from one reach to the next. For example, an increase in channel gradient, coupled with sparse distribution of channel bars would generally indicate a higher transport capacity. However, significant sediment or water input from tributary, spring or groundwater can change the transport capacity downstream of that input.

Transport capacity, coupled with sediment and woody debris supplied to the system, is a deterministic factor in the development of channel morphology. These three factors affect bar formation and channel form, as well as the shape and dimension of the channel, and ultimately, its behavior and relative migration potential. In river reaches where sediment delivery and transport capacity are well balanced, channel pattern and behavior tend to be relatively stable. In systems where the volume of sediment delivery continually exceeds transport capacity, significant deposition will occur resulting in reach- or valley-scale streambed aggradation and destabilization of the channel. Under these conditions, channel form typically consists of multi-thread braided channels with high width-to-depth ratios in higher gradient areas, or highly sinuous meander bends in lower gradient areas. In contrast, where transport capacity continually exceeds sediment supply, bank erosion and channel incision and entrenchment typically result. Where transport capacity exceeds sediment supply, erosional conditions prevail resulting in an increase in the mean size of bedload materials, lack of bed forms and reduction of channel complexity. Under these conditions, channel pattern is often straight and incised with smaller width to depth ratios.

Regional and Local Topography

The type of channel pattern we observe is partially controlled by topography (both, regional and local) that confines the river channel or protrudes into the channel altering flow direction. Channel patterns are affected where portions of valley walls protrude into a channel, effectively directing the course of the flow away from the feature towards the opposite bank, thus changing the flow dynamic. Changes in flow dynamics often result

in changes in the patterns of erosion and deposition, and can lead to the redirection of channel migration.

CHANNEL MIGRATION

Migration is a reach-scale response of the channel to local and regional processes, as described above. In natural drainage systems, stream channels entering lower gradient reaches are seldom straight except over short distances. Lower gradients usually encourage deposition of a portion of the sediment load in transport, which causes small to large changes in the flow patterns, often resulting in erosion along the outside bank of channel bends. In a state of dynamic equilibrium, erosion along the outside bank of a meander bend and deposition on the point bar at the inside bank of a meander bend occur simultaneously, and at more or less similar rates. A result of this process is the lateral movement, or migration, of the channel across the floodplain.

The type and character of channel migration can vary considerably from one section of a steam to the next. The variation is controlled largely by the combined effect of differing sets of processes; gradient, sediment discharge, bank soils, as well as changes in existing processes. Over the course of the historic aerial photographic record for the project area, three principle types of migration were noted to have occurred most commonly: meander bend migration, channel avulsion, and braided channel migration. A fourth, less often noted type of migration, referred to as vertical migration, is also noted in the project area. Following is a description of each migration type.

Meander Bend Migration

Meander bend migration involves erosion of the outside bank of the river bend coupled with concurrent deposition of sediment along the inside bank of the bend. This process results in the lateral movement of the channel, while maintaining consistent channel shape and width. However, the area of most pronounced migration usually occurs where flow converges against the outer bank near the downstream end of a bend, resulting in simultaneous lateral and downstream migration of the bend. Prior to confinement of project area channels, highly sinuous meander bends tended to develop in low to moderate gradient areas subject to sandy bedload and erosion prone riverbanks. Highly sinuous bends are typically the product of both lateral and downstream migration.

Avulsion

Avulsion is the abrupt movement of an active channel to a new location in the river corridor. This process usually occurs in response to sudden deposition and infilling of the active channel by sediment or debris, causing the stream to erode a new channel or reoccupy a formerly abandoned channel. Avulsion is most common in aggrading channel sections, where the active channel may abruptly abandon its location for a new channel area during a single high flow event.

Avulsion is also observed in meander bend areas. Under these conditions avulsion typically occurs as a meander bend cutoff, wherein a highly sinuous, looping bend is pinched off at the neck, thus abandoning the bend and straightening the channel pattern. Avulsion by meander bend cutoffs is common in lower gradient reaches with highly erosive bank soils.

Braided Channel Migration

Braided channel sections typically consist of multi-thread channels separated by gravel and cobble bars. The channels are typically shallow and migrate rapidly within the braided area as bars are eroded and redeposited within the channel corridor. Braided channel sections tend to develop in areas with a decreasing gradient and where the channel was subject to an influx of large volumes of sediment. Highly braided channel

migration was not observed within the project area. Historically, short sections of the creek experienced some braided channel migration.

Vertical Migration

Vertical migration involves the downward vertical movement of the channel floor, generally resulting in a deeply entrenched channel detached from its floodplain. Vertical migration usually occurs in channel sections with erosion-resistant bank materials, such as mudflow or glacial till, or where the channel has been held in place by artificial structures such as revetments. Vertically migrating channel sections are generally straight, single thread channels exhibiting virtually no observable lateral migration.

Over time, vertical migration can lead to cut-bank failures and minor channel widening. Many sections of South Prairie Creek show evidence of incision and vertical migration. The evidence includes rip-rap found stranded high on channel banks and undercut root systems of riparian trees.

REACH SCALE GEOMORPHIC EVALUATION

This section of the report summarizes the results of the geomorphic analysis conducted for the South Prairie Creek CMZ study. The summary is based on detailed descriptions of the geomorphic conditions for stream reaches comprising the SPC basin. The results of the detailed evaluation are provided in Appendix B of this report.

For this evaluation, South Prairie Creek was divided into seven geomorphic sections, or reaches (Figure 6). The following summary includes the upper basin, and six project area reaches, which includes a large portion of the South Prairie Valley. A stationing system was created to assist in locating specific features on the creek. The Stationing STA 0 to STA 360 was created from the DNR stream center line (1998) beginning at the confluence with the Carbon River. Each integer represents 100 feet (i.e. STA 0 begins at the confluence and STA 360 is 36,000 feet upstream of the confluence). Reach delineations are based on the presence and continuity of physical features, and dominant geomorphic characteristics. Reach delineations are included in the GIS CD-ROM package accompanying this report.

The following summary includes information regarding the existing channel condition, historic channel behavior, and potential future behavior.

UPPER BASIN

The upper basin is situated in the rugged terrain comprising the northwest face of Carbon Ridge. From the headwater lakes (located between Elevations 3,600 and 4,000 feet) down to roughly Elevation 490 feet the main stem stream and tributaries descend from 3,000 to 3,500 feet in 22 miles through deeply incised volcanic bedrock ravines. All major tributaries enter the mainstem SPC within the upper basin.

Main stem and tributary ravines are generally straight with occasional bends, probably originating from ancient joints and/or other weaknesses contained within the bedrock. The main stem channel gradient is greater than 2 percent on average. In general, the walls of the main stem and tributary ravines are steep, and presently, well forested. The bedrock walls of the ravine are overlain by a thin to thick layer of colluvial soil and organic debris. The volcanic bedrock and colluvium are both prone to mass wasting, which can deliver sediment and large woody debris directly to adjacent stream channels. The main stem high flow corridor contains many small alluvial fans and talus cones composed of gravel, cobbles boulders likely derived from erosional processes along the valley walls. Aerial photograph observations suggest that, compared against mass wasted sediment volumes entering the channels, relatively small volumes of gravel, cobbles and boulders are stored within the high flow corridor. This condition indicates that channel transport capacity greatly exceeds sediment influx throughout the ravine,

and that most sediment entering the reach is transported through it to a significant break in slope at the mouth of the mainstem ravine. No evidence of measurable lateral migration was detected within the ravine during this evaluation.

REACH 6 (RAVINE MOUTH TO STA-323)

An alluvial fan extends from the mouth of the main stem ravine (about Elevation 490 feet) to approximately Elevation 440 (Plate 1). Across the alluvial fan in the downstream direction, channel gradients decrease significantly and the valley widens to join the South Prairie Valley. In this zone, the stream is well braided; indicating that a large portion of the sediment load exiting the ravine is depositing in response to the sharp decrease in channel gradient, and associated loss of transport capacity.

Downstream from the alluvial fan the mainstem enters South Prairie Valley and a much lower channel gradients prevails (1 to 2 %). Throughout the South Prairie Valley, the main stem channel is bounded by floodplains composed of historic White River alluvium and Osceola mudflow deposits, which bury the White River alluvium in several areas (see Figure 4).

REACH 5 (STA 323-215)

Reach 5 defines the upstream end of the project area. This reach is characterized by a single, moderately sinuous channel that is relatively well entrenched in flood plain deposits (Figures 6 and 7). Throughout the reach, the channel is relatively narrow, compared to its depth, and channel gradients are generally higher than upstream reaches. Roughly 20 percent of the stream banks are confined by revetments. The rest of the banks consist of Osceola Mudflow deposits or SPC overbank deposits. Locally deep scour pools and eroded cut banks occur along the outside banks of channel bends. The channel is locally entrenched in the floodplain. The stream bed is composed of gravel, cobbles and boulders: the boulders inferred to be derived from White River alluvium or Osceola mudflow. However, a few side channel bars or lag deposits were observed at the time of our site visits, indicating that transport capacity exceeds the influx of sediment from upstream sources.

The pattern and position of the main stem channel appears to have changed little since 1961. However, reach dynamics were far more active in the late 1800s, the major bends likely migrated and the stream flowed in a channel that is now abandoned (see Figure 7). Historical maps and dated aerial photographs indicate that a channel avulsion occurred sometime after 1897 and before 1961. The avulsion event significantly altered the flow dynamics of the stream, which in turn caused a meander bend to form downstream between STA 276 and 260.

Since 1965, the channel pattern throughout Reach 5 has evolved to a static, non-migrating and sediment starved channel section. In-channel bars have disappeared or have become vegetated overtime, the channel is locally entrenched, and stream banks, revetments, and road embankments are subject to erosion during bank full flows.

No meander-bend migration has occurred within Reach 5 since 1965. However, over the last 42 years, very localized episodes of severe bank erosion have been reported. The erosion is typically associated with the recession of a vegetated cutbank, primarily along the outside banks of bends. In most cases, point bar or side channel bar building did not occur concurrently with the bank erosion, and the erosional episode occurs but once, with additional erosion detected at the site in successive photo years. For example at STA 297, property owners witnessed the recession of a bank during the February 1996 flooding event. Despite other significant high flow events over the last 8 years no additional, measurable erosion has been reported.

The potential for future migration is relatively low. Over the period or record, the channel has remained stationary and stable, due primarily to the entrenchment of the channel in Osceola mudflow deposits. Localized bank recession in Osceola Mudflow

deposits and erosion of alluvial soils will likely continue, but is unlikely to result in migration of channel. The abandoned channel on the north side of the current channel could provide an avenue for avulsion, however, the potential for avulsion here is very low, again due to channel entrenchment.

REACH 4 (STA 215-195)

This reach is characterized by a lower channel gradient, and moderately sinuous low flow and secondary channels bounded by large side channel bars (Figures 6 and 8). The low flow channel is relatively wide and shallow, with some pools and riffles between the gravel bars, and sections of localized entrenchment. The main and secondary channels are separated from one another by bars, composed of sand, gravel, cobbles, and a few boulders (probably derived from White River alluvium). This condition suggests that Reach 4 has been subject to aggradation, at least within the last several decades.

The right bank is composed of recent alluvium (sand and silt), and the left bank is composed of Osceola Mudflow and alluvial deposits. Roughly 20 percent of the total length of the stream banks is armored by bridge piers and revetments, which are located primarily along the right bank.

Historic maps suggest that migration was probably more active prior to 1965. The 1874 GLO and 1897 USGS maps indicate that two channels occupied the reach in the late 1800s and early 1900s. The 1874 GLO map shows the two channels running separately for more than 3000 feet; the 1897 USGS map indicates somewhat shorter channel lengths. One of the channels was situated in the present day channel location and the other channel was situated along the foot of the northern valley wall (see Figure 8). The northern channel was abandoned some time between 1897 and 1961.

Historical aerial photographs indicate that the main channel prevailed as a single meandering channel from 1961 to 2002. During the February 1996 flood, however, a portion of the creek flow was directed across the Spring Site Road and along the north side of SR 162 (Reach 3), nearly resulting in the formation of a second channel and possible avulsion (personal communication with Pierce County staff). In spite of the 1996 flood event, the aerial photograph record indicates that the low flow channel width has steadily decreased with time. The decrease in width suggests that 1) the rate of migration has decreased and 2) sediment influx has likely decreased and the channel has become entrenched.

Based on historic and recent trends of migration, the potential for future migration is relatively high. Channel gradients, coupled with the potential for the influx of sediment arriving from upstream source areas and erosion of sensitive bank soils, form excellent conditions under which migration and continue to occur. Future redevelopment of the riparian zone throughout the reach could also lead to an increase of woody debris in the active and the high flow channel corridor, which would, in turn, contribute to bar building and erosion associated with migration.

REACH 3 (STA 195-135)

Reach 3 bears great similarity to Reach 5. The reach can be characterized by a single, moderately sinuous channel entrenched into the valley floor (Figures 6 and 8). Throughout the reach, the channel is relatively narrow; on average 50 feet wide, and 2 to 5 feet deep at the bank full condition. Channel gradients are generally higher than the upstream reach. The channel floor is well armored with relic boulders from the White River alluvium and/or Osceola Mudflow deposits, and only a few gravel/sand bars are present throughout the reach. The stream banks are generally composed of Osceola Mudflow deposits or valley wall soils. Roughly 11% of the total stream bank length within the reach has been reveted to date.

Reach 3 has been subject to major modifications, which have significantly altered channel conditions. Historically, the channel occupied a different alignment; the 1897

USGS map indicates that the upper half of the creek was located in the middle portion of the valley and the lower half parallel to the train tracks on the left side of the valley, as shown in Figure 8. State Route 162 was built in the 1950s and it is not clear when or how (by human intervention or natural avulsion) the creek came to occupy its present channel location. Presently, the upper one-third of the channel within the reach is confined between SR 162 and the abandoned railroad bed (See Figure 8), where the banks are well reveted with riprap. Along the lower two thirds of Reach 3, the channel crosses from one side of the valley to the other in large sweeping bends. However, the channel is either entrenched or semi-confined by the presence of the Orting Formation or Osceola Mudflow exposed in the channel banks.

The pattern and position of the main stem channel appears to have changed little since 1961. However, the channel is still able to respond somewhat to external stimuli. For example, the 1978 photograph shows a sediment mass (presumably a landslide deposit) at the toe of the left valley wall and within the active flow corridor (STA 147 in Figure 8). In response to the sediment mass, the channel migrated approximately 25 feet to the north. Subsequent photographs show that the creek migrated back to its original course as the mass of sediment diminished. As described in the Hydrology Section above, flooding in 1996 resulted in a portion of the creek flow being directed across the Spring Site Road (within Reach 4) and down the north side of SR 162 within Reach 3. The flow re-entered the current creek channel at STA 187 and 175 (see Figure 8).

Reach 3 is subject to localized episodes of significant erosion and bank recession. Similar to Reach 5, small isolated channel movements were observed over the last 42 years. In all cases a tree or clump of trees lining the bank was missing and presumed to be carried downstream. The majority of the problems occurred between 1970 and 1978 (presumably during a 10-year flood event in 1975), and sometime within the 1996 flood season. Field observations confirm that in some areas local vegetation is being undercut along the cut bank side of the river.

Sustained channel migration has not been a dominant geomorphic characteristic in the reach since the channel was moved to its present location. Therefore, the potential for future migration is limited to periodic episodes of bank recession, which do not comprise lateral movement of the channel across the floodplain. In the event of an avulsion in Reach 4, the channel would likely occupy a low lying floodplain north of SR 162 and the creek.

REACH 2 (STA 135-20)

Reach 2 is characterized by a highly sinuous single channel with several active meander bends and multiple abandoned channels. The high flow corridor includes numerous large bars and secondary channels (Figures 6 and 9). The low flow channel is generally broad (about 70 feet wide on average). It is bounded by gravel bars and is relatively complex, compared to upstream reaches. Channel complexity consists of channel pools and riffles, buried woody debris, a few small log-jams, and extensive off channel and riparian habitat. Woody debris that is entrained in the active channel may be associated with local bar building and aggradation of the channel floor.

The streambed consists of gravel, sand and cobbles in the upper reach and medium to fine sand in the lower reach. The floodplains and streambanks are composed of: SPC alluvium, Osceola Mudflow deposits or Orting Formation. The majority of Reach 2 is unconfined; up to 10 percent of the total bank length within the reach has been hardened by bridge crossings, and revetments placed to protect the railroad and the highway.

Reach 2 has been subject to relatively active migration from 1874 to 2002. Oxbows located within the flood plains indicate that the channel was, historically, capable of very of dynamic movement. More recently sequential photographs (from 1961 to 2002) indicate that channel behavior is still quite active. These photographs identify many

aggrading, and therefore, unstable channel sections whose bends migrate both laterally and in a downstream direction. The most active migration appears to have occurred in aggrading channel sections, in particular those sections where woody debris is present.

Similar to upstream reaches, however, migration appears to have slowed over the last 22 years. Aerial photographs indicate that the channel has moved smaller distances or less frequently. In additions, the size of in-stream bars appears to have decreased over the same period, suggesting that sediment influx has decreased.

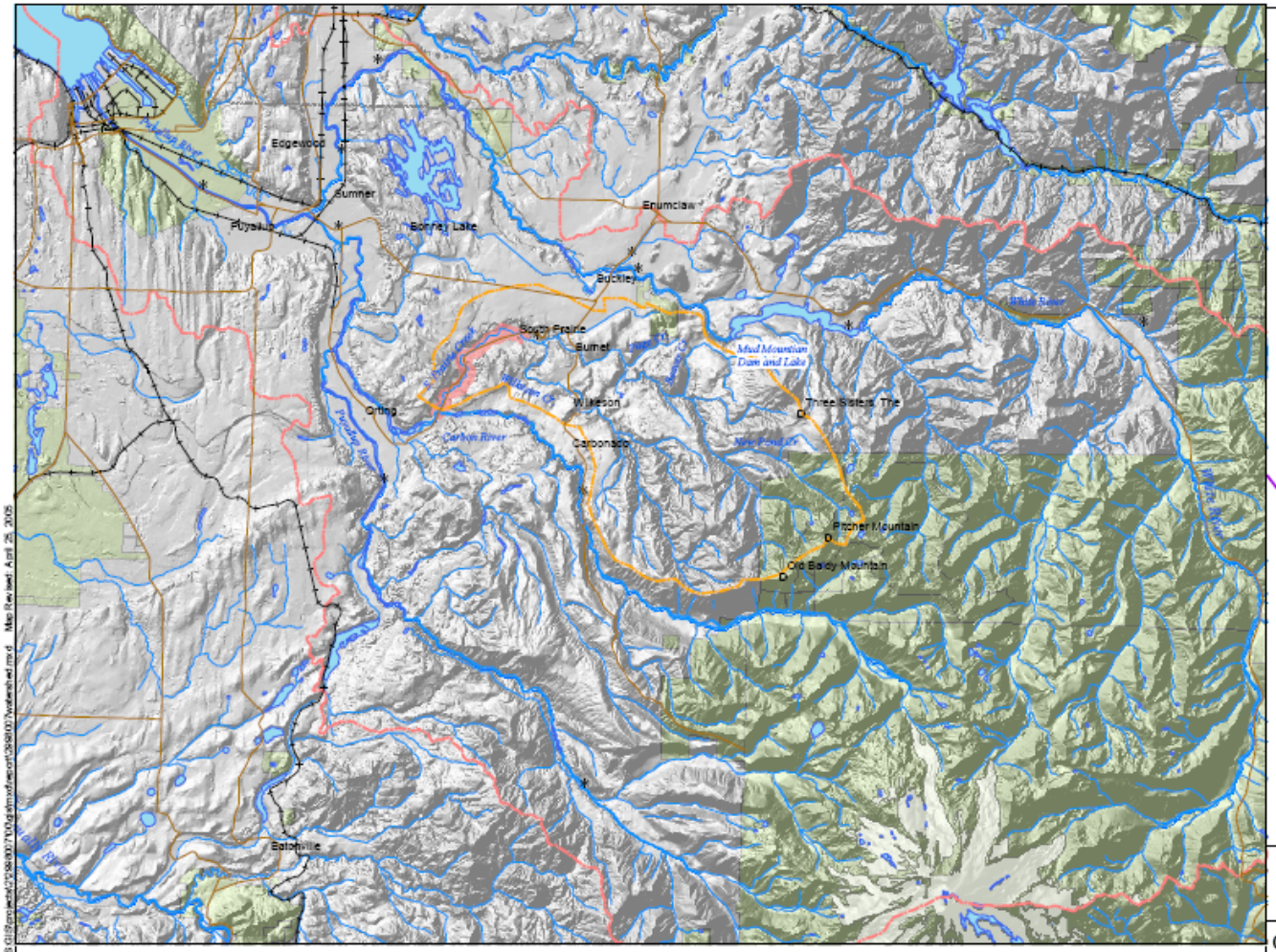
The potential for future migration within Reach 2 is high. Based on the results of the geomorphic evaluation, this reach will likely remain active with respect to lateral migration of the main and secondary channels and downstream migration of channel bends.

REACH 1 (STA 20-0)

Reach 1 joins the Carbon River. The reach is a sinuous, single channel, whose last 500 feet flows in a former Carbon River channel which is seasonally inundated by Carbon River flood flows (Figures 6 and 9). The channel is generally 60 feet wide and 2-4 feet deep at bank full conditions.

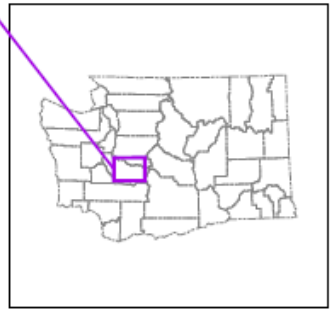
The streambed is composed primarily of sand, however, the lower channel at the confluence is armored with cobbles and boulders likely deposited by either the ancestral White River or the Carbon River. The low-lying floodplains on either side of the creek consist of low relief fields. No evidence of former SPC channel migration, such as abandoned channels or relict bars, are preserved in the floodplains.

No appreciable migration is likely within Reach 1. Historical and recent records indicate that this reach is dominated by Carbon River hydraulics and sedimentation.



Study Area
South Prairie Creek Watershed Boundary
Puyallup Watershed Boundary
USGS Gage Stations
Towns
Mountains
State Highways
Railroad Lines
Rivers
Waterbodies
Glaciers (Mount Rainer)
Major Public Lands
County Boundaries

0 1 2 4 6 Miles



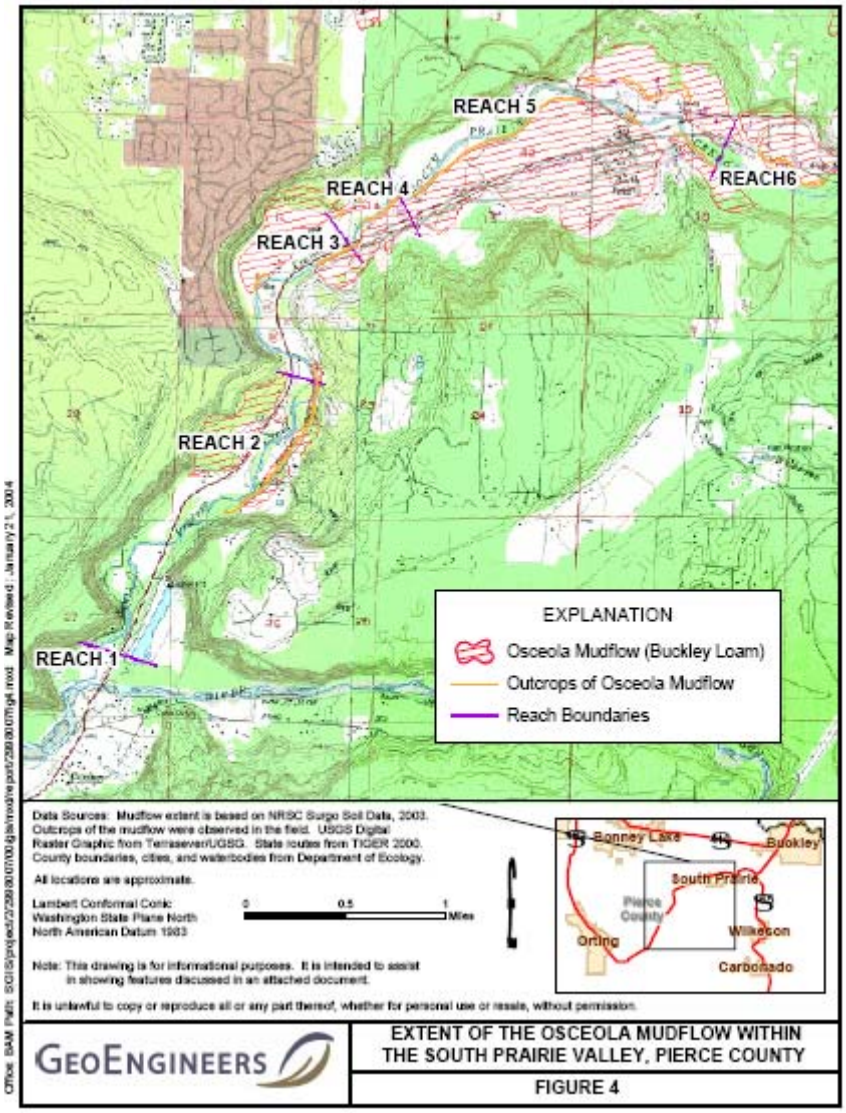
Data Sources: Rivers, waterbodies, state highways, railways, and political boundaries are provided by the Washington Department of Transportation. Watersheds, glaciers, and major public lands are from the Washington Department of Natural Resources. Study area, gage stations, and towns locations were created by GeoEngineers.

This map is for information purposes. Data were compiled from multiple sources as listed on this map. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this map. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication. The locations of all features shown are approximate.

GeoEngineers

CHANNEL MIGRATION ZONE STUDY
SOUTH PRAIRIE CREEK
PIERCE COUNTY

FIGURE 1



Data Sources: Mudflow extent is based on NRSC Surgo Soil Data, 2003. Outcrops of the mudflow were observed in the field. USGS Digital Raster Graphic from Terraserver/USGS. State routes from TIGER 2000. County boundaries, cities, and waterbodies from Department of Ecology.

All locations are approximate.

Lambert Conformal Conic
Washington State Plane North
North American Datum 1983

0 0.5 1 Miles

Note: This drawing is for informational purposes. It is intended to assist in showing features discussed in an attached document.

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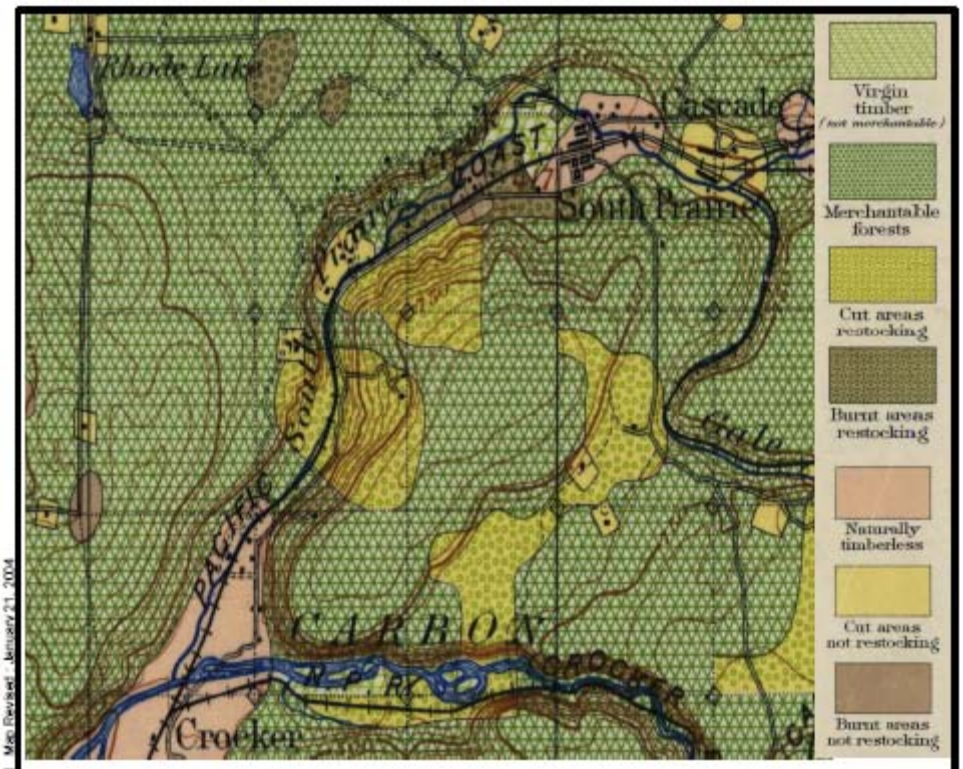
GeoEngineers

EXTENT OF THE OSCEOLA MUDFLOW WITHIN THE SOUTH PRAIRIE VALLEY, PIERCE COUNTY

FIGURE 4

Office: BAM Path: SGIS/project/2/2598007/00/gis/mxd/report/2598007fig4.mxd Map Revised: January 21, 2004



No Scale

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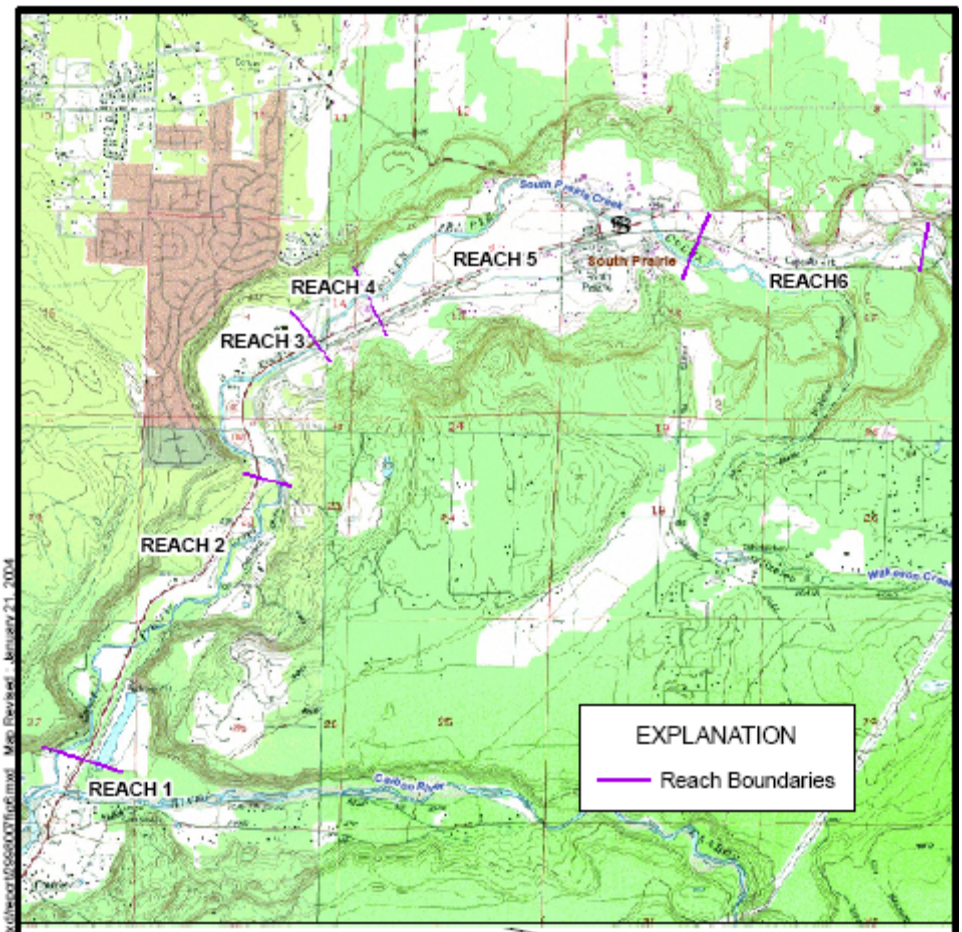
GEOENGINEERS

1897 USGS TACOMA, WASHINGTON
LAND CLASSIFICATION MAP (clipped)

FIGURE 5

Office: BAM Path: S:\GIS\project\2/2998\007\00\xls\mxd\report\2998007fig5.mxd Map Revised: January 21, 2004



Data Sources: Stream Reach boundary were idenfied by GeoEngineers. USGS Digital Raster Graphic from Terraseven/UGSG. State routes from TIGER 2000. County boundaries, cities, and waterbodies from Department of Ecology.

All locations are approximate.

Lambert Conformal Conic
Washington State Plane North
North American Datum 1983

0 0.5 1 Miles

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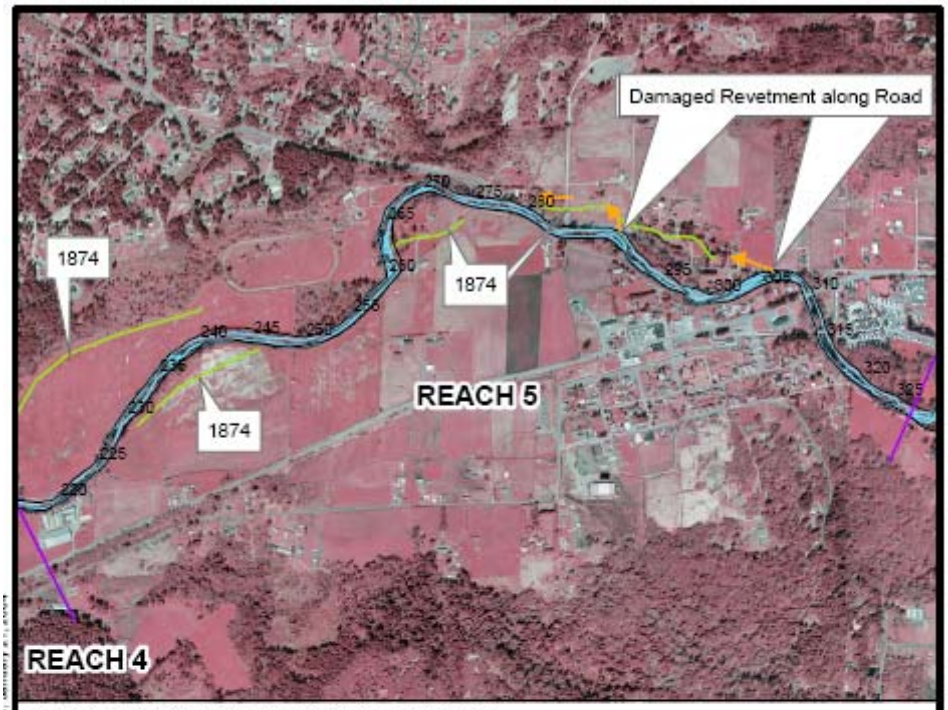
GEOENGINEERS

CHANNEL MIGRATION REACHES
SOUTH PRAIRIE CREEK, PIERCE COUNTY

FIGURE 6

Office: BAM Path: S:\GIS\project\2\2998007\00\gis\mxd\report\2998007fig6.mxd Map Revised: January 21, 2004



Data Sources: Reach boundaries created by GeoEngineers. Active channel digitized by GeoEngineers from 2002 orthophotographs with permission/assistance of Pierce County GIS. Historical channel occupation tract and ancient abandoned channel tracts digitized by GeoEngineers from rectified aerial photographs and maps. GEI creek stationing created by GeoEngineers from Washington Department of Ecology 1998 stream centerlines (3/04). The Background is a 2002 Ortho-Infrared photograph provided by Pierce County GIS.

0 600 1,200 Feet

Notes: 1) The locations of all features shown are approximate.
2) All data is produced at a scale of 1:12K unless otherwise noted.
3) Map Projection: Lambert Conformal Conic, Washington State Plane South (feet), North American Datum 1983

EXPLANATION

- Potenial Avulsion Routes
- Abandon Channels (prior to 1961)
- Active Channel (2002)
- Historical Channel Occupation Tract (1961-2002)
- Reach Boundaries
- 20 GEI Creek Stationing

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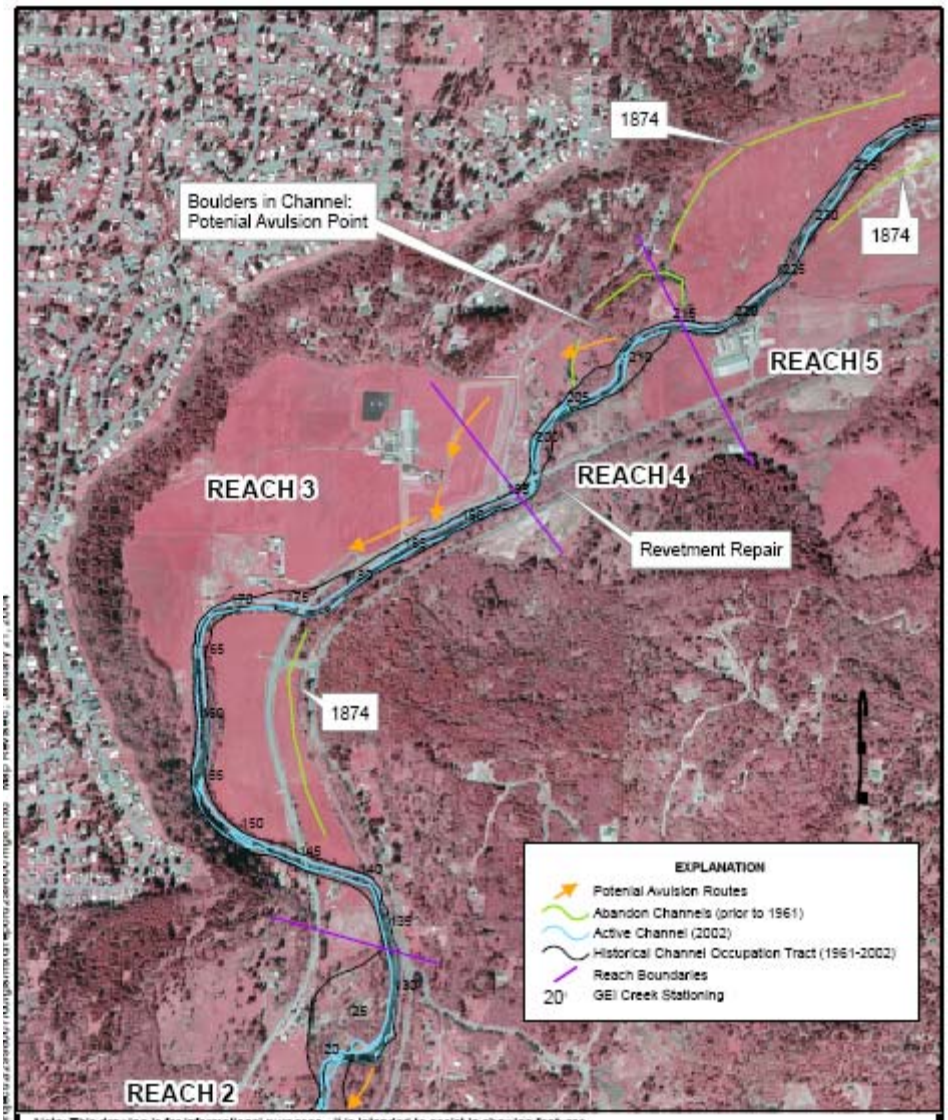
GEOENGINEERS

ABANDONED CHANNELS AND POTENIAL AVULSION PATHWAYS: REACH 5 SOUTH PRAIRIE CREEK CMZ ANALYSIS

FIGURE 7



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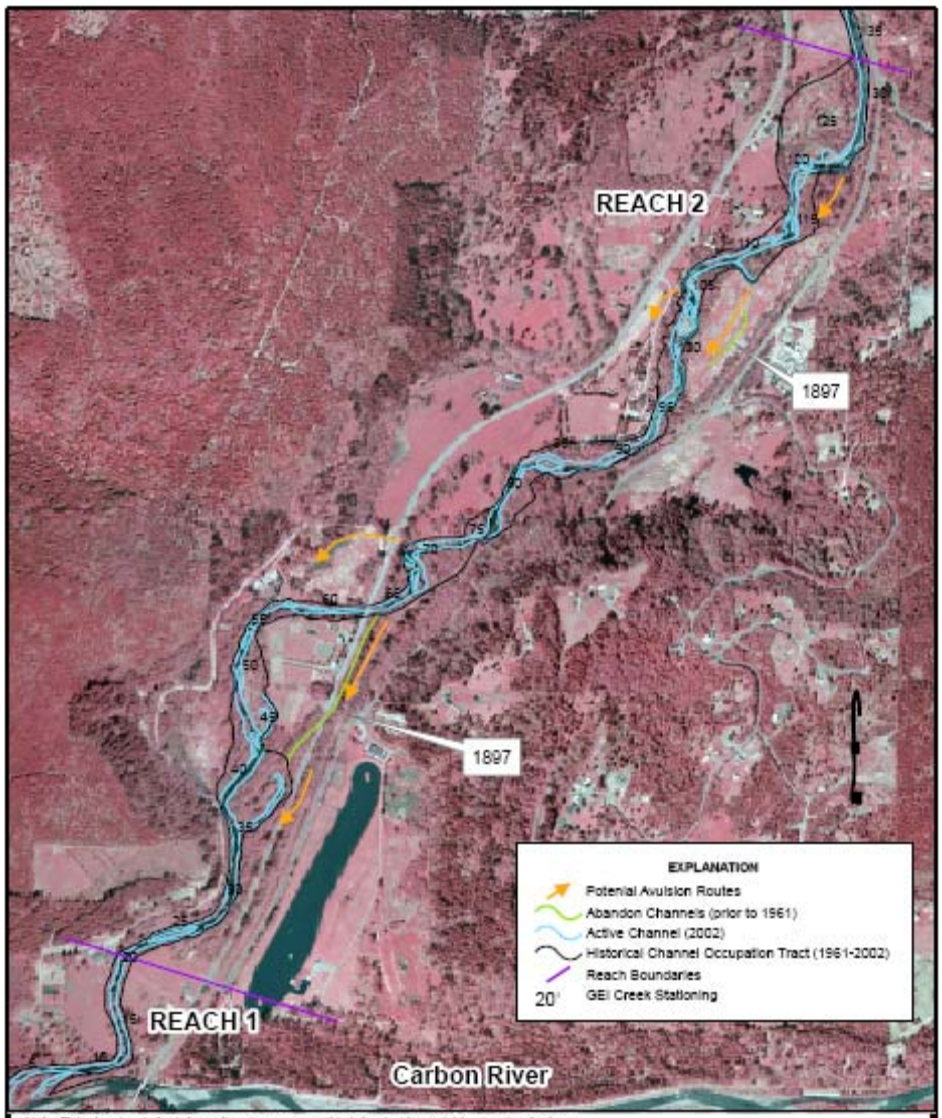
0 600 1,200 Feet

GEOENGINEERS

ABANDONED CHANNELS AND POTENIAL AVULSION PATHWAYS: REACHES 3 AND 4 SOUTH PRAIRIE CREEK CMZ ANALYSIS

FIGURE 8



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0 600 1,200 Feet

GEOENGINEERS

ABANDONED CHANNELS AND POTENIAL AVULSION PATHWAYS: REACHES 1 AND 2
SOUTH PRAIRIE CREEK CMZ ANALYSIS

FIGURE 9