



**2017 Mission Hills Open Channel
Masterplan Update
Final Report**
Prepared for the City of Mission Hills, Kansas
October 20, 2017



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October 20, 2017

Ms. Courtney Christensen
City Administrator
City of Mission Hills
6300 State Line Road
Mission Hills, Kansas 66208

Subject: Mission Hills 2017 Open Channel Masterplan Update

Dear Ms. Christensen:

Water Resources Solutions, LLC is pleased to present the Mission Hills 2017 Open Channel Masterplan Update to the City of Mission Hills, Kansas.

Within this Masterplan, you will find the final report, maps, project summaries, opinions of probable project costs, and the GIS data package.

If you have any questions or require additional information, please contact me at (314) 458-7852.

Sincerely,

Water Resources Solutions, LLC

Matt Harper, P.E.
Water Resources Engineer



10-20-17





Table of Contents

Executive Summary	1	Pembroke Lane Street	
Evaluation	1	and Stormwater Improvements	8
Proposed Recommended Improvements		Brush Creek, 63rd Street To Kansas City	
and Costs	1	Country Club Low-Water Crossing	9
Introduction	3	Peetwood Park Stream Restoration	9
Methodology	3	Belinder Low-Water Crossing	9
Data Collection	3	Brush Creek, Belinder Avenue	
Open Channels	3	To East Mission Drive.	9
Retaining Walls	5	Brush Creek Ramp	10
Stream Buffers.	5	Miscellaneous Retaining Wall Repairs.	10
Results	5	Proposed Improvements And Recommendations .	11
Open Channels	5	Open Channels	11
Retaining Walls	6	Stream Buffers.	11
Stream Buffers.	7	Proposed Improvement Project	
Completed Stream Studies		Costs and Ranking	11
and Improvement Projects	8	Channel Improvement Costs	11
63rd Street Bridge Replacement	8	Channel Improvement Project Ranking	11
Hiawasse Park		Original Masterplan Compliance	16
Channel Improvements	8	Conclusions.	16
Brush Creek Bank Stabilization	8	References	16
Mission Drive Channel Improvements	8	Appendices	17

List of Tables

Table 1: Open Channel Reach	
Evaluation Summary	5
Table 2 : Retaining Wall Evaluation Summary	6
Table 3: Stream Buffer Evaluation Summary	7
Table 4: Channel Condition Ratings	11
Table 5: Retaining Wall Condition Ratings	11
Table 6: Channel Improvement Projects	
by Stream Reach Rating	12
Table 7: Channel Improvement Projects	
by Stream Reach Ranking	14

List of Figures

Figure 1: Planform Geometry Components	4
Figure 2: Concrete lined channel	6
Figure 3: Major erosion behind	
a retaining wall	7
Figure 4: Open channel with an “Excellent” rated	
buffer	7
Figure 5: Open channel with a “None”	
rated buffer	7

Appendix A

- Maps
- Open Channel Condition Map
- Retaining Wall Condition Map
- Stream Buffer Condition Map
- Completed Stream Studies
- and Stream Projects Map
- Proposed Improvement Reaches Map

Appendix B

- Reach Descriptions and Cost Estimates
- Reach Descriptions (Existing Condition, Channel
- Condition Scoring Matrix, Proposed
- Improvements, Cost Estimate)
- Bank Reshaping Only Localized Improvements
- Opinion of Probable Costs
- System-wide Improvements Opinion of Probable Costs





Executive Summary

This report is an update to the 2007 Mission Hills Open Channel Masterplan prepared by Black & Veatch. Over the period from 2007 to now, there have been several stream studies and stream improvement projects within the City. This Masterplan identifies those stream studies and improvement projects, as well as provides recommendations on how to improve the condition of the streams, retaining walls and stream buffers. The stream reach projects are prioritized and construction cost estimates are also included.

EVALUATION

The open channels were evaluated to determine their stability. The open channels were divided into reaches and evaluated using the Channel Condition Scoring Matrix (CCSM) as defined in the Kansas City Metropolitan Area Chapter of the American Public Works Association (APWA) Standard Specification and Design Criteria Section 5605 guidelines (Table 5605-2). The scores can range between 9.8 and 29.4. Reaches with scores of 12 or less are given a ranking of “Good,” indicating an adequate stream stability condition. Reaches with scores between 12 and 19.6 are given a ranking of “Fair,” indicating instability does exist and special measures may be necessary to address the instability. Reaches with scores greater than 19.6 are given a ranking of “Poor,” indicating significant instability issues exist and measures are necessary to address them.

The retaining walls along the open channel reaches were identified and their conditions evaluated. The locations of the walls were recorded as either left or right bank, and the condition of walls was rated as “Good” (no repair needed), “Fair” (some repair needed), or “Poor” (failing). The locations of major wall failures and other wall issues were also identified.

Stream buffers were identified and evaluated along each of the open channel reaches included in this masterplan. A riparian buffer zone consists of appropriate native vegetation along the banks that would

enhance the habitat function of the riparian corridor, improve bank stability and improve water quality. The buffers for this masterplan were classified as “None” (< 1 foot), “Acceptable” (1-5 feet), “Good” (5-15 feet) or “Excellent” (> 15 feet).

There were 40 open channel reaches evaluated as part of this masterplan update, totaling just over 6.1 miles. Each reach was evaluated using the APWA Channel Condition Scoring Matrix (CCSM) to determine a total score and ranking for each reach. The stream conditions ranged between “Poor” and “Fair,” with 13 reaches in “Poor” condition and 27 in “Fair” condition. In general, the CCSM rating is negatively impacted due to steep bank slopes and the lack of sinuosity and pool-riffle structure. Most reaches have a low score on these three indicators. Lack of vegetative protection also has a negative impact on the stability rating. Most of the main channel widths are less than those found in stable natural channels.

There are approximately 5.6 miles of retaining walls lining the open channels with Mission Hills, and they are divided into 189 individual segments in this masterplan. Wall conditions vary extensively. The channels with newer walls are in good condition, and some older walls remain in good condition. Other older walls show signs of periodic repairs. In many instances, stream bed degradation has allowed exposure of the wall foundations, creating conditions that could compromise the stability of the walls. Locations were noted identifying individual wall issues, including wall failures and erosion behind the walls.

Stream buffers were identified and evaluated on both banks along each of the open channel reaches. The condition of the stream buffers ranged from “None” to “Excellent (>15 feet). The most common stream buffer condition was “None,” and the least common was “Acceptable.”

PROPOSED IMPROVEMENTS AND COSTS

This 2017 Open Channel Evaluation identified 13 reaches in “Poor” condition and 27 reaches in “Fair” condition. Proposed improvements were developed



for each reach, including both localized improvements and system-wide improvements. The localized improvements include those that correct immediate concerns, such as repairing or replacing retaining walls and reshaping steep banks to a more stable side slope. System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles or drop structures, reshaping the channel banks to a stable cross section and restoring the banks with native vegetation.

The total cost of the improvements necessary for localized improvements to the open channels is \$15,276,378. The total cost of the improvements necessary for the system-wide improvements is \$34,412,404.

Actions should also be taken to improve the stream buffers. A healthy, vegetated, streamside buffer is critical to the long term health of streams, especially in urban environments where stressors are more prevalent. Measures should be taken to revegetate the corridor with more native plant species, especially shrubs, grasses and wildflowers. Homeowners and the golf courses should be encouraged to remove the exotic non-natives and replant using native riparian species and be urged to allow for a healthier vegetative buffer along the stream channel. This can be accomplished by planting a semi manicured transition zone between the stream and the main yards. There should also be a concerted effort by the City to educate citizens and elected officials on the benefits of streams and stream corridors, the proper use of landscape chemicals and the need to reduce impervious surfaces adjacent to streams.



Introduction

This report is an update to the 2007 Mission Hills Open Channel Masterplan prepared by Black & Veatch. It outlines the open channel assessment, retaining wall condition and stream buffer condition of the City of Mission Hills' open channels. Over the period from 2007 to now, there have been multiple studies and improvements made to the open channels within the City.

The following report outlines the methodology used to evaluate the City's open channels, retaining walls,

stream buffers and the results of the evaluation. The open channels, retaining walls and stream buffers are illustrated on the maps in Appendix A of this report.

Following the methodology and results sections, proposed improvements and recommendations are presented, along with cost estimates for the proposed improvements. The projects are ranked and prioritized based on the open channel evaluation and costs.

Methodology

This section outlines the methodology used to evaluate the condition of the open channels, retaining walls and stream buffers.

DATA COLLECTION

The data were collected in April of 2017 by Water Resources Solutions. All field data for this project were collected using a Trimble GPS data collector. The collector contained a set of stored forms that were completed to evaluate open channel, retaining wall and stream buffer conditions. Photos were taken of the channels, retaining walls and stream buffers. The data were imported into ArcMap for analysis. GIS shapefiles were developed to analyze the data and to create maps to illustrate the results. The ArcMap files, GIS shapefiles and photos are on a DVD included with this report.

OPEN CHANNELS

The open channels were evaluated to determine their stability. The open channels were divided into reaches and evaluated using the Channel Condition Scoring Matrix (CCSM) as defined in the Kansas City Metropolitan Area Chapter of the American Public Works Association (APWA) Standard Specification and Design Criteria Section 5605 guidelines (Table 5605-2). The CCSM includes indices that evaluate channel geometry, bank slope stability, streambed and bank material composition and evidence of unstable con-

ditions. Channel geometry indicators compare the stream on plan and profile to optimal conditions of stable channels, based on fluvial geomorphologic concepts. The stability indicators within the CCSM are listed below.

- Bank soil texture and coherence
- Average bank slope angle
- Average bank height
- Vegetative bank protection
- Bank cutting
- Mass wasting
- Bar development
- Debris jam potential
- Obstructions, flow deflectors and sediment traps
- Channel bed material consolidation and armoring
- Sinuosity
- Ratio of radius of curvature to channel width
- Ratio of pool-riffle spacing to channel width at elevation of 2-yr flow
- Percentage of channel constriction
- Sediment movement

For every channel reach, the stability indicators are given a score of "Good," "Fair," or "Poor" and an associated value of "1," "2," or "3." The score values are then multiplied by a weight ($\Sigma S*W$) to determine the rating for each stability indicator. The rating for each indicator is then summed to determine the total score. The scores can range between 9.8 and 29.4. Reaches



with scores of 12 or less are given a ranking of “Good,” indicating an adequate stream stability condition. Reaches with scores between 12 and 19.6 are given a ranking of “Fair,” indicating instability does exist and special measures may be necessary to address the instability. Reaches with scores greater than 19.6 are given a ranking of “Poor,” indicating significant instability issues and measures are necessary to address them.

Channel Stability and Fluvial Geomorphology

The definition of a stable channel depends on whether the channel boundaries are considered rigid (static) or movable (dynamic). The stability of a rigid channel is achieved when the material forming the channel boundary effectively resists the erosive forces of flow. Stability of a dynamic channel is more difficult to define. In this case, a channel is considered stable if changes are within “acceptable” levels. In general, such stability is attained when the sediment supply rate equals the sediment transport rate.

In the urban/suburban context the acceptable levels of change are constrained by rights-of-way and existing or proposed infrastructure. In many cases possible lateral migration and bank instability cannot be tolerated. Therefore, as stated by the Federal Highway Administration (FHA, 1988), development of static equilibrium conditions is preferable in urban/suburban areas. Thus, under static equilibrium conditions a stable channel will have a rigid boundary that effectively resists the erosive forces of flow while avoiding sedimentation of particles that are transported by the flow upstream from the channel of interest.

Recent regulatory trends promote that land use changes and stream modifications do not adversely impact

downstream or upstream stability and environmental conditions. To mitigate the impact on the overall stream stability, it has been proposed that channel designs and stream modifications should mimic natural channels. Under this new paradigm, there is a preference for meandering channels that include pools and riffles instead of using constant-slope straight channels. In principle, this new approach would reduce flow velocities and shear stress in the designed or modified channel, thus making it more stable to erosion. Reduction of flow velocities and shear stress allows the use of flexible lining (riprap, vegetation, etc.) as opposed to rigid linings (concrete, soil cement, gabions, etc.). Flexible linings are generally less expensive, allow infiltration, and they also have an aesthetic value (natural appearance).

Philip J. Soar and Colin R. Thorne (2001), provide a framework for designing stable channels for river restoration. The underlying assumptions behind this framework are that (1) the dimensions of stable natural channels are proportionally related to the discharge and (2) the dimensions of the channel are inter-correlated. Based on extensive literature review and research, Soar and Thorne calculated average proportionality relations between discharge and channel dimensions for typical stable natural channels. These average relationships provide a set of guidelines that serve as a basis for dimensioning a stable channel. Figure 1: Planform Geometry Components shows the planform geometry components. The following is a summary of guidelines as suggested by Soar and Thorne:

Design of main channel is based on bank full discharge (Q_b).

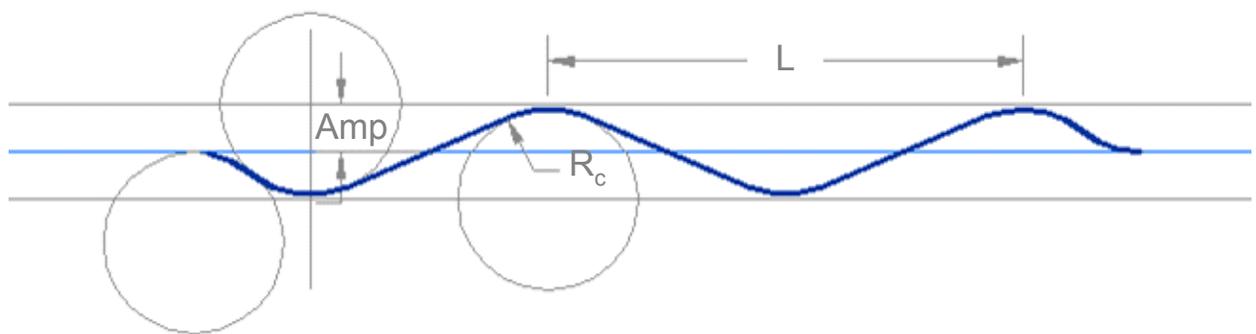


Figure 1:
Planform
Geometry
Components



- a. Soar and Thorne (2001) indicate that the 2-year flood (Q_2) is an approximate upper boundary to bank full discharge. Preliminary studies in Kansas indicate that, for local urban areas, the 1-yr flood (Q_1) may be a better estimate of bank full discharge.
- b. Channel width: $w = aQ_b^{0.5}$ where Q_b = bank full discharge in cfs and $a = 2.03$ (90% confidence: $a = 1.12$ to 3.69; lower values of “ a ” are associated with resistant banks as opposed to erodible banks). For the evaluation and conceptual design for Brush Creek and its tributaries, the lower end of the confidence interval was selected ($a = 1.12$) assuming stable banks and considering rights-of-way and existing infrastructure constraints. Larger widths, within the 90% confidence range, would also be acceptable.
- c. Wave length: $L \cong 12w$ and/or pool riffle spacing $L_{p-r} \cong 6w$.
- d. Radius of curvature: $R = c_{rc}w$ where $c_{rc} \cong 2.4$ (absolute minimum: $c_{rc} = 2$).
- e. Amplitude is set to obtain a sinuosity of between 1.2 and 1.4. The amplitude may also be set based on sediment transport requirements and rights-of-way limitations.

RETAINING WALLS

The retaining walls along the open channel reaches were identified and their condition evaluated. The locations of the walls were recorded as either left or right bank, and the condition of walls was rated as “Good” (no repair needed), “Fair” (some repair needed) or “Poor” (failing). The locations of major wall failures and other wall issues were also identified.

STREAM BUFFERS

Stream buffers were identified and evaluated along each of the open channel reaches included in this masterplan. A riparian buffer zone consisting of appropriate native vegetation along the banks that would enhance the habitat function of the riparian corridor, improve bank stability and improve water quality. Riparian buffer zones help to reduce the amount of excess nutrients (e.g. nitrogen, phosphorus, typically present in lawn fertilizers) and other pollutants. The buffers for this masterplan were classified as “None” (< 1 foot), “Acceptable” (1-5 feet), “Good (5-15 feet) or “Excellent” (> 15 feet). The approximate location of the buffer was determined for both stream banks.

RESULTS

This section summarizes the results of the evaluation of the open channels, retaining walls and stream buffers.

OPEN CHANNELS

There were 40 open channel reaches evaluated as part of this masterplan update, totaling just over 6.1 miles. Each reach was evaluated using the APWA Channel Condition Scoring Matrix (CCSM) to determine a total score and ranking for each reach. The stream conditions ranged between “Poor” and “Fair,” with scores ranging between 15.4 and 22.4. Table 1 summarizes the results of the open channel reach evaluation.

Table 1: Open Channel Reach Evaluation Summary

Rating	Number of Reaches	Length (miles)	Percentage of Total Length
Poor	13	1.63	27%
Fair	27	4.55	73%

In general, the CCSM rating is negatively impacted due to steep bank slopes and the lack of sinuosity and pool-riffle structure. Most reaches have a low score on these three indicators. Lack of vegetative protection also has a negative impact on the stability rating. Most of the main channel widths are less than those found in stable natural channels. The lo-



as the concrete and walls provide the required protection. Concrete lined channels can become unstable over time if the concrete is eroded by the abrasive action of high velocity flows. If not maintained, once the concrete lining on the bed is lost, streambed degradation will progress at a rapid pace, and the wall foundations will be compromised. Without the concrete and the walls, the stream will be extremely unstable, especially if no vegetative protection exists on the banks.

RETAINING WALLS

There are approximately 5.6 miles of retaining walls lining the open channels within Mission Hills, and they are divided into 189 individual segments in this masterplan. Wall conditions vary extensively. The channels with newer walls are in good condition, and some older walls remain in good condition. Other older walls show signs of periodic repairs. In many instances, stream bed degradation has allowed exposure of the wall foundations, creating conditions that could compromise the stability of the walls. Table 2 : Retaining Wall Evaluation Summary summarizes the results of the retaining wall evaluation.

Table 2 : Retaining Wall Evaluation Summary			
Rating	Number of Wall Segments	Length (miles)	Percentage of Total Length
Poor (failing)	38	0.86	15.4%
Fair (need some repair)	106	3.38	60.1%
Good (no repair needed)	56	1.38	24.5%

There were six gabion wall segments identified during the evaluation, and all were rated in fair condition. Also, 11 locations were noted identifying individual wall issues, including wall failures and erosion behind the walls. Figure 3 is a photo of one of the locations where there is major erosion behind a retaining wall. The locations and condition of each wall segment are illustrated on the Retaining Wall Conditions Map in Appendix A of this report.

Figure 2:
Concrete lined channel

cations and ranking of each open channel reach are illustrated on the Open Channel Conditions Map in Appendix A of this report. The CCSM and reach description for each open channel reach are provided in Appendix B.

Despite impending unstable conditions, the extensive use of walls and other bank stabilization mechanisms has prevented excessive bank failures in the form of bank cutting and mass wasting.

The most stable channels include the ones lined with grouted stone walls and a concrete bed. Figure 2 is a photo of one of the many concrete lined channels in Mission Hills. These channels, however, do not have a higher rating, because the banks are stable as long



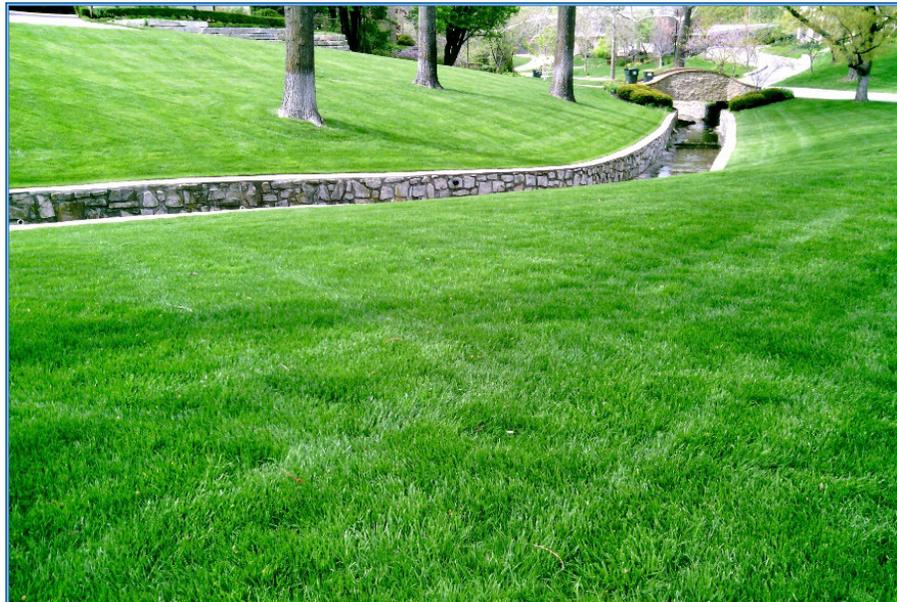
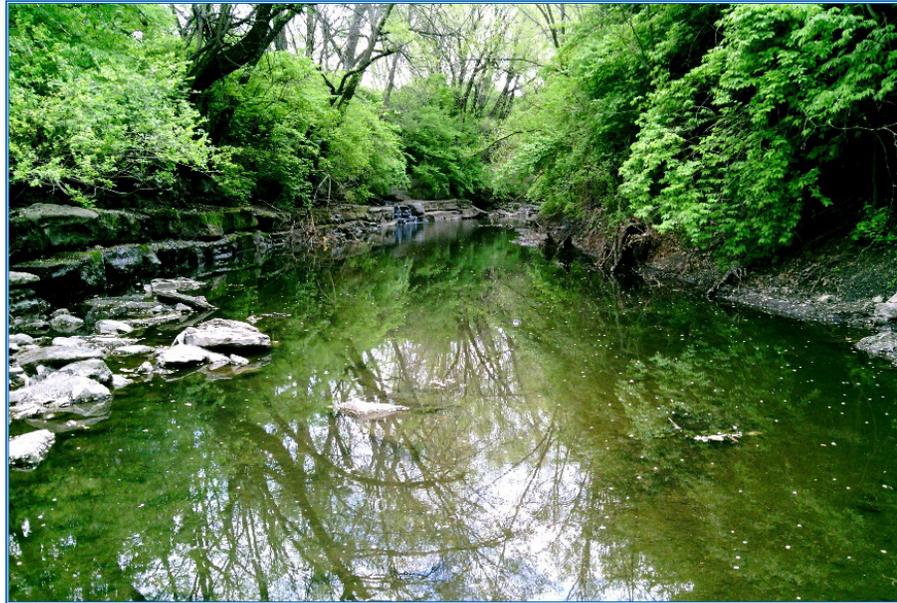
STREAM BUFFERS

Stream buffers were identified and evaluated on both banks along each of the open channel reaches. The condition of the stream buffers ranged from “None” to “Excellent” (>15 feet). The most common stream buffer condition was “None,” and the least common was “Acceptable.” Table 3: Stream Buffer Evaluation Summary summarizes the results of the stream buffer evaluation.

Table 3: Stream Buffer Evaluation Summary

Rating	Length (miles)	Percentage of Total Length
None	5.28	44.5%
Acceptable (1-5 feet)	1.21	10.2%
Good (5-15 feet)	3.83	32.3%
Excellent (>15 feet)	1.54	13.0%

The locations and condition of the stream buffers are illustrated on the Stream Buffer Conditions Map in Appendix A of this report. Figure 4 is an example of an “Excellent” rated buffer, Figure 5 is an example of a “None” rated buffer.



(At right, from top)

Figure 3:

Major erosion behind a retaining wall

Figure 4:

Open channel with an “Excellent” rated buffer

Figure 5:

Open channel with a “None” rated buffer



Completed Stream Studies and Improvements

Several stream studies and stream improvement projects have been completed since the 2007 Mission Hills Open Channel Masterplan was completed. This section provides a brief description of those stream studies and improvement projects. The locations of the stream studies and improvement projects are shown on the Completed Stream Studies and Stream Projects Map in Appendix A of this report.

63RD STREET BRIDGE REPLACEMENT

The 63rd Street Bridge Replacement project included replacing the 63rd Street Bridge over Brush Creek just west of Wenonga Road. The new bridge is a skewed arch bridge, and the channel was realigned to direct the flow through the bridge. The channel improvements upstream of the bridge include a new stacked stone retaining wall on the left descending bank and a new stacked stone toe protection on the right descending bank upstream of the bridge. There are also two graded controls upstream of the bridge. A new stacked stone retaining wall was constructed on the left descending bank downstream of the bridge continuing to the Indian Lane low-water crossing. The stream banks were restored with native vegetation. Construction was completed in Fall 2016.

HIAWASSEE PARK CHANNEL IMPROVEMENTS

The Hiawassee Park Channel Improvements project included the design and restoration of the open channel through Hiawassee Park west of Wenonga Road and south of 63rd Street. The stream design included realigning the channel to a more stable planform based on the alignment proposed in the 2007 Mission Hills Open Channel Masterplan. The project is comprised of a series of the rock grade controls in the form of modified Newbury rock riffles, both to dissipate stream specific energy and to facilitate aquatic organism passage. The project also includes a pedestrian bridge designed to aesthetically complement the design of the new 63rd Street bridge. Construction was completed in the Fall of 2016.

BRUSH CREEK BANK STABILIZATION

The Brush Creek Bank Stabilization project included the restoration of a section of Brush Creek along Indian Lane north of 63rd Street between the Indian Lane low-water crossing and Mission Drive. Approximately 230 linear feet of existing concrete retaining wall lining the left descending bank were deteriorating and failing, along with a segment of retaining wall on the right descending bank. Both retaining walls were removed and the banks reshaped and stabilized with longitudinal peaked stone toe protection and a geogrid reinforced upper bank. The channel was reshaped to include an internal flood bench, to increase capacity through the project reach. The channel was grade stabilized with an engineered rock riffle. The channel banks were restored using native vegetation. Construction was completed in the Spring of 2012.

MISSION DRIVE CHANNEL IMPROVEMENTS

The Mission Drive Channel project consisted of channel, stormwater pipe system and bridge improvements, to reduce flooding of the First Lutheran Church and roadways that include State Line Road, Tomahawk Road, Mission Drive and 63rd Street. In addition, the project improved the stability of approximately 500 linear feet of unstable creek between State Line Road and 63rd Street. The stream improvements included longitudinal peaked stone toe protection and a geogrid reinforced upper bank. The channel bed was stabilized using engineered rock riffles. The channel banks were restored using native vegetation. Construction was completed in 2013.

PEMBROKE LANE STREET AND STORMWATER IMPROVEMENTS

The Pembroke Lane Street and Stormwater Improvements project consists of the design and replacement of an undersized and aging stormwater system, stream restoration and street improvements along Pembroke Lane east of State Line Road. The stream design consisted of approximately 175 linear feet of failing channel wall replacement paralleling Pembroke Lane. The stream improvement also included bank reshaping and TRM



installation to armor the reshaped slope. The slope toe was protected with natural limestone block and vegetation. Construction was completed in Summer 2014.

BRUSH CREEK 63RD STREET TO KANSAS CITY COUNTRY CLUB LOW-WATER CROSSING

The Brush Creek 63rd Street to KCCC Low-Water Crossing project consisted of hydraulically modeling the reach of Brush Creek between 63rd Street and the low-water crossing on Mission Drive at the entrance to the Kansas City Country Club. The intent of the project was to identify hydraulic and stream stability issues along the reach and to develop recommendations for improvement. Both a physical model and a two-dimensional hydraulic model were developed to analyze this reach of Brush Creek. The physical model provided a more detailed analysis of approximately 550 linear feet of the reach, and the entire reach was modeled using the two-dimensional hydraulic model. In addition, the project resulted in a calibrated hydraulic model that can be used by other engineers. The hydraulic modeling identified two hydraulic jumps along the reach, which resulted in a stacked stone retaining wall being constructed to protect against erosion. The study was completed in the Summer of 2015.

PEETWOOD PARK STREAM RESTORATION

The Peetwood Park Stream Restoration project consisted of a stream restoration project along approximately 800 linear feet of Brush Creek along Indian Lane near W. 65th Terrace. The project was a City demonstration project to illustrate the implementation of the City's stream masterplan. The project included the construction of a stable planform and bed slope for the stream through the City's Peetwood Park. Stone grade controls were designed to provide the vertical stabilization of the stream bed. Stone tree wells were constructed to protect existing trees. Two experimental tree wells were constructed out of stone-faced porous concrete to allow drainage of the tree root zone. The stream banks were graded to a stable slope and restored with native vegetation. Post-construction water quality monitoring was per-

formed and will continue for 10 years. Construction was completed in 2009.

BELINDER LOW-WATER CROSSING

The Belinder Low-Water Crossing project was located along Rock Creek along Belinder Avenue near the confluence with Brush Creek. The project consisted of constructing 165 linear feet of stacked stone toe protection and 80 linear feet of stacked stone retaining wall, to replace a failing wall along the left descending bank of Rock Creek. The stream bank above the stacked stone toe protection was graded to a stable slope and restored with native vegetation. The area at the top of the stacked stone retaining wall was restored with reinforced sod. Construction was completed in Fall of 2014. The low-water cross at Belinder Avenue is the subject of a future study in 2018.

BRUSH CREEK, BELINDER AVENUE TO EAST MISSION DRIVE

The Brush Creek, Belinder Avenue to East Mission Drive project was a hydraulic and stream stability study of Brush Creek from Belinder Avenue to East Mission Drive. Erosion along the stream bank that had exposed a sanitary sewer encasement along the backyard of a resident was one particular location of concern along the project reach. The modeling for this project was completed using both numerical and physical models, to analyze the creek hydraulics and erosion potential. Both one-dimensional (HEC-RAS) and two-dimensional numerical models (SRH-2D) were used for the entire reach from Belinder to Mission Drive. A three-dimensional physical model was used to analyze the creek through the reach near the exposed sanitary sewer encasement. The study results led to the conclusion that the subsidence occurring in the back yard at the exposed sanitary sewer line was the result of the stream toe scour. The recommended solution was to protect the toe of the stream along the sanitary sewer encasement from scour, provide a soil barrier to retain the soil behind the sanitary sewer encasement, and regrade the backyard to the top of the existing sanitary sewer encasement. The study was completed in Spring 2017.



BRUSH CREEK RAMP

The Brush Creek Ramp project included replacing a Brush Creek access ramp and 254 linear feet of deteriorating retaining wall along Brush Creek near the intersection of Mission Drive and East Mission Drive. The ramp was constructed of concrete, and the retaining wall was a stacked stone retaining wall. Construction was completed in the Fall of 2013.

MISCELLANEOUS RETAINING WALL REPAIRS

There have been many small retaining wall repairs both on residential and City property since the completion of the 2007 Mission Hills Open Channel Masterplan. Many of these repairs involved repairing retaining walls that had failed or were deteriorating.

Proposed Improvements And Recommendations

This section discusses the proposed improvements and recommendations for improving the condition of the open channels and the stream buffers.

OPEN CHANNELS

The condition of the open channels ranged from “Poor” to “Fair.” Proposed improvements were developed for each reach, including both localized improvements and system-wide improvements. The localized improvements include those that corrected immediate concerns, such as repairing or replacing retaining walls and reshaping steep banks to a more stable side slope.

System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles or drop structures, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation. Proposed improvements for each reach are outlined in Appendix B of this report.

STREAM BUFFERS

A healthy, vegetated, streamside buffer is critical to the long term health of streams, especially in urban environments where stressors are more prevalent. With no stream buffer along approximately 44% of the stream banks, and only 10% having an Acceptable (1-5 feet) rating, improvements to the stream buffer need to be made. Measures should be taken to revegetate the corridor with more native plant species, especially shrubs, grasses and wildflowers. Homeowners and the golf courses should be encouraged to remove the exotic non-natives and replant using native riparian species and urged to allow for a healthier vegetative buffer along the stream channel. This can be accomplished by planting a semi manicured transition zone between the stream and the main yards. There should also be a concerted effort by the City to educate citizens and elected officials on the benefits of streams and stream corridors, the proper use of landscape chemicals, and the need to reduce impervious surfaces adjacent to streams.



Proposed Improvement Project Costs And Ranking

This section describes the proposed improvement project costs and ranking of each project reach.

CHANNEL IMPROVEMENT COSTS

The opinions of probable project costs, including construction costs, contingencies and engineering costs, are included in Appendix B of this report and show the itemized costs used to determine the localized project costs. Assumptions were made to determine the amount of retaining wall to be replaced based on the existing condition of the retaining wall. For walls in “Fair” condition, it was assumed 50% of the wall needed to be replaced. For walls in “Poor” condition, it was assumed 100% of the wall would need to be replaced. For those reaches whose walls were in “Good” condition or which did not contain any retaining walls, assumptions were made to determine the length of channel to be restored. For channels with a channel ranking of “Fair,” it was assumed 40% of the channel length needed to be restored. For those channels with a “Poor” channel ranking, it was assumed 75% of the channel length needed to be restored.

Costs for the system-wide improvements were also developed, and a complete table for each reach is included in Appendix B of this report. Items included in the system-wide improvement costs are channel construction, roadway bridge, driveway/pedestrian bridge, retaining wall and engineered rock riffle/grade control/drop structure, along with contingencies and engineering costs.

CHANNEL IMPROVEMENT PROJECT RANKING

The ranking for each stream reach was computed by dividing the cost of the proposed improvements for the stream reach by its stream reach rating. The stream reach rating is based on two criteria. The first criterion is based on the channel condition of the stream reach. Each reach was evaluated using the APWA Channel Condition Scoring Matrix (CCSM) to determine the channel condition rating. Table 4: Channel Condition Ratings shows the channel condition ratings for each channel condition.

Channel Condition	Rating
Good (CCSM Score < 12)	3
Fair (12 < CCSM Score < 19.6)	2
Poor (19.6 < CCSM Score)	1

The second criterion was based on the condition of the retaining walls along the stream reach. The retaining walls along each stream reach were given a Retaining Wall Condition Rating as shown in Table 5: Retaining Wall Condition Ratings. The rating for each retaining wall was then multiplied by the length of the retaining wall to determine a Wall Condition Length Factor. The Wall Condition Length Factors were then averaged and divided by the total length of retaining wall along the stream reach to determine the Weighted Retaining Wall Condition Rating.

Retaining Wall Condition	Rating
No Walls	4
Good	3
Fair	2
Poor	1

The Stream Reach Rating was computed by averaging the Channel Condition and Weighted Retaining Wall Condition Ratings. The lower Ratings indicate the higher priority channel improvements.

Table 6: Channel Improvement Projects by Stream Reach Rating lists the stream reaches in order of priority based on the ranking system developed for this masterplan. The table lists the cost of localized repair channel improvements, including engineering and contingencies and Stream Reach Rating.



Table 6: Channel Improvement Projects by Stream Reach Rating			
Stream Reach Number	Location	Cost	Stream Reach Rating
26	Brush Creek beginning near the Kansas City County Club entrance and Mission Drive and ends near Brookbank Lane	\$258,171	0.63
12	Tributary to Brush Creek along Wenonga Road	\$291,305	0.65
30	Brush Creek along Mission Drive downstream of a pedestrian bridge on the Mission Hills Country Club to near the intersection of Mission Drive and East Mission Drive	\$884,169	0.67
15	Brush Creek along Indian Lane north of 63rd Street immediately downstream of Reach 14	\$397,096	0.68
17	Tributary to Brush Creek paralleling Willow Lane, beginning at W. 65th Street and ending at the culvert under Tomahawk Road, upstream of Willow Lake	\$300,686	0.68
08	Brush Creek along Indian Lane just north of W. 64th Street	\$236,361	0.69
33	Tributary to Brush Creek along Pembroke Lane downstream of Reach 32	\$175,120	0.69
05	Brush Creek along Indian Lane near W. 65th Street	\$342,644	0.71
22	Tributary to Brush Creek along Mission Drive between W. 63rd Street and High Drive	\$533,319	0.74
09	Brush Creek along Indian Lane and 63rd Street upstream and downstream of the 63rd Street Bridge	\$223,242	0.75
03	Brush Creek along Mission Drive near W. 55th Street	\$826,802	0.76
06	Brush Creek along Indian Lane between W. 65th Street and W. 64th Street	\$145,555	1.00
18	Tributary to Brush Creek downstream of Willow Lake, paralleling Ensley Lane, beginning at Tomahawk and ending at the culvert under intersection of Ensley Lane and Mission Drive	\$580,814	1.08
25	Tributary to Brush Creek along Mission Drive beginning at the culvert under the intersection of Ensley Lane and Mission Drive and ending at the confluence with Brush Creek	\$872,389	1.09
28	Rock Creek along State Park Road	\$1,243,705	1.11
24	Tributary to Brush Creek within the island along Brookwood Road	\$266,902	1.12
11	Tributary to Brush Creek downstream of Reach 10 beginning at Tomahawk Road and ending at the culvert under Seneca Road	\$465,810	1.13
04	Brush Creek along Indian Lane near W. 65th Terrace	\$77,074	1.14
27	Brush Creek along Brookbank Lane and Belinder Avenue	\$392,707	1.14
10	Tributary to Brush Creek beginning at W.69th Street and ending at the culvert under W. 66th Terrace	\$619,874	1.15

Table 6: Channel Improvement Projects by Stream Reach Rating

Stream Reach Number	Location	Cost	Stream Reach Rating
19	Tributary to Brush Creek beginning at State Line Road and continuing north along State Line Road, south of First Evangelical Lutheran Church parking lot	\$102,228	1.17
34	Tributary to Brush Creek along East Mission Drive downstream of Reach 33	\$731,455	1.17
16	Brush Creek along Indian Lane north of 63rd Street immediately downstream of Reach 15, ending at the Mission Drive low-water crossing near the entrance to the Kansas City Country Club	\$105,846	1.17
23	Tributary to Brush Creek along Mission Drive between High Drive and the culvert under the intersection of Ensley Lane and Mission Drive	\$662,001	1.17
31	Brush Creek along the United Presbyterian Village Church ending along W. 66th Street at the Indian Lane culvert	\$650,127	1.18
36	Brush Creek within Mission Hills Country Club downstream of Reach 35 and ending at State Line Road	\$474,472	1.20
35	Brush Creek within Mission Hills Country Club near the Mission Drive and State Line Road	\$666,589	1.20
01	Brush Creek along Mission Road south of Tomahawk Road	\$414,215	1.21
07	Brush Creek along Indian Lane between W. 65th Street and W. 64th Street	\$453,332	1.25
21	Tributary to Brush Creek along Mission Drive between Tomahawk Road and W. 63rd Street	\$83,344	1.25
40	Tributary to Brush Creek along W. 65th Street	\$34,290	1.25
02	Brush Creek along Mission Road north of Tomahawk Road	\$480,275	1.29
29	Brush Creek downstream of the Belinder Avenue low-water crossing to a pedestrian bridge on the Mission Hills Country Club	\$618,641	1.29
13	Tributary to Brush Creek along Wenonga Road through Hiawasse Park southwest of the 63rd Street and Wenonga Road intersection	\$35,475	1.35
20	Tributary to Brush Creek immediately downstream of Reach 19 along the south side of the First Evangelical Lutheran Church parking lot ending at the Tomahawk Road culvert	\$78,036	1.50
38	Tributary to Brush Creek between the Seneca Road culvert and Wenonga Road culvert	\$127,222	1.50
14	Brush Creek along Indian Lane immediately downstream of the Indian Lane low-water crossing north of 63rd Street	\$92,841	1.64
32	Tributary to Brush Creek along Pembroke Lane near State Line Road	\$58,896	1.75
37	Brush Creek along Mission Road immediately north of W. 71st Street	\$197,942	2.50
39	Tributary to Brush Creek north of W. 64th Street	\$75,406	3.00



The Stream Reach Ranking was computed by dividing the cost of the proposed improvements for the stream reach by its Stream Reach Rating. The higher

rankings indicate the higher priority channel improvements. Table 7 lists the stream reaches in order of priority based the Stream Reach Ranking.

Table 7: Channel Improvement Projects by Stream Reach Ranking		
Stream Reach Number	Location	Stream Reach Ranking
30	Brush Creek along Mission Drive downstream of a pedestrian bridge on the Mission Hills Country Club to near the intersection of Mission Drive and East Mission Drive	1309938.95
28	Rock Creek along State Park Road	1125277.82
03	Brush Creek along Mission Drive near W. 55th Street	1081719.96
25	Tributary to Brush Creek along Mission Drive beginning at the culvert under the intersection of Ensley Lane and Mission Drive and ending at the confluence with Brush Creek	801105.72
22	Tributary to Brush Creek along Mission Drive between W. 63rd Street and High Drive	719428.94
34	Tributary to Brush Creek along East Mission Drive downstream of Reach 33	626961.43
15	Brush Creek along Indian Lane north of 63rd Street immediately downstream of Reach 14	587769.64
23	Tributary to Brush Creek along Mission Drive between High Drive and the culvert under the intersection of Ensley Lane and Mission Drive	56470.84
35	Brush Creek within Mission Hills Country Club near the Mission Drive and State Line Road	553882.76
31	Brush Creek along the United Presbyterian Village Church ending along W. 66th Street at the Indian Lane culvert	553284.42
18	Tributary to Brush Creek downstream of Willow Lake, paralleling Ensley Lane, beginning at Tomahawk and ending at the culvert under intersection of Ensley Lane and Mission Drive	539390.58
10	Tributary to Brush Creek beginning at W.69th Street and ending at the culvert under W. 66th Terrace	537470.89
05	Brush Creek along Indian Lane near W. 65th Street	481581.96
29	Brush Creek downstream of the Belinder Avenue low-water crossing to a pedestrian bridge on the Mission Hills Country Club	478549.13
12	Tributary to Brush Creek along Wenonga Road	445492.64
17	Tributary to Brush Creek paralleling Willow Lane, beginning at W. 65th Street and ending at the culvert under Tomahawk Road, upstream of Willow Lake	441844.87
11	Tributary to Brush Creek downstream of Reach 10 beginning at Tomahawk Road and ending at the culvert under Seneca Road	412774.04
26	Brush Creek beginning near the Kansas City County Club entrance and Mission Drive and ends near Brookbank Lane	410617.68
36	Brush Creek within Mission Hills Country Club downstream of Reach 35 and ending at State Line Road	395393.33



Table 7: Channel Improvement Projects by Stream Reach Ranking

Stream Reach Number	Location	Stream Reach Ranking
02	Brush Creek along Mission Road north of Tomahawk Road	372913.02
07	Brush Creek along Indian Lane between W. 65th Street and W. 64th Street	362665.60
27	Brush Creek along Brookbank Lane and Belinder Avenue	343618.63
08	Brush Creek along Indian Lane just north of W. 64th Street	343342.35
01	Brush Creek along Mission Road south of Tomahawk Road	342012.39
09	Brush Creek along Indian Lane and 63rd Street upstream and downstream of the 63rd Street Bridge	297656.00
33	Tributary to Brush Creek along Pembroke Lane downstream of Reach 32	252662.54
24	Tributary to Brush Creek within the island along Brookwood Road	238798.59
06	Brush Creek along Indian Lane between W. 65th Street and W. 64th Street	145555.00
16	Brush Creek along Indian Lane north of 63rd Street immediately downstream of Reach 15, ending at the Mission Drive low-water crossing near the entrance to the Kansas City Country Club	90295.31
19	Tributary to Brush Creek beginning at State Line Road and continuing north along State Line Road, south of First Evangelical Lutheran Church parking lot	87624.00
38	Tributary to Brush Creek between the Seneca Road culvert and Wenonga Road culvert	84814.67
37	Brush Creek along Mission Road immediately north of W. 71st Street	79176.80
04	Brush Creek along Indian Lane near W. 65th Terrace	67664.23
21	Tributary to Brush Creek along Mission Drive between Tomahawk Road and W. 63rd Street	66675.20
14	Brush Creek along Indian Lane immediately downstream of the Indian Lane low-water crossing north of 63rd Street	56683.06
20	Tributary to Brush Creek immediately downstream of Reach 19 along the south side of the First Evangelical Lutheran Church parking lot ending at the Tomahawk Road culvert	52024.00
32	Tributary to Brush Creek along Pembroke Lane near State Line Road	33654.86
40	Tributary to Brush Creek along W. 65th Street	27432.00
13	Tributary to Brush Creek along Wenonga Road through Hiawasse Park southwest of the 63rd Street and Wenonga Road intersection	26305.98
39	Tributary to Brush Creek north of W. 64th Street	25135.33

The total cost of the improvements necessary for localized improvements to the open channels is \$15,276,378. The channel condition ranking identified 13 reaches as “Poor” and 27 reaches as “Fair.” To make the localized improvements to the “Poor” condi-

tion reaches, it will cost approximately \$4,812,412. To make the localized improvements to the “Fair” condition reaches, it will cost approximately \$10,463,966. The total cost of the improvements necessary for the system-wide improvements is \$34,412,404.



Original Masterplan Compliance

The 2007 Open Channel Masterplan recommended measures be taken to revegetate the corridor with more native plant species. It encouraged homeowners and golf courses to remove the exotic non-natives and replant using native riparian species and to allow for a healthier vegetative buffer along the stream channel. It was also recommended to replace retaining walls with flatter sloping vegetated stream banks.

The wall and stream buffer evaluation from this 2017 Open Channel Masterplan shows many of the recommendations from the previous masterplan were not followed. Evidence of this is that over 50% of the stream banks in Mission Hills still have no buffer or less than five feet of buffer. Also, approximately 5.6 miles of retaining walls line the open channels within Mission Hills.

Conclusions

Stability indicators showed the existing streams in the City of Mission Hills have a fair to poor stability rating. Despite impending unstable conditions, the extensive use of walls and other bank stabilization mechanisms has prevented excessive bank failures in the form of bank cutting and mass wasting. The mix of natural and manmade elements along Brush Creek are relatively more stable than would have been predicted for an urbanized stream.

Wall conditions vary extensively. Newer walls are in good conditions. Older walls typically are either in poor condition or show signs of periodic repairs; in a few instances old walls have collapsed. Undermining of the wall foundations due to streambed degradation is a common problem that compromises the stability of many walls that are otherwise in good conditions.

A healthy, vegetated, streamside buffer is critical to the long term health of streams, especially in urban environments where stressors are more prevalent. Allowing greater channel width where room permits (channel is not confined by structures like roads and

homes) will provide the stream with opportunities to create natural meanders as it works to provide balance or stability within its own system. In some instances, meanders that mimic conditions typically present in natural channels would have to be built to account for space limitations. The meandering pattern, the pool-riffle sequence, wider stream channel and a flexible stream bed structure (rock and gravel) have a positive impact to the habitat function of a healthy stream.

Measures should be taken to revegetate the corridor with more native plant species, especially shrubs, grasses and wildflowers. Homeowners and the golf courses should be encouraged to remove the exotic non-natives and replant using native riparian species and to allow for a healthier vegetative buffer along the stream channel. This can be accomplished by planting a semi manicured transition zone between the stream and the main yards. There should also be a concerted effort by the City to educate citizens and elected officials on the benefits of streams and stream corridors, the proper use of landscape chemicals and the need to reduce impervious surfaces adjacent to streams.

References

APWA. 2006. "Division V, Section 5600, Storm Drainage Systems and Facilities." Kansas City Metro Chapter American Public Works Association. Kansas City. April 15.

Soar, Philip J. and Thorne, Colin R. "Channel Restoration Design for Meandering Rivers." Engineer Research and Development Center, US Army Corps of Engineers, 2001.

Appendix A

Maps

Open Channel Condition Map

Retaining Wall Condition Map

Stream Buffer Condition Map

Completed Stream Studies and Stream Projects Map

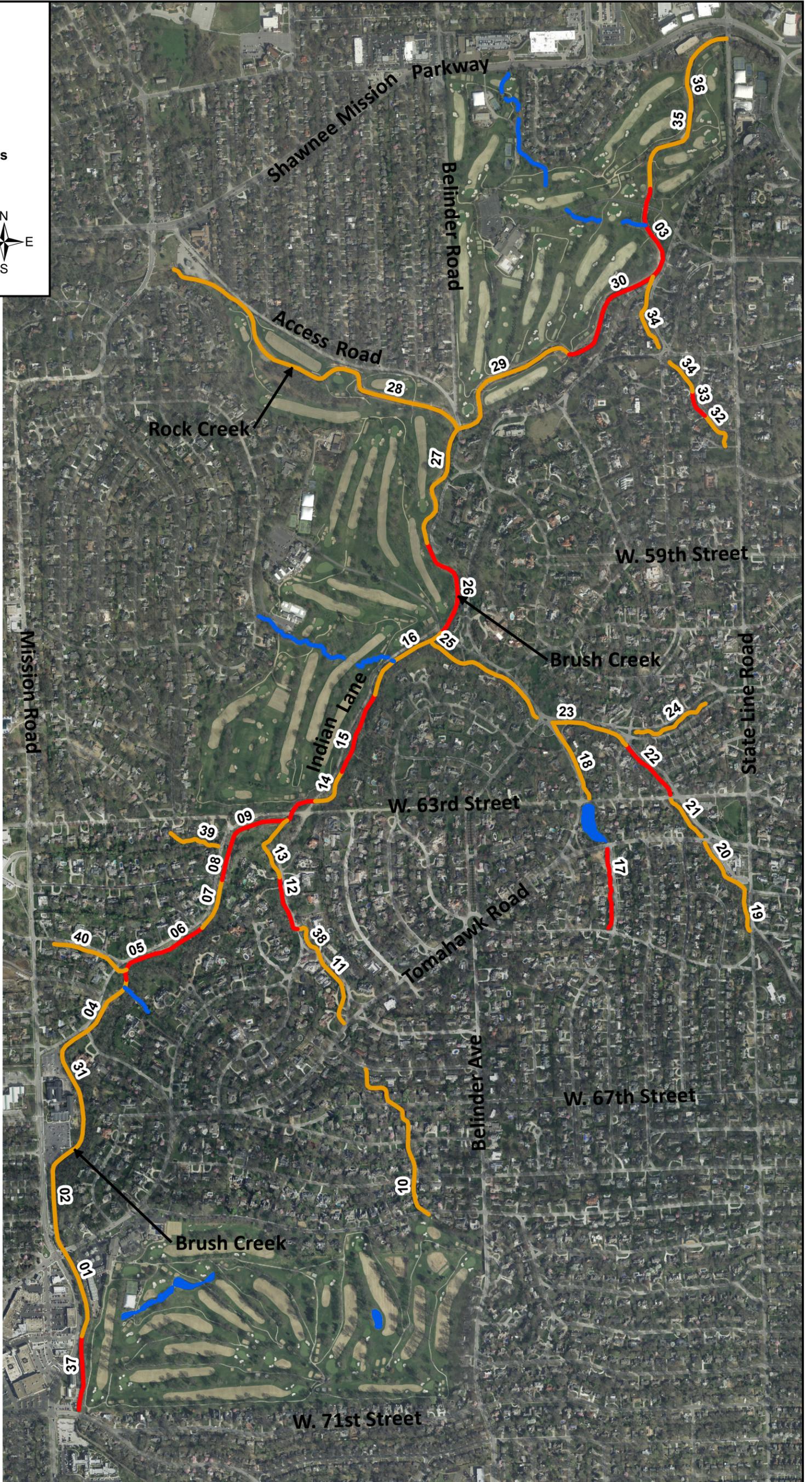
Proposed Improvement Reaches Map

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Legend

-  Fair
-  Poor
-  Drainage Swales

0 450 900
Feet



City of Mission Hills

Open Channel Condition Map

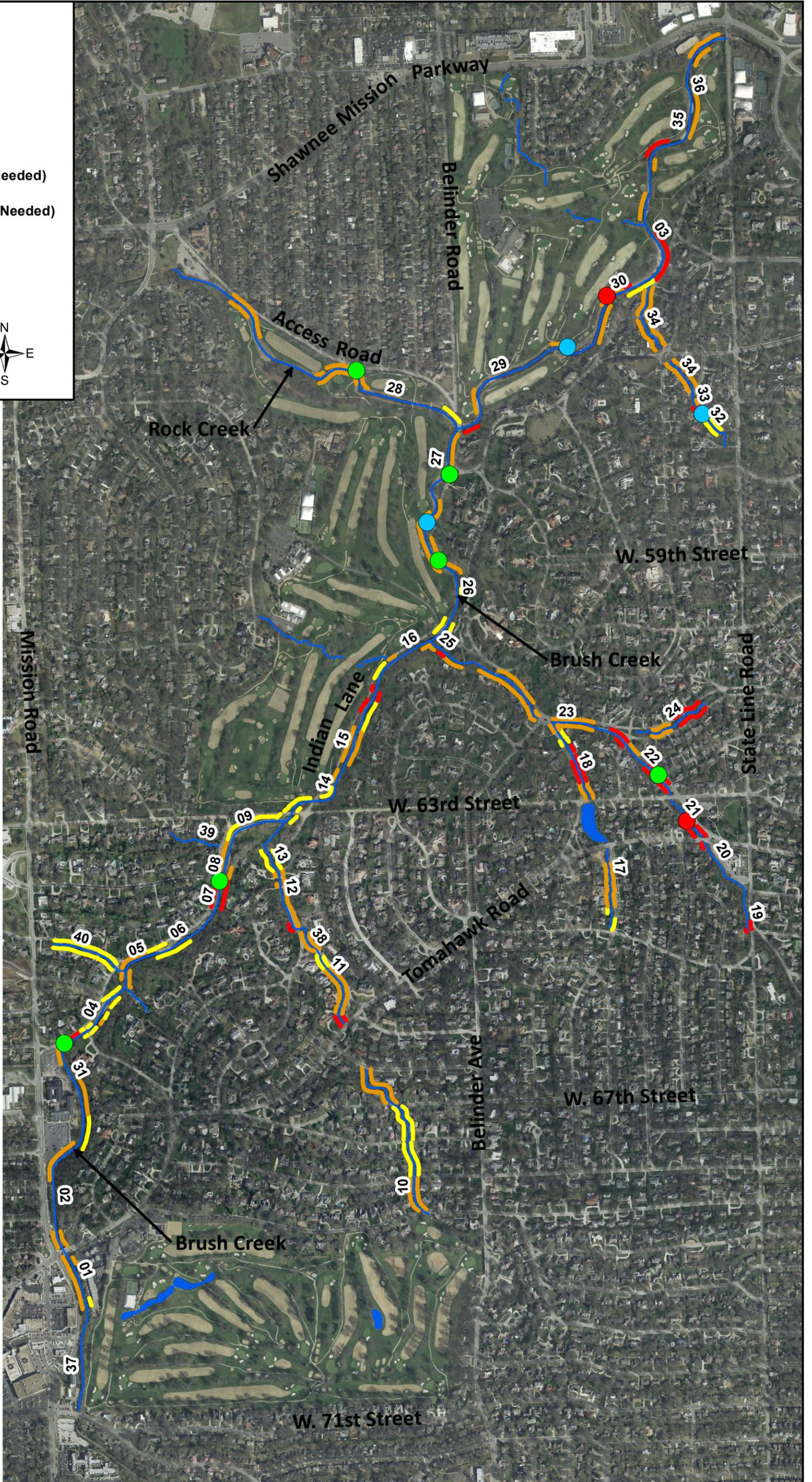


Water Resources Solutions

Legend

- Wall failure
- Major erosion
- Minor erosion
- Good (No Repair Needed)
- Fair (Some Repair Needed)
- Poor (Failing)
- Open Channels

0 450 900
Feet



City of Mission Hills

Retaining Wall Condition Map

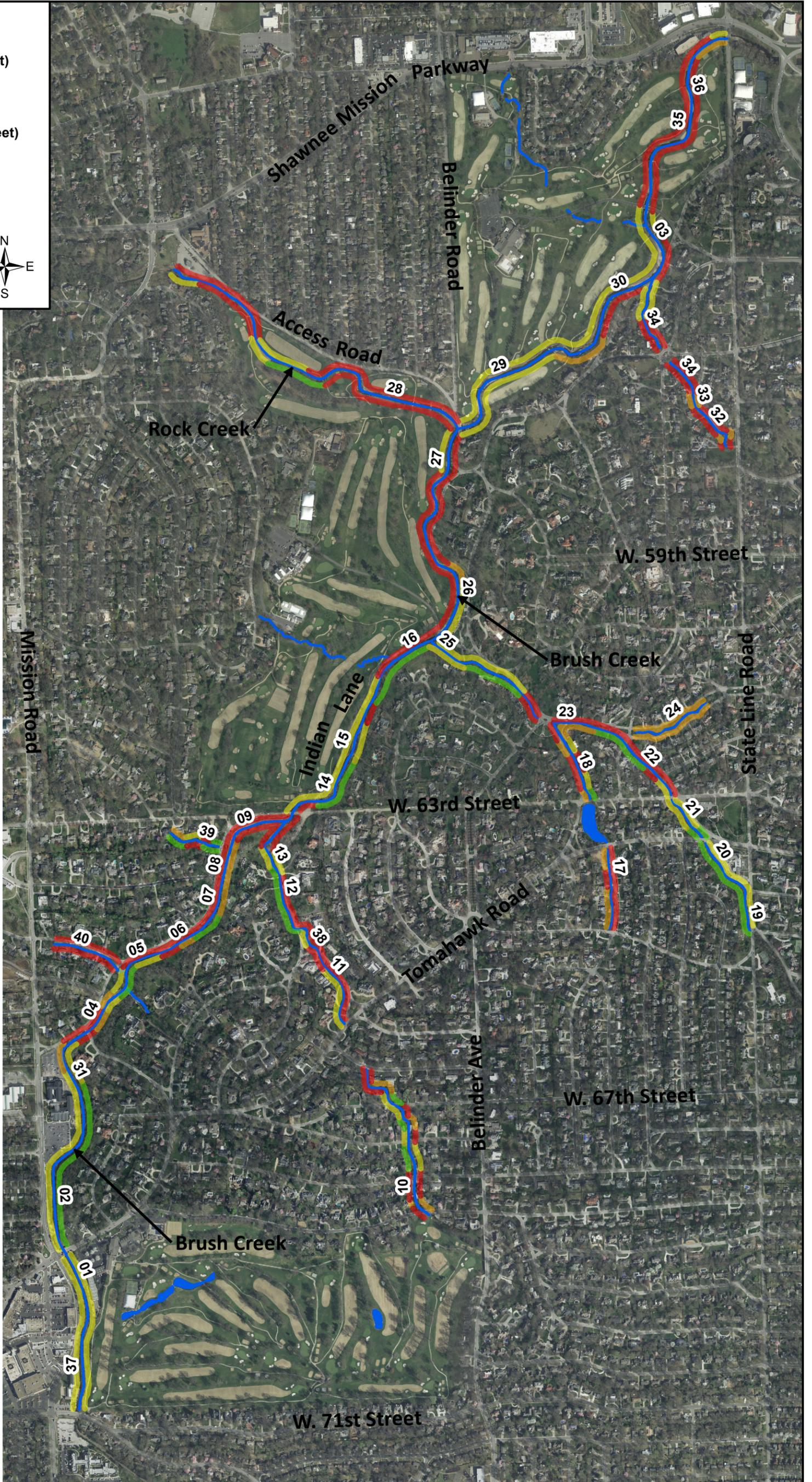


Water Resources Solutions

Legend

-  Excellent (>15 feet)
-  Good (5-15 feet)
-  Acceptable (1-5 feet)
-  None
-  Open Channels

0 450 900
Feet



City of Mission Hills

Stream Buffer Condition Map



Water Resources Solutions

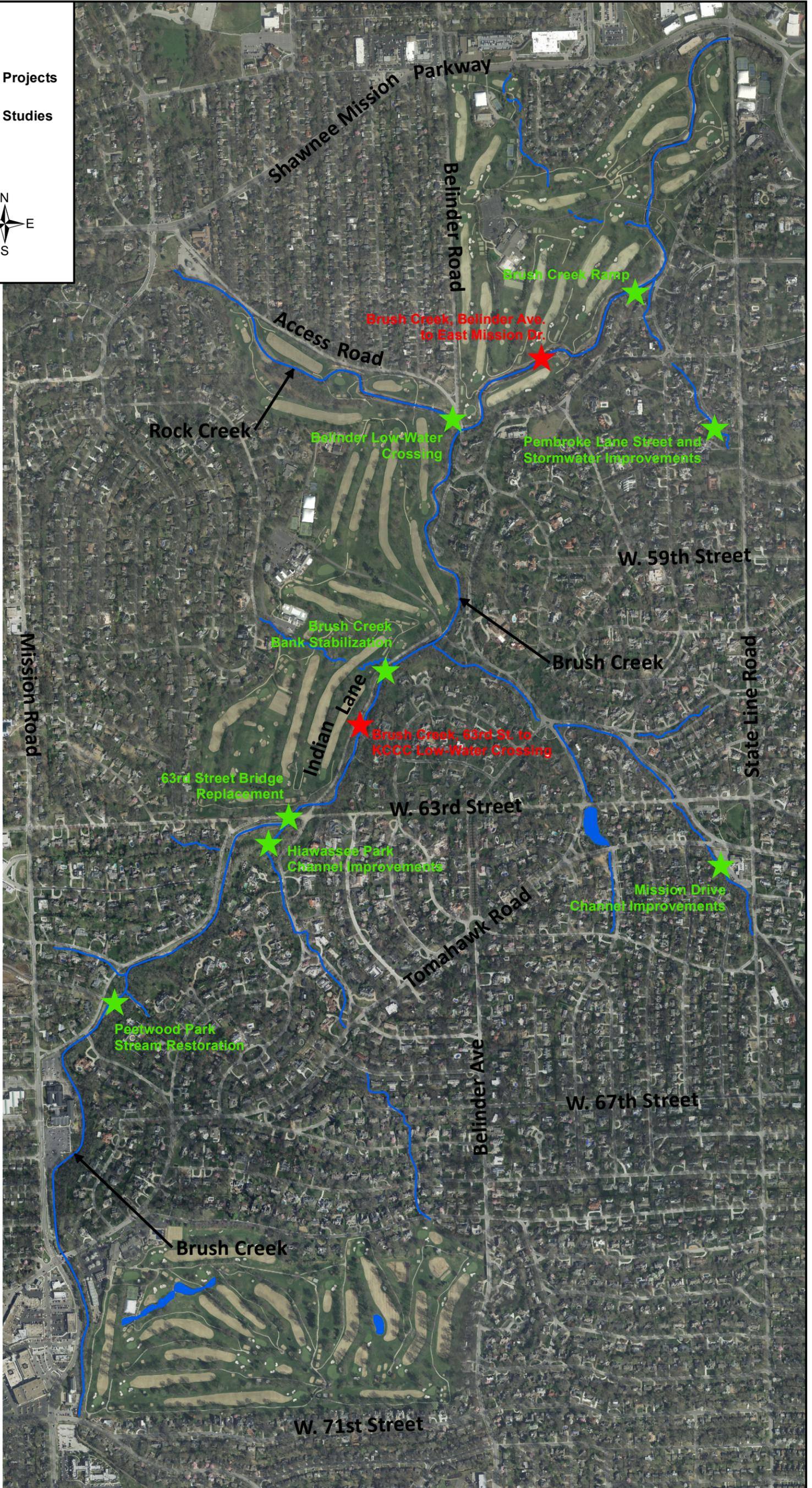
Legend

 Completed Stream Projects

 Completed Stream Studies

 Open Channels

0 450 900
Feet



City of Mission Hills

Completed Stream Studies and Stream Projects Map



Water Resources Solutions

Legend

-  Not Rated
-  0.50 - 1.00 Rating
-  1.01 - 1.50 Rating
-  1.51 - 2.00 Rating
-  2.01 - 2.50 Rating
-  2.51 - 3.00 Rating
-  Stable Plan Form

0 450 900
Feet



City of Mission Hills

Proposed Improvement Reaches Map



Water Resources Solutions

Appendix B

Reach Descriptions and Cost Estimates

Reach Descriptions (Existing Condition, Channel Condition Scoring Matrix, Proposed Improvements, Cost Estimate)

Bank Reshaping Only Localized Improvements Opinion of Probable Costs

System-wide Improvements Opinion of Probable Costs

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Reach 01 – Existing Conditions

Location: Brush Creek along Mission Road south of Tomahawk Road.

Length: 808 feet

Channel Condition Score: 18.2

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having bank angles greater than 60 degrees, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having well vegetated banks, little evidence of bank cutting and infrequent mass wasting.

Retaining Walls: There are a total of 489 feet of retaining wall on the left descending bank and 132 feet of retaining wall on the right descending bank. There are 390 feet of gabion retaining wall on the left descending bank. A 69-foot section of retaining wall on the right descending bank is in “Good” condition, and the rest of the retaining walls are in “Fair” condition with some repair needed.

Stream Buffers: The stream buffer condition is “Good” at 5 to 15 feet wide on both banks. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 1
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	1	0.8	0.8
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	2	0.2	0.4
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	1	0.8	0.8
Percentage of channel constriction	< 25%	26-50%	> 50%	2	0.8	1.6
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 18.2

OVERALL RANKING Fair

Reach 01 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 226 feet of retaining wall will need to be replaced for along this reach and 310 square yards of stream planting and sodding.

The Stream Reach Rating is 1.21. The estimated total cost to make the localized improvements is \$414,215.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

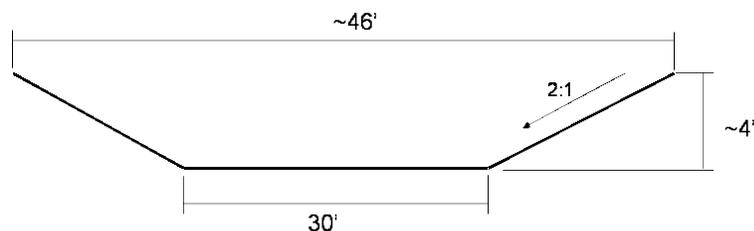
The 1-yr flow for this reach is 1,593 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,593 cfs flow:

Parameter	Value
Main channel width (w)	45 ft
Wave length (L)	503 ft
Pool-riffle spacing	252 ft
Radius of curvature (Rc)	107 ft
Range *	89-224 ft
Amplitude (Amp)	81 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section (see sketch below).
- Add meandering pattern to channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$641,350.

Reach 01
 Mission Hills, Kansas
 Brush Creek along Mission Road south of Tomahawk Road

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 48,319.00	\$ 48,319.00
2	Mobilization	LS	1	\$ 15,462.00	\$ 15,462.00
3	Traffic Control	LS	1	\$ 3,866.00	\$ 3,866.00
4	New Retaining Wall	SF	2484	\$ 75.00	\$ 186,300.00
4	Streambank Planting	SY	310	\$ 15.00	\$ 4,650.00
5	Sodding	SY	310	\$ 7.50	\$ 2,325.00

Subtotal Construction Cost	\$	260,922.00
Contingencies @ 25%	\$	65,231.00
Total Construction Cost	\$	326,153.00
Engineering @ 20%	\$	65,231.00
Construction Administration @ 7%	\$	22,831.00

Total Cost for Reach 01 \$ 414,215.00

Reach 02 – Existing Conditions

Location: Brush Creek along Mission Road north of Tomahawk Road.

Length: 1,322 feet

Channel Condition Score: 17.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having a lack of sinuosity and having a large radius of curvature to channel width ratio. This reach received “Good” ratings for having well vegetated banks, little evidence of bank cutting and infrequent mass wasting.

Retaining Walls: There are a total of 563 feet of retaining wall on the left descending bank and 431 feet of retaining wall on the right descending bank. There is 415 feet of gabion retaining wall on the left bank. A 291-foot section of retaining wall on the right descending bank is in “Good” condition, and the rest of the retaining walls are in “Fair” condition with some repair needed.

Stream Buffers: The stream buffer condition is “Good” at 5 to 15 feet wide on the left descending bank and “Excellent” at greater than 15 feet wide on the right descending bank. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 2
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	2	0.6	1.2
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	1	0.8	0.8
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	2	0.2	0.4
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	2	0.8	1.6
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 17.6

OVERALL RANKING Fair

Reach 02 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 358 feet of retaining wall will need to be replaced along this reach and 400 square yards of stream planting and sodding.

The Stream Reach Rating is 1.29. The estimated total cost to make the localized improvements is \$480,275.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

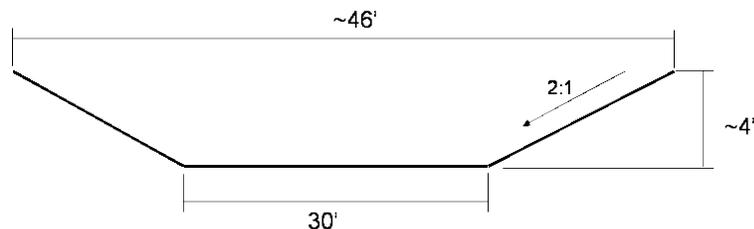
The 1-yr flow for this reach is 1,593 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,593 cfs flow:

Parameter	Value
Main channel width (w)	45 ft
Wave length (L)	503 ft
Pool-riffle spacing	252 ft
Radius of curvature (Rc)	107 ft
Range *	89-224 ft
Amplitude (Amp)	81 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section (see sketch below).
- Add meandering pattern to channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$1,049,338.

Reach 02
 Mission Hills, Kansas
 Brush Creek along Mission Road north of Tomahawk Road

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 56,025.00	\$ 56,025.00
2	Mobilization	LS	1	\$ 17,928.00	\$ 17,928.00
3	Traffic Control	LS	1	\$ 4,482.00	\$ 4,482.00
4	New Retaining Wall	SF	2,868	\$ 75.00	\$ 215,100.00
4	Streambank Planting	SY	400	\$ 15.00	\$ 6,000.00
5	Sodding	SY	400	\$ 7.50	\$ 3,000.00

Subtotal Construction Cost	\$	302,535.00
Contingencies @ 25%	\$	75,634.00
Total Construction Cost	\$	378,169.00
Engineering @ 20%	\$	75,634.00
Construction Administration @ 7%	\$	26,472.00

Total Cost for Reach 02 \$ 480,275.00

Reach 03 – Existing Conditions

Location: Brush Creek along Mission Drive near W. 55th Street.

Length: 1,003 feet

Channel Condition Score: 20.8

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having a lack of sinuosity, steep bank slopes, lack of vegetative bank protection, and having a large radius of curvature to channel width ratio. This reach received “Fair” ratings for having average bank heights between six and 15 feet, significant and frequent bank cutting and mass wasting, and wide bar widths relative to the stream width. This reach was part of the Brush Creek, Belinder Avenue to East Mission Drive Project (2017) and also the Brush Creek Ramp Project (2013).

Retaining Walls: There are a total of 235 feet of retaining wall on the left descending bank and 596 feet of retaining wall on the right descending bank. The retaining wall on the left descending bank is in “Fair” condition. A 126-foot section of retaining wall on the right descending bank is in “Good” condition, which was replaced as part of the Brush Creek Ramp Project (2013), and the rest of the retaining walls are in “Poor” condition.

Stream Buffers: The stream buffer condition is “Good” at 5 to 15 feet wide on the left descending bank up to the golf course Access Road. Downstream of the Access Road there is no stream buffer. The right descending bank stream buffer condition is “Good” except where the stream parallels Mission Drive and north of the Access Road where there is no stream buffer. The stream buffer generally consists of a strip of taller unmown grass within the golf course.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 3
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	2	0.8	1.6

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 20.8

OVERALL RANKING Poor

Reach 03 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 587 feet of retaining wall will need to be replaced along this reach and 310 square yards of stream planting and 654 square yards of sodding.

The Stream Reach Rating is 0.76. The estimated total cost to make the localized improvements is \$826,802.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

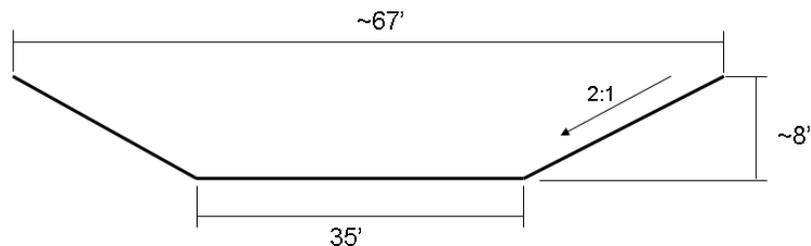
The 1-yr flow for this reach is 3,410 cfs. The following parameters were determined based on Soar and Thorne criteria for a 3,410 cfs flow:

Parameter	Value
Main channel width (w)	65 ft
Wave length (L)	736 ft
Pool-riffle spacing	368 ft
Radius of curvature (Rc)	157 ft
Range *	131-327 ft
Amplitude (Amp)	118 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section.
- Remove wall on right bank and reduce side slopes to 2:1 (see sketch below).
- Replace pedestrian bridge to accommodate wider channel.
- Replace roadway bridge to accommodate wider channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$891,381.

Reach 03
 Mission Hills, Kansas
 Brush Creek along Mission Road near W. 55th Street

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 96,448.00	\$ 96,448.00
2	Mobilization	LS	1	\$ 30,863.00	\$ 30,863.00
3	Traffic Control	LS	1	\$ 7,716.00	\$ 7,716.00
4	New Retaining Wall	SF	5,053	\$ 75.00	\$ 378,938.00
5	Streambank Planting	SY	130	\$ 15.00	\$ 1,950.00
6	Sodding	SY	654	\$ 7.50	\$ 4,905.00

Subtotal Construction Cost	\$	520,820.00
Contingencies @ 25%	\$	130,205.00
Total Construction Cost	\$	651,025.00
Engineering @ 20%	\$	130,205.00
Construction Administration @ 7%	\$	45,572.00

Total Cost for Reach 03 \$ 826,802.00

Reach 04 – Existing Conditions

Location: Brush Creek along Indian Lane near W. 65th Terrace.

Length: 597 feet

Channel Condition Score: 17.4

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having a steep bank slopes, lack of vegetative bank protection, and having pool-riffle spacing to channel width ratio between 3 and 9. This reach received “Good” ratings for having little bank cutting and mass wasting and having a sinuosity between 1.2 and 1.4 and a radius of curvature to channel width ratio between 3 and 5. This section of Brush Creek was part of the Peetwood Park Stream Restoration Project (2009).

Retaining Walls: There are 10 sections of retaining wall totaling 181 feet on the left descending bank and 327 feet of retaining wall on the right descending bank. The retaining walls on the left descending bank are in “Good” condition. 105 feet of retaining wall on the right descending bank is in “Fair” condition with the rest in “Good” condition.

Stream Buffers: The stream buffer condition on the left descending bank ranges between no stream buffer where the stream is closer Indian Lane to “Good” as the stream moves away from Indian Lane. The stream buffer on the right descending bank ranges between “Fair” and “Excellent” moving downstream. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 4
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	2	0.2	0.4
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	1	0.8	0.8
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	1	0.8	0.8
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 17.4

OVERALL RANKING Fair

Reach 04 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 55 feet of retaining wall will need to be replaced along this reach and 65 square yards of stream planting and sodding.

The Stream Reach Rating is 1.14. The estimated total cost to make the localized improvements is \$77,074.

System-wide Improvements: There are no system-wide improvements for this reach. This reach was part of the Peetwood Park Stream Restoration Project (2009) which included the construction of a stable planform and bed slope for the stream through the City’s Peetwood Park.

Reach 04
 Mission Hills, Kansas
 Brush Creek along Indian Lane near W. 65th Terrace

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 8,991.00	\$ 8,991.00
2	Mobilization	LS	1	\$ 2,877.00	\$ 2,877.00
3	Traffic Control	LS	1	\$ 719.00	\$ 719.00
4	New Retaining Wall	SF	460	\$ 75.00	\$ 34,500.00
5	Streambank Planting	SY	65	\$ 15.00	\$ 975.00
6	Sodding	SY	65	\$ 7.50	\$ 488.00

Subtotal Construction Cost	\$	48,550.00
Contingencies @ 25%	\$	12,138.00
Total Construction Cost	\$	60,688.00
Engineering @ 20%	\$	12,138.00
Construction Administration @ 7%	\$	4,248.00

Total Cost for Reach 04 \$ 77,074.00

Reach 05 – Existing Conditions

Location: Brush Creek along Indian Lane near W. 65th Street.

Length: 401 feet

Channel Condition Score: 20.2

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having a steep bank slopes, lack of vegetative bank protection, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of mass wasting and having small amounts of debris in the channel.

Retaining Walls: There are a total of 385 feet of retaining wall on the left descending bank and 78 feet of retaining wall on the right descending bank. A 53-foot section of retaining wall on the left descending bank is in “Good” condition, and the rest of the left descending bank retaining walls are in “Fair” condition with some repair needed. The retaining walls on the right descending bank in “Fair” condition.

Stream Buffers: There is no stream buffer on a majority of the left descending bank because the stream is close to Indian Lane. A portion of the stream buffer is in “Good” condition where the stream moves away from Indian Lane. The stream buffer on the right descending bank ranges between “Good” and “Excellent”. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 5
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	Sinuosity < 1.1	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 20.2

OVERALL RANKING Poor

Reach 05 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included.

An estimated 204 feet of retaining wall will need to be replaced along this reach and 72 square yards of stream planting and 230 square yards of sodding associated with the retaining wall. Approximately 250 feet of streambank will need to be regraded and restored.

The Stream Reach Rating is 0.71. The estimated total cost to make the localized improvements is \$342,644.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 1,658 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,658 cfs flow:

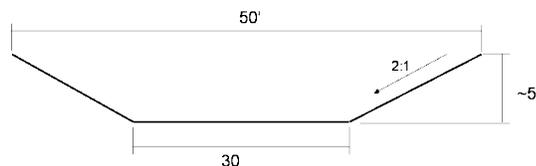
Parameter	Value
Main channel width (w)	46 ft
Wave length (L)	514 ft
Pool-riffle spacing	257 ft
Radius of curvature (Rc)	109 ft
Range *	91-228 ft
Amplitude (Amp)	82 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove wall and match proposed cross-section.
- Add meander pattern to channel.
- Vegetate 2:1 banks and create buffer zone.

The following main channel cross section assumes an increase in slope that can be obtained if the Bloch weir is lowered.



The estimated total cost to make the system-wide improvements is \$318,294.

Reach 05
 Mission Hills, Kansas
 Brush Creek along Indian Lane near W. 65th Street

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 39,970.00	\$ 39,970.00
2	Mobilization	LS	1	\$ 12,790.00	\$ 12,790.00
3	Traffic Control	LS	1	\$ 3,198.00	\$ 3,198.00
4	New Retaining Wall	SF	1,261	\$ 75.00	\$ 94,575.00
5	Streambank Reshaping	LF	250	\$ 250.00	\$ 62,500.00
6	Streambank Planting	SY	72	\$ 15.00	\$ 1,080.00
7	Sodding	SY	230	\$ 7.50	\$ 1,725.00

Subtotal Construction Cost	\$	215,838.00
Contingencies @ 25%	\$	53,960.00
Total Construction Cost	\$	269,798.00
Engineering @ 20%	\$	53,960.00
Construction Administration @ 7%	\$	18,886.00

Total Cost for Reach 05 \$ 342,644.00

Reach 06 – Existing Conditions

Location: Brush Creek along Indian Lane between W. 65th Street and W. 64th Street.

Length: 488 feet

Channel Condition Score: 20.4

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having a steep bank slopes, lack of vegetative bank protection, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting and having small amounts of debris in the channel.

Retaining Walls: There are a total of 105 feet of retaining wall on the left descending bank and 319 feet of retaining wall on the right descending bank. All the retaining wall in this reach are in “Good” condition.

Stream Buffers: There is no stream buffer on the left descending bank because the stream is close to Indian Lane. The stream buffer on the right descending bank ranges between “None” to “Excellent”. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 6
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 20.4

OVERALL RANKING Poor

Reach 06 – Proposed Improvements

Localized Improvements: The retaining walls along this reach are in “Good” condition. Localized improvements for this reach include streambank reshaping and restoration.

An estimated 367 feet of streambank will need to be reshaped and restored.

The Stream Reach Rating is 1.00. The estimated total cost to make the localized improvements is \$145,555.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 1,658 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,658 cfs flow:

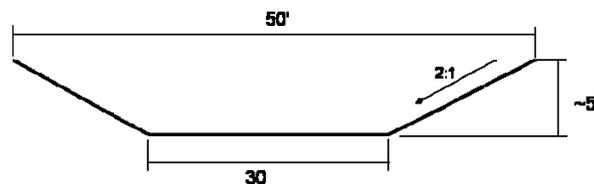
Parameter	Value
Main channel width (w)	46 ft
Wave length (L)	514 ft
Pool-riffle spacing	257 ft
Radius of curvature (Rc)	109 ft
Range *	91-228 ft
Amplitude (Amp)	82 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove retaining walls and match proposed cross-section.
- Add meander pattern to channel.
- Modify channel to accommodate transition through bridge.
- Replace the Merriman Bridge with a wider bridge that accommodates stream restoration modifications.
- Vegetate 2:1 banks and create buffer zone.

The following main channel cross section assumes an increase in slope that can be obtained if the Bloch weir is lowered.



The estimated total cost to make the system-wide improvements is \$419,894.

Reach 06
Mission Hills, Kansas
Brush Creek along Indian Lane between W. 65th Street
and W. 64th Street

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

This reach did not contain any retaining walls rated "Fair" or "Poor". The reach received a "Poor" Channel Condition Ranking indicating significant instability issues. The CCSM identified steep bank angles, lack of woody bank vegetation, poor sinuosity, and pool riffle spacing contributing to the instability. The cost of the improvements to this reach is \$145,555.00.

Reach 07 – Existing Conditions

Location: Brush Creek along Indian Lane just south of W. 64th Street.

Length: 472 feet

Channel Condition Score: 18.2

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having a steep bank slopes, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting and having small amounts of debris in the channel.

Retaining Walls: There are a total of 282 feet of retaining wall on the left descending bank and 281 feet of retaining wall on the right descending bank. All the retaining wall in this reach are in “Poor” condition with failures.

Stream Buffers: There is no stream buffer on the left descending bank because the stream is close to Indian Lane. The stream buffer on the right descending bank ranges is “Excellent” for the upstream half of the reach and “Acceptable” the downstream half. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 7
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	2	0.8	1.6
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 18.2

OVERALL RANKING Fair

Reach 07 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included.

An estimated 510 feet of retaining wall will need to be replaced along this reach and 285 square yards of stream planting and 567 square yards of sodding associated with the retaining wall. Approximately 200 feet of streambank will need to be regraded and restored. Also, the Bloch weir will be lowered.

The Stream Reach Rating is 1.25. The estimated total cost to make the localized improvements is \$453,332.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 1,658 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,658 cfs flow:

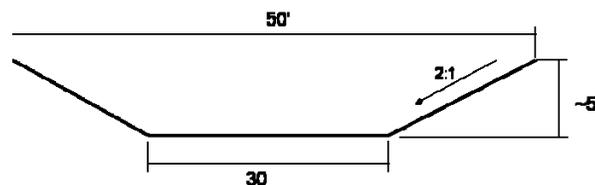
Parameter	Value
Main channel width (w)	46 ft
Wave length (L)	514 ft
Pool-riffle spacing	257 ft
Radius of curvature (Rc)	109 ft
Range *	91-228 ft
Amplitude (Amp)	82 ft

* Absolute minimum – APWA max

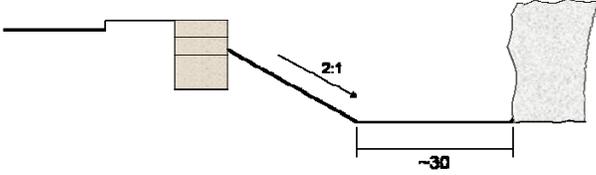
Optimal restoration:

- Remove both retaining walls and match proposed cross-section.
- Add meander pattern to channel.
- Remove Bloch weir.
- Possibly extend and lower encased sewer line.
- Vegetate 2:1 banks and create buffer zone.

The following main channel cross section assumes an increase in slope that can be obtained if the Bloch weir is lowered.



A layer of rock is exposed on the right descending bank. This condition and the closeness to the road (Indian Lane) on the left may limit restoration efforts. It is possible a section of wall would have to be built on the left descending bank (see sketch below).



The estimated total cost to make the system-wide improvements is \$374,650.

Reach 07
 Mission Hills, Kansas
 Brush Creek along Indian Lane near W. 65th Street and W. 64th Street

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 52,882.00	\$ 52,882.00
2	Mobilization	LS	1	\$ 16,922.00	\$ 16,922.00
3	Traffic Control	LS	1	\$ 4,231.00	\$ 4,231.00
4	New Retaining Wall	SF	2,040	\$ 75.00	\$ 153,000.00
5	Streambank Reshaping	LF	200	\$ 250.00	\$ 50,000.00
6	Streambank Planting	SY	285	\$ 15.00	\$ 4,275.00
7	Sodding	SY	567	\$ 7.50	\$ 4,253.00

Subtotal Construction Cost \$ 285,563.00
 Contingencies @ 25% \$ 71,391.00
Total Construction Cost \$ 356,954.00
 Engineering @ 20% \$ 71,391.00
 Construction Administration @ 7% \$ 24,987.00

Total Cost for Reach 07 \$ 453,332.00

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Reach 08 – Existing Conditions

Location: Brush Creek along Indian Lane just north of W. 64th Street.

Length: 349 feet

Channel Condition Score: 21.4

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having a steep bank slopes, a lack of bank vegetation, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting and having small amounts of debris in the channel.

Retaining Walls: There are a total of 316 feet of retaining wall on the left descending bank and 96 feet of retaining wall on the right descending bank. All the retaining wall in this reach are in “Fair” condition needing some repair.

Stream Buffers: There is no stream buffer on the left descending bank because the stream is close to Indian Lane. The stream buffer on the right descending bank is “Acceptable” with a width of 1 to 5 feet. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 8
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	2	0.2	0.4
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	2	0.8	1.6
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 21.4

OVERALL RANKING Poor

Reach 08 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included.

An estimated 212 feet of retaining wall will need to be replaced along this reach and 205 square yards of stream planting and 495 square yards of sodding associated with the retaining wall. Approximately 96 feet retaining wall on the right descending bank will be removed and regraded to a 2:1 slope and restored.

The Stream Reach Rating is 0.69. The estimated total cost to make the localized improvements is \$236,361.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 1,658 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,658 cfs flow:

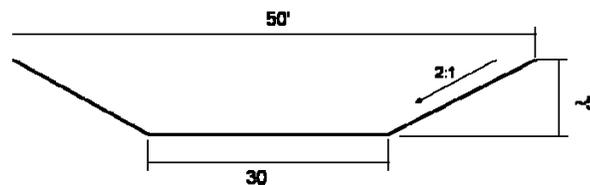
Parameter	Value
Main channel width (w)	46 Ft
Wave length (L)	514 Ft
Pool-riffle spacing	257 Ft
Radius of curvature (Rc)	109 Ft
Range *	91-228 Ft
Amplitude (Amp)	82 Ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove both retaining walls and match proposed cross-section.
- Add meander pattern to channel.
- Vegetate 2:1 banks and create buffer zone.

The following main channel cross section assumes an increase in slope that can be obtained if the Bloch weir is lowered.



The estimated total cost to make the system-wide improvements is \$277,019.

Reach 08
 Mission Hills, Kansas
 Brush Creek along Indian Lane just north of W. 64th Street

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 27,572.00	\$ 27,572.00
2	Mobilization	LS	1	\$ 8,823.00	\$ 8,823.00
3	Traffic Control	LS	1	\$ 2,206.00	\$ 2,206.00
4	New Retaining Wall	SF	1,060	\$ 75.00	\$ 79,500.00
5	Streambank Reshaping	LF	96	\$ 250.00	\$ 24,000.00
6	Streambank Planting	SY	205	\$ 15.00	\$ 3,075.00
7	Sodding	SY	495	\$ 7.50	\$ 3,713.00

Subtotal Construction Cost	\$	148,889.00
Contingencies @ 25%	\$	37,222.00
Total Construction Cost	\$	186,111.00
Engineering @ 20%	\$	37,222.00
Construction Administration @ 7%	\$	13,028.00

Total Cost for Reach 08 \$ 236,361.00

Reach 09 – Existing Conditions

Location: Brush Creek along Indian Lane and 63rd Street upstream and downstream of the 63rd Street Bridge.

Length: 910 feet

Channel Condition Score: 20.6

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having a steep bank slopes, a lack of bank vegetation, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting.

Retaining Walls: There are a total of 810 feet of retaining wall on the left descending bank and 112 feet of retaining wall on the right descending bank. All the retaining walls in this reach are in “Good” condition. The retaining walls along the section of this reach immediately upstream and downstream of the 63rd Street Bridge were replaced as part of the 63rd Street Bridge Replacement Project (2016).

Stream Buffers: There is no stream buffer on the left descending bank upstream of the 63rd Street Bridge. Downstream of the bridge the stream buffer is “Good” with a width of 5 to 15 feet. The stream buffer generally consists of large trees and with unmown taller grass along the golf course.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 9
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	2	0.2	0.4
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 20.6

OVERALL RANKING Poor

Reach 09 – Proposed Improvements

Localized Improvements: The retaining walls along this reach are in “Good” condition. Localized improvements for this reach include streambank reshaping and restoration.

An estimated 750 feet of streambank will need to be reshaped and restored. The reshaped banks should match the proposed cross section.

The Stream Reach Rating is 0.75. The estimated total cost to make the localized improvements is \$223,242.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach upstream of the 63rd Street Bridge is 1,658 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,658 cfs flow:

Parameter	Value
Main channel width (w)	46 ft
Wave length (L)	514 ft
Pool-riffle spacing	257 ft
Radius of curvature (Rc)	109 ft
Range *	91-228 ft
Amplitude (Amp)	82 ft

* Absolute minimum – APWA max

The 1-yr flow for this reach downstream of the 63rd Street Bridge is 1,748 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,748 cfs flow:

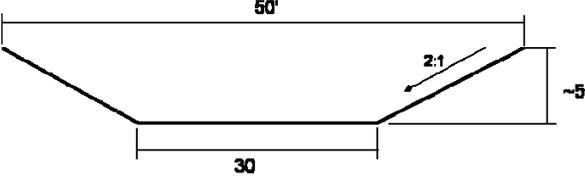
Parameter	Value
Main channel width (w)	47 ft
Wave length (L)	527 ft
Pool-riffle spacing	264 ft
Radius of curvature (Rc)	112 ft
Range *	94-234 ft
Amplitude (Amp)	85 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section.
- Existing wall can be used to define the limits of a two-stage channel.
- Add meander pattern to channel.
- Vegetate 2:1 banks and create buffer zone.

The following main channel cross section assumes an increase in slope that can be obtained if the Bloch weir is lowered.



The estimated total cost to make the system-wide improvements is \$722,313.

Reach 09
Mission Hills, Kansas
Brush Creek along Indian Lane and 63rd Street upstream
and downstream of the 63rd Street Bridge

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

This reach did not contain any retaining walls rated "Fair" or "Poor". The reach received a "Poor" Channel Condition Ranking indicating significant instability issues. The CCSM identified steep bank angles, lack of woody bank vegetation, poor sinuosity, and pool riffle spacing contributing to the instability. The cost of the improvements to this reach is \$223,242.00.

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Reach 10 – Existing Conditions

Location: Tributary to Brush Creek beginning at W.69th Street and ending at the culvert under W. 66th Terrace.

Length: 1,596 feet

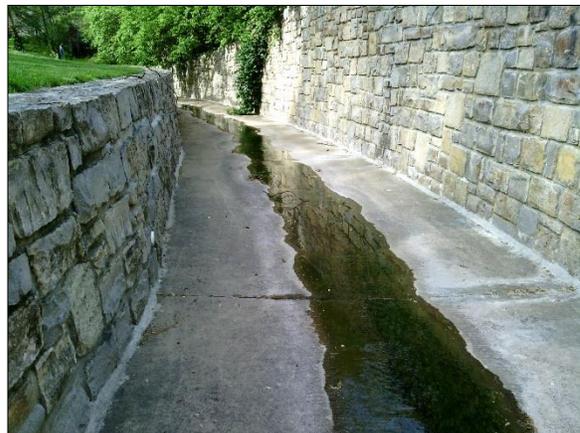
Channel Condition Score: 16.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach is a concrete lined channel with short retaining walls (< 6' tall) on each bank for the entire length of the reach. This reach received "Poor" ratings for having steep bank slopes, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received "Good" ratings for having little evidence of bank cutting and mass wasting, bank heights less than 6 feet, and small amounts of debris in the channel.

Retaining Walls: There are a total of 1,393 feet of retaining wall on the left descending bank and 1,379 feet of retaining wall on the right descending bank. The retaining walls on both banks between W. 69th Street and W. 68th Street as well as the retaining walls on both banks between W. 67th Street and W. 66th Terrace are in "Fair" condition in need of some repair. The retaining walls on both banks between W. 68th Street and W. 67th Street are in "Good" condition.

Stream Buffers: The stream buffers along this reach range between "None" and "Excellent" on both banks. The stream buffer generally consists of smaller trees and residentially landscaping at the top of the retaining walls.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 10
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	1	0.8	0.8

TOTAL 16.6

OVERALL RANKING Fair

Reach 10 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 755 feet of retaining wall will need to be replaced along this reach and 840 square yards of sodding.

The Stream Reach Rating is 1.15. The estimated total cost to make the localized improvements is \$619,874.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

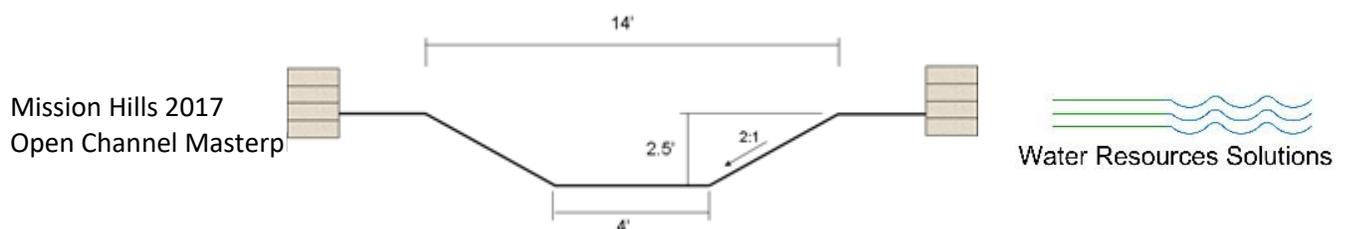
The 1-yr flow for this reach is 130 cfs. The following parameters were determined based on Soar and Thorne criteria for a 130 cfs flow:

Parameter	Value
Main channel width (w)	12.8 ft
Wave length (L)	144 ft
Pool-riffle spacing	72 ft
Radius of curvature (Rc)	31 ft
Range *	26-64 ft
Amplitude (Amp)	23 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove existing walls and build a new wider non-concrete-lined channel.
- The main channel will have 2:1 side slopes. Where possible a flood bench should be created (see sketch below).
- Walls would have to be built for main or secondary bank stability.
- The channel should be built to convey the 100-yr flow since there would be extremely limited space for overflows (that is beyond proposed walls).
- Replace 3 bridges with wider bridges. Alternatively, provide a transition between the bridge opening and the new channel to avoid local scour or bank instability.
- Because meandering would be difficult to attain in this reach, a stepped channel is recommended as an alternative to a meandering channel. Preliminary calculations indicate that 19 10-in drops, spaced every 72 ft can be built to produce the stepped channel.
- Vegetate flood benches and banks and create buffer zone where possible.



Alternative:

- Do nothing; existing concrete lined channel should be stable. Repairs and maintenance will be required over time. This alternative does not provide any environmental benefits.

The estimated total cost to make the system-wide improvements is \$2,892,029.

Reach 10
 Mission Hills, Kansas
 Tributary to Brush Creek beginning at W. 69th Street and
 ending at the culvert under W. 66th Terrace

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 72,310.00	\$ 72,310.00
2	Mobilization	LS	1	\$ 23,139.00	\$ 23,139.00
3	Traffic Control	LS	1	\$ 5,785.00	\$ 5,785.00
4	New Retaining Wall	SF	3,773	\$ 75.00	\$ 282,938.00
5	Streambank Planting	SY	0	\$ 15.00	\$ -
6	Sodding	SY	840	\$ 7.50	\$ 6,300.00

Subtotal Construction Cost	\$	390,472.00
Contingencies @ 25%	\$	97,618.00
Total Construction Cost	\$	488,090.00
Engineering @ 20%	\$	97,618.00
Construction Administration @ 7%	\$	34,166.00

Total Cost for Reach 10 \$ 619,874.00

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Reach 11 – Existing Conditions

Location: Tributary to Brush Creek downstream of Reach 10 beginning at Tomahawk Road and ending at the culvert under Seneca Road.

Length: 722 feet

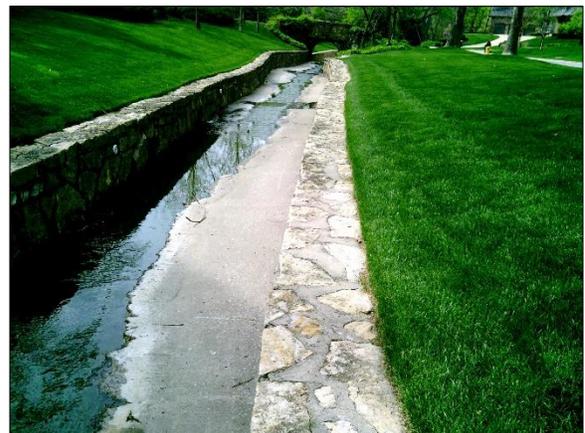
Channel Condition Score: 18.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach is a concrete lined channel with short retaining walls (< 6' tall) on each bank for the entire length of the reach. This reach received "Poor" ratings for having steep bank slopes, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received "Good" ratings for having little evidence of bank cutting and mass wasting, bank heights less than 6 feet, and small amounts of debris in the channel.

Retaining Walls: There are a total of 642 feet of retaining wall on the left descending bank and 590 feet of retaining wall on the right descending bank. The retaining walls on both banks immediately downstream of the Tomahawk Road culvert are in "Poor" condition, and the retaining walls on both banks immediately upstream of the Seneca Road culvert are in "Good" condition. The rest of the retaining walls on both banks are in "Fair" condition in need of some repair.

Stream Buffers: There is no stream buffer on the right descending bank. The stream buffer on the left descending bank is "Good" except for 150 feet upstream of the Seneca Road culvert, where there is no stream buffer. The stream buffer generally consists of smaller trees and residentially landscaping at the top of the retaining walls.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 11
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	3	0.6	1.8
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	1	0.8	0.8

TOTAL 18.6

OVERALL RANKING Fair

Reach 11 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 567 feet of retaining wall will need to be replaced along this reach and 630 square yards of sodding.

The Stream Reach Rating is 1.13. The estimated total cost to make the localized improvements is \$465,810.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

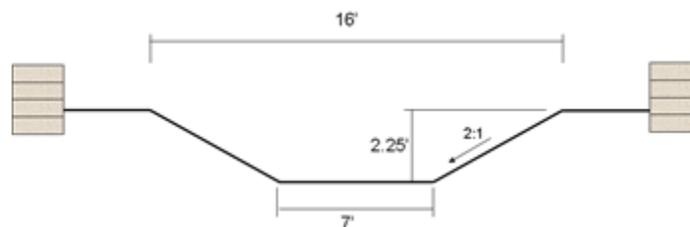
The 1-yr flow for this reach is 185 cfs. The following parameters were determined based on Soar and Thorne criteria for a 185 cfs flow:

Parameter	Value
Main channel width (w)	15 ft
Wave length (L)	172 ft
Pool-riffle spacing	86 ft
Radius of curvature (Rc)	37 ft
Range *	30-76 ft
Amplitude (Amp)	28 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section and add meandering pattern to main channel. Create flood benches. Remove walls and reduce side slopes to 2:1. Add walls where necessary for bank stability.
- Replace 3 driveway bridges and replace bridge on Seneca Rd as necessary to accommodate new channel.
- Vegetate banks and create buffer zone.



Alternative:

- Repair existing walls and replace concrete bottom with stable rock.
- The existing channel conveys the 100-yr flow.
- Vegetate banks and create buffer zone if possible on both banks.

The estimated total cost to make the system-wide improvements is \$1,160,463.

Reach 11
Mission Hills, Kansas
Tributary to Brush Creek downstream of Reach 10
beginning at Tomahawk Road and ending at the culvert
under Seneca Road

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 54,338.00	\$ 54,338.00
2	Mobilization	LS	1	\$ 17,388.00	\$ 17,388.00
3	Traffic Control	LS	1	\$ 4,347.00	\$ 4,347.00
4	New Retaining Wall	SF	2,835	\$ 75.00	\$ 212,625.00
5	Streambank Planting	SY	0	\$ 15.00	\$ -
6	Sodding	SY	630	\$ 7.50	\$ 4,725.00

Subtotal Construction Cost	\$	293,423.00
Contingencies @ 25%	\$	73,356.00
Total Construction Cost	\$	366,779.00
Engineering @ 20%	\$	73,356.00
Construction Administration @ 7%	\$	25,675.00

Total Cost for Reach 11 \$ 465,810.00

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Reach 12 – Existing Conditions

Location: Tributary to Brush Creek along Wenonga Road.

Length: 517 feet

Channel Condition Score: 20.4

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting, bank heights less than 6 feet, and small amounts of debris in the channel.

Retaining Walls: There is a small 24-foot section of retaining wall on the left descending bank. Retaining walls line the right descending bank for the entire length of the project reach totaling 430 feet. All the retaining walls along this reach are in “Fair” condition needing some repair.

Stream Buffers: There is no stream buffer on the right descending bank with Wenonga Road at the top of bank. The stream buffer on the left descending bank is “Excellent” with a width greater than 15 feet. The stream buffer generally consists of large trees and smaller understory trees. In other areas, the stream buffer consists of large trees with landscaped ground cover.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 12
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	2	0.2	0.4
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	2	0.8	1.6
Percentage of channel constriction	< 25%	26-50%	> 50%	2	0.8	1.6
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 20.4

OVERALL RANKING Poor

Reach 12 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 308 feet of retaining wall will need to be replaced along this reach and 105 square yards of streambank planting and 215 square yards of sodding. The Wenonga Road Bridge will also need to be replaced because the bridge abutments are in poor condition and may be structurally unstable.

The Stream Reach Rating is 0.65. The estimated total cost to make the localized improvements is \$291,305.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 185 cfs. The following parameters were determined based on Soar and Thorne criteria for a 185 cfs flow:

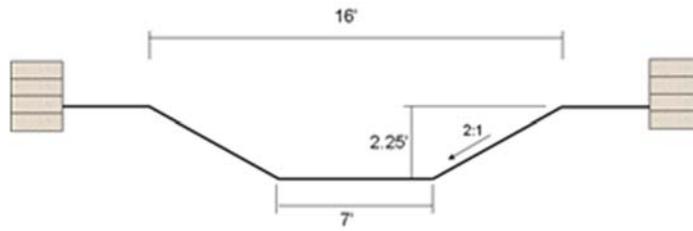
Parameter	Value
Main channel width (w)	15 ft
Wave length (L)	172 ft
Pool-riffle spacing	86 ft
Radius of curvature (Rc)	37 ft
Range *	30-76 ft
Amplitude (Amp)	28 ft

* Absolute minimum – APWA max

Optimal restoration:

- Replace bridge on Wenonga Road. Bridge abutments are in poor condition and may be structurally unstable.
- Match proposed cross-section. Create flood benches (see figure below).
- Repair or replace right bank walls. Add walls on the left bank for slope stability.
- Because meandering would be difficult to attain in this reach, a stepped channel is recommended as an alternative to a meandering channel. Preliminary calculations indicate that 7 12-in drops, spaced every 86 ft can be built to produce the stepped channel.
- Replace two driveway bridges to accommodate new channel.

- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$1,010,524.

Reach 12
 Mission Hills, Kansas
 Tributary to Brush Creek along Wenonga Road

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 33,981.00	\$ 33,981.00
2	Mobilization	LS	1	\$ 10,874.00	\$ 10,874.00
3	Traffic Control	LS	1	\$ 2,719.00	\$ 2,719.00
4	New Retaining Wall	SF	1,234	\$ 75.00	\$ 92,550.00
5	New Culvert	LS	1	\$ 40,000.00	\$ 40,000.00
6	Streambank Planting	SY	105	\$ 15.00	\$ 1,575.00
7	Sodding	SY	240	\$ 7.50	\$ 1,800.00

Subtotal Construction Cost \$ 183,499.00
 Contingencies @ 25% \$ 45,875.00
Total Construction Cost \$ 229,374.00
 Engineering @ 20% \$ 45,875.00
 Construction Administration @ 7% \$ 16,056.00

Total Cost for Reach 12 \$ 291,305.00

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Reach 13 – Existing Conditions

Location: Tributary to Brush Creek along Wenonga Road through Hiawassee Park southwest of the 63rd Street and Wenonga Road intersection.

Length: 636 feet

Channel Condition Score: 15.4

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for the lack of vegetative bank protection and having pool-riffle spacing to channel width ratio between 3 and 9. This reach received “Good” ratings for having little bank cutting and mass wasting and having a sinuosity between 1.2 and 1.4 and a radius of curvature to channel width ratio between 3 and 5. This section of this Brush Creek tributary was part of the Hiawassee Park Channel Improvements Project (2016).

Retaining Walls: There are a total of 266 feet on the left descending bank and 235 feet of retaining wall on the right descending bank. The retaining wall are located at the beginning of the reach before the channel enters Hiawassee Park. 48 feet of retaining wall on the left descending bank and 57 feet of retaining wall on the right descending bank are in “Fair” condition. The rest of the retaining walls on both banks are in “Good” condition.

Stream Buffers: The stream buffer condition on both banks before entering Hiawassee Park are in “Good” condition. There is no stream buffer on either bank along the lower 300 feet of the reach because the vegetation from the Hiawassee Park Channel Improvement project had not been established yet. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 13
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	1	0.6	0.6
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	1	0.8	0.8
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	2	0.8	1.6
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 15.4

OVERALL RANKING Fair

Reach 13 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 53 feet of retaining wall will need to be replaced along this reach and 27 square yards of streambank planting and 33 square yards of sodding.

The Stream Reach Rating is 1.35. The estimated total cost to make the localized improvements is \$35,475.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

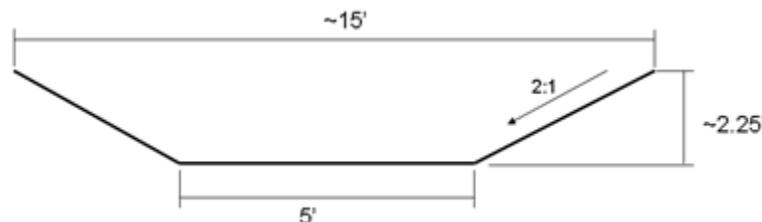
The 1-yr flow for this reach is 185 cfs. The following parameters were determined based on Soar and Thorne criteria for a 185 cfs flow:

Parameter	Value
Main channel width (w)	15 ft
Wave length (L)	172 ft
Pool-riffle spacing	86 ft
Radius of curvature (Rc)	37 ft
Range *	30-76 ft
Amplitude (Amp)	28 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove stacked-stone wall (250 ft).
- Match proposed cross-section and add meander pattern to main channel (260 ft). Create flood benches. Remove walls and reduce side slopes to 2:1 (see figure below).
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$214,313.

Reach 13
Mission Hills, Kansas
Tributary to Brush Creek along Wenonga Road through
Hiawassee Park southwest of the 63rd Street and
Wenonga Road intersection

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 4,138.00	\$ 4,138.00
2	Mobilization	LS	1	\$ 1,324.00	\$ 1,324.00
3	Traffic Control	LS	1	\$ 331.00	\$ 331.00
4	New Retaining Wall	SF	212	\$ 75.00	\$ 15,900.00
5	Streambank Planting	SY	27	\$ 15.00	\$ 405.00
6	Sodding	SY	33	\$ 7.50	\$ 248.00

Subtotal Construction Cost	\$	22,346.00
Contingencies @ 25%	\$	5,587.00
Total Construction Cost	\$	27,933.00
Engineering @ 20%	\$	5,587.00
Construction Administration @ 7%	\$	1,955.00
Total Cost for Reach 13	\$	35,475.00

Reach 14 – Existing Conditions

Location: Brush Creek along Indian Lane immediately downstream of the Indian Lane low-water crossing north of 63rd Street.

Length: 410 feet

Channel Condition Score: 19.4

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having banks steeper than 60 degrees and having pool-riffle spacing to channel width ratio between 3 and 9. This reach received “Good” ratings for having little bank cutting and mass wasting. A majority of the stability indicators within the Channel Condition Scoring Matrix received a “Fair” rating. This reach was part of the Brush Creek 63rd Street to Kansas City Country Club (KCCC) Low-Water Crossing Project (2015).

Retaining Walls: There are a total of 257 feet of retaining wall on the left descending bank and no retaining walls on the right descending bank. 144 feet of retaining wall on the left descending bank is in “Good” condition, and 113 feet of retaining wall on the right descending bank are in “Fair” condition.

Stream Buffers: The stream buffer condition on the left descending bank is in “Good” condition, and the stream buffer on the right descending bank is in “Excellent” condition. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 14
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	Sinuosity < 1.1	2	0.8	1.6
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	2	0.8	1.6
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	2	0.8	1.6
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 19.4

OVERALL RANKING Fair

Reach 14 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included.

An estimated 113 feet of retaining wall will need to be replaced along this reach and 126 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 1.64. The estimated total cost to make the localized improvements is \$92,841.

System-wide Improvements: A head-cut on rock is advancing upstream towards the Indian Lane low-water crossing. The right bank is composed of a massive rock formation. This rock formation, however, has been undermined as the head cut advanced upstream. Modification of the right bank is limited by the existing geology. Some aggradation has occurred on the left bank as the stream reaches a stable condition. The section is close to ideal geomorphic conditions.

The 1-yr flow for this reach is 1,748 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,748 cfs flow:

Parameter	Value
Main channel width (w)	47 Ft
Wave length (L)	527 Ft
Pool-riffle spacing	264 Ft
Radius of curvature (Rc)	112 Ft
Range *	94-234 Ft
Amplitude (Amp)	85 Ft

* Absolute minimum – APWA max

Optimal restoration (upper 270 feet):

- Rebuild walls on left bank to protect road and for aesthetic purposes. Existing walls on the left bank combine grouted rock with stacked limestone.
- Vegetate banks and create buffer zone.
- Monitor head cut to determine whether it will progress toward the Indian Ln. low water crossing culverts. A grade control may have to be built to protect the downstream end of the culverts.

Alternative:

- Short term: do nothing.
- Long term: A drop structure may have to be built to protect the downstream end of the culverts.

Optimal restoration (lower 140 feet):

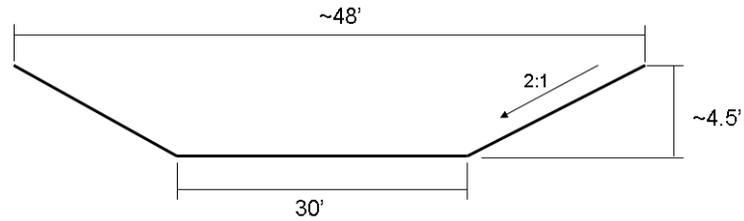
- Match proposed cross section using 2:1 slopes on both sides.
- Add meandering pattern.

- Vegetate banks and create buffer zone.

Note: Optimal restoration will be difficult to obtain throughout these sections. The proximity of Indian Ln. and geologic conditions on the right bank will limit restoration options. Optimal restoration will require realigning Indian Lane and potentially building more bridges or culverts.

Alternative:

- Do nothing.



The estimated total cost to make the system-wide improvements is \$499,865.

Reach 14
 Mission Hills, Kansas
 Brush Creek along Indian Lane immediately downstream
 of the Indian Lane low-water crossing north of 63rd

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 10,830.00	\$ 10,830.00
2	Mobilization	LS	1	\$ 3,466.00	\$ 3,466.00
3	Traffic Control	LS	1	\$ 866.00	\$ 866.00
4	New Retaining Wall	SF	565	\$ 75.00	\$ 42,375.00
5	Streambank Planting	SY	0	\$ 15.00	\$ -
6	Sodding	SY	126	\$ 7.50	\$ 945.00

Subtotal Construction Cost	\$	58,482.00
Contingencies @ 25%	\$	14,621.00
Total Construction Cost	\$	73,103.00
Engineering @ 20%	\$	14,621.00
Construction Administration @ 7%	\$	5,117.00
Total Cost for Reach 14	\$	92,841.00

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Reach 15 – Existing Conditions

Location: Brush Creek along Indian Lane north of 63rd Street immediately downstream of Reach 14.

Length: 761 feet

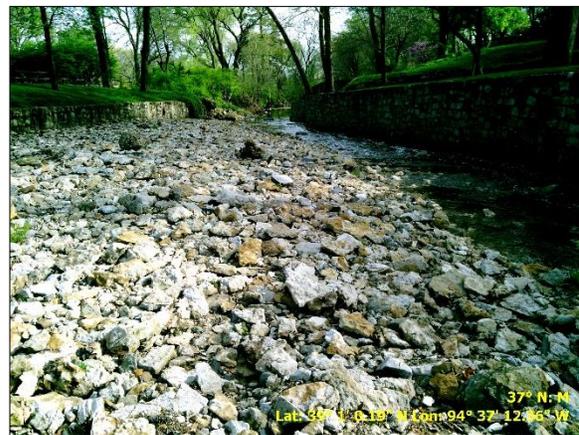
Channel Condition Score: 21.2

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having a steep bank slopes, a lack of bank vegetation, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting and also small amounts of debris in the channel. This reach was part of the Brush Creek 63rd Street to Kansas City Country Club (KCCC) Low-Water Crossing Project (2015).

Retaining Walls: There are a total of 443 feet of retaining wall on the left descending bank and 593 feet on the right descending bank. 322 feet of retaining wall on the left descending bank and 315 feet on the right descending bank are in “Fair” condition in need of some repair. There is 121 feet of retaining wall on the left descending bank in “Poor” condition. The rest of the retaining walls are in “Good” condition.

Stream Buffers: The stream buffer condition on the left descending bank is in “Good” condition, and the stream buffer on the right descending bank ranges between “Good” and “Excellent” with a 200-foot stretch of no stream buffer. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 15
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	3	0.6	1.8
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	2	0.8	1.6
Percentage of channel constriction	< 25%	26-50%	> 50%	2	0.8	1.6
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 21.2

OVERALL RANKING Poor

Reach 15 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included.

An estimated 479 feet of retaining wall will need to be replaced along this reach and 220 square yards of streambank planting and 315 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 0.68. The estimated total cost to make the localized improvements is \$397,096.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

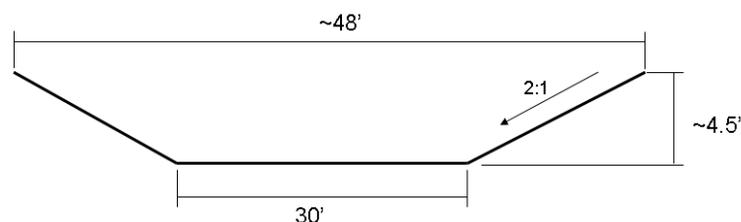
The 1-yr flow for this reach is 1,748 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,748 cfs flow:

Parameter	Value
Main channel width (w)	47 Ft
Wave length (L)	527 Ft
Pool-riffle spacing	264 Ft
Radius of curvature (Rc)	112 Ft
Range *	94-234 Ft
Amplitude (Amp)	85 Ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross section using 2:1 slopes on both sides.
- Remove wall and add meandering pattern.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$604,044.

Reach 15
Mission Hills, Kansas
Brush Creek along Indian Lane north of 63rd Street
immediately downstream of Reach 14

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 46,322.00	\$ 46,322.00
2	Mobilization	LS	1	\$ 14,823.00	\$ 14,823.00
3	Traffic Control	LS	1	\$ 3,706.00	\$ 3,706.00
4	New Retaining Wall	SF	2,395	\$ 75.00	\$ 179,625.00
5	Streambank Planting	SY	220	\$ 15.00	\$ 3,300.00
6	Sodding	SY	315	\$ 7.50	\$ 2,363.00

Subtotal Construction Cost	\$	250,139.00
Contingencies @ 25%	\$	62,535.00
Total Construction Cost	\$	312,674.00
Engineering @ 20%	\$	62,535.00
Construction Administration @ 7%	\$	21,887.00

Total Cost for Reach 15 \$ 397,096.00

Reach 16 – Existing Conditions

Location: Brush Creek along Indian Lane north of 63rd Street immediately downstream of Reach 15, ending at the Mission Drive low-water crossing near the entrance to the Kansas City Country Club.

Length: 849 feet

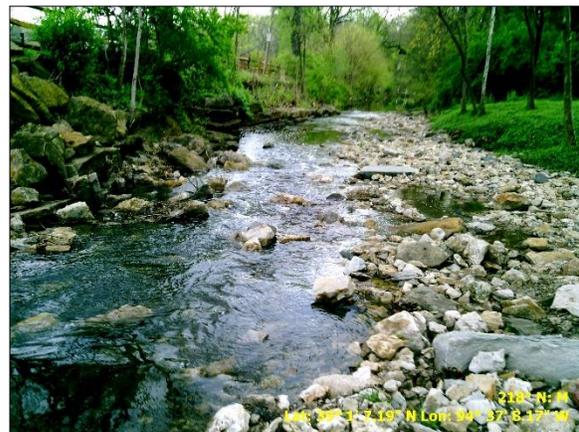
Channel Condition Score: 17.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having a lack of sinuosity and having a large radius of curvature to channel width ratio. This reach received “Good” ratings for having average bank heights less than 6 feet, showing little evidence of mass wasting, and having small amounts of debris in the channel. This reach was part of the Brush Creek 63rd Street to Kansas City Country Club (KCCC) Low-Water Crossing Project (2015). A section of this reach was part of the Brush Creek Bank Stabilization Project (2012).

Retaining Walls: There are five sections of retaining wall along this reach. A total of 264 feet of retaining wall on the left descending bank and 129 feet on the right descending bank. 40 feet of retaining wall on the left descending bank is in “Poor” condition and 62 feet in “Fair” condition. The rest of the left descending bank retaining wall is in “Good” condition. There is 68 feet of retaining wall on the right descending bank in “Poor” condition and 61 feet in “Fair” condition. The rest of the retaining walls are in “Good” condition.

Stream Buffers: The stream buffer condition on the left descending bank is in “Good” condition for 150 feet then the stream buffer diminishes to “None”. The stream buffer on the right descending bank is “Excellent” the entire reach. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 16
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	2	0.6	1.2
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	1	0.8	0.8
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 17.6

OVERALL RANKING Fair

Reach 16 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included.

An estimated 120 feet of retaining wall will need to be replaced along this reach and 65 square yards of streambank planting and 80 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 1.17. The estimated total cost to make the localized improvements is \$105,846.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

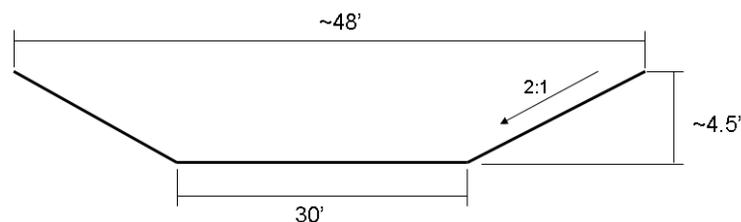
The 1-yr flow for this reach is 1,748 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,748 cfs flow:

Parameter	Value
Main channel width (w)	47 Ft
Wave length (L)	527 Ft
Pool-riffle spacing	264 Ft
Radius of curvature (Rc)	112 Ft
Range *	94-234 Ft
Amplitude (Amp)	85 Ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross section using 2:1 slopes on both sides.
- Remove wall and add meandering pattern.
- Vegetate banks and create buffer zone.



Note: Optimal restoration will be difficult to obtain throughout these sections. The proximity of Indian Ln. and geologic conditions on the right bank will limit restoration options. Optimal restoration will require realigning Indian Lane and potentially building more bridges or culverts.

The estimated total cost to make the system-wide improvements is \$673,894.

Reach 16
 Mission Hills, Kansas
 Brush Creek along Indian Lane north of 63rd Street
 immediately downstream of Reach 15, ending at the
 Mission Drive low-water crossing near the entrance to the
 Kansas City Country Club

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 12,347.00	\$ 12,347.00
2	Mobilization	LS	1	\$ 3,951.00	\$ 3,951.00
3	Traffic Control	LS	1	\$ 988.00	\$ 988.00
4	New Retaining Wall	SF	638	\$ 75.00	\$ 47,813.00
5	Streambank Planting	SY	65	\$ 15.00	\$ 975.00
6	Sodding	SY	80	\$ 7.50	\$ 600.00

Subtotal Construction Cost	\$	66,674.00
Contingencies @ 25%	\$	16,669.00
Total Construction Cost	\$	83,343.00
Engineering @ 20%	\$	16,669.00
Construction Administration @ 7%	\$	5,834.00

Total Cost for Reach 16 \$ 105,846.00

Reach 17 – Existing Conditions

Location: Tributary to Brush Creek paralleling Willow Lane, beginning at W. 65th Street and ending at the culvert under Tomahawk Road, upstream of Willow Lake.

Length: 724 feet

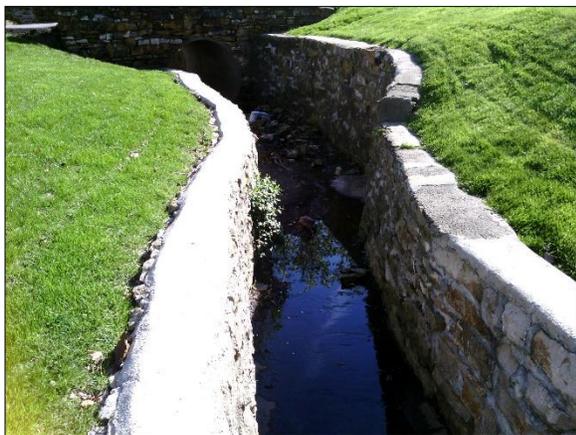
Channel Condition Score: 20.2

Channel Condition Ranking: Poor

Channel Condition Description: This reach is a concrete lined channel with short retaining walls (< 6' tall) on each bank for most of the reach. This reach received "Poor" ratings for having steep bank slopes, a lack of vegetation a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received "Good" ratings for having little evidence of bank cutting and mass wasting, bank heights less than 6 feet, and small amounts of debris in the channel.

Retaining Walls: There are a total of 411 feet of retaining wall on the left descending bank and 467 feet of retaining wall on the right descending bank. The retaining walls on both banks just downstream of W. 65th Street are in "Good" condition. The rest of the retaining walls on both banks are in "Fair" condition.

Stream Buffers: The stream buffers along this reach range between "None" and "Acceptable" on the left descending bank. There is no stream buffer on the right descending bank as it is very close to Willow Lane. The stream buffer generally consists of smaller trees and residentially landscaping at the top of the retaining walls.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 17
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 20.2

OVERALL RANKING Poor

Reach 17 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 366 feet of retaining wall will need to be replaced along this reach and 407 square yards of sodding.

The Stream Reach Rating is 0.68. The estimated total cost to make the localized improvements is \$300,686.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

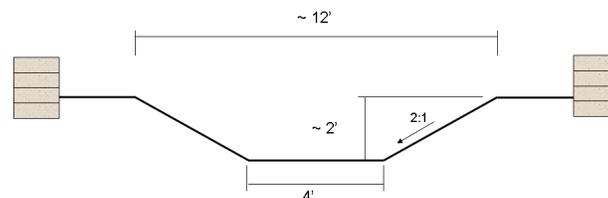
The 1-yr flow for this reach is 100 cfs. The following parameters were determined based on Soar and Thorne criteria for a 100 cfs flow:

Parameter	Value
Main channel width (w)	11 ft
Wave length (L)	125 ft
Pool-riffle spacing	63 ft
Radius of curvature (Rc)	27 ft
Range *	22-56 ft
Amplitude (Amp)	20 ft

* Absolute minimum – APWA max

Optimal restoration:

- Replace 5 driveway bridges with larger bridges.
- Remove existing walls and build a new channel with 2:1 side slopes (see sketch below). Create flood bench if possible.
- Because meandering would be difficult to attain in this reach, a stepped channel is recommended as an alternative to a meandering channel. Preliminary calculations indicate that 17 8.5-in drops, spaced every 44 ft can be built to produce the stepped channel. This spacing allows having one drop at every bridge and one in the middle of the segment between bridges.
- Vegetate flood benches and banks and create buffer zone where possible.



The estimated total cost to make the system-wide improvements is \$1,656,160.

Reach 17
Mission Hills, Kansas
Tributary to Brush Creek paralleling Willow Lane,
beginning at W. 65th Street and ending at the culvert
under Tomahawk Road, upstream of Willow Lake

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 35,076.00	\$ 35,076.00
2	Mobilization	LS	1	\$ 11,224.00	\$ 11,224.00
3	Traffic Control	LS	1	\$ 2,806.00	\$ 2,806.00
4	New Retaining Wall	SF	1,830	\$ 75.00	\$ 137,250.00
5	Streambank Planting	SY	0	\$ 15.00	\$ -
6	Sodding	SY	407	\$ 7.50	\$ 3,053.00

Subtotal Construction Cost	\$	189,409.00
Contingencies @ 25%	\$	47,352.00
Total Construction Cost	\$	236,761.00
Engineering @ 20%	\$	47,352.00
Construction Administration @ 7%	\$	16,573.00

Total Cost for Reach 17 \$ 300,686.00

Reach 18 – Existing Conditions

Location: Tributary to Brush Creek downstream of Willow Lake, paralleling Ensley Lane, beginning at Tomahawk and ending at the culvert under intersection of Ensley Lane and Mission Drive.

Length: 765 feet

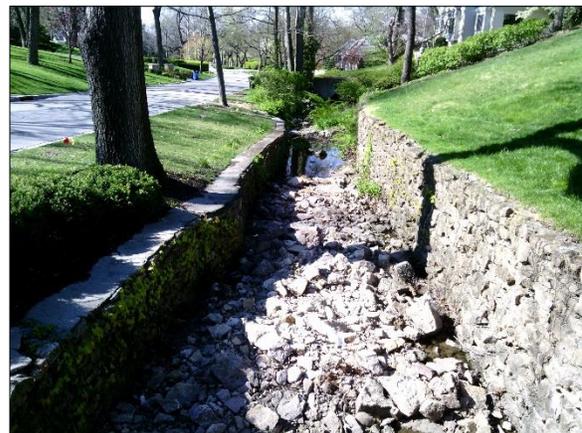
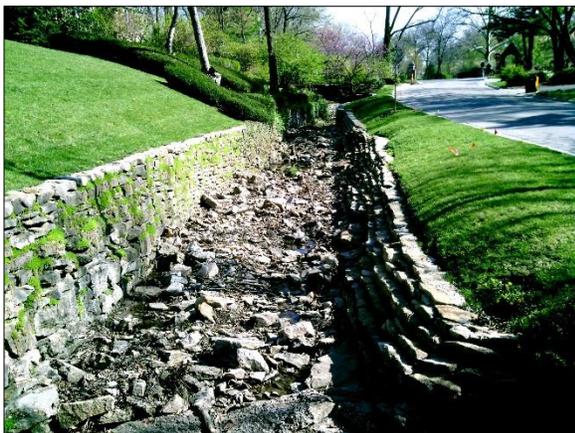
Channel Condition Score: 18.2

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, a lack of vegetation a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting, bank heights less than 6 feet, and small amounts of debris in the channel.

Retaining Walls: There are a total of 472 feet of retaining wall on the left descending bank and 633 feet of retaining wall on the right descending bank. The retaining walls on both banks at the beginning of the reach just downstream of Tomahawk Road are in “Fair” condition. There is 200 feet of retaining wall on the left descending bank in “Poor” condition and 44 feet in “Good” condition. There is 295 feet of retaining wall on the right descending bank in “Poor” condition. The retaining wall approaching Mission Drive is in “Fair” condition.

Stream Buffers: The stream buffers along this reach range between “None” and “Acceptable” on the left descending bank along Ensley Lane. The stream buffer on the right descending bank ranges between “None” and “Good”, with it being “Excellent” immediately downstream of Tomahawk Road. The stream buffer generally consists of smaller trees and residentially landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 18
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	Sinuosity < 1.1	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 18.2

OVERALL RANKING Fair

Reach 18 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 707 feet of retaining wall will need to be replaced along this reach and 785 square yards of sodding.

The Stream Reach Rating is 1.08. The estimated total cost to make the localized improvements is \$580,814.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

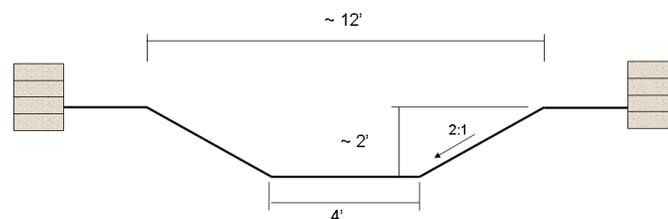
The 1-yr flow for this reach is 100 cfs. The following parameters were determined based on Soar and Thorne criteria for a 100 cfs flow:

Parameter	Value
Main channel width (w)	11 ft
Wave length (L)	125 ft
Pool-riffle spacing	63 ft
Radius of curvature (Rc)	27 ft
Range *	22-56 ft
Amplitude (Amp)	20 ft

* Absolute minimum – APWA max

Optimal restoration:

- Replace 3 driveway bridges with larger bridges.
- Remove existing walls and build a new channel with 2:1 side slopes (see sketch below). Create flood bench if possible.
- Because meandering would be difficult to attain in this reach, a stepped channel is recommended as an alternative to a meandering channel. Preliminary calculations indicate that 11 2-ft drops, spaced every 63 ft can be built to produce the stepped channel.
- Vegetate flood benches and banks and create buffer zone where possible.



Alternative restoration:

- Remove existing walls and build new channel that would convey the 10-yr flow.

The estimated total cost to make the system-wide improvements is \$1,510,904.

Reach 18
Mission Hills, Kansas
Tributary to Brush Creek downstream of Willow Lake,
paralleling Ensley Lane, beginning at Tomahawk and
ending at the culvert under intersection of Ensley Lane

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 67,753.00	\$ 67,753.00
2	Mobilization	LS	1	\$ 21,681.00	\$ 21,681.00
3	Traffic Control	LS	1	\$ 5,420.00	\$ 5,420.00
4	New Retaining Wall	SF	3,535	\$ 75.00	\$ 265,125.00
5	Streambank Planting	SY	0	\$ 15.00	\$ -
6	Sodding	SY	785	\$ 7.50	\$ 5,888.00

Subtotal Construction Cost	\$	365,867.00
Contingencies @ 25%	\$	91,467.00
Total Construction Cost	\$	457,334.00
Engineering @ 20%	\$	91,467.00
Construction Administration @ 7%	\$	32,013.00

Total Cost for Reach 18 \$ 580,814.00

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Reach 19 – Existing Conditions

Location: Tributary to Brush Creek beginning at State Line Road and continuing north along State Line Road, south of First Evangelical Lutheran Church parking lot.

Length: 380 feet

Channel Condition Score: 16.0

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for a lack of sinuosity. This reach received “Good” ratings for having bank heights less than 6 feet, little evidence of bank cutting and infrequent mass wasting. A majority of the stability indicators within the Channel Condition Scoring Matrix received a “Fair” rating.

Retaining Walls: The only retaining walls along the reach are located on both banks immediately downstream of State Line Road totaling 88 feet. All retaining wall are in “Poor” condition.

Stream Buffers: The stream buffer condition is “Excellent” at greater than 15 feet wide on the left descending bank and “Good” at 5 to 15 feet wide on the right descending bank. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 19
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	2	0.6	1.2
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	2	0.8	1.6
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	2	0.8	1.6
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 16.0

OVERALL RANKING Fair

Reach 19 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 88 feet of retaining wall will need to be replaced along this reach and 100 square yards of streambank planting.

The Stream Reach Rating is 1.17. The estimated total cost to make the localized improvements is \$102,228.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

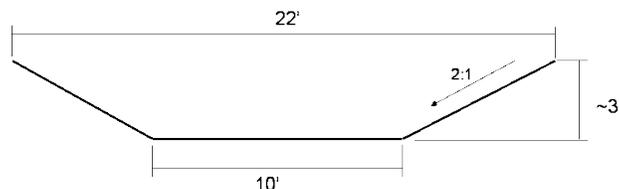
The 1-yr flow for this reach is 373 cfs. The following parameters were determined based on Soar and Thorne criteria for a 373 cfs flow:

Parameter	Value
Main channel width (w)	22 ft
Wave length (L)	244 ft
Pool-riffle spacing	122 ft
Radius of curvature (Rc)	52 ft
Range *	43-108 ft
Amplitude (Amp)	39 ft

* Absolute minimum – APWA max

Optimal restoration:

- Add meandering pattern.
- Match cross section (see sketch).
- Vegetate banks and create buffer zone where possible.



The estimated total cost to make the system-wide improvements is \$302,419.

Reach 19
 Mission Hills, Kansas
 Tributary to Brush Creek beginning at State Line Road
 and continuing north along State Line Road, south of
 First Evangelical Lutheran Church parking lot

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 11,925.00	\$ 11,925.00
2	Mobilization	LS	1	\$ 3,816.00	\$ 3,816.00
3	Traffic Control	LS	1	\$ 954.00	\$ 954.00
4	New Retaining Wall	SF	616	\$ 75.00	\$ 46,200.00
5	Streambank Planting	SY	100	\$ 15.00	\$ 1,500.00
6	Sodding	SY	0	\$ 7.50	\$ -

Subtotal Construction Cost	\$	64,395.00
Contingencies @ 25%	\$	16,099.00
Total Construction Cost	\$	80,494.00
Engineering @ 20%	\$	16,099.00
Construction Administration @ 7%	\$	5,635.00

Total Cost for Reach 19 \$ 102,228.00

Reach 20 – Existing Conditions

Location: Tributary to Brush Creek immediately downstream of Reach 19 along the south side of the First Evangelical Lutheran Church parking lot ending at the Tomahawk Road culvert.

Length: 571 feet

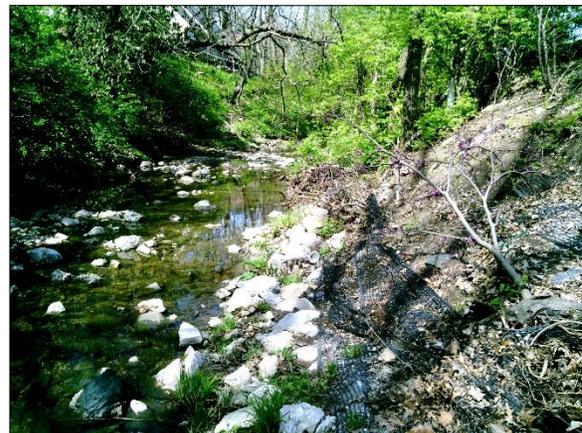
Channel Condition Score: 19.4

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for a lack of sinuosity. This reach received “Good” ratings for having small amounts of debris in the channel and a few small obstructions in the channel. A majority of the stability indicators within the Channel Condition Scoring Matrix received a “Fair” rating. This reach was part of the Mission Drive Channel Improvements Project (2013).

Retaining Walls: The only retaining wall along the reach are located on the left descending bank just upstream of the Tomahawk Road culvert, and it is in “Poor” condition.

Stream Buffers: The stream buffer condition is “Excellent” at greater than 15 feet wide on the left descending bank and “Good” at 5 to 15 feet wide on the right descending bank. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 20
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	2	0.6	1.2
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	2	0.8	1.6

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	2	0.8	1.6
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 19.4

OVERALL RANKING Fair

Reach 20 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 48 feet of retaining wall will need to be replaced along this reach and 55 square yards of sodding.

The Stream Reach Rating is 1.50. The estimated total cost to make the localized improvements is \$78,036.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

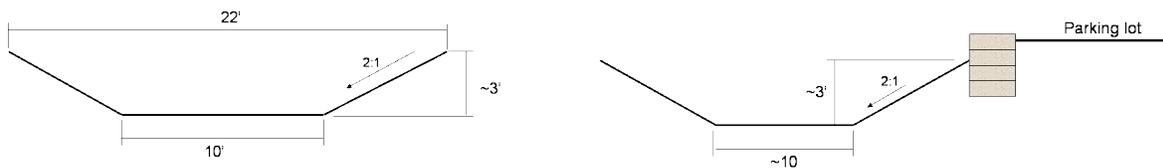
The 1-yr flow for this reach is 373 cfs. The following parameters were determined based on Soar and Thorne criteria for a 373 cfs flow:

Parameter	Value
Main channel width (w)	22 ft
Wave length (L)	244 ft
Pool-riffle spacing	122 ft
Radius of curvature (Rc)	52 ft
Range *	43-108 ft
Amplitude (Amp)	39 ft

* Absolute minimum – APWA max

Optimal restoration:

- Add meandering pattern and reduce slope on right bank to 2:1 (see sketch).
- Provide a smooth transition upstream of Tomahawk Road Bridge (125 ft).
- Vegetate banks and create buffer zone.
- Section of the parking lot on right bank would have to be removed to accommodate the new left bank slope and buffer zone.



The estimated total cost to make the system-wide improvements is \$453,231.

Reach 20
Mission Hills, Kansas
Tributary to Brush Creek immediately downstream of
Reach 19 along the south side of the First Evangelical
Lutheran Church parking lot ending at the Tomahawk

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 9,103.00	\$ 9,103.00
2	Mobilization	LS	1	\$ 2,913.00	\$ 2,913.00
3	Traffic Control	LS	1	\$ 728.00	\$ 728.00
4	New Retaining Wall	SF	480	\$ 75.00	\$ 36,000.00
5	Streambank Planting	SY	0	\$ 15.00	\$ -
6	Sodding	SY	55	\$ 7.50	\$ 413.00

Subtotal Construction Cost	\$	49,157.00
Contingencies @ 25%	\$	12,289.00
Total Construction Cost	\$	61,446.00
Engineering @ 20%	\$	12,289.00
Construction Administration @ 7%	\$	4,301.00
Total Cost for Reach 20	\$	78,036.00

Reach 21 – Existing Conditions

Location: Tributary to Brush Creek along Mission Drive between Tomahawk Road and W. 63rd Street.

Length: 436 feet

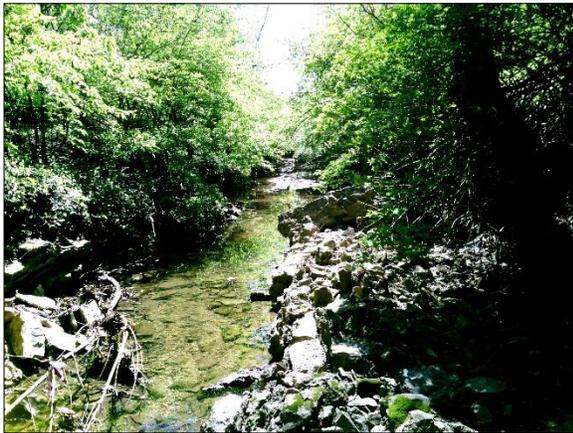
Channel Condition Score: 19.2

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received “Good” ratings for having bank heights shorter than six feet, showing little signs of mass wasting, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: The only retaining wall along the reach are located on both banks just downstream of the Tomahawk Road culvert, and they are in “Poor” condition.

Stream Buffers: The stream buffer condition is “Excellent” at greater than 15 feet wide on both banks immediately downstream of the Tomahawk Road culvert and “Good” at 5 to 15 feet wide on both banks for the remainder of the reach. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 21
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 19.2

OVERALL RANKING Fair

Reach 21 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include replacing the retaining walls downstream of Tomahawk Road with a 2:1 slope and restoring the banks with native vegetation. It also includes providing a smooth transition downstream from Tomahawk Road Bridge (125 ft) and upstream of 63rd Street Bridge (80 ft).

An estimated 130 feet of retaining wall will need to be removed along this reach and an additional 80 feet of bank reshaping.

The Stream Reach Rating is 1.25. The estimated total cost to make the localized improvements is \$83,344.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

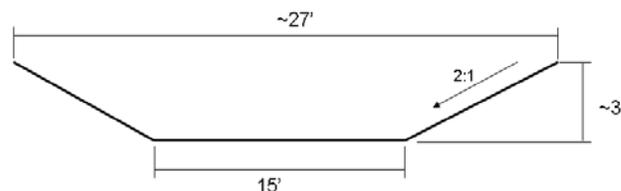
The 1-yr flow for this reach is 556 cfs. The following parameters were determined based on Soar and Thorne criteria for a 556 cfs flow:

Parameter	Value
Main channel width (w)	26 ft
Wave length (L)	297 ft
Pool-riffle spacing	149 ft
Radius of curvature (Rc)	63 ft
Range *	53-132 ft
Amplitude (Amp)	48 ft

* Absolute minimum – APWA max

Optimal restoration:

- Widen Tomahawk Road Bridge.
- Add meandering pattern and replace walls with a 2:1 slope (see sketch).
- Walls may have to be built for main or secondary bank stability.
- Provide a smooth transition downstream from Tomahawk Road Bridge (125 ft).
- Provide a smooth transition upstream of 63rd Street Bridge (80 ft).
- Vegetate banks and extend buffer zone if required on both banks.



The estimated total cost to make the system-wide improvements is \$346,075.

Reach 21
Mission Hills, Kansas
Tributary to Brush Creek along Mission Drive between
Tomahawk Road and W. 63rd Street

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

This reach did contain retaining walls rated "Fair" or "Poor". The reach received a "Fair" Channel Condition Ranking indicating significant instability issues. The CCSM indentified steep bank angles, poor sinuosity, and pool riffle spacing contributing to the instability. The proposed improvements include replacing the retaining walls with 2:1 bank slopes. The cost of the improvements to this reach is \$83,344.00.

Reach 22 – Existing Conditions

Location: Tributary to Brush Creek along Mission Drive between W. 63rd Street and High Drive.

Length: 604 feet

Channel Condition Score: 21.8

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, frequent and extensive evidence of mass wasting, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received “Good” ratings for showing little signs of bank cutting, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: There is 292 feet of retaining wall on the left descending bank and 360 feet on the right descending bank. All the retaining wall on the left descending bank is in “Poor” condition, and 245 feet is in “Poor” condition on the right descending bank. 115 feet of retaining wall is in “Fair” condition on the right descending bank.

Stream Buffers: There is no stream buffer on the right descending bank as the channel is close to Mission Drive. The stream buffer on the left descending bank ranges from “Good” at 5 to 15 feet wide near W. 63rd Street to “Excellent” at greater than 15 feet approaching High Drive with a section of no stream buffer midway along the reach. The stream buffer generally consists of large trees and smaller understory trees and landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 22
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	3	0.8	2.4

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 21.8

OVERALL RANKING Poor

Reach 22 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included. Repairing a sanitary sewer concrete encasement and constructing an appropriate energy dissipation structure is also included.

An estimated 594 feet of retaining wall will need to be replaced along this reach and 325 square yards of streambank planting and 337 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 0.74. The estimated total cost to make the localized improvements is \$533,319.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 590 cfs. The following parameters were determined based on Soar and Thorne criteria for a 590 cfs flow:

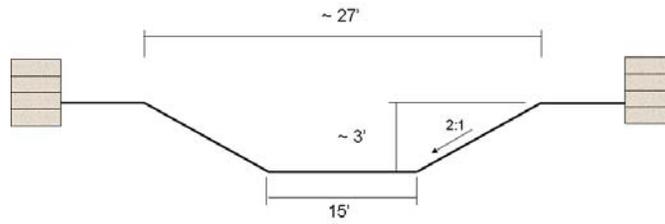
Parameter	Value
Main channel width (w)	27 ft
Wave length (L)	306 ft
Pool-riffle spacing	153 ft
Radius of curvature (Rc)	65 ft
Range *	53-136 ft
Amplitude (Amp)	49 ft

* Absolute minimum – APWA max

Optimal restoration:

- Repair or replace existing wall on the right bank. Rebuild wall as close as possible to Mission Drive to allow widening of the channel.
- Match proposed cross section (see sketch below). Create flood bench where possible.
- Because meandering would be difficult to attain in this reach, a stepped channel is recommended as an alternative to a meandering channel. Preliminary calculations indicate that 4 2-ft drops, spaced approximately every 150 ft can be built to produce the stepped channel. One of the drop structures can be placed at the location of a sanitary sewer crossing. The sanitary sewer concrete encasement needs replacement.

- Vegetate flood benches and banks and create buffer zone where possible.



The estimated total cost to make the system-wide improvements is \$1,006,158.

Reach 22
 Mission Hills, Kansas
 Tributary to Brush Creek along Mission Drive between
 W. 63rd Street and High Drive

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 62,213.00	\$ 62,213.00
2	Mobilization	LS	1	\$ 19,908.00	\$ 19,908.00
3	Traffic Control	LS	1	\$ 4,977.00	\$ 4,977.00
4	New Retaining Wall	SF	2,973	\$ 75.00	\$ 222,938.00
5	Energy Dissipation Structure	LS	1	\$ 15,000.00	\$ 15,000.00
6	Concrete Encasement	CY	27	\$ 130.00	\$ 3,510.00
7	Streambank Planting	SY	325	\$ 15.00	\$ 4,875.00
8	Sodding	SY	337	\$ 7.50	\$ 2,528.00

Subtotal Construction Cost	\$	335,949.00
Contingencies @ 25%	\$	83,987.00
Total Construction Cost	\$	419,936.00
Engineering @ 20%	\$	83,987.00
Construction Administration @ 7%	\$	29,396.00

Total Cost for Reach 22 \$ 533,319.00

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Reach 23 – Existing Conditions

Location: Tributary to Brush Creek along Mission Drive between High Drive and the culvert under the intersection of Ensley Lane and Mission Drive.

Length: 720 feet

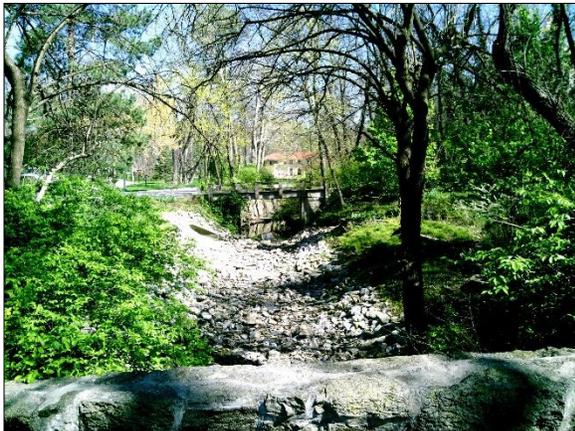
Channel Condition Score: 19.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, lack of bank vegetation, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received “Good” ratings for having bank heights less than six feet, showing little signs of bank cutting and mass wasting, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: There is 435 feet of retaining wall on the left descending bank and 543 feet on the right descending bank. The retaining walls on both banks just downstream of High Drive are in “Poor” condition, and the retaining walls on both banks approaching the culvert under the intersection of Ensley Lane and Mission Drive are in “Fair” condition.

Stream Buffers: There is no stream buffer on the right descending bank as the channel is close to Mission Drive. The stream buffer on the left descending bank is “Excellent” at greater than 15 feet wide from High Drive to midway along the reach, then it is “Good” at 5 to 15 feet wide the remainder of the reach. The stream buffer generally consists of large trees and smaller understory trees and landscaping. The stream buffer generally consists of large trees and smaller understory trees and landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 23
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	2	0.8	1.6
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 19.6

OVERALL RANKING Fair

Reach 23 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Constructing drop structures at the High Drive Bridge and the driveway bridge is also included.

An estimated 604 feet of retaining wall will need to be replaced along this reach and 274 square yards of streambank planting and 398 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 1.17. The estimated total cost to make the localized improvements is \$662,001.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

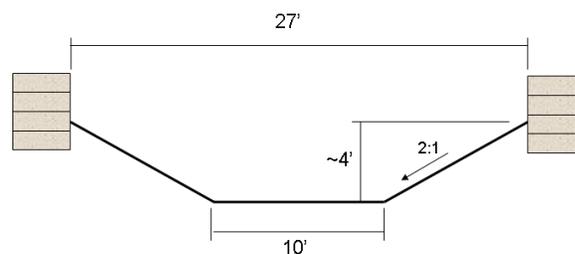
The 1-yr flow for this reach is 590 cfs. The following parameters were determined based on Soar and Thorne criteria for a 590 cfs flow:

Parameter	Value
Main channel width (w)	27 ft
Wave length (L)	306 ft
Pool-riffle spacing	153 ft
Radius of curvature (Rc)	65 ft
Range *	53-136 ft
Amplitude (Amp)	49 ft

* Absolute minimum – APWA max

Optimal restoration (first 190 feet downstream from High Drive):

- Replace High Drive Bridge to accommodate wider channel.
- Repair or replace existing walls and widen channel using 2:1 side slopes (see sketch below). Rebuild the right wall as close as possible to Mission Drive to allow widening of the channel.
- Because meandering would be difficult to attain in this reach, a stepped channel is recommended as an alternative to a meandering channel. The steps can be placed at the downstream end of the High Drive Bridge and at the downstream end of the reach at the driveway bridge.
- Remove concrete from bottom of the channel, except if needed at the drop structures.
- Vegetate flood benches and banks and create buffer zone where possible.

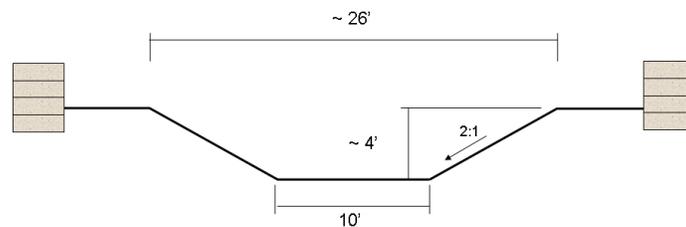


Optimal restoration (next 110 feet):

- Channel width seems to be appropriate. Actual dimensions need to be checked with survey data. Modify section if needed (see sketch below). Create flood benches if possible.
- Because meandering would be difficult to attain in this reach, a stepped channel is recommended. The proposed improvements for the previous section call for a step at the end of that section. This step will be the first step for this section. The second step can be placed on the driveway bridge at the downstream end of the section. The separation between the two driveway bridges is relatively close to optimal riffle spacing.
- Check driveway bridges dimensions. Replace bridges or create transitions as necessary for channel stability (the proposed step may be an appropriate transition).
- Vegetate flood benches and banks and create buffer zone where possible.

Optimal restoration (last 410 feet of reach):

- Repair or replace existing walls and match proposed cross section (see sketch below). Rebuild the right wall as close as possible to Mission Drive to allow widening of the channel. Create flood benches if possible.
- Because meandering would be difficult to attain in this reach, a stepped channel is recommended as an alternative to a meandering channel. A step can be placed near the middle of the reach.
- Remove concrete from bottom of the channel, except if needed at the drop structures.
- Vegetate flood benches and banks and create buffer zone where possible.



The estimated total cost to make the system-wide improvements is \$1,332,706.

Reach 23
Mission Hills, Kansas
Tributary to Brush Creek along Mission Drive between
High Drive and the culvert under the intersection of
Ensley Lane and Mission Drive

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 77,224.00	\$ 77,224.00
2	Mobilization	LS	1	\$ 24,712.00	\$ 24,712.00
3	Traffic Control	LS	1	\$ 6,178.00	\$ 6,178.00
4	New Retaining Wall	SF	3,624	\$ 75.00	\$ 271,800.00
5	Drop Structure	Each	2	\$ 15,000.00	\$ 30,000.00
6	Streambank Planting	SY	274	\$ 15.00	\$ 4,110.00
7	Sodding	SY	398	\$ 7.50	\$ 2,985.00

Subtotal Construction Cost	\$	417,009.00
Contingencies @ 25%	\$	104,252.00
Total Construction Cost	\$	521,261.00
Engineering @ 20%	\$	104,252.00
Construction Administration @ 7%	\$	36,488.00

Total Cost for Reach 23 \$ 662,001.00

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Reach 24 – Existing Conditions

Location: Tributary to Brush Creek within the island along Brookwood Road.

Length: 742 feet

Channel Condition Score: 19.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, lack of bank vegetation, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received “Good” ratings for having bank heights less than six feet, showing little signs of bank cutting and mass wasting, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: There is 447 feet of retaining wall on the left descending bank and 417 feet on the right descending bank. There is 257 feet of retaining wall on the left descending bank and 252 feet on the right descending bank in “Poor” condition. There is 190 feet of retaining wall on the left descending bank and 165 feet on the right descending bank in “Fair” condition.

Stream Buffers: The stream buffer on both banks is in Acceptable condition generally consisting of large trees with turf grass and landscaping ground cover.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 24
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	2	0.8	1.6
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 19.6

OVERALL RANKING Fair

Reach 24 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. The bridge structural stability should be checked and the bridge repaired or replaced if necessary.

An estimated 506 feet of retaining wall will need to be replaced along this reach and 564 square yards of streambank planting and 282 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 1.12. The estimated total cost to make the localized improvements is \$266,902.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

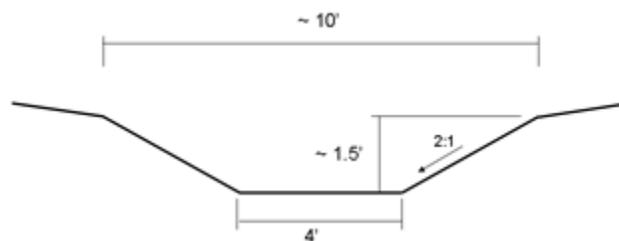
The 1-yr flow for this reach is 60 cfs. The following parameters were determined based on Soar and Thorne criteria for a 60 cfs flow:

Parameter	Value
Main channel width (w)	9 ft
Wave length (L)	98 ft
Pool-riffle spacing	49 ft
Radius of curvature (Rc)	21 ft
Range *	17-43 ft
Amplitude (Amp)	16 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove both walls and stabilize banks with a 2:1 slope. Create flood benches (see sketch below).
- Add meandering pattern.
- Replace pedestrian bridge if necessary to accommodate new proposed geometry.
- Vegetate banks and flood benches and create buffer zone.



The estimated total cost to make the system-wide improvements is \$620,713.

Reach 24
 Mission Hills, Kansas
 Tributary to Brush Creek within the island along
 Brookwood Road

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 31,135.00	\$ 31,135.00
2	Mobilization	LS	1	\$ 9,963.00	\$ 9,963.00
3	Traffic Control	LS	1	\$ 2,491.00	\$ 2,491.00
4	New Retaining Wall	SF	1,520	\$ 75.00	\$ 113,963.00
5	Streambank Planting	SY	564	\$ 15.00	\$ 8,460.00
6	Sodding	SY	282	\$ 7.50	\$ 2,115.00

Subtotal Construction Cost	\$	168,127.00
Contingencies @ 25%	\$	42,032.00
Total Construction Cost	\$	210,159.00
Engineering @ 20%	\$	42,032.00
Construction Administration @ 7%	\$	14,711.00

Total Cost for Reach 24 \$ 266,902.00

Reach 25 – Existing Conditions

Location: Tributary to Brush Creek along Mission Drive beginning at the culvert under the intersection of Ensley Lane and Mission Drive and ending at the confluence with Brush Creek.

Length: 1,240 feet

Channel Condition Score: 17.2

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received “Good” ratings for showing little signs of bank cutting and mass wasting, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: There is 955 feet of retaining wall on the left descending bank and 439 feet on the right descending bank. All the retaining walls on the left descending bank are in “Fair” condition, except for a 58-foot section in “Poor” condition near the confluence with Brush Creek. The retaining walls on the right descending bank are in “Fair” condition.

Stream Buffers: There is no stream buffer on either bank for approximately 270 feet downstream of the culvert under the intersection of Ensley Lane and Mission Drive. The stream buffer on the left descending bank then is “Excellent” and changes to “Good” approaching Brush Creek. The stream buffer on the right descending bank is “Good” for the remainder of the reach. The stream buffer generally consists of large trees and smaller understory trees and landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 25
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	1	0.8	0.8
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 17.2

OVERALL RANKING Fair

Reach 25 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Replacing or repairing the driveway bridge at 6012 Mission Drive is included. Constructing energy dissipation structures downstream of the two weirs along the reach is also included.

An estimated 725 feet of retaining wall will need to be replaced along this reach and 560 square yards of streambank planting and 322 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 1.09. The estimated total cost to make the localized improvements is \$872,389.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 953 cfs. The following parameters were determined based on Soar and Thorne criteria for a 953 cfs flow:

Parameter	Value
Main channel width (w)	35 ft
Wave length (L)	389 ft
Pool-riffle spacing	195 ft
Radius of curvature (Rc)	83 ft
Range *	69-173 ft
Amplitude (Amp)	62 ft

* Absolute minimum – APWA max

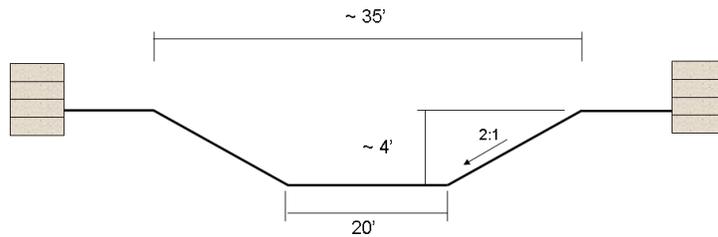
Optimal restoration (downstream of Overhill Road to 6034 Mission Drive driveway bridge):

- Remove walls and match proposed cross section.
- It is possible a section of wall would have to be built at the top of the 2:1 slope to match the existing grade.
- Create flood benches if possible.
- Repair, lower and extend the two weirs and potentially add another weir at downstream end of bridge. Build appropriate energy dissipation structure downstream from weirs to protect the toe of the weir. The weirs will be drop structures. Their separation is adequate, thus meandering in these sections is not necessary.
- Replace two driveway bridges with wider span bridges that accommodate the new channel shape. Bridges seem to be in fair conditions; their size, however, is inadequate. Increasing the span would reduce flooding potential in the area.

- Vegetate banks and extend buffer zone as required on both banks.

Optimal restoration (downstream of the 6034 Mission Drive driveway bridge):

- Match proposed cross-section and add meandering pattern to channel.
- Vegetate banks and create buffer zone.
- Remove walls on the left bank and reduce side slopes to 2:1.
- Replace driveway bridge with a wider span bridge. Existing bridge is in poor conditions. Visual inspection suggests that there could be serious problems with the structural integrity of the bridge.
- Vegetate banks and extend buffer zone as required on both banks.



The estimated total cost to make the system-wide improvements is \$1,570,038.

Reach 25
 Mission Hills, Kansas
 Tributary to Brush Creek along Mission Drive beginning
 at the culvert under the intersection of Ensley Lane and
 Mission Drive and ending at the confluence with Brush

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 101,766.00	\$ 101,766.00
2	Mobilization	LS	1	\$ 32,565.00	\$ 32,565.00
3	Traffic Control	LS	1	\$ 8,141.00	\$ 8,141.00
4	New Retaining Wall	SF	4,350	\$ 75.00	\$ 326,250.00
5	New Driveway Bridge	LS	1	\$ 40,000.00	\$ 40,000.00
6	Energy Dissipation Structure	EACH	2	\$ 15,000.00	\$ 30,000.00
7	Streambank Planting	SY	560	\$ 15.00	\$ 8,400.00
8	Sodding	SY	322	\$ 7.50	\$ 2,415.00

Subtotal Construction Cost \$ 549,537.00
 Contingencies @ 25% \$ 137,384.00
Total Construction Cost \$ 686,921.00
 Engineering @ 20% \$ 137,384.00
 Construction Administration @ 7% \$ 48,084.00

Total Cost for Reach 25 \$ 872,389.00

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Reach 26 – Existing Conditions

Location: Brush Creek beginning near the Kansas City County Club entrance and Mission Drive and ends near Brookbank Lane.

Length: 967 feet

Channel Condition Score: 21.8

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received “Good” ratings for showing little signs of bank cutting and mass wasting, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: There is 418 feet of retaining walls on the left descending bank and 586 feet on the right descending bank. The retaining walls on both banks at beginning of the reach are in “Good” condition. All the other retaining walls are in “Fair” condition.

Stream Buffers: There is no stream buffer on the left descending bank along the golf course. The stream buffer on the right descending bank is “Good” at the beginning of the reach and goes to “Acceptable” and then “None” near Brookbank Lane. The stream buffer generally consists of large trees and smaller understory trees and landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 26
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	2	0.8	1.6
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 21.8

OVERALL RANKING Poor

Reach 26 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 312 feet of retaining wall will need to be replaced along this reach and 114 square yards of stream planting and 234 square yards of sodding.

The Stream Reach Rating is 0.63. The estimated total cost to make the localized improvements is \$258,171.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

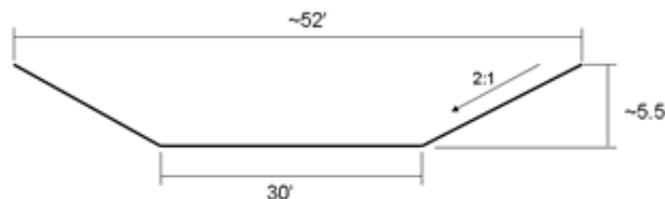
The 1-yr flow for this reach is 2,136 cfs. The following parameters were determined based on Soar and Thorne criteria for a 2,136 cfs flow:

Parameter	Value
Main channel width (w)	52 ft
Wave length (L)	583 ft
Pool-riffle spacing	291 ft
Radius of curvature (Rc)	124 ft
Range *	104-259 ft
Amplitude (Amp)	93 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section (see sketch below).
- Add meandering pattern.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$767,556.

Reach 26
 Mission Hills, Kansas
 Brush Creek beginning near the Kansas City County
 Club entrance and Mission Drive and ends near

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 30,116.00	\$ 30,116.00
2	Mobilization	LS	1	\$ 9,637.00	\$ 9,637.00
3	Traffic Control	LS	1	\$ 2,409.00	\$ 2,409.00
4	New Retaining Wall	SF	1,560	\$ 75.00	\$ 117,000.00
5	Streambank Planting	SY	114	\$ 15.00	\$ 1,710.00
6	Sodding	SY	234	\$ 7.50	\$ 1,755.00

Subtotal Construction Cost	\$	162,627.00
Contingencies @ 25%	\$	40,657.00
Total Construction Cost	\$	203,284.00
Engineering @ 20%	\$	40,657.00
Construction Administration @ 7%	\$	14,230.00

Total Cost for Reach 26 \$ 258,171.00

Reach 27 – Existing Conditions

Location: Brush Creek along Brookbank Lane and Belinder Avenue.

Length: 1,172 feet

Channel Condition Score: 15.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes and a lack of woody vegetation on the banks, a lack of sinuosity. This reach received “Good” ratings for having a radius of curvature to channel width ratio between 3 and 5, showing little signs of bank cutting and mass wasting, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: There is 299 feet of retaining walls on the left descending bank and 651 feet on the right descending bank. The retaining walls on both banks in “Fair” condition.

Stream Buffers: There is no stream buffer on the right descending bank along Brookbank Lane and Belinder Avenue. There is no stream buffer on the left descending bank along the golf course to the end of Brookbank Lane. The stream buffer on the left descending bank is “Good” for the remainder of the reach. The stream buffer generally consists of large trees and smaller understory trees and unmown turf grass along the golf course.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 27
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	2	0.8	1.6
Ratio of radius of curvature to channel width	$3 \leq \text{Rc/Wb} \leq 5$	$2 < \text{Rc/Wb} < 3,$ $5 < \text{Rc/Wb} < 7$	$2 < \text{Rc /Wb},$ $\text{Rc /Wb} > 7$	1	0.8	0.8
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length/Wb} < 8$	$3 \leq \text{Length/Wb} < 4,$ $8 < \text{Length/Wb} \leq 9$	$3 < \text{Length/Wb},$ $\text{Length/Wb} > 9,$ unless long pool or run because of geologic influence	1	0.8	0.8
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 15.6

OVERALL RANKING Fair

Reach 27 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 478 feet of retaining wall will need to be replaced along this reach and 532 square yards of sodding.

The Stream Reach Rating is 1.14. The estimated total cost to make the localized improvements is \$392,707.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

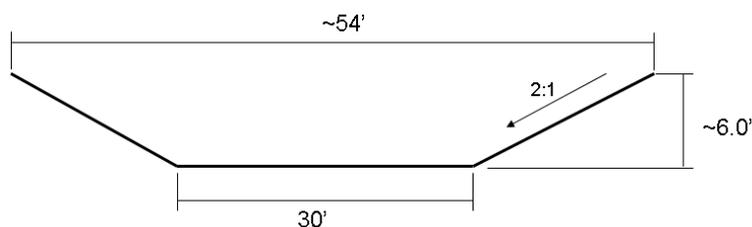
The 1-yr flow for this reach is 2,136 cfs. The following parameters were determined based on Soar and Thorne criteria for a 2,136 cfs flow:

Parameter	Value
Main channel width (w)	52 ft
Wave length (L)	583 ft
Pool-riffle spacing	291 ft
Radius of curvature (Rc)	124 ft
Range *	104-259 ft
Amplitude (Amp)	93 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section (see sketch below).
- Add meandering pattern.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$930,275.

Reach 27
 Mission Hills, Kansas
 Brush Creek along Brookbank Lane and Belinder Avenue

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 45,810.00	\$ 45,810.00
2	Mobilization	LS	1	\$ 14,659.00	\$ 14,659.00
3	Traffic Control	LS	1	\$ 3,665.00	\$ 3,665.00
4	New Retaining Wall	SF	2,390	\$ 75.00	\$ 179,250.00
5	Streambank Planting	SY	0	\$ 15.00	\$ -
6	Sodding	SY	532	\$ 7.50	\$ 3,990.00

Subtotal Construction Cost	\$	247,374.00
Contingencies @ 25%	\$	61,844.00
Total Construction Cost	\$	309,218.00
Engineering @ 20%	\$	61,844.00
Construction Administration @ 7%	\$	21,645.00

Total Cost for Reach 27 \$ 392,707.00

Reach 28 – Existing Conditions

Location: Rock Creek along State Park Road.

Length: 3,230 feet

Channel Condition Score: 15.4

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having a lack of woody vegetation on the banks. This reach received “Good” ratings for having a radius of curvature to channel width ratio between 3 and 5, showing little signs mass wasting, having narrow bar development, having small amounts of debris in the channel and a few small obstructions in the channel. Many stability indicators from the Channel Condition Scoring Matrix were given a “Fair” rating. The end of this reach was included in the Belinder Low-Water Crossing Project (2014).

Retaining Walls: There is 1,149 feet of retaining walls on the left descending bank and 568 feet on the right descending bank. There is 181 feet of retaining wall on the left descending bank in “Good” condition, and the rest of the retaining walls on both banks are in “Fair” condition.

Stream Buffers: There is no stream buffer on the left descending bank for a majority of the reach. There is approximately 520-foot section of “Good” stream buffer midway along the reach. There is no stream buffer on the right descending bank for a majority of the reach with the exception of two areas of “Good” stream buffer and one area of “Excellent” stream buffer. The stream buffer generally consists of large trees with small understory trees and unmown turf grass through the golf course.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 28
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	2	0.6	1.2
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	2	0.8	1.6
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	1	0.8	0.8
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	1	0.8	0.8
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	1	0.8	0.8

TOTAL 15.4

OVERALL RANKING Fair

Reach 28 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included.

An estimated 800 feet of retaining wall will need to be replaced along this reach and 893 square yards of sodding associated with the retaining wall. Approximately 850 feet of streambank will need to be regraded and restored.

The Stream Reach Rating is 1.11. The estimated total cost to make the localized improvements is \$1,243,705.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 1,520 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,520 cfs flow:

Parameter	Value
Main channel width (w)	44 ft
Wave length (L)	492 ft
Pool-riffle spacing	246 ft
Radius of curvature (Rc)	105 ft
Range *	87-218 ft
Amplitude (Amp)	79 ft

* Absolute minimum – APWA max

Optimal restoration (upper 1,600 feet of reach):

- Remove walls and match proposed cross-section.
- Create flood benches and add walls as necessary.
- Add meander pattern to channel.
- Replace two pedestrian bridges to accommodate new proposed geometry.
- Vegetate banks and flood benches and create buffer zone.

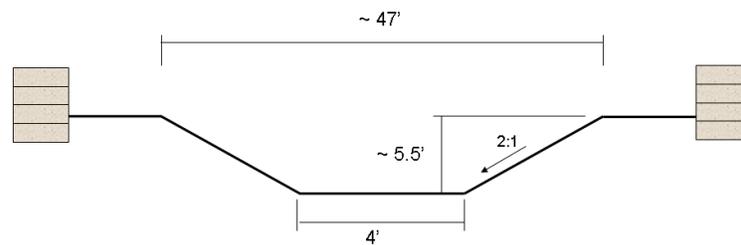
Optimal restoration (middle 90 feet of reach):

- Remove walls and match proposed cross-section.
- Create flood benches and add walls as necessary.
- Add meander pattern to channel.

- Move concrete weir upstream. The new weir should be placed in between meanders. This will significantly reduce the impact the existing weir is having on the right bank located immediately downstream from the weir.
- Vegetate banks and flood benches and create buffer zone.

Optimal restoration (lower 920 feet of reach):

- Remove walls and match proposed cross-section.
- Create flood benches and add walls as necessary.
- Add meander pattern to channel.
- Replace pedestrian bridge to accommodate new proposed geometry.
- Remove low-water crossing or rebuild to accommodate new proposed geometry.
- Replace sanitary sewer crossing to accommodate new proposed geometry.
- Vegetate banks and flood benches and create buffer zone.



The estimated total cost to make the system-wide improvements is \$2,948,781.

Reach 28
Mission Hills, Kansas
Rock Creek along State Park Road

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 145,081.00	\$ 145,081.00
2	Mobilization	LS	1	\$ 46,426.00	\$ 46,426.00
3	Traffic Control	LS	1	\$ 11,606.00	\$ 11,606.00
4	New Retaining Wall	SF	4,815	\$ 75.00	\$ 361,125.00
5	Streambank Reshaping	LF	850	\$ 250.00	\$ 212,500.00
6	Streambank Planting	SY	0	\$ 15.00	\$ -
7	Sodding	SY	893	\$ 7.50	\$ 6,698.00

Subtotal Construction Cost	\$	783,436.00
Contingencies @ 25%	\$	195,859.00
Total Construction Cost	\$	979,295.00
Engineering @ 20%	\$	195,859.00
Construction Administration @ 7%	\$	68,551.00

Total Cost for Reach 28 \$ 1,243,705.00

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Reach 29 – Existing Conditions

Location: Brush Creek downstream of the Belinder Avenue low-water crossing to a pedestrian bridge on the Mission Hills Country Club.

Length: 1,405 feet

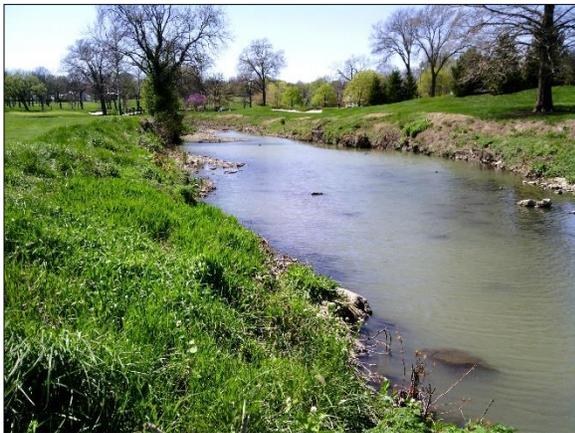
Channel Condition Score: 16.4

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having a lack of woody vegetation on the banks. This reach received “Good” ratings for having a radius of curvature to channel width ratio between 3 and 5, showing little signs of bank cutting and mass wasting, having small amounts of debris in the channel, and a few small obstructions in the channel. This reach was part of the Brush Creek, Belinder Avenue to East Mission Drive Project (2017).

Retaining Walls: There is 415 feet of retaining walls on the left descending bank and 131 feet on the right descending bank. The retaining walls on the left descending bank is in “Fair” condition. The retaining wall on the right descending bank is in “Poor” condition.

Stream Buffers: The stream buffer on the left descending bank is “Good” for the entire reach. The stream buffer on the right descending bank is “Good” for a majority of the reach, except for the last 100 feet where it is “Acceptable”. The stream buffer generally consists of large trees and smaller understory trees and unmown turf grass along the golf course.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 29
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	2	0.6	1.2
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	2	0.8	1.6
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	1	0.8	0.8
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	1	0.8	0.8
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 16.4

OVERALL RANKING Fair

Reach 29 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included. Other improvements include bank reshaping and constructing a drop structure,

An estimated 337 feet of retaining wall will need to be replaced along this reach and 375 square yards of sodding associated with the retaining wall. Approximately 340 feet of streambank will need to be regraded and restored.

The Stream Reach Rating is 1.29. The estimated total cost to make the localized improvements is \$618,641.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 3,508 cfs. The following parameters were determined based on Soar and Thorne criteria for a 3,508 cfs flow:

Parameter	Value
Main channel width (w)	66 ft
Wave length (L)	747 ft
Pool-riffle spacing	373 ft
Radius of curvature (Rc)	159 ft
Range *	133-332 ft
Amplitude (Amp)	120 ft

* Absolute minimum – APWA max

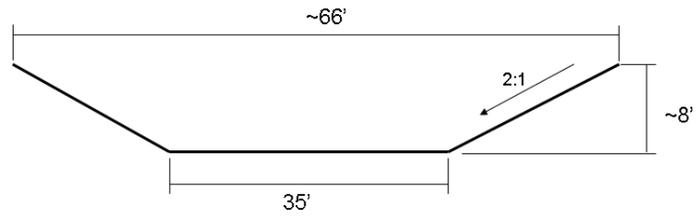
Water flow through this segment is controlled by the low water crossing located at the downstream end. This feature effectively produces a flat streambed along this stream segment causing backwater effects throughout the stream segment.

To allow water to move slightly faster through the segment, it is recommended to remove the low water crossing. If crossing the stream at this location is necessary, the low water crossing can be moved upstream or upstream of the bend to a point where a riffle would naturally occur. The new water crossing would have to be a culvert or low bridge that would at least allow the channel forming flow to pass without producing a backwater effect. Removing the low water crossing would increase the channel slope.

Optimal restoration (upper 1,400 feet of reach):

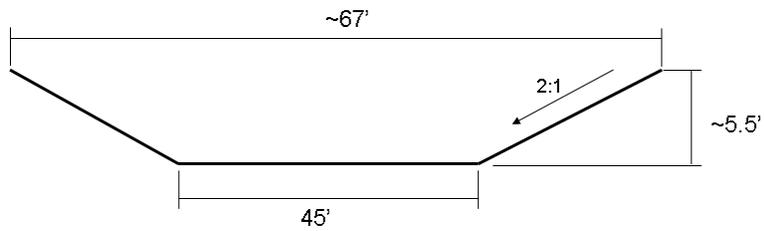
- Remove walls and match proposed cross-section.
- Add meander pattern to channel.

- Stabilize knickpoint by building a drop structure.
- Vegetate banks and create buffer zone.



Optimal restoration (lower 240 feet of reach):

- Remove walls and match proposed cross-section.
- Add meander pattern to channel.
- Relocate sewer if necessary to accommodate widened channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$1,139,031.

Reach 29
 Mission Hills, Kansas
 Brush Creek downstream of the Belinder Avenue low-
 water crossing to a pedestrian bridge on the Mission Hills
 Country Club

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 72,166.00	\$ 72,166.00
2	Mobilization	LS	1	\$ 23,093.00	\$ 23,093.00
3	Traffic Control	LS	1	\$ 5,773.00	\$ 5,773.00
4	New Retaining Wall	SF	2,478	\$ 75.00	\$ 185,850.00
5	Streambank Reshaping	LF	340	\$ 250.00	\$ 85,000.00
6	Drop Structure	EA	1	\$ 15,000.00	\$ 15,000.00
7	Streambank Planting	SY	0	\$ 15.00	\$ -
8	Sodding	SY	375	\$ 7.50	\$ 2,813.00

Subtotal Construction Cost	\$	389,695.00
Contingencies @ 25%	\$	97,424.00
Total Construction Cost	\$	487,119.00
Engineering @ 20%	\$	97,424.00
Construction Administration @ 7%	\$	34,098.00

Total Cost for Reach 29 \$ 618,641.00

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Reach 30 – Existing Conditions

Location: Brush Creek along Mission Drive downstream of a pedestrian bridge on the Mission Hills Country Club to near the intersection of Mission Drive and East Mission Drive.

Length: 974 feet

Channel Condition Score: 22.4

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, a lack of woody vegetation on the banks, frequent bank cutting and mass wasting, and bar widths greater than ½ the stream width. This reach received “Good” ratings for having small amounts of debris in the channel and a few small obstructions in the channel. This reach was part of the Brush Creek, Belinder Avenue to East Mission Drive Project (2017) and also the Brush Creek Ramp Project (2013).

Retaining Walls: There is 348 feet of retaining walls on the left descending bank and 475 feet on the right descending bank. The retaining walls on the left descending bank is in “Fair” condition, except for a 46-foot section in “Poor” condition. The retaining walls on the right descending bank are in “Fair” condition except a 78-foot section in “Good” condition which was replaced as part of the Brush Creek Ramp Project (2013).

Stream Buffers: The stream buffer on the left descending bank is “Good” for the entire reach. The stream buffer on the right descending bank is “Acceptable” for the first 444 feet, and there is no stream buffer for the remainder of the reach. The stream buffer generally consists of large trees and smaller understory trees and unmown turf grass along the golf course.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 30
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	3	0.4	1.2
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	3	0.8	2.4

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	3	0.6	1.8
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	2	0.8	1.6
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	2	0.8	1.6
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	3	0.8	2.4

TOTAL 22.4

OVERALL RANKING Poor

Reach 30 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping is also included. Bank reshaping is also included.

An estimated 371 feet of retaining wall will need to be replaced along this reach and 413 square yards of sodding associated with the retaining wall. Approximately 450 feet of streambank will need to be regraded and restored.

The Stream Reach Rating is 0.67. The estimated total cost to make the localized improvements is \$884,169.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

The 1-yr flow for this reach is 3,508 cfs. The following parameters were determined based on Soar and Thorne criteria for a 3,508 cfs flow:

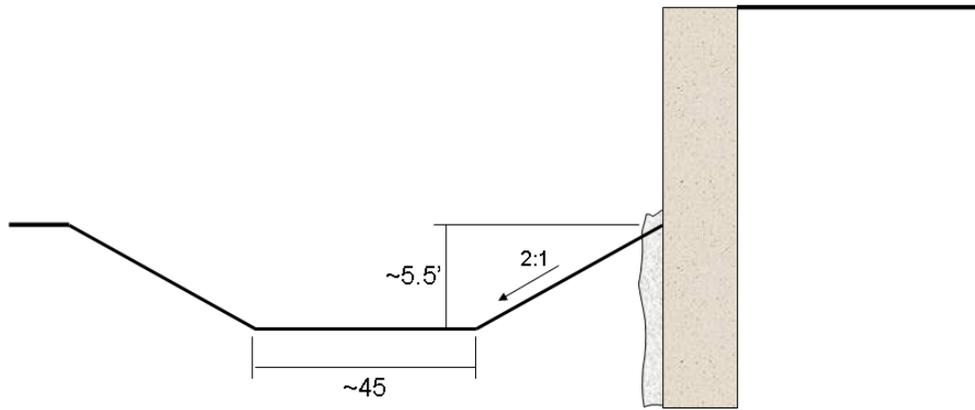
Parameter	Value
Main channel width (w)	66 ft
Wave length (L)	747 ft
Pool-riffle spacing	373 ft
Radius of curvature (Rc)	159 ft
Range *	133-332 ft
Amplitude (Amp)	120 ft

* Absolute minimum – APWA max

True optimal conditions are not possible to obtain in this stream segment without removing the existing home located on the right bank. Because this segment is located in between bends it is possible to allow the home to remain without significantly altering typical stable stream conditions.

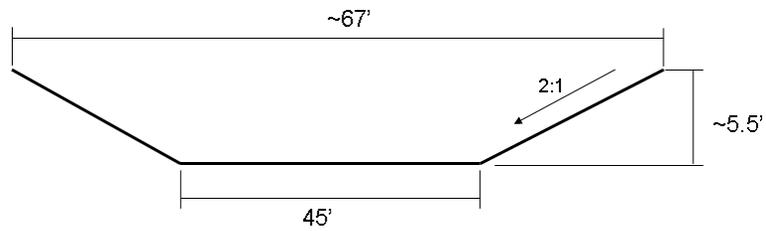
Optimal restoration (upper 370 feet):

- Match proposed cross-section (see sketch below).
- Repair wall where needed. Use same material for the entire wall for aesthetic reasons. The wall should be keyed into the channel side slope on both the upstream and downstream side to create a smooth transition between the sloped banks and the wall.
- Create a stable riffle through this reach by placing large rocks.
- Vegetate banks and create buffer zone.



Optimal restoration (lower 320 feet):

- Remove wall on left bank and match proposed cross-section (see sketch below).
- Modify meandering pattern to obtain smoother bend.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$1,535,113.

Reach 30
 Mission Hills, Kansas
 Brush Creek along Mission Drive downstream of a
 pedestrian bridge on the Mission Hills Country Club to
 near the intersection of Mission Drive and East Mission

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 103,140.00	\$ 103,140.00
2	Mobilization	LS	1	\$ 33,005.00	\$ 33,005.00
3	Traffic Control	LS	1	\$ 8,251.00	\$ 8,251.00
4	New Retaining Wall	SF	3,960	\$ 75.00	\$ 296,963.00
5	Streambank Reshaping	LF	450	\$ 250.00	\$ 112,500.00
6	Streambank Planting	SY	0	\$ 15.00	\$ -
7	Sodding	SY	413	\$ 7.50	\$ 3,098.00

Subtotal Construction Cost \$ 556,957.00
 Contingencies @ 25% \$ 139,239.00
Total Construction Cost \$ 696,196.00
 Engineering @ 20% \$ 139,239.00
 Construction Administration @ 7% \$ 48,734.00

Total Cost for Reach 30 \$ 884,169.00

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Reach 31 – Existing Conditions

Location: Brush Creek along the United Presbyterian Village Church ending along W. 66th Street at the Indian Lane culvert.

Length: 944 feet

Channel Condition Score: 17.0

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes and a lack of woody vegetation on the banks. This reach received “Good” ratings for having bank heights less than six feet, little evidence of bank cutting and infrequent mass wasting, small amounts of debris in the channel, a sinuosity between 1.2 and 1.4, and a radius of curvature to channel width ratio between 3 and 5.

Retaining Walls: There are a total of 412 feet of retaining wall on the left descending bank and 346 feet of retaining wall on the right descending bank. A 142-foot section of gabion retaining wall on the left descending bank and a 316-foot section of concrete retaining wall on the right descending bank are in “Fair” condition. A 248-foot section on the left descending bank is in “Poor” condition. The remaining retaining walls are in “Good” condition.

Stream Buffers: The stream buffer condition ranges from “Good” at 5 to 15 feet wide to “Acceptable” at 1 to 5 feet wide on the left descending bank behind the church parking lot. There is no stream buffer on the left descending bank along W. 66th Street. The stream buffer on the right descending bank ranges from “Excellent” at greater than 15 feet wide to “Good” along the church parking lot and part of W. 66th Street. There is no stream buffer on the right descending bank approaching the Indian Lane culvert. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 31
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	2	0.6	1.2
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	1	0.8	0.8
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	1	0.8	0.8
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 17.0

OVERALL RANKING Fair

Reach 31 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping and restoration is also included.

An estimated 485 feet of retaining wall will need to be replaced along this reach and 262 square yards of stream planting and 280 square yards of sodding. Approximately 250 feet of streambank will need to be reshaped and restored.

The Stream Reach Rating is 1.18. The estimated total cost to make the localized improvements is \$650,127.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

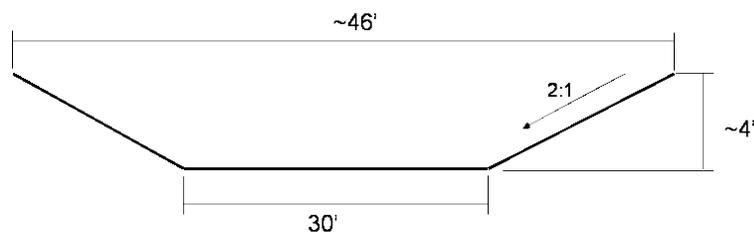
The 1-yr flow for this reach is 1,593 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,593 cfs flow:

Parameter	Value
Main channel width (w)	45 ft
Wave length (L)	503 ft
Pool-riffle spacing	252 ft
Radius of curvature (Rc)	107 ft
Range *	89-224 ft
Amplitude (Amp)	81 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove walls and match proposed cross-section (see sketch below).
- Add meandering pattern to channel.
- Replace Indian Lane Bridge to accommodate widened channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$812,800.

Reach 31
Mission Hills, Kansas
Brush Creek along the United Presbyterian Village
Church ending along W. 66th Street at the Indian Lane

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 75,839.00	\$ 75,839.00
2	Mobilization	LS	1	\$ 24,268.00	\$ 24,268.00
3	Traffic Control	LS	1	\$ 6,067.00	\$ 6,067.00
4	New Retaining Wall	SF	3,131	\$ 75.00	\$ 234,825.00
5	Streambank Reshaping	LF	250	\$ 250.00	\$ 62,500.00
6	Streambank Planting	SY	262	\$ 15.00	\$ 3,930.00
7	Sodding	SY	280	\$ 7.50	\$ 2,100.00

Subtotal Construction Cost \$ 409,529.00
 Contingencies @ 25% \$ 102,382.00
Total Construction Cost \$ 511,911.00
 Engineering @ 20% \$ 102,382.00
 Construction Administration @ 7% \$ 35,834.00

Total Cost for Reach 31 \$ 650,127.00

Reach 32 – Existing Conditions

Location: Tributary to Brush Creek along Pembroke Lane near State Line Road.

Length: 371 feet

Channel Condition Score: 19.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having a lack of woody vegetation on the banks, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received “Good” ratings for showing little signs of bank cutting and mass wasting, narrow bar widths, having small amounts of debris in the channel and a few small obstructions in the channel. This reach was part of the Pembroke Lane Street and Stormwater Improvements Project (2014)

Retaining Walls: There is 186 feet of retaining wall on the left descending bank and 173 feet on the right descending bank. The retaining walls on both banks are in “Good” condition.

Stream Buffers: There is no stream buffer on either bank for a majority of the reach, except for one location on each bank where the stream buffer is “Acceptable”. The stream buffer generally consists of large trees and landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 32
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	3	0.6	1.8
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	2	0.6	1.2
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 19.6

OVERALL RANKING Fair

Reach 32 – Proposed Improvements

Localized Improvements: The retaining walls along this reach are in “Good” condition. Localized improvements for this reach include streambank reshaping and restoration.

An estimated 150 feet of streambank will need to be reshaped and restored.

The Stream Reach Rating is 1.75. The estimated total cost to make the localized improvements is \$58,896.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

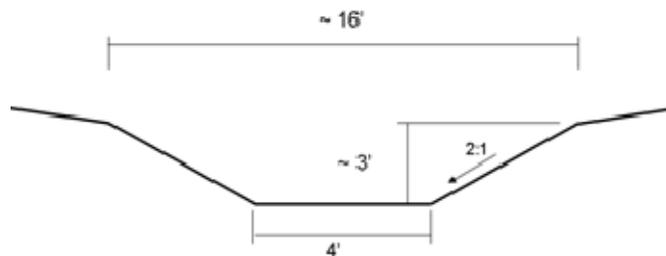
The 1-yr flow for this reach is 165 cfs. The following parameters were determined based on Soar and Thorne criteria for a 165 cfs flow:

Parameter	Value
Main channel width (w)	11 ft
Wave length (L)	162 ft
Pool-riffle spacing	81 ft
Radius of curvature (Rc)	35 ft
Range *	29-130 ft
Amplitude (Amp)	26 ft

* Absolute minimum – APWA max

Optimal restoration (upper 130 feet):

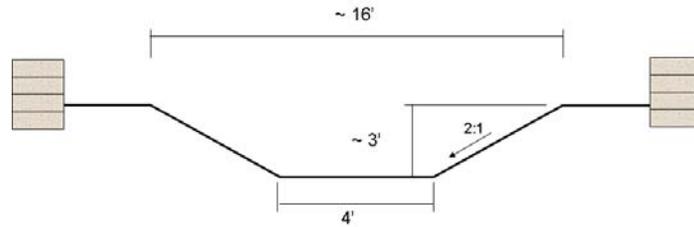
- Remove retaining walls and match proposed cross-section.
- Add meander pattern to channel.
- Stabilize banks using 2:1 slope. Create flood benches (see sketch below).
- Replace bridge if necessary to accommodate new proposed geometry.
- Vegetate banks and flood benches and create buffer zone.



Optimal restoration (lower 240 feet):

- Remove retaining walls and match proposed cross-section.
- Add meander pattern to channel.

- Stabilize banks using 2:1 slope. Create flood benches and building walls as needed for bank stability (see sketch below).
- Replace bridge if necessary to accommodate new proposed geometry.
- Vegetate banks and flood benches and create buffer zone.



The estimated total cost to make the system-wide improvements is \$522,288.

Reach 32
Mission Hills, Kansas
Tributary to Brush Creek along Pembroke Lane near
State Line Road

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

This reach did not contain any retaining walls rated "Fair" or "Poor". The reach received a "Fair" Channel Condition Ranking indicating significant instability issues. The CCSM identified lack of woody bank vegetation, poor sinuosity, and pool riffle spacing contributing to the instability. The cost of the improvements to this reach is \$58,896.00.

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Reach 33 – Existing Conditions

Location: Tributary to Brush Creek along Pembroke Lane downstream of Reach 32.

Length: 254 feet

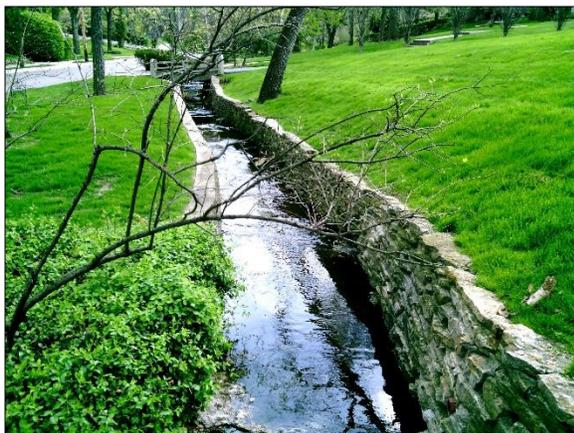
Channel Condition Score: 21.8

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, a lack of woody vegetation on the banks, frequent evidence of mass wasting, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received “Good” ratings for showing little signs of bank cutting, bank heights less than six feet, narrow bar widths, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: There is 95 feet of retaining wall on the left descending bank and 132 feet on the right descending bank. The retaining wall on the left descending bank is in “Poor” condition. 96 feet of retaining wall on the right descending bank is in “Poor” condition, and the remaining wall on the right descending bank is in “Fair” condition.

Stream Buffers: There is no stream buffer on either bank for the first half of the reach and “Acceptable” for the second half of the reach. The stream buffer generally consists of large trees and landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 33
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	3	0.6	1.8
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	3	0.8	2.4

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	Sinuosity < 1.1	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 21.8

OVERALL RANKING Poor

Reach 33 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 210 feet of retaining wall will need to be replaced along this reach and 106 square yards of streambank planting and 233 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 0.69. The estimated total cost to make the localized improvements is \$175,120.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

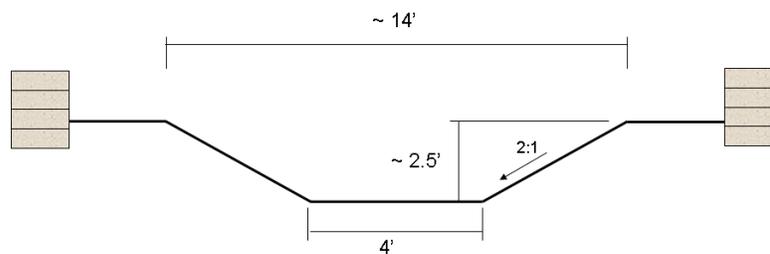
The 1-yr flow for this reach is 165 cfs. The following parameters were determined based on Soar and Thorne criteria for a 165 cfs flow:

Parameter	Value
Main channel width (w)	11 ft
Wave length (L)	162 ft
Pool-riffle spacing	81 ft
Radius of curvature (Rc)	35 ft
Range *	29-130 ft
Amplitude (Amp)	26 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove retaining walls and match proposed cross-section.
- Add meander pattern to channel.
- Stabilize banks using 2:1 slope. Create flood benches (see sketch below).
- Replace bridge if necessary to accommodate new proposed geometry.
- Vegetate banks and flood benches and create buffer zone.



The estimated total cost to make the system-wide improvements is \$411,956.

Reach 33
 Mission Hills, Kansas
 Tributary to Brush Creek along Pembroke Lane
 downstream of Reach 32

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 20,428.00	\$ 20,428.00
2	Mobilization	LS	1	\$ 6,537.00	\$ 6,537.00
3	Traffic Control	LS	1	\$ 1,634.00	\$ 1,634.00
4	New Retaining Wall	SF	1,045	\$ 75.00	\$ 78,375.00
5	Streambank Planting	SY	106	\$ 15.00	\$ 1,590.00
6	Sodding	SY	233	\$ 7.50	\$ 1,748.00

Subtotal Construction Cost	\$	110,312.00
Contingencies @ 25%	\$	27,578.00
Total Construction Cost	\$	137,890.00
Engineering @ 20%	\$	27,578.00
Construction Administration @ 7%	\$	9,652.00

Total Cost for Reach 33 \$ 175,120.00

Reach 34 – Existing Conditions

Location: Tributary to Brush Creek along East Mission Drive downstream of Reach 33.

Length: 1,048 feet

Channel Condition Score: 17.4

Channel Condition Ranking: Fair

Channel Condition Description: This reach is a concrete lined channel with short retaining walls (< 6' tall) on each bank for the entire length of the reach. This reach received "Poor" ratings for having steep bank slopes, a lack of woody vegetation on the banks, a lack of sinuosity, and a high radius of curvature to channel width ratio. This reach received "Good" ratings for showing little signs of bank cutting and mass wasting, bank heights less than six feet, narrow bar widths, having small amounts of debris in the channel and a few small obstructions in the channel.

Retaining Walls: There is 908 feet of retaining wall on the left descending bank and 894 feet on the right descending bank. The retaining walls on both banks are in "Fair" condition.

Stream Buffers: There is no stream buffer on either bank for a majority of the reach. The stream buffer is "Good" approaching the confluence with Brush Creek. The stream buffer generally consists of large trees and landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 34
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	1	0.8	0.8

TOTAL 17.4

OVERALL RANKING Fair

Reach 34 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 885 feet of retaining wall will need to be replaced along this reach and 272 square yards of streambank planting and 713 square yards of sodding associated with the retaining wall.

The Stream Reach Rating is 1.17. The estimated total cost to make the localized improvements is \$731,455.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

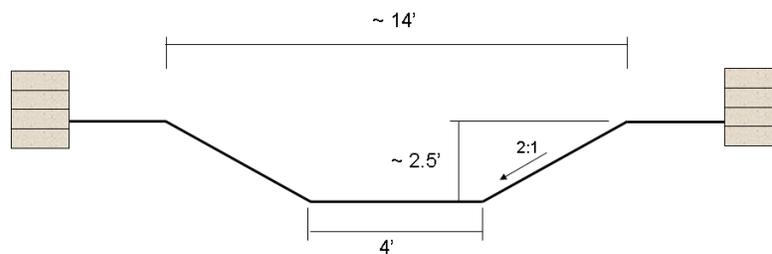
The 1-yr flow for this reach is 165 cfs. The following parameters were determined based on Soar and Thorne criteria for a 165 cfs flow:

Parameter	Value
Main channel width (w)	11 ft
Wave length (L)	162 ft
Pool-riffle spacing	81 ft
Radius of curvature (Rc)	35 ft
Range *	29-130 ft
Amplitude (Amp)	26 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove retaining walls and match proposed cross-section.
- Add meander pattern to channel.
- Stabilize banks using 2:1 slope. Create flood benches (see sketch below).
- Replace bridge if necessary to accommodate new proposed geometry.
- Vegetate banks and flood benches and create buffer zone.



The estimated total cost to make the system-wide improvements is \$1,349,375.

Reach 34
Mission Hills, Kansas
Tributary to Brush Creek along East Mission Drive
downstream of Reach 33

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 85,326.00	\$ 85,326.00
2	Mobilization	LS	1	\$ 27,304.00	\$ 27,304.00
3	Traffic Control	LS	1	\$ 6,826.00	\$ 6,826.00
4	New Retaining Wall	SF	4,425	\$ 75.00	\$ 331,875.00
5	Streambank Planting	SY	272	\$ 15.00	\$ 4,080.00
6	Sodding	SY	713	\$ 7.50	\$ 5,348.00

Subtotal Construction Cost	\$	460,759.00
Contingencies @ 25%	\$	115,190.00
Total Construction Cost	\$	575,949.00
Engineering @ 20%	\$	115,190.00
Construction Administration @ 7%	\$	40,316.00

Total Cost for Reach 34 \$ 731,455.00

Reach 35 – Existing Conditions

Location: Brush Creek within Mission Hills Country Club near the Mission Drive and State Line Road.

Length: 1,005 feet

Channel Condition Score: 19.6

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes and a lack of woody vegetation on the banks. This reach received “Good” ratings for having little evidence of mass wasting and small amounts of debris in the channel and a few small obstructions in the channel. Many of the stream stability indicators within the Channel Condition Scoring Matrix received a “Fair” rating.

Retaining Walls: There is 243 feet of retaining walls on the left descending bank and 317 feet on the right descending bank. 288 feet of the retaining wall on the right descending bank is gabion wall. The retaining wall on the left descending bank is in “Poor” condition. The retaining walls on the right descending bank are in “Fair” condition.

Stream Buffers: There is no stream buffer on either bank along this reach.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 35
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	3	0.6	1.8
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	2	0.8	1.6
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	2	0.8	1.6
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	2	0.8	1.6
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 19.6

OVERALL RANKING Fair

Reach 35 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping and restoration is also included.

An estimated 448 feet of retaining wall will need to be replaced along this reach and 498 square yards of sodding. Approximately 400 feet of streambank will need to be reshaped and restored.

The Stream Reach Rating is 1.20. The estimated total cost to make the localized improvements is \$666,589.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

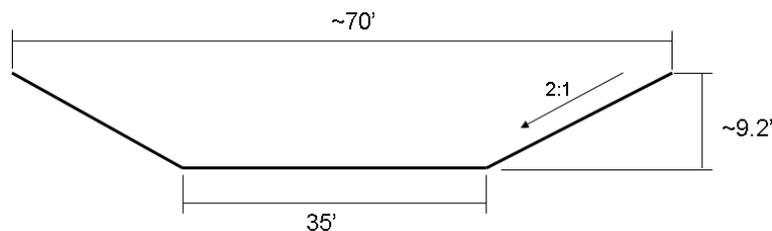
The 1-yr flow for this reach is 3,410 cfs. The following parameters were determined based on Soar and Thorne criteria for a 3,410 cfs flow:

Parameter	Value
Main channel width (w)	65 ft
Wave length (L)	736 ft
Pool-riffle spacing	368 ft
Radius of curvature (Rc)	157 ft
Range *	131-327 ft
Amplitude (Amp)	118 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section.
- Remove walls and reduce side slopes to 2:1 (see sketch below).
- Replace two pedestrian bridges to accommodate wider channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$861,219.

Reach 35
 Mission Hills, Kansas
 Brush Creek within Mission Hills Country Club near the
 Mission Drive and State Line Road

Date: 9/21/17
 By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 77,759.00	\$ 77,759.00
2	Mobilization	LS	1	\$ 24,883.00	\$ 24,883.00
3	Traffic Control	LS	1	\$ 6,221.00	\$ 6,221.00
4	New Retaining Wall	SF	2,764	\$ 75.00	\$ 207,300.00
5	Streambank Reshaping	LF	400	\$ 250.00	\$ 100,000.00
6	Streambank Planting	SY	0	\$ 15.00	\$ -
7	Sodding	SY	498	\$ 7.50	\$ 3,735.00

Subtotal Construction Cost \$ 419,898.00
 Contingencies @ 25% \$ 104,975.00
Total Construction Cost \$ 524,873.00
 Engineering @ 20% \$ 104,975.00
 Construction Administration @ 7% \$ 36,741.00

Total Cost for Reach 35 \$ 666,589.00

Reach 36 – Existing Conditions

Location: Brush Creek within Mission Hills Country Club downstream of Reach 35 and ending at State Line Road.

Length: 759 feet

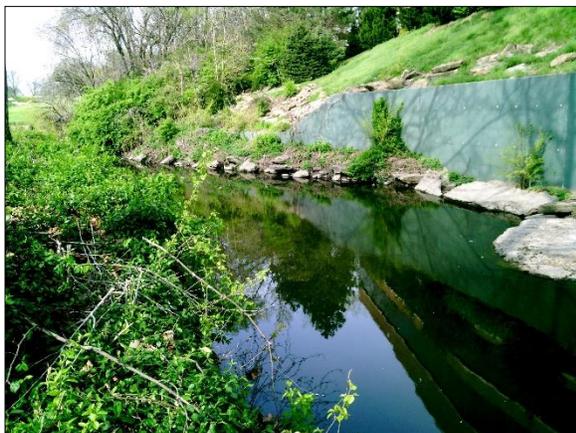
Channel Condition Score: 18.8

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having steep bank slopes, bank heights higher than 15 feet, a lack of woody vegetation on the banks, and a lack of sinuosity. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting, small amounts of debris in the channel, and a few small obstructions in the channel.

Retaining Walls: There is 322 feet of retaining walls on the left descending bank and 345 feet on the right descending bank. 178 feet of the right descending bank retaining wall is gabion wall. The retaining walls on both banks are in “Fair” condition.

Stream Buffers: There is no stream buffer for a majority of the reach on the left descending bank before changing to “Good” just upstream of State Line Road. There is no stream buffer on the right descending bank for the first half of the reach. The stream buffer on the right descending bank is “Acceptable” for the second half of the reach. The stream buffer generally consists of large trees with small understory trees and unmown turf grass through the golf course.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 36
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	3	0.8	2.4
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	2	0.8	1.6
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	1	0.8	0.8
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 18.8

OVERALL RANKING Fair

Reach 36 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” and “Poor” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity. Streambank reshaping and restoration is also included.

An estimated 338 feet of retaining wall will need to be replaced along this reach and 177 square yards of streambank planting and 200 square yards of sodding. Approximately 300 feet of streambank will need to be reshaped and restored.

The Stream Reach Rating is 1.20. The estimated total cost to make the localized improvements is \$474,472.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

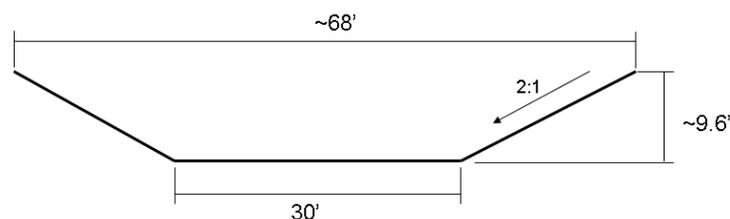
The 1-yr flow for this reach is 3,433 cfs. The following parameters were determined based on Soar and Thorne criteria for a 3,433 cfs flow:

Parameter	Value
Main channel width (w)	66 ft
Wave length (L)	739 ft
Pool-riffle spacing	369 ft
Radius of curvature (Rc)	157 ft
Range *	131-328 ft
Amplitude (Amp)	118 ft

* Absolute minimum – APWA max

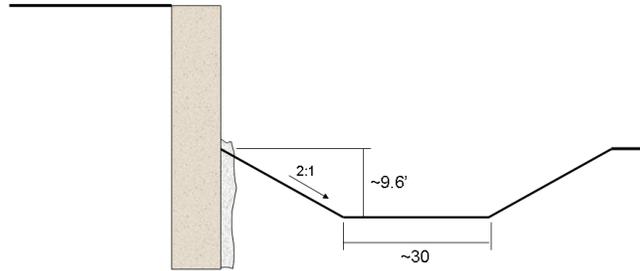
Optimal restoration (upper 500 feet):

- Match proposed cross-section.
- Modify meandering pattern to increase sinuosity.
- Remove wall and reduce side slopes to 2:1 (see sketch below).
- Replace pedestrian bridge to accommodate wider channel.
- Vegetate banks and create buffer zone.



Optimal restoration (lower 250 feet):

- Removing the existing wall on the left bank would be ideal, but it may compromise the foundations of the adjacent building, thus removing the wall is not advisable and may not be feasible.
- A stable channel can still be achieved by modifying the meandering pattern and matching the proposed cross section (see sketch below).
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$634,206.

Reach 36
Mission Hills, Kansas
Brush Creek within Mission Hills Country Club
downstream of Reach 35 and ending at State Line Road

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 55,348.00	\$ 55,348.00
2	Mobilization	LS	1	\$ 17,711.00	\$ 17,711.00
3	Traffic Control	LS	1	\$ 4,428.00	\$ 4,428.00
4	New Retaining Wall	SF	1,897	\$ 75.00	\$ 142,238.00
5	Streambank Reshaping	LF	300	\$ 250.00	\$ 75,000.00
6	Streambank Planting	SY	177	\$ 15.00	\$ 2,655.00
7	Sodding	SY	200	\$ 7.50	\$ 1,500.00

Subtotal Construction Cost	\$	298,880.00
Contingencies @ 25%	\$	74,720.00
Total Construction Cost	\$	373,600.00
Engineering @ 20%	\$	74,720.00
Construction Administration @ 7%	\$	26,152.00

Total Cost for Reach 36 \$ 474,472.00

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Reach 37 – Existing Conditions

Location: Brush Creek along Mission Road immediately north of W. 71st Street.

Length: 665 feet

Channel Condition Score: 21.8

Channel Condition Ranking: Poor

Channel Condition Description: This reach received “Poor” ratings for having bank angles greater than 60 degrees, frequent evidence of mass wasting, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having cohesive bank materials and small amounts of debris in the channel. Many of the Channel Condition Scoring Matrix stream stability indicators were given a “Fair” rating.

Retaining Walls: There are no retaining wall along this reach.

Stream Buffers: The stream buffer condition is “Good” at 5 to 15 feet wide on both banks. The stream buffer generally consists of large trees and smaller understory trees.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 37
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	2	0.4	0.8
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	3	0.8	2.4

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	2	0.6	1.2
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	2	0.2	0.4
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 21.8

OVERALL RANKING Poor

Reach 37 – Proposed Improvements

Localized Improvements: There are no walls along this reach. Localized improvements for this reach include streambank reshaping and restoration.

An estimated 500 feet of streambank will need to be reshaped and restored.

The Stream Reach Rating is 2.50. The estimated total cost to make the localized improvements is \$197,942.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

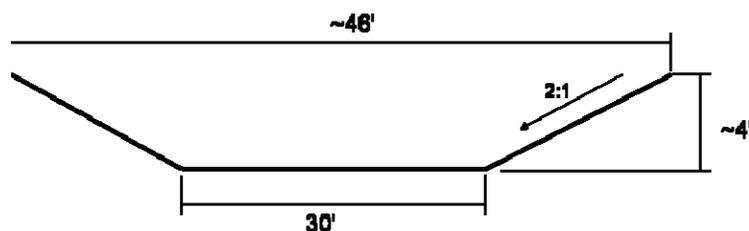
The 1-yr flow for this reach is 1,593 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1,593 cfs flow:

Parameter	Value
Main channel width (w)	45 ft
Wave length (L)	503 ft
Pool-riffle spacing	252 ft
Radius of curvature (Rc)	107 ft
Range *	89-224 ft
Amplitude (Amp)	81 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section (see sketch below).
- Add meandering pattern to channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$527,844.

Reach 37
Mission Hills, Kansas
Brush Creek along Mission Road immediately north of W.
71st Street

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

This reach did not contain any retaining walls rated "Fair" or "Poor". The reach received a "Poor" Channel Condition Ranking indicating significant instability issues. The CCSM identified steep bank angles, lack of woody bank vegetation, frequent evidence of mass wasting, poor sinuosity, and pool riffle spacing contributing to the instability. The cost of the improvements to this reach is \$197,942.00.

Reach 38 – Existing Conditions

Location: Tributary to Brush Creek between the Seneca Road culvert and Wenonga Road culvert.

Length: 355 feet

Channel Condition Score: 19.4

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having bank angles greater than 60 degrees, lack of woody vegetation, and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having little evidence of bank cutting and mass wasting, narrow bar widths, small amounts of debris in the channel, few obstructions in the channel, and a sinuosity between 1.2 and 1.4.

Retaining Walls: There are a total of 195 feet on the left descending bank and 188 feet of retaining wall on the right descending bank. The retaining walls on both banks are in “Fair” condition.

Stream Buffers: The stream buffer condition is “Good” at 5 to 15 feet wide for most of the left descending bank. There is no stream buffer on the right descending bank. The stream buffer generally consists of large trees and residential landscaping at the top of the retaining walls.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 38
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	3	0.6	1.8
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	2	0.8	1.6
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	1	0.2	0.2
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	Sinuosity < 1.1	1	0.8	0.8
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 19.4

OVERALL RANKING Fair

Reach 38 – Proposed Improvements

Localized Improvements: The localized improvements for this reach include repairing/replacing the sections of retaining walls in “Fair” condition along the reach. Site restoration includes Streambank Planting and Sodding. Streambank Planting includes planting native vegetation along the stream bank above the repaired/replaced retaining walls to restore/improve the stream buffer where space is allowed. Sodding includes restoring all other areas disturbed by construction activity.

An estimated 192 feet of retaining wall will need to be replaced along this reach and 215 square yards of sodding.

The Stream Reach Rating is 1.50. The estimated total cost to make the localized improvements is \$127,222.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

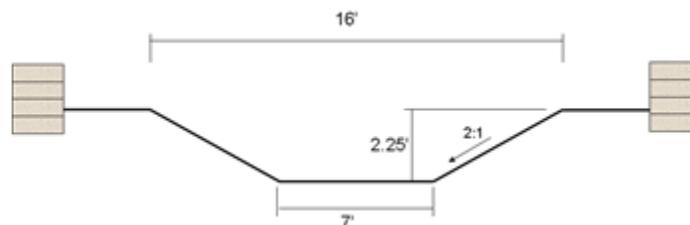
The 1-yr flow for this reach is 185 cfs. The following parameters were determined based on Soar and Thorne criteria for a 185 cfs flow:

Parameter	Value
Main channel width (w)	15 ft
Wave length (L)	172 ft
Pool-riffle spacing	86 ft
Radius of curvature (Rc)	37 ft
Range *	30-76 ft
Amplitude (Amp)	28 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section and add meandering pattern to main channel. Create flood benches. Remove walls and reduce side slopes to 2:1. Add walls were necessary for bank stability.
- Vegetate banks and create buffer zone.



Alternative:

- Repair existing walls and replace concrete bottom with stable rock.
- The existing channel conveys the 100-yr flow.

- Vegetate banks and create buffer zone if possible on both banks.

The estimated total cost to make the system-wide improvements is \$412,154.

Reach 38
Mission Hills, Kansas
Tributary to Brush Creek between the Seneca Road
culvert and Wenonga Road culvert

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Clearing, Grubbing, & Demolition	LS	1	\$ 14,841.00	\$ 14,841.00
2	Mobilization	LS	1	\$ 4,749.00	\$ 4,749.00
3	Traffic Control	LS	1	\$ 1,187.00	\$ 1,187.00
4	New Retaining Wall	SF	770	\$ 75.00	\$ 57,750.00
5	Streambank Planting	SY	0	\$ 15.00	\$ -
6	Sodding	SY	215	\$ 7.50	\$ 1,613.00

Subtotal Construction Cost	\$	80,140.00
Contingencies @ 25%	\$	20,035.00
Total Construction Cost	\$	100,175.00
Engineering @ 20%	\$	20,035.00
Construction Administration @ 7%	\$	7,012.00

Total Cost for Reach 38 \$ 127,222.00

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Reach 39 – Existing Conditions

Location: Tributary to Brush Creek north of W. 64th Street.

Length: 475 feet

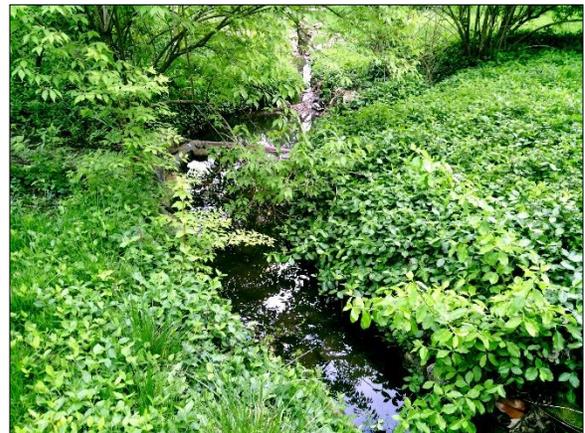
Channel Condition Score: 17.0

Channel Condition Ranking: Fair

Channel Condition Description: This reach received “Poor” ratings for having a lack of sinuosity and a large radius of curvature to channel width ratio. This reach received “Good” ratings for having bank heights less than six feet, little evidence of bank cutting and mass wasting, narrow bar widths, small amounts of debris in the channel, and few obstructions in the channel.

Retaining Walls: There are no retaining walls along this reach.

Stream Buffers: The stream buffer condition ranged from “None” to “Excellent” on both bank of this reach. The stream buffer generally consists of large trees and residential landscaping.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 39
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	1	0.6	0.6
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	2	0.6	1.2
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	2	0.8	1.6
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	2	0.2	0.4
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	2	0.8	1.6
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c /W_b,$ $R_c /W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	2	0.8	1.6
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	2	0.8	1.6

TOTAL 17.0

OVERALL RANKING Fair

Reach 39 – Proposed Improvements

Localized Improvements: There are no walls along this reach. Localized improvements for this reach include streambank reshaping and restoration.

An estimated 190 feet of streambank will need to be reshaped and restored.

The Stream Reach Rating is 3.00. The estimated total cost to make the localized improvements is \$75,406.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

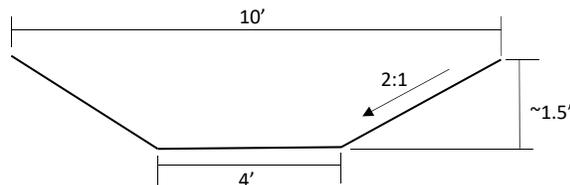
The 1-yr flow for this reach is 5.67 cfs. The following parameters were determined based on Soar and Thorne criteria for a 5.67 cfs flow:

Parameter	Value
Main channel width (w)	5 ft
Wave length (L)	60 ft
Pool-riffle spacing	30 ft
Radius of curvature (Rc)	12 ft
Range *	10-25 ft
Amplitude (Amp)	8 ft

* Absolute minimum – APWA max

Optimal restoration:

- Match proposed cross-section.
- Add meander pattern to channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$377,031.

Reach 39
Mission Hills, Kansas
Tributary to Brush Creek north of W. 64th Street

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

This reach did not contain any retaining walls rated "Fair" or "Poor". The reach received a "Fair" Channel Condition Ranking indicating significant instability issues. The CCSM identified poor sinuosity and pool riffle spacing contributing to the instability. The cost of the improvements to this reach is \$75,406.00.

Reach 40 – Existing Conditions

Location: Tributary to Brush Creek along W. 65th Street.

Length: 720 feet

Channel Condition Score: 19.0

Channel Condition Ranking: Fair

Channel Condition Description: This reach is a concrete lined channel with short retaining walls (< 6' tall) on each bank for the entire length of the reach. This reach received "Poor" ratings for having steep bank slopes, lack of woody vegetation, a lack of sinuosity, and a large radius of curvature to channel width ratio. This reach received "Good" ratings for having little evidence of bank cutting and mass wasting, bank heights less than 6 feet, and small amounts of debris in the channel.

Retaining Walls: There are a total of 568 feet of retaining wall on the left descending bank and 556 feet of retaining wall on the right descending bank. The retaining walls on both banks are in "Good" condition.

Stream Buffers: There is no stream buffer along this reach.



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Channel Condition Scoring Matrix

(adapted from Johnson, et al 1999)

Reach No.: 40
 Evaluation Date: April 2017
 Evaluated By: WRS

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)	3	0.6	1.8
Average bank slope angle	slopes \leq 2:1 on one or occasionally both banks	slopes up to 1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks	3	0.6	1.8
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet	1	0.8	0.8
Vegetative bank protection	wide to medium band of woody vegetation with 70- 90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank	3	0.8	2.4
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent	1	0.4	0.4
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.	1	0.8	0.8

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bar development	narrow relative to stream width at low flow, well- consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation	1	0.6	0.6
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent	1	0.2	0.2
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow	3	0.2	0.6
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm	1	0.8	0.8
Sinuosity	$1.2 \leq \text{Sinuosity} \leq 1.4$	$1.1 < \text{Sinuosity} < 1.2$	$\text{Sinuosity} < 1.1$	3	0.8	2.4
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3,$ $5 < R_c/W_b < 7$	$2 < R_c/W_b,$ $R_c/W_b > 7$	3	0.8	2.4
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4,$ $8 < \text{Length}/W_b \leq 9$	$3 < \text{Length}/W_b,$ $\text{Length}/W_b > 9,$ unless long pool or run because of geologic influence	3	0.8	2.4
Percentage of channel constriction	< 25%	26-50%	> 50%	1	0.8	0.8
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment	1	0.8	0.8

TOTAL 19.0

OVERALL RANKING Fair

Reach 40 – Proposed Improvements

Localized Improvements: The retaining walls along this reach are in “Good” condition. Localized improvements for this reach include streambank reshaping and restoration.

An estimated 80 feet of streambank will need to be reshaped and restored. The 80 feet is located between Indian Lane and the confluence with Brush Creek.

The Stream Reach Rating is 1.25. The estimated total cost to make the localized improvements is \$34,290.

System-wide Improvements: System-wide improvements include realigning the channel to a stable planform and meander pattern, grade stabilizing the channel bed with engineered rock riffles, reshaping the channel banks to a stable cross section, and restoring the banks with native vegetation.

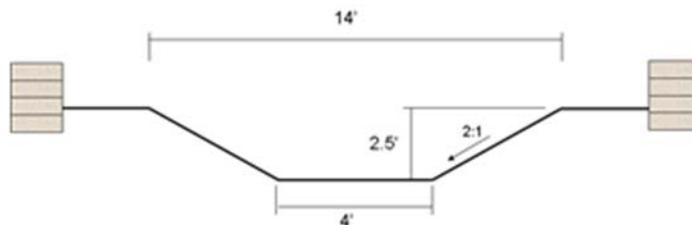
The 1-yr flow for this reach is 130 cfs. The following parameters were determined based on Soar and Thorne criteria for a 130 cfs flow:

Parameter	Value
Main channel width (w)	12.8 ft
Wave length (L)	144 ft
Pool-riffle spacing	72 ft
Radius of curvature (Rc)	31 ft
Range *	26-64 ft
Amplitude (Amp)	23 ft

* Absolute minimum – APWA max

Optimal restoration:

- Remove walls and reduce side slopes to 2:1. Add wall were necessary for bank stability.
- Match proposed cross section and add meandering patter to main channel. Create flood benches.
- Replace two driveway culverts to accommodate new channel.
- Vegetate banks and create buffer zone.



The estimated total cost to make the system-wide improvements is \$635,000.

Reach 40
Mission Hills, Kansas
Tributary to Brush Creek along W. 65th Street

Date: 9/21/17
By: MAH

Water Resources Solutions

OPINION OF PROBABLE CONSTRUCTION COST

This reach did not contain any retaining walls rated "Fair" or "Poor". The reach received a "Fair" Channel Condition Ranking indicating significant instability issues. The CCSM identified steep bank angles, lack of woody bank vegetation, poor sinuosity, and pool riffle spacing contributing to the instability. The cost of the improvements to this reach is \$34,290.00.

2017 Mission Hills Open Channel Masterplan - System-wide Improvements Opinion of Probable Costs

Stream Reach No.	Location	Channel Condition Ranking	Length	Channel Construction Cost (\$500/LF)	Number of Roadway Bridge	Roadway Bridge Cost (\$40,000/EA)	Number of Driveway/ Pedestrian Bridges	Driveway/ Pedestrian Bridge Cost (\$20,000/EA)	Retaining Wall Length (ft)	Retaining Wall Height (ft)	Retaining Wall Face Area (SF)	Retaining Wall Cost (\$75/SF)	Number of ERR/Grade Controls/Step Structures	ERR/Grade Controls/Step Structure Cost (\$15,000/EA)	Subtotal Construction Cost	Contingencies (25%)	Total Construction Cost	Engineering (20%)	Construction Administration (7%)	Total Cost	Comments	
01	Brush Creek along Mission Road south of Tomahawk Road	Fair	808	\$ 404,000.00		\$ -		\$ -			0	\$ -		\$ -	\$ 404,000.00	\$ 101,000.00	\$ 505,000.00	\$ 101,000.00	\$ 35,350.00	\$ 641,350.00		
02	Brush Creek along Mission Road north of Tomahawk Road	Fair	1322	\$ 661,000.00		\$ -		\$ -			0	\$ -		\$ -	\$ 661,000.00	\$ 165,250.00	\$ 826,250.00	\$ 165,250.00	\$ 57,838.00	\$ 1,049,338.00		
03	Brush Creek along Mission Drive near W. 55th Street	Poor	1003	\$ 501,500.00	1	\$ 40,000.00	1	\$ 20,000.00			0	\$ -		\$ -	\$ 561,500.00	\$ 140,375.00	\$ 701,875.00	\$ 140,375.00	\$ 49,131.00	\$ 891,381.00		
04	Brush Creek along Indian Lane near W. 65th Terrace	Fair	0	\$ -		\$ -		\$ -			0	\$ -		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	There are no system-wide improvements for this reach because improvements were made as part of the Peetwood Park Stream Restoration Project (2009)
05	Brush Creek along Indian Lane near W. 65th Street	Poor	401	\$ 200,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 200,500.00	\$ 50,125.00	\$ 250,625.00	\$ 50,125.00	\$ 17,544.00	\$ 318,294.00		
06	Brush Creek along Indian Lane between W. 65th Street and W. 64th Street	Poor	489	\$ 244,500.00		\$ -	1	\$ 20,000.00			0	\$ -		\$ -	\$ 264,500.00	\$ 66,125.00	\$ 330,625.00	\$ 66,125.00	\$ 23,144.00	\$ 419,894.00		
07	Brush Creek along Indian Lane between W. 65th Street and W. 64th Street	Fair	472	\$ 236,000.00		\$ -		\$ -			0	\$ -		\$ -	\$ 236,000.00	\$ 59,000.00	\$ 295,000.00	\$ 59,000.00	\$ 20,650.00	\$ 374,650.00		
08	Brush Creek along Indian Lane just north of W. 64th Street	Poor	349	\$ 174,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 174,500.00	\$ 43,625.00	\$ 218,125.00	\$ 43,625.00	\$ 15,269.00	\$ 277,019.00		
09	Brush Creek along Indian Lane and 63rd Street upstream and downstream of the 63rd Street Bridge	Poor	910	\$ 455,000.00		\$ -		\$ -			0	\$ -		\$ -	\$ 455,000.00	\$ 113,750.00	\$ 568,750.00	\$ 113,750.00	\$ 39,813.00	\$ 722,313.00		
10	Tributary to Brush Creek beginning at W.69th Street and ending at the culvert under W. 66th Terrace	Fair	1596	\$ 798,000.00	3	\$ 120,000.00		\$ -	2750	3	8250	\$ 618,750.00	19	\$ 285,000.00	\$ 1,821,750.00	\$ 455,438.00	\$ 2,277,188.00	\$ 455,438.00	\$ 159,403.00	\$ 2,892,029.00		
11	Tributary to Brush Creek downstream of Reach 10 beginning at Tomahawk Road and ending at the culvert under Seneca Road	Fair	722	\$ 361,000.00	1	\$ 40,000.00	3	\$ 60,000.00	1200	3	3600	\$ 270,000.00		\$ -	\$ 731,000.00	\$ 182,750.00	\$ 913,750.00	\$ 182,750.00	\$ 63,963.00	\$ 1,160,463.00		
12	Tributary to Brush Creek along Wenonga Road	Poor	517	\$ 258,500.00	1	\$ 40,000.00	2	\$ 40,000.00	858	3	2574	\$ 193,050.00	7	\$ 105,000.00	\$ 636,550.00	\$ 159,138.00	\$ 795,688.00	\$ 159,138.00	\$ 55,698.00	\$ 1,010,524.00		
13	Tributary to Brush Creek along Wenonga Road through Hiawasse Park southwest of the 63rd Street and Wenonga Road intersection	Fair	270	\$ 135,000.00		\$ -		\$ -			0	\$ -		\$ -	\$ 135,000.00	\$ 33,750.00	\$ 168,750.00	\$ 33,750.00	\$ 11,813.00	\$ 214,313.00		
14	Brush Creek along Indian Lane immediately downstream of the Indian Lane low-water crossing north of 63rd Street	Fair	410	\$ 205,000.00		\$ -		\$ -	253	5	1265	\$ 94,875.00	1	\$ 15,000.00	\$ 314,875.00	\$ 78,719.00	\$ 393,594.00	\$ 78,719.00	\$ 27,552.00	\$ 499,865.00		
15	Brush Creek along Indian Lane north of 63rd Street immediately downstream of Reach 14	Poor	761	\$ 380,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 380,500.00	\$ 95,125.00	\$ 475,625.00	\$ 95,125.00	\$ 33,294.00	\$ 604,044.00		
16	Brush Creek along Indian Lane north of 63rd Street immediately downstream of Reach 15, ending at the Mission Drive low-water crossing near the entrance to the Kansas City Country Club	Fair	849	\$ 424,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 424,500.00	\$ 106,125.00	\$ 530,625.00	\$ 106,125.00	\$ 37,144.00	\$ 673,894.00		
17	Tributary to Brush Creek paralleling Willow Lane, beginning at W. 65th Street and ending at the culvert under Tomahawk Road, upstream of Willow Lake	Poor	724	\$ 362,000.00		\$ -	5	\$ 100,000.00	1450	3	4350	\$ 326,250.00	17	\$ 255,000.00	\$ 1,043,250.00	\$ 260,813.00	\$ 1,304,063.00	\$ 260,813.00	\$ 91,284.00	\$ 1,656,160.00		
18	Tributary to Brush Creek downstream of Willow Lake, paralleling Ensey Lane, beginning at Tomahawk and ending at the culvert under intersection of Ensey Lane and Mission Drive	Fair	765	\$ 382,500.00		\$ -	3	\$ 60,000.00	1530	3	4590	\$ 344,250.00	11	\$ 165,000.00	\$ 951,750.00	\$ 237,938.00	\$ 1,189,688.00	\$ 237,938.00	\$ 83,278.00	\$ 1,510,904.00		
19	Tributary to Brush Creek beginning at State Line Road and continuing north along State Line Road, south of First Evangelical Lutheran Church parking lot	Fair	381	\$ 190,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 190,500.00	\$ 47,625.00	\$ 238,125.00	\$ 47,625.00	\$ 16,669.00	\$ 302,419.00		
20	Tributary to Brush Creek immediately downstream of Reach 19 along the south side of the First Evangelical Lutheran Church parking lot ending at the Tomahawk Road culvert	Fair	571	\$ 285,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 285,500.00	\$ 71,375.00	\$ 356,875.00	\$ 71,375.00	\$ 24,981.00	\$ 453,231.00		
21	Tributary to Brush Creek along Mission Drive between Tomahawk Road and W. 63rd Street	Fair	436	\$ 218,000.00		\$ -		\$ -			0	\$ -		\$ -	\$ 218,000.00	\$ 54,500.00	\$ 272,500.00	\$ 54,500.00	\$ 19,075.00	\$ 346,075.00		
22	Tributary to Brush Creek along Mission Drive between W. 63rd Street and High Drive	Poor	604	\$ 302,000.00		\$ -		\$ -	1208	3	3624	\$ 271,800.00	4	\$ 60,000.00	\$ 633,800.00	\$ 158,450.00	\$ 792,250.00	\$ 158,450.00	\$ 55,458.00	\$ 1,006,158.00		
23	Tributary to Brush Creek along Mission Drive between High Drive and the culvert under the intersection of Ensey Lane and Mission Drive	Fair	720	\$ 360,000.00	1	\$ 40,000.00	3	\$ 60,000.00	1420	3	4260	\$ 319,500.00	4	\$ 60,000.00	\$ 839,500.00	\$ 209,875.00	\$ 1,049,375.00	\$ 209,875.00	\$ 73,456.00	\$ 1,332,706.00		
24	Tributary to Brush Creek within the island along Brookwood Road	Fair	742	\$ 371,000.00		\$ -	1	\$ 20,000.00			0	\$ -		\$ -	\$ 391,000.00	\$ 97,750.00	\$ 488,750.00	\$ 97,750.00	\$ 34,213.00	\$ 620,713.00		
25	Tributary to Brush Creek along Mission Drive beginning at the culvert under the intersection of Ensey Lane and Mission Drive and ending at the confluence with Brush Creek	Fair	1240	\$ 620,000.00		\$ -	3	\$ 60,000.00	1240	3	3720	\$ 279,000.00	2	\$ 30,000.00	\$ 989,000.00	\$ 247,250.00	\$ 1,236,250.00	\$ 247,250.00	\$ 86,538.00	\$ 1,570,038.00		
26	Brush Creek beginning near the Kansas City County Club entrance and Mission Drive and ends near Brookbank Lane	Poor	967	\$ 483,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 483,500.00	\$ 120,875.00	\$ 604,375.00	\$ 120,875.00	\$ 42,306.00	\$ 767,556.00		
27	Brush Creek along Brookbank Lane and Belinder Avenue	Fair	1172	\$ 586,000.00		\$ -		\$ -			0	\$ -		\$ -	\$ 586,000.00	\$ 146,500.00	\$ 732,500.00	\$ 146,500.00	\$ 51,275.00	\$ 930,275.00		
28	Rock Creek along State Park Road	Fair	3230	\$ 1,615,000.00		\$ -	2	\$ 40,000.00	900	3	2700	\$ 202,500.00		\$ -	\$ 1,857,500.00	\$ 464,375.00	\$ 2,321,875.00	\$ 464,375.00	\$ 162,531.00	\$ 2,948,781.00		
29	Brush Creek downstream of the Belinder Avenue low-water crossing to a pedestrian bridge on the Mission Hills Country Club	Fair	1405	\$ 702,500.00		\$ -		\$ -			0	\$ -	1	\$ 15,000.00	\$ 717,500.00	\$ 179,375.00	\$ 896,875.00	\$ 179,375.00	\$ 62,781.00	\$ 1,139,031.00		
30	Brush Creek along Mission Drive downstream of a pedestrian bridge on the Mission Hills Country Club to near the intersection of Mission Drive and East Mission Drive	Poor	974	\$ 487,000.00		\$ -		\$ -	350	8	2800	\$ 210,000.00	18	\$ 270,000.00	\$ 967,000.00	\$ 241,750.00	\$ 1,208,750.00	\$ 241,750.00	\$ 84,613.00	\$ 1,535,113.00	The optimal solution for the upper 370 feet is to create a stable riffle through the reach by placing large rocks. To estimate the cost for the riffle, 18 grade controls is used.	
31	Brush Creek along the United Presbyterian Village Church ending along W. 66th Street at the Indian Lane culvert	Fair	944	\$ 472,000.00	1	\$ 40,000.00		\$ -			0	\$ -		\$ -	\$ 512,000.00	\$ 128,000.00	\$ 640,000.00	\$ 128,000.00	\$ 44,800.00	\$ 812,800.00		
32	Tributary to Brush Creek along Pembroke Lane near State Line Road	Fair	371	\$ 185,500.00		\$ -	2	\$ 40,000.00	460	3	1380	\$ 103,500.00		\$ -	\$ 329,000.00	\$ 82,250.00	\$ 411,250.00	\$ 82,250.00	\$ 28,788.00	\$ 522,288.00		
33	Tributary to Brush Creek along Pembroke Lane downstream of Reach 32	Poor	254	\$ 127,000.00		\$ -	1	\$ 20,000.00	500	3	1500	\$ 112,500.00		\$ -	\$ 259,500.00	\$ 64,875.00	\$ 324,375.00	\$ 64,875.00	\$ 22,706.00	\$ 411,956.00		
34	Tributary to Brush Creek along East Mission Drive downstream of Reach 33	Fair	1049	\$ 524,500.00	1	\$ 40,000.00	1	\$ 20,000.00	1180	3	3540	\$ 265,500.00		\$ -	\$ 850,000.00	\$ 212,500.00	\$ 1,062,500.00	\$ 212,500.00	\$ 74,375.00	\$ 1,349,375.00		
35	Brush Creek within Mission Hills Country Club near the Mission Drive and State Line Road	Fair	1005	\$ 502,500.00		\$ -	2	\$ 40,000.00			0	\$ -		\$ -	\$ 542,500.00	\$ 135,625.00	\$ 678,125.00	\$ 135,625.00	\$ 47,469.00	\$ 861,219.00		
36	Brush Creek within Mission Hills Country Club downstream of Reach 35 and ending at State Line Road	Fair	759	\$ 379,500.00		\$ -	1	\$ 20,000.00			0	\$ -		\$ -	\$ 399,500.00	\$ 99,875.00	\$ 499,375.00	\$ 99,875.00	\$ 34,956.00	\$ 634,206.00		
37	Brush Creek along Mission Road immediately north of W. 71st Street	Poor	665	\$ 332,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 332,500.00	\$ 83,125.00	\$ 415,625.00	\$ 83,125.00	\$ 29,094.00	\$ 527,844.00		
38	Tributary to Brush Creek between the Seneca Road culvert and Wenonga Road culvert	Fair	355	\$ 177,500.00		\$ -		\$ -	365	3	1095	\$ 82,125.00		\$ -	\$ 259,625.00	\$ 64,906.00	\$ 324,531.00	\$ 64,906.00	\$ 22,717.00	\$ 412,154.00		
39	Tributary to Brush Creek north of W. 64th Street	Fair	475	\$ 237,500.00		\$ -		\$ -			0	\$ -		\$ -	\$ 237,500.00	\$ 59,375.00	\$ 296,875.00	\$ 59,375.00	\$ 20,781.00	\$ 377,031.00		
40	Tributary to Brush Creek along W. 65th Street	Fair	720	\$ 360,000.00		\$ -	2	\$ 40,000.00			0	\$ -		\$ -	\$ 400,000.00	\$ 100,000.00	\$ 500,000.00	\$ 100,000.00	\$ 35,000.00	\$ 635,000.00		

2017 Mission Hills Open Channel Masterplan - Bank Reshaping Only Localized Improvements Opinion of Probable Costs

Stream Reach No.	Location	Channel Condition Ranking	Length	Percentage of Length	Improvement Length	Subtotal Construction Cost	Contingency (25%)	Total Construction Cost	Engineering (20%)	Construction Administration (7%)	Total Cost	Comments
06	Brush Creek along Indian Lane between W. 65th Street and W. 64th Street	Poor	489	75%	366.75	\$ 91,688.00	\$ 22,922.00	\$ 114,610.00	\$ 22,922.00	\$ 8,023.00	\$ 145,555.00	
09	Brush Creek along Indian Lane and 63rd Street upstream and downstream of the 63rd Street Bridge	Poor	750	75%	562.5	\$ 140,625.00	\$ 35,156.00	\$ 175,781.00	\$ 35,156.00	\$ 12,305.00	\$ 223,242.00	
21	Tributary to Brush Creek along Mission Drive between Tomahawk Road and W. 63rd Street	Fair	210	100%	210	\$ 52,500.00	\$ 13,125.00	\$ 65,625.00	\$ 13,125.00	\$ 4,594.00	\$ 83,344.00	This reach included retaining walls, but the 2007 Masterplan localized improvements included removing the retaining wall and reshaping the banks to 2:1 slope and also transitioning the slopes upstream of 63rd Street and downstream of Tomahawk Road. 100% was used for this reach because of this.
32	Tributary to Brush Creek along Pembroke Lane near State Line Road	Fair	371	40%	148.4	\$ 37,100.00	\$ 9,275.00	\$ 46,375.00	\$ 9,275.00	\$ 3,246.00	\$ 58,896.00	
37	Brush Creek along Mission Road immediately north of W. 71st Street	Poor	665	75%	498.75	\$ 124,688.00	\$ 31,172.00	\$ 155,860.00	\$ 31,172.00	\$ 10,910.00	\$ 197,942.00	
39	Tributary to Brush Creek north of W. 64th Street	Fair	475	40%	190	\$ 47,500.00	\$ 11,875.00	\$ 59,375.00	\$ 11,875.00	\$ 4,156.00	\$ 75,406.00	
40	Tributary to Brush Creek along W. 65th Street	Fair	720	12%	86.4	\$ 21,600.00	\$ 5,400.00	\$ 27,000.00	\$ 5,400.00	\$ 1,890.00	\$ 34,290.00	This reach has retaining walls in "Good" condition on each bank for the entire reach, except the last 80 feet before the confluence with Brush Creek. 12% was used to get the improvement length close to 80 feet.

