Shoreline and Water Quality Impacts from Recreational Boating on the Mississippi River

Mississippi River Landscape Team

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Overview

The rapid growth in the numbers and size of recreational boats is having serious ecological and social effects on the Upper Mississippi River System (UMRS). Environmental studies have shown that the height and frequency of waves generated by recreational traffic is the principal causal factor for the high rates of erosion affecting the entire streambank profile. Shorelines exposed to significant recreational boat traffic are eroding at an average rate of 2-3 feet/year. Over the period of a decade, this translates to a loss of 20-30 feet of main channel shoreland and the ecological values associated with the floodplain forest community. An estimate of sediment release to the river (Johnson 1997), from Lock and Dam 3 to the head of Lake Pepin, indicates that streambank erosion contributes 82,600 cubic yards of sediment annually. This is approximately four times the amount of sediment dredged annually from this reach for channel maintenance. In addition to the loss of forested or other shoreline, this mobilized sediment contributes to the chronic resource problems of sedimentation and infilling of Lake Pepin and important backwater areas; high turbidities and the reduction of light transmission necessary for aquatic plant growth; and the economic costs to the public for dredging the fraction of these sediments deposited in the navigation channel. Wake damage to the navigation system infrastructure (shoreline protection works etc.) is an associated cost. Air and water pollutants, noise, sediment resuspension, and disturbance of fish and wildlife and their critical habitats are problems frequently discussed in the scientific literature.

The discussion in this summary report focuses on upper Pool 4, defined as that river reach from Lock and Dam 3 to the head of Lake Pepin. Studies published by the Illinois State Water Survey and U. S. Fish and Wildlife Service, Environmental Management Technical Center developed information on wave and vessel characteristics, and shoreline and water quality impacts within this geographical setting. Because of the similarity in geological conditions in Pools 2, 3, and upper 4, study results are most directly applicable to these reaches of the Mississippi River. However, observations of resource managers indicate that these problems are pervasive throughout the UMRS. Recent analysis and modeling of recreational traffic (Carlson et al. 2000) by the U. S. Army Corps of Engineers demonstrates that current (2000) and projected (2050) traffic forecasts show highest usage in Pools 3 and 4, of all 29 pools in the UMRS. The results of the above mentioned studies point to the serious consequences of continuing the present recreation management practices along the Upper Mississippi River. Protection and enhancement of the critically important ecological and social values of the river requires that local, state, federal, and private constituencies begin a collaborative process to identify and implement new management strategies. Water surface use authority rests with local governmental units in Minnesota, pointing to the important role county and municipal governments will play in their respective jurisdictions of the UMRS. The intent of this issue analysis document is to provide a basis and justification for responsible actions directed at the appropriate management of this great resource.

Environmental Studies

By the late 1980s, Mississippi River managers had recognized the potential for recreational boating activities to have negative impacts on the river environment. The "Cumulative Impacts Analysis of Proposed Recreational Marina Expansions, Pools 2, 3, Upper 4, Mississippi River" (The Mississippi River Marina Cumulative Impacts Task Force, 1990) provided analysis of current and future issues concerning the growth in recreational traffic on the river. Although a number of the proposed marina expansions have not occurred to date, the analysis provided useful insight for river management. Conclusions and recommendations developed by the interagency task force include the following summarized findings:

1. Cruisers, houseboats, and fast runabouts now (1990) make up 61% of the recreational craft, and smaller fishing boats comprise 32%. Free public access to the river is only 8.2% of total access. The trend is toward larger craft (26 feet and over). If proposed marina expansions resulted in full occupancy, cruisers, houseboats, and fast runabouts would comprise 82.5% of all recreational craft.

2. Increased boating will degrade water quality by churning up fine sediments and by keeping them in suspension. Main channel bank erosion will accelerate, especially on islands, degrading fish and wildlife habitat for all species.

3. With increasing recreational traffic, user conflicts and environmental degradation appear to be certain in the future unless appropriate management actions are taken.

4. Research is needed to identify the physical impacts of recreational boating activity.

The first scientific study designed to address recreational boating impacts on the Mississippi River was completed by the Illinois State Water Survey (ISWS,1990). In a report titled: "Waves Generated by Recreational Traffic on the Upper Mississippi River System", researchers measured wave height and other wave characteristics. This was done for different types of recreational boats in controlled runs during normal boating times, at a site near Red Wing, Minnesota. The report concluded that the shoreline is subjected to wave activity of fairly high intensity. A 58mph onshore wind would be needed to generate wave heights comparable to those measured during normal boating activity. The report recommended that the effects of recreational boat waves on the stability of stream banks and the resuspension of sediments should be determined.

As a follow up to the Illinois State Water Survey report, the Minnesota Department of Natural Resources completed a number of studies to evaluate streambank stability, sediment resuspension and physical forces on the Mississippi River near Red Wing, Minnesota. In a report titled: "Recreational Boating Impact Investigations, Upper Mississippi River System, Pool 4, Red Wing, Minnesota" (MDNR for NBS-EMTC, 1994), researchers found a very high erosion rate (on an order of 2-3 feet of bank recession per year) on the main channel, irrespective of geomorphic position, when compared to the Wisconsin channel. After looking at all possible contributing physical forces, it was concluded that recreational boating was the factor most responsible for the high shoreline erosion rate. Repeat transect surveys in 1997 and 2003 confirm that the rate of shoreline degradation has continued unabated over the last 14 years of investigation. In addition, recreational boat waves were found to be directly responsible for elevated turbidity levels in the littoral zone, during peak boating times, due to the resuspension of bank and bottom sediments. Ambient river turbidity measured less than 50 NTUs (units of measure for the amount of light scattered or absorbed by suspended particles). In some reaches subject to sediment resuspension by boat waves, turbidity measurements were greater than 300 NTUs which exceeds the State's water quality standard (25 NTU) by a factor of 12.

From 1995 to 2000, the MDNR led an interagency team to further investigate recreational boating impacts. The investigation focused on the upper most part of Pool 3 in a reach of the St Croix River just north of Stillwater. The "St. Croix River Shoreline Studies - 1995 to 2000" (Interagency Team, 2001) found that between 1969 and 1991, the forested portions of the islands below the Arcola Sandbar (more boats) had become increasingly smaller and more fragmented, while those above the Sandbar (fewer boats) had become larger and more concentrated. It was determined that the majority of the shorelines associated with the main navigational channel were experiencing moderate to high erosion rates. Fourteen sites were surveyed twice each year from 1995 to 2000. Over six successive boating seasons, eleven sites experienced net erosion and three sites experienced net deposition. Those sites with boat waves and/or foot traffic trampling experienced net erosion of the shoreline. Sites with no boat waves and no foot traffic experienced net deposition of material. Data from 23 controlled boat runs suggested a positive relationship between sediment mobilization and maximum wave height. Sediment trap results indicate a maximum wave height of 0.4 feet as the erosive energy threshold for beach and nearshore sands. Controlled run boat speeds less than 5 miles per hour generated maximum wave heights below the erosive energy threshold. Additional off-peak and peak boating days investigations confirmed the 0.4 foot sediment mobilization threshold identified in the controlled run studies. The more boat waves 0.4 feet and higher in a 30 minute monitoring period, the greater the amount of sediment mobilized and redeposited. Likewise, the larger the maximum wave height in a 30 minute monitoring period, the greater the amount of sediment mobilized and redeposited. Of all the boat types recorded, runabouts and cruisers had the highest correlation to the measured maximum wave heights, amount of sediment mobilized, and number of waves greater than the sediment mobilization threshold. Since 1993, the number of boats on the St. Croix River has increased. Cruisers appear to be increasing more rapidly than fishing boats and runabouts. The report concluded that while natural forces continue to shape the islands and shorelines of the Lower St. Croix, human induced impacts are causing the loss of vegetative ground cover, the erosion of shorelines and islands and the loss of trees. To protect the islands and shorelines from further deterioration, management actions such as lower boat speeds and closure of damaged sites may be required.

As part of the Corps of Engineers Navigation Expansion Feasibility Studies, a number of subtasks were scoped to assess recreational boating impacts. Some of the results have not yet been published, but the following information is available as part of the Feasibility Studies updates and from a PowerPoint presentation currently posted on the Corps web site: http://www.mvp.usace.army.mil/navigation/default.asp?pageid=187

With 6.9 million boater-days per year, more than 600 boat ramps, 18,000 marina slips and more than 200,000 lockages per year, recreational boating is a very popular past-time and is big business on the Upper Mississippi River. Recreational boating is forecast to increase about 20%

by the year 2050 with the largest boating increases in Pools 3 and 4. There are now more medium and large cruisers than all other types of boats. The studies measured hydraulic disturbance by recreational vessels traffic including: vessel wake waves, propeller jet turbulence, propeller entrainment of water, sediment resuspension in shallow areas, and bank erosion. The USACE studies concluded that recreational boat traffic is having an adverse effect on the river environment. Ecological effects of these hydraulic disturbances include effects on aquatic plants through breakage and light limitation, entrainment, impingement and stranding of fish, habitat disturbance and impingement and disturbance of wildlife. It was found that medium to large cruisers produce the largest maximum wave heights, resuspend sediments, suppress growth of aquatic plants and contribute to bank erosion. Resuspended sediment concentrations increase cumulatively in controlled runs. Models predicted that resuspended sediment, attributable to large cruisers, may reduce total wild celery and sago pondweed by as much as 100% in the impacted areas.

Historical Context

Construction of the series of locks and dams, by the U. S. Army Corps of Engineers during the period of the 1930’s, brought major hydrological and ecological changes to the Upper Mississippi River. Vast areas of bottomland forest, meadow, marsh, and island habitat were permanently inundated in the lower portions of all the newly created navigation pools. With the loss of these historical habitats came a major increase in new shallow marsh habitat that quickly produced an upsurge of wetland fish and wildlife populations. Wetlands that historically would have been dry, with the low flows of late summer and fall, now produced spectacular autumn waterfowl hunting. Fishing for such species as bass, sunfish and northern pike flourished with the rapid expansion of emergent and submerged aquatic plant beds. This bonanza lasted generally through the period of the 1950’s, following which it became more evident that the reservoir system had serious and increasing problems. Permanently flooded wetlands were susceptible to increasing sedimentation from the modernization of agricultural practices following the end of World War II. The large expanses of water created in the lower pools also increased wind fetch and associated wave action. In some lower pool locations, this has resulted in the gradual wind erosion of aquatic plant beds, islands and other shorelines, and the frequent resuspension of fine sediment deposits that cause plant inhibiting turbidity levels. From the 1960’s until today, these problems have persisted and worsened rendering many important backwater habitats to highly degraded vestiges of the recent past.

Main channel habitats fared considerably better through the 1960’s. River flows here prevented most fine sediment deposition, and riprap shore protection of susceptible sites helped to maintain a high degree of stability and biological productivity along the main channel shoreline. The most serious navigation related problem here was the unloading of dredge material within the floodplain. Since the 1970’s, interagency agreements have rectified many of the problems associated with the deposit of dredge material on islands, within wetland areas, and along main channel shorelines. However, rapidly increasing recreational navigation and size of craft have brought increasing levels of impairment to the ecologically important shoreline zones. Protected areas and substrates important for adult and juvenile fish habitat, mussel and other invertebrate production, and foraging areas for river associated birds and mammals are in a state of continual destabilization and degradation. Many areas formerly protected with rock riprap have been undermined and revetment materials now lay submerged on the bottom of the river, leaving susceptible stream banks to erode at alarming rates. Fallen trees and other woody debris, that would have remained anchored and provided important cover and food production for fish, is now dislodged out into the channel or left parallel on the beach by receding water levels. Turbidity in the water column is elevated by these processes, with it's accompanying negative biological affects and recreational user perceptions.

River stage is an important contributing factor to wake caused streambank erosion. Bankfull or higher stages typically occur in April with the combination of snowmelt runoff and spring rainfall. Major over-bank flood events occurred in 1965, 1969, 1993, 1997, and 2001. However, it is the frequently occurring river stages from bankfull down to 2-3 feet above normal summer pool levels that create the highest susceptibility to accelerated erosion. Waves striking the steep upper banks and tree root zone have their most dramatic affects on this part of the bank profile, and the result is large amounts of soil washed into the river and considerable loss of riparian forest habitat. These intermediate higher flows occur less frequently during the summer period, but are particularly problematic at that time of year. Boating intensity is at its' highest levels, turtles are nesting on sand bars above normal river level, and vegetation attempts to colonize and stabilize stream banks.

Public advisories, in the form of news releases, have been provided on numerous occasions to protect the river during these intermediate high flow events that occur during the spring/summer period. At those times, the Department of Natural Resources requested voluntary no-wake operation to protect sensitive shoreline environments, and to promote public safety in regard to collisions with floating debris. River managers have reported that there has been little or no compliance with these requests for public cooperation, indicating that voluntary measures will not protect the important resource values of the Mississippi River.

A recent process to develop the *Environmental Pool Plans* for pools 1-10 has been undertaken by the St. Paul District, USACE in cooperation with other state and federal agencies and the public. The purpose of this initiative is to establish common habitat goals and objectives, and to define the desired future condition for the river. Plan components include protection and restoration of backwater, island and forested shoreline habitats. A series of public meetings accepted recommendations for this initiative, and the Pool Plans have been adopted by the St. Paul District - River Resources Forum, a working group of river management agencies. The success of this important process will rely on the continued cooperation of all entities involved with managing river resources, including the strong support of local governmental units responsible for water surface use.

Conclusions and Current Needs

The Upper Mississippi River has formed and evolved within the fine alluvial soils deposited in the valley since the last period of glaciation. With a relatively narrow and sinuous channel, wind driven onshore waves have not been a significant part of the natural processes that created the present day river corridor. These factors have defined the streams geological and morphological characteristics that make it particularly vulnerable to environmental degradation from watercraft-induced wave action.

The results of river studies and task force findings make clear the need for additional water surface use management of the Upper Mississippi River. All state and federal agencies involved with management of this resource have a strong commitment to preserving the concept of a multiple-use river, which requires maintaining a careful balance of the important values and uses of this complex river environment. Among these are the values as a wildlife sanctuary and rich mosaic of ecological communities; an important fishery resource; a corridor for commercial navigation; and as a provider of an extensive variety of recreational opportunities. **The important underlying principal for assuring the continued sustainability of the river is to ensure any single use does not impair other uses.**. Certain aspects of current water surface use practices are in direct conflict with this principal, and the resulting environmental degradation and user conflicts must be addressed through a collaborative and adaptive management process.

Impairment of the condition and beneficial uses of the river environment, as a result of currently under-regulated recreational traffic, has significant consequences for all public user groups as well as public and private landowners. Lost or reduced opportunity for fishing, boating, sailing, canoeing, hunting, trapping, nature observation, and other esthetic pursuits represents important public costs. The $1.2B derived annually (USACE) from these uses of the Upper Mississippi River System is vital to the economy of the bordering states. Displacement of more passive river uses, as a result of habitat destruction and the user conflicts associated with the wakes from large, fast moving recreational craft, has become a distortion of the concept of a multiple-use river.

A primary element for river management planning must be the control of wakes, for all motorized craft, during high flow/pool stage. Water levels approximating a 2-3 foot rise above normal operating pool should be considered as a point of initiation for protected high flow periods. At these times, waves strike the steeper and highly erodible portions of the banks, and the root zones for trees and other riparian vegetation. Additionally, excessive wakes from large craft damage shoreline structure and impair water quality and recreation values at all water stages. Excessive wakes are generated principally from large V-hulled craft operating at a high horsepower output that results in an exceedance of the design hull speed. Even when a semi-planing condition can be achieved, these craft produce wakes with high amplitude and velocity that cause high-energy waves to impact the shoreline.

Because of multi-jurisdictional authorities along the considerable extent of the UMRS, and in many cases a lack of water surface use regulatory authority, a system-wide solution will likely not occur within a timeframe that will protect against further impairment of the values and uses of the Mississippi River. Resource values are being lost at an unsustainable rate and local units of government will have to partner with other management entities, by exercising their existing authorities, for the protection and enhancement of the river resources within their jurisdiction. A list of potential options to reduce recreational boating impacts is provided in Table 1. This list is not comprehensive, but does identify a range of alternatives for regulatory authorities, boat manufacturers, recreational users, and other interested parties to begin addressing this issue. Surface water use regulations are an especially important tool. Most would agree it is in the best interest of recreational boaters, regulatory authorities, and the boat industry to work cooperatively to ensure the long-term health and sustainability of the river and continued recreational opportunities for future generations.

"A river belongs to no one. And it belongs to everyone. And no one has the right to contribute to the desecration of a river by irresponsible and abusive acts, at the expense of his neighbors and fellow American citizens, near or far removed from the stream itself." – Richard J. Dorer 1968

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MDNR Contacts:

Jack Enblom – River Surveys Project Supervisor
500 Lafayette Road, St. Paul, MN 55155
651/296/0785

Scot Johnson – Mississippi River Hydrologist
1801 Oak Street, Lake City, MN 55041
651/345/5601

Table 1. Upper Mississippi River System – Potential Options to Reduce Recreational Boating Impacts.

Effectiveness of alternative*: **H = High** **M = Medium** **L = Low**	**Alternative**	**Comments**
H	No wake based on boat size	Could reduce impacts from boats causing the most damaging wakes while not impacting other users; would not be popular with large boat operators; **would require local, state, or federal water surface use regulations**
H	No wake periods – based on season and/or water levels	Would reduce impacts during especially critical times; **would require local, state, or federal water surface use regulations**
H	No wake zones	Could be used in specific locations or reaches; currently used in some locations**; would require local, state, or federal water surface use regulations**
H	Enforcement – add more water patrol officers	Would help in existing no-wake locations; not a systemic solution unless there are more restrictive local, state, or federal water surface use regulations
H	Engineering – design more "river-friendly" boats	Construct boats/hulls that minimize or eliminate wake; could also be an outcome of more stringent surface water use regulations
M	Limit boats based on size, horsepower, and or hull design	To be effective only smaller boats could be used unless hulls can be designed to reduce wake; would not be popular with large boat operators
M	Limit/schedule – days and times of use, access points	Difficult to enforce; **would require local, state, or federal surface water use regulations**
M	Marinas – cap or reduce the number and/or length of boat slips	Would reduce or limit number of large boats causing most impact; address social conflicts with increasing numbers of boats; not popular with marina owners or boat manufacturers
M	Restore natural shorelines – add sand, re-vegetate	Could work in specific locations with heavy boat traffic, but not a systemic solution; water level management (drawdowns) or bank restoration projects could help establish vegetation to increase bank stability
L	Advertising campaign – raise public awareness level	Has been tried unsuccessfully in the past despite broad media releases and brochures distributed at marinas
L	Armor (rock) shorelines	Could work at specific sites, however not a systemic solution; very costly; ecologically undesireable
L	Boat drivers license	Could help educate but would not by itself reduce impacts
L	Boat ramps – reduce number of trailer parking spaces or accesses	Would limit the number of boats but would not address impacts erosion caused by larger boats which are typically not trailered to access sites, but are moored at marinas

L	Education	Has not worked in the past
L	Limit cruising – limit number of drive-by passes allowed	Very difficult to enforce; most trips now once down or up, and back
L	No wake – voluntary	Has not worked in the past

* Effectiveness represents the MN DNR Mississippi River Team's assessment of how well the alternative reduces recreational boating impacts.