

POTENTIAL USE OF INNOVATIVE DREDGE TECHNOLOGY AND BENEFICIAL USE OF SEDIMENT FOR RIVER RESTORATION

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During the past century sediment has filled over 70 percent of the volume of the Illinois River backwaters and side channels. Areas that were once six to eight feet deep are now 18 inches or less at normal pool. Sedimentation's dramatic adverse impact on recreational and environmental resources has been well documented (see references below). The sediment has essentially replaced a diverse benthic habitat with a flat, featureless layer of fine grained sediment under shallow water. Additionally, since 1900 higher average water levels resulting from the altered hydrologic regime have made it impossible for many native floodplain flora and fauna to remain in their historic locations. Within a generation most of the 60,000 acres of backwaters will be converted to willow covered mudflats if depth is not restored and sediment input reduced.

The filling of the of the backwaters is dramatically illustrated by the Department of Natural Resources flyer "Illinois River Backwaters Between Chillicothe and Lacon," included as Figure 1. In this seven mile stretch it is readily apparent that the islands which separated Babbs Slough from the main channel in 1970 were one long, wide peninsula by 1994. Areas such as the upper end of Sawyer Slough have essentially been converted to land and other areas such as the island in Wightman Lake near river mile 189 have widened and in some instances are now connected to the shore. At normal pool Babb's Slough now averages about eight inches in depth. This area was once several feet deep and famous for waterfowl hunting. Today hunters have difficulty getting their boats into the slough.

This paper focuses on an overview of concepts for removing sediment from the backwaters and side channels. Other speakers will discuss programs for reducing sediment inputs. The shallowness of the backwaters lends a sense of urgency to finding a way to remove vast quantities of sediment. The impending conversion of these areas from marginal aquatic habitat to terrestrial floodplain will further stress regional populations of invertebrates, fish, mussels, waterfowl and other organisms. Sediment in shallow water also contributes to turbidity and other water quality problems. It is easily stirred up by fish, waterfowl, waves and boats. Aerial photographs show sediment plumes up to a mile long behind recreational boats and several miles long behind barge tows (Figure 2).

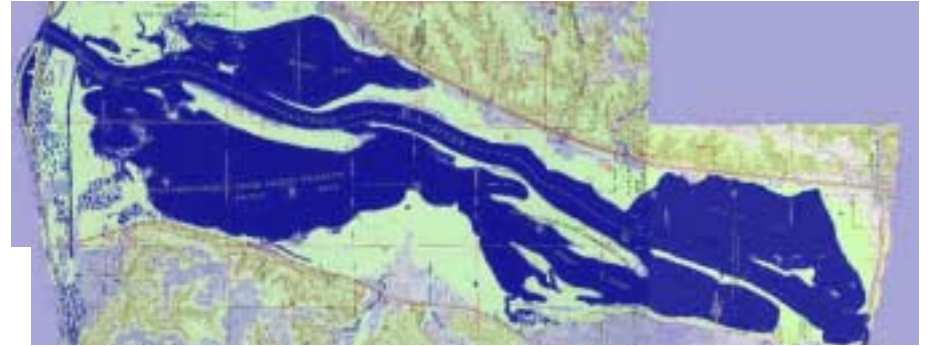
The near-term sediment removal concept concentrates on restoring habitat diversity to some areas in the backwaters and on the floodplain. In short it calls for providing varied water depth in selected areas to provide areas for fish to overwinter outside the main channel while nearby shallows remain suitable for shorebirds. Excavated sediment can be used to build islands and elevated floodplain areas which approximate the elevations and hopefully the soil moisture conditions that existed prior to 1900. This will allow the return of many floodplain hardwoods and other species which cannot tolerate the current flood regime. The concept calls for converting shallow, marginal aquatic habitat into higher quality aquatic as well terrestrial habitat.

Illinois River Backwaters Between Chillicothe and Lacon

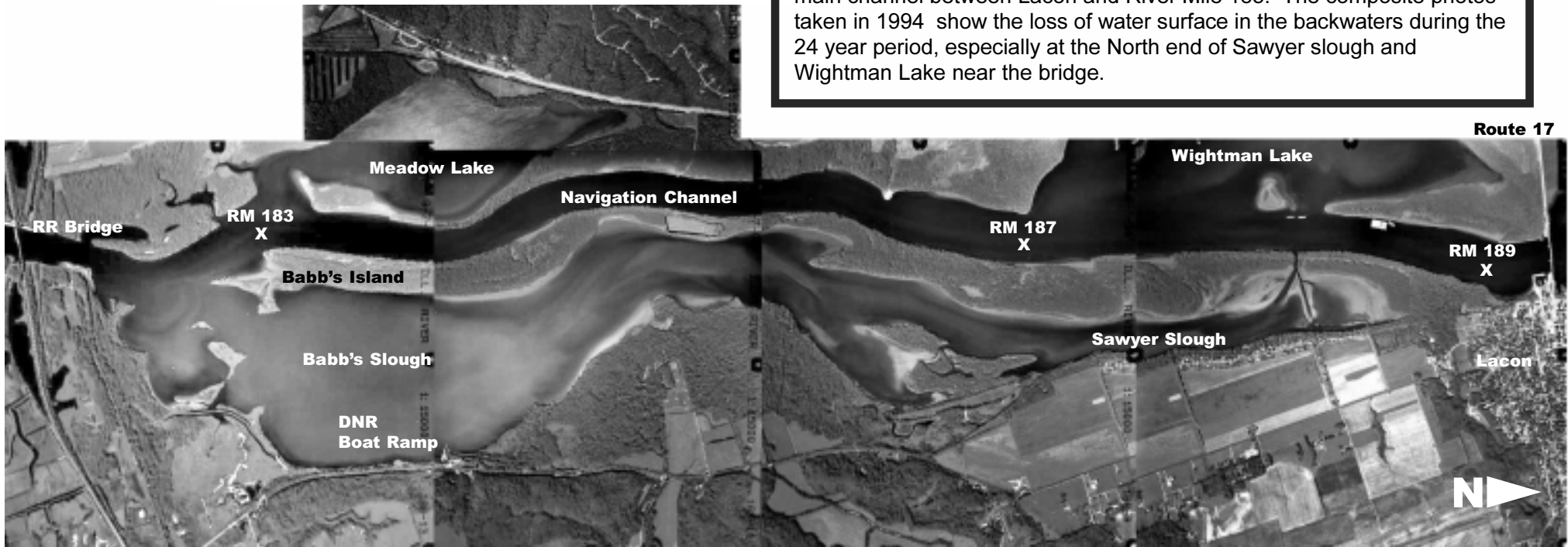
This map is a composite of aerial color infrared photographs taken by the U.S. Geological Survey in 1994. The photos are available on the Web site of the Upper Midwest Environmental Sciences Center in LaCrosse WI. (<http://www.umesc.usgs.gov/>). Map compiled by the Waste Management and Research Center of the Illinois DNR.

The 60,000 acres of Illinois River backwaters have lost over 70% of their capacity since 1900. Backwaters that were six to eight feet deep now average less than 18 inches due to accumulated sediment.

The lakes and sloughs pictured here have lost much of their value to fish, waterfowl, and other plants and animals. Even shallow draft recreational boats frequently are unable to navigate these areas. The public has a huge investment in these backwaters, many are currently state and federal refuges. Unless depth is restored, these waters will totally fill with sediment and be converted to willow-covered mudflats.



Above is a topographic map of the area in the photo below. It is based on aerial photography taken in 1970. Note that Babb's island was once much narrower and there were two natural entrances to the sloughs from the main channel between Lacon and River Mile 183. The composite photos taken in 1994 show the loss of water surface in the backwaters during the 24 year period, especially at the North end of Sawyer slough and Wightman Lake near the bridge.



The alternative is to lose virtually all of the aquatic habitat outside the main channel.

Most of the accelerated sedimentation in Illinois River has occurred since the Lake Michigan diversion began in 1900. Other dramatic changes over the century also impacted the river hydrology including the navigation channel and dams, altered farm practices, stream channelization, and urban runoff. Since the problem developed over a century, it is reasonable to expect a restoration effort to take as long as twenty years. This would provide time to remove, dewater, and find uses for sediment and allow funding to be appropriated over many years. A large scale restoration could involve removing hundreds of millions of cubic yards of sediment. In the Peoria area the sediment generally consists of fine grained silt and clay particles with little sand. The sediment averages about 50 percent moisture content and is similar to cookie dough in consistency. Figure 3 is a photo of a fresh sediment core.

TECHNOLOGY

River dredging to maintain Mississippi and Illinois navigation channels was historically associated with environmental problems, because the dredged material was frequently placed in backwaters and side channels. Conventional hydraulic dredges agitate the sediment, mix it with water and discharge a slurry consisting mainly of water carrying five to fifteen percent sediment. Today the slurry is usually pumped to a diked or bermed placement site where it settles and gradually dewater. Because it is mostly water it must be placed in a diked area and dried before



Figure 2. Fine grained sediment is easily resuspended, especially in shallow water. In this picture a suspended sediment plume several miles long is visible behind a barge tow in Upper Peoria Lake. Plumes of varying lengths are also generated by fish and recreational craft.

it can be moved or put to most beneficial uses. An advantage of the hydraulic dredge is that it can efficiently move the slurry for miles through relatively inexpensive pipelines. Disadvantages include the need to manage large volumes of water, resuspension of contaminants and sediment particles, and the total disruption of the structure and consistency of the in-place sediment. An alternate technique that reduces the amount of water added to the sediment, maintains its consistency, reduces resuspension would be desirable.

A number of high solids slurry pumps and similar devices exist which manufacturers claim can pump material with 30 to 50 percent moisture content under suitable conditions (Figure 4). A high solids pump could place material in a barge or on-shore holding area. Its advantage lies in the greater amount of sediment contained in the slurry which decreases the required amount of storage and bermed dewatering area. Such pumps could also be used to discharge sediment directly from the river or from barges onto fields or containment areas.

Clam shell buckets on floating cranes are commonly used to dredge channels and boat slips. They mix little water with sediment and can be used to directly build low islands such as those built in 1994 in Upper Peoria Lake. Their primary limitation on a major restoration project is the length of the boom. Material must be double handled if it is placed farther than the crane can reach.

DRE Technologies, Inc. of Nashville developed a new type of dredge which combines a small clam shell bucket with a displacement pump. Their dredge takes bites of sediment without



Figure 3. Sediment cores up to nine feet in length show that the sediment is soft but relatively firm. As seen above a fresh core keeps its shape and loses little water. If the sediment can maintain its in place consistency during excavation, it will be much easier to build islands or dewater on shore for other uses.

adding water, drops it into a small hopper, and a displacement pump sends it through a pipe at essentially *in situ* moisture content. The discharge is much thicker than that of a hydraulic dredge (Figure 5).

Bucket wheel excavators on tracks have been used for many years in the mining industry and for handling bulk materials. Engineers familiar with the design of these machines believe that they can be modified to operate in shallow areas of Peoria Lake and other backwaters. They would scoop sediment off the bottom and place it on a conveyor belt. Traction would be provided by wide, low ground pressure tracks. Figure 6 is an excavator on conventional tracks.

Caterpillar Inc and at least one other company is investigating the use of a large diameter excavating wheel mounted on a floating platform to remove sediment with very little resuspension or added water. The concept is a high volume device that would bring sediment off the bottom at essentially its natural consistency. A conveyor could be used to move the sediment to a placement site.

Floating conveyor belts are used in several mining operations. Figure 7 shows a 2100 foot floating conveyor operating in California. Several engineers have concluded that conveyors could move Illinois River sediment for miles if necessary, provided it is not mixed with excessive amounts water during excavation.



Figure 4. A number of companies make pumps which are capable of handling material with a high solids content. The pumps are available in various sizes and can be mounted on conventional excavator arms or cranes.

BENEFICIAL USE OF SEDIMENT

A comprehensive river restoration project could generate millions of cubic yards of dredged material. DNR is looking into potential uses which will depend on the chemical constituents and the cost of moving sediment. Some potential uses include: constructing islands and other habitat, landscaping soil, strip mine and brownfield reclamation, construction fill and flowable fill for construction. The Corps of Engineers Waterways Experiment Station is investigating some of these uses.

DNR collected 900 pounds of sediment from the river bottom in April, 1999. It was dried and used to grow five species of plants in pots at an Illinois Natural History Survey greenhouse. Preliminary results indicate no noticeable difference in germination, wet weight and dry weight of plants grown in sediment and Champaign County top soil. Peoria Lake sediment has been successfully used by IDOT contractors to vegetate a new highway intersection. A University of Illinois soil lab is evaluating soil formed by sediment placed in fields many years ago. The texture, mineralogy, organic matter content and nutrients contained in sediment are similar to that found in high quality topsoil. River sediment is initially quite hard, but after weathering develops soil structure and much improved tilth.

Building new islands in the river or enlarging existing ones is a likely use of some sediment. The islands would most likely be long and narrow to minimize the impact on flood heights and



Figure 5. The DRY DREdge (TM) by DRE , Inc. uses a small clamshell bucket and a displacement pump to remove and transport sediment at essentially its *in situ* moisture content. The discharge above is about the consistency of toothpaste. The current working model has a low capacity compared to conventional machines.

could be built high enough to provide habitat for a number of floodplain hardwood trees and other native species that are unable to adapt to the current altered hydrologic conditions. They would also reduce wind and wave action and provide safe nesting and resting areas for numerous bird species. The large number of waterfowl using the two artificial islands in Upper Peoria Lake provide evidence that this concept will prove useful to wildlife.

The Corps of Engineers built two small islands in Upper Peoria Lake as part of the Environmental Management Program (Figure 8). In 1994 a clamshell dredge was used to place sediment into two narrow islands in the lake about a mile long. The primary limitation on their size was the distance the crane's boom could reach. The first island consisted of the soft material of the upper sediment layer and was expected to wash away. The larger island used more consolidated sediment and sand from the original bottom. Both islands are still in place and the larger one is covered with trees. Neither island has any rip rap or other shoreline protection. The islands are viewed by many as prototypes for the design of future islands.

Large new islands up to several hundred feet wide could be developed using a number of techniques. A conventional or high solids dredge could pump sediment into an island shaped containment area built with a clamshell or other device. It would take a relatively long time for these sediment to dewater and consolidate.

Another option would use a conventional floating crane and clamshell in combination with a conveyor to overcome the short reach limitation of the clamshell (Figure 9). The conveyor could



Figure 6. Conventional tracked wheel excavators are used in mining and materials handling situations. The machine could be adapted with wider tacks and other features to operate in shallow water in Upper Peoria Lake. The excavator discharges to a conveyor belt.

effectively extend the reach of the crane for miles if desired. This would allow sediment with relatively low moisture content and some of its initial consistency to be conveyed intact to an island under construction. It would decrease the amount of time needed for the material to consolidate. The island's height above normal pool could be increased by adding lifts as the sediment dries. If one of the excavator concepts proves feasible, such construction could become even more efficient. The conveyor could also transport sediment for land placement.

If it is necessary to protect new islands from the erosive force of waves, a number of methods could be employed including rip rap and geotextile tubes. These tubes can be 30 feet in circumference and hundreds of feet in length. When pumped full of sediment they are quite firm and can perform like an erosion proof berm. In coastal areas such tubes are used to develop wetlands and protect beaches and diked areas (Figure 10). The Fox Waterway Agency in Northern Illinois placed a geotextile tube as a breakwater several years ago that is still performing well. They are currently in the process of constructing an island using about 6,000 linear feet of tubes. The tubes may also prove useful to break up wave and wind fetch in wildlife areas such as Lake Senachwine.

Huge amounts of sediment could be pumped or conveyed to areas on shore and stockpiled until used for landscaping soil, fill or other purposes. It is possible that it may be built into large mounds and planted with trees or grasses until needed. Large mounds built in southern Illinois by Native Americans consist of sediment and provide examples of the potential durability of such stockpiles.



Figure 7. This 2100 foot floating conveyor belt is operated by CalMat, Inc. at Irvine Lake in California. Conveyors could be used to move excavated Illinois river sediment at *in situ* moisture content. Like pipelines, conveyors could move sediment over several miles to a shore facility or to build islands. They are more expensive than pipelines.

The Peoria Lakes and other backwaters could be deepened by using of the technologies discussed above. For the most part the techniques have existed for some time, but have not been commonly used in combination or for environmental habitat restoration. It is likely that several techniques will be used in any restoration project given the varying conditions in the river valley. Judicious dredging could preserve the areas as aquatic habitat until erosion control methods have time to reduce the sediment inputs and society decides the long term future of the river corridor.

REFERENCES

- Bellrose, F.C., S. P. Havera, F. L. Pavaglio, and D. W. Steffeck. 1983. The Fate of Lakes in the Illinois River Valley. Illinois Natural History Survey. Biological Notes No. 119. 27pp. Champaign, Il.
- Demissie, M. and N. G. Bhowmik. 1986. Peoria Lake Sediment Investigation. Illinois State Water Survey, Contract Report, 371. 88pp. Champaign, Il.
- Demissie, M., L. Keefer, and R. Xia. 1992. Erosion and Sedimentation in the Illinois River Basin. ILENR/RE-WR-92/104. Illinois Department of Energy and Natural Resources. Springfield, Il.



Figure 8. The two long, narrow islands in the foreground were constructed by the Corps of Engineers in 1994 as part of the Environmental Management Program. They are still in good shape after withstanding five years of waves and weathering without riprap or other protection. The islands are used extensively by numerous species, especially birds. They also break up wind fetch and reduce the adverse effect of waves.

- Demissie, M. 1997. Patterns of Erosion and Sedimentation in the Illinois River Basin. In Proceedings of the 1997 Governor's Conference on the Management of the Illinois River System, pp. 69–78.
- Environmental Studies Work Team. 1981. Technical Report D, Environmental Report, Comprehensive Master Plan for the Management of the Upper Mississippi River System. Upper Mississippi River Basin Commission. Minneapolis.
- Mills, H. B., W.C. Starrett, and F. C. Bellrose. 1966. Man's Effect on the Fish and Wildlife of the Illinois River. Illinois Natural History Survey Biological Notes 57. 24pp.
- Talkington, L. 1991. The Illinois River: Working for Our State. Illinois State Water Survey. Misc. Pub. 128. Champaign, IL.

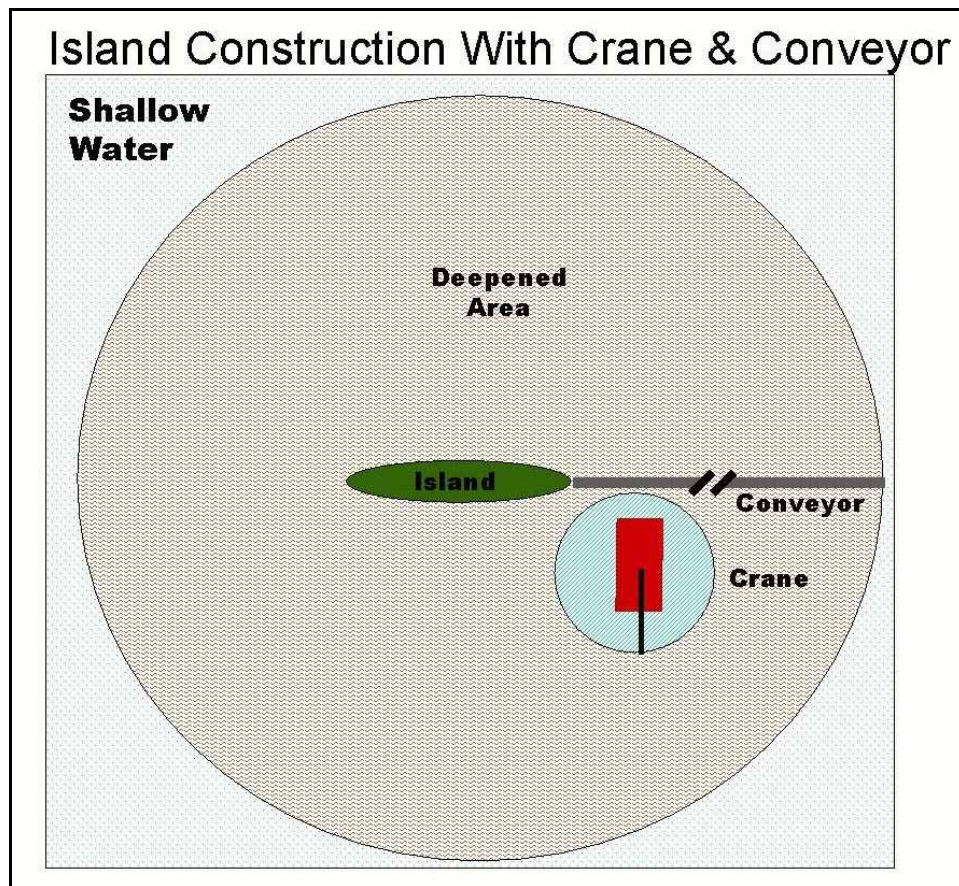


Figure 9. A conventional clam shell bucket on a floating crane built the islands in Figure 8. Its main limitation was that material could not be excavated over an area larger than the crane could reach and still deposit material on the island. By using a conveyor belt in combination with a crane, sediment could be moved long distances from the excavation point and used to build islands, be placed on shore or in barges. Floating conveyors could extend several miles.



Figure 10. Geotextile tubes filled with sand and sediment are becoming increasingly popular in water resource applications. They can be used in place of riprap to protect shorelines and are capable of supporting vegetation. Tubes could be used in shallow water to break up waves. They could serve numerous functions in an Illinois River Restoration Project including protecting islands from the erosive force of waves generated by wind and vessels.

