The Ozarks Environmental and Water Resources Institute (OEWRI)
Missouri State University (MSU)

Channel Stability and Riparian Corridor Assessment to Identify Nonpoint Source Pollution, Wilson Creek, Springfield, Missouri

Field work completed July 20, 2012

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Scope and Objectives

The James River Basin Partnership (JRBP) is implementing a riparian corridor easement on City of Springfield owned property along Wilson Creek, a major tributary of the James River. This conservation easement is part of a Section 319 Grant from the Missouri Department of Natural Resources and the Environmental Protection Agency Region VII designed to reduce nonpoint source pollution to the James River. The Ozarks Environmental and Water Resources Institute (OEWRI) at Missouri State University is responsible for documenting the pre-implementation conditions of the channel and riparian corridor along the proposed easement. The purpose of this assessment is to describe the current conditions of the channel and riparian corridor within a 100 foot buffer from the centerline of Wilson Creek. The specific objectives of this assessment are:

1. Perform a field survey describing current channel characteristics including channel size and shape, bed conditions, and bank stability at the sub-reach scale.
2. Determine the current condition of the riparian corridor using recent aerial photography and field surveys.
3. Make specific recommendations for reducing nonpoint source pollution from the study reaches based on field observations.

Site Description

The Wilson Creek watershed is approximately 84 mi^2 and drains the central and western edges of the City of Springfield in Greene County flowing south to the confluence of the James River in Christian County (Figure 1). The entire proposed easement is approximately 1.35 miles long located at two different sites along Wilson Creek in southwest Springfield. The north segment is approximately 3,900 feet long between FR 156 and James River Expressway (Figure 2). The south segment is around 3,200 feet long from FR 168 to Republic Road (Figure 3). A United States Geological Survey (USGS) gaging station is located immediately upstream of each of the sites at FR 156 and FR 168 (Table 1). The upstream drainage area of the north segment is 31.4 mi^2 and 51.0 mi^2 for the south segment. The south segment is below the City of Springfield's Southwest Wastewater Treatment Facility that has an average daily discharge of 35 million gallons per day ($\approx$54 ft^3/s). Mean annual discharge at the south segment is 3 times higher than the north segment, mostly due to discharges from the wastewater treatment facility.

The underlying geology of the area is the Burlington-Keokuk limestone of Mississippian age within which is formed a karst landscape where sinkholes, losing streams, and springs are common (Vineyard and Feder, 1982). Soils of the valley bottom are silty-loam terraces with inset floodplains composed of 35-80% chert fragments in the subsurface horizons (Hughes, 1982). Limestone bluffs are common where the stream meets the valley margin and bedrock is often exposed in the bed of the stream. Land use of the watershed ranges from high-low density urban in the upper watershed to residential, livestock grazing, and forage crop production outside the city limits.

Methods
The channel was divided into sub-reaches based on field observations of channel morphology, substrate, and bank conditions to evaluate channel stability. The riparian corridor within the proposed easement at each site was assessed, both in the field and remotely, using aerial photography. The field assessment used basic indicators of geomorphic process and a modified rapid geomorphic assessment every 300-400 ft along the channel (Rosgen, 1996, Fitzpatrick et al., 1998). Riparian vegetation was also digitized from 2009 aerial photos provided by the City of Springfield and classified by both vegetation type (grass, mature trees, etc.) and landform (floodplain or bluff). The total area of each was calculated within the proposed easement area. Additionally, a channel cross-section was surveyed at each site, using an auto-level, representing the typical size and shape of the channel (Harrelson et al., 1994, Rosgen, 1996). Channel slope was estimated using topographic maps. The channel flood capacity was estimated using Manning's equation and compared to flood frequency estimates based on USGS gage data (Knighton, 1998, Flynn et al, 2006).

Reach Descriptions
This section contains detailed descriptions of the channel and banks for both sites divided into sub-reaches. Sub-reach locations and points of interest have been mapped and photographed (Figures 2 and 3, Photos 1-28).

<u>North Segment</u>
With the exception of a few standing pools, the north segment channel is dry. Bedrock is common along the bed and there are several knickpoint features in the bed that create local scour and erosion. The stream is adjacent to bedrock bluffs at the beginning and end of the 3,900 foot section. In general, the riparian corridor consists of a thin line of mature trees, but the banks show signs of slight-moderate erosion throughout. More severe erosion occurs in localized areas where there is little riparian vegetation and where cattle have entered the stream or have been loafing along the banks. Additionally, there is a lot of trash (tires, scrap metal, etc.) in the channel and along the banks at this site. More detail is given in the sub-reach descriptions below:

1. *Bridge Reach (3,950-3,850 ft)* – This reach is immediately downstream of the FR 156 Bridge (Photo 1). The wire cable with cattle panels stretched across the channel at the right-of-way collects trash and debris just below of the bridge. The bed is about 50% bedrock with the remainder large gravel and cobble. Banks show slight to moderate erosion with an adequate riparian corridor. Local erosion is typical downstream of bridges where the alignment can deflect flow toward the bank.

2. *Bedrock Bed Reach (3,850-3,650 ft)* – The entire bed along this reach is a bedrock slab or large boulders where pieces of the bed have broken off (Photo 2). The banks along this reach

show moderate erosion with a fairly healthy riparian corridor. This suggests this area is trying to widen due to the bedrock control of the bed.

3. *Knickpoint Reach #1 (3,650-3,600 ft)* – A knickpoint is a drop off, or step, cut into the bedrock along the bed of the stream over geologic time. Locations of the knickpoints described in this report are probable locations that would have to be determined by a more thorough survey of the stream. The knickpoint in this reach appears to be caused by a fracture/swallowhole within the bedrock creating a 7-8 foot drop in the bed at this location (Photo 3). Additionally, flow deflection during large floods is causing left bank erosion locally (Photo 4).

4. *Bedrock Bluff Reach (3,600-3,400 ft)* – The channel through this reach is adjacent to a bedrock bluff along the left bank (Photo 5). Approximately 50% of the bed is bedrock or large boulders with gravel deposits along the right margin of the channel. The right bank has moderate erosion with a thin line of mature trees protecting the bank.

5. *Cattle Entrance and Cutbank Reach (3,400-3,200 ft)* – The right bank along this reach has little to no riparian cover creating a cutbank that is approximately 7-8 ft high (Photo 6). Additionally, cattle have been entering the stream at this location causing further bank instability. A new floodplain is forming along the left bank of the stream adjacent to the bedrock bluff suggesting the channel has been moving at this location. The bed is mostly bedrock here as well.

6. *Bedrock/Cattle Entrance Reach (3,200-2,900 ft)* – The bedrock bed continues through this reach with bedrock also along the toe of the left bank (Photo 7). The right bank shows signs of erosion but is weakly protected by a thin line of mature trees. However, cattle have been entering the stream at two locations in this reach creating localized erosion.

7. *Knickpoint Reach #2 (2,900-2,850 ft)* – Similar to the knickpoint at station 3,600, but at a smaller scale, a fracture/swallowhole has created a knickpoint in the bedrock at this location that is approximately 5 feet deep (Photo 8). Also, flow deflection has caused erosion along the left bank where cattle are entering the stream.

8. *Gravel Bed Reach #1 (2,850-2,200 ft)* – The bed of this reach is gravel, however bedrock is likely close to the surface and a small pool of water is located at 2,500 ft. There is a cattle crossing between stations 2,600-2,700 ft with no riparian vegetation on the right bank (Photo 9). The riparian corridor that is present is a thin line of mature trees, but cattle appear to be using it as a loafing area, damaging the banks (Photo 10). A channel cross-section was collected at station 2,300 ft.

9. *Bedrock Pinnacles (2,200-2,100 ft)* – Localized bed obstruction

10. *Gravel Bed Reach #2 (2,100-1,700 ft)* – The stream bed in this reach is a gravel and cobble bed (Photo 11). The thin riparian corridor is interrupted by several cattle entrance points and loafing areas that cause localized erosion. However, a 6-7 ft diameter "legacy" tree at 1,800 ft on the left bank suggests the channel has not moved much at this location, but may have been widening (Photo 12). A road/cattle crossing is located at station 1,700 ft.

11. *Bedrock/Knickpoint Reach #3 (1,700-1,400 ft)* – Bedrock appears at the surface along the bed in this reach and ends with a 5 ft knickpoint at station 1,450 ft (Photo 13).

12. *Bank Erosion Reach (1,400-1,000 ft)* – This gravel bed reach is located just upstream of where the channel meets a bluff. Erosion is occurring along the 6-8 ft high, 200 ft long, right bank where there is no riparian vegetation (Photo 14). Additionally, localized erosion is occurring at a cattle crossing at 1,350 ft and cattle loafing areas near 1,050 ft.

13. *Bedrock/Bluff Pool Reach (1,000-700 ft)* – The right side of the channel in this reach is adjacent to a bedrock bluff and is currently holding water (Photo 15). This is the largest of three pools of water on this site and cattle have been entering the stream here at several locations causing local erosion (Photo 16).

14. *Utility Easement and Cattle Entrance Reach (700-600 ft)* – In this reach a utility easement crosses the channel with overhead powerlines coming down from the bluff on the right. Here the bluff has been cleared of mature vegetation. The left bank is eroding due to a cattle entrance ramp and no riparian vegetation present on the bank (Photo 17).

15. *Gravel Bed Reach #4 (600-200 ft)* – This reach has a gravel bed with slight-moderate erosion on both banks (Photo 18). Here, the right bank has a relatively narrow floodplain where the channel has left the valley wall and has mature vegetation. The left bank has a thin line of mature trees with cattle entrances at 400 and 500 ft.

16. *Bedrock/Bridge Reach (200-0 ft)* – This reach has a bedrock bed with banks that have slight-moderate erosion with a thin riparian corridor (Photo 19). A cable across the channel at station 100 ft collects large woody debris and trash at the property line.

<u>South Segment</u>

Discharge from the Southwest Waste Water Treatment Facility upstream provides consistent flow to the south segment that otherwise would likely be dry. Bedrock is prominent in the bed along this reach. The channel is adjacent to a bluff on the west side of the stream in the upper section of the site. Also, the stream has exposed bedrock at the base of a floodplain/low terrace along the east side of the channel at some locations. The riparian buffer at this site is relatively wider and more mature than the north segment. However, some bank erosion does occur in localized areas where the buffer is thinner. Overall, the south segment is much more stable than the north segment. More detail is given in the sub-reach descriptions below:

1. *Bedrock Controlled/Bluff Reach (3,200-2,100 ft)* – The channel is adjacent to a bluff along the right bank and there is moderate erosion along the left bank in this reach (Photo 20). Bedrock is exposed in the bed along with deposits of gravel and cobble. A spring seep appears along the right bank at 2,600 ft and a currently dry tributary enters on the left at 2,500 ft.

2. *Transition Reach (2,100-1,800 ft)* – Through this reach the channel moves away from the bluff and forms a floodplain on the right bank with a thin riparian buffer consisting of tall grass and small trees (Photo 21). The banks on the both sides have slight-moderate erosion, but the right bank appears to be more susceptible due to less deep-rooted vegetation along the bank. A tributary enters this reach at 1,900 ft.

3. *Straight/Bedrock Toe Reach (1,800-1,300 ft)* – Bedrock is prominent along the bed and the toe of the left bank through this reach (Photo 22 and 23). The 500 ft reach is very straight with a bedrock knick/riffle from 1,500-1,400 ft. The right bank has slight-moderate erosion and a thin riparian buffer of mature trees.

4. *Bedrock Reach (1,300-650 ft)* – This reach is similar to the upstream reach, but there is no bedrock exposed along the bank, only in the bed (Photo 24). Both banks show slight erosion. The right bank has a thin riparian corridor of small trees and is susceptible to more severe erosion than the vegetated left bank (Photo 25). There is a floodplain scour hole at 700 ft (Photo 26).

5. *Gravel Bed Reach (650-250 ft)* – The bed through this reach consists of gravel with bedrock exposed only in the bottom of deep pools. There is 200 ft of right bank erosion near the confluence with a tributary coming into the channel from the west at 500 ft (Photo 27). Additional erosion occurs downstream at 400 ft on the left bank.

6. *Bedrock Bed/Bridge Reach (250-0 ft)* – Around 250 ft upstream of the Republic Road Bridge, bedrock is exposed along the bed of the stream (Photo 28). Bedrock is also exposed at the toe of the right bank. The riparian buffer stops at the road right-of-way line at station 100 ft.

Rapid Geomorphic/Riparian Corridor Assessment

North Segment

The stream though the north segment has evidence of both channel incision and widening, that is typical of the bedrock controlled urban streams around Springfield (Owen et al., 2007; Pavlowsky and Owen, 2009; Pavlowsky and Owen, 2010). Channel incision, or degradation, in urban streams occurs when the channel adjusts to increased floods by eroding the bed of the stream to increase flow capacity. Visual evidence of channel incision though this segment includes; channel incision into bedrock, elevated tree roots/root fan above channel bed, and absence of depositional features (gravel bars) in the channel. Channel widening is also an erosion response to increased floods where the stream is increasing flow capacity by attacking the banks. Evidence of channel widening though this segment includes; exposed tree roots, steep bank angles, and block failures/slump scars/fracture lines along the banks.

Channel and bed width decreased downstream and bedrock was exposed along the bed throughout the majority of the reach (Figure 4). Bed width ranged from 20-38 ft and channel width ranged from 43-62 ft wide. While channel width should be expected to increase downstream, bedrock can control bed elevation and slope locally to disrupt that downstream pattern. The banks through this segment ranged from 4.6-16.4 ft high. The majority of the banks through this reach would be considered moderate to moderately high (4-8 ft) (Figure 5). Bank in the upper 500 ft and near station 1,200 ft would be considered high and susceptible to erosion (> 8ft). Bank heights were highest in the upper 500 ft of the site, with banks exceeding 12 ft near the knickpoint at 3,600 ft where the bed drops 8 ft . Bank angles that exceed 70° are common all along the north segment reach. High banks with steep angles should be considered an erosion risk.

The riparian corridor was assessed 100 ft on both sides of the centerline of the stream. The buffer through the north segment is mostly pasture with a thin line of mature trees along both banks (Figure 6). The entire buffer area is approximately 15.6 acres with around 8.7 acres of pasture (≈56%). Mature floodplain trees that make up the current thin corridor make up about 3.6 acres (23%) of the entire 100 buffer (Table 2). The vegetation along the bluffs is also mature, with the exception of the powerline easement between 700-600 ft. Also, the road fill along James River Expressway is grass and appears to be periodically maintained.

South Segment

The stream through the south segment is bedrock controlled, but there is less evidence of recent channel incision and widening with lower bank heights and bank angles compared to the north segment. The channel is incised to bedrock, there are few depositional features (gravel bars) and exposed tree roots are common. However, this segment appears to already have responded, or is resisting adjustment to urban influences with a healthy riparian corridor and bedrock control.

The geomorphic history of this segment is presently unknown and would need to be investigated further.

Channel width and bed width increase slightly downstream and bedrock is exposed at the surface along most of the reach (Figure 7). Bed width ranged from 35-55.6 ft and channel width ranged from 45-74.1 ft. Bed and channel widths were higher in the areas of the channel where no bedrock was present in the channel (Stations 1,900-2,300 ft). Banks along the south segment range from 3.3-6.9 ft and appear to be relatively less susceptible to erosion than the north segment with lower bank heights and angles. Bank heights through the south segment would be classified moderate (<6 ft) with the exception of the moderately high bank at station 600 ft (Figure 8). High bank angles were mostly along the right bank though this reach. The highest erosion risk is along the right bank near 600 ft where the height is >6 ft with a steep angle.

The riparian corridor through the south segment is much healthier and more mature than the north segment. The east bank in particular is in good shape with a thin line of mature trees flanked by younger trees along the floodplain, likely allowed to grow when the Greenway was established (Figure 9). The upper 1,000 ft of the west side of the stream is bluff covered by mature trees. The remaining 2,000 ft has a thin line of mature trees and grass pasture beyond. The entire buffer area is 12 acres, with 4.8 acres (40.3%) covered by young trees on the floodplain (Table 3). The bluff is 2.5 acres (20.8%) of the buffer and the grass pasture makes up about 2.3 acres (19%) of the buffer. The remaining 0.7 acres (5.9%) is the road fill near Republic Road.

Channel Capacity and Shape

The total channel is represented by the width of the water surface at the point just before it spills out into the adjacent floodplain. The total channel width at the cross-section for the north segment at 2,300 ft is 63.3 ft at 6.7 ft deep, for a channel discharge (Q) of 1,158 ft^3/s (Table 4). The flood chute along the right bank (west side) of the cross-section along the north segment does not appear to be connected to the channel. However, by adding that chute to the total channel capacity increases the discharge to 1,379 ft^3/s. The total channel width at the cross-section for the south segment at 1,900 ft is 106.2 ft at 5.5 ft deep, for a Q of 1,499 ft^3/s. Channels in both reaches appear to be undersized, having the capacity to pass the 1-1.1 year flood (Table 5). Typically, the "bankfull" channel should be large enough to pass the 1.5 year flood (Rosgen, 1996). This suggests that the channel may be expected to continue to widen to accommodate the capacity of the 1.5 year flood. However, bedrock control, gravel deposition in channel, and tree root protection may resist channel enlargement process due to urban increases in floods (Pavlowsky, 2004).

The width:depth (W/D) ratio is defined as the channel width divided by the mean depth and is a measure of channel shape and incision (Rosgen, 1996). The W/D ratio for the north segment is

16.1 and is 32.4 downstream at the south segment. High W/D ratios typically suggest sediment transport is low and gravel deposition creates near bank erosion and widening. However, both reaches have a lack of gravel deposition (few if any bars) suggesting these areas are transport reaches and have high W/D ratios due to bedrock control and near bank resistance. Banks along Ozarks channels of this size have the ability to resist widening and channel migration with anchor trees and very cohesive gravelly banks (Pavlowsky, 2004). This is significant because losing trees within the already thin riparian corridor, particularly at the north segment, may trigger more wide spread and rapid channel erosion.

Recommendations

Wilson Creek has a long history of pollution from industrial sources and wastewater effluent from Springfield and eroding stream banks in urban areas can be a significant nonpoint source of sediment, metals, and nutrients to this stream (Rodgers, 2004; Shade, 2005; Miller, 2006). Specific recommendation for these two segments are attended to address reducing fine and coarse sediment and associated pollutants from entering the stream from bank erosion and on-site runoff by removing cattle and incorporating a more robust riparian corridor than is currently present. Here are four specific recommendations:

1. *Remove Trash from Stream* - Both sites, but particularly the north segment, have a large amount of trash in the channel and along the banks that needs to be removed. Trash has obviously washed into the stream from the upstream urban area. However, large items such as tires, appliances, and other scrap metal have been dumped here in the past.

2. *Fence Cattle Out of Stream* - Unlimited access for cattle to the stream at the north segment is a significant nonpoint source for pollution to the stream. Hoof action has caused floodplain scour gullies and erosion near several cattle entrance points along the channel. Additionally, cattle allowed to loaf in the riparian corridor further destabilizes banks, damages vegetation, and concentrates manure near the channel with no buffer to filter sediment and pollutants during storm events. Fencing 100 ft on either side of the stream will allow the banks and vegetation to recover over time and reduce nonpoint sediment and nutrients from entering the stream during storms. This will also allow for the removal of the cables on each end of the property that are currently trash and large woody debris traps. Debris collected here can cause flows to deflect, creating local erosion problems. This property can still be used to pasture cattle and provides an opportunity to demonstrate best management practices for cattle operations near stream corridors. The Missouri Department of Conservation and the Natural Resources Conservation Service private land specialists can provide technical assistance for installing alternative water sources, limiting access to stabilized cattle crossings, and providing shaded areas away from the stream.

3. *Establish a Healthy Riparian Buffer* - Currently, the riparian corridor along most of the north segment and the west side of the south segment is too thin. There is 8.7 acres of riparian buffer currently in pasture available for planting in the north segment and 2.3 acres of pasture available along the south segment. Since the stream on the north segment is intermittent, drought tolerant native trees and shrubs appropriate for planting around streams should be used. Trees and shrubs should be planted at a higher density than is currently present that will provide resistance to erosion during flood events, help filter pollutants and sediment washing into the stream, and provide habitat to birds and other non-aquatic species using the stream corridor. The main channel should remain disconnected from urban drainage system now and in future. Runoff from pasture areas and from upstream areas during floods should be forced to go over buffer for filtering and infiltration, not through channels or pipes.

4. *Monitor High Erosion Areas* - In-channel work is probably not necessary at either site at this time, but should be monitored. Most severe bank erosion at both sites is limited to local areas associated with cattle entrances and thin riparian buffers. The floodplain and riparian corridor areas are connected by flashy urban hydrology, so systematic channel recovery should be closely monitored. The south segment is unique because it has base flow augmentation and water quality improvements by the treatment plant will directly affect aquatic habitat and water quality of Wilson Creek. Specific areas to be monitored are:

   a. North segment areas to be monitored:
      1) Bank erosion at 3,600 ft
      2) Cattle entrance 3,500 ft
      3) Bank erosion 3,400-3,200 ft,
      4) Cattle entrance at 3,200 ft
      5) Cattle entrance at 2,900 ft
      6) Cattle entrance at 2,700 ft
      7) Cattle entrance 1,900 ft
      8) Road/Cattle crossing at 1,700 ft
      9) Bank erosion at 1,400-1,000 ft,
      10) Cattle entrance at 800 ft
      11) Cattle entrance at 700 ft
      12) Bank erosion 700-600 ft
      13) Cattle entrance at 500 ft
      14) Cattle entrance at 400 ft

   b. South segment areas to be monitored:
      1) Channel widening at 1,900 ft
      2) Floodplain scour hole at 700 ft
      3) Bank erosion at 600-400 ft

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Tables

Table 1. USGS Gaging Stations on Wilson Creek near Study Sites

ID	Name	Period of Record	Drainage Area (mi^2)	Annual Mean Q (ft^3/s)	10% Exceeds (ft^3/s)	90% Exceeds (ft^3/s)
07052100	Wilson Creek Near Springfield, MO at FR 156	Sept. 21, 1972 to Sept. 30, 1982; May 28, 1998 to Present	31.4	21.5	43	0
07052152	Wilson Creek Near Brookline, MO at FR 168	July 10, 2001 to Present	51	70.6*	102	33

* Gage is located downstream of Springfield's Southwest Wastewater Treatment Facility which has a mean annual discharge of 54 ft^3/s.

Table 2. Riparian Corridor within 100 ft Buffer (North Site)

Type	Acres	Percent of Total
Pasture	8.7	55.8
Floodplain - Mature Trees	3.6	23.1
Floodplain - Young Trees	0.0	0.0
Bluff - No Trees	0.2	1.4
Bluff - Mature Trees	2.1	13.3
Road Fill	1.0	6.3
Total	15.6	100

Table 3. Riparian Corridor within 100 ft Buffer (South Site)

Type	Acres	Percent of Total
Pasture	2.3	19.0
Floodplain - Mature Trees	1.7	14.0
Floodplain - Young Trees	4.8	40.3
Bluff - No Trees	0.0	0.0
Bluff - Mature Trees	2.5	20.8
Road Fill	0.7	5.9
Total	12.0	100

Table 4. Total Channel Capacity for the North and South Segments

Location		Channel						
Site	Station (ft)	Slope (ft/ft)	Width (ft)	Depth (ft)	Area (ft^2)	Manning's "n"	Q (ft^3/s)	W/D Ratio
North	2,300	0.0021	63.6	6.7	251.1	0.035	1,158	16.1
South	1,900	0.0022	106.2	5.5	348.3	0.035	1,499	32.4

Table 5. Flood Recurrence Intervals for USGS Gaging Station at FR 156.

Q-RI	Discharge (ft^3/s)
1.005-yr	897
1.01-yr	1,003
1.05-yr	1,354
1.11-yr	1,586
1.25-yr	1,919
1.5-yr	2,289
2-yr	2,750

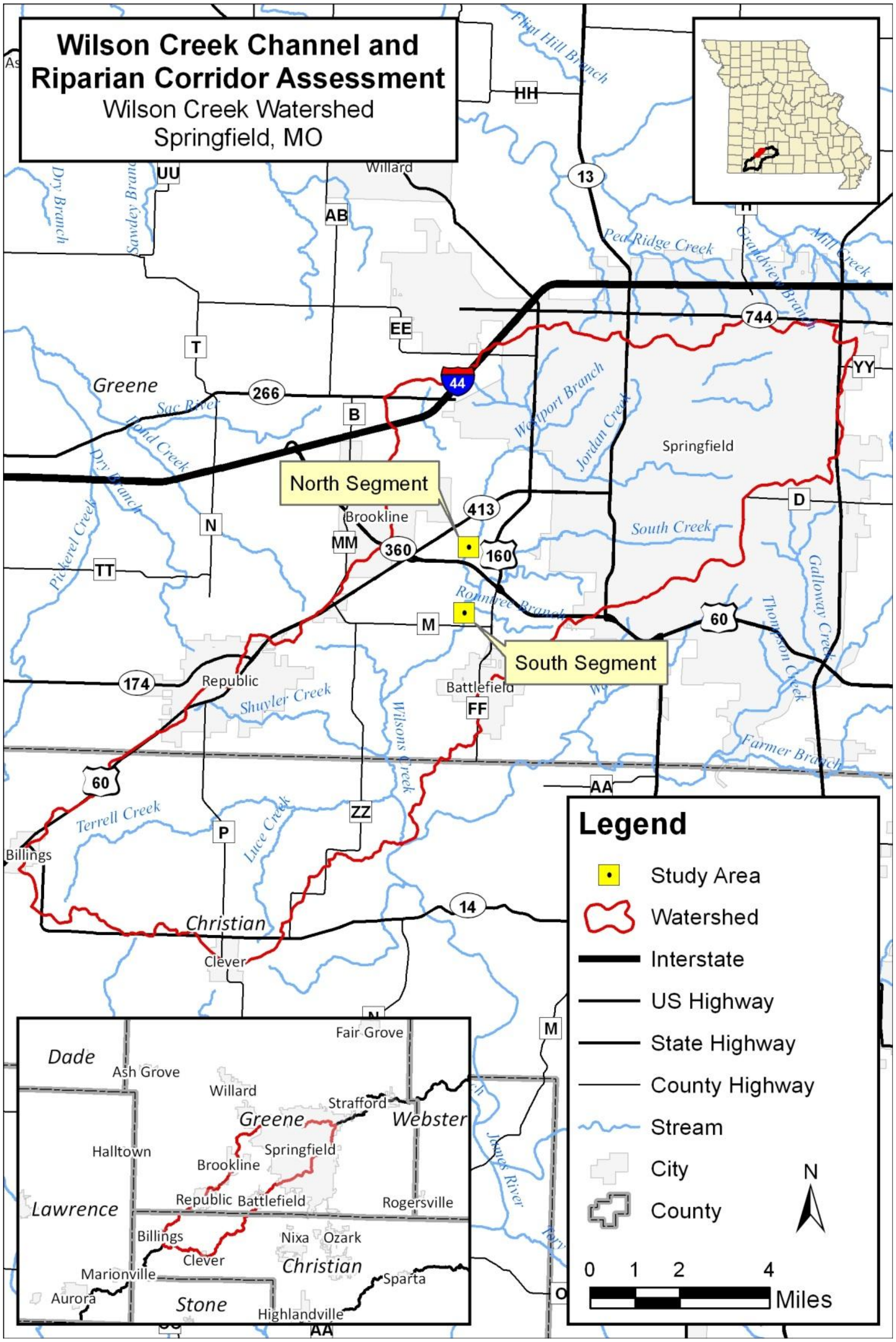

Figure 1. Location Map.

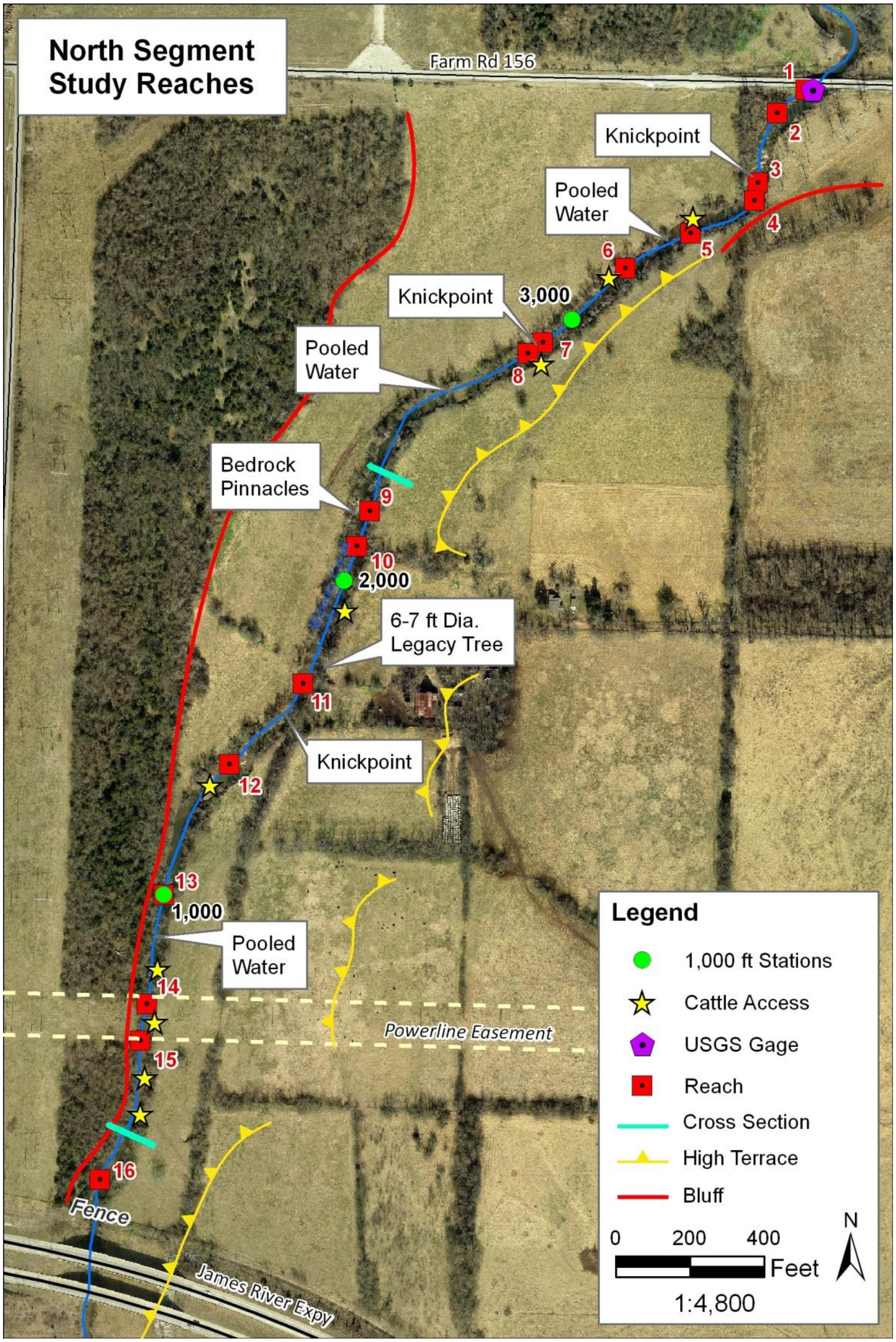

Figure 2. North Segment Sub-Reach Map.

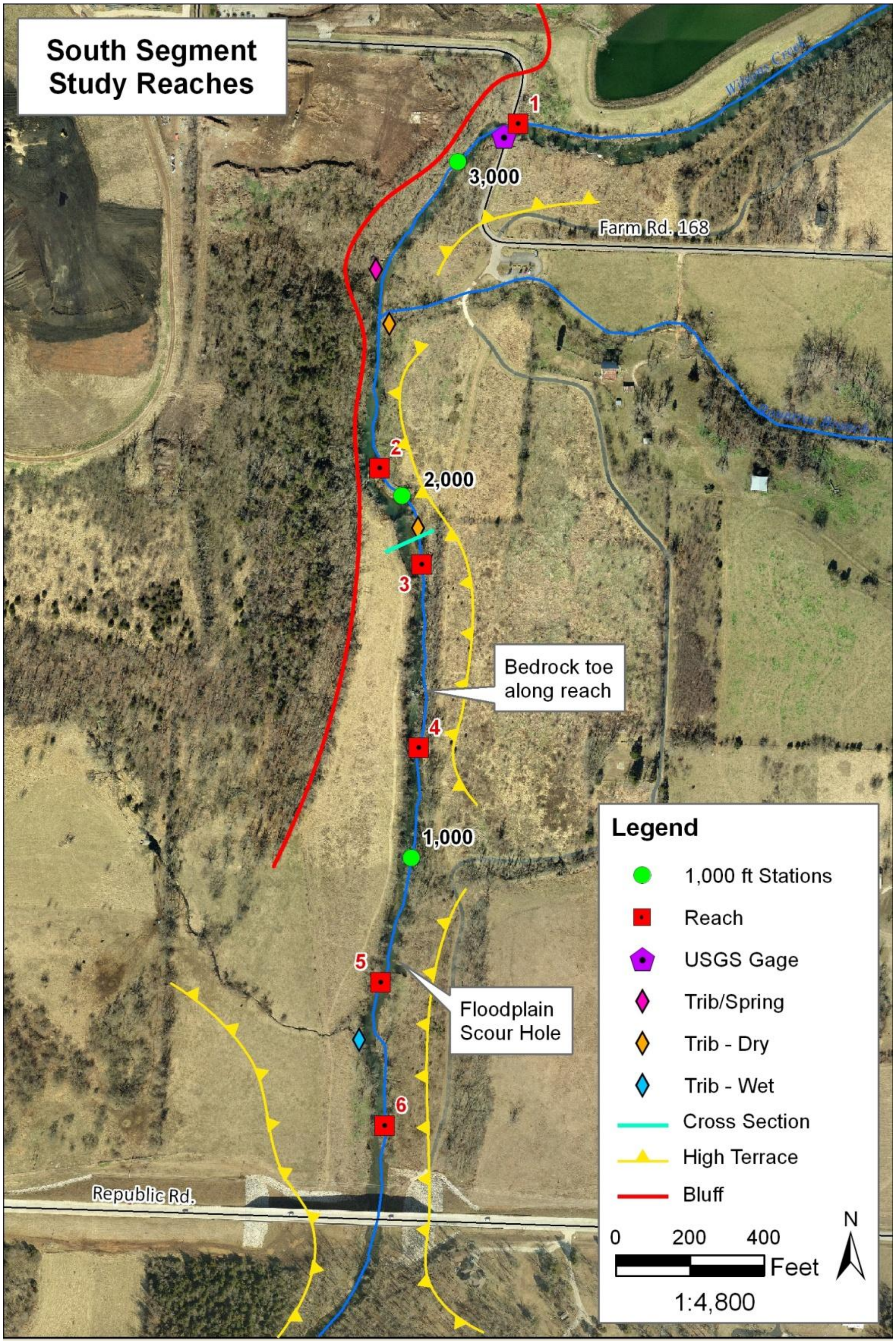

Figure 3. South Segment Sub-Reach Map.

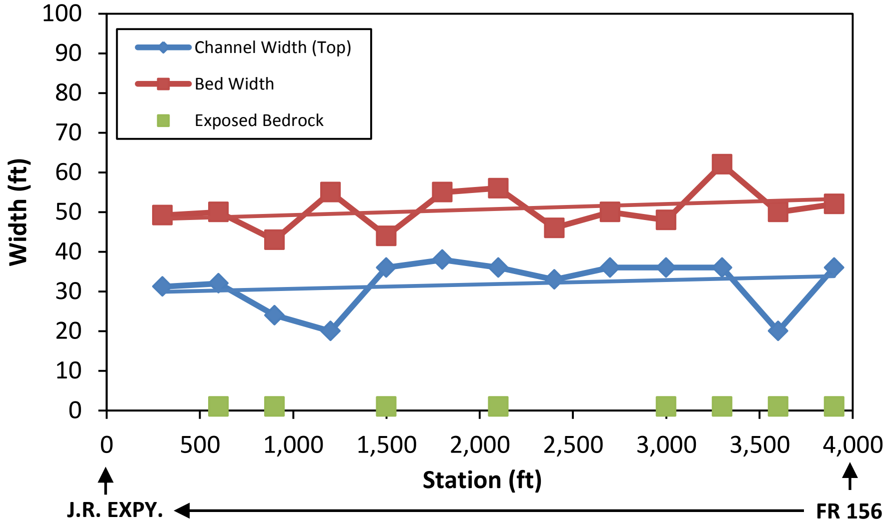

Figure 4. North Segment – Channel Width and Bedrock

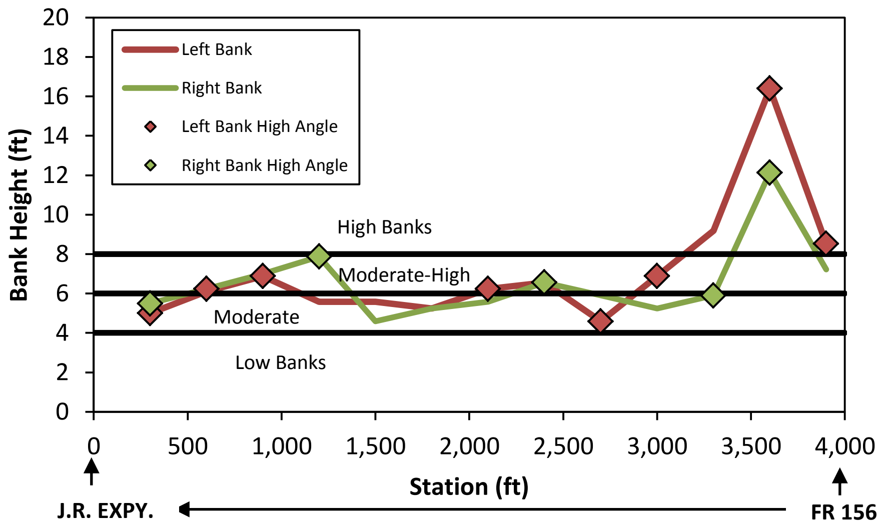

Figure 5. North Segment - Bank Height and Angle

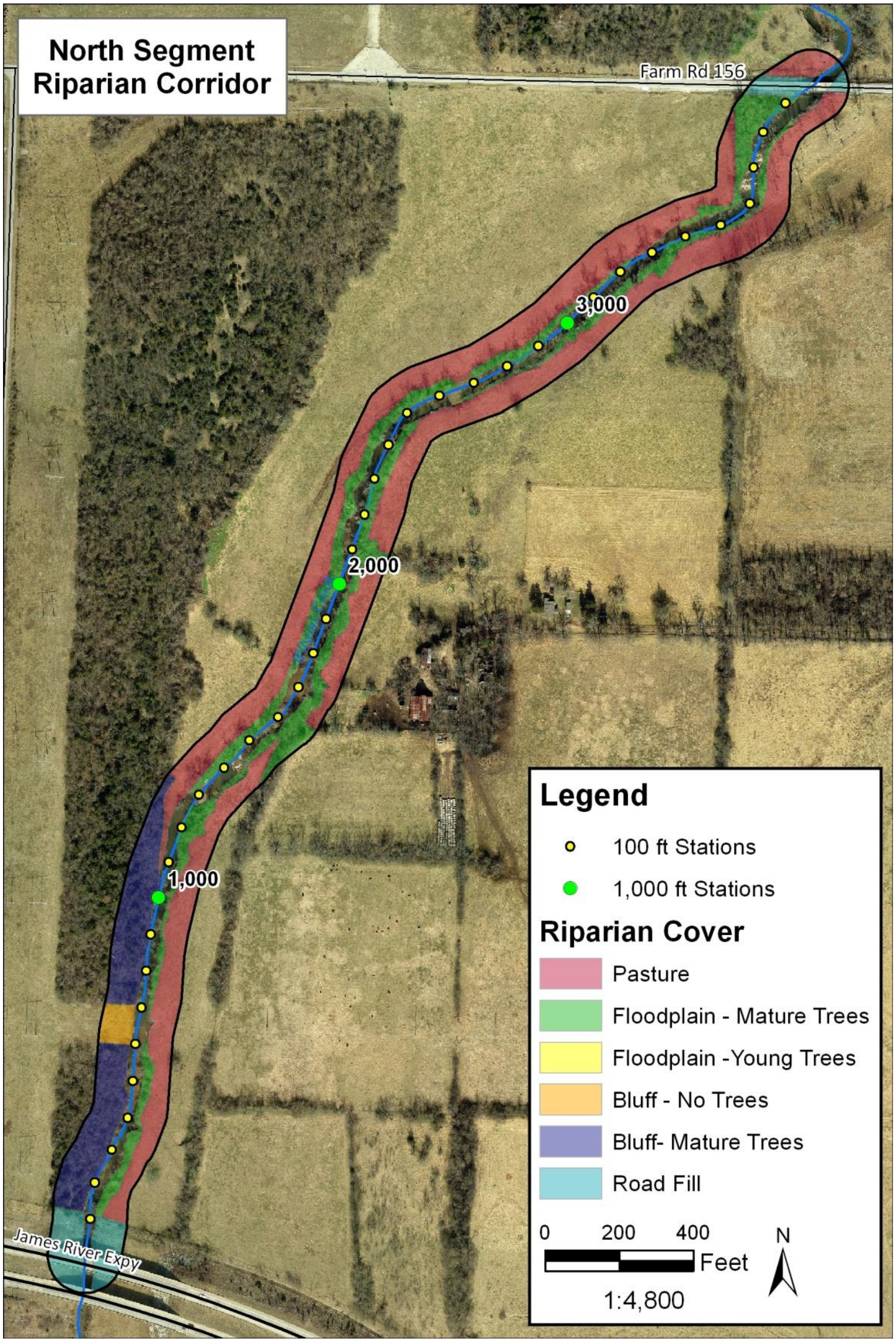

Figure 6. North Segment Riparian Corridor

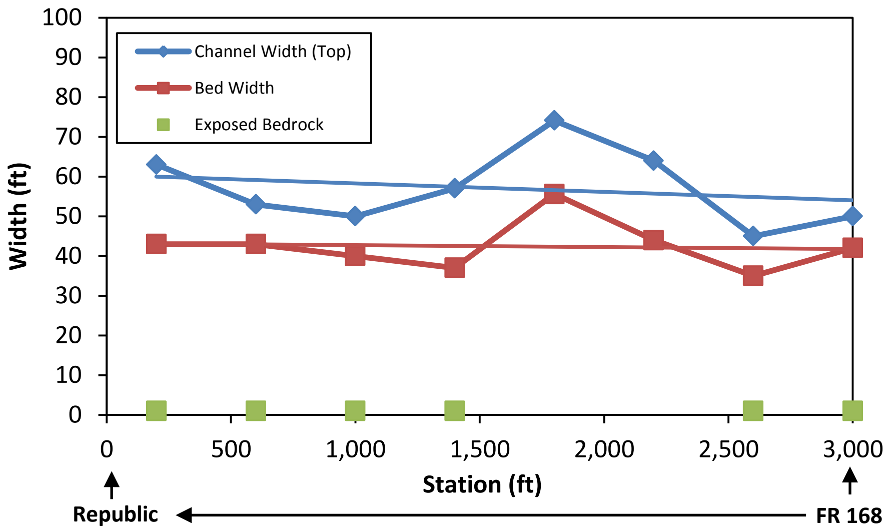

Figure 7. South Segment – Channel Width and Exposed Bedrock

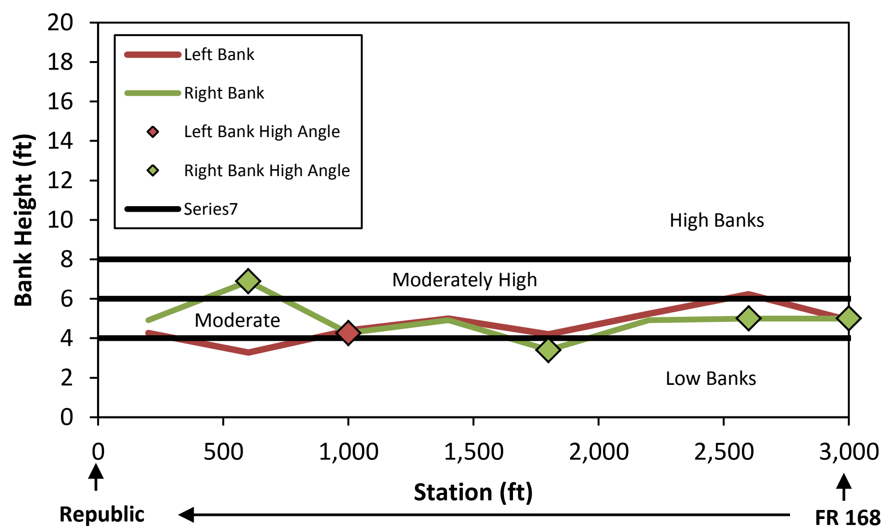

Figure 8. South Segment – Bank Height and Angle

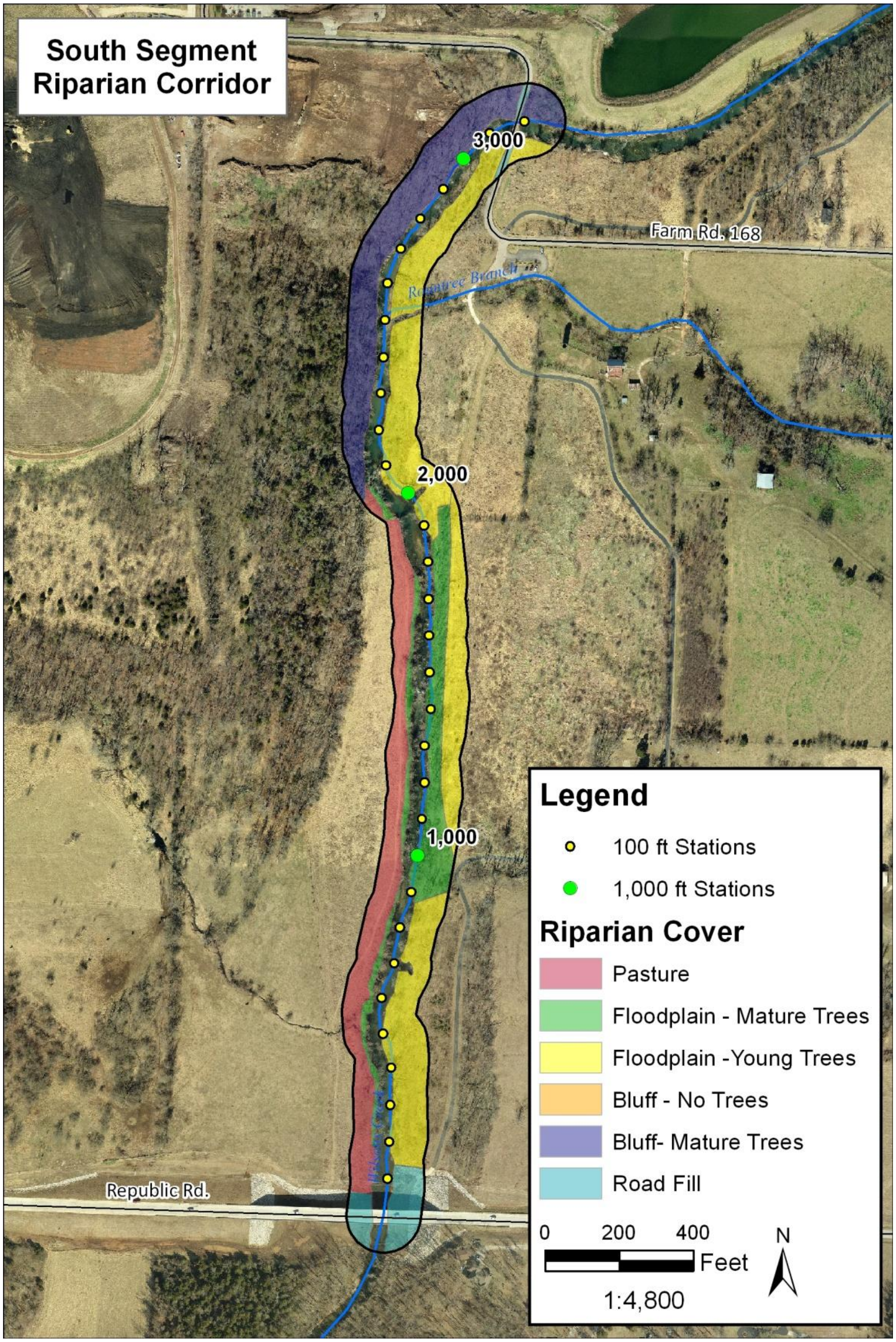

Figure 9. South Segment Riparian Corridor

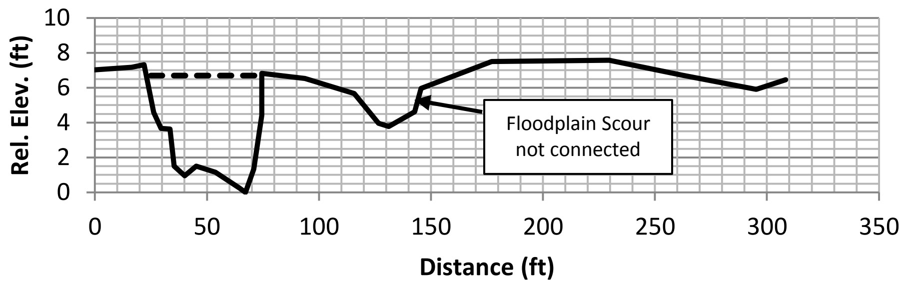

Figure 10. North Segment Channel Cross-Section at 2,300 ft.

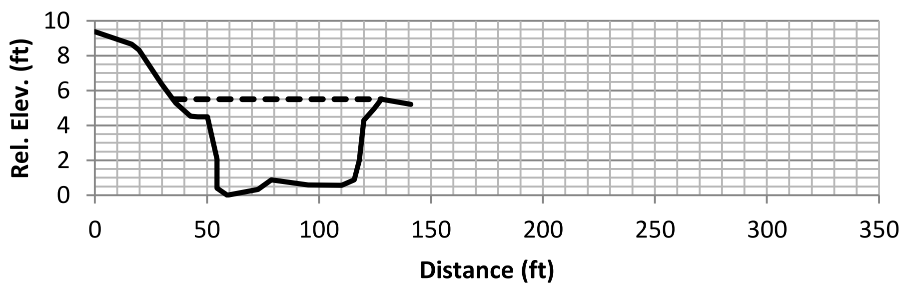

Figure 11. South Segment Channel Cross-Section at 1,900 ft.

Photos

Photo 1. Bridge Reach (3,850 ft) looking upstream at USGS gage at FR 156.

Photo 2. Bedrock Bed Reach (3,800 ft) looking downstream.

Photo 3. Knickpoint Reach (3,600 ft) looking upstream from the bottom of the knick/reverse sinkhole?

Photo 4. Knickpoint Reach (3,600 ft) left bank erosion.


Photo 5. Bedrock Bluff Reach (3,500 ft) looking downstream.


Photo 6. Cattle Entrance and Cutbank Reach (3,300 ft) looking at the right bank.

Photo 7. Bedrock/Cattle Entrance Reach (3,200 ft) looking downstream.

Photo 8. Bedrock Knickpoint #2 (2,900 ft) looking at the left bank erosion near the second knickpoint on the north property.


Photo 9. Gravel Bed Reach #1 (2,700 ft) cattle entrance on right bank.


Photo 10. Cattle damaged banks (2,600 ft).

Photo 11. Gravel Bed Reach #2 (2,100 ft) looking downstream.

Photo 12. Legacy tree at station 1,800 ft.


Photo 13. Bedrock Knickpoint Reach #3 (1,450 ft) looking downstream.


Photo 14. Bank Erosion Reach (1,300 ft) looking at the right bank.

Photo 15. Bedrock/Bluff Pool Reach (700 ft) looking upstream.

Photo 16. Erosion caused by a cattle entrance to water along the bluff pool.

Photo 17. Utility Easement and Cattle Entrance Reach (600 ft) looking at the cattle entrance and left bank erosion.

Photo 18. Gravel Bed Reach #3 (300 ft) looking downstream.


Photo 19. Bedrock/Bridge Reach (200 ft) looking downstream.


Photo 20. Bedrock Controlled/Bluff Reach (3,100 ft) looking upstream toward old FR 168 bridge.

Photo 21. Transition Reach (2,100 ft) looking downstream.

Photo 22. Straight/Bedrock Toe Reach (1,800 ft) looking downstream.

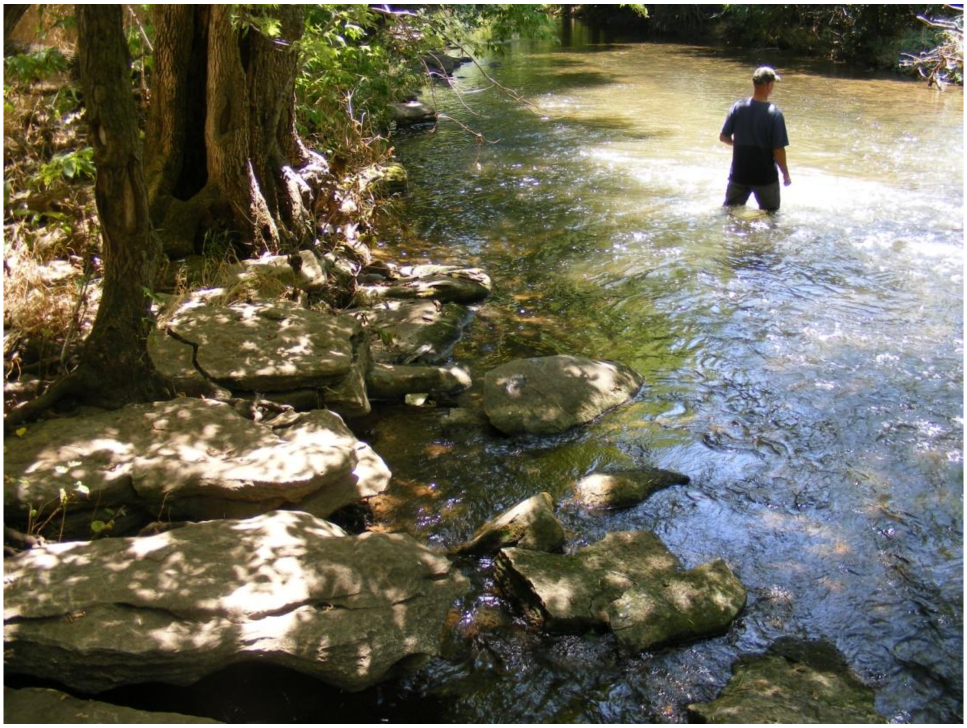
Photo 23. Bedrock exposed along the toe of the left bank at station 1,400 ft.


Photo 24. Slick Bedrock Reach (1,300 ft) looking downstream.

Photo 25. Thin riparian buffer on right bank at station 900 ft.

Photo 26. Floodplain scour hole on left bank at station 700 ft.

Photo 27. Gravel Bed Reach (500 ft) looking at the right bank.

Photo 28. Bedrock Bed/Bridge Reach (250 ft) looking downstream toward Republic Road Bridge.

Appendices

Wilson Creek Riparian Easement Assessment **Workers:** Aubree Vaughan, Lindsay Olson **Date:** 7/20/2012

North Site

Location		**Channel**	**Channel Width**			**Substrate**		**LEFT Bank**						**RIGHT Bank**						**Cattle Effect**	
R-ft (ft)	GPS (pt #)	**Unit** (R,N,P,G)	Wbed (ft)	Wbf (ft)	Wtop (ft)	%BR (% area)	%MBar (% area)	Ht bf (ft)	Ht top (ft)	%raw (% len)	%>70 (% len)	%roots (% len)	Wbuffer (ft)	Ht bf (ft)	Ht top (ft)	%raw (% len)	%>70 (% len)	%roots (% len)	Wbuffer (ft)	Bank (0,1,2)	Manure (0,1,2)
3,900		P	36	39	52	100	0	1.7	2.6	70	100	30	0	1.2	2.2	20	0	0	20	2	2
3,600		P	20	35	50	100	0	0.8	5	100	100	20	0	1.6	3.7	100	100	100	0	1	0
3,300		G	36	46	62	30	0	2	2.8	90	0	5	0	1.1	1.8	90	10	5	0	2	2
3,000		G	36	42	48	10	0	1.6	2.1	100	20	5	0	1.1	1.6	100	0	5	0	2	1
2,700		R	36	44	50	0	0	1.4	1.4	100	100	5	0	0.9	1.8	100	0	5	0	1	1
2,400		P	33	42	46	0	0	1.4	2	100	0	0	0	1.4	2	100	10	0	0	2	2
2,100		R	36	50	56	80	0	1.9	1.9	100	100	0	0	1	1.7	100	0	0	0	1	1
1,800			38	45	55	0	0	1.3	1.6	80	0	20	0	1.3	1.6	40	0	5	0	2	2
1,500		G	36	44	44	40	0	1.7	1.7	20	0	10	0	1.4	1.4	10	0	5	0	0	0
1,200		P	20	43	55	0	0	0.9	1.7	0	0	0	0	2.4	2.4	90	100	0	0	2	2
900		P	24	43	43	10	0	N/A	2.1	90	100	5	0	bluff	bluff	50	bluff	0	bluff	2	2
600		G	32	50	50	5	0	1	1.9	100	100	0	0	1.9	1.9	0	0	0	0	2	2
300		N				0	0			0	0	5	0			20	100	5	100	1	1

Wilson Creek Riparian Easement Assessment **Workers:** Aubree Vaughan, Lindsay Olson **Date:** 7/20/2012

South Site

Location		Channel	Channel Width			Substrate		LEFT Bank						RIGHT Bank						Cattle Effect	
R-ft (ft)	GPS (pt #)	Unit (R,N,P,G)	Wbed (ft)	Wbf (ft)	Wtop (ft)	%BR (% area)	%MBar (% area)	Ht bf (ft)	Ht top (ft)	%raw (% len)	%>70 (% len)	%roots (% len)	Wbuffer (ft)	Ht bf (ft)	Ht top (ft)	%raw (% len)	%>70 (% len)	%roots (% len)	Wbuffer (ft)	Bank (0,1,2)	Manure (0,1,2)
3,000		R	42	50	50	10	0	1.5	1.5	5	0	10	15	BLUFF	BLUFF	0	100	0	BLUFF	0	0
2,600		G	35	38	45	10	0	1	1.9	0	0	0	100	BLUFF	BLUFF	0	100	0	BLUFF	0	0
2,200		P	44	58	64	0	0	0.6	1.6	0	0	0	0	1.5	1.5	0	0	5	BLUFF	0	0
1,800		R				0	0			10	0	10	15			5	100	0	0	0	0
1,400		R	37	47	57	30	0	0.7	1.5	0	0	5	15	1	1.5	0	0	0	0	0	0
1,000		R	40	50	50	30	0	1.3	1.3	0	10	5	30	1.3	1.3	0	0	0	0	0	0
600		N	43	53	53	20	0	1	1	10	0	5	100	2.1	2.1	80	10	30	0	0	0
200		G	43	58	63	70	0	1.3	1.3	0	0	20	10	0.5	1.5	0	0	0	0	0	0

	MODIFIED RAPID GEOMORPHIC ASSESSMENT (MRGA) Geomorphic Indicator --> *Record "X" if present*	Site # or R-distance												
		3,900	3,600	3,300	3,000	2,700	2,400	2,100	1,800	1,500	1,200	900	600	300
	Evidence of Aggradation													
1	Lateral bars										X			
2	Embedded riffles (>20% fines by area)													
3	Siltation in pools													
4	Mid-channel or center bars (split thalwag)													
5	Deposition on top of "wide" point bars													
6	Poor lateral sorting of bed materials (not armor or lag)								X					
7	Soft, unconsolidated bed (feet sink into it)													
8	Deposition in/around bank structures						X							
9	Deposition in overbank zone (gravel splay or sheets)													
	Evidence of Degradation													
1	Channel incision into residuum or bedrock	X	X	X	X			X		X		X		
2	Elevated tree roots/root fan above channel bed	X	X	X	X			X			X	X	X	X
3	Bank height increases downstream				X									
4	Absence of depositional features (no bars)	X	X	X	X	X	?	X	X	X		X	X	X
5	Cut face on bar forms													
6	Head cutting due to knickpoint migration		X											
7	"Hanging" armor layer visible in bank		X		X					X	X			
	Evidence of Widening													
1	Fallen/leaning trees/fence posts/etc.	X	X				X					X		
2	Occurrence of large woody debris	X	X	X			X	X				X		X
3	Exposed tree roots	X	X	X	X		X	X	X	X	X	X	X	
4	Basal scour on <u>inside</u> of bends	X	X											
5	Toe erosion on both sides of channel through riffle													
6	Steep bank angles along most of the reach	X	X		X	X						X	X	
7	Length of bank scour >50% through subject reach	X	X	X	X	X	X	X			X	X	X	X
8	Block failures/slump scars/fracture lines	X	X			X		X			X		X	X
	Evidence of Planform Adjustment													
1	Formation of chutes													
2	Change: single-thread to multiple channel													
3	Change: riffle-pool to plane-bed													
4	Cut-off channels and recent oxbows													
5	Formation of Islands													
6	Thalweg alignment out-of-phase with meander form													
7	Bar forms poorly formed/reworked/removed										X			

MODIFIED RAPID GEOMORPHIC ASSESSMENT (MRGA)		Site # or R-distance							
	Geomorphic Indicator *--> Record "X" if present*	3,000	2,600	2,200	1,800	1,400	1,000	600	200
	Evidence of Aggradation								
1	Lateral bars	X							
2	Embedded riffles (>20% fines by area)								
3	Siltation in pools								
4	Mid-channel or center bars (split thalwag)				X				
5	Deposition on top of "wide" point bars								
6	Poor lateral sorting of bed materials (not armor or lag)								
7	Soft, unconsolidated bed (feet sink into it)								
8	Deposition in/around bank structures								
9	Deposition in overbank zone (gravel splay or sheets)								
	Evidence of Degradation								
1	Channel incision into residuum or bedrock	X	X		X	X	X		X
2	Elevated tree roots/root fan above channel bed	X							
3	Bank height increases downstream								
4	Absence of depositional features (no bars)		x	x		x	x	X	X
5	Cut face on bar forms								
6	Head cutting due to knickpoint migration								
7	"Hanging" armor layer visible in bank								
	Evidence of Widening								
1	Fallen/leaning trees/fence posts/etc.				X				
2	Occurrence of large woody debris		X	X	X	X		X	X
3	Exposed tree roots	X		X	X		X	X	X
4	Basal scour on <u>inside</u> of bends							X	
5	Toe erosion on both sides of channel through riffle								
6	Steep bank angles along most of the reach								
7	Length of bank scour >50% through subject reach								
8	Block failures/slump scars/fracture lines								
	Evidence of Planform Adjustment								
1	Formation of chutes							X	
2	Change: single-thread to multiple channel				X				
3	Change: riffle-pool to plane-bed								
4	Cut-off channels and recent oxbows								
5	Formation of Islands								
6	Thalweg alignment out-of-phase with meander form								
7	Bar forms poorly formed/reworked/removed	X		X					