Mississippi River Whole Body Contact Recreational Use Attainability Analysis

October 11, 2007

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EXECUTIVE SUMMARY

In 2005, MEC Water Resources, Inc. (MEC) completed a use attainability analyses (UAA) on behalf of the Metropolitan St. Louis Sewer District (MSD) recommending removal of whole body contact recreation (WBCR) use designation for the Mississippi River from the Missouri Department of Conservation North Riverfront Park Access to the Meramec River confluence. The US Environmental Protection Agency (USEPA) requested additional data collection and analysis to support the UAA conclusions, which were approved by the Missouri Clean Water Commission in 2005 and adopted by state rule within 10 CSR 20-7.031. Pursuant to this end, a UAA scope of study was developed through a stakeholder process led by USEPA, which included the Missouri Department of Natural Resources (MDNR), MSD, the Missouri Coalition for the Environment, the Washington University Interdisciplinary Environmental Clinic, and USEPA designated consultants.

Results of this UAA study further support the conclusion that WBCR is not an attainable use for the Mississippi River in the vicinity of St. Louis Metropolitan area. Field observations conducted over 13 days (between July 4 to August 12, 2007), including two weekends and the Fourth of July and approximately 80,000 surveillance photos (from July 2 to August 19, 2007) from five locations distributed throughout the study segment showed no evidence of WBCR use. Extensive interviews suggest only extremely rare and infrequent instances of WBCR in the UAA segment. The overwhelming consensus among river authorities (e.g., US Army Corps of Engineers, US Coast Guard, Missouri Water Patrol, Illinois Conservation Police) is that barge traffic and hydrologic modifications present extremely dangerous hazards for WBCR uses.

Analyses conducted by MEC demonstrate that numerous factors prevent WBCR attainment including heavy barge traffic, excessive strong current, floating and submerged debris (e.g., logs and trees), low transparency and steep banks slopes with irregular surfaces and drop offs. Barge traffic in the St. Louis area is extremely heavy and ranks as the 3rd busiest inland port in the contiguous United States. Commercial boat traffic in St. Louis area exceeds the combined traffic in the Port of Chicago, Mobile Harbor and the Port of Erie. State led UAAs for these waterways cited commercial boat traffic in removing WBCR uses. Near-shore river velocities and bank slopes exceed recommended limits of human stability and channel velocities greatly exceed limits for safe swimming. Access to the river is also largely restricted by steep bluffs, the railroad, and industrial and commercial development. For these reasons, the US Coast Guard considers this river segment the most treacherous within this eight state district, which spans from Illinois to Colorado and Missouri to North Dakota.

Extensive data collection efforts support the same conclusion found in the 2005 UAA and that was ultimately adopted by state rulemaking. The State of Missouri portion of the Mississippi River from North Riverfront Park (RM 188.7) down to the confluence with the Meramec River (RM 160.8) should not be designated for WBCR use. This conclusion is based on extensive data collection efforts that, to our knowledge, far exceed any other applicable recreational UAA completed to date in any other state or USEPA Region.

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1. Introduction

In September 2000, U.S. Environmental Protection Agency (USEPA) notified the Missouri Department of Natural Resources (MDNR) that several items contained within Missouri's Water Quality Standards were inconsistent with the intent of the Federal Clean Water Act of 1972 (CWA). USEPA noted that MDNR's limited designation of streams for swimming uses was inconsistent with the CWA. Section 101(a)(2) of the CWA establishes as a national goal of "water quality which provides for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water," wherever attainable. This goal presumes that all waters should be suitable for fishing and swimming unless attainment of these uses is not feasible per Title 40 Code of Federal Regulations (CFR) Section 131.10. At that time MDNR designated only about 25% of Missouri's classified waters by stream miles as having Whole Body Contact Recreation (WBCR) uses (e.g., swimming) (MDNR, 2006).

In response to concerns raised by USEPA, MDNR proposed WBCR use designation of all classified waters listed in State regulations in 2005. However as allowed by Federal regulations, Use Attainability Analyses (UAA) were conducted to determine if WBCR use was an appropriate and attainable use for several specific waterbodies.

A UAA is a structured scientific assessment of the factors affecting use attainment, which may include physical, chemical, biological, and economic factors. If a designated use is not an existing use attained on or after November 28, 1975, one of the following attainability factors may be used to justify the removal or downgrading of a designated use (from 40 CFR 131.10(g)):

(1) Naturally occurring pollutant concentrations prevent the attainment of the use;

(2) Natural, ephemeral, intermittent, or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for with sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met;

(3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place;

(4) Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modifications in a way that would result in the attainment of the use;

(5) Physical conditions related to the natural features of the water body, such as lack of proper substrate, cover, flow, depth, pools, riffles, and the like unrelated to water quality, preclude attainment of aquatic life protection uses; or

(6) Controls more stringent than those required by Title III Sections 301 and 306 of the CWA would result in substantial and widespread economic and social impact.

MDNR, in cooperation with State, Federal, municipal, and private stakeholders, developed a recreational UAA protocol for Missouri waters (MDNR, 2004). This recreational UAA framework addresses use attainability factors that may allow reclassifying waters to appropriate recreational uses.

The Metropolitan St. Louis Sewer District (MSD) operates eight wastewater treatment plants and over 6,600 miles of wastewater sewers in a service area containing approximately 525 square miles – the fourth largest wastewater collection and treatment system in the United States. Three of MSD's treatment plants and 60 of its 201 combined sewer overflows (CSOs) outfall to the Mississippi River. The remaining treatment plants discharge to the Missouri or Meramec Rivers. The remaining CSOs outfall to smaller tributaries. MSD anticipates significant capital expenditures for improvements to its collection and treatment systems over a period of several decades.

MSD is committed to improving its collection and treatment systems, but must act responsibly in allocating available funding to meet diverse environmental goals. Ongoing wastewater treatment and CSO control should be founded on realistic and achievable goals for area receiving waters. Therefore, MSD is interested in determining whether WBCR is an existing or attainable use for the Mississippi River segment within the vicinity of St. Louis. To address this issue, Mississippi River data were collected and evaluated to gain an understanding of existing, potential, and attainable recreational uses. Use attainability evaluations such as this are consistent with EPA's CSO Control Policy.

In 2005, MEC Water Resources, Inc. (MEC) completed a UAA on behalf of MSD, recommending removal of WBCR use designation for the Mississippi River from the Missouri Department of Conservation North Riverfront Park Access to the Meramec River confluence. The Missouri Clean Water Commission (MCWC) approved the use removal and, in fact, extended the designated reach from Dam 27 to the confluence with the Ohio River. However, on January 4, 2006, the MCWC redirected MDNR staff to restore WBCR use on the Mississippi River south of the Meramec River confluence and north of North Riverfront Park. Therefore, WBCR use will be removed from North Riverfront Park to the Meramec River confluence. MDNR plans to revise these designated uses during a state rulemaking to be initiated in late 2007. The USEPA made use determinations on all recreational use downgrades or removals adopted by the 2005 Missouri rulemaking with the exception of the Mississippi River. The USEPA requested additional data collection and analysis to support the UAA conclusions provided by MEC (2005), which were approved by the MCWC in 2005 and adopted by state rule within 10 CSR 20-7.031.

MEC has conducted additional analyses to support removal of the WBCR use designation for the segment of the Mississippi River approved by the MCWC on January 4, 2006. The scope of this study was developed through a stakeholder process

led by USEPA, which included MDNR, MSD, Missouri Coalition for the Environment (MCE), Washington University Interdisciplinary Environmental Clinic, and USEPA's designated consultants. This stakeholder process included scoping meetings, regular progress meetings and phone conferences, as well as a field survey led by the MCE and the Interdisciplinary Environmental Clinic. This report presents the results of MEC's analysis and where applicable, presents summaries from other waters where WBCR (primary) use removal has been recommended or approved for many of the reasons presented herein.

2. Review of Other Applicable Use Attainability Analyses

USEPA and other stakeholders requested additional data collection and analysis to support the UAA conclusions provided by MEC (2005). As part of this effort, existing proposed or approved UAAs were reviewed to compare and contrast effort levels and approaches with the Mississippi River UAA. UAAs reviewed included the Chicago Area Waterways (CAWs), the Mobile River, Erie Harbor, the Los Angeles River, and the New York Harbor Complex. Specific approaches for determining the impacts of barge traffic, high velocities and other factors on attainability of recreational uses were evaluated.

Commercial traffic and hydrologic modifications were common factors cited in removing WBCR uses from the Mobile River, the CAWs, and Presque Isle Bay and Outer Erie Harbor. Lack of suitable shoreline was also presented as evidence for removal of WBRC as a use in both the Mobile River and CAWs UAAs. The Los Angeles UAA primarily cited dangerous conditions due to the swift conveyance of stormwater as a reason for suspending recreational uses. With the exception of the CAWs, all of these UAAs have been approved by the USEPA. Use recommendations for the CAWs will be presented to the Illinois Pollution Control Board for a ruling in the near future (Scott Twait, Water Quality Standards Unit, IEPA, personal communication, September 10, 2007). A brief summary of the UAAs is provided below in Table 2.1. A more complete summary of these UAAs is provided in Appendix A.

The analysis presented in this report uses many of the same factors cited in the above referenced UAAs. As will be demonstrated in subsequent sections, this UAA meets or exceeds any precedent set by these UAAs with regards to justifying removal of the WBCR use. Furthermore, the amount of data collected for this UAA far exceeds the level performed for the other UAAs, as verified in review.

TABLE 2.1. Summary of Other Applicable Recreational Use Attainability Analyses

Use Attainability Analysis	Type of Action	Data Collection	UAA Recommendation	Year	UAA Factor(s)	Rationale
Mobile River (approved by USEPA)	Re-examine basis for excluding primary contact recreation as a use	No data collected for recreation portion of UAA. Ship traffic, industry, and shoreline access qualitatively described.	Upgrade use to limited warmwater fishery (i.e., not designated for primary contact).	2001	3	Proximity to shipping lanes, industrialization of area, and lack of shoreside access
Chicago Area Waterways (approval pending)	Re-examine basis for excluding primary contact recreation as a use	1. Request quantification of uses from stakeholders, 2. Postcard survey of marinas, 3. Letter to public entities soliciting development plans, and 4. Field surveys by boat	Assign secondary contact uses to Chicago Area Waterways.	2004	1	High bacteria levels at Lake Calumet attributed to waterfowl
					3	High commercial traffic, steep sides, deep draft, and minimal shallow shoreline
					4	Hydrologic modifications (i.e., man-made canals constructed to convey stormwater, wastewater and provide for navigation) are incompatible with primary contact recreation
Presque Isle Bay and Outer Erie Harbor (approved by USEPA)	Re-examine basis for excluding primary contact recreation as a use	Field surveys were primarily directed towards characterizing bacteria levels. Water depth, water uses, macrophyte growths, shoreline structures, and land uses noted during sampling events.	Assign primary contact recreation to all of Presque Isle Bay and the Outer Harbor with the exception of the Harbor Basin and entrance channel.	1985	3	Boat and shipping traffic within the Harbor Basin and entrance channel is considered an irretrievable man-induced condition which has an adverse impact on water contact recreation
Engineered Channels of Los Angeles (approved by USEPA)	Temporary suspension of recreation use	Analysis of rainfall/flow relationships. Field surveys conducted to confirm physical characteristics and access restrictions.	Suspend recreational uses for 24 hours following a rainfall event greater than 1/2 inch.	2003	2	Natural flashy conditions result in intermittent dangerous flow volumes and velocities after rain events
					4	Channel modification designed with steep slopes for the swift conveyance of water result in life-threatening conditions during and immediately following rain events
New York Harbor Complex (approved by USEPA)	Re-examine basis for excluding primary contact recreation as a use	Relied on 208 study of fecal levels and coliform reduction alternatives.	Uses were not recommended for upgrade to primary contact recreation, with the exception of one portion of the Hudson River.	1985	3	Based on environmental, technical, and institutional factors, sufficient coliform reduction was not considered a feasible option (i.e., zero discharge with 90% CSO control not considered feasible)

3. Study Area

The study segment for this project includes the Missouri side of the Mississippi River segment from North Riverfront Park to the Meramec River confluence. This segment of the Mississippi River is adjacent to the majority of the St. Louis, Missouri metropolitan area. The Mississippi River segment is a Class P Water of the State throughout Missouri and is divided into four classified segments, totaling 490 stream miles (Figure 3.1) (Carnahan, 2005). The upstream classified segment originates at the Des Moines River confluence and terminates at the Missouri River confluence (Missouri waterbody identification number [WBID] 0001). On September 7, 2005 the MCWC ruled to partition the classified segment extending from the Missouri River confluence to the Ohio River confluence (WBID 1707) into two segments. The upstream partition of WBID 1707 extends from the Missouri River confluence to Dam Number 27. The downstream partition of WBID 1707 extends from Dam Number 27 to the Ohio River. The final segment of the Mississippi River extends from the Ohio River confluence to the southern state line (WBID 3152). Beneficial uses currently designated within all segments include: Protection of Warm-Water Aquatic Life and Human Health (Fish Consumption), Livestock and Wildlife Watering, Drinking Water Supply, and Secondary Contact Recreation. All but the upper segment (WBID 0001) of the Mississippi River are also designated for Irrigation. Whole body contact recreation was not designated from the downstream partition of WBID 1707 during the September 7, 2005 MCWC ruling; however, the other three Mississippi River segments are designated for this use. Upstream segment WBID 0001 is classified for Category A WBCR; whereas the other two segments south of the Ohio River confluence are categorized for Category B WBCR. A map of the UAA study area is provided in Figure 3.2.

It should be noted that on January 4, 2006, the MCWC redirected staff at MDNR to restore WBCR use on the Mississippi River south of the Meramec River confluence and north of North Riverfront Park. This was the extent of the WBCR use removal originally recommended in the 2005 Mississippi River UAA completed by MEC. Missouri's water quality standards do not currently reflect this January 4, 2006 recommendation by the MCWC; however, MDNR plans to revise the standards accordingly during a state rulemaking to be initiated in late 2007.

As noted above, the UAA study segment is limited to the Missouri side of the Mississippi River, as conditions on this side dictate Missouri water quality standards decisions. There are marked differences between the two sides in terms of physical characteristics and water quality. Some of these differences are due to training structures that effectively channel current to the Missouri side of the river. The Missouri side of the river is more notable for its swift currents, steep banks, and tall bluffs. Turbidity is also markedly higher (lower clarity) on the Missouri side due to sediment input from the Missouri River. Figures 3.3 and 3.4 illustrate the influence of the Missouri River at its confluence and in the downstream portion of the UAA segment, respectively.

The Illinois side of the river also differs in its use designation. The Illinois side of the Mississippi River is designated for "primary contact" throughout its entire length. However, the State of Illinois recognizes the hazards associated with WBCR in the St. Louis area of the Mississippi River by granting the Village of Sauget, which is directly across the river from downtown St. Louis, a year-round disinfection exemption.

Missouri's water quality standards do not impact use attainment on the Illinois side of the Mississippi River within the UAA segment. Mixing modeling of MSD discharges included within the District's Long-Term Control Plan suggests that discharge plumes do not reach the Illinois shore inside of the UAA segment (note turbid waters hugging the Missouri side of the Mississippi River in Figures 3.3 and 3.4). Furthermore, mixing modeling suggests complete mixing may not occur for up to 100 miles. Again, the focus of the present study is not to evaluate the attainability of the Illinois beneficial use designations, rather the focus is to support Missouri water quality standards decisions.

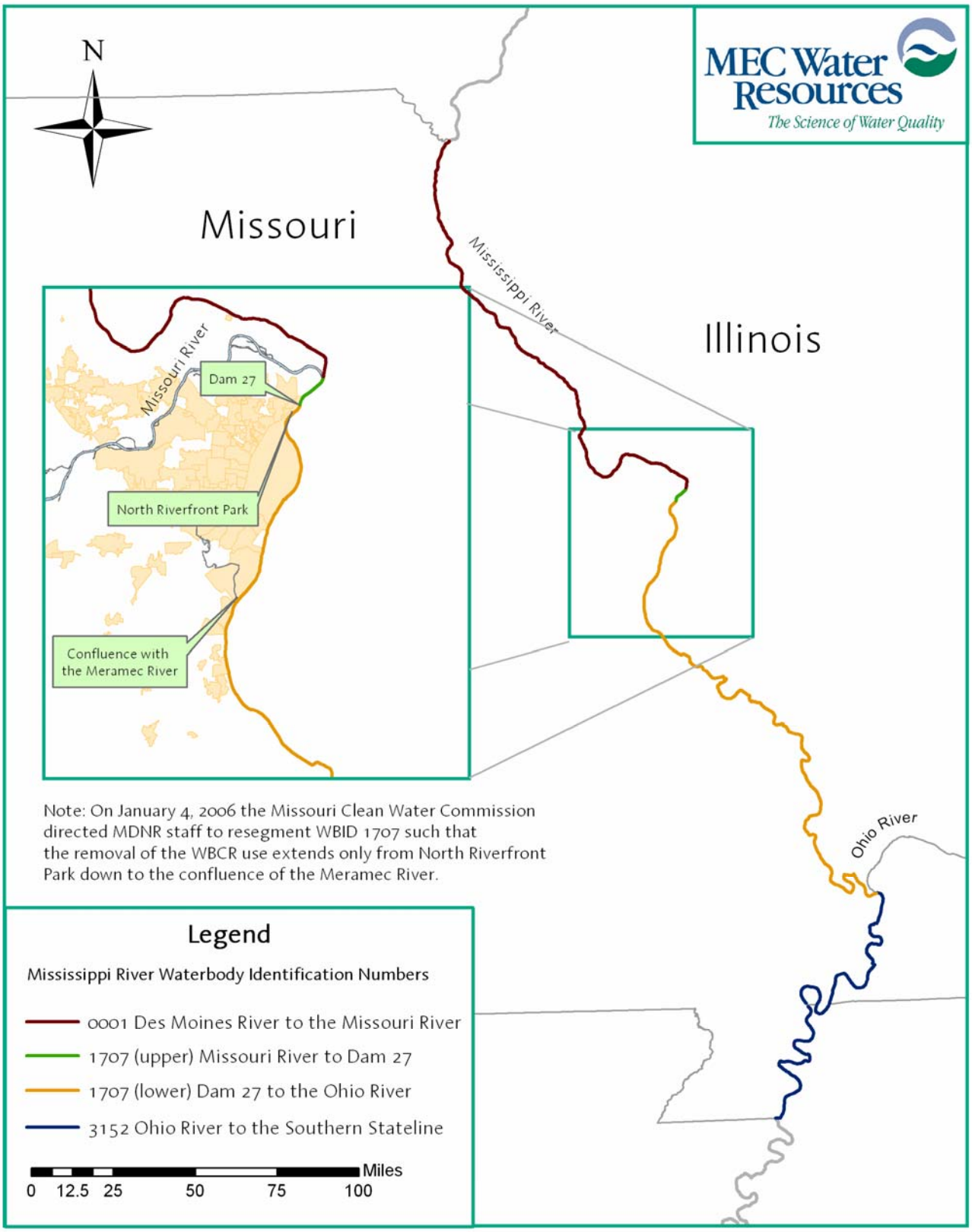


FIGURE 3.1. Mississippi River Classified Waterbody Segments

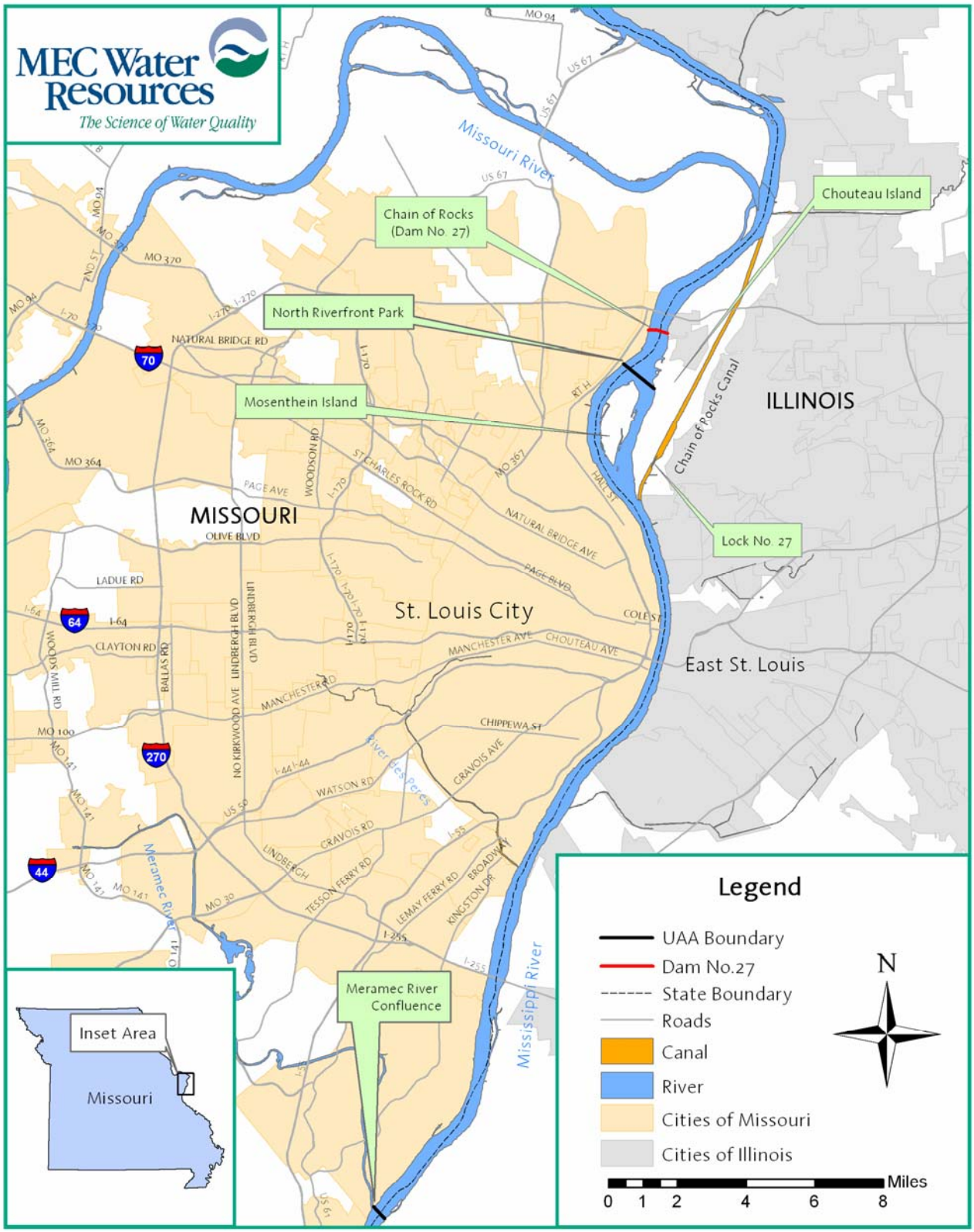


FIGURE 3.2. Mississippi River UAA Study Area Map

FIGURE 3.3. Aerial Image Depicting the Influence of the Missouri River on Turbidity on the Missouri Side of the Mississippi River

FIGURE 3.4. Aerial Image Depicting Higher Turbidity on the Missouri Side of the Mississippi River

4. Hydrologic Modifications to the River Segment

4.1. History of Hydrologic Modifications

St. Louis marks the critical transition point between the Upper Mississippi River and the "open river" to the south. Historically, the Upper Mississippi River (the segment of river between the Missouri River confluence and St. Paul, Minnesota) was hazardous for navigation. Shallow and swift currents, rock ledges, small waterfalls, unchartered shoals and sandbars were common for the Upper Mississippi River during low water periods prior to the early part of the 20th century. In 1930, Congress authorized the U.S. Army Corps of Engineers (USACE) to construct a slack-water navigation system on the Upper Mississippi River. The navigation system consisted of a 9-foot navigation channel constructed through a series of locks and dams from St. Paul to St. Louis. The dams create pools, or small lakes, which facilitate safe navigation of the river. The navigation locks raise and lower river-bound vessels from one pool to the next (USACE, 2007).

Melvin Price Locks and Dam replaced Lock and Dam 26, which was demolished in 1990. Lock and Dam 26 was located near Mississippi River Mile (RM) 202.5 near Alton, Illinois and was the first lock and dam structure located upstream of the Missouri River confluence. Opened in 1938, Lock and Dam 26 had structural deficiencies from the beginning resulting in dangerous scour holes below the dam. Construction of Melvin Price Locks and Dams began in 1978 and was completed in 1994. Located at RM 200.78, Melvin Price Locks and Dam consist of a 1,200 foot main lock, a 600 foot auxiliary lock, and a 1,160 foot long dam.

FIGURE 4.1. Lock 27 at Southern End of Chouteau Island (USACE photo)

Lock 27 is the southernmost lock system on the Mississippi River and is the only lock south of the Missouri River confluence (Figure 4.1). This lock is situated on the southern end of Chouteau Island in the man-made Chain of Rocks Canal. The 10-mile segment of Mississippi River bordering the western edge of Chouteau Island is regarded as the southern end of the Chain of Rocks reach, which is known for its hazardous rock formations. After 1940, the Chain of Rocks reach remained the last impediment preventing the maintenance of a safe and reliable 9-foot navigation channel on the Mississippi River south of St. Paul. The 8.4 mile Chain of Rocks Canal was constructed in the late 1940's and early 1950's to

bypass the treacherous Chain of Rocks reach. In 1960, a low water dam was constructed across the Mississippi River near the Chain of Rocks bridge to ensure adequate depths in the pool below Lock and Dam 26 (Figure 4.2). Since navigation was not an issue, the USACE created the dam by dumping multiple barge loads of rock into the river. Lock 27 was constructed at the south end of the canal, which maintains a 15 foot difference in water level between its upper and lower ends. Although the lock and canal were constructed to bypass the Chain of Rocks reach, limited barge traffic does still exist west of Chouteau Island (between North Riverfront Park and the shipping canal).

FIGURE 4.2. River Dam 27 on the Mississippi River at Chain of Rocks (outside UAA segment)

The Mississippi River south of Lock 27 and the Chain of Rocks Dam typically maintains depths sufficient for navigation; however, maintenance dredging and regulating works are still necessary to facilitate river navigation. Naturally deposited sediment can impede navigation over time without proper maintenance and control. The USACE repetitively dredges the bottom of the Mississippi River to remove sediment deposits. Sedimentation issues are also managed through regulating works, which are structural designs, such as chevrons, revetments, and notched dikes.

Currently, the USACE is in the process of constructing three chevron dikes within the Mississippi River UAA segment. The chevrons will be located downstream of the Chain of Rocks area near the McKinley Bridge. This area typically requires regular dredging activities due to slower currents and increased silting. The chevrons are designed to split the current, forcing water into the navigation channel and toward the Missouri bank. The modified river currents are designed to increase scouring, lessening the need for dredging. Increased flow on the bankside will help maintain depths for towboats in service of industrial docks (O'Neil, 2007).

Hydrologic Modification Terminology

Chevron – Two stone dikes placed next to each other positioned in a "V" pattern with the pointed end upstream.
Revetment – A hard river structure constructed parallel to the flow on the outside of a bend designed to guide the flow and prevent erosion.
Dike - A hard river structure that is constructed perpendicular to the flow on the inside of a river bend designed to contract the river channel and prevent erosion.
Notched Dike – Dikes with openings providing habitat diversity and improvement in flow conveyance for the passage of floods.
Riprap – A layer, facing, or protective mound of stones randomly placed to prevent erosion, scour, or sloughing or a structure or embankment; also the stone so used.
Wingdam – Wingdams are rock and brush structures extending from the bank toward the navigation channel to concentrate flow in the navigation channel.

4.2. Impacts of Hydrologic Modifications on Recreational Uses

Hydrologic modifications designed to facilitate commercial barge traffic on the Mississippi River negatively impact recreation. Research suggests that increased commercial barge traffic reduces recreational boating (Becker, 1981 and Graman *et al.*, 1984 as cited in Committee to Review the Upper Mississippi River - Illinois River Waterway, 2001). Recreational boaters tend to either forego recreational boating or recreate elsewhere in response to increased commercial traffic. Additionally, regulating works designed to constrict the river into a narrower cross section cause water velocities to increase. Increased water velocities reduce human stability in water and increase the risks associated with WBCR (Abt *et al.*, 1989; Karvonen *et al.*, 2000; Hyra, 1978). Regulating works also increase bank slopes in areas, reducing the suitability of shorelines for recreational uses.

Safety guidance published by the USACE regarding Missouri River safety tips also warns of the dangers of barge traffic and currents impacted by hydrologic modifications. Although published for the Missouri River, this guidance is applicable to the Mississippi River. USACE guidance has the following warnings (USACE, undated brochure titled "Missouri River Safety Tips"):

- Pilots of towboats have a blind spot in front of their vessels and it could take a barge and tow up to 1 ½ mile to stop;
- These barges also create extreme turbulence up to ½ mile behind the tow;
- The strong wake may lift your boat onto the rocks, dikes or other hazards;
- Wakes generated by barges can suck under objects including smaller crafts so it's best to give them a wide berth;
- Playing games with this kind of vessel can result in serious injury or even death;
- Swimming and tubing on the Missouri River is extremely dangerous and is strongly discouraged;
- A river current of 3-4 mph can quickly exhaust even the strongest swimmer;
- Inner tubes should never be used on the river. There is no way to control them in the current and they pose problems with boats and tugs; and

- Never swim in floodwaters, the main river channel, around structures like wing dikes or around moored barges. Strong hidden currents, drop-offs and hidden obstacles make these areas extremely hazardous to swimmers.

The Missouri River Water Trail coalition (MRWT)[1] offers similar warnings about boating in the Missouri River. With regards to paddle boating, the MRWT website offers the following advice (MRWT, 2007):

> Another consideration is the hazard posed by barges moored on the river. Stay well clear of these, as the river is rushing under the front of the vessel and could pull a small craft under. The lower Missouri River is a channelized river system. The U.S. Army Corps of Engineers has constructed rock-reinforced structures along the entire lower river, used to direct the current into the channel. These "wing dams" or "L-dikes" can create turbulence and strong currents that are best avoided by small craft.

Specifically with regards the Mississippi River near St. Louis, the MRWT says the following (MRWT, 2007):

> Keep in mind that the river front near St. Louis is typically very busy, with barges plying the river and moored along the banks. A paddle trip down to the Arch presents some complex hazards to paddlers and should not be taken lightly.

US Coast Guard (USCG) representatives also feel strongly that the hydrologic modifications and associated barge traffic make this segment far too dangerous for WBCR. They also feel that even the operation of small recreational vessels is dangerous in this segment. In particular, USCG representatives state that the fleeting operations within this area are very dangerous for boaters and other potential recreators, including both near-shore and main channel areas. Chief Warrant Officer Bill Perkins described recreating at the near-shore areas like hiking on the shoulder of major interstate highways. At times, barges break loose from fleeting areas and docks. One such instance resulted in 126 barges sinking or freely floating downstream after one loose barge created a "domino effect" which knocked other barges loose from their mooring locations. Another such instance occurred during the 2007 recreational season. During this May event, all vessel traffic was shut down for four miles of the segment after 15 barges broke away from their towboat and free floated downstream. One barge sunk after hitting the McKinley Bridge (Figure 4.3).

Officer Perkins has also responded to several incidents in which recreational vessels and/or individuals were pulled beneath barges by undertows. In addition, the channel training structures also create hazardous turbulence and undertows that are difficult to predict or observe. Finally, Officer Perkins states that these hazards induced by

[1] The Missouri River Water Trail coalition was created in the fall of 2006, when the Missouri Governor Matt Blunt directed several Missouri agencies – including the Department of Natural Resources, Department of Conservation and the Department of Economic Development's Division of Tourism to formally establish a water trail on the lower Missouri River.

hydrologic modifications make this segment of the Mississippi River the most dangerous water body in their eight state region.

FIGURE 4.3. Barge Sinks after Breaking Free of its Towboat and Striking the McKinley Bridge on May 31, 2007

The overwhelming consensus among river authorities (e.g., USCG, USACE, Missouri Department of Natural Resources, Missouri Department of Conservation and the Missouri Water Patrol) is that barge traffic and hydrologic modifications present extremely dangerous hazards for secondary contact uses. Additionally, as noted by the Missouri River Water Trails organization, the St. Louis area is particularly dangerous for recreational boaters due to its heavy barge traffic. With regards to swimming near barges and hydrologic modifications, the USACE clearly states that people should never swim in these conditions.

5. River Access and Adjacent Land Use

5.1. Potential Public Accesses

Accessibility is a factor in determining the likelihood of a waterbody being used for recreational purposes. Factors that affect accessibility to the waterbody include: vehicle access, shoreline slope and composition, hindrances (railroad tracks, walls, fences, etc.), and proximity to sanitation services.

Public access to the Mississippi River within the UAA segment is very limited despite its 28-mile length within one of the most densely populated metropolitan areas in the Midwest. For the purposes of this study, MEC considered access points upstream of the proposed study area in order to include two known access points with recreational use – Old Chain of Rocks Bridge and Chouteau Island, Illinois. Potential public access points discussed below within the study area include North Riverfront Park, a Riverfront Bike Trail Access near the MSD Ferry Pump Station, Laclede's Landing, Jefferson National Expansion Memorial park grounds (St. Louis Arch), Sister Marie Charles Park, Jefferson Barracks County Park, Cliff Cave County Park, and Bee Tree County Park (Figure 5.1).

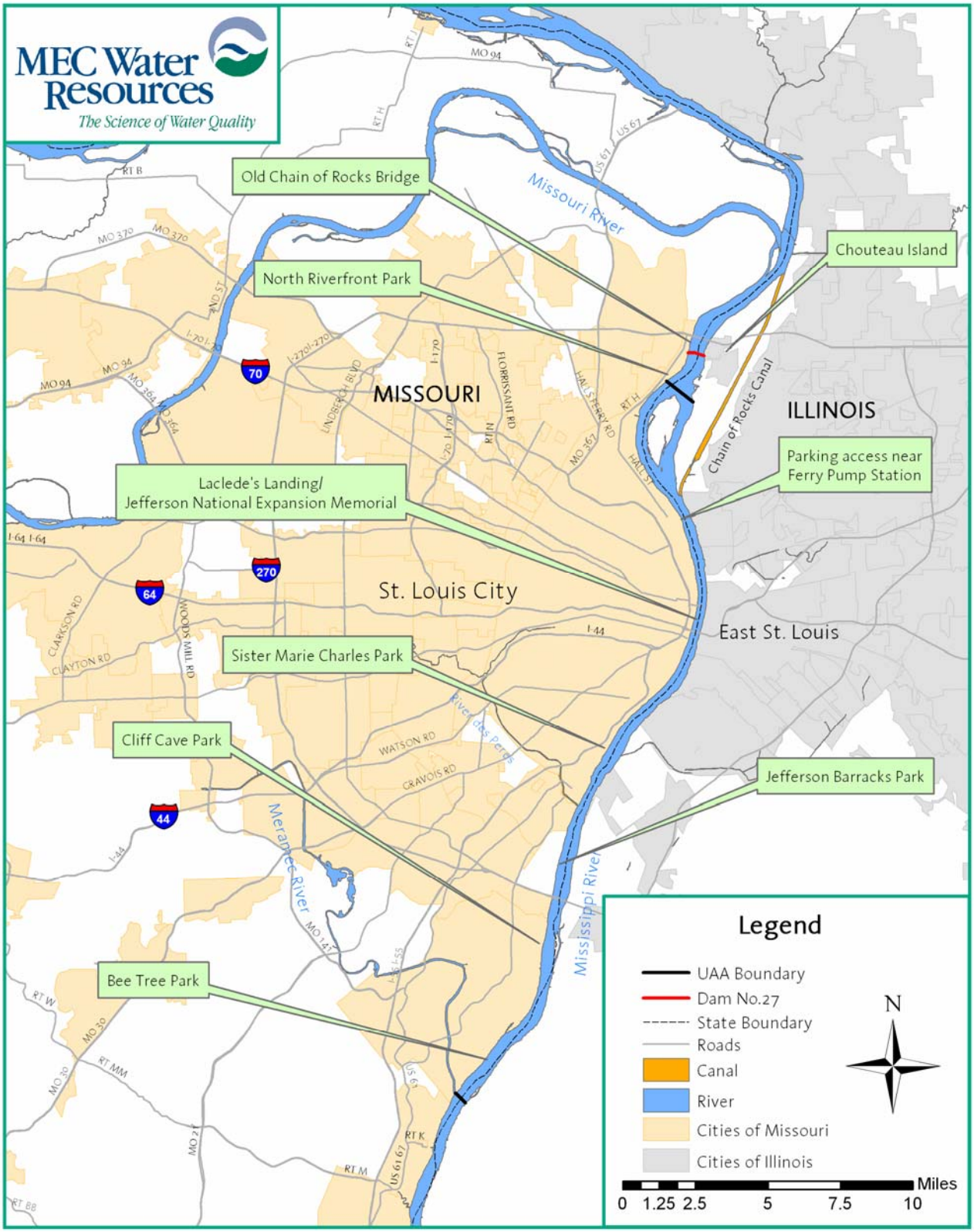


FIGURE 5.1. Potential Public Access Points to the Mississippi River located along the UAA Segment

5.1.1. Accesses Outside of the Study Area

5.1.1.1. Old Chain of Rocks Bridge

This access located upstream of the UAA segment can be reached by car from Riverview Drive off of I-270. The bridge has a small parking area on the Missouri side of the river. It should be noted that the Old Chain of Rocks Bridge is upstream and outside the UAA study segment. The only access to the river is down a steep and brushy riverbank near to or under the bridge (Figure 5.2). Bicyclists and pedestrians may also use the Old Chain of Rocks Bridge to access Chouteau Island on the Illinois side of the river (also outside the UAA segment). A parking area on the Illinois side of the river, near the Old Chain of Rocks Bridge, can be accessed from West Chain of Rocks Road. Located west of Riverview Drive and just south of the Bridge lies Chain of Rocks Park; however, this park does not include any river shoreline.

FIGURE 5.2. Aerial View of Old Chain of Rocks Bridge

5.1.1.2. Chouteau Island, Illinois Access

A man-made island created by the construction of Lock 27, the Chouteau Island access can be reached by car from West Chain of Rocks Road or by foot or bicycle via the Old Chain of Rocks Bridge (Figures 5.3 and 5.4). It should be noted that Chouteau Island is in Illinois and is outside the UAA segment. A parking area is located along the east bank of the Mississippi River on Chouteau Island immediately downstream of Dam 27. Sand bars form on the west bank of Chouteau Island during moderate and low flow conditions. A large sand bar is present immediately downstream of Dam 27, which is accessed by the public parking area.

FIGURE 5.3. Aerial View of Chouteau Island Access Area

FIGURE 5.4. View of Dam 27 and Sandbar at Chouteau Island

Chouteau Island is part of the confluence greenway, a regional recreation corridor. Several walking/biking trails have been developed on the Island. Over 70% of Chouteau Island is publicly owned, by the USACE, the Illinois Department of Natural Resources and the City of Madison, Illinois. Plans are in development to convert Chouteau Island into a recreational complex with floodplain and grasslands restoration, additional trails, interpretive overlooks, picnic areas, camping areas and a visitor's center near the entrance to the Old Chain of Rocks Bridge.

5.1.2. Accesses Inside of the Study Area

5.1.2.1. North Riverfront Park

North Riverfront Park is owned by the City of St. Louis and partially managed by the Missouri Department of Conservation. The Park's 112 acres encompass approximately 1.8 miles of shoreline on the west bank of the Mississippi River, with two accessible parking areas (Figure 5.5). A boat access is located at the northern end of the park (Figure 5.6). The shoreline can be accessed by the boat ramp at the northern portion of the park, or down a steep embankment at the southern portion of the park. The shoreline is composed of vegetated sandy/silty soil. There is also a bike path that runs along the length of the park, and a fishing lake at the northern end of the park.

FIGURE 5.5. Aerial View of North Riverfront Park

FIGURE 5.6. Access Ramp at North Riverfront Park

5.1.2.2. Riverfront Bike Trail Parking Access

At the Merchants Bridge (railroad) on the west bank of the Mississippi River there is a small parking area along the Riverfront Bike Trail that is not well known (Figures 5.7 and 5.8). This access is in a heavily industrialized area. The riverfront trail passes through a gate in the floodwall at this location, also allowing access to individuals, by vehicle. The riverbank is extremely steep (>30% slope) composed of riprap, stone, and discarded building materials such as brick and concrete.

FIGURE 5.7. Aerial View of Parking Area near Ferry Pump Station

FIGURE 5.8. View of Parking Access near Ferry Pump Station

5.1.2.3. Laclede's Landing and Jefferson National Expansion Memorial Area

Adjacent to the Gateway Arch, one of the most popular tourist destinations in the Midwest, the Laclede's Landing area provides access to the Mississippi River after crossing busy downtown streets or (if river level permits) by parking on the cobble stone-lined riverbank (Figures 5.9 and 5.10). As noted later, no WBCR use has been observed at this location even though it is accessible to many individuals.

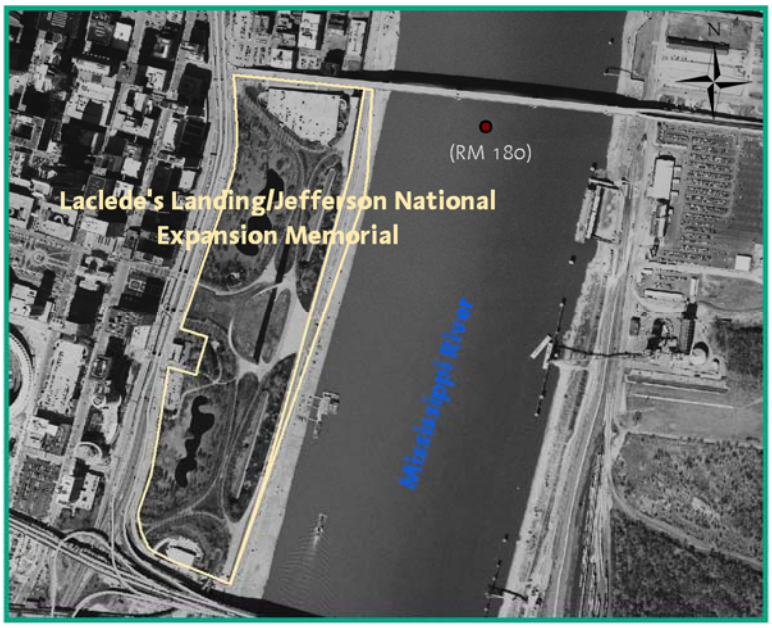


FIGURE 5.9. Aerial View of Laclede's Landing/Jefferson National Expansion Memorial

FIGURE 5.10. View of Laclede's Landing/Jefferson National Expansion Memorial

5.1.2.4. Sister Marie Charles Park

Located just south of Bellerive Park, Sister Marie Charles Park is a three acre promenade along the Mississippi River (Figures 5.11 and 5.12). Its steep riverbank is composed of riprap and brush and the Mississippi River is essentially inaccessible at this area. This segment of the river is used heavily for barge fleeting, with multiple rows of barges commonly moored on the riverbank next to the park.

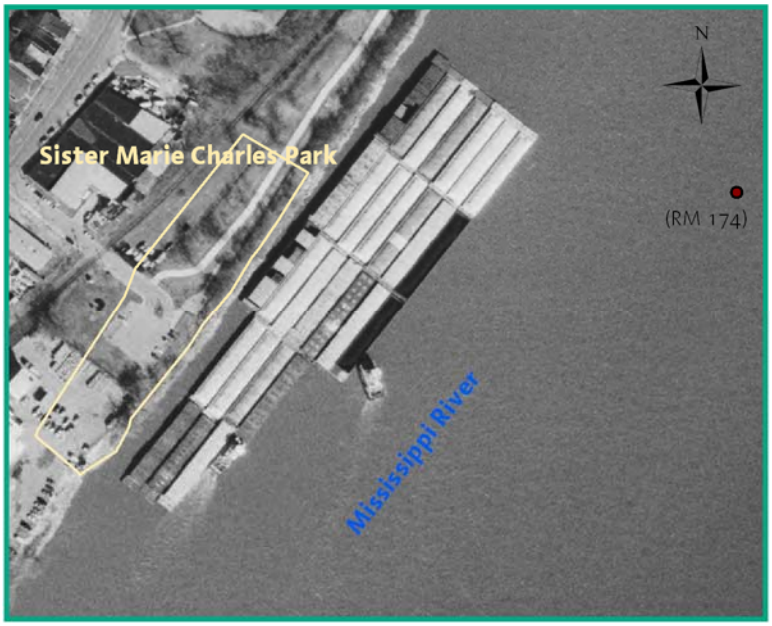


FIGURE 5.11. Aerial View of Sister Marie Charles Park

FIGURE 5.12. River View from Sister Marie Charles Park

5.1.2.5. Jefferson Barracks Park

Jefferson Barracks Park is a county park perched on a scenic bluff overlooking the Mississippi River with a past steeped in American military history (Figures 5.13 and 5.14). The Park is separated from the Mississippi River by fencing, a steep bluff and railroad tracks at the base of the bluff, making the river inaccessible.

FIGURE 5.13. Aerial View of Jefferson Barracks Park

FIGURE 5.14. River View from Jefferson Barracks Park

5.1.2.6. Cliff Cave Park

Cliff Cave Park is a heavily wooded 222-acre park used mostly for hiking and cycling (Figures 5.15 and 5.16). There are a few paths leading down steep inclines that allow access to the Mississippi River. The shoreline is steep (>25% in most areas) and composed of stone and riprap. As shown in Figure 5.16, barges are commonly moored along the bank at the downstream end of the park. St. Louis County Parks Department has posted no swimming signs within the park. As noted later, a park manager has no knowledge of anyone swimming in the Mississippi River and considers it to be unsafe.

FIGURE 5.15. Aerial View of Cliff Cave Park

FIGURE 5.16. View of Riverbank at Cliff Cave Park

5.1.2.7. Bee Tree Park

Near the confluence of the Meramec River, Bee Tree Park sits on a bluff above the Mississippi River with essentially no access to the river (Figures 5.17 and 5.18). There are railroad tracks at the base of the bluff along the river. There is a fishing lake in the park. No swimming signs are posted within the park. As noted later, a park manager has no knowledge of anyone swimming in the Mississippi River and considers it to be unsafe.

FIGURE 5.17. Aerial View of Bee Tree Park

FIGURE 5.18. River View from Bee Tree Park Overlook

5.2. Adjacent Land Use

An assessment of land use on the Missouri side of the study area largely shows commercial and industrial activity with limited proximity to residential areas. Land parcels were obtained in a geographic information system format from St. Louis City and County to assist in this assessment. Parcels adjacent to the Mississippi River from North Riverfront Park to the Meramec River were extracted from this database for assessment purposes.

Industrial activity best characterizes land use adjacent to the Missouri shoreline from North Riverfront Park down to approximately RM 167 (near Cliff Cave Park). Rail lines essentially parallel this entire riverfront area in service of the dense industrialization. Interspersed within this industrialized segment are some parks (notably Jefferson Expansion National Memorial, Sister Marie Charles Park, and Jefferson Barracks Park), limited residential areas, and some non-industrial commercial land uses (primarily in the downtown area). The area south of Cliff Cave Park to the confluence of the Meramec River is largely vacant low lying land or bluff top residential areas. Bee Tree Park is located in this bluff top area. Appendix B lists every parcel of land adjacent to the Mississippi River within the study area, documenting the fact that adjacent lands are largely industrial and commercial.

Residential developments adjacent to or in relatively close proximity to the river (i.e., within approximately one-quarter mile and not separated from the river by commercial or industrial development), are limited to only a few areas. West of North Riverfront Park is a large residential area; however, railroad tracks and Riverview Drive impede pedestrian access to the riverfront. An approximately three-quarter mile long segment of single and multi-family housing overlooking the Mississippi River is located south of the downtown area near RM 174.5. The only immediately adjacent residential land (i.e., land contiguous with the Mississippi River) within the UAA segment is located within this segment, but represents only approximately 0.2 miles (i.e., less than 1% of the UAA segment). However, access from these adjacent parcels to the riverfront itself is obstructed by an approximately 50-foot tall cliff[1] and railroad tracks (Figure 5.19). Residential development in the area south of RM 167 is limited to steep bluff tops and is generally set back from the river a minimum 0.1 to 0.5 miles. Railroad tracks also separate residential development from the river along this southern end of the UAA segment.

[1] The height of the cliff is based on an assessment of hypsography files in a GIS.

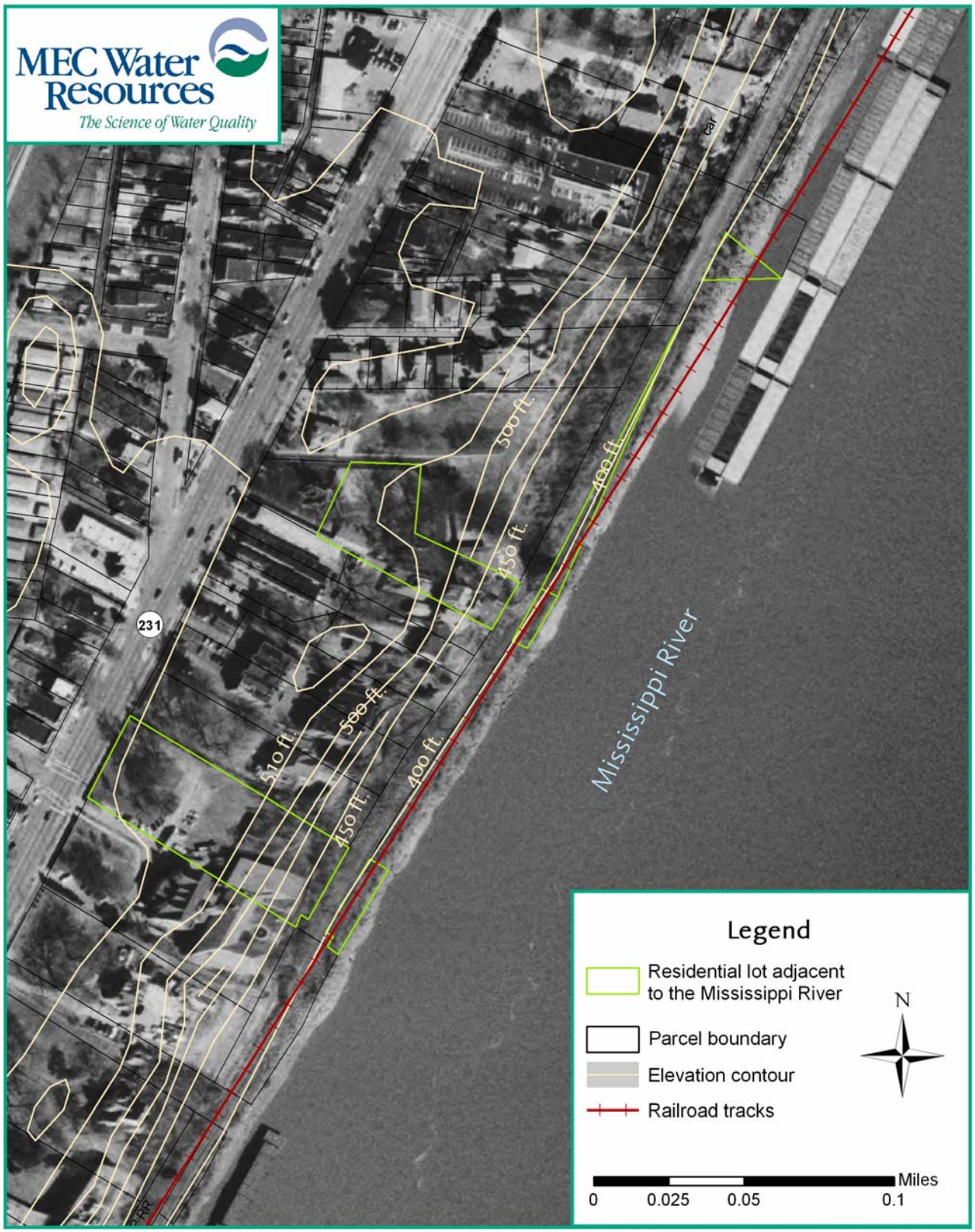


FIGURE 5.19. Map Depicting the Only Residential Parcels Adjacent to the Mississippi River within the UAA Segment (near RM 174.5)

5.3. Waterbody Access Comparison to other UAAs

Access to the Mississippi River UAA segment is generally as limited if not more so relative to recreational UAA segments discussed in Section 2. The lower half of the Lower Mobile River segment is highly industrialized with no apparent access points. However, aerial imagery of the upper two to three miles of the Lower Mobile River segment shows little to no development. Although undeveloped, access to the upper portion of the Lower Mobile River is likely hindered by lack of road access and a railroad that parallels its west bank. The CAWs encompasses 78 miles of waterways, 75 percent of which are man-made canals. On the whole, the CAWs is inaccessible (i.e., heavy industrialization and steep bank slopes); however, several accesses to the CAWs are available to the public. Boat launches exist in portions of the CAWs and significant segments of the CAWs are adjacent residential areas. Many of these homes have built docks providing access to the CAWs. The portion of Presque Isle Bay and Outer Erie Harbor with no WBCR use has no shoreside access and is demarked by USGS buoys and channel markers. Access to the Engineered Channels of Los Angeles is limited by vertical walls or steep-sided slopes in conjunction with restrictive fencing. Access to the New York Harbor Complex was not a factor in its UAA. Based on this precedence, the limited access to the Mississippi River UAA segment supports removal of the WBCR use.

5.4. Summary of River Access and Adjacent Land Use

Within the approximately 28-mile UAA segment, access to the Mississippi River is limited to just a few locations despite being located within one of the most densely populated metropolitan areas in the Midwest. Access is largely restricted by bluffs, steep inclines, railroad tracks, industrial docks, and industrial/commercial development. North Riverfront Park and Laclede's Landing potentially offer the easiest pedestrian access to the Mississippi River within the UAA segment; however, as documented later in the report uses in these areas are limited to shoreline activities (e.g., sightseeing and fishing). Although some potential access points do exist within the UAA segment, the shoreline itself is primarily comprised of stone and riprap, which discourages swimming activities. Outside of the UAA segment on the Illinois side of the river, access to sandbars are readily available from a parking area on Chouteau Island.

6. Recreational Uses of River Segment

To identify and evaluate actual recreational uses of the Mississippi River in the St. Louis area, MEC employed a three-pronged approach: interviews, personal field observations, and surveillance via web cameras. These efforts were conducted during the height of the recreational season, July and August 2007, and represent the greatest amount of data ever gathered during a recreational UAA to document WBCR use (or lack thereof). These approaches provide a thorough and compelling picture of whole body and secondary contact recreational uses of the Mississippi River in the study area. Each of these approaches and the results of these efforts are described in the following three sections.

6.1. Interviews

MEC interviewed various Federal, State and private organization representatives, as well as individuals, to determine the type and frequency of whole body and secondary contact recreational use within the study segment. Interview questions focused on observed and anecdotal WBCR use (swimming, tubing, snorkeling/skindiving, waterskiing) as well as safety and other factors that influence these uses.

The interviews with agency and organization representatives were conducted via telephone or email/mail; with the majority completed by phone. The interviewer provided their names and the focus of the study. With agreement these representatives were presented with a series of questions. The questions focused on:

1. The representatives' role within their organization and their organization's responsibilities and roles with regard to Mississippi River usage in and around St. Louis,
2. Specific barge traffic related topics; quantities, frequencies and seasonality,
3. Health and safety issues associated with river conditions,
4. The potential usability of the river for WBCR,
5. Hazards presented to individuals that may perform WBCR,
6. Observations of WBCR, including the location, the season and action (swimming, tubing, snorkeling/skindiving, waterskiing), and
7. Other entities or people that could provide additional information.

The interviews with the public were conducted during visual observation efforts (Section 6.2). These interviews employed Data Sheet D - Recreational Use Interview developed by MDNR for use during recreational UAA efforts.

The completed questionnaires are included in Appendix C.

6.1.1. Federal and State Agency Interviews

Four Federal and three State agency representatives were interviewed in 2007. These agencies included:

U.S. Army Corps of Engineers – Public Affairs Officer Allen Dulley (314) 331-8002
U.S. Coast Guard - Chief Warrant Officer Bill Perkins (314) 269-2571; Master Chief Dan Kilkeary (314) 771-4325; Lieutenant Commander Jesse Stevenson (314) 269-2540
Missouri State Water Patrol – Major Jody Hughes, Corporal Mike Porter (573) 751-3333
Illinois Conservation Police - Captain Mark Otis (618) 462-1181

The organizational contacts interviewed were familiar with and had direct experience with the Mississippi River between Lock 27 and the confluence of the Meramec River. The Illinois Conservation Police district patrols the Mississippi River from Alton, IL to south of East St. Louis, IL.

The agencies represented are responsible for boater safety, regulatory compliance, law enforcement, rescue and recovery operations, and in the case of the USACE, maintaining the shipping channel for commerce along the Mississippi River.

The USACE was cited as having the best data with regard to barge traffic. Several respondents noted that the St. Louis port was one of the nation's busiest, with the heaviest traffic during the planting (Spring) and harvesting (Autumn) seasons. [Note: This seasonal pattern is not supported by barge traffic data (See Section 7).]

Most respondents had not observed WBCR in the Mississippi River in the St. Louis area. Two respondents noted swimming has occurred on a very rare occasion for a charity event (when barge traffic is prohibited) and the annual Polar Bear club event on New Years Day at the Arch. The USCG Lieutenant Commander noted that the Coast Guard typically receives reports of one or two people in the water around the Fourth of July near the Chain of Rocks. The USCG Chief Warrant Officer stated that a few individuals have been infrequently observed swimming from anchored boats near Laclede's Landing during the Fourth of July. Respondents noted some fishermen and others wading near shore. Kayaking was also cited as occurring near Chain of Rocks and Mosenthein Island (Illinois side).

All of the respondents stated that they believe that this segment of the Mississippi River is unsafe for WBCR use. The overwhelming responses given for the reason(s) for their opinions were the hazardous conditions created by barge traffic, currents, and debris (e.g., logs, trees, etc.). Many of the respondents did not believe it was even safe to operate small pleasure craft in this segment of the Mississippi due to currents and barge traffic. Strong undertow currents around barges and channel training structures were stated frequently as a safety concern. Two respondents noted recreational vessels being pulled under barges when propulsion was lost.

Representatives of the three state and federal agencies tasked with protecting public safety in and on the water (i.e., USCG, Missouri Water Patrol and Illinois Conservation Police) strongly feel that river currents coupled with the intense barge traffic make this segment far too dangerous for WBCR, as well as operation of small recreational vessels. In fact, a USCG representative stated that the Mississippi River in the St. Louis area is the most dangerous waterbody in their eight state region, which spans from Illinois to Colorado and Missouri to North Dakota.

USCG Chief Warrant Officer Perkins stated that the fleeting operations within this area are very dangerous for boaters and other potential recreators, including both near-shore and main channel areas. Officer Perkins described recreating at the near-shore areas like hiking on the shoulder of major interstate highways. At times, barges break loose from fleeting areas and docks (see Figure 6.1). One such instance resulted in 126 barges sinking or freely floating downstream after one loose barge created a "domino effect" which knocked other barges loose from their mooring locations. Officer Perkins has also observed dangerous conditions at near-shore areas due to barge traffic. During low flow conditions when the navigation channel is constricted, suction created by towboats moving upstream causes currents directed away from the shore and towards the navigation channel. This phenomenon is strong enough to have caused two docked barges to break loose from their dock and to be swept into the navigation channel. These suction-induced currents are also an obvious danger to potential near-shore recreators.

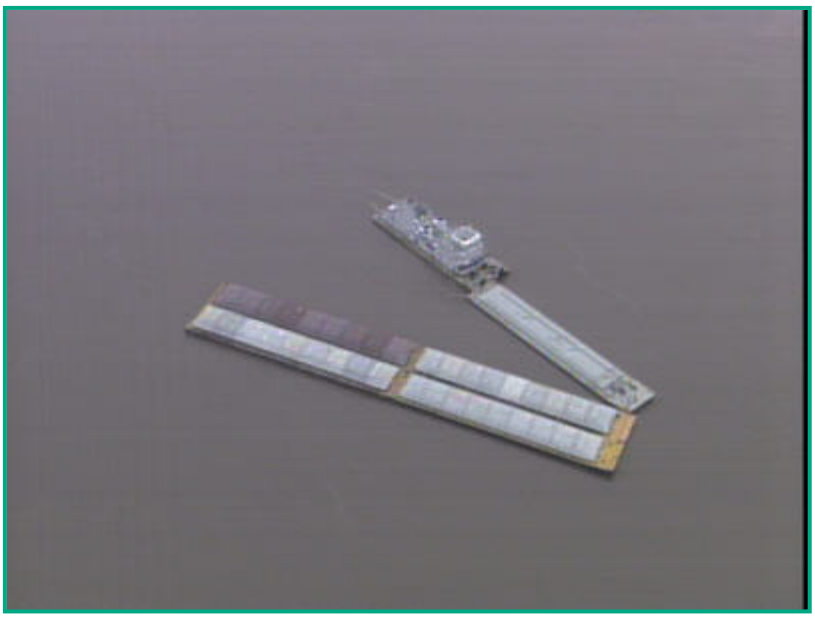


FIGURE 6.1. Free Floating Barges and Recovery Attempt on May 31, 2007

Officer Perkins has also responded to several incidents in which recreational vessels and/or individuals were pulled beneath barges by undertows. Officer Perkins himself almost jumped overboard to avoid being pulled under barges after his USCG vessel, with twin engines, lost propulsion near a fleeting area. Luckily, a towboat deckhand rescued their vessel prior to a serious accident. Unfortunately, Officer Perkins has responded to several search and recovery missions following drownings within the study area. Recently, two individuals drowned after their pontoon boat was sucked under a barge. Two other drownings occurred after their small fishing boat sunk due to river hydraulics. Officer Perkins has also recovered several barge crew members that have fallen overboard and been subsequently trapped underneath their barges. Lastly, he states that most recreational life jackets do not adequately protect individuals within the main channel currents and definitely not for undertows near barges.

In 2006, the Missouri State Water Patrol reported one drowning and seven boating accidents (resulting in one fatality) along this segment of the Mississippi. Unfortunately, during this study the Missouri State Water Patrol responded to another drowning downstream of the study area. The individual used the Mississippi River frequently over a long period of time and was very familiar with the river. Officials responding to this incident noted that regardless of one's familiarity with the river, the Mississippi River presents its dangers. David Nelson with the Missouri Water Patrol cited ever-changing currents, undertows, drop-offs, snags and root logs as dangerous aspects of the Mississippi River (Eddington, 2007). USCG Officer Perkins also noted that channel training structures also create hazardous turbulence and undertows that are difficult to predict or observe.

In summary, the federal organizations represented noted only very rare WBCR use of the Mississippi River around St. Louis. The organizations represented unanimously concluded that the river conditions such as extremely strong currents, heavy barge traffic, and large floating and subsurface debris make WBCR use unsafe in the Mississippi River in and around St. Louis.

6.1.2. Local Government Interviews

A representative of the St. Louis Port Authority (Nick Nichols (314) 259-3465) was interviewed using the same questionnaire as used for the federal and state agencies. The St. Louis Port Authority leases city owned land along the Mississippi River to commercial and other operations. Mr. Nichols noted that the area around Chain of Rocks is not used for commercial traffic because it is too shallow and it frequently gets filled with silt from the Missouri River. Mr. Nichols also stated that the Mississippi River currents in the St. Louis area rendered the river too dangerous for WBCR. According to Mr. Nichols, the City of St. Louis owns approximately 65% of land adjacent to the Mississippi River in the St. Louis area.

An interview with a park manager from Cliff Cave and Bee Tree Parks (Larry Inadnit (314) 846-8337) indicated no WBCR uses in the UAA area. Larry Inadnit referred to the Mississippi River as a "big scary river", personally has never used the Mississippi for WBCR and has never witnessed any WBCR. However, Larry Inadnit did state that he observes fishing maybe once or twice a week in the Mississippi River.

6.1.3. Trade Organization and Public Interest Group Interviews

Jim Patterson, President of the St. Louis Port Association (314-421-3575), was interviewed. The St. Louis Port Association was described by Mr. Patterson as a fairly informal association of tow operators around St. Louis. He recalled very infrequent WBCR use of the Mississippi River near St. Louis. He noted a one-time fundraising/charity event when boat traffic was halted so someone could swim across the Mississippi River. He also noted that the local Polar Bear Club briefly swims in the Mississippi River near the Arch on New Years Day. Mr. Patterson stated that he has not observed much recreational boating on this segment of the river except on the Fourth of July holiday.

American Waterways Operators, represented by Lynne Muench (314-446-6474), is a national trade association for the tug and barge operators, representing approximately 300 members nationwide. Ms. Muench had not observed or heard of WBCR use in the Mississippi River around St. Louis.

Herm Smith, representing himself and a St. Louis based paddling club, streamteach.org, was interviewed. Mr. Smith and other kayakers routinely recreate on the Mississippi River in the Chain of Rocks area. According to Mr. Smith kayakers typically launch their watercraft near the Old Chain of Rocks Bridge and take out at North Riverfront Park. Mr. Smith noted that the river is used between July and December when the water levels at Chain of Rocks drop below 9 feet. During these conditions, the Chain of Rocks area exhibit Class III and IV rapids; therefore, kayakers reportedly often become immersed in the water at this point. This use was identified in MSD's 2005 UAA (MEC 2005) and was used as the basis for excluding this area from the UAA segment. Mr. Smith also noted that he frequently observes swimmers near sandbars that form near Chain of Rocks and Mosenthein Island. He also has observed camping on these sandbars. These swimming uses are within Illinois and are outside of the UAA segment. When asked about paddlers using the lower stretches of the Mississippi River near St. Louis, Mr. Smith noted that some paddling occurs on the Meramec River.

6.1.4. Dock and Service Terminal Representative Interviews

Owners and operators of docks, service terminals and river structures on the Mississippi River in the St Louis area were interviewed with respect to WBCR and safety issues. A list of owners and operators was obtained from the USACE. Company/organization name, location, operations, contact name and contact information were provided. A total of 45 individuals were listed, covering 87 different facilities in the study area.

More than one-third of the Dock and Service Terminal Representatives were successfully contacted after efforts to contact all representatives were attempted (Table 6.1). Individuals provided a response to the majority of the questions asked, providing considerable detail regarding their observations of river use. The following is a summary of those interviewed and their responses.

TABLE 6.1. Dock Operator Characteristics

Number of Respondants	19 of 45 contacted
Facilities Represented	35 docks and service terminals
Locations Represented	RM 167.3 to 187.1
Experience on Mississippi River in St. Louis	Range: 7-35 years Average: 19 years Collective: 361 years

Range and Location: Nineteen individuals provided responses to the survey questions, covering thirty-five different facilities. The facilities represent the entire stretch of the Mississippi River in the St. Louis metropolitan area. The mileage markers for the locations range from RM 167.3 to 187.1.

Experience and Tasks: The individuals interviewed had an average of 19 years of experience in the St. Louis barge industry. Their careers ranged in duration between seven and 35 years. The tasks performed by the individuals are directly related to the barge industry or use of the Mississippi River in the St. Louis metropolitan area. Examples of these activities are shipping and receiving of commodities and mooring of barges for fleeting operations.

Barge Traffic Quantities, Frequencies and Seasonality: Individual responses varied for barge traffic quantities at their specific locations. There was a general agreement that the St. Louis port area is consistently busy throughout the year. Several operators noted that heavier traffic occurred during the fertilizing and harvesting seasons, specifically during the spring and fall months.

Observations of Recreational Use, Location and Frequency: Based upon interviews of dock and service terminal operators, no frequent WBCR occurs in the UAA segment. During the collective 361 years of experience working on or near the river, six individuals had observed very infrequent WBCR uses. One individual referred to the January 1 Polar Bear Club as an observed swimming use. This publicity stunt is conducted out of the recreational season over a very short duration. Another individual has observed two to three individuals attempt to swim over his 28 year career on the river. Four individuals stated that they had observed waterskiing. One individual provided little detail (frequency, period, etc.) about this observation and was not responsive to several attempts to contact for additional information. Another individual that observed waterskiing referred to the January 1 charity waterskiing event. Another individual stated that he has observed waterskiers infrequently north of the Arch on July 4th. Lastly, a respondent observes 2 to 3 waterskiers per year in the area just north of the Meramec River confluence.

Potential Hazards of Recreational Use: All individuals stated that WBCR uses are unsafe in the UAA segment for various safety concerns. The overwhelming responses given for the potential hazards associated with WBCR in the Mississippi River in the St. Louis area were barge traffic and currents. Dock and service terminal representatives expressed major concerns with encouraging WBCR in this waterbody due to the river currents, specifically undertow currents. They frequently noted observing debris (logs, trees, etc.) being pulled under the water's surface by the currents. One operator stated,

"Boats don't have brakes" and that "most people who work on the river don't recreate on the river, they know the dangers".

6.1.5. Citizen Interviews

During field recreational use observation visits (Section 6.2) MEC attempted to interview 37 individuals or small groups of individuals recreating or working along the study area. Six individuals or groups declined to be interviewed. The interviews took place between July 4 and August 5, 2007. MEC deployed interviewers to the various public access points along the study areas to provide a representative sampling of recreational use interviews. There were 11 days when interviews were completed, including one holiday (July 4th) and one weekend (August 4 and 5). The Fourth of July was specifically singled out for observation because it was often cited as the time of most probable recreational use, particularly near the Arch.

The interviews took place at various access points along the river and were distributed among Chouteau Island (outside the UAA area) where two interviews occurred, the northern segment of the study area (North Riverfront Park and Riverfront Trail locations) where 10 interviews occurred, the central portion of the study area (Laclede's Landing, Gateway Arch area) where 13 interviews occurred, and the southern portion of the study area (Cliff Cave and Bee Tree Parks) where six interviews occurred. Most of the interviewees reported they were from the St. Louis area (23 of 31). Of the eight interviewees that claimed not to be from the area, three were from Illinois, four were from other states, and one gave a St. Louis address (despite reporting not being from the area).

The frequency of visits to the Mississippi River varied among those interviewed. Ten of those interviewed stated that they visit the river and riverfront area once or twice per year. Another ten interviewees visit the area daily or weekly. The remaining interviewees used the area several times per year, with several respondents noting more frequent use in the summer months.

Of the 31 individuals or small groups interviewed, three had participated in, observed, or heard anecdotal evidence of WBCR use in the Mississippi River near St. Louis – all on the Illinois side of the river, by Chouteau Island, outside of the UAA segment. Twenty six of those interviewed participated in, observed or heard anecdotal evidence of secondary contact recreation (SCR) use in the study area. Four of the five interviewees that reported no knowledge of SCR use were from out of state.

Two of the interviewees were attendants to parking lots near the Mississippi River in the downtown area. One of the two parking lot attendants noted that he has worked the weekday shift (7:30 AM to 2 PM) for the past two years. Despite working at a location in view of the Mississippi River, neither parking lot attendant had either witnessed or had any anecdotal evidence of WBCR. However, both parking lot attendants noted observing SCR uses such as fishing and wading occurring on an approximately weekly basis.

One interviewee reported recreating on a personal watercraft (PWC) within the area once or twice a year. The interviewee has used the PWC to travel from the Meramec River to the St. Louis Arch; however, he claims to operate it in such a way as to not immerse himself in the river. The interviewee felt the Mississippi River was not safe to swim in. The currents and undertows are such a concern that the interviewee tethers himself to his PWC in the event that he falls.

When asked the reasons why they did not use the Mississippi River for WBCR in the study area the respondents stated several factors. The most frequently cited reasons were strong current, color/clarity, debris, safety, barges, and general safety concerns. Pollution was cited only twice as a reason to avoid WBCR.

6.2. Field Recreational Use Observation

MEC observed river and riverfront uses at the various access points in the study area. This occurred during 13 days between July 4 and August 12, 2007, including two weekends and the Fourth of July. Typically, the observers were in the field from 11 AM to 6 PM. Approximately 100 and 35 recreational uses were observed within and outside the UAA segment during this time, respectively. There were no observations of swimming or waterskiing during the surveys. The field observation notes are included in Appendix D.

6.2.1. Northern Portion of the UAA Segment

Observations in the northern portion of the UAA segment were made from North Riverfront Park down to just south of the Ferry Pump Station. Within this segment the most predominate observed use was fishing followed by small craft boating (Table 6.2). One observation of a kayaker was made during this survey (Figure 6.2). No observations were made of anyone swimming or waterskiing.

TABLE 6.2. Observed Recreational Uses in Northern Portion of the UAA Segment

Observation	Number of Observations
Recreational/Safety Patrol Boat	13
Fishing (Shore, or Wading)	25
Wading	0
Personal Watercraft/Kayak	1
Other (sightseeing, walking, throwing rocks, etc.)	3
Swimming	0
Waterskiing	0

FIGURE 6.2. Kayaker near McKinley Bridge

6.2.2. Central Portion of the UAA Segment

Observations in the central potion of the of the UAA segment were made south of the northern segment and north of Cliff Cave Park. Excluding shoreline activities, the most predominate observed recreational use within this segment was small craft boating (Table 6.3 and Figure 6.3). Hundreds of people were observed at Laclede's Landing during July Fourth festivities; however, most activities in this area occurred on the road and park area well above the water level. There was relatively little foot traffic near the water's edge. There were no observed instances of swimming or waterskiing. Two observations were made of people operating PWCs. .

TABLE 6.3. Observed Recreational Uses in Central Portion of the UAA Segment

Observation	Number of Observations
Recreational/Safety Patrol Boat	29
Fishing (Shore, or Wading)	7
Wading	9
Personal Watercraft/Kayak	2
Other (sightseeing, walking, throwing rocks, etc.)	Numerous*
Swimming	0
Waterskiing	0

* Observations during the July Fourth festivities yielded observations too numerous to count.

FIGURE 6.3. Recreational Boat at Laclede's Landing

6.2.3. Southern Portion of the UAA Segment

Observations in the southern potion of the of the UAA segment were made south of and including Cliff Cave Park. The greatest number of recreational use observations was made of small craft boating (Table 6.4). The only other observed recreational uses included shoreside activities such as sightseeing and walking.

TABLE 6.4. Observed Recreational Uses in Southern Portion of the UAA Segment

Observation	Number of Observations
Recreational/Safety Patrol Boat	8
Fishing (Shore, or Wading)	0
Wading	0
Personal Watercraft/Kayak	0
Other (sightseeing, walking, throwing rocks, etc.)	3
Swimming	0
Waterskiing	0

6.2.4. Outside of the UAA Segment

Observations outside of the UAA segment were made at Chouteau Island and the Old Chain of Rocks Bridge. The greatest number of recreational use observations was made of fishing (Table 6.5). The only other observed recreational uses included shoreside activities such as sightseeing and walking. A photo of people on Chouteau Island is depicted below in Figure 6.4.

TABLE 6.5. Observed Recreational Uses Outside of the UAA Segment

Observation	Number of Observations
Recreational/Safety Patrol Boat	0
Fishing (Shore, or Wading)	30
Wading	1
Personal Watercraft/Kayak	0
Other (sightseeing, walking, throwing rocks, etc.)	4
Swimming	0
Waterskiing	0

FIGURE 6.4. People Recreating on Chouteau Island

6.3. Recreational Use Surveillance

Automated web-based surveillance was utilized to supplement the interviews and personal field observations. MEC installed web cameras at five locations along the Missouri side of the Mississippi River on July 2, 2007. Web cameras were installed at Baden Pump Station (RM 186.0), Ferry Pump Station (RM 183.2), Carr Street Pump Station (RM 180.4), Mill Creek Pump Station (RM 178.8), and Jefferson Barracks Pump Station (RM 170.7) (Figure 6.5). The web cameras wirelessly transmitted photos to a centralized database, in general every one to two minutes. The frequency of the photos was limited by transmission speed. The web cameras continued operation through August 19, 2007 with the exception of the downtown camera, which ended its transmissions on August 17, 2007. It should be noted that technical difficulties prevented an uninterrupted series of photos. However, camera outages were relatively infrequent and generally lasted less than one day.

Approximately 135,000 photos were collectively taken between the five camera stations from July 2, 2007 to August 19, 2007. MEC examined and recorded activities for each photo taken from first light[1] to 8:30 PM (i.e., approximately 80,000 photos were examined). Activities were categorized into the following groups: active barge, docked barge, small craft, and PWC. Active barge photos depict observations of barges, tug boats, or commercial ferries in motion. Docked barge photos depict observations of docked barges which are not moving. Small craft photos depict observations of small craft boats in operation. These craft included water patrol, fishing, work, and large recreational boats. PWC photos depict observations of PWC (e.g., Jet-Skis™ and WaveRunners™) in operation.

[1] First light is defined as the time at which there is sufficient light for photo analysis. First light ranged from approximately 6:25 am to 7:12 am over the course of the photo study period.

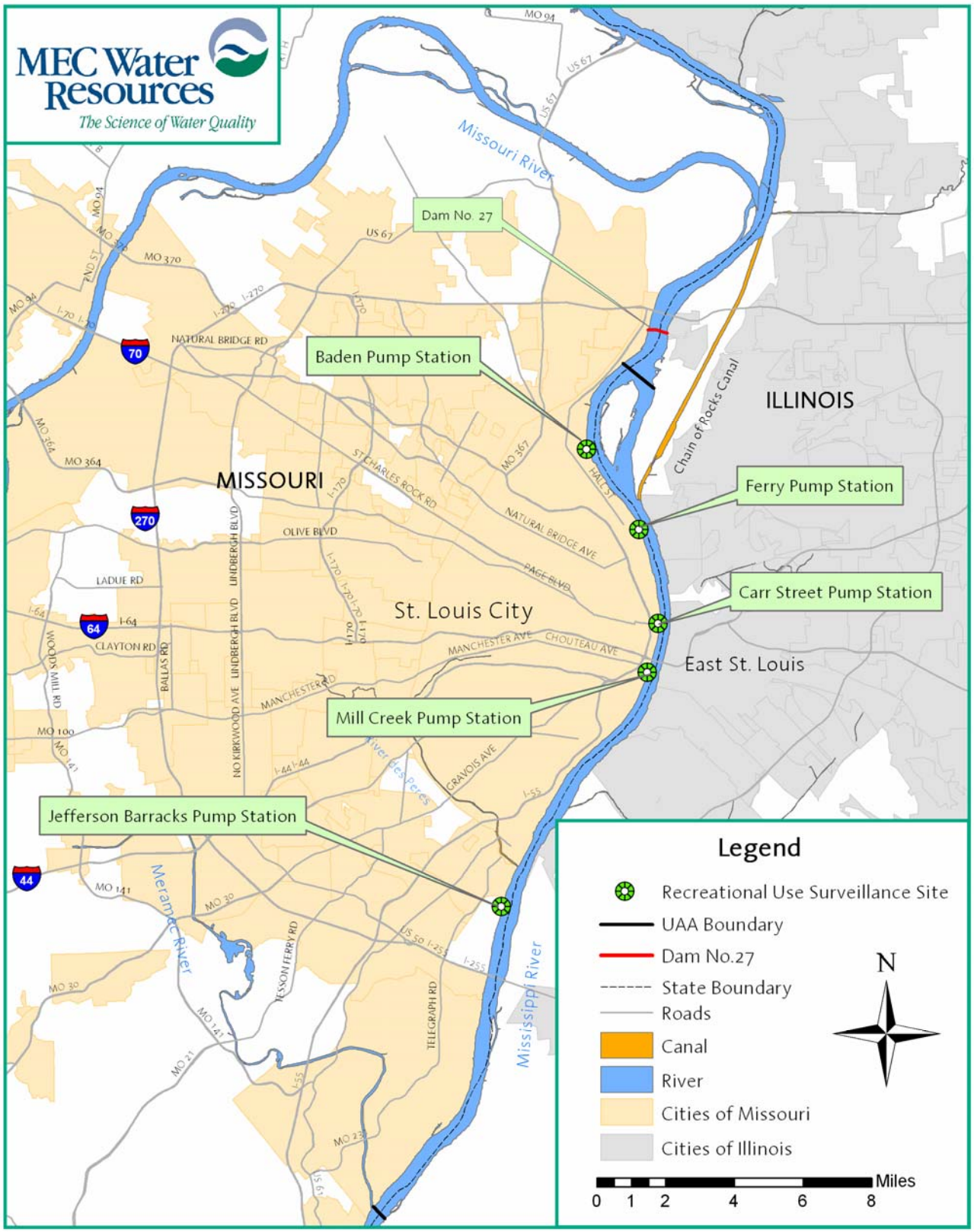


FIGURE 6.5. Recreational Use Surveillance Locations along the Mississippi River

6.3.1. Baden Pump Station Camera Site (38.70842, -90.21697 [RM 186.0])

The Baden Pump Station is located on the Missouri side of the Mississippi River between the Chain of Rocks dam and Lock 27. Since most river traffic bypasses this segment of the Mississippi River, the least amount of activity was recorded at this camera site. Photos are available for the Baden Pump Station site from July 2, 2007 through August 19, 2007, with the exceptions of July 25 and July 26. Out of approximately 14,000 examined photos, 38 were categorized for active barge activity and 30 were categorized for small craft. However, this does not imply that 30 small crafts were observed. For example, at least 18 of the 30 small craft photos are of a single boat observed on August 17, 2007. Example photos from the Baden site are depicted in Figures 6.6 and 6.7 below.

FIGURE 6.6. Towboat at Baden Pump Station Site (August 1, 2007)

FIGURE 6.7. Small Craft at Baden Pump Station Site (August 13, 2007)

6.3.2. Ferry Pump Station Camera Site (38.67395, -90.18995 [RM 183.2])

The Ferry Pump Station is located about one mile downstream of Lock 27 and overlooks the Riverfront Trail and parking access. Photos are available for the Ferry Pump Station site from July 2, 2007 through August 19, 2007, with the exceptions of July 5, 6, 25, 26, and August 16. Out of approximately 19,000 examined photos, 1,877 were categorized for active barge activity and 118 were categorized for small craft. Fishermen using the parking access were observed several times. Only one instance of a PWC was observed. Example photos from the Ferry Pump Station site are depicted in Figures 6.8 and 6.9.

FIGURE 6.8. Barge and Fishing at Ferry Pump Station Site (July 24, 2007)

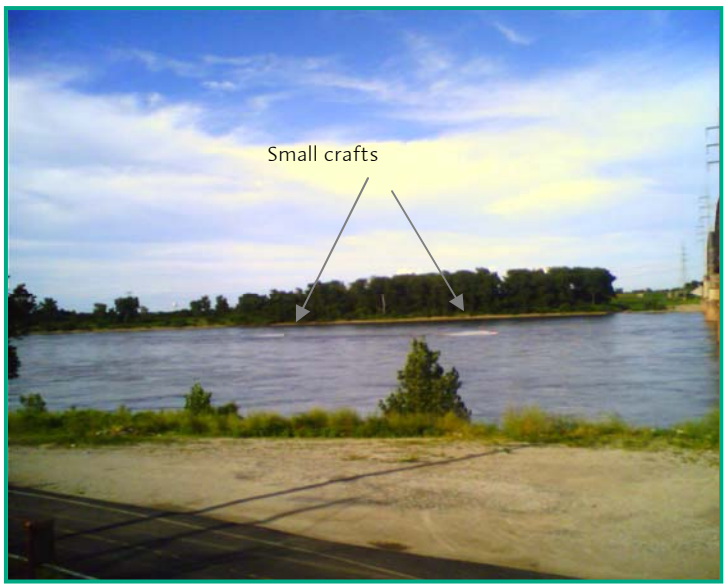


FIGURE 6.9. Small Crafts at the Ferry Pump Station Site (July 11, 2007)

6.3.3. Carr Street Pump Station Camera Site (38.63391, -90.18136 [RM 180.4])

The Carr Street Pump Station camera site is located immediately upstream of Laclede's Landing and approximately one-half mile upstream of the Jefferson National Expansion Memorial. Photos are available for the Carr Street site from July 2, 2007 through August 19, 2007, with the exceptions of July 21, 25 and 26. Out of approximately 11,000 examined photos, 942 were categorized for active barge activity and 96 were categorized for small craft. No observations were made of PWCs. Example photos from the Carr Street site are depicted in Figures 6.10 and 6.11.

FIGURE 6.10. Small Crafts at the Carr Street Site (July 14, 2007)

FIGURE 6.11. Barges at the Carr Street Site (August 3, 2007)

6.3.4. Mill Creek Pump Station Camera Site (38.61353, -90.18790 [RM 178.8])

The Mill Creek Pump Station camera site is located less than one-half mile downstream of the Highway 64 bridge in an area of dense barge traffic. Photos are available for the Mill Creek Pump Station site from July 7, 2007[2] through August 19, 2007, with the exceptions of July 25 and July 26. Of the approximately 19,000 examined photos, all had docked barges present. Active barges were observed in 3,673 photos, which accounts for more than 10 percent of all examined photos. Small crafts were observed in 172 photos. No observations were made of PWCs. Figure 6.12 below depicts a series of photos taken at the Mill Creek Pump Station site on Saturday July 14, 2007, where multiple small crafts appear in procession. The procession of small crafts exits the area within 8 minutes once a barge enters the frame of view, demonstrating the interference of recreational use by barge traffic. No other photos from the study period depict more than two or three small crafts together any camera site.

[2] Technical start-up issues prevented the availability of photos from July 2 through July 6.

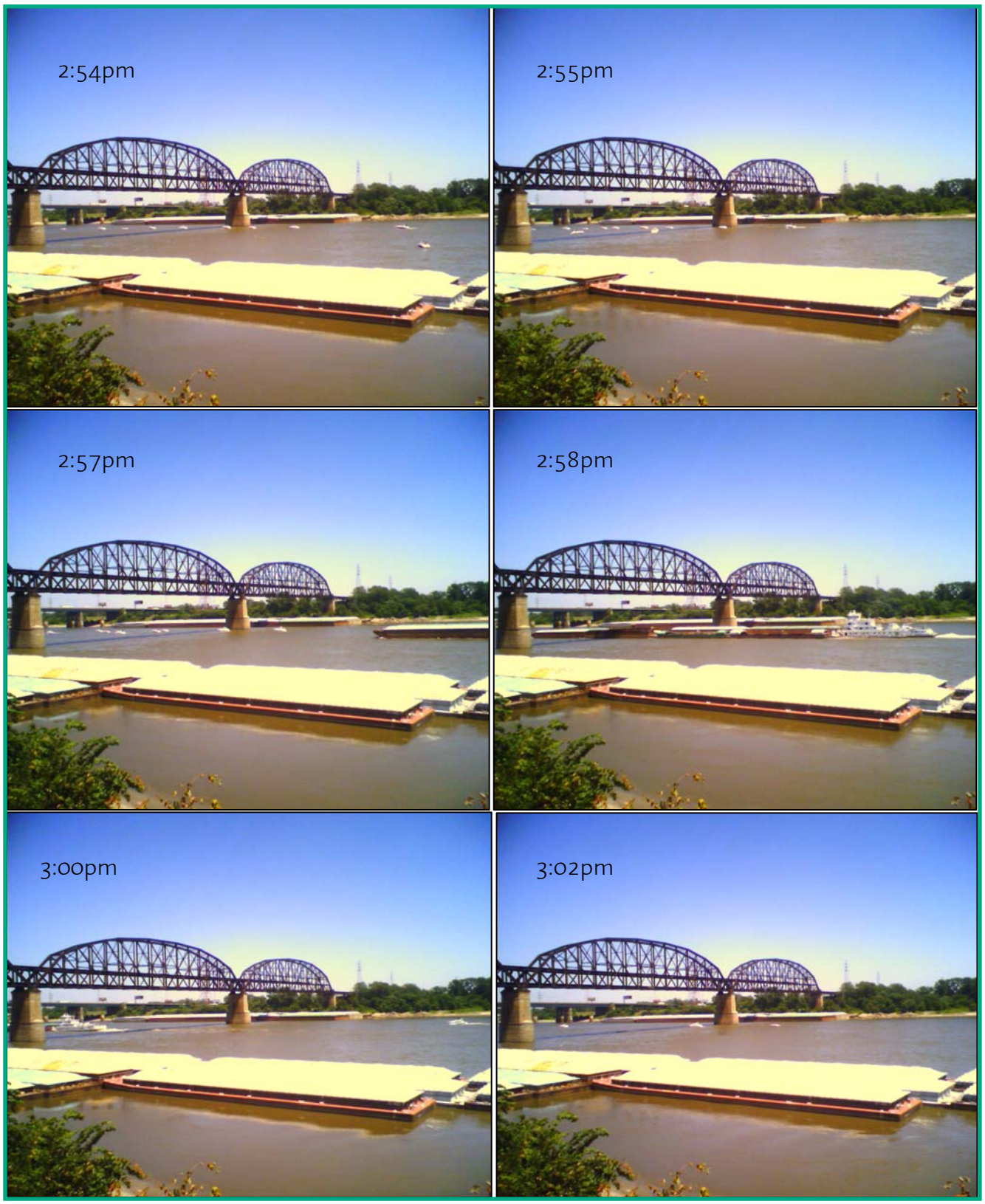


FIGURE 6.12. Series of Photos Depicting Multiple Small Crafts Displaced by Barge at the Mill Creek Pump Station Site (July14, 2007)

6.3.5. Jefferson Barracks Pump Station Camera Site (38.51632, -90.18790 [RM 170.7])

The Jefferson Barracks Pump Station camera site is located near the southern end of St. Louis. Photos are available for the Jefferson Barracks site from July 7, 2007[3] through August 19, 2007, with the exceptions of July 25 and July 26. Out of approximately 18,000 examined photos, 876 were categorized for active barge activity and 74 were categorized for small craft. No observations were made of PWCs. An example photo from the Jefferson Barracks site is depicted in Figure 6.13 below.

FIGURE 6.13. Barge Traffic at the Jefferson Barracks Site (August 10, 2007)

6.3.6. Summary of Recreational Use Surveillance

Out of approximately 80,000 photos examined, only one photo depicted a PWC and there was no evidence of any swimming or waterskiing. However, the photos did document a significant volume of barge traffic. With the exception of the Baden Pump Station site, which is upstream of Lock 27, approximately 5 to 20 percent of the photos contained barge traffic. Photo documentation is summarized in Table 6.6. More detailed tables summarizing photo observations by day are found in Appendix E.

[3] Technical start-up issues prevented the availability of photos from July 2 through July 6.

TABLE 6.6. River Activity Statistics at Mississippi River UAA Camera Sites

Camera Site	Total Photos[1]	Barge	Docked Barge	Small Craft	Personal Watercraft
Baden Pump Station	13,913	38 (0.3%)	0 (0.0%)	30 (0.2%)	0 (0.0%)
Ferry Pump Station	18,738	1,921 (10.2%)	0 (0.0%)	125 (0.7%)	1 (0.0%)
Carr Street Pump Station	10,883	942 (8.7%)	0 (0.0%)	96 (0.9%)	0 (0.0%)
Mill Creek Pump Station	19,017	3,673 (19.3%)	19,017 (100%)	172 (0.9%)	0 (0.0%)
Jefferson Barracks Pump Station	17,872	876 (4.9%)	15 (0.1%)	74 (0.4%)	0 (0.0%)

Note: Counts represent the number of photos with at least one observation of a watercraft (e.g., barge). The actual number of watercrafts may be higher or lower than the number depicted (e.g., multiple photos may be of one watercraft or vice versa). The value in parenthesis represents the percentage of the photo count relative to the total number of photos.

[1] Total photos include all photos taken from first light to 8:30 pm over the entire study period. The exact number is unknown but is slightly higher than the value shown in this table. Total photo counts were generally not available for the first few days of the study due to startup issues with the web camera service provider.

6.4. Summary of Recreational Use of UAA Segment

The body of evidence provided by interviews, field observations and surveillance photodocumentation leads to the conclusion that the UAA segment is not used for WBCR. To our knowledge, the amount of data gathered under this UAA to demonstrate WBCR use (or lack thereof) far exceeds any other applicable recreational UAA completed to date in other state or USEPA Region.

Interviews with seasoned Mississippi River dock operators, cognizant federal, state and local officials, and frequent visitors to the St. Louis Mississippi Riverfront specifically corroborate the assertion that the conditions of the Mississippi River in the UAA segment are too dangerous for WBCR. Those most familiar with the river (i.e., USACE, USCG, Missouri Water Patrol and Illinois Conservation Police) stated that the main hazards include barge traffic, strong currents, clarity, and floating and submerged debris (i.e., logs, trees, etc.). Fleeting operations also create a unique hazard within this free-flowing river segment. Some of the water safety professionals interviewed felt that not only is this segment too dangerous for WBCR, but for operation of small recreational vessels as well. In fact, a USCG representative stated that the approximate 20-mile segment from the Chain of Rocks to the Jefferson Barracks Bridge is the most dangerous waterbody in their eight state region, which spans from Illinois to Colorado and Missouri to North Dakota.

Field observations along the study segment during 11 days within the height of the recreation season, including the Fourth of July, did not include a single instance of WBCR use. Lastly, surveillance cameras established at five locations in the UAA segment documented 80,000 daylight images between July 2 and August 19, 2007 without a single image of WBCR use.

Interviews, field observations and surveillance support the conclusion that the UAA segment is used for secondary contact recreation. Relatively frequent occurrences of recreational boating and shoreline activities, such as fishing and wading, were documented along the UAA segment. Evidence suggests kayaking and PWC use is very infrequent in the UAA segment (1 surveillance photo of a PWC, 2 observations of a PWC, 1 observation of a kayak, and 1 interviewee's reported use of a PWC).

Results of the recreational use survey strongly suggest any contact with water resulting from kayaking or operation of a PWC in the UAA segment would only be incidental or accidental (i.e., criteria for secondary contact recreation). River conditions north of the UAA segment in the Chain of Rocks are much more favorable for "whitewater" kayaking. The Chain of Rocks region is frequented by kayakers for its Class III and IV rapids and lack of barge traffic. Kayakers are more likely to immerse themselves in the waters of this region than they are in the UAA segment where there is no evidence of any "whitewater" kayaking. Similarly, operation of a PWC in the UAA segment is unlikely to result in contact with the water that is other than incidental or accidental. The interview conducted with the operator of a PWC indicates in the UAA segment they are used for recreational touring and not for risky maneuvers such as wave jumping. Falling off a PWC in the Mississippi River presents dangers not associated with its use elsewhere (e.g., lakes). If separated from a PWC, strong river currents could easily cause it to become separated from the operator. It is for this reason that the interviewee mentioned above takes precautions not to lose his PWC (e.g., operating in a safe manner so as to not fall off and tethering himself to the PWC). Therefore, these very infrequently occurring activities should be considered secondary contact recreation for which the Mississippi River is designated.

In summary, the interviews, observations, and recreation use surveillance demonstrate that WBCR use in this segment is extremely infrequent and should not be considered an existing use. All individuals and agencies interviewed did not consider WBCR as a safe use of the Mississippi River. The stated reasons include heavy barge traffic, very strong currents, color/clarity, debris (i.e., logs, trees, etc.), and general safety concerns

7. Barge and Towboat Activity

MEC performed extensive analysis of barge traffic for the St. Louis area. This analysis depicts the magnitude of barge traffic within the area, as well as the comparison of St. Louis barge traffic to other ports in which UAAs have been approved or are under development. The data used in this analysis were collected from the USACE, the agency tasked with maintaining river infrastructure to support the barge industry.

7.1. Background Shipping Statistics

The Port of St. Louis is the 3rd most active inland port (in terms of tonnage of commodities shipped) in the contiguous United States (USACE, 2005a). With respect to ports shipping domestic commodities, only the Huntington-Tristate and Pittsburgh ports (major coal-shipment locations) are more active. It is also the 24th most active port in respect to all ports in the United States, including ports importing and exporting oceanic shipments. More than 30 million tons of goods and materials are shipped from the Port of St. Louis each year. In addition to the goods and materials shipped up and down the Mississippi River from the Port of St. Louis and the approximately 8 million tons of goods shipped to St. Louis, an even greater amount of goods and materials pass through the St. Louis area destined for other ports upstream and downstream. All of these shipments are carried by barges, pushed by some of the most powerful towboats in the world.

Barge Industry Terminology

Barge - A barge is a flat-bottomed boat, built mainly for river and canal transport of heavy goods. Most barges are not self-propelled and are moved by towboats pushing them.
Towboat - A towboat is a boat designed for pushing barges. Towboats are characterized by powerful engines (3,000 to 10,000 horsepower) and a square bow with steel knees for pushing. These vessels are most often seen on inland waterways and western rivers where they can push more than 50 large barges lashed together into a tow of varying shapes and sizes.
Tow - Multiple barges lashed together, pushed by a towboat.
Splitting Tows - The process by which a large tow (e.g., 30 barges) is split into a smaller tow (e.g., 15 barges), splitting tows commonly occurs below locks and dams, or near docking facilities.
Mooring Point/Dolphin - Clusters of timber, steel, and/or concrete piles in planned patterns and spacing or can be closed structures such as sheet pile, steel or concrete caissons used to moor (anchor/tie off) shipping vessels.
Fleeting Area - Areas where barges are temporarily stored for the disassembly or assembly of larger tows. These areas do not include loading/unloading operations.
Berthing Area - Area near dock where barges are moored for loading/unloading operations.
Dock - Fixed facility or structure within the waterway where loading/ unloading/repair of shipping vessels is performed.
Lock and Dam - Large structure spanning a river to both raise water levels upstream of the structure, and allow vessels to travel through the structure within the lock chamber(s).

7.2. History and Shipping Dynamics

The St. Louis area is bordered by two of the nation's largest rivers, the Mississippi and Missouri. St. Louis was originally settled because of the shipment of goods made possible by these rivers. Today, the Mississippi River represents the backbone of the inland waterway shipping system, connecting ports from the upper Midwest and Great

Lakes to those in the southern United States and Gulf of Mexico. Through the development of this waterway system, it is now possible to economically ship goods by water from areas such as Chicago to the ports on the Ohio, Tennessee, Arkansas, Missouri, and Mobile Rivers, as well as to ports in the Gulf of Mexico (Figure 7.1).

The development of the inland waterway system occurred largely during the late nineteenth and early twentieth centuries with the dredging of channels and building of locks and dams along these rivers. The St. Louis area represents the start of the lock and dam system for the Mississippi River at the Chain of Rocks Lock and Dam, also known as Lock and Dam 27. From this point upstream, the Mississippi becomes a "slack-water" river, with its flow controlled by a series of lock and dam structures, reaching as far north as Minneapolis, MN. Downstream from the St. Louis area to the Gulf of Mexico, the Mississippi is a free-flowing river, controlled only by flow-directing structures such as wingdams.

This change in river structure also greatly affects the way commerce is transported on the river. Barge shipping economics dictate that the more barges a towboat moves at a time, the lower the transport cost of the material. Tows, or multiple barges pushed by towboats, traveling upstream to and downstream from the St. Louis area may have 30 or more barges connected together. Barge size can vary, but most barges are approximately 200 feet in length by 30-35 feet in width. From the St. Louis area upstream, most tows are comprised of 15 barges or less. This size restriction is due to the dimensions of the lock and dam structures upstream of St. Louis. The largest locks within the Mississippi River measure 1200 feet in length by 110 feet wide, allowing for tows to pass that are five barges long by three barges wide. This requires barge operators to split or compile tows downstream of Lock 27, mooring the tows downstream, so the barges can be moved (15 at a time) through the lock. This procedure greatly increases the shipping activity on the Mississippi River near St. Louis.

In addition to barges shipping commodities to and from other ports, shipment of goods and materials to, from, and within the St. Louis area comprises substantial barge traffic as well. The St. Louis area is a major shipment point for commodities such as grain, coal, petroleum products, and many other goods and materials. There are approximately 52 dock facilities for the loading and unloading of Mississippi River commerce in the St. Louis area (RM 160.8 to 188.7 – not including facilities in the navigation canal). Many of these locations unload barges one or two at a time, requiring the other barges in the original tow to be moored in one of the 29 fleeting areas, also increasing the amount of traffic on the river.

7.3. Methods of Data Analysis

To assess barge traffic for the St. Louis area, commodity and traffic data representing summaries for 2005 were collected from the USACE. The data collected represents Lock & Dam activities as well as summaries of commodity shipments. These data were compiled to most accurately characterize barge traffic within the St. Louis area. Since the direct tabulation of barges passing through the St. Louis area is not provided in the USACE reports, some assumptions were made while compiling the data. These assumptions with corresponding calculations follow.

FIGURE 7.1. Inland Waterway Map (Commerce Routes), Source: USACE, 2005b

Based upon USACE 2005 data from Lock 27 (USACE, 2005b), average barge loading rate (commodity weight) is an estimated 1,610 tons/barge (Table 7.1). This is calculated by dividing the total tonnage of goods transferred through the lock by the number of loaded barges transiting the lock (42,404 for Lock 27 in 2005), also taking into account seasonal variability of loading rates (monthly average loading rate varies from 1,549 to 1,652 tons/barge).

Total barge traffic is estimated based upon commodity movement values from the USACE data retrieved from the Waterborne Commerce Statistics Center (USACE, 2005d) and from barge counts supplied by Mississippi River Lock 27 monthly reports. Values retrieved from these datasets represent commodity movements in weight (tons). These values were divided by 1,610 tons/barge (average barge loading rate computed at Lock 27) to calculate the number of barges transporting these goods.

TABLE 7.1. Lock 27 (Chain of Rocks Lock and Dam) 2005 Lockages Summary

	Tonnage		Empty Barges		Loaded Barges						
Month	Tot Ktons Up	Tot Ktons Dn	Up	Down	Up	Down	Total Passages	% of Yearly Tonnage	Loading Rate Up (tons)	Loading Rate Down (tons)	Avg. Loading Rate (tons)
January	1,516	2,607	839	257	932	1,583	3,611	6%	1,627	1,647	1,637
February	1,539	2,203	511	248	943	1,343	3,045	5%	1,632	1,641	1,636
March	2,715	2,697	1,147	324	1,706	1,668	4,845	8%	1,592	1,617	1,604
April	2,986	3,449	1,030	371	1,889	2,160	5,450	9%	1,581	1,597	1,589
May	3,042	3,926	925	427	1,903	2,409	5,664	10%	1,598	1,630	1,614
June	2,650	3,982	1,251	378	1,701	2,458	5,788	10%	1,558	1,620	1,589
July	2,752	4,130	1,352	395	1,729	2,557	6,033	10%	1,591	1,615	1,603
August	2,795	4,256	814	477	1,804	2,646	5,741	10%	1,549	1,608	1,579
September	2,482	2,427	282	535	1,554	1,459	3,830	7%	1,597	1,663	1,630
October	2,512	2,915	565	503	1,552	1,787	4,407	8%	1,619	1,631	1,625
November	1,993	3,764	1,340	460	1,206	2,353	5,359	9%	1,652	1,600	1,626
December	1,687	3,329	888	350	1,042	2,020	4,300	7%	1,619	1,648	1,634
Summary	28,668	39,683	10,944	4,725	17,961	24,443	58,073	**Average Monthly Loading Rate (tons):**			1,614

Values within the dataset are divided by origin and destination waterway section. Using this information, we estimated the amount of traffic through (not destined for) the St. Louis area. Estimating the amount of traffic destined for the St. Louis area (particularly the UAA area) is more difficult. The waterway section that includes the St. Louis area (Lower Upper Mississippi River) is defined as the Mississippi River from the Mississippi/Illinois River confluence downstream to the Mississippi/Ohio River confluence. Almost all of the commerce traffic for this waterway section originates or is destined for the St. Louis area, but the exact percentage of traffic that originates or is destined for the waterway section that transits the St. Louis area is unknown. For purposes of this assessment, we have included all barge traffic destined for/originating in/transporting within the Lower Upper Mississippi River within the total traffic for the St. Louis area (28,964).

Estimating empty barge traffic in and around St. Louis is also difficult. We can confidently estimate that all loaded barge traffic destined for or originating in St. Louis also moves within the area (at some point) while empty. Therefore, our conservative estimate of empty barge traffic only includes the number of loaded barges destined for, moving within, or originating in St. Louis (28,964). This number is fairly conservative, since it is very likely that some empty barges travel from other destinations through St. Louis.

Towboats also represent a substantial portion of the Mississippi River traffic through St. Louis. All towboat operators submit operational reports to the USACE, which are compiled into a Trips/Drafts report for the Port area by the Waterborne Commerce Statistics Center (2005c). These trips are counted each time a towboat moves through the Port, or is deployed to move barges within the Port (e.g., the splitting of a large tow for transport through Lock 27, fifteen barges at a time). Based on these data, there were 15,520 towboat trips in the St. Louis area in 2005.

Seasonal patterns of barge traffic are derived from monthly reports of barge movement from Lock 27 (Table 7.1). The total number of barge movements for the month has been divided by the total barge movements for the year to determine the percentage of yearly barge traffic for each month. The use patterns for towboat

operations would also follow the patterns observed from the Lock 27 data, and are therefore calculated from the same percentages.

The location of docks, berthing areas, and fleeting areas were derived from geographic information system data collected from the USACE (2006) and is the same data used to create the navigation maps available to the general public. These data were overlayed on the 2005 aerial imagery for St. Louis County. The berthing and fleeting area layer was developed from dock information data collected from USACE (2005e). These data provided geographic location and operational information for each facility (dock/fleeting area). The berthing and fleeting areas for each facility were then digitized into the GIS (containing the navigation map data) to depict total coverage for the St. Louis area. The total river length occupied by the berthing and fleeting areas was computed from the facility information report.

7.4. Analysis Results

The annual number of barge and towboat traffic (trips) calculated for the Mississippi river at or near St. Louis in 2005 is approximately 91,300 barge and 15,520 towboat trips (Table 7.2). Monthly data are presented in Table 7.3. This does not take into account empty barges moving from one waterway to another, transiting the entire St. Louis navigation area. The number of loaded barges transiting through the entire St. Louis navigation area (not originating or destined for St. Louis) is approximately 33,300. This estimate is further evaluated by the monthly values given in Table 7.4.

With regard to barge traffic patterns on weekends vs. weekdays, surveillance camera data at the Mill Creek and Ferry sites provide some indication that there was between a 19% and 43% decrease in barge traffic during weekends between July and mid-August, 2007. Assuming this decrease is consistent throughout the recreational season, the weekend barge traffic throughout the study reach remains substantial and inhibits safe recreational use of the Mississippi River in the study area. Although the data are not available, one could assume that there would also be a commensurate increase in barge fleeting on weekends. As pointed out by the Missouri River Water Trail coalition (see Section 4.2), even moored barges create dangerous hazards.

Eighty-one facilities on the Mississippi River near St. Louis (between RM 160.8 to 188.7 - not including facilities in the navigation canal) are used as fleeting areas or docks (USACE, 2005e). Of these facilities, 52 are designated as dock locations, with the remaining 29 facilities designated as fleeting areas. These facilities vary in size and river area occupied. Dock areas, quantified in terms of berthing area length, ranges from 80 to 3,000 feet. Total river length covered by berthing areas is approximately 21,800 feet on the right descending bank and 13,500 feet on the left descending bank. Fleeting areas are much larger in terms of total river area occupied, and vary in length from 195 to 9,000 feet. Fleeting areas occupy approximately 34,100 feet on the right descending bank (Missouri shore) and 38,500 feet on the left descending bank (Illinois shore). The areas occupied by fleeting operations are mostly in addition to the areas occupied by docks (berthing areas). The docks, berthing areas, and fleeting areas are shown in Figures 7.2 through 7.6 (Navigation Maps 95-99).

TABLE 7.2. Summary of Barge Traffic within the St. Louis Area

	Upbound		Downbound		Originating in St. Louis area		
	Through	To	Through	To	Upbound	Downbound	Within Area
Loaded Barges	12,326	20,544	21,013	502	2,897	3,084	1,937

	Empty Barge Trips through/in St. Louis		
	Outbound	Inbound	Within Area
Empty Barges	21,046	5,982	1,937

Towboat Trips through/in St. Louis area		
Inbound	Outbound	Total
7,758	7,762	**15,520**

	Total St. Louis Barge Traffic Summary		
Barge Traffic Summary	Empty	Loaded	Grand Total
	28,964	62,303	**91,267**

TABLE 7.3. Monthly Total Barge/Towboat Traffic (Trips)

Month	% of Annual Traffic	Calculated Barges & Towboats/Month
January	6.2%	6,640
February	5.2%	5,599
March	8.3%	8,909
April	9.4%	10,022
May	9.8%	10,415
June	10.0%	10,643
July	10.4%	11,094
August	9.9%	10,557
September	6.6%	7,043
October	7.6%	8,104
November	9.2%	9,854
December	7.4%	7,907
Monthly Avg.		8,899

Note: Includes barges originating, destined for, and transiting – only the St. Louis area

TABLE 7.4. Monthly Loaded Barges Transiting through the Entire St. Louis Area

Month	% of Annual Traffic	Calculated Barges/Month
January	6.2%	2,073
February	5.2%	1,748
March	8.3%	2,781
April	9.4%	3,129
May	9.8%	3,252
June	10.0%	3,323
July	10.4%	3,463
August	9.9%	3,296
September	6.6%	2,199
October	7.6%	2,530
November	9.2%	3,077
December	7.4%	2,469
Monthly Avg.		2,778

Note: Represents only those barges not originating in or destined for the St. Louis area

Although not monitored by the USACE or quantified in this section, Gateway Arch Riverboat tours contribute additional large boat traffic to the UAA segment. Gateway Arch Riverfront operates daily sightseeing cruises from April through November and dinner cruises year round. Riverboat tours are conducted on two large 19th century replica steamboats using the Gateway Arch riverfront as its base of operation. Field observations and photo surveillance conducted by MEC suggests these tour boats routinely pass through the northern segment of the UAA area.

7.5. Comparison with other UAA Ports

Similar UAAs are in progress or have been completed for at least three ports/rivers within the United States. UAAs have been approved for the Port of Erie, Pennsylvania and for the Port of Mobile, Alabama on the Mobile River. A UAA is in progress for the Chicago Area Waterways (CAWs). A comparative assessment of barge/ship traffic was conducted for all of these ports.

Data assessment of these ports is not as complicated as that of the Port of St. Louis, since these ports only serve as points of origin or destination rather than including transiting traffic. Essentially, St. Louis represents a major beginning/end point located on the barge highway. Data characterizing the shipping activity for the comparative ports were collected from the USACE 2005 Trips and Drafts portion of the Waterborne Commerce Statistics Center report for each respective waterway (USACE, 2005c). Similar to the method by which the towboat activity was characterized for St. Louis, shipping activity for both the Mobile River and CAWs was fully represented in each of these reports. Shipping activity for the Port of Erie, Pennsylvania was calculated (Table 7.5) from the total amount (tonnage) of commerce reported from that port, then divided by the probable tonnage of the shipping vessels using that port (between 27 and 107 vessels/year). These values were then doubled to represent empty vessel traffic (between 54 and 214 vessels/year). These assumptions were made due to the lack of Trips and Drafts data within the Waterborne Commerce Statistics Center report, for the Port of Erie.

The type of vessels using the port is a significant point of difference between the three comparative ports and the Port of St. Louis. Shipping activity in the Port of St. Louis is limited to barge traffic alone, whereas the shipping activity in the comparative ports is a mixture of barge and large ship traffic. At these ports, the trip data report distinguishes between barges and ships.

Activity differences between the comparative ports and the Port of St. Louis are substantial. Total shipping barge traffic for the Port of St. Louis for 2005 is approximately 91,300 barges and 15,520 towboats. Comparatively, Mobile Harbor (including Mobile River and nearby tributaries) tabulated barge/ship traffic for 2005 was 32,156 barges and towboats as well as 5,395 deep-draft ships (Table 7.5, Figure 7.7). The Port of Chicago, which includes all of the waterbodies of the CAWs UAA, had less activity than the Port of Mobile. Total shipping vessel traffic for 2005 was 34,949 barges and 1,603 deep-draft ships (Table 7.5, Figure 7.7). As stated above, the shipping traffic through the Port of Erie, Pennsylvania is significantly less than that of all the comparative ports, with approximately 27 to 107 deep-draft ships loaded at the port per year, with the total number of ship movements for the year between 54 and 214,

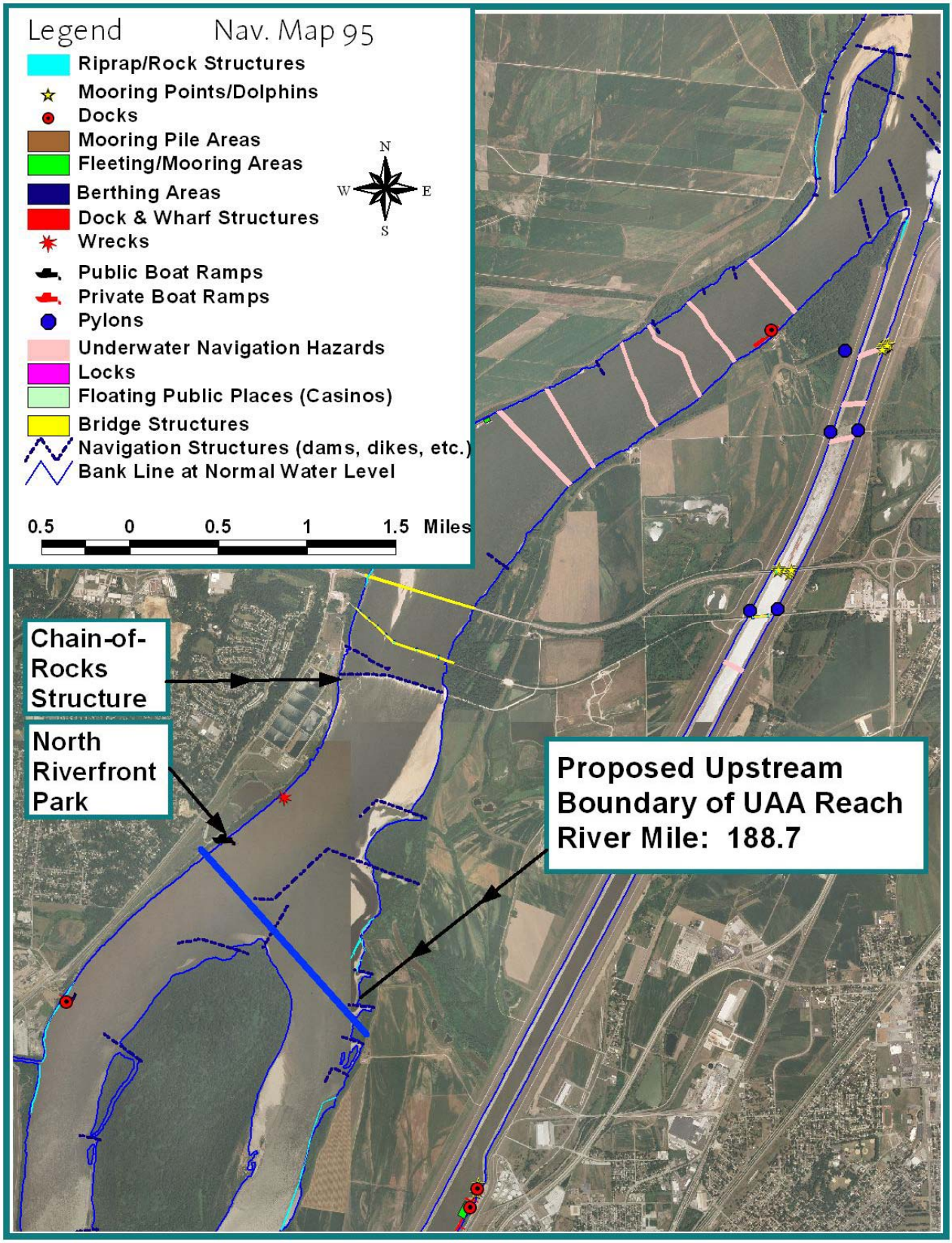


FIGURE 7.2. Navigation Map 95

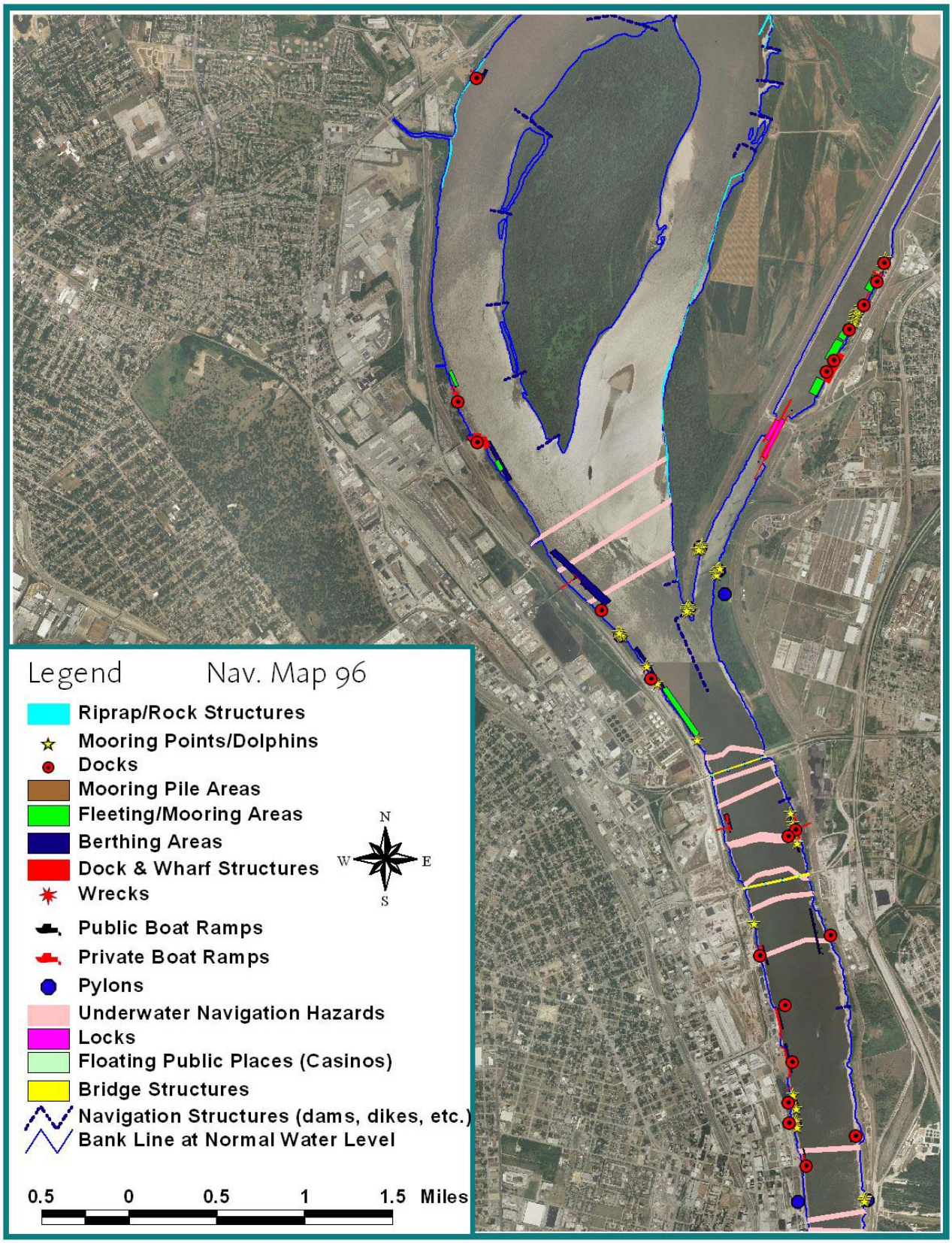


FIGURE 7.3. Navigation Map 96

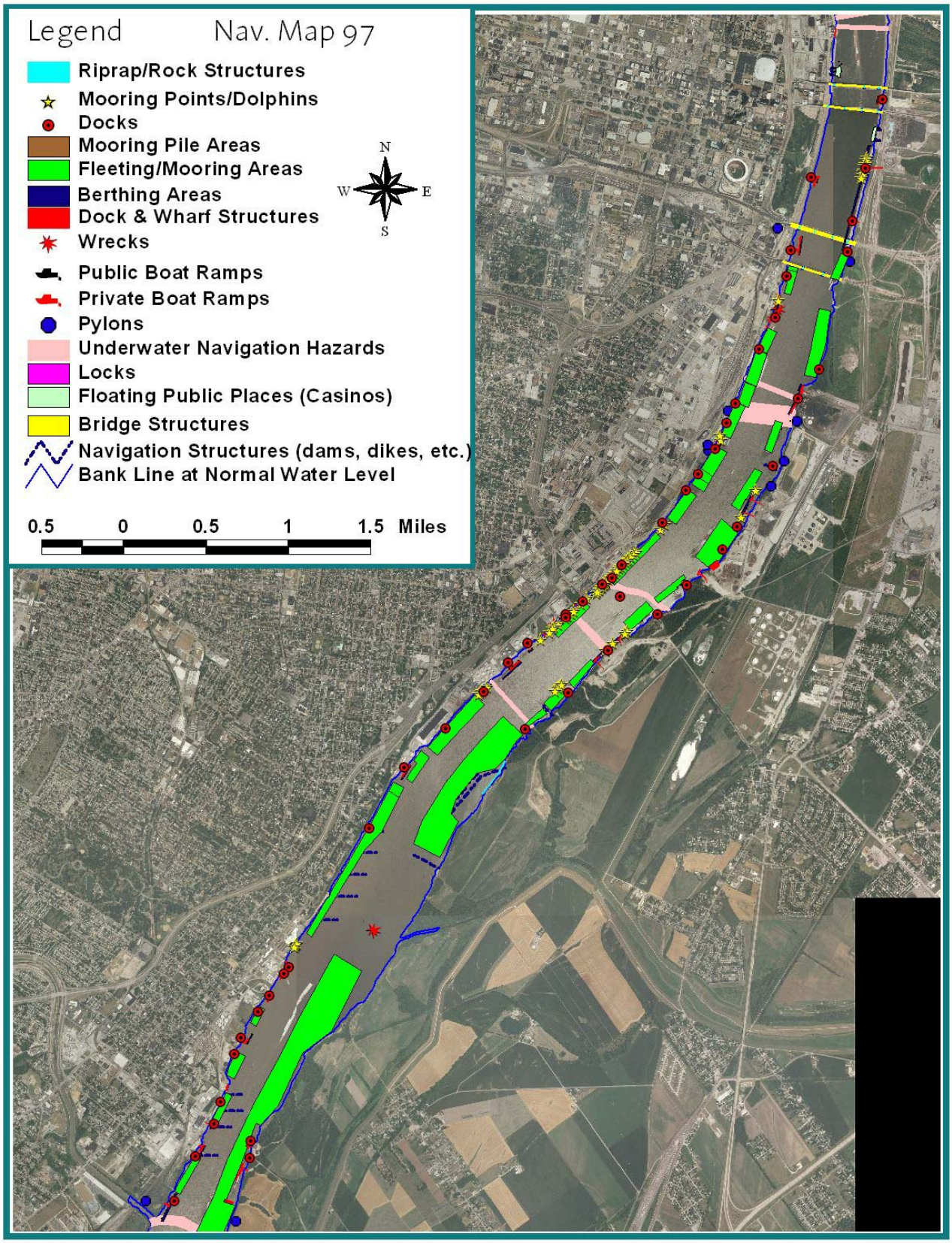


FIGURE 7.4. Navigation Map 97

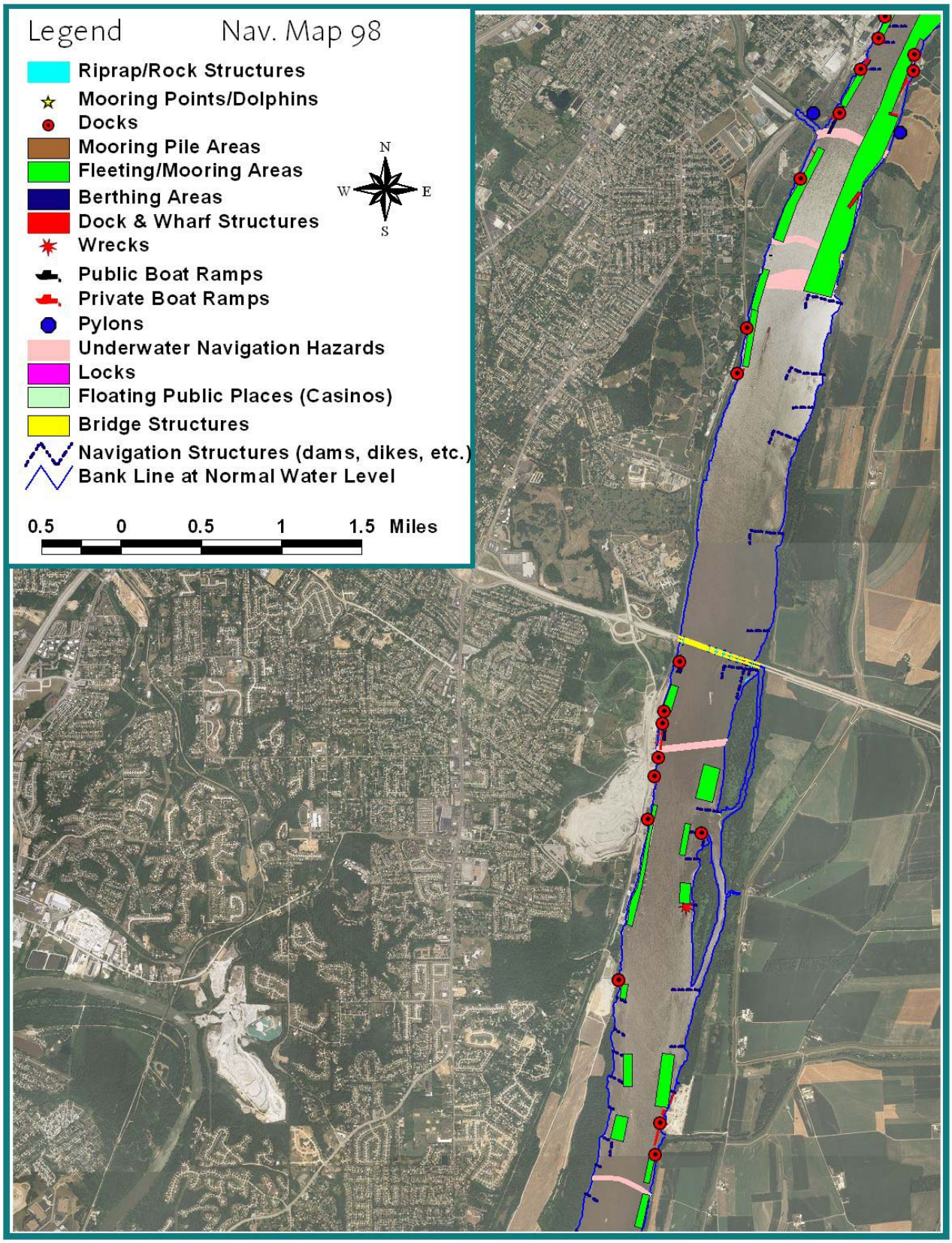


FIGURE 7.5. Navigation Map 98

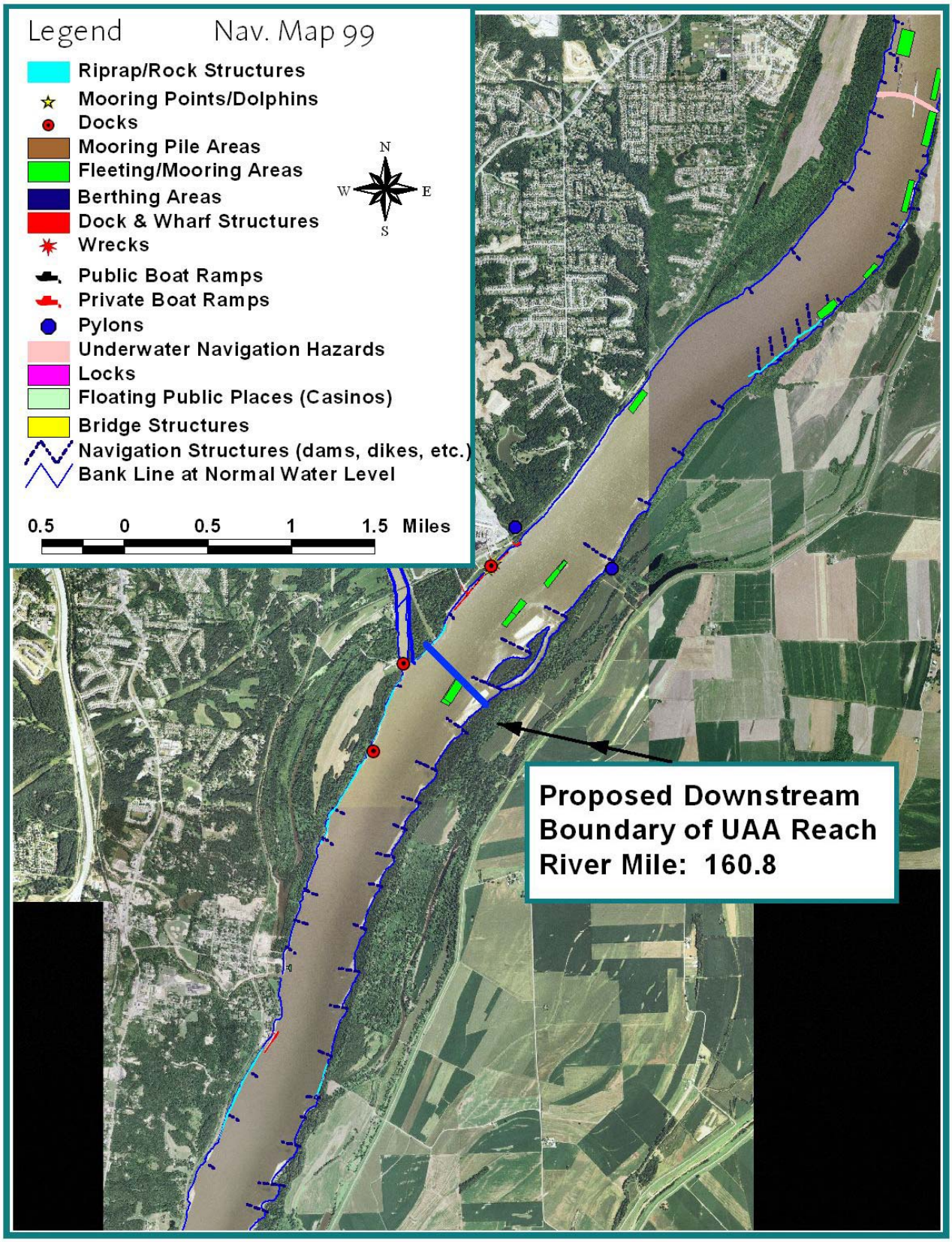


FIGURE 7.6. Navigation Map 99

taking into consideration empty vessel traffic (Table 7.5). Little, if any, barge traffic is expected at the Port of Erie due to the restricted activity, and corresponding minimal use of river barges on the Great Lakes.

TABLE 7.5. Barge Traffic Summary for Comparison Ports

Port	Inbound						Outbound						Total Yearly Vessel Movement Summary	
	Self-Propelled				Non-Self-Propelled		Self-Propelled				Non-Self-Propelled			
	Total	Dry Cargo	Tanker	Tow/ Tug	Dry Cargo	Tanker	Total	Dry Cargo	Tanker	Tow/ Tug	Dry Cargo	Tanker	Barges & Tugs	Ships & Ferrys
Mobile	18,749	2,513	177	3,490	9,858	2,711	18,802	2,532	173	3,472	9,922	2,703	**32,156**	**5,395**
Chicago	18,259	790	3	6,341	9,570	1,555	18,293	807	3	6,323	9,607	1,553	**34,949**	**1,603**

	Summary for Port of Erie, Pennsylvania						
	Total Tonnage	Minimum Tonnage of Cargo Ship	Maximum Tonnage of Cargo Ship	Min Number of Ships		Max Number of Ships	
				Loaded	Total	Loaded	Total
Erie	1,065,659	10,000	40,000	27	**54**	107	**214**

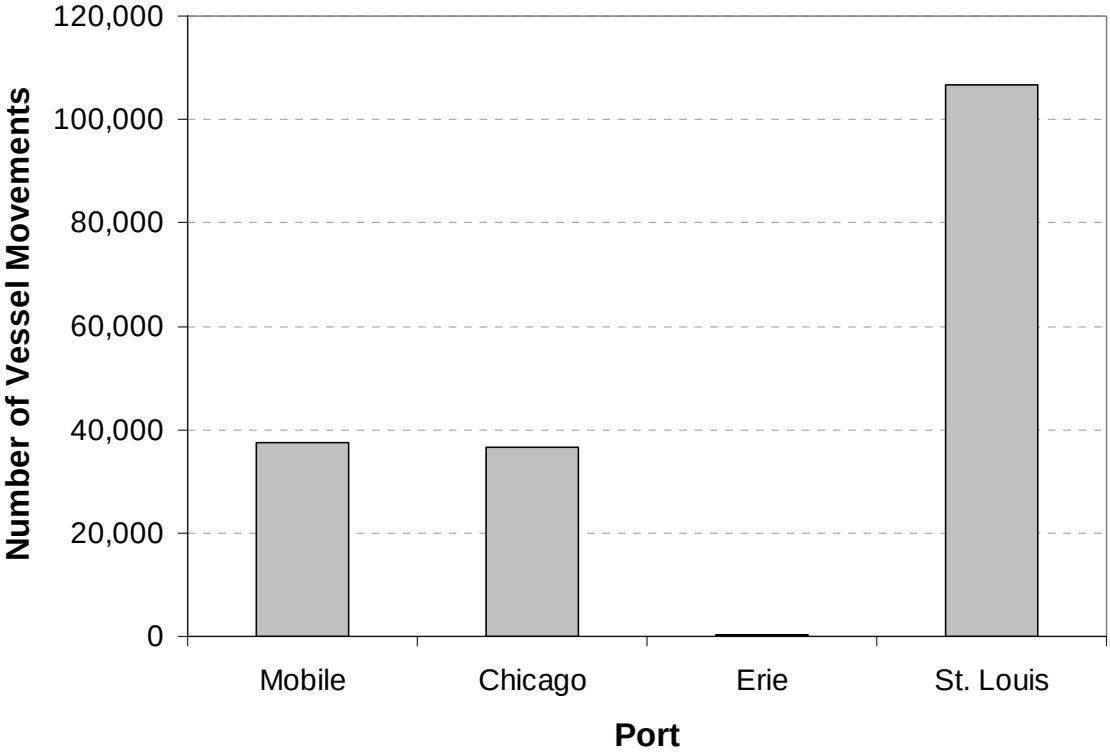


FIGURE 7.7. Total Vessel Traffic at Selected Ports

7.6. Summary of Barge Traffic Findings

Barge activity on the Mississippi River in the vicinity of St. Louis is heavy by most any measure. Statistics supporting this fact include:

- The Port of St. Louis is the 3rd busiest inland port in the contiguous United States;
- There were approximately 91,300 barge and 15,500 towboat trips for the Mississippi at or near St. Louis in 2005;
- There are approximately 52 dock facilities for the loading and unloading of Mississippi River commerce in the St. Louis area (RM 160.8 to RM 188.7);
- Total river length covered by dock/berthing areas is approximately 21,800 feet on the right descending bank and 13,500 on the left descending bank (RM 160.8 to RM 188.7); and
- Fleeting areas occupy approximately 34,100 feet on the right descending bank and 38,500 feet on the left descending bank (RM 160.8 to RM 188.7).

Barge activity is incompatible with recreational uses and has been cited as a factor in removing WBCR use from at least three other recreational UAAs. The incompatibility of barge traffic with recreational activities is well documented ((Becker, 1981 and Graman *et al.,* 1984 as cited in Committee to Review the Upper Mississippi River - Illinois River Waterway, 2001). Additionally, the USACE advises against recreating in or around barge traffic. The USACE warns that wakes from barges may lift boats onto dikes or other hazards and undertows near barges suck under objects including smaller boats (USACE, undated brochure titled "Missouri River Safety Tips"). It is in part for these reasons that WBCR has been removed or is being considered for removal from the Mobile River, the Port of Erie, and the CAWs.

Commercial boat traffic on the Mississippi River in the vicinity of St. Louis exceeds the combined traffic from the Mobile River, the Port of Erie, and the CAWs. In all three cases, WBCR was recommended for removal. Based on this precedence, the heavy barge traffic in the St. Louis area and the known dangers of barge traffic, assigning a WBCR use in the Mississippi River UAA segment would be inappropriate.

8. River Hydraulics and Morphology

8.1. Studies and Guidance on River Safety and Recreation

An early and well known model for assessing streamflow-recreation relations was developed by Hyra (1978) based on methods used to evaluate fish habitat. The Hyra (1978) model translates stream depth and velocity into an overall assessment of usable recreational potential. Measured depths and velocities are translated into indices of recreational suitability based on "probability-of-use" curves. An overall usable surface area is calculated by multiplying the product of the depth and velocity suitability indices by the associated surface area of the stream segment. The "probability of use" curves are based on criteria developed by Hyra (1978) for a variety of stream-oriented recreation activities. Minimum and maximum criteria were developed for both depth and velocity with regards to physical and safety considerations[1]. Based upon the author's clarification, safety criteria are most applicable for assessing recreational use safety in this context. A summary of recreation criteria developed by Hyra (1978) is presented below in Table 8.1.

The first study of human stability in flood conditions was conducted at Colorado State University in the late 1980's. This study sought to identify conditions under which an adult human could not stand or maneuver in simulated flood flow. Twenty healthy, lightly dressed human subjects were placed in a recirculating flume at various depths, slopes, and velocities until the point of instability was observed. They used four different surfaces in the flume: simulated turf, smooth concrete, steel and sand, and gravel chip. Although surface material clearly affects one's footing, results of the Abt *et al.* (1989) study suggest this variable is not very important. Slope also appeared to have a relatively minor effect on stability; however, the tested slopes were limited to 0.5% and 1.5%. Product numbers (P.N.) of instability ranged from 7.56 ft^2/s for a 122 lb subject to 22.84 ft^2/s for a 201 lb subject, where the P.N. is defined as the product of the depth of flow and average velocity.

A more recent study by Karvonen *et al.* (2000) completed at the Helsinki University of Technology Ship Laboratory sought to define the limits for a safe rescue action in the case of a dam-break flood. Similar to the Abt *et al.* (1989) study, the Karvonen *et al.* (2000) study measured conditions of human stability in terms of the P.N. of depth and flow. Karvonen *et al.* (2000) tested seven human subjects aged 17 to 60 wearing Gore-Tex survival suits on a specially constructed steel grated structure at different depths and velocities. Results of the study ranged widely from a P.N. of 6.89 ft^2/s to a P.N. of 13.56 ft^2/s. Consistent with Abt *et al.* (1989), taller and heavier individuals managed better in flowing water. However, overall P.N. values were lower than in the Abt *et al.* (1989) study. The lower P.N. may be attributed to the clothing and bottom material. The survival suits in the Karvonen *et al.* (2000) study resulted in a greater drag coefficient and the steel grating was slippery which made it more difficult to maneuver in the flow.

[1] "Regarding physical criteria, recreation activities have certain physical or absolute limits or requirements which must be met (i.e., a boat requires a certain minimum of depth of water to float). In the case of safety criteria there are no absolutes; however, it can generally be stated that certain depths or velocities may be unsafe for the average participant. Safety criteria may also be considered a preferred physical limitation" (Hyra, 1978).

TABLE 8.1. Recreation Criteria Developed by Hyra (1978)

Activity		Depth (feet)			Velocity (feet per second)			Hyra (1978) Comments
		Physical	Safety	Optimum	Physical	Safety	Optimum	
Fishing Wading	*minimum*	0.5	0.75	1.0-2.5	0	0	0.25-2.0	Depth in ft multiplied by velocity in fps should equal 10 or less. Safety depends upon height and weight of individual as well as substrate type.
	maximum	4.0	3.5		3.0	2.5		
Fishing Boat Power	*minimum*	2.5	3.0	3.5+	0	0	0.5-2.0	Size of boat and motor important. Generally includes boats of low power.
	maximum	NA	NA		5.0	4.0		
Fishing Boat Non-Power	*minimum*	0.5	1.0	2.0+	0	0	0.5-1.5	Type boat important.
	maximum	NA	NA		4.0	3.0		
Water Contact Wading	*minimum*	0.3	0.5	0.75-2.5	0	0	0.25-2.0	Depth in feet multiplied by velocity in fps should equal 10 or less. Safety depends upon height and weight of individual as well as substrate type.
	maximum	4.0	3.0		3.0	2.5		
Water Contact Swimming	*minimum*	2.5	3.0	4.0+	0	0	0.25-0.75	Water quality, temperature, slope of beach, visibility and underwater slope important. Depth safey criteria does not permit diving.
	maximum	NA	NA		3.0	2.0		
Water Contact Skiing	*minimum*	5.0	7.0	9+	0	0	0.25-1.5	Width is also critical.
	maximum	NA	NA		3.0	2.5		
Boating Sailing	*minimum*	3.0	4.0	5+	0	0	0.25-0.75	Keel or centerboard depth is critical.
	maximum	NA	NA		1.5	1.25		
Boating Low Power	*minimum*	2.5	3.0	3.5+	0	0	0.5-3.0	Low power boats are less than 50 hp.
	maximum	NA	NA		7.0	6.0		
Boating High Power	*minimum*	3.0	3.5	4.0+	0	0	0.5-8.0	High power is greater than 50 hp. Jet boats or sleds require only 1.0 ft ± water depth. Higher velocities safe only under certain conditions.
	maximum	NA	NA		12.0	10.0		

Biases and constraints present in both the Abt *et al.* (1989) and Karvonen *et al.* (2000) studies included the presence of safety equipment, optimal test conditions (e.g., good lighting and no debris), subjects' abilities to learn to maneuver in the flow with time, and the good health of the subjects. Additionally, children's ability to cope with flow was not studied. Noting these limitations, Karvonen *et al.* (2000) provides approximations for limits of adult human maneuverability and stability in flowing water based on the combined results of Abt *et al.* (1989) and Karvonen *et al.* (2000). The approximations are based on a person's height and weight and are categorized into three conditions: poor, normal, and good. Limits of maneuverability and stability suggested by Karvonen *et al.* (2000) are presented in Figure 8.1. Poor, normal, and good conditions are described in Figure 8.2.

Results of the Karvonen *et al.* (2000) study suggest U.S. Geological Survey (USGS) guidance regarding safe wading conditions may not be protective for most people. USGS guidance suggests that field personnel should not attempt to wade within a stream for which the P.N. exceeds 10 ft^2/s (USGS, 1997). Under normal conditions (e.g., stream bottom neither smooth nor too uneven and relatively average health of the subject) a P.N. of 10 ft^2/s translates to a height-weight product number of approximately 1,300 ft-lbs (e.g., 6 ft, 217 lbs) based on the findings of Karvonen *et al.* (2000).

An appropriate P.N. for the UAA segment is 4.0., based on the results of the Karvonen *et al.* (2000) study and conditions of the Mississippi River(particularly along the Missouri shoreline). Steep banks, poor visibility, and floating debris suggest the Mississippi River should be categorized as "poor" based on the categories of conditions presented by Karvonen *et al.* (2000) (Figure 8.2). Under poor conditions a P.N. of 4.0 translates into an approximate height-weight product number of 1,000 (e.g., 5 ft 11 in, 170 lbs). The Karvonen *et al.* (2000) criteria for average males (5 ft 9.5 in, 191 lbs) and females (5 ft 4 in, 164 lbs) are 4.4 and 3.7, respectively, with a midpoint of approximately 4.0 (CDC, 2004). It should be noted that this approach does not account for wading stability of children.

Guidance regarding swimming from the USACE is not as quantitative as that provided by Hyra (1978); however, it does offer strong warnings. An undated brochure from the USACE titled "Missouri River Safety Tips" has the following warning: "Swimming and tubing on the Missouri River is extremely dangerous and is strongly discouraged. A river current normally 3-4 mph can quickly exhaust even the strongest swimmer. Inner tubes should never be used on the river." Although this guidance is targeted for the Missouri River, it is applicable for the Mississippi River near St. Louis as well.

Criteria for recreational beaches can be found in various guidance documents and state regulations. Recreational beach criteria are designed for a safe recreating environment and include such factors as bank slope. The Colorado Mined Land Reclamation Board established bank slope criteria for gravel pit lakes to be reclaimed as recreational amenities. They require that the bank slopes of the lakes should be no steeper than a ratio of 5 horizontal to 1 vertical (i.e., 5:1) for a distance from the top berm to a point 8 feet under the normal water surface (Wright Water Engineers, 2004). The United

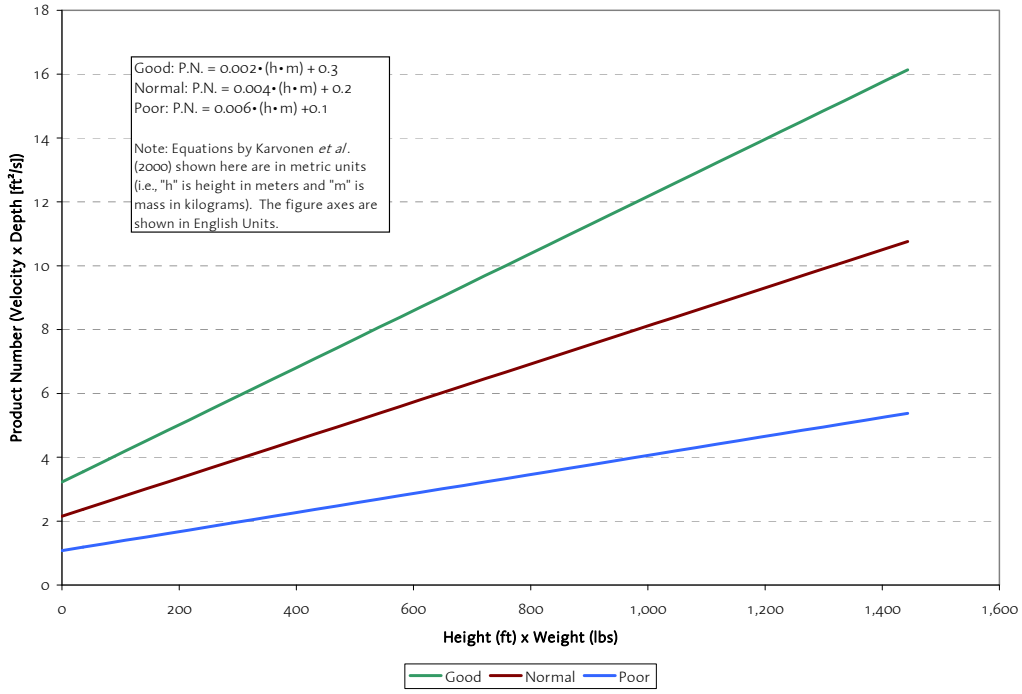


FIGURE 8.1. Recommendations for Human Stability in Flowing Water (Adapted from Karvonen *et al.* [2000])

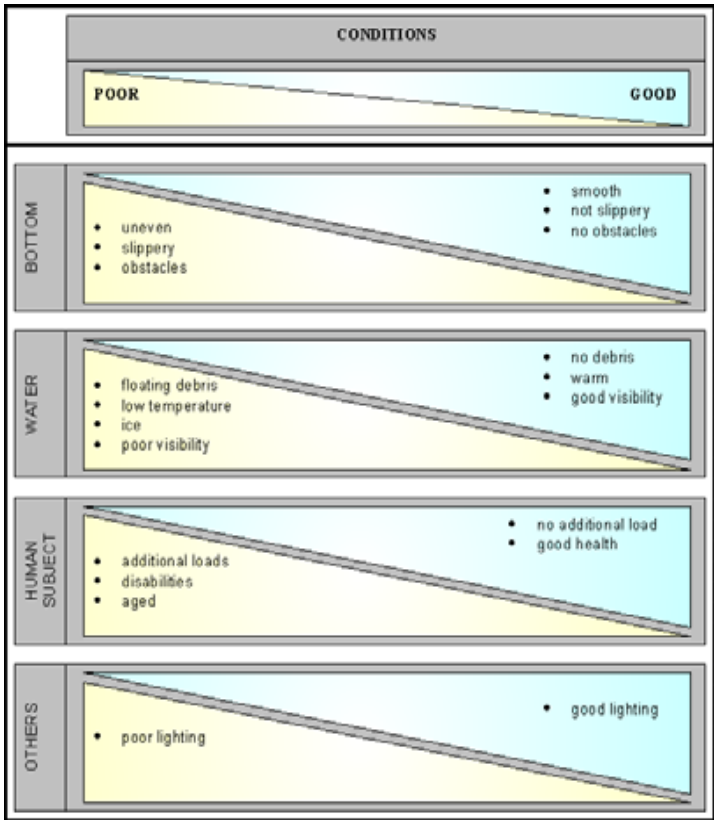


FIGURE 8.2. Human Subject in Flowing Water, Categories of Conditions (taken from Karvonen *et al.* [2000])

States Department of Agriculture Natural Resources Conservation Service (NRCS) requires that streambanks to be used for public access (i.e., fishing, swimming and related activities) have side slopes no steeper than a 4:1 ratio (NRCS, 2002). New York State regulations regarding bathing beaches requires that bank slopes are no steeper than a 10:1 ratio for depths up to 4 feet and no greater than a 3:1 ratio for greater depths (NYCRR, 2004).

This review of recreational use safety studies and design criteria yields a set of objective and technically-defensible criteria to assess Mississippi River hydraulics and morphology characteristics. Criteria for whole body contact recreational use should be based upon the highest criteria for the appropriate recreational activities (e.g., swimming near-shore and waterskiing in deep areas without obstructions). Potential swimming areas should also be safe to wade as well, since presumably one must safely wade to and from the potential swimming area (areas greater than 3.3 ft per MDNR (2004)). Based upon this rationale, the recommended safety criteria are included below. Exceedence of these criteria indicates unsafe swimming or wading conditions.

Wading

- Bank slope ratios no steeper than 4 horizontal to one vertical (i.e., 4:1) (NRCS, 2002)
- Depth/velocity product numbers less than 4 ft^2/s (Karvonen *et al.*, 2000)

Swimming

- Near surface velocities less than 2.0 fps (Hyra, 1978)

Waterskiing

- Near surface velocities less than 2.5 fps in areas with depths greater than 7 ft and lacking obstructions (e.g., wing dikes and docks) (Hyra, 1978)

8.2. Mississippi River Hydrologic and Hydraulic Statistics

MEC evaluated available historic hydrologic data on the Mississippi River to:

1. Assess the suitability of the Mississippi River for recreation relative to published guidance and regulations; and
2. Determine the appropriate flow conditions under which to perform river hydraulics evaluations for further assessment.

Based upon stakeholder input, this hydrologic evaluation was based upon the period of July 15 through September 15, which likely poses the highest probability of WBCR use.

MEC obtained USGS long-term hydrologic and hydraulic data for the Mississippi River at St. Louis (Station 07010000) for this evaluation. Historic flow data are available at

this gaging station from 1861 to the present, representing one of the most robust hydrologic datasets in the country. MEC selected the period spanning from 1965 to 2006 for data analysis since this is the longest period available after consistent operation of the Missouri River basin flow control dams.

The available hydrologic and hydraulic data provide valuable insight into typical flow regimes within the Mississippi River UAA segment. Flow regimes vary dramatically from year to year, as well as through the course of each year. Daily flow records (entire year) through the selected period of record range from 41,200 to 1,050,000 cubic feet per second (cfs). Annually, flows are typically highest during the spring runoff period April through June, although the highest flows recorded occurred during July and August 1993 (Figure 8.3). Monthly flow statistics are also provided in tabular form as Table 8.2. Flows typically decline during July and remain relatively consistent August through February (Figure 8.3). Lowest monthly median flow conditions occur during September, October and January.

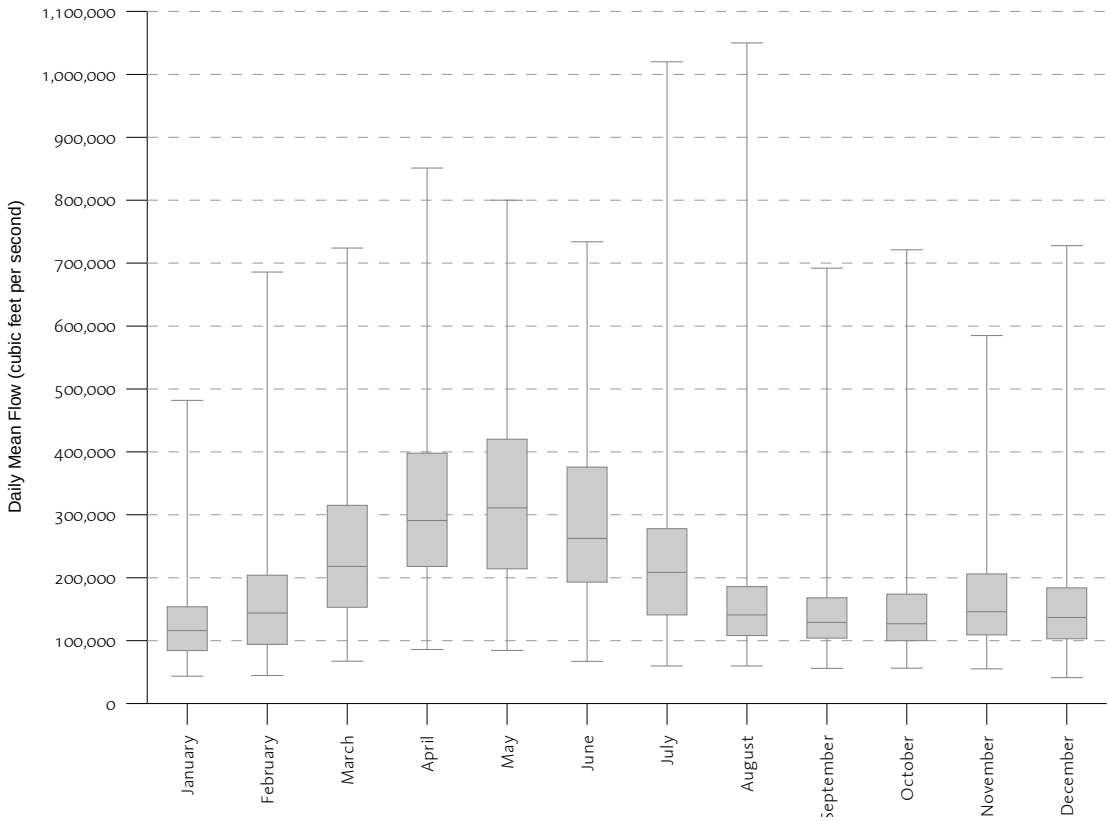


FIGURE 8.3. Daily Mean Flow Values by Month at USGS Gage Station 07010000 - Mississippi River at St. Louis (1965 - 2007)

TABLE 8.2. Flow Statistics for USGS Gage Station 07010000 - Mississippi River at St. Louis (1/1/1965 – 6/6/2007)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of values	1,333	1,214	1,333	1,290	1,333	1,266	1,302	1,302	1,260	1,302	1,260	1,302
Minimum	43,500	44,500	67,600	85,900	84,500	67,200	59,800	59,700	56,100	56,200	55,200	41,200
Maximum	482,000	686,000	724,000	851,000	800,000	734,000	1,020,000	1,050,000	692,000	721,000	585,000	728,000
Mean	132,800	163,500	245,100	317,700	323,900	285,200	231,400	161,500	152,700	159,400	167,400	156,100
Median	116,000	144,000	218,000	291,000	311,000	262,000	208,000	141,000	129,000	127,000	146,000	137,000
First quartile	84,100	94,200	153,000	218,000	214,000	193,000	141,000	108,000	104,000	100,000	109,000	103,000
Third quartile	154,000	204,000	314,000	398,000	419,000	376,000	278,000	186,000	167,000	174,000	206,000	184,000
95% confidence interval	3,903	5,087	6,554	7,632	7,539	6,778	7,376	5,654	4,946	5,653	4,609	4,728
99% confidence interval	5,125	6,680	8,607	10,020	9,900	8,901	9,686	7,424	6,495	7,424	6,053	6,209
Standard deviation	72,750	90,510	122,200	140,000	140,500	123,200	135,900	104,200	89,650	104,200	83,540	87,120

Flow conditions substantially vary on an annual basis during the critical summer period selected for recreational uses (July 15 through September 15). Average daily flows for the period of record ranged from 56,100 to 1,050,000 cfs, with median and mean flows of 147,000 and 171,000 cfs, respectively (Table 8.3). Figure 8.4 illustrates daily flow data as an exceedance plot or flow duration curve. This depiction shows that 100,000 and 200,000 cfs are exceeded approximately 80% and 25% of the time within this period, respectively.

TABLE 8.3. Average Daily Flow Statistics for July 15 through September 15 at USGS Gage Station 17010000 - Mississippi River at St. Louis (1965-2006)

Statistic	Flow (cfs)
Min	56,100
25th	109,000
Mean	171,000
50th	147,000
75th	200,000
Max	1,050,000

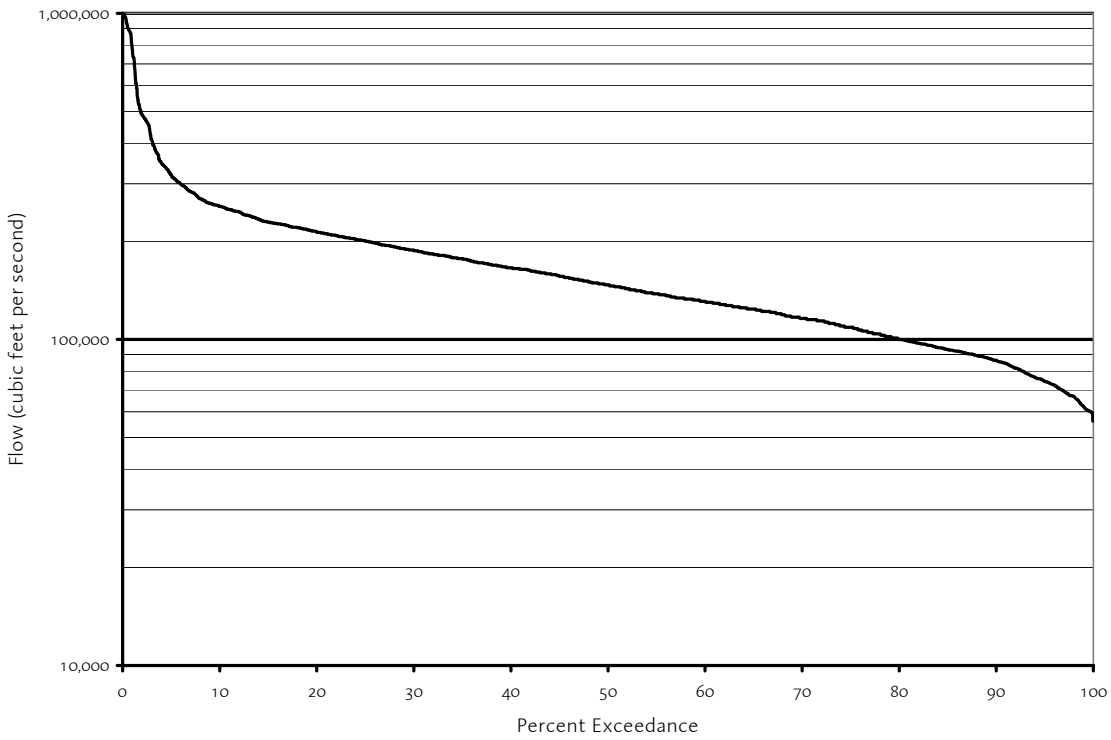


FIGURE 8.4. Flow Duration Curve for July 15 through September 15 at USGS Gage Station 17010000 - Mississippi River at St. Louis (1965-2006)

On an annual basis, average daily flows for the period of record ranged from over 67,000 to 700,000 cfs, with median and mean annual average daily flows of 157,000 and 171,000 cfs, respectively (Table 8.4). These values were calculated using the average flows recorded during each year for the July 15 to September 15 period. Lowest and highest flow conditions occurred within six years, during 1988 and 1993, respectively.

TABLE 8.4. Annual Average Daily Flow Statistics for July 15 through September 15 at USGS Gage Station 17010000 - Mississippi River at St. Louis (1965-2006)

Statistic	Flow (cfs)
Min	67,600
25th	127,000
Mean	171,000
50th	158,000
75th	195,000
Max	703,000

Flow regimes typically decrease on a daily basis during the selected summer period. Figure 8.5 illustrate flow statistics for each day during the selected summer period. The two graphs in Figure 8.5 differ only due to scale with respect to flow (y-axis) to provide greater resolution for typical flow ranges. The means of the daily flow records decrease from approximately 235,000 cfs on July 15 to 138,000 cfs in mid September. The 25th and 75th of daily flow records range from 152,000 to 268,000 cfs in mid July to 91,000 to 154,000 cfs in mid September, respectively.

The 2007 Mississippi River UAA effort includes collection and evaluation of hydraulic and morphologic data to determine if hydrologic modifications influence these factors to the point that WBCR use attainment is precluded (40 CFR 131.10(g) Factor 4). The Mississippi River UAA stakeholders agreed to base this analysis on typical conditions occurring during July 15 through September 15.

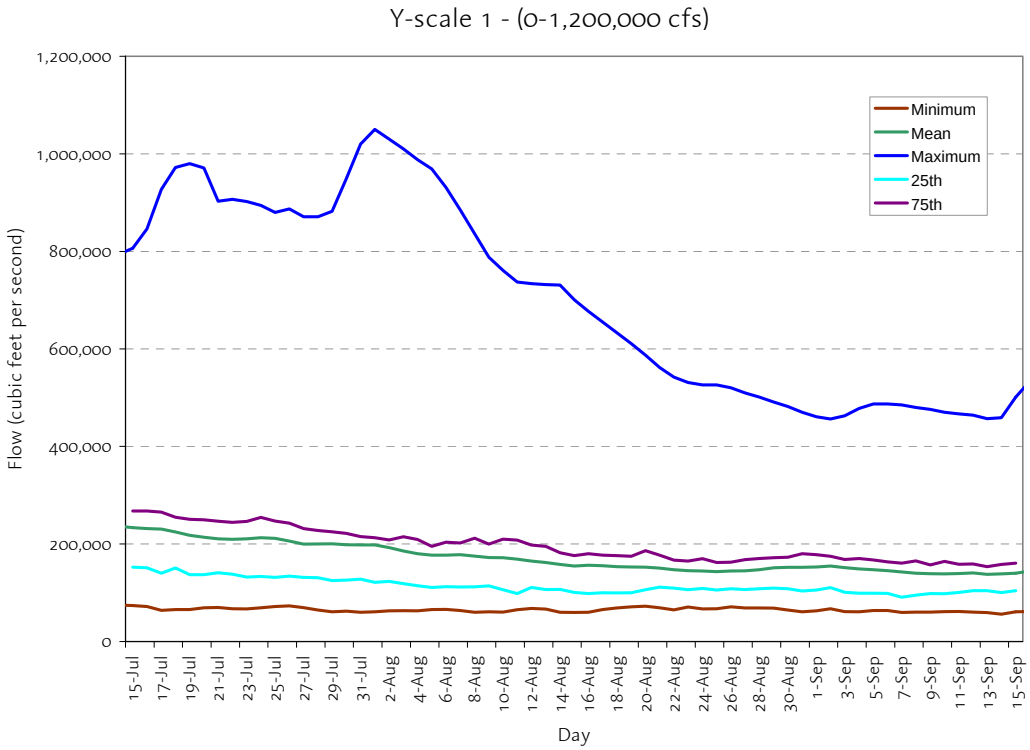
Based on the hydraulic analysis presented above, MEC targeted flow conditions from 110,000 to 150,000 cfs for the field hydraulic and morphologic analysis. This range represents the 25th percentile to the median of summer flow conditions during the selected period of record.

8.3. Morphologic and Hydraulic Field Assessment Methods

Morphologic and hydraulic data were collected during field assessments, including collection of bathymetric and water velocity data. Velocity data collection focused on both near-shore and channel velocity regimes. Near-shore areas were the focus of bathymetric surveys to assess bank slopes at areas of potential entry into the river.

MEC crews used a boat-mounted SonTek™ Acoustic Doppler Current Profiler (ADCP) coupled with a sub-meter accurate Trimble™ differentially-corrected global positioning system (DGPS). The ADCP collected velocity data at vertical depth increments (bins) allowing users to characterize water velocities throughout a vertical profile (ensemble). Numerous ensembles are collected as the boat travels across a given transect providing a complete vertical and lateral characterization of water velocity. Unfortunately, ADCPs do not collect surface velocities which are likely the highest velocities present within the water column and are most representative of those conditions that potential swimmers face. ADCPs begin collecting data 2 to 3 ft below the water surface (blanking distance), depending upon the frequency of the acoustic signal. The sub-meter accurate DGPS integrated into the data collection platform also provides georeferenced locations of each ensemble, removing the potential error in velocity measurements due to boat movement. In addition, the ADCP provides water depth measurements for use in bathymetric analyses. Figure 8.6 illustrates the output provided by these sophisticated systems.

Near-shore velocity and bathymetry data were collected by initiating lateral (perpendicular) transects near the river bank. Personnel safety and equipment damage was considered when locating the initial lateral transect points since submerged obstacles (e.g., snags, large rock, etc.) could easily be hit given the water's low transparency. Initial points were located either within 15 feet of shore or at a



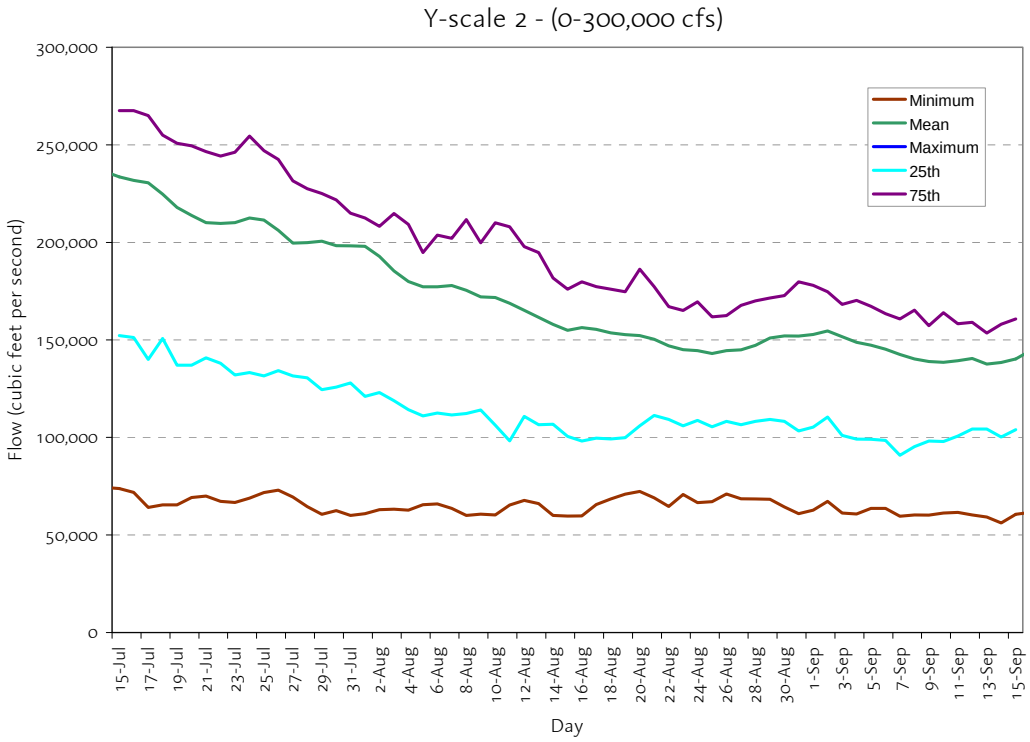


FIGURE 8.5. Daily Flow Values for July 15 through September 15 at USGS Gage Station - 17010000 Mississippi River at St. Louis (1965-2006)

minimum water depth of 5 to 6 feet, whichever was limiting. Transect data were then collected by slowly moving the boat horizontally across the channel, collecting data at 5-second averaging intervals. Lateral transects were typically terminated after average water column velocities exceeded 3 fps. Longitudinal (parallel) transects were also performed to collect velocity and bathymetry data at nearly constant distances from shore.

Near-shore velocities at depths too shallow to survey by boat were not collected due to safety considerations. After preliminary assessment, the irregular banks and lack of transparency to identify obstacles were deemed too dangerous for wading. Therefore, this component of the survey was abandoned.

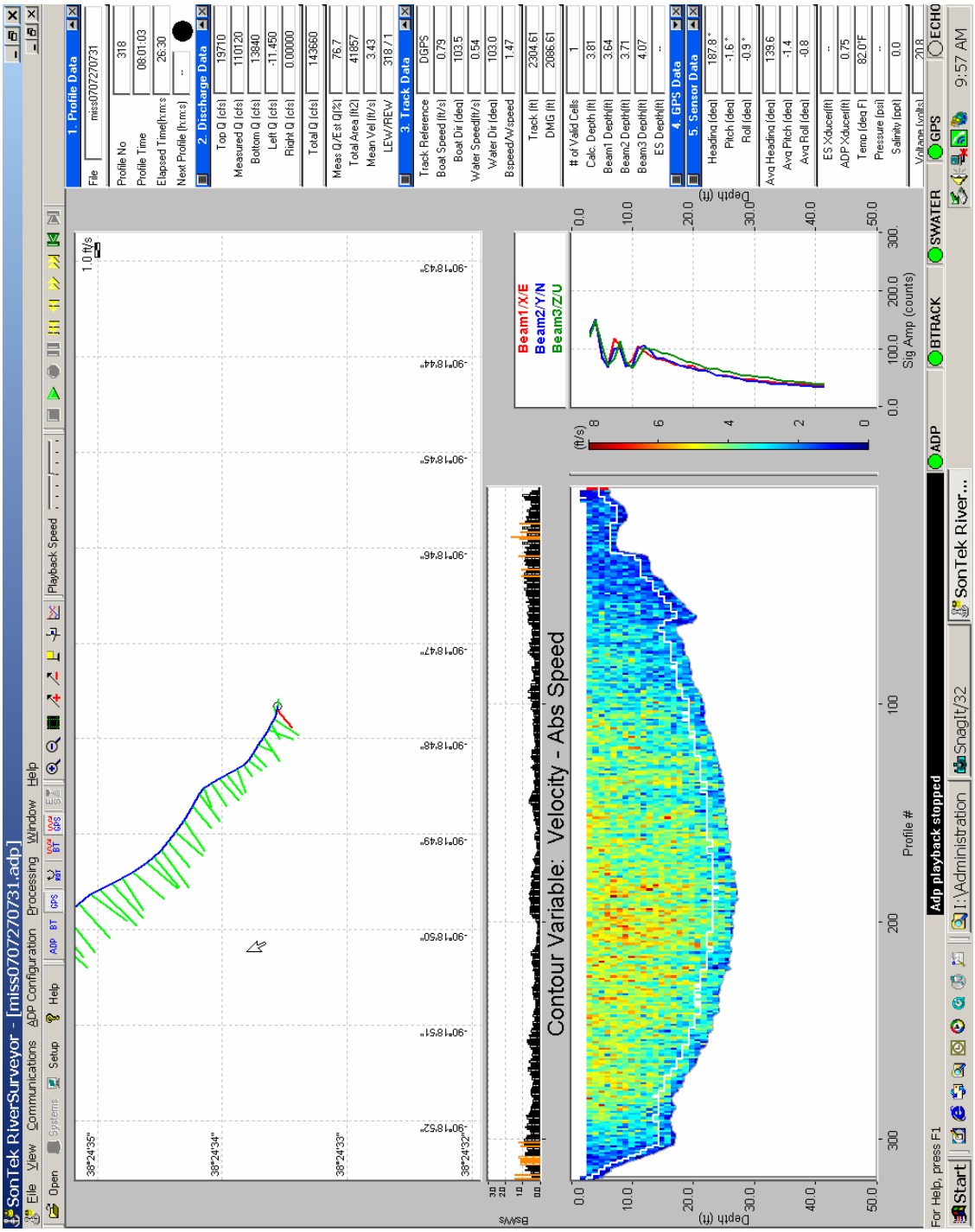
MEC crews also performed lateral transects across the entire river cross-section to measure flow and characterize hydraulic conditions throughout the river channel. These data were collected similar to near-shore horizontal transects, beginning as close to the shore as possible, then progressing across the river, ending near the opposite shore. Flow rate data collected during each river cross-section agreed (typically within 5%) with the flow data recorded by the nearest USGS gaging station (Mississippi River at St. Louis).

The hydraulic and morphologic field assessments were performed on July 27 and August 6, 2007. Provisional flow readings at the St. Louis gage were 114,000 and 144,000 cfs on August 6 and July 27, respectively. These flow conditions bracketed the target conditions (110,000 to 150,000 cfs) well and were only available for a very limited period (Figure 8.7).

Survey locations were primarily based upon accessible areas identified during the July 17, 2007 field survey with the project stakeholders. Six areas were surveyed as illustrated in Figure 8.8. MEC added a survey location at the MSD Ferry Pump Station, which is immediately downstream of the Chain of Rocks Lock 27 Canal. This site was identified as another potential access site after observing recreational fishermen. During the lower flow August 6 assessment, MEC also surveyed the area immediately upstream of Maline Creek due to shallow conditions and obstructions near the North Riverfront Park survey location. These additional locations also aid in characterizing the hydraulic transition zone downstream of the Chain of Rocks (Dam 27). Representative shoreline areas were assessed at each survey location (Figures 8.9 through 8.14). These figures also illustrate the locations of lateral cross-section transects.

Field data collection efforts yielded a valuable set of site-specific characteristics. Table 8.5 displays the number and types of assessments performed during each survey. Data collection was shortened during the July 27 survey due to a heavy afternoon storm. After reviewing the July 27 field data, MEC revised the technical approach for the August 6 survey. During the latter event, efforts were more heavily focused on collection of longitudinal bathymetric data rather than near-shore lateral velocity profiling. This modification allowed more accurate depictions of bank characteristics, while also yielding valuable velocity data at uniform distances from shore.

FIGURE 8.6. Acoustic Doppler Current Profiler Output



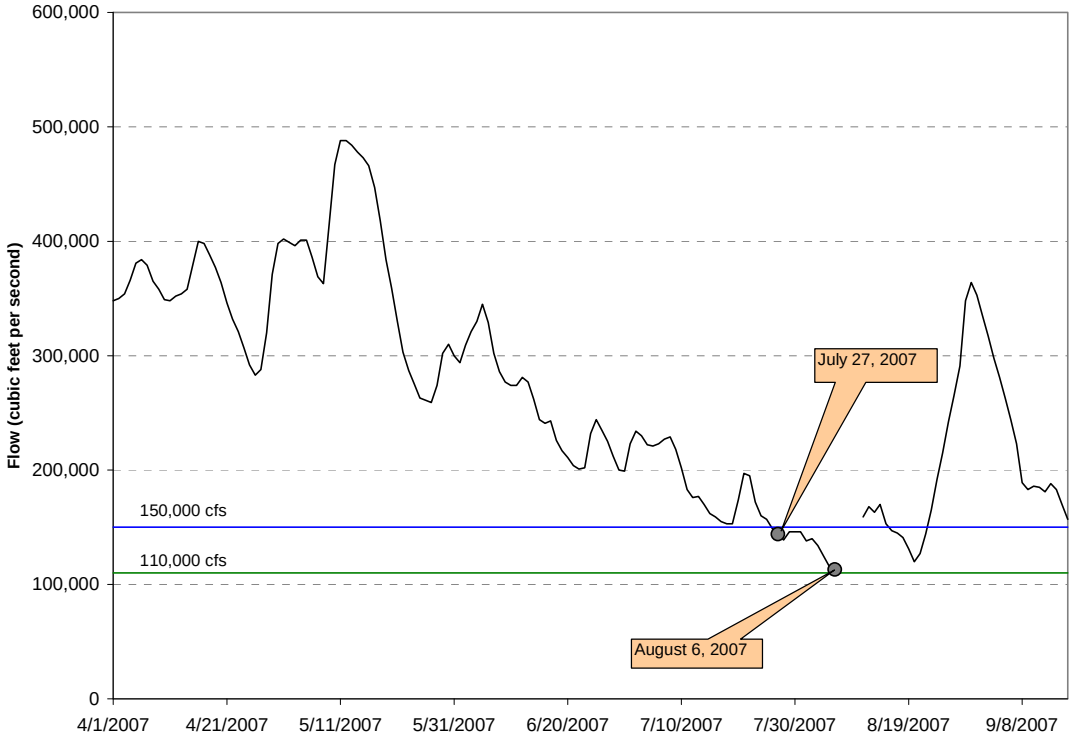


FIGURE 8.7. Summer 2007 Hydrograph at USGS Gage Station 17010000 (Mississippi River at St. Louis)

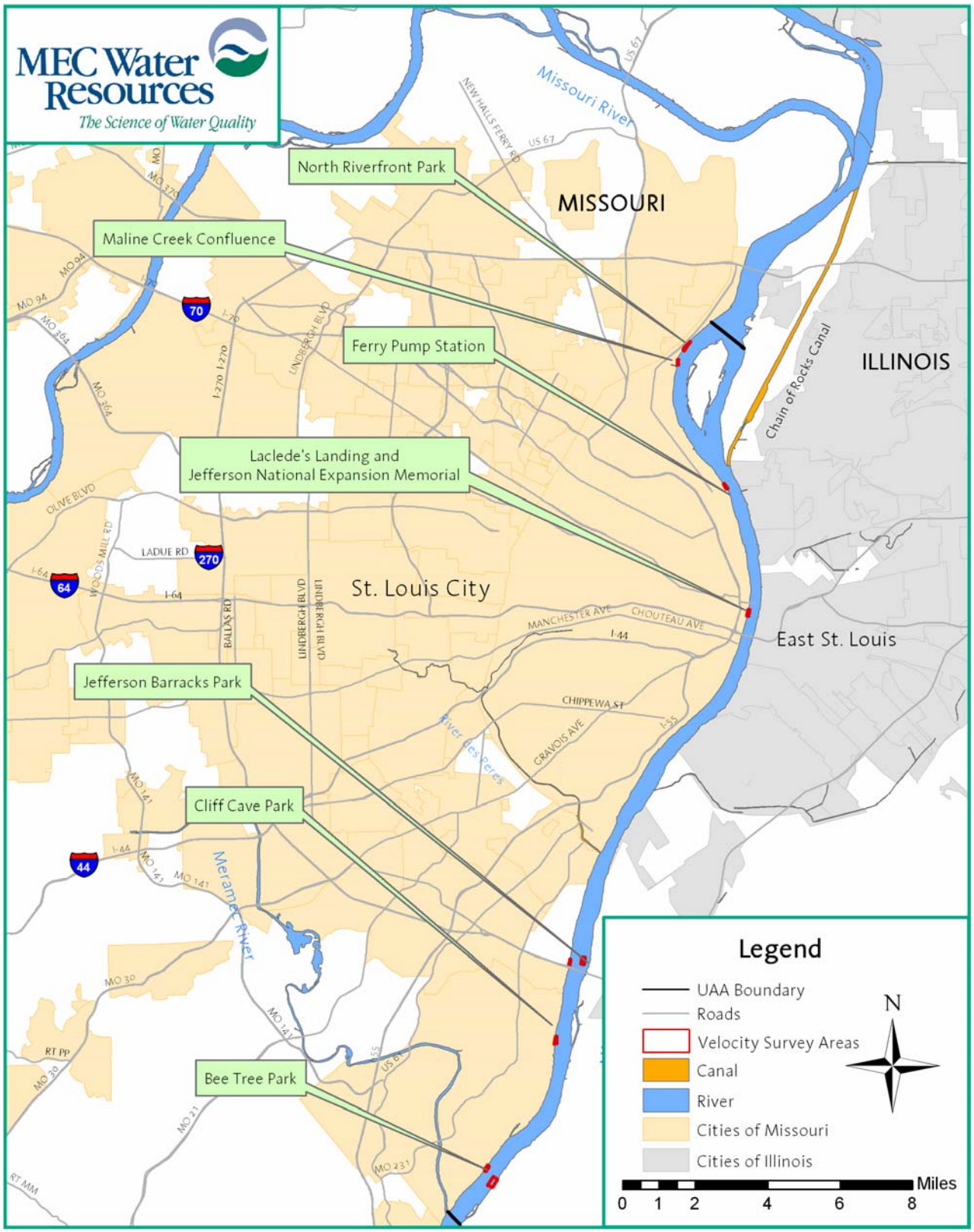


FIGURE 8.8. River Velocity Survey Areas on the Mississippi River UAA Segment

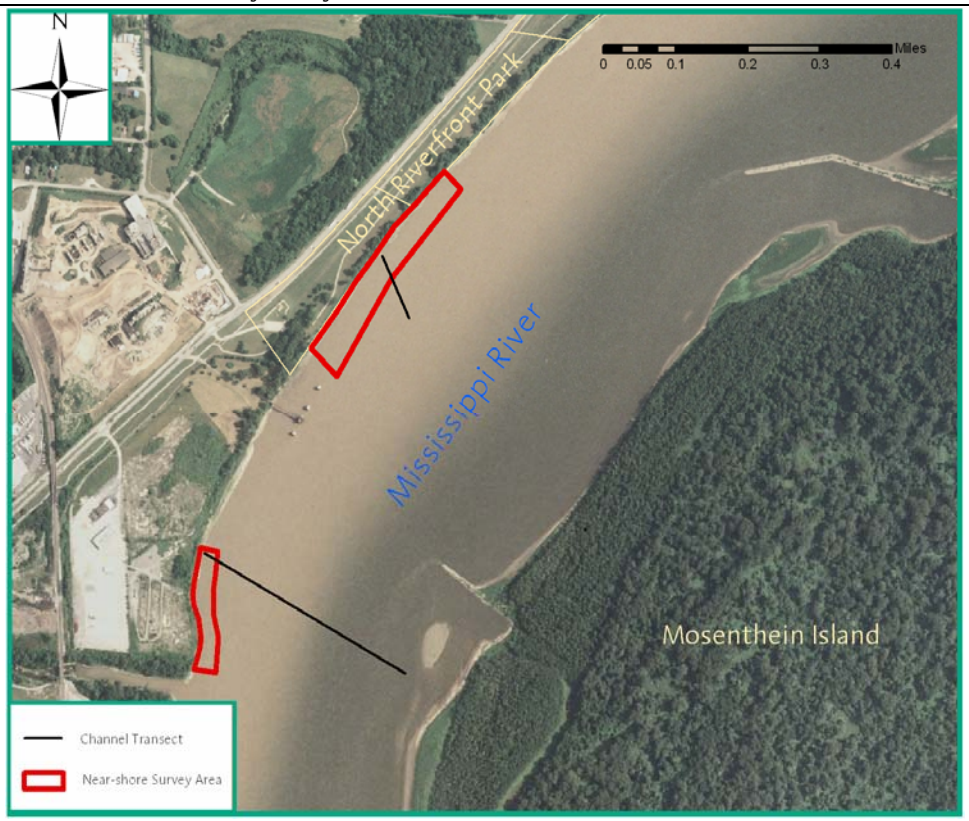


FIGURE 8.9. North Riverfront Park and Maline Creek Confluence Field Survey Areas

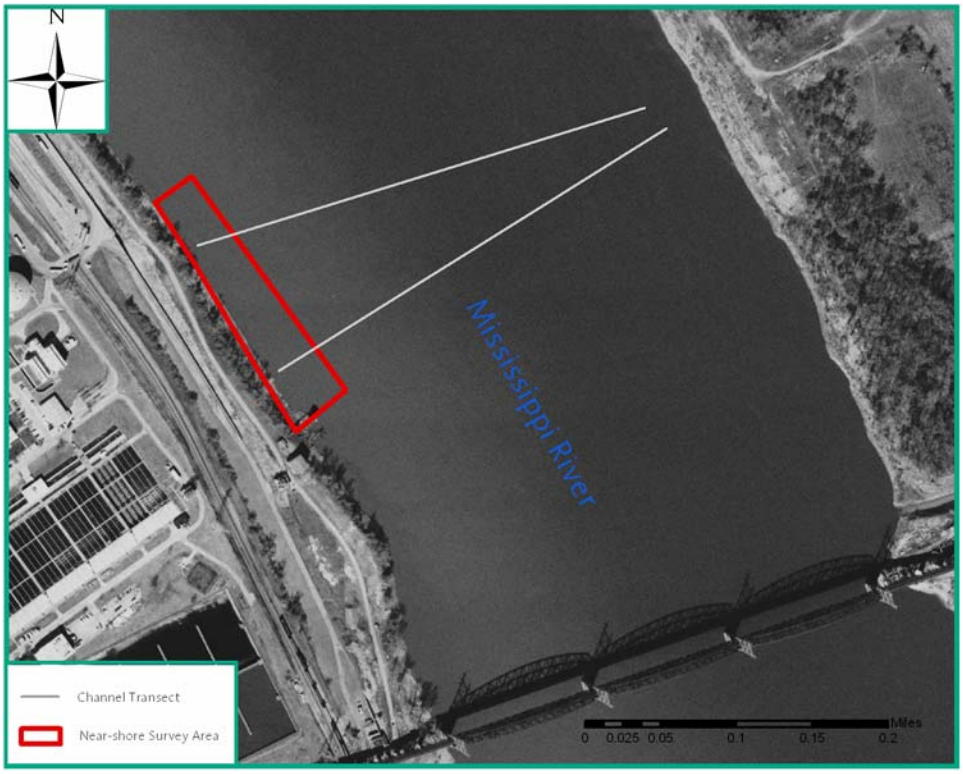


FIGURE 8.10. Ferry Pump Station Field Survey Areas

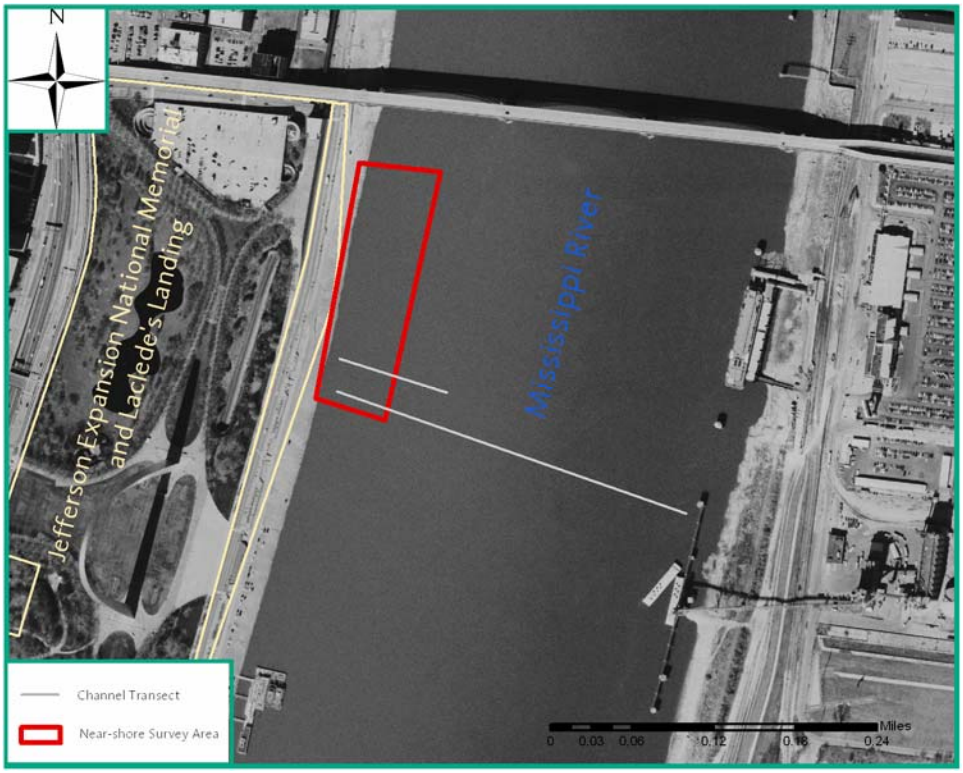


FIGURE 8.11. Laclede's Landing Field Survey Areas

FIGURE 8.12. Jefferson Barracks Park Field Survey Areas

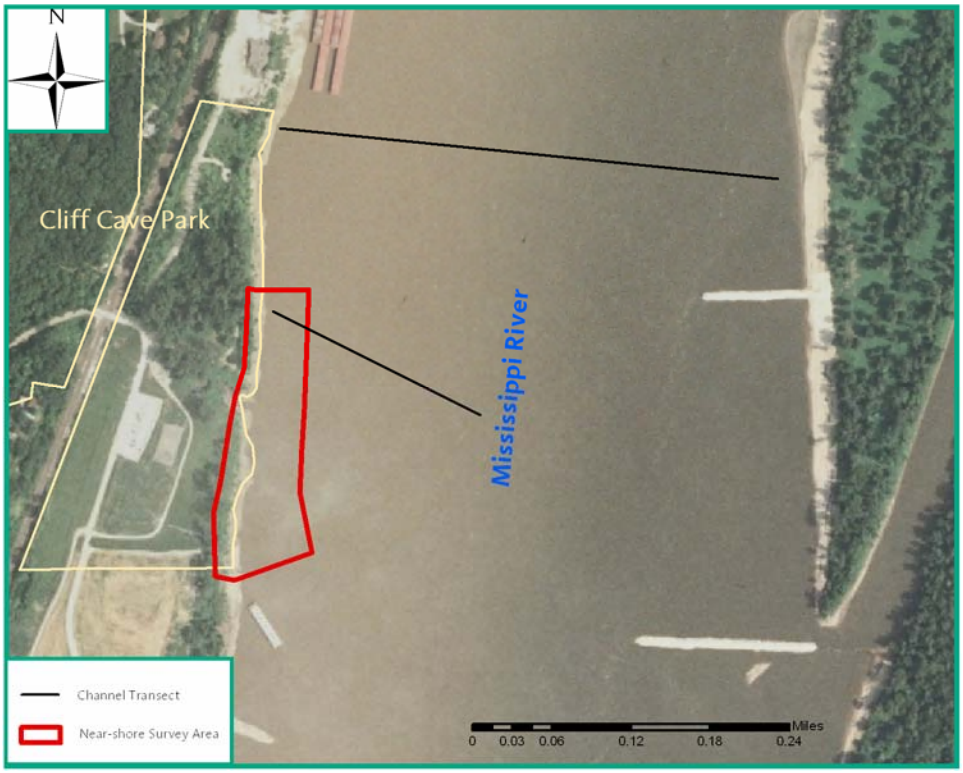


FIGURE 8.13. Cliff Cave Park Field Survey Areas

FIGURE 8.14. Bee Tree Park Field Survey Areas

TABLE 8.5. Table of Field Surveys at Each Site

	Near-Shore Velocity Transects		Channel Velocity Transects	
Site	**114,000 cfs**	**144,000 cfs**	**114,000 cfs**	**144,000 cfs**
North Riverfront Park	1 RDB	3 RDB		1*
Maline Creek Confluence **	2 RDB		1	
Ferry Pump Station	2 RDB	3 RDB	1	1
Laclede's Landing	3 RDB	1 RDB *	1	1*
Jefferson Barracks	3 RDB/2 LDB	3 RDB/2 LDB	1	1
Cliff Cave Park	3 RDB	7 RDB	1	1
Bee Tree Park	1 RDB/1 LDB	5 RDB/2 LDB	1	1

RDB - Right Descending Bank (Missouri)
LDB - Left Descending Bank (Illinois)
* Weather prohibited further data collection, including partial completion of channel transect
** Maline Creek Confluence site added during 114,000 cfs monitoring event due to shallow conditions at North Riverfront Park.

8.4. Morphologic and Hydraulic Field Assessment Results

Morphologic and hydraulic data collection efforts allow valuable insight into safety concerns associated with Mississippi River recreational use. Previous safety studies provide an objective set of criteria to assess river morphologic and hydraulic characteristics. Near-shore areas should provide safe wading and swimming conditions to be deemed swimmable since an individual must wade to a sufficient depth before beginning to swim. Also, near-surface velocities are most important since these zones are where swimming may possibly occur. As stated previously, the following criteria should be met to provide safe conditions for water recreation.

Wading

- Bank slope ratios no steeper than 4 horizontal to 1 vertical (i.e., 4:1) (NRCS, 2002)
- Depth/velocity product numbers less than 4 ft^2/s (Karvonen *et al.*, 2000)

Swimming

- Near surface velocities less than 2 fps (Hyra, 1978)

Waterskiing

- Near surface velocities less than 2.5 fps in areas with depths greater than 7 ft and lacking obstructions (e.g., wing dikes and docks) (Hyra, 1978)

8.4.1. Morphologic Field Assessment Results

Survey areas within the UAA segment exhibited various morphologic characteristics that are unsafe for wading and WBCR. These characteristics include steep bank slopes, irregular surfaces, submerged obstacles and debris (e.g., sunken logs, riprap, etc.). In many areas, there were sudden drop-offs of three feet or more that were observed during the low flow conditions (Figure 8.15). Banks along many areas were also lined with riprap to prevent bank erosion, which yields an irregular surface dangerous for wading (Figure 8.16).

FIGURE 8.15. Bank with Steep Ledges at Jefferson Barracks Park

FIGURE 8.16. Steep Riprap Bank at Cliff Cave Park

These characteristics are particularly dangerous given the low transparency (high turbidity) in the Mississippi River, particularly along the Missouri bank which is influenced by the Missouri River inflow. During the July 27 field survey, Secchi transparency was measured at 0.5 to 1.0 feet along the Missouri shore, and 1.2 to 1.75 feet along the Illinois shore. Water along the Illinois shore was not as turbid as the Missouri shore although still considered to have low to moderate transparency. Therefore, a wading individual would not be able to see most obstacles or irregular surfaces within one-half to one foot of the surface and would likely never see the sudden drop-offs present at many locations (see example in Figure 8.17). Sand banks were present along most of the Illinois shore.

FIGURE 8.17. Turbid Water with Submerged Obstacles

Bank slopes are very steep in most Missouri shoreline areas within the UAA segment. Study bathymetric data collected during both surveys allow assessment of near-shore river morphology, in particular to prepare bathymetric surveys to estimate bank slopes. The survey information for each site is displayed as Figures 8.18 through 8.26. These figures illustrate the steep bank slopes present along much of the Missouri shores.

Near-shore bank slopes at the survey areas varied substantially within the study area. Bank slopes during each targeted flow conditions were calculated by dividing the distance from shore by nearest shore average depths and are included as Table 8.6.

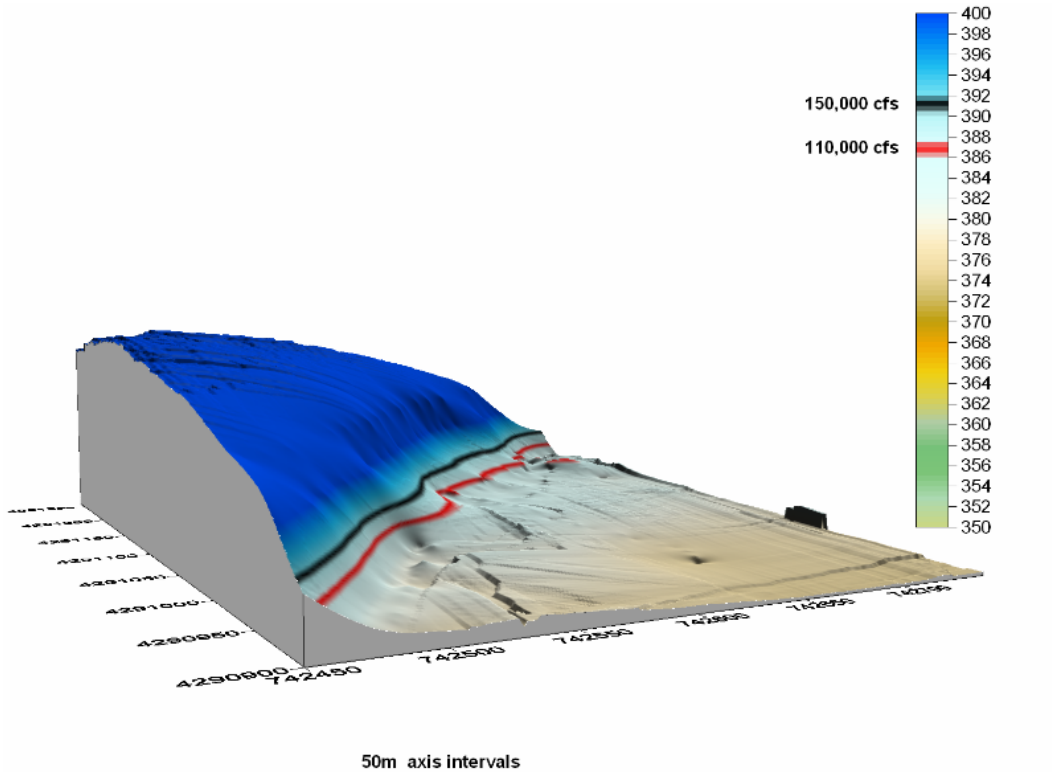


FIGURE 8.18. River Bathymetry at North Riverfront Park

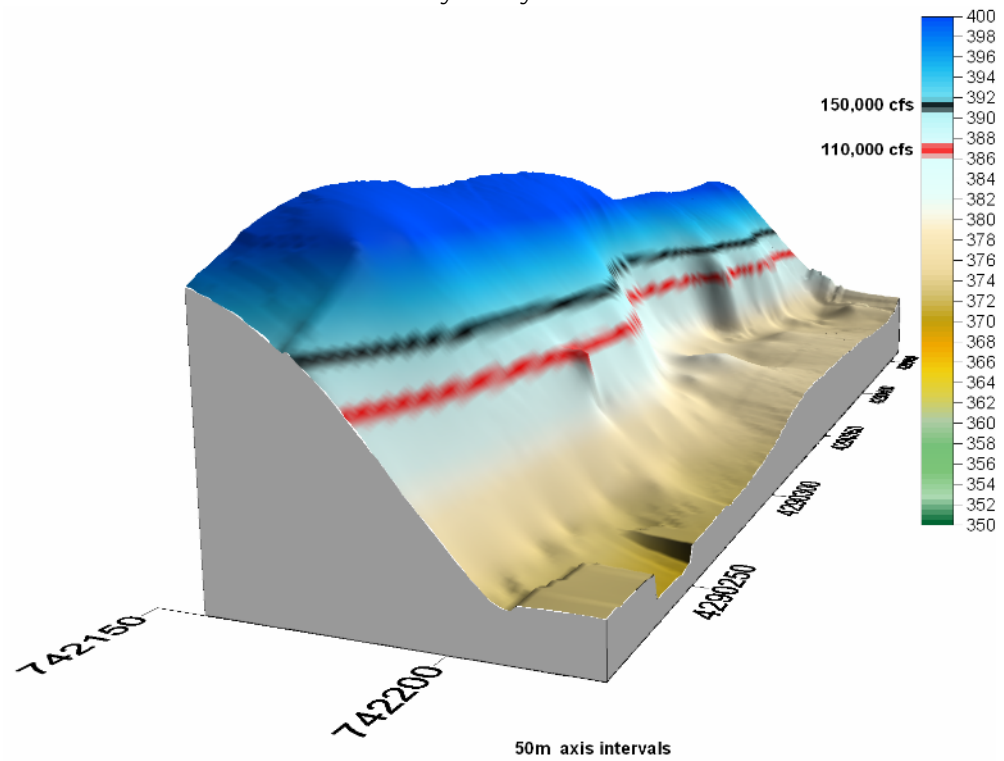


FIGURE 8.19. River Bathymetry near Maline Creek

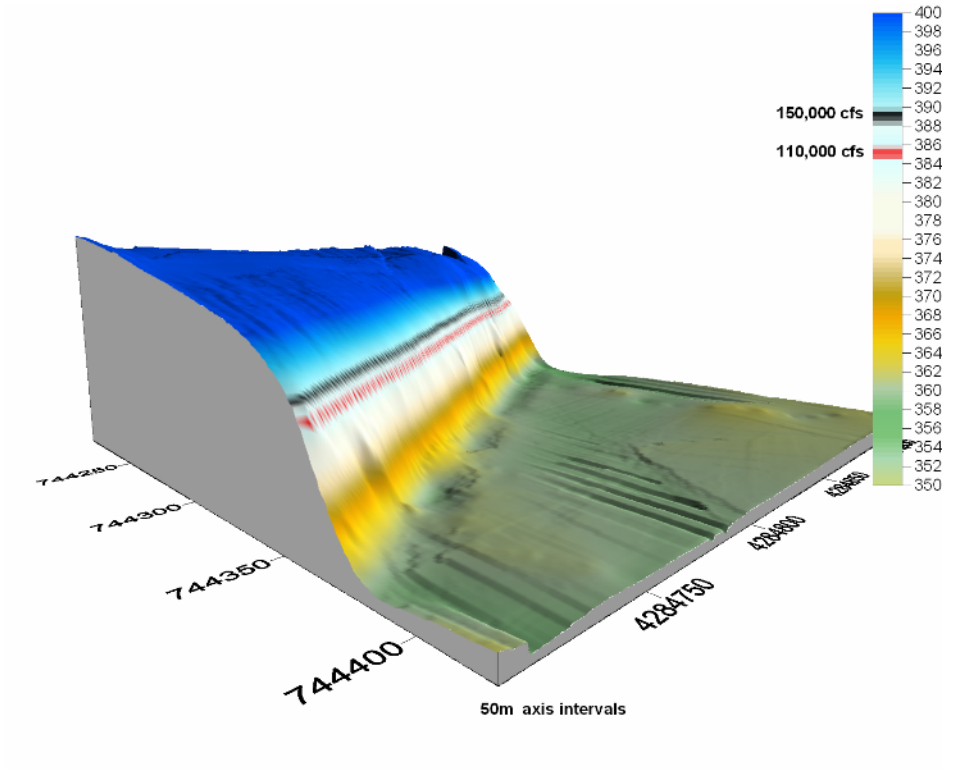


FIGURE 8.20. River Bathymetry near Ferry Pump Station

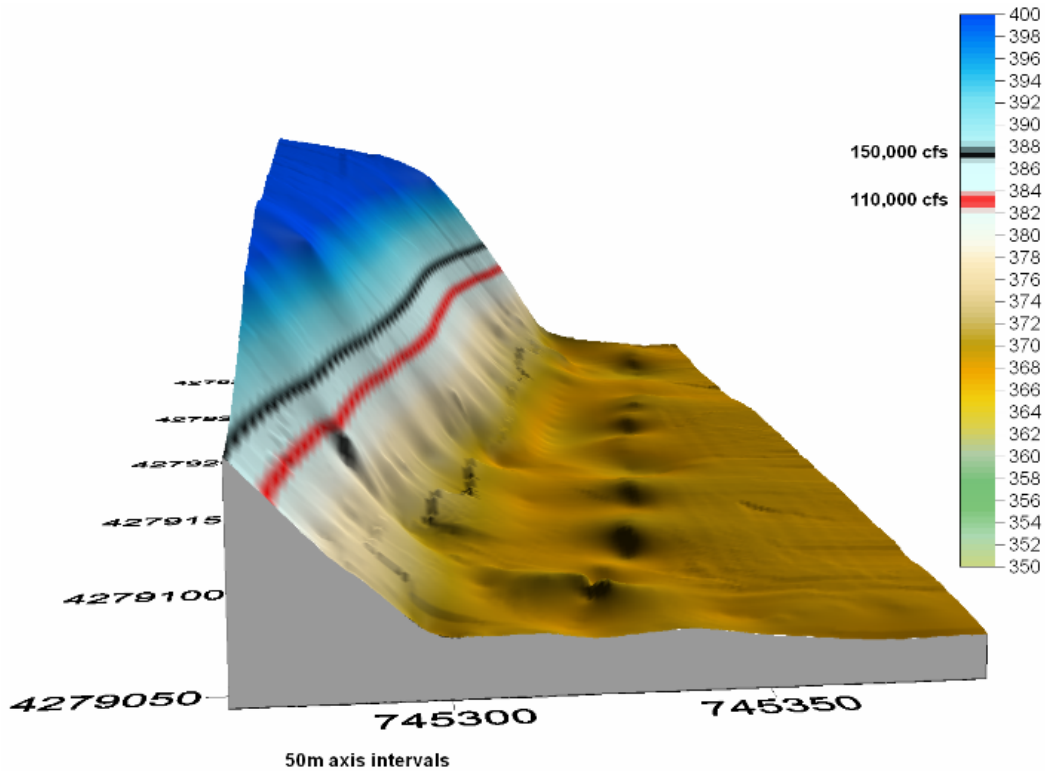


FIGURE 8.21. River Bathymetry at Laclede's Landing

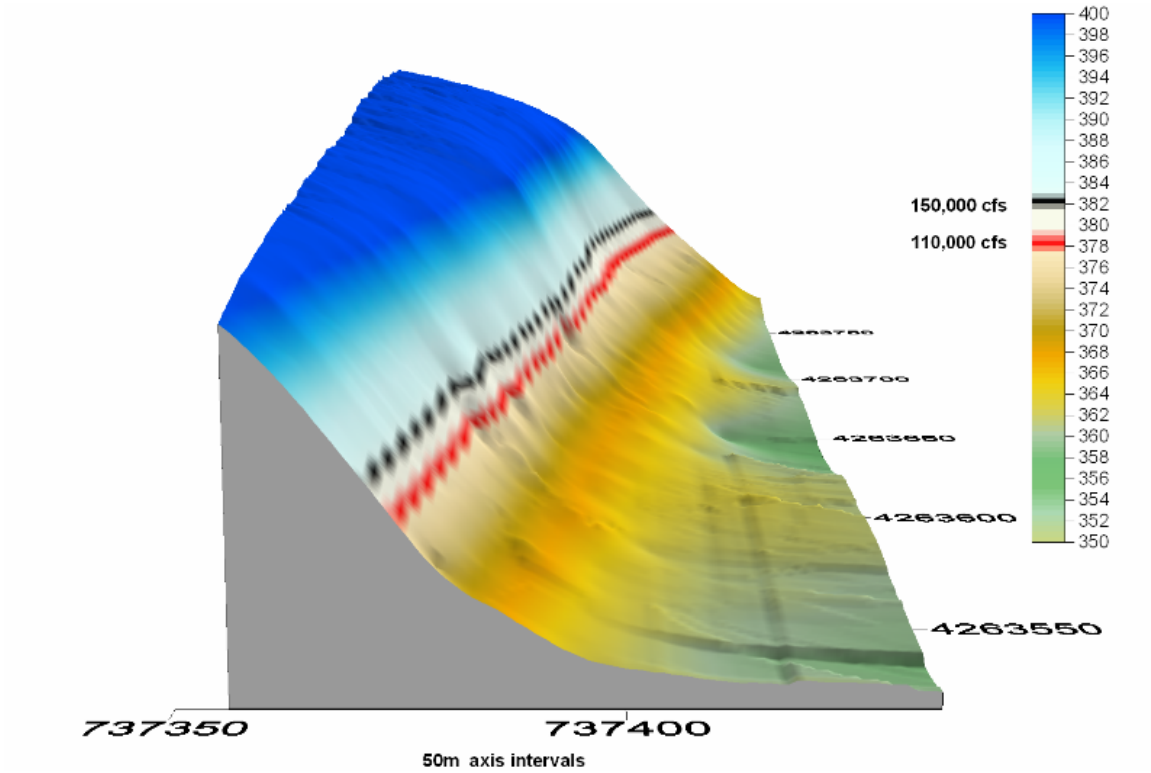


FIGURE 8.22. River Bathymetry at Jefferson Barracks (Missouri shore)

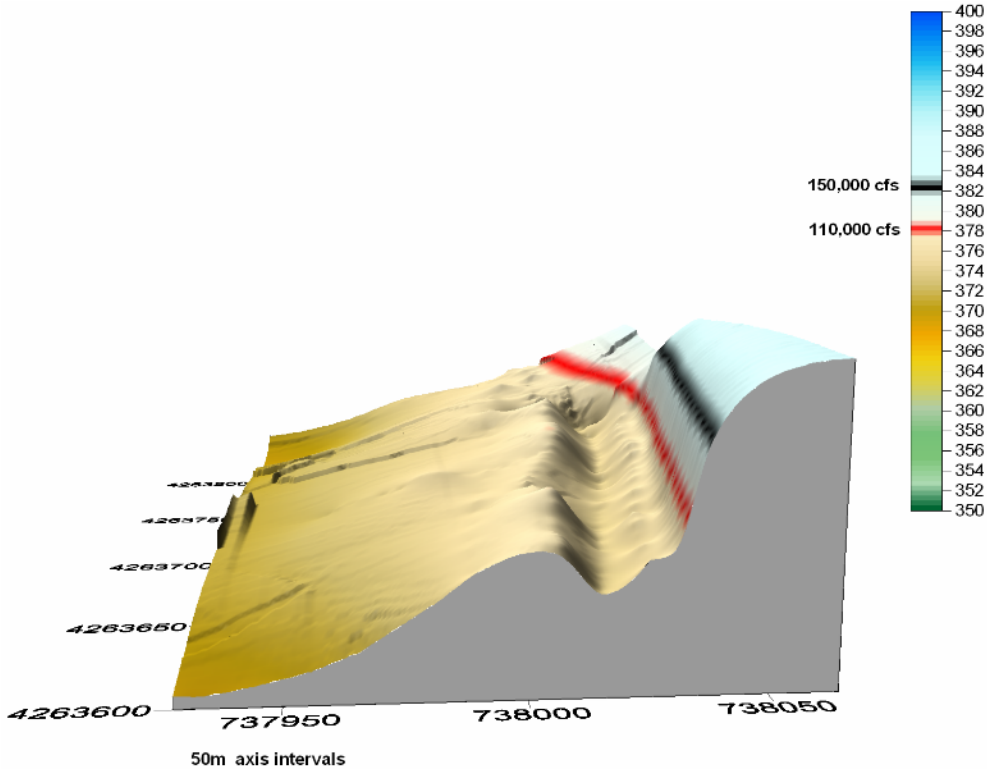


FIGURE 8.23. River Bathymetry at Jefferson Barracks (Illinois shore)

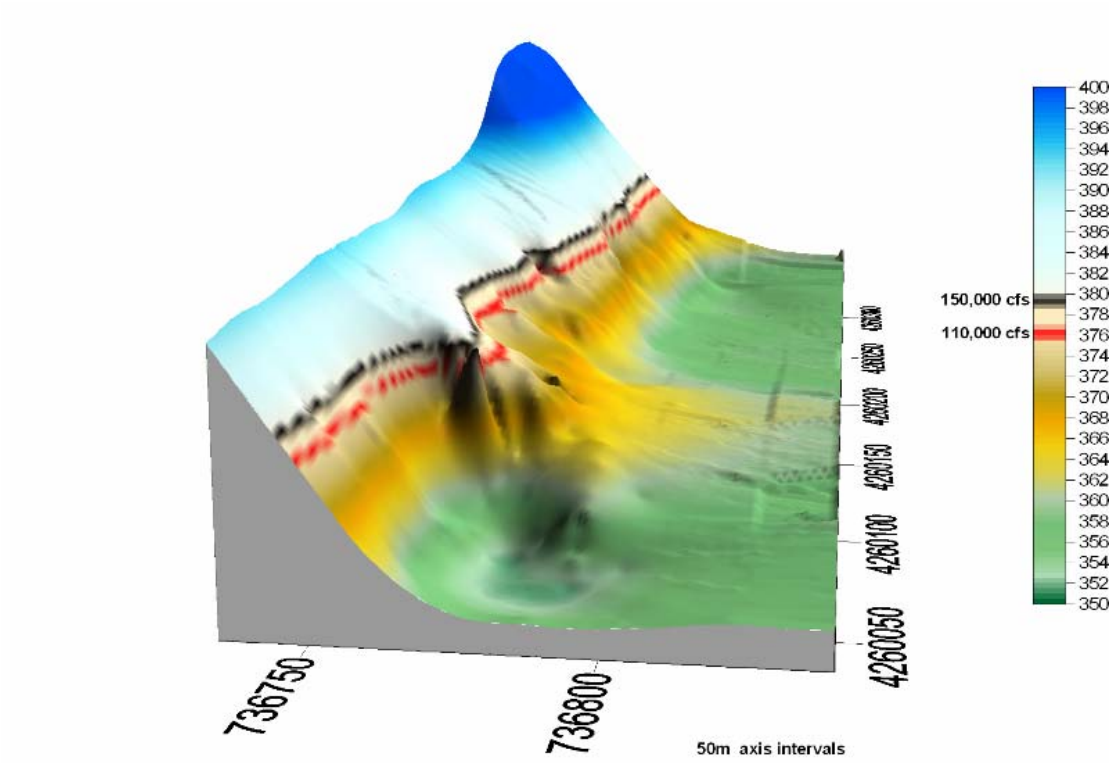


FIGURE 8.24. River Bathymetry at Cliff Cave Park (Missouri shore)

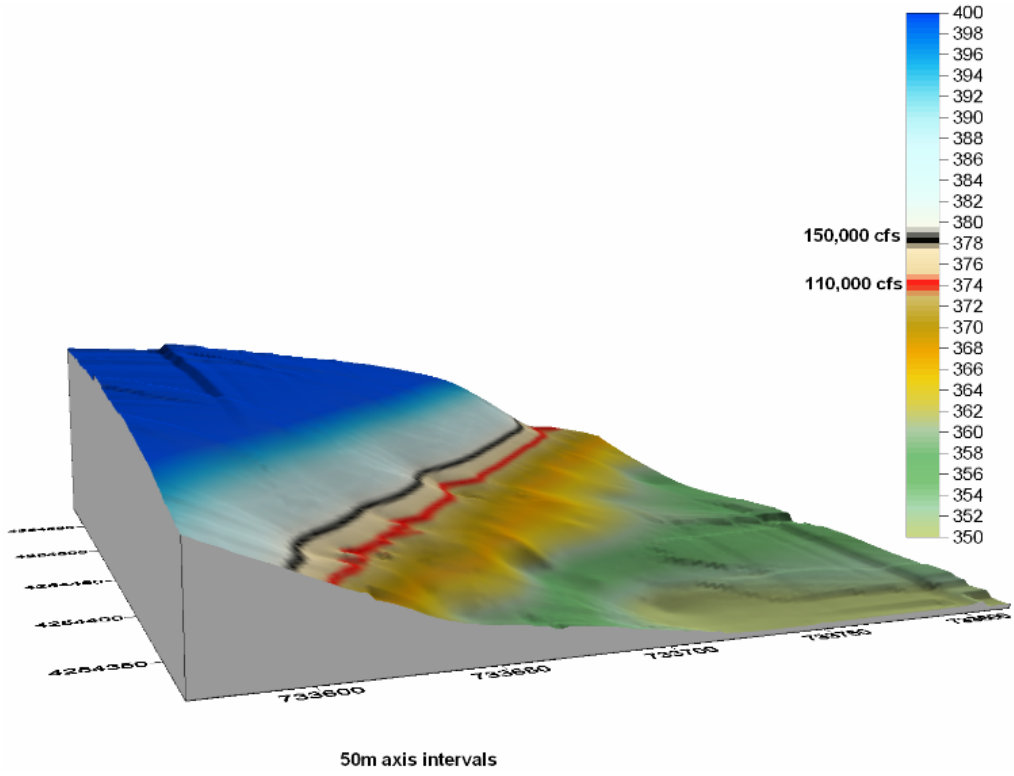


FIGURE 8.25. River Bathymetry at Bee Tree Park (Missouri shore)

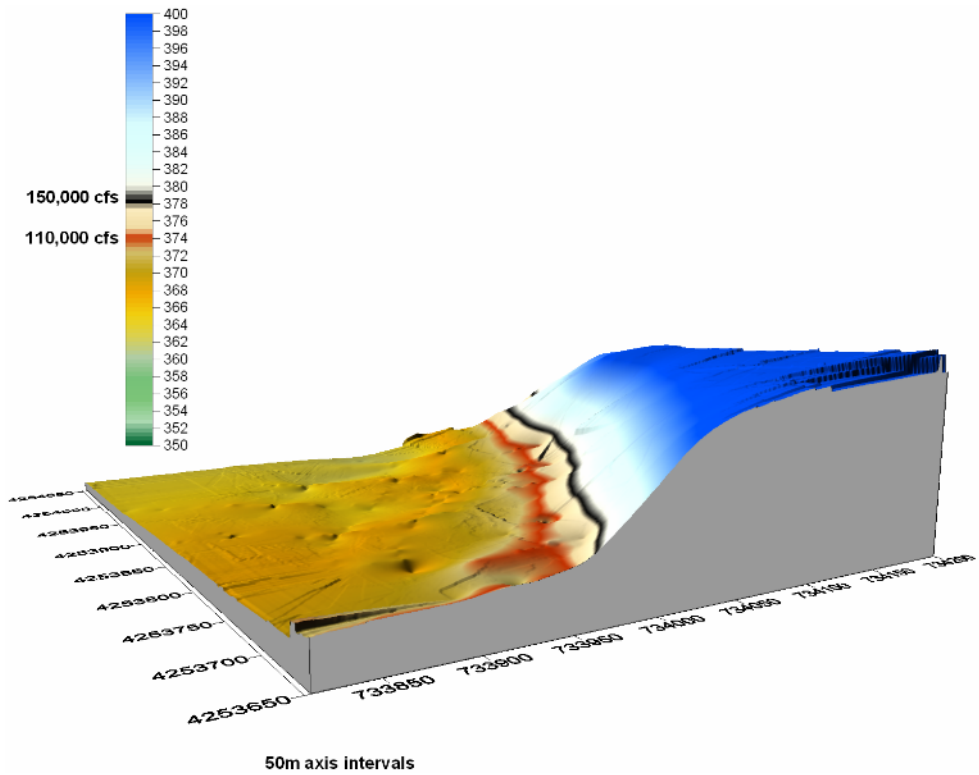


FIGURE 8.26. River Bathymetry at Bee Tree Park (Illinois shore)

TABLE 8.6. Bank Slopes at Locations and Flow Conditions

Survey Area	July 27 - 144,000 cfs				August 6 - 114,000 cfs			
	Distance To Shore (ft)	Mean Depth (ft)	Sample Points	Bank Slope Ratio (x:1)	Distance To Shore (ft)	Mean Depth (ft)	Sample Points	Bank Slope Ratio (x:1)
North Riverfront Park	30	4.8	62	**6.3**	30	6.2	54	**4.9**
Maline Creek Confluence	--	--	--	--	20	7.1	70	**2.8**
Ferry Pump Station	15	7.3	61	**2.0**	30	22.7	103	**1.3**
Laclede's Landing	16	5.7	4	**2.9**	20	8.4	106	**2.4**
Jefferson Barracks Park	15	5.7	59	**2.6**	20	8.4	98	**2.4**
Cliff Cave Park	20	7.6	63	**2.6**	20	10.6	120	**1.9**
Bee Tree Park	70	6.1	65	**11.5**	50	5.7	81	**8.8**
Jefferson Barracks Park - Illinois Shore	15	4.7	52	**3.2**	50	5.7	155	**8.8**
Bee Tree Park - Illinois Shore	30	6.6	22	**4.5**	100	6.7	49	**14.9**

Note: All survey areas are Missouri shoreline unless noted.

Bank slopes along the Illinois shore (outside of the UAA segment) are more gradual than the steep banks present along the Missouri shore. Illinois shorelines were assessed at

the Jefferson Barracks and Bee Tree Park study areas. During the higher flow condition, average bank slopes ranged from 3.2:1 to 4.5:1, whereas observed slopes were more gradual during the low flow assessment (8.8:1 to 14.9:1).

As demonstrated, most of the UAA segment exceeds the quantitative bank slope criterion recommended for safe recreation, 4:1 (NRCS, 2002). In addition, the entire Missouri shoreline has morphologic conditions, such as irregular submerged surfaces, submerged obstacles and debris (e.g., sunken logs, riprap, etc.), and sudden drop-offs that coupled with low visibility qualitatively make wading unsafe. Based upon the quantitative analysis of bank slope, the following Missouri shoreline survey areas are considered unsafe for wading and therefore whole body contact recreation:

- *Maline Creek Confluence,*
- *Ferry Pump Station,*
- *Laclede's Landing,*
- *Jefferson Barracks Park, and*
- *Cliff Cave Park.*

8.4.2. Hydraulic Field Assessment Results

Near-shore and channel hydraulic surveys were performed to assess recreational use safety. Near-shore hydraulic assessments evaluated safety considerations with respect to swimming as well as wading to the potential swimming area. Waterskiing was not considered appropriate for evaluation in these areas since water depths and obstacles, such as debris, controls, and docked and fleeted barges, make these areas far too dangerous for waterskiing. Channel hydraulic assessments were judged based upon swimming and waterskiing criteria.

8.4.2.1. Near-shore Hydraulic Assessment Results

The near-shore hydraulic assessment focused on both swimming and wading safety to assess WBCR use attainability. As previously stated, an individual must be able to safely wade to and from depths suitable for swimming. MDNR (2004) established Missouri's depth criterion for WBCR uses as 3.3 ft (1 m). Therefore, Missouri considers WBCR attainable after this depth criterion is met, unless other use attainability factors prevent attainment. The near-shore hydraulics assessment and the bank slope evaluation provide a quantitative weight of evidence that much of the UAA segment is unsafe for wading and therefore whole body contact recreation.

The Karvonen *et al.* (2000) human stability criteria is recommended for assessing wading safety, which is based upon the product number (P.N.) of depth multiplied by velocity. The recommended P.N. is 4.0 as previously discussed, based upon poor wading conditions and appropriate individual height and weight assumptions. However based upon field observations, the Illinois shoreline may constitute normal wading conditions due to increased transparency and more uniform banks.

Bathymetric and velocity data collected at various transect locations within each survey area were used to compare river characteristics to the Karvonen *et al.* (2000) criterion. One limitation in this analysis is the use of velocity data within areas of 5 to 6 ft depths rather than velocities at 3.3 ft. As previously stated, boat access to shallower areas was dangerous as well as wading in from the bank given the velocities present as well as the submerged obstacles, irregular surfaces, and sudden drop-offs discussed earlier.

The available ADCP data were used for analysis since collection of shallow velocities via wading from shore was deemed unsafe. Velocity measurements with depths less than 6 ft were multiplied by Missouri depth criterion (3.3 ft) to estimate the product number in comparison to Karvonen *et al.* (2000) human stability criterion. Maximum velocities within each ensemble (vertical water column slice) were used to determine mean velocity in a given survey area since these likely represent the upper water column velocities. In many areas, only two velocity bins were available for analysis. Most lower values were recorded within bins closest to the river bottom, which are likely misrepresentative due to influences by channel roughness. Although maximum velocities are used for calculation purposes, this approach is conservative since the velocities represent the lower 25% to 50% of the water column due to the ADCP blanking distance from surface (approximately 3').

Average maximum velocities at depths less than 6 ft varied from 1.5 to 3.7 fps for both Illinois and Missouri survey areas, including the southern end of North Riverfront Park (Table 8.7). Velocities typically increased at the lower flow condition as bank slopes also become steeper. The P.N. for these velocities applied to a 3.3 ft (1m) depth ranged from 5.0 to 12.2, all exceeding the recommended Karvonen *et al.* (2000) human stability criteria for poor wading conditions of 4.0. Therefore, safety of near-shore wading to potential swimming locations is deemed unsafe due to both human stability associated with velocities and depths, as well as steep bank slopes coupled with irregular surfaces.

Near-shore velocities were also compared to the Hyra (1978) criterion (2 fps for swimming safety). For this analysis, near surface velocities (2 to 4 ft) were averaged for all locations (ensembles) with average depths less than 10 ft so that velocities are not skewed by near bottom velocities. These areas are generally within 20 to 50 ft from shore, depending upon bank slope. However, these surveys extended 100 to 400 feet from shore for more gradually sloping areas (i.e., North Riverfront Park and downstream Illinois survey areas). Again, near-surface velocities are deemed most applicable to the swimming criterion since the potential use occurs within this portion of the water column. In addition, this approach likely does not represent the maximum surface velocities that would be experienced due to ADCP blanking distance.

Near-shore average velocities present unsafe swimming conditions at most survey areas and flow conditions (Table 8.8). Graphical depictions of the underlying data for these calculations are included in Appendix F. Pockets of low velocities are present at some near-shore areas; however, hydraulic conditions should be viewed more

holistically within these areas to provide the most representative conditions. Therefore, average velocities were used for this analysis.

TABLE 8.7. Average Maximum Velocities (Less than Six Foot Depth) with Product Number based upon 3.3 Foot Wading Depth

Survey Area	July 27 - 144,000 cfs				August 6 - 114,000 cfs			
	Sample Points	Mean Velocity (fps)	Product Number (ft^2/s)	Bank Slope Ratio (x:1)	Sample Points	Mean Velocity (fps)	Product Number (ft^2/s)	Bank Slope Ratio (x:1)
North Riverfront Park	116	2.7	8.9	6.3	51	1.5	4.9	4.9
Maline Creek Confluence	--	--	--	--	28	3.7	12.2	2.8
Ferry Pump Station	9	2.8	9.0	2.0	--	--	--	1.3
Laclede's Landing	4	1.5	5.0	2.6	13	1.6	5.2	2.4
Jefferson Barracks Park	5	2.1	6.9	1.9	0	0.0	0.0	0
Cliff Cave Park	57	2.3	7.4	2.6	5	2.1	6.9	1.9
Bee Tree Park	47	1.7	5.7	11.5	75	2.6	8.7	8.8
Jefferson Barracks Park - Illinois Shore	63	2.1	6.9	3.2	166	2.4	7.8	8.8
Bee Tree Park - Illinois Shore	23	2.2	7.2	5.5	26	2.3	7.5	14.9

Note: All survey areas are Missouri shoreline unless noted. Velocity data represent the means of maximum velocities recorded in individual ens

TABLE 8.8. Near-Shore Average Velocities

Survey Area	July 27 - 144,000 cfs		August 6 - 114,000 cfs	
	Sample Points	Mean Velocity (fps)	Sample Points	Mean Velocity (fps)
North Riverfront Park	288	2.6	105	1.1
Maline Creek Confluence			138	3.4
Ferry Pump Station	77	2.4	15	2.6
Laclede's Landing			129	1.7
Cliff Cave Park	142	1.7	62	2.0
Jefferson Barracks Park	121	2.2	118	2.4
Bee Tree Park	110	1.8	99	2.1
Jefferson Barracks Park - Illinois Shore	150	2.2	253	2.2
Bee Tree Park - Illinois Shore	38	2.3	206	2.7

Note: All survey areas are Missouri shoreline unless noted.

The Hyra (1978) criterion was exceeded at both flow conditions at the Maline Creek Confluence, Ferry Pump Station, Jefferson Barracks Park and at both Illinois survey areas (Jefferson Barracks and Bee Tree Parks). Near-shore shallow velocities at the Missouri

shorelines within the Cliff Cave and Bee Tree Park areas exceeded the Hyra (1978) criterion at the lower flow condition (113,000 cfs). The velocities at these locations during the higher flow condition, as well as Laclede's Landing during the lower flow condition, were near the Hyra (1978) criterion (1.7 to 1.8 fps). There were insufficient data available at the Laclede's Landing survey area during the higher flow condition due to inclement weather. Regardless, these areas are not suitable for whole body contact recreation due to hazards associated with wading out into water of sufficient depth for swimming.

Based upon these analyses of potential wading and swimming hazards, the following near-shore areas within the UAA segment are considered unsafe for whole body contact recreation:

- *Southern North Riverfront Park,*
- *Maline Creek Confluence,*
- *Ferry Pump Station,*
- *Laclede's Landing,*
- *Jefferson Barracks Park,*
- *Cliff Cave Park, and*
- *Bee Tree Park.*

8.4.2.2. Channel Hydraulic Assessment Results

The channel hydraulics survey data were used to assess whole body contact recreation safety with respect to the Hyra (1978) criteria for swimming and waterskiing, 2.0 and 2.5 fps, respectively. Waterskiing is only applicable where depths are greater than 7 ft and obstacles do not present dangerous conditions. Qualitative factors not included within this analysis that also present serious safety concerns for waterskiing include barge traffic, navigation structures, and large debris (e.g., logs).

Velocity surveys show that the entire segment is unsafe for swimming and waterskiing within the channel. Average velocities near surface (2-6 ft) ranged from 3.8 to 5.0 fps at upper stream flow and 3.3 to 5.0 fps at the lower targeted flow condition (Table 8.9). Graphical depictions of the channel transect data are also provided as Figures 8.27 through 8.38). Maximum near-surface velocities exceeded 8 fps. Velocities sharply rise away from the bank, leaving relatively little room for potential swimming uses prior to being swept downstream.

TABLE 8.9. Average Velocities by Transect

Survey Area	July 27 Survey Event			August 6 Survey Event		
	Measured Flow (cfs)	Transect Length (ft)	Mean Velocity (fps)	Measured Flow (cfs)	Transect Length (ft)	Mean Velocity (fps)
North Riverfront Park	Partial X-sect.	485	3.2	114,000	1,677	5.2
Maline Creek Confluence	--	--	--	114,000	1,677	5.2
Ferry Pump Station	138,000	1,116	5.8	121,000	976	5.2
Laclede's Landing	Partial X-sect.	448	3.8	114,000	1,431	3.7
Jefferson Barracks Park	143,000	2,091	4.7	115,000	2,154	4.2
Cliff Cave Park	141,000	1,995	4.4	Partial X-sect.	946	4.5
Bee Tree Park	144,000	2,087	4.1	114,000	1,922	4.2

MEC (2005) used mean channel velocity at Laclede's Landing as the basis for considering the Mississippi River within the UAA segment unsafe for swimming. This analysis significantly underestimated the hazards of high velocities within the study area. One factor lending to the underestimation is the use of data collected at Laclede's Landing which is the lowest velocity location within the UAA segment. In addition, this analysis was based solely on average channel velocities rather than near surface velocities where potential WBCR could occur. Figures8.39 and 8.40 show the potential underestimation of channel hydraulics by displaying the 2007 near-surface velocity data at all sites overlain on the velocity rating and duration curves. It should be noted that average channel velocities measured during the low flow survey at Laclede's Landing agreed well with the velocity rating curve developed from USGS flow measurements. Therefore, this simplistic analysis used in MEC (2005) significantly underestimated the risk associated with WBCR in the main channel.

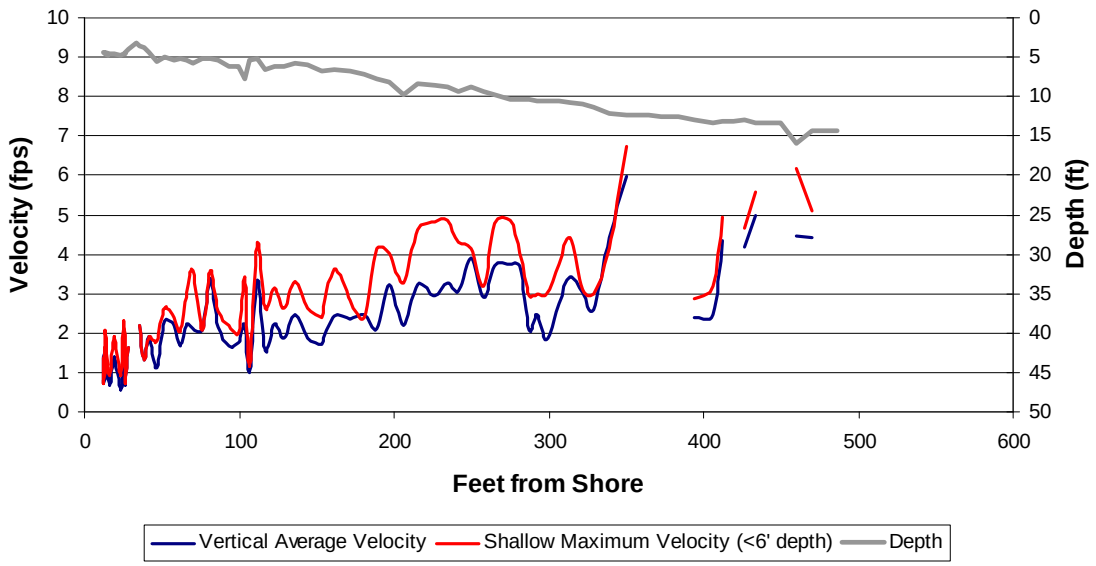


FIGURE 8.27. Velocity Summary for Partial River Transect (beginning at Missouri shore), North Riverfront Park (7/27/07)

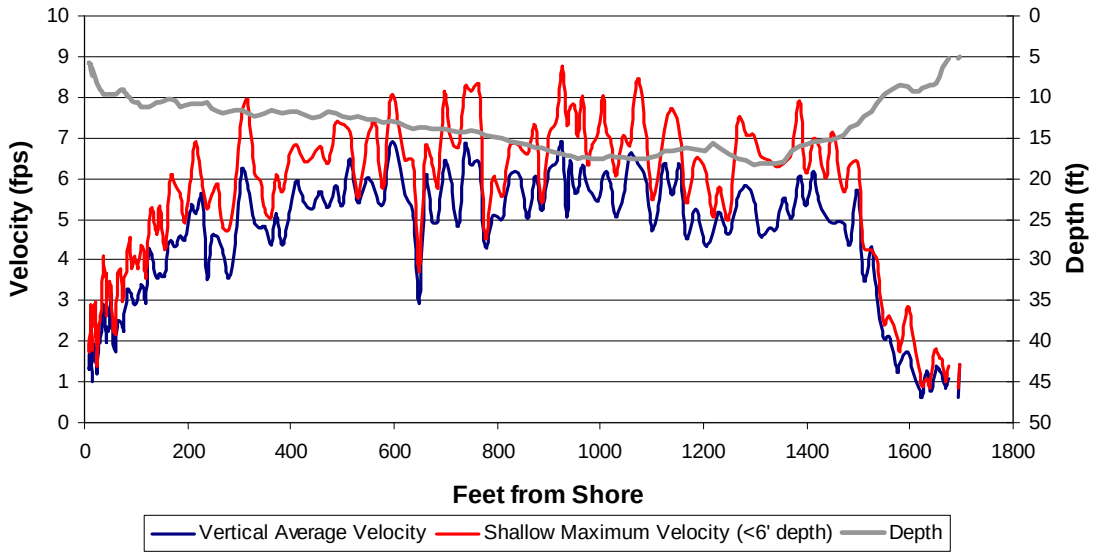


FIGURE 8.28. Velocity Summary for Entire River Transect (beginning at Missouri shore), Maline Creek Confluence (8/6/07)

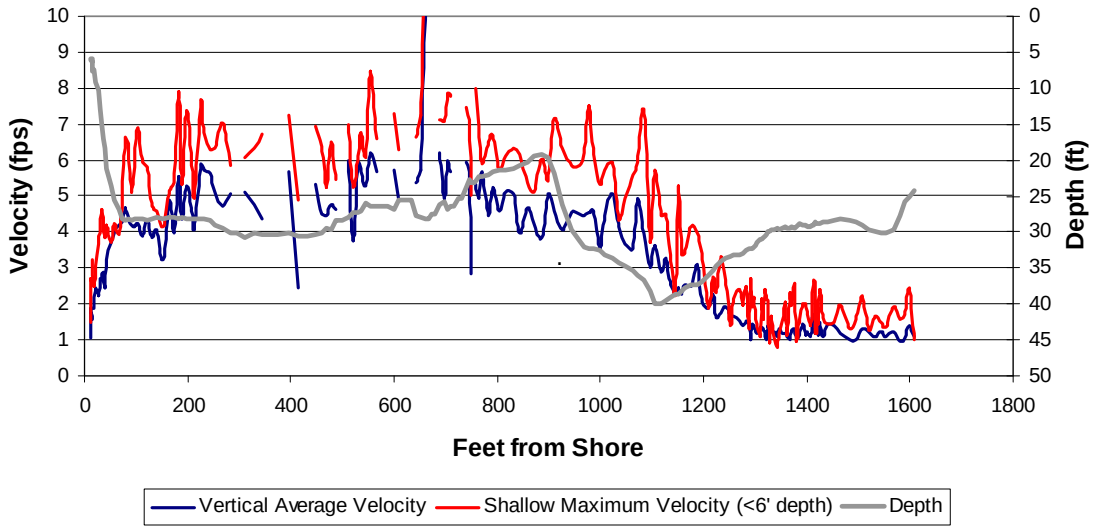


FIGURE 8.29. Velocity Summary for Entire River Transect (beginning at Missouri shore), Ferry Pump Station (7/27/07)

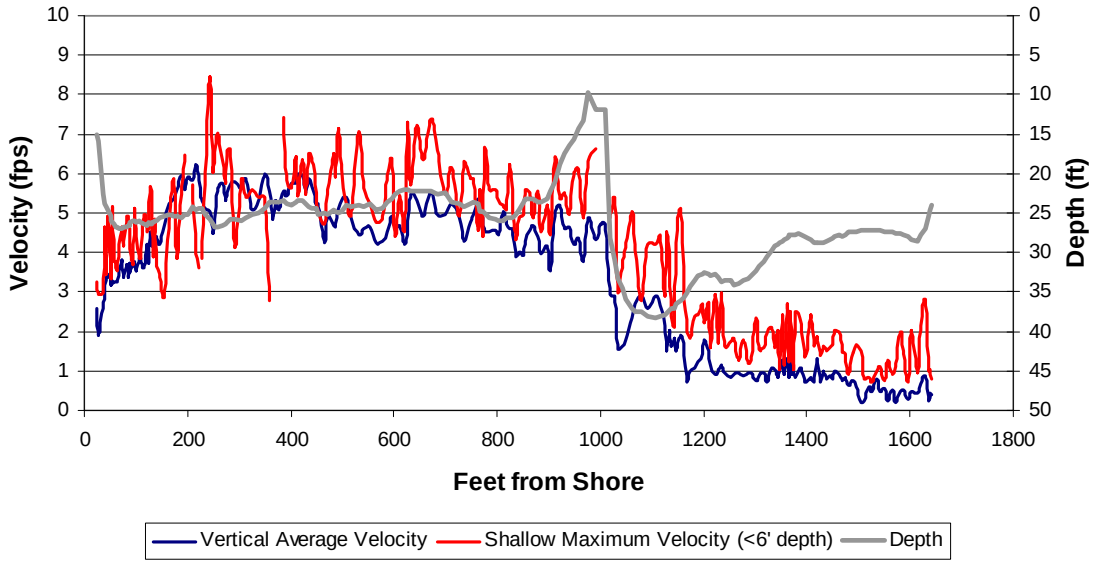


FIGURE 8.30. Velocity Summary for Entire River Transect (beginning at Missouri shore), Ferry Pump Station (8/6/07)

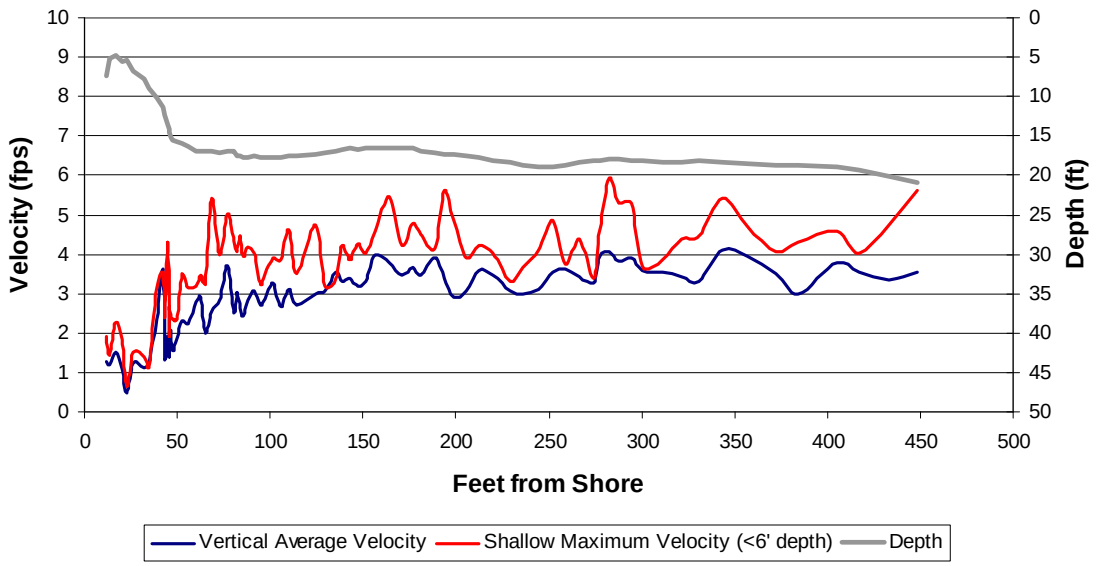


FIGURE 8.31. Velocity Summary for Partial River Transect (beginning at Missouri shore), Laclede's Landing (7/27/07)

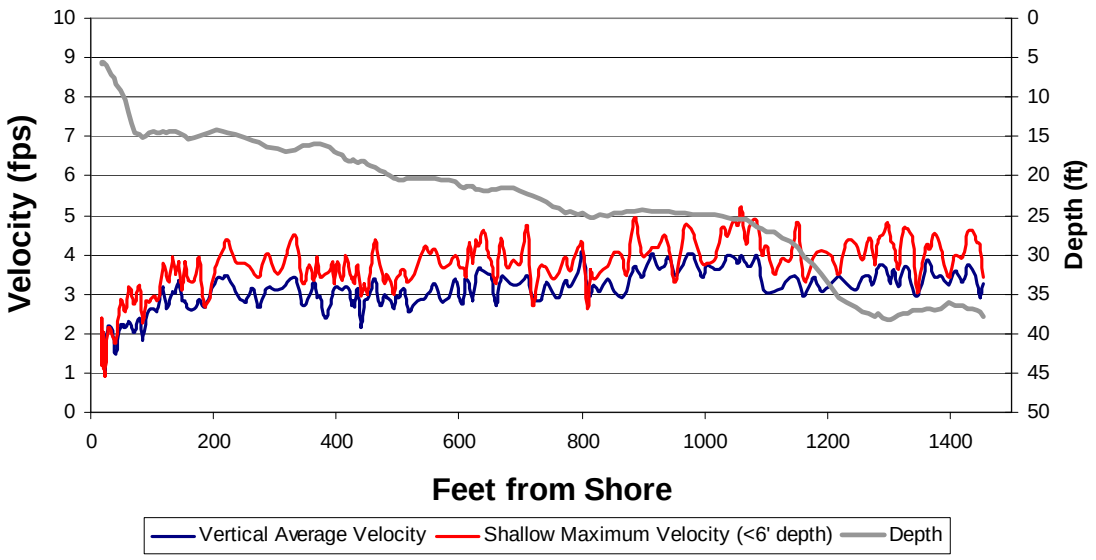


FIGURE 8.32. Velocity Summary for Entire River Transect (beginning at Missouri shore), Laclede's Landing (8/6/07)

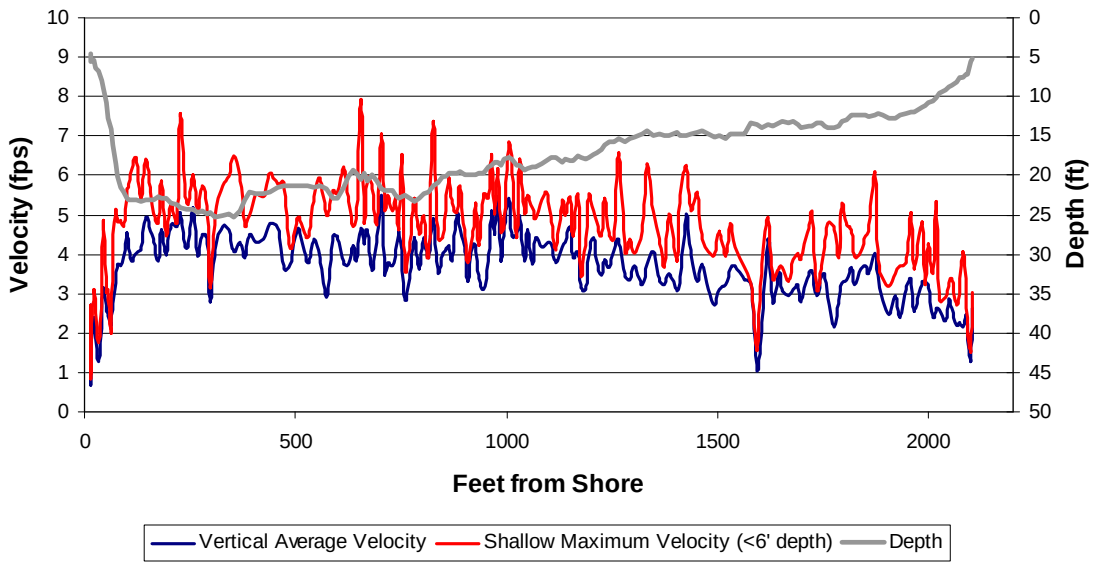


FIGURE 8.33. Velocity Summary for Entire River Transect (beginning at Missouri shore), Jefferson Barracks Park (7/27/07)

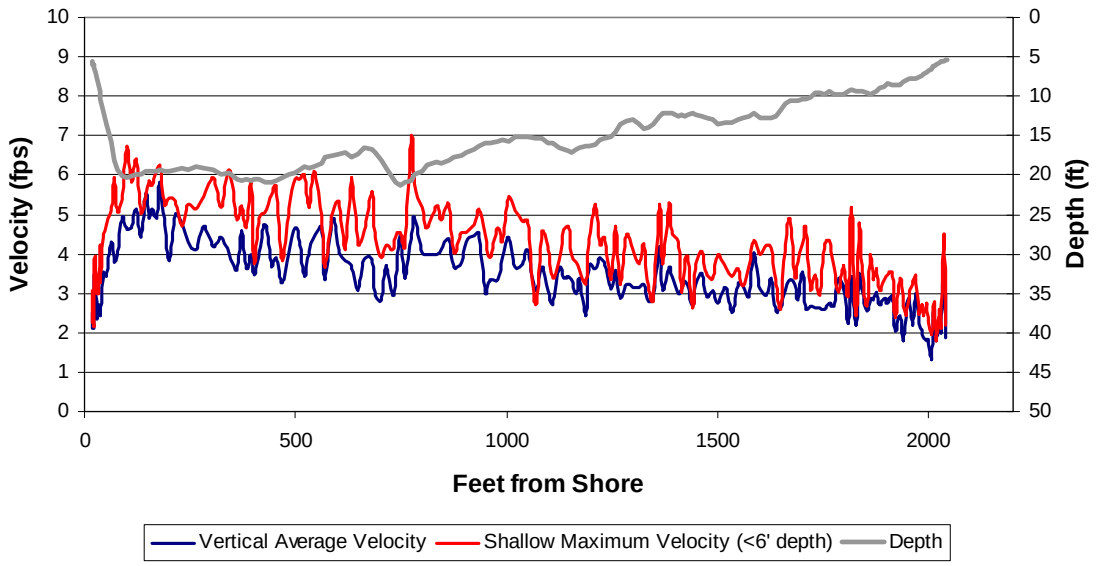


FIGURE 8.34. Velocity Summary for Entire River Transect (beginning at Missouri shore), Jefferson Barracks Park (8/6/07)

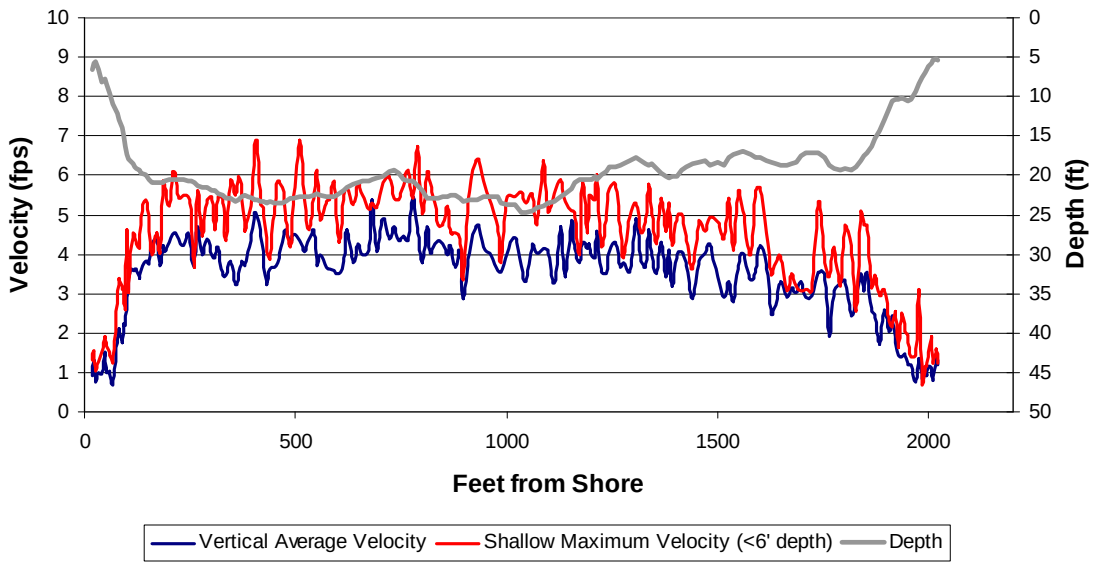


FIGURE 8.35. Velocity Summary for Entire River Transect (beginning at Missouri shore), Cliff Cave Park (7/27/07)

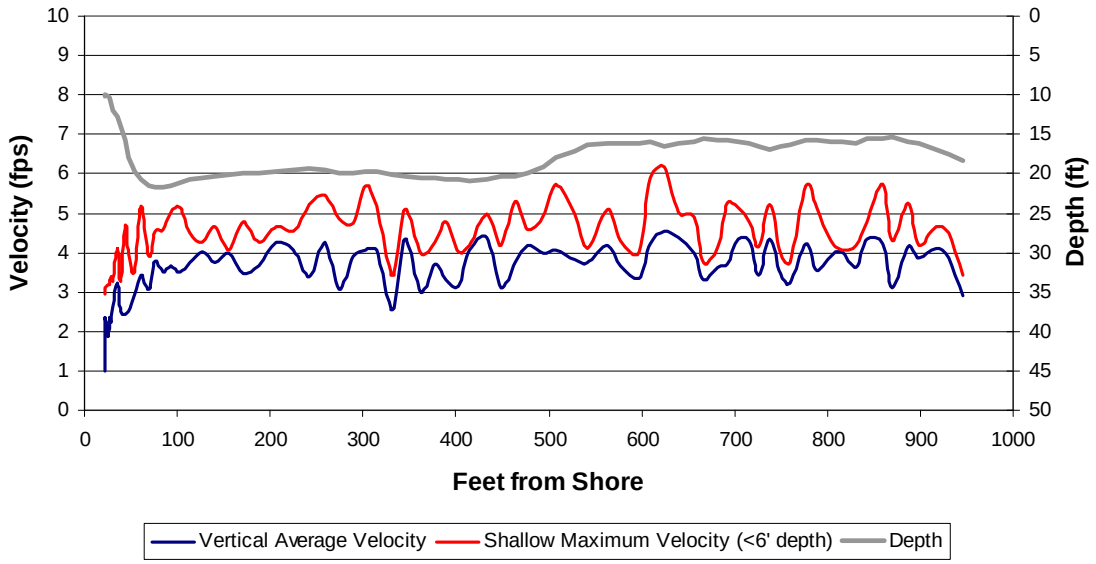


FIGURE 8.36. Velocity Summary for Partial River Transect (beginning at Missouri shore), Cliff Cave Park (8/6/07)

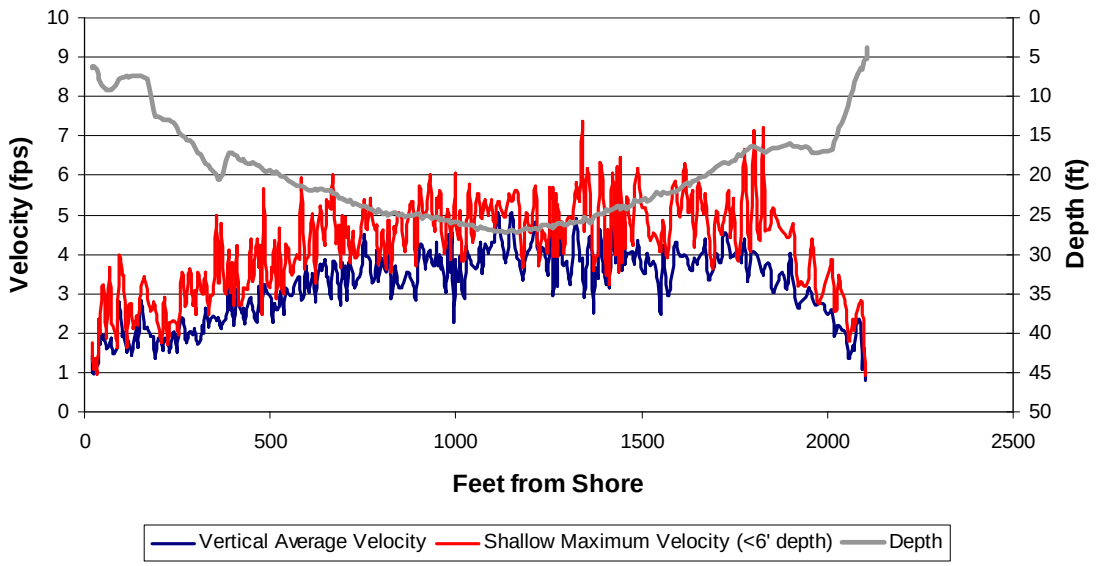


FIGURE 8.37. Velocity Summary for Entire River Transect (beginning at Missouri shore), Bee Tree Park (7/27/07)

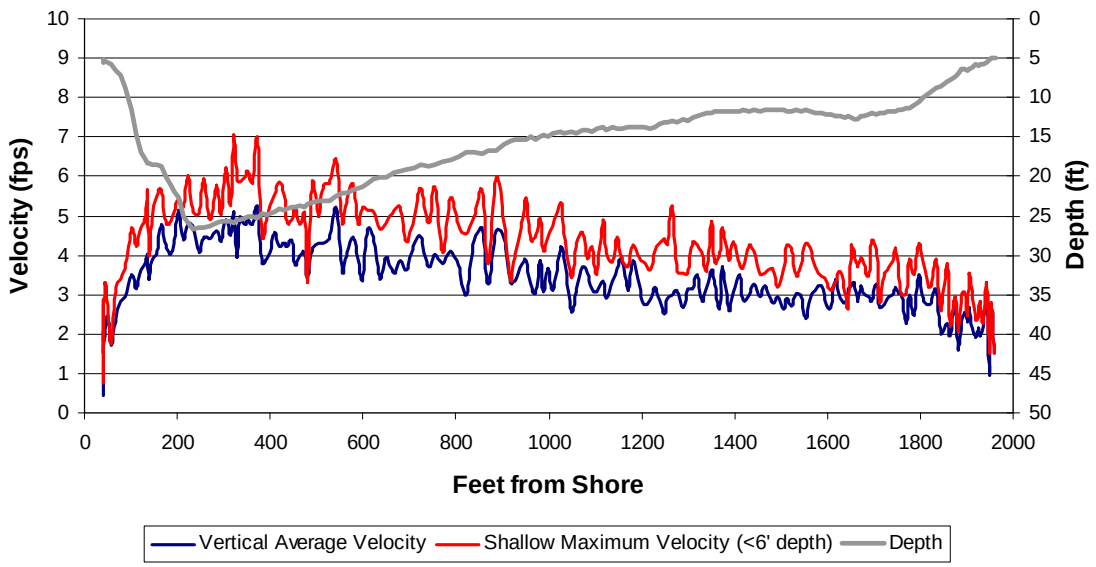


FIGURE 8.38. Velocity Summary for Entire River Transect (beginning at Missouri shore), Bee Tree Park (8/6/07)

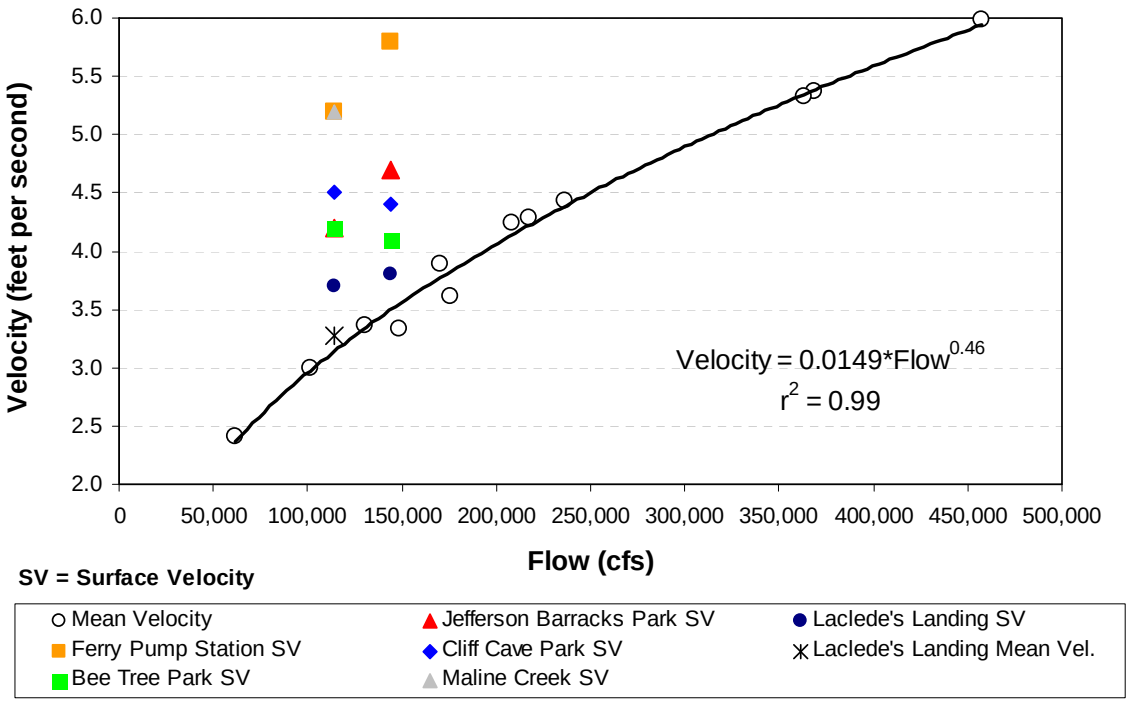


FIGURE 8.39. Rating Curve with Surface Velocity Points at all Stations for the Two Events (USGS Gage Station 17010000 - Mississippi River at St. Louis)

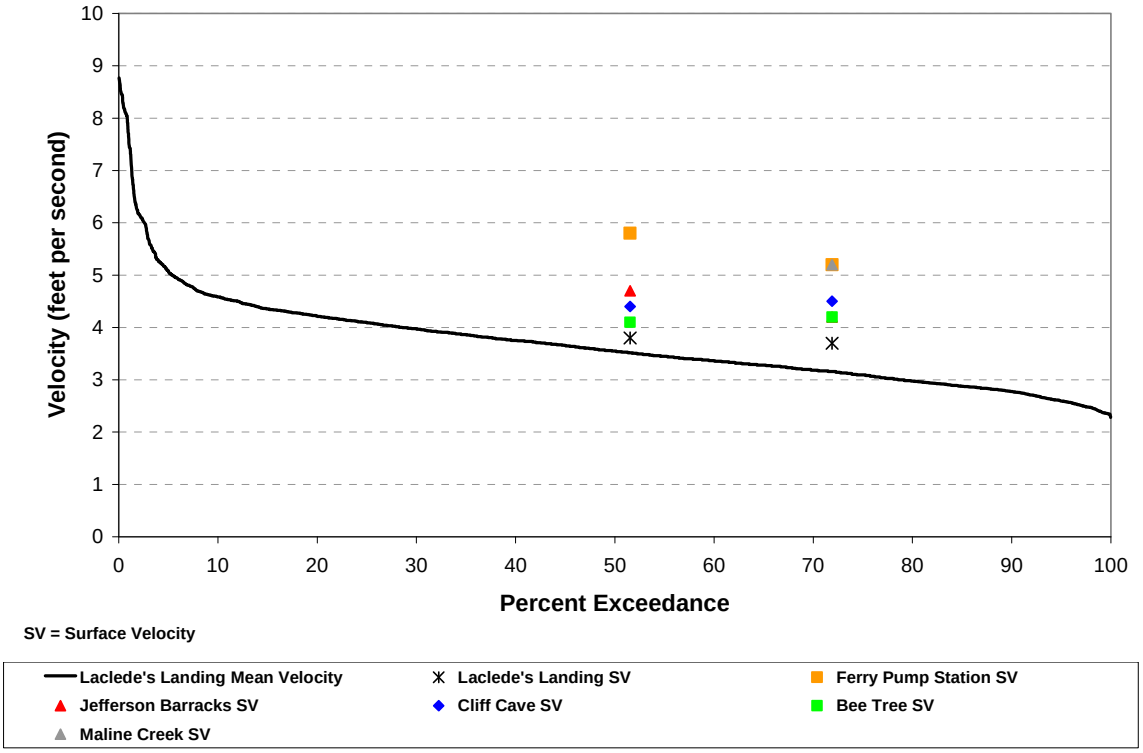


FIGURE 8.40. Duration Curve with Surface Velocity Points at all Stations for the Two Events (USGS Gage Station 17010000 - Mississippi River at St. Louis)

Channel velocities within the entire UAA study segment render the area unsafe for whole body contact recreation based upon the objective criteria from Hyra (1978). Therefore, the following survey areas are considered unsafe for whole body contact recreation:

- *Southern North Riverfront Park,*
- *Maline Creek Confluence,*
- *Ferry Pump Station,*
- *Laclede's Landing,*
- *Jefferson Barracks Park,*
- *Cliff Cave Park, and*
- *Bee Tree Park.*

8.5 Summary of River Hydraulics and Morphology

Based upon multiple qualitative and quantitative factors, the morphologic and hydraulic assessments demonstrate that the entire study segment is unsafe for whole body contact recreation, and therefore this use is unattainable. Qualitatively, the irregular banks along the Missouri shoreline yield several hazards for potential recreators, including steep drop-offs, irregular surfaces, and submerged debris. All of these obstructions are particularly dangerous coupled with the low transparency created by the river's high sediment load. Quantitatively, most Missouri bank slopes are too steep for safe wading to and from potential swimming areas and individuals would likely lose their balance prior to reaching a depth sufficient for swimming. Near-surface velocities are also too high for safe swimming at most near-shore areas once potential recreators could reach locations of sufficient depth for swimming. Lastly, WBCR is completely unsafe within the main channel due to excessive velocities. This weight of evidence approach demonstrates that the hydrologic modifications, such as channelization, have produced conditions that make whole body contact recreation unattainable. Table 8.10 summarizes the various criteria that apply to each survey location.

TABLE 8.10. Suitability Violations by Different Criteria for Whole Body Contact Recreation Use

Survey Area	Qualitative Factors	Bank Slope	Human Stability	Near-shore Velocity	Channel Velocity
North Riverfront Park	x		x	1	x
Maline Creek Confluence	x	x	x	x	x
Ferry Pump Station	x	x	x	x	x
Laclede's Landing	x	x	x	1	x
Jefferson Barracks Park	x	x	x	x	x
Cliff Cave Park	x	x	x	1	x
Bee Tree Park	x		x	1	x

Notes: An "x" indicates the survey area is not suitable for whole body contact recreation based on the indicated criterion.

[1] At North Riverfront, Laclede's Landing, Cliff Cave, and Bee Tree Parks during one survey period, near-shore velocities approached the exceedence criterion (i.e., 1.7 fps compared to 2.0 fps). Cliff Cave and Bee Tree Parks near-shore velocities exceeded criterion during one survey period.

9. Conclusions

The Mississippi River segment within the St. Louis Metropolitan area is unlike the vast majority of our Nation's waters with respect to recreational use safety. Numerous factors contribute to this situation including heavy barge traffic, excessive strong current, floating and submerged debris (i.e. logs, trees, etc.), low transparency and steep banks slopes with irregular surfaces and drop offs. This unique combination of factors along with other considerations, such as restricted access issues, was considered in assessing the attainability of WBCR.

The preponderance of evidence presented in this assessment unequivocally supports the conclusion that WBCR is not an attainable use for the Mississippi River UAA segment. This conclusion is based on extensive data collection efforts that, to our knowledge, far exceed any other applicable recreational UAA completed to date in any other state or USEPA Region. The scope of this study was developed through a stakeholder process led by USEPA, which included MDNR, MSD, the Missouri Coalition for the Environment (MCE), the Washington University Interdisciplinary Environmental Clinic, and USEPA designated consultants. This stakeholder process included scoping meetings, regular progress meetings and phone conferences, as well as a field survey hosted by the MCE and the Interdisciplinary Environmental Clinic.

9.1. Existing Use Assessment

Extensive interviews, field observations conducted over the height of the recreational season, and approximately 80,000 surveillance photos provide scant evidence of WBCR use in the Mississippi River UAA segment. Interviews with Federal and State agency representatives, local government representatives, trade organizations and local interest groups, dock and service terminal representatives, and citizens identified in the study area, yielded only a few reports of infrequent swimming and waterskiing in the UAA segment. The overwhelming response from interviewees was that they had no knowledge of anyone swimming in the Mississippi River UAA segment and it was too dangerous to do so. Field observations conducted over 13 days (between July 4 and August 12, 2007), including two weekends and the Fourth of July, and approximately 80,000 surveillance photos (from July 2 to August 19, 2007) from five locations distributed throughout the study segment showed no evidence of WBCR use.

Field observations conducted over 13 days (between July 4 and August 12, 2007), including two weekends and the Fourth of July, and approximately 80,000 surveillance photos (from July 2, to August 19, 2007) from five locations distributed throughout the study segment showed no evidence of WBCR use.

The rare and infrequent reports of swimming and waterskiing do not constitute an "existing use" according to USEPA. Advance notice of a proposed rulemaking to the Water Quality Standards Regulation at 40 CFR Part 131 published in the Federal Register on July 7, 1998 states the following:

> A somewhat common existing use question applies to primary contact recreation: if a few people on a few occasions "swim" in a water body that does not have the quality or physical characteristics to support swimming, is this an existing use, even if the water body is posted "no swimming" due to bacterial contamination and lacks the physical features to actually support swimming? The straightforward answer to this question is that "swimming" is not an existing use because the present (or past) condition does not support that use. This conclusion is based on the very limited actual "use" and, more importantly, the lack of suitable water quality and physical characteristics that would support a recreational swimming use now or in the future (as determined by the water quality requirements and recreational swimming considerations, including safety considerations, in the State or Tribal classification system for primary contact recreation)" (63 FR 36752-36753).

This report has clearly demonstrated through assessments of barge traffic and hydrologic conditions that the Mississippi River UAA segment does not have the physical characteristics to support swimming. This fact coupled with the extremely infrequent WBCR use supports the conclusion that WBCR is not an existing use.

9.2. Attainable Use Assessment

Federal regulations (40 CFR 131.10(g)) specify that States and Tribes may only remove a designated use if it is not an existing use and if attainment of a use is not feasible due to one of six criteria. As documented in this report, WBCR is not an existing use. Summarized below are two UAA factors applicable for removing WBCR use from the Mississippi River UAA segment.

Factor 3. *Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place.*

Human caused conditions preventing the attainment of WBCR use in the Mississippi River UAA segment include: 1) restricted shoreline access due to the industrialization/commercialization of the shoreline, 2) dangerous hydraulic conditions created by regulating works, and 3) dangerous conditions created by barge traffic. Additionally, there are no reasonable or practical means by which to remedy these human caused conditions. The St. Louis port ships and receives over 32 million tons of freight a year worth over $5 billion. A modal transfer of this tonnage would require an additional 1,260,533 trucks through the metropolitan St. Louis area alone, increasing road traffic, noise, and air pollution (RCGA, 2007).

Within the approximately 28-mile UAA segment, there are only a small number of river access points not restricted by either steep bluffs or industrialized/commercialized development. The railroad essentially parallels the entire UAA segment further restricting access. Only 0.2 miles of residential property are immediately adjacent to the

> The U.S. Coast Guard, the Federal agency tasked with the safety of our Nation's Waters, considers this segment the most treacherous within the eight state region.

UAA segment (i.e., less than 1%). This residential property is dissected by the railroad and the adjacent portion is only accessible by scaling at least 50 feet down a bluff. Additionally, most of the shoreline consists of steep slopes, obstacles and irregular surfaces which discourage accessing the river for purposes of wading or swimming.

Regulating works such as chevrons, wingdams, and dredging activities exacerbate dangerous flow conditions inherent in the Mississippi River and create bank slopes too steep for recreational purposes. The USACE is charged with maintaining a navigation channel in the river that is at least 9 feet deep and 300 feet wide. This is accomplished through a series of regulating works designed to force water into the navigation channel and toward the Missouri bank, as well as through dredging operations. These works by the USACE are designed to facilitate barge traffic but effectively increase the dangers of recreating in or on the river.

Missouri shoreline conditions of the Mississippi River UAA segment are hazardous for wading. Most of the shoreline is characterized by steep drop-offs, irregular surfaces, submerged debris and riprap. This coupled with the low transparency of the water due to high sediment loads, creates dangerous wading conditions. Additionally, bank slopes in most shoreline areas exceed the quantitative bank slope criterion of 4:1 recommended for safe recreation (NRCS, 2002). Conservative estimates of near-shore velocities also suggest an average person would lose their stability wading into waters sufficiently deep for swimming (i.e., 3.3 ft based on MDNR guidance). The Karvonen *et al.* (2000) human stability criteria is recommended for assessing wading safety, which is based upon the product number (P.N.) of depth multiplied by velocity. The recommended P.N. is 4.0 ft^2/s as previously discussed, based upon poor wading conditions and appropriate individual height and weight assumptions. Based on conservative estimates of near-shore river velocities, the P.N. at 3.3 ft ranges from 5.0 to 12.2 ft^2/s (i.e., in excess of safe conditions).

Field surveys demonstrated that average river velocities near the surface within the main channel are unsafe even during low flow conditions. Average river velocities near the surface ranged from 3.3 fps to 5.0 fps, which exceeds the safe criteria established by Hyra (1978) of 2 fps. An undated brochure from the USACE entitled "Missouri River Safety Tips" corroborates that river velocities are unsafe for swimming. "Swimming and tubing on the Missouri River is extremely dangerous and is strongly discouraged. A river current normally 3-4 mph can quickly exhaust even the strongest swimmer. Inner tubes should never be used on the river. (Missouri River Safety Tips, USACE)" This and other Missouri River safety resources are directly applicable to the Mississippi River since these unsafe conditions are much more prevalent on the Mississippi River.

Stationary structures such as dikes also create hazardous conditions in the presence of the strong Mississippi River currents. Within the St. Louis area stationary structures such as docks, dikes, and pylons are extremely common. The USACE warns that approaching these structures is extremely dangerous.

> Never attempt to moor to stationary objects such as dikes and moored barges and never approach these objects from upstream. Swift water flowing over, under and around these objects creates very strong turbulence and undertow currents that may overturn your boat and pull you under (Missouri River Safety Tips, USACE).

Barge activity in the UAA segment is extremely heavy creating a dangerous environment. The Port of St. Louis is the 3rd busiest inland port in the contiguous United States. Barge fleeting areas represent nearly one-quarter of the shoreline in the UAA segment. Authorities such as the USACE and the Missouri River Water Trails website strongly warn of the dangers associated with recreational boating near barges.

> These barges also create extreme turbulence up to ½ mile behind the tow. The strong wake may lift your boat onto the rocks, dikes or other hazards. Wakes generated by barges can suck under objects including smaller craft …" (Missouri River Safety Tips, USACE).

Analysis of access restrictions, hydrologic conditions, and barge traffic overwhelmingly supports the conclusion that WBCR is not an attainable use in the Mississippi River UAA segment.

Barge and commercial boat traffic is widely recognized as a hazard and has been used as a basis for removing primary contact recreation from the Mobile River, the Port of Erie, and the CAWS. Barge traffic in the St. Louis area exceeds the combined traffic from all three of these locations, clearly indicating that WBCR is not an attainable use.

Analysis of access restrictions, hydrologic conditions, and barge traffic overwhelmingly supports the conclusion that WBCR is not an attainable use in the Mississippi River UAA segment. The amount of data collected in support of these analyses and the certainty of this conclusion far exceeds the other UAAs presented in Section 2; most of which utilized the same factors for removing the WBCR use.

Factor 4. *Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or operate such modifications in a way that would result in the attainment of a use.*

The same hydrologic modifications discussed under Factor 3 are applicable to Factor 4. Regulating works designed to direct river current and maintain channel depths prevent the attainment of the WBCR use. In fact, additional hydrologic modifications (three chevrons near McKinley Bridge) are currently under construction. Additionally, it is not feasible to restore the Mississippi River to its original condition or to operate these modifications in a way that would result in the attainment of the WBCR use.

9.3. Weight of Evidence

Considering all factors, the Mississippi River in the vicinity of St. Louis is at best inhospitable and at worst is deadly with regards to recreational activities in or on the water. Qualitative and quantitative assessments of existing uses, access to the river, barge traffic, hydrologic conditions, bank slopes, near shore surface conditions, depths, and visibility issues, all corroborate this conclusion as noted in the bulleted items below:

- The U.S. Coast Guard, the Federal agency tasked with the safety of our Nation's Waters, considers this segment the most treacherous within this eight state region;
- The Port of St. Louis is the 3rd busiest inland port in the contiguous United States;
- Barge traffic in the St. Louis area exceeds the combined traffic from the Mobile River, the Port of Erie, and the CAWs;
- Approximately 80,000 surveillance photos show no evidence of WBCR use;
- Interviewees overwhelmingly responded that the Mississippi River is too dangerous to swim in and they had no knowledge of its occurrence;
- Thirteen days of field observations during the height of the recreational season (including two weekends and the Fourth of July) indicated no evidence of WBCR use;
- Access to the shoreline is severely restricted by industrial/commercial development, steep bluffs, and a railroad;
- Barge fleeting areas represent approximately one-quarter of the shoreline;
- Average near-surface velocities exceed Hyra (1978) recommended safe swimming and waterskiing criteria;
- Bank slopes in most shoreline areas exceed the quantitative bank slope criterion of 4:1 recommended for safe recreation (NRCS, 2002);
- Near-shore hydraulics exceed PN values recommended by Karvonen *et al.* (2000) for safe wading conditions;
- The shoreline is characterized by steep drop-offs, irregular surfaces, and submerged debris; and
- Transparency in the river water is very low due to high sediment loading.

More anecdotally, given that the greater St. Louis area has a population well over 2 million people one would expect more evidence of WBCR uses if such uses were indeed attainable. The high population density in close vicinity to the Mississippi River considered with the lack of evidence for WBCR use is very telling. People are choosing not to swim in the Mississippi River. Based on interviews and data collection efforts, this is likely due to dangerous conditions that make it unsafe to swim (e.g., barge traffic, strong currents, etc.), lack of access, lack of suitable shoreline, and poor water visibility.

9.4. Recommendation

Extensive data collection efforts support the same conclusion found in the 2005 UAA (MEC, 2005) and that was ultimately adopted by the Missouri Clean Water Commission.

The State of Missouri portion of the Mississippi River from North Riverfront Park (RM 188.7) down to the confluence with the Meramec River (RM 160.8) should not be designated for WBCR use (Table 9.1 and Figure 9.1).

TABLE 9.1. Extent of Mississippi River Recommended for Removal of Whole Body Contact Recreation Use

Boundary	River Mile	Latitude	Longitude
Upstream	188.7	38.74125	-90.19173
Downstream	160.8	38.38838	-90.34103

Note: Coordinates are in decimal degrees.

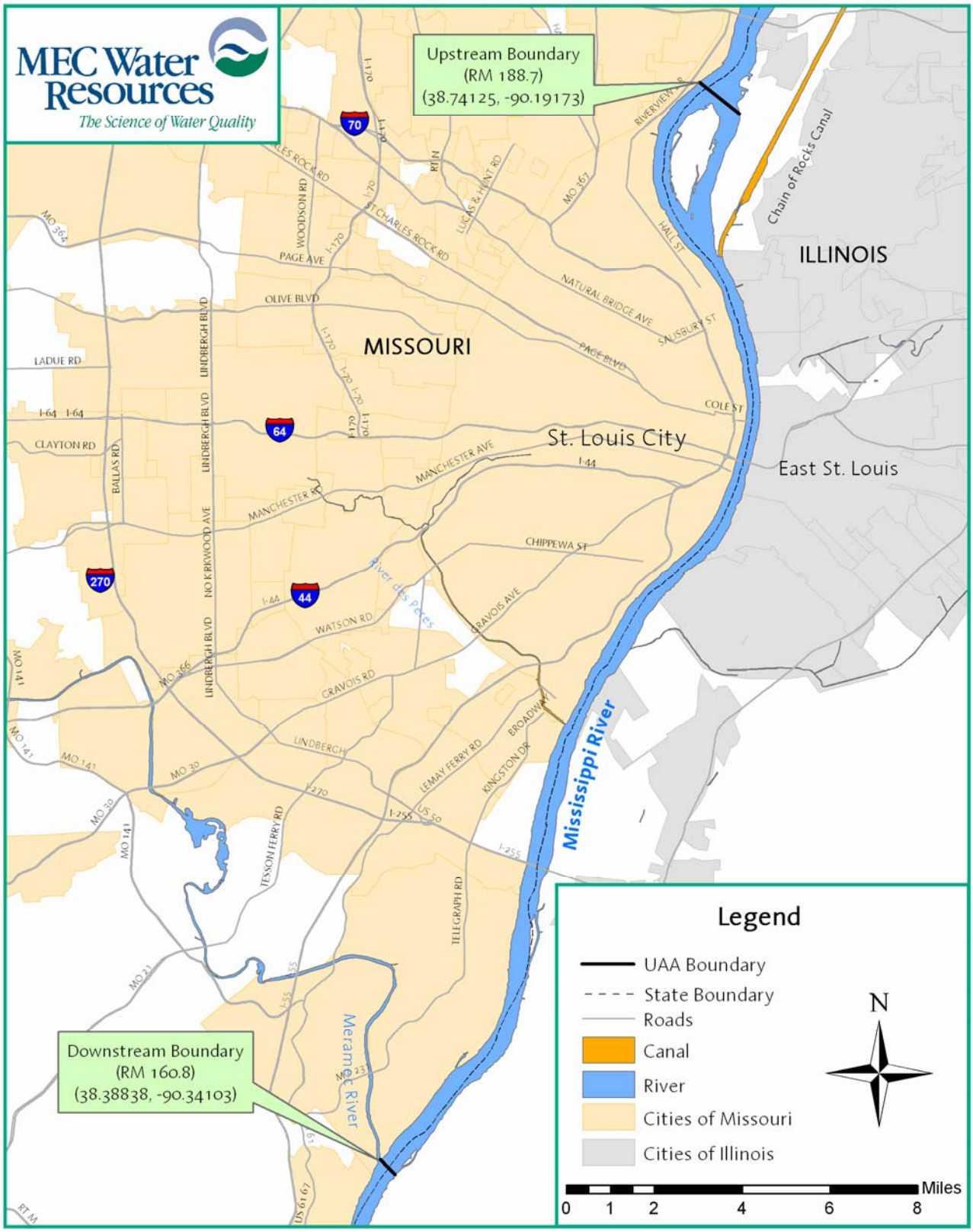


FIGURE 9.1. Extent of Mississippi River Recommended for Removal of Whole Body Contact Recreation Use

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