Current River – Chilton Creek Area Fluvial Geomorphology
Final Report

Revision 1

Prepared for:

Ozark National Scenic Riverways

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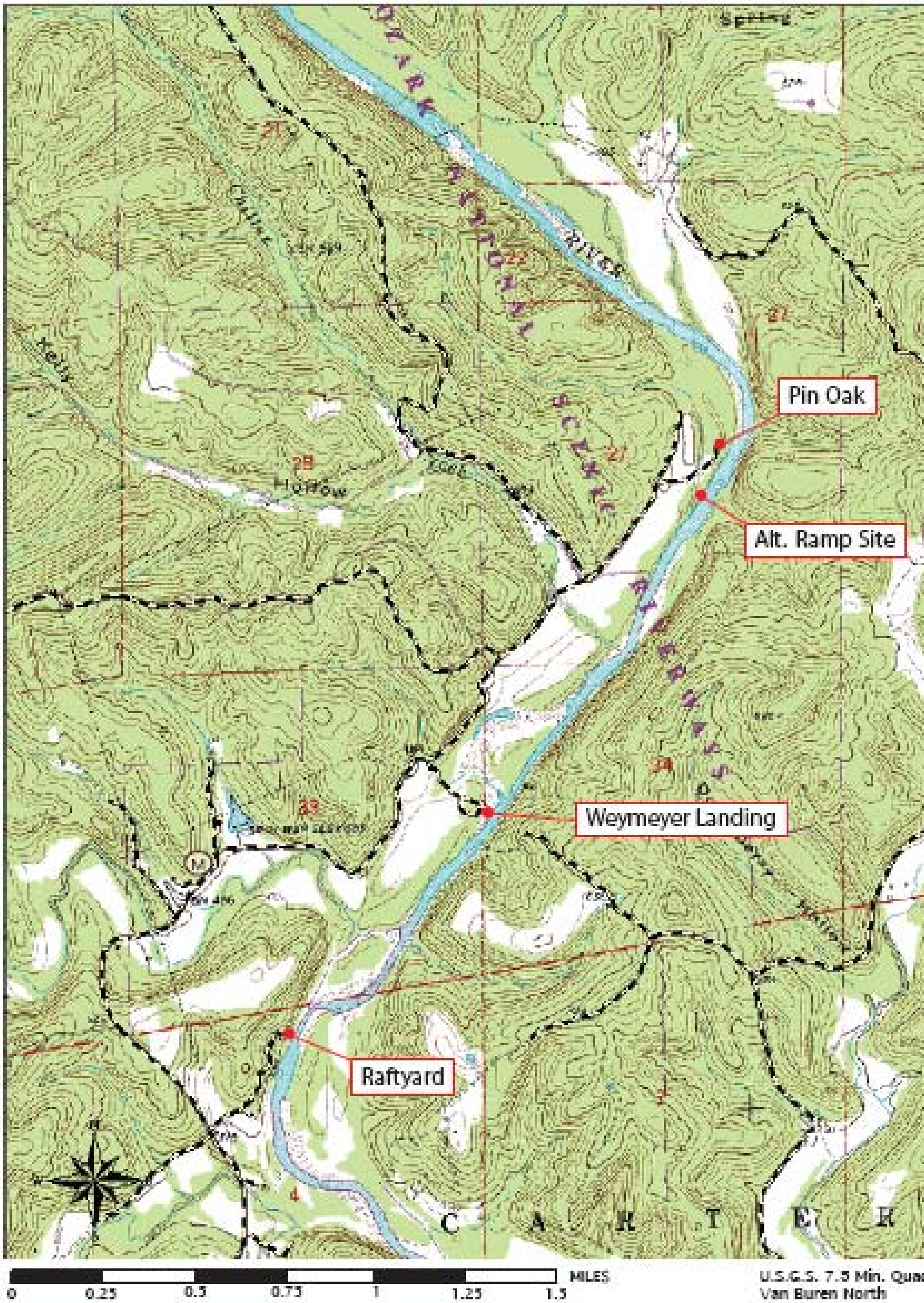

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1.0 INTRODUCTION

A fluvial geomorphology assessment was conducted for the Chilton Creek Area as part of a growing concern by the Ozark National Scenic Riverways. The problem is fluvial erosion issues appear to be threatening the public's future access to the Current River provided by Waymeyer Landing. Fluvial erosion is an environmental phenomenon that consists of many complex factors. As a result, this fluvial geomorphology assessment consists of an integrated assessment summarizing various scientific frameworks associated with fluvial erosion and bank stability for three river-access sites. Figure 1 shows the study reach limits and location of each of the sites.

The primary objective of the integrated assessment is the following products:

- Document the historical trends of the channel system
- Establish the current stability of the channel system and identification of the dominant processes and features within the system
- Provide rational basis for identification and design of effective alternatives to meet future goals

The assessment results should be vital in providing the Ozark National Scenic Riverways information in managing financial, maintenance and river-accessibility issues for the study reach.

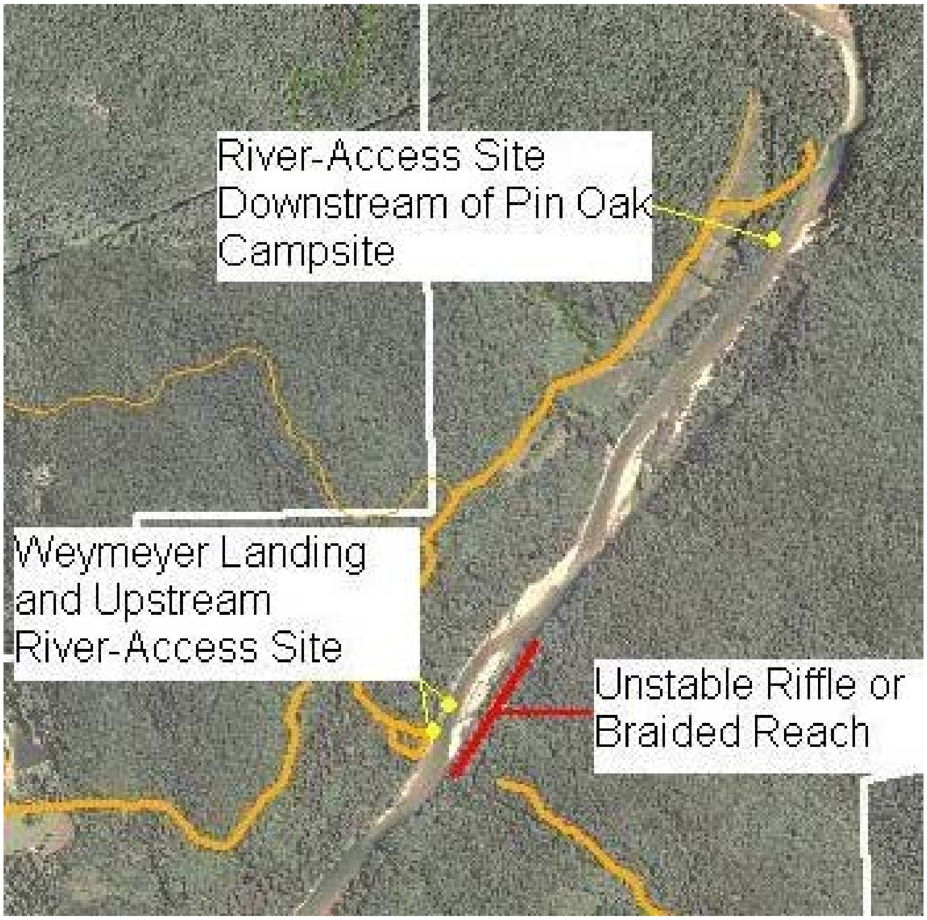

Figure 1. Study-Reach Limit and Details.

2.0 STUDY-REACH RISK ASSESSMENT

A scientific approach consisting of fluvial geomorphology and hydraulic engineering was used to assess the stability of the study-reach. This scientific approach provided a rational process to investigate many of the complex phenomenon acting in a dynamic channel system including hazards to river-access development and maintenance.

A review of the aerial photographs from the 1960's, 1995, 2003, 2004, 2005, 2006, and 2007 provided an indication of the relative stability of the study reach. In general, the study reach has been relatively stable since 1995 with the last major channel shift (upstream of Waymeyer Landing) shown in the 1960's aerial photograph. Bank retreat was observed to be minor throughout the study-reach.

Overall, the study-reach is a pool-riffle system with mobile bed and bank sediments. Figure 1 illustrates this pool-riffle system with darker areas indicating pools and lighter areas showing riffles in the river channel. This figure also identifies an unstable riffle area located immediately upstream from Waymeyer Landing and the upstream adjacent site. Figure 1 shows the unstable riffle has now developed into a braided or multi-channel reach with no defined thalweg. This unstable riffle was observed and documented in the June 9, 2008 site investigation.

A braided river is one that consists of multiple and interlacing channels. One cause of braiding is the large quantity of bed load from major flooding. Generally, the magnitude of the bed load is more important than its size. If the channel is overloaded with sediment, deposition occurs, the bed aggrades, and the slope of the channel increases in an effort to obtain a stable state. As the channel steepens, the velocity increases, and multiple channels develop. These interlaced multiple channels cause the overall channel system to widen. Multiple channels are generally formed as bars of sediment are deposited within the main channel.

Another cause of braiding is easily eroded banks. If the banks are easily eroded, the stream widens at high flow and forms bars at low flow which become stabilized, thus forming islands. In general, a braided channel has a relatively steep slope, a large bed-material load in comparison with its suspended load, and relatively small amounts of silts and clays in the bed and banks.

In the reach of the unstable riffle or braided channel, the banks consist of easily erodible materials, and major flooding including a considerable sediment aggregation has occurred in the past few months. Therefore, a braided reach has developed upstream from Waymeyer Landing and the upstream adjacent site. The impact of this braided channel will cause significant river channel adjustments and increased erosional forces on the river-access sites located downstream.

In contrast, the river-access site located downstream of Pin Oak Campground is stable. This site is located in a pool downstream of a stable riffle. Accordingly, this site is predicted to remain stable as demonstrated in the last 40 years.

Additional support for the previous predictions can be summarized using the following qualitative assessment. Figure 2 summarizes possible channel stability interpretations according to stream characteristics, as well as additional factors that commonly influence stream stability. Figure 2 is also useful in making a qualitative assessment of stream stability based on stream characteristics. It shows that straight channels are relatively stable only where flow velocities and sediment load are low. As these variables increase, flow meanders in the channel causing the formation of alternate bars and the initiation of a meandering channel pattern. Similarly, meandering channels are progressively less stable with increasing velocity and bed load. At high values of these variables, the channel becomes braided. The presence and size of point bars and middle bars are indications of the relative lateral stability of a stream channel. Bed material transport is directly related to stream power, and relative stability decreases as stream power increases as shown by Figure 2. Stream power is a measure of the work rate of a river computed as the product of gravitational acceleration, mass density of the fluid flow, river discharge, and water-surface slope. It represents the power available per unit length of channel including the power dissipated in the transport of sediment.

The stability of each river-access site was qualitatively assessed by matching each channel pattern (in the reach bounding the specific site) with those shown in Figure 2. The site downstream of Pin Oak Campground matched the channel classification number 2. This classification indicated the site has the following characteristics:

- Straight channel pattern
- Mixed load channel type
- Moderate-to-High relative stability variables
    - Low bed load/total load ratio
    - Small sediment size and load
    - Low flow velocity
    - Low stream power

The result of the qualitative assessment indicated the site downstream of Pin Oak Campground has a high level of relative stability with the only the risk of alternate bar development near the site. However, past and present sediment transfer in this reach provided no indication of an alternate bar development risk.

Similarly, the Waymeyer Landing and adjacent upstream site are estimated to have a channel classification number between 4 and 5 as shown in Figure 2. This classification indicates the sites have the following vital characteristics:

- Braided channel pattern
- Bed load channel type
- Low relative stability variables
    - High bed load/total load ratio
    - Large sediment size and load
    - High flow velocity
    - High stream power

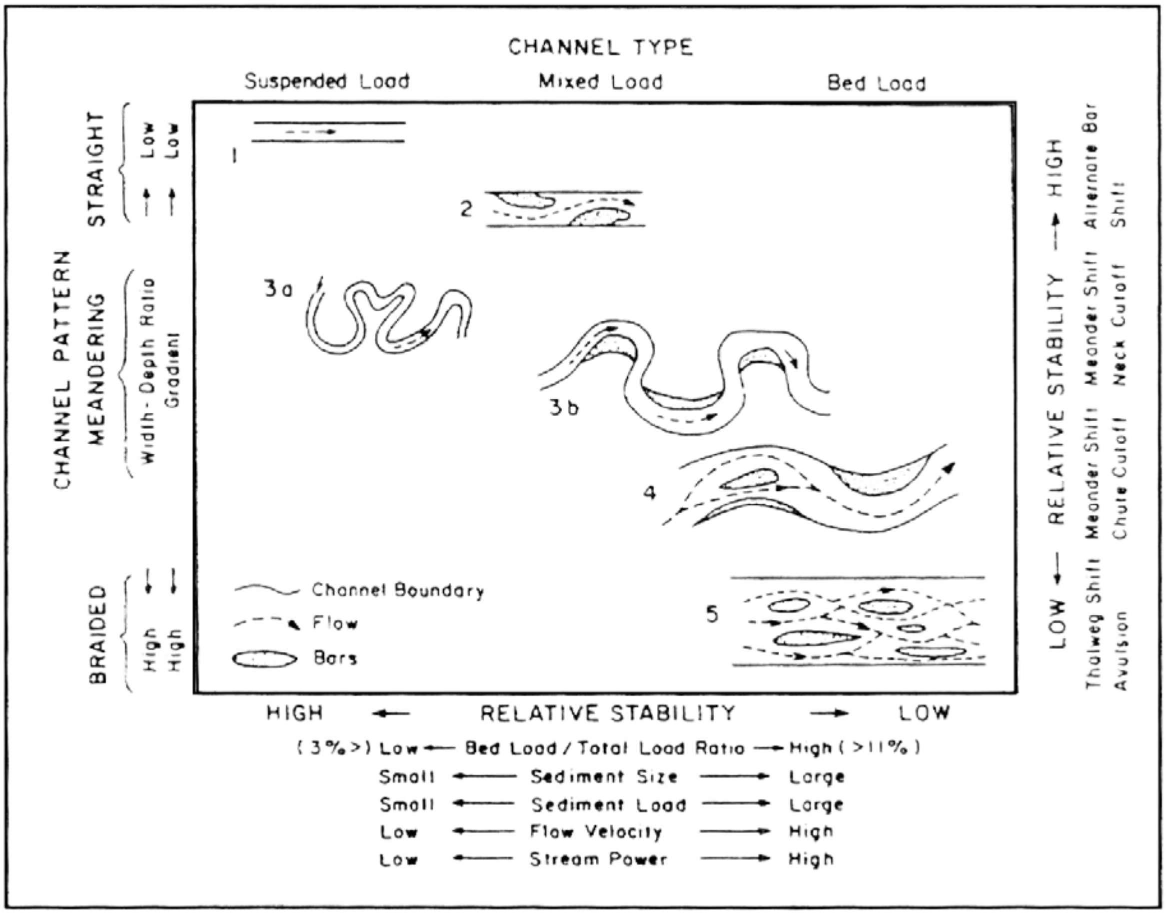

Figure 2. Channel classification showing relative stability and types of hazards encountered with each pattern. (modified from *Shen, H., Schumm, S., Nelson, J., Doehring, D., & Skinner, M. 1981. Methods for assessment of stream-related hazards to highways and bridges. Washington D.C.: Federal Highway Administration*).

The result of the qualitative assessment indicated the Waymeyer Landing and adjacent upstream site have a low level of relative stability with the risk of meander and/or thalweg shifts. This braided channel will respond to these variables by making significant adjustments to restore sediment transport continuity. These adjustments may include channel steepening, or changing channel pattern and cross-section shape. The impact to the two sites will be a variety of changes. One change will be limited boat access to going upstream of the braided channel due to shallow depths. Another change will be increased bank erosion of the two sites. A more detailed analysis of having a river-access located downstream of a braided channel on the Current River has been included in Appendix A.

The study-reach risk assessment provided an overall geomorphic setting for the three river-access sites. The river-access site located downstream of Pin Oak access has no significant reach-risks. In contrast, the two downstream sites at and near Waymeyer Landing will require considerable resources to mitigate the hazards of being in a braided channel reach. Therefore, careful planning and design are necessary to provide a robust erosion countermeasure for these sites.

Figure 3. Estimated bank erosion at Waymeyer Landing.

3.0 SITE-SPECIFIC RISK ASSESSMENT

A site-specific risk assessment was conducted for each river-access site as part of the decision-making process for future development, maintenance and/or renovation. The overall purpose was to provide a site-specific assessment for decision-makers in developing a stabilization plan.

3.1 Waymeyer Landing

Over the past few months, Waymeyer Landing has experienced substantial bank loss as shown in Figure 3. The bank retreat is the result of hydraulic erosion and geotechnical failure of the non-cohesive soil. Hydraulic erosion has occurred due to parallel and impinging flow removing the non-cohesive soil. Fluvial entrainment by water flowing parallel to the bank causes erosion by removal of soil particles when fluid shear stresses exerted on the bank are greater than the shear resistance of the bank material. Fluvial entrainment is a common cause of bank retreat, and indicates that the bank material is unable to withstand the near-bank velocities imposed by the flow in the channel. To be successful, any type of mitigation must deal with this imbalance either by reducing velocities or by increasing bank erosion resistance. This imbalance occurs mainly during high, in-bank flows, is usually concentrated on the lower third of the bank, and is characterized by a lack of bank vegetation and a steep bank-slope.

Impinging flow attacks the bank at an angle to the long-stream direction. Erosion can occur at a range of discharges because of the intense turbulence generated when impinging flow strikes the bank. Impinging flow will usually occur downstream of braided channels due to concentration and conveyance of flow energy into the bank by bars and fallen trees.

Geotechnical failure has occurred due to the steepness of the bank slope. The non-cohesive soil will only be stable with a bank angle of 40 degrees or less. Geotechnical failure is the downward movement of soil masses. It occurs when the down-slope shear stress (weight) exceeds the shear strength (resistance to weight) of earth material. Shear stress is the driving force from gravity and/or loads acting on the slope. Shear strength is the characteristic of soil, rock and root structure that resists one unit of material sliding along another. Any cause that increases the shear stress or conversely decreases the shear strength will cause geotechnical failure.

Waymeyer Landing can be stabilized with considerable development and maintenance. The entire bank must be graded to have a 3-to-1 (3 horizontal to 1 vertical) slope. Any material for a boat ramp and erosion control must be a flexible solution like the proposed ACM (articulating concrete mattress). A combination of erosion control methods with vegetation could be used to provide stability. Yet, substantial maintenance would be required to maintain stability and public use at the access. In addition, bank-toe scour and bank-key design would be vital to achieving an effective instability countermeasure.

3.2 Site Upstream of Waymeyer Landing

This site has the same site-specific risks and countermeasures as the Waymeyer Landing, except a rock foundation would need to be constructed below a new boat ramp. The rock would replace sand in the selected ramp location to provide a structurally sound foundation.

3.3 Site Downstream of Pin Oak Campground

The river-access site located downstream of Pin Oak access has no significant risks. A concrete boat ramp graded into the bank would cause no additional hazards. The side slopes of the boat ramp should be lined with a permanent erosion control mat and vegetation. Also, the boat ramp should have a rock-lined shoulder for safe walking similar to the Missouri Department of Conservation Ramps.

4.0 SUMMARY AND CONCLUSIONS

The Current River is one of the weakest channel types because it is a pool-riffle system with mobile bed and bank sediments. Therefore, it is one of the most sensitive channels to changes in the load. The dimensions (depth and width) and bank stability of this channel type are very sensitive to changes in coarse sediment supply and to increases in discharge. Specifically, bed material in these channels is very responsive to changes in sediment supply and water discharge. As a result, the assessment results should be vital in providing stakeholders information in managing financial, maintenance and river-accessibility issues for any access.

The river-access site located downstream of Pin Oak access has no significant risks. In contrast, the two downstream sites at and near Waymeyer Landing will require considerable resources to mitigate the hazards of being in a braided channel reach. Therefore, careful planning and design are necessary to provide a robust erosion countermeasure. Appendix B has been included to aid in strategic planning and the design process. A conceptual design with estimated material quantities has been included in Appendix C using specified materials from Appendix D.

Finally, any boat ramp will need to be oriented either perpendicular or angled downstream to flow to minimize bed scour and maximize boat “put-in/take-out” capabilities.

5.0 GENERAL COMMENTS

The scientific methods presented do not omit the fact of uncertainty of prediction, the variability of nature and its ever-present complexity. While more time and measurements are required to predict the equilibrium status of channel response to many complex interactions of watershed and stream-channel processes with any certainty, this report has been prepared for the exclusive use of the Ozark National Scenic Riverways for specific applications as specified. It has been prepared in accordance with generally accepted river assessment practices within the constraints of the Ozark National Scenic Riverways’ directives. No warranties, either expressed or implied, are intended or made. Others drawing conclusions from the results of this assessment should recognize the limitations of the assessment methods used in this report.

APPENDIX A

T.L. WRIGHT MEMORIAL ACCESS RIVER-ACCESS FINAL REPORT March 30, 2007

Available upon request.

APPENDIX B

STABILITY THRESHOLDS FOR STREAM RESTORATION MATERIALS ERDC TNEMRRP-SR-29

Available upon request.

APPENDIX C

ESTIMATED RIVER-ACCESS DEVELOPMENT QUANTITIES

C1.0 Site Upstream of Waymeyer Landing

The river-access site located upstream of Waymeyer Landing has significant risks. As a counterneasure, an articulating concrete mattress (ACM) on a foundation of rockfill (4 ft. thickness) would provide the minimum requirements for a stable ramp. The development area would need to be a minimum of 33 ft (w) x 100 ft (l) for a footprint of 3300 s.f. or 366.7 s.y. An estimated 11,600 c.f., 430 c.y. or 645 tons of rockfill would be necessary for a stable foundation. The downstream shoulder would need to be an 8 ft. (w) x 100 ft. (l) ACM section to counter river forces. On the upstream side of the ramp, a 4 ft. (w) x 100 ft (l) longitudinal fill stone toe protection (LFSTP) will be required to counter river forces. If exposed rock fill is not acceptable for safe foot traffic and/or scenic reasons, then a 2 ft. (w) x 100 ft. (l) LFSTP capped with an 8 ft. (w) x 100 ft. (l) ACM section would be an acceptable alternative.

C2.0 Site Downstream of Pin Oak Campground

The river-access site located downstream of Pin Oak Campground has no significant risks. As a result, a concrete or articulating concrete ramp on a foundation of rockfill (2 ft. thickness) would provide the minimum requirements for a stable ramp. The development area would need to be a minimum of 16 ft (w) x 100 ft (l) for a footprint of 1600 s.f. or 177.8 s.y. An estimated 3200 c.f., 118.5 c.y. or 177.8 tons of rockfill would be necessary for a stable foundation. A 4 ft. (w) x 100 ft. (l) x 0.5 ft. (d) gravel shoulder on both sides of the ramp would be necessary for public safety (foot traffic). The side slopes of the boat ramp should be lined with a permanent erosion control mat and vegetation.

APPENDIX D

GENERAL CONSTRUCTION MATERIAL SPECIFICATION Retained for park use.