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First Name: Thomas
Middle Initial: J
Last Name: Murphy
Organization: DePaul University
Address:
Address 2:
Address 3:
City:
State:
Zip: 60614
Country:
Privacy Preference: Don't withhold name or address from public record
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Comment Submitted:

GLMRIS Focus Area 2 Summary Report; August 2012

Comments: Thomas J. Murphy, Ph. D.

October 14, 2012

The Design of a Hydrologic 'Maginot Line'

This early report on Focus Area 2 aquatic pathway connections between the Great Lakes and Mississippi River basins begins to fill in the details of a plan that has only a small chance of meeting its overall objective: halting the movement of aquatic nuisance species (ANS) between these two watersheds. A reasonable estimate of the chance of preventing one or more Asian carp species–and many of the other ANS studied, from getting to the Great Lakes basin in the next 50 years is probably one in three, at best. There are two principal reasons for this pessimistic assessment. 1) The design criteria for the construction of a hydrologic barrier (HB) in the numerous possible connection locations overstates the probability that the system will function as desired by a factor of five to ten. 2) This study is crippled at the onset by the §3061(d) authorization authority that is interpreted to limit the study to transfer 'through aquatic pathways' only. The *Scope of the Assessment* recognizes this severe limitation, and states that a thorough and effective assessment 'would require a separate study'.

For the first reason, the study identifies and makes pathway assessment reports for the 19 areas of risk of ANS transfer with the exception of the Chicago Area Waterway System (CAWS), which is Focus Area 1. Based on detailed studies of each of the sites, the study determined what would be required to limit the transfer at each of the sites to a probability of one percent per year—equivalent to circumventing the hydrologic barrier during the 100 year storm.

The major error here is in assuming that the overall risk to the system is equivalent to the risk at any one individual site rather than the cumulative risk at all of the sites (your chance of winning a jackpot at the slot machines is ten times greater if you play ten machines rather than if you play just one). If each of the sites is engineered so that overtopping has a probability of occurrence of 1% per year, then the chance that it will be overtopped within 100 years is 63% (1-.99^100); it has a 50% chance of being overtopped in 69 years and a 40% chance in 50 years.

On the other hand, if there are five independent sites or their effective equivalent (CAWS, Eagle Marsh, Parker-Cobb Ditch, etc.), each with a 1% probability per year of being circumvented, then the chance that an overtopping will occur at one of them in any year is 4.9%; there is a 50% chance of it occurring in 14 years, and a 92% chance of it occurring within 50 years. Is the USACE planning a system that will cost billions of dollars to construct but that has a 50% probability of failing within 14 years, perhaps before the full system is completed? The 50 year storm event that occurred in the Duluth-Swan River area this past June is a reminder that these rare events can and do occur, and can result in temporary hydrologic connections between different watersheds.

To achieve a 1% per year overall probability of failure of a hydrologic barrier system, if there are five equivalent sites where a bypass could occur, then each site must be engineered to withstand the 500-year storm; 0.2% per year risk; 50% probability in 348 years. Thus all of the 34 identified potential locations for ANS transfer ranked medium or low in their probability of pathway viability between the basins, will need to be re-evaluated for their current ability to survive a 500-yr storm event without ANS transfer.

During World War I (WWI) Germany invaded France and epic land battles were fought on French soil. Between WWI and WWII, France constructed a massive and expensive defensive wall west of its border with Germany to defend against an invasion of German troops and tanks in the future. Widely considered to be one of the strongest defensive structures ever built, it was named the Maginot line after the French minister of war. However in WWII the Germans first invaded Belgium and marched through it to easily invade France from the north, bypassing the Maginot line entirely. A classic end-run.

During WWII, the Germans developed an extremely complex machine for enciphering communications between headquarters, and troop units and ships at sea, the Enigma. The encryption keys used to set the initial state of the machine's rotors were changed daily, so even if the British had working models of the machine, they still would be unable to decipher the messages. Many times during the war, the Germans considered the possibility that their secret messages were being read by the British. In each case however, they decided that the complexity of the enciphering–hundreds of million of letters sent before the key would repeat, would keep all the communications secure.

Ingenious and very sophisticated reverse engineering enabled the British to keep up with changes in the mechanics of the machine, but it was still useless without knowing the initial, daily settings. However, if one attacked and sunk an isolated German ship–say a weather ship in the seas off the coast of Iceland, but were able to board it and remove monthly lists of enciphering codes, there would be no need to crack the encipherment. Such raids and other fortuitous captures of code keys lead in 1943 to a 90% decrease in the sinking of Allied shipping, and to victory in the war in the Atlantic. With the rotor settings and daily keys, the German communications could be deciphered and read in real time by the English, rendering useless the complexities of the cipher machine and all of the faith placed in it by the German high command.

The second major limitation of this GLMRIS risk assessment process, is the assumption that aquatic species can *only* transfer between hydrologic basins via aquatic pathways and that a robust HB is also an absolute ecological barrier. In reality, however, it is just another example of a Maginot line or Enigma machine. There can be unforeseen vulnerabilities and the occurrence of improbable events, and the enemy—armies or ANS, do not have to follow *your* rules or regulations. In fact their greatest successes come when breaking the rules. There is abundant evidence involving numerous examples and species that extremely robust HB are easily bypassed and rendered obsolete. Consider:

- Zebra mussels, an ANS the invaded the Great Lakes in 1988 crossed the hydrologic divide at Chicago and invaded the Mississippi river system. In spite of thorough and

intensive information campaign to all aquatic users in Minnesota, Zebra mussels have invaded more than 100 aquatic systems in Minnesota, many of them not hydrologicly connected to the Mississippi river.

- Recently, Zebra mussels have been discovered in Lake Mead of the Colorado River system, having crossed the formidable continental and hydrologic divide–the Rocky Mountains, and are now also in the irrigation system in southern California.
- Asian snakehead fish:
    - The Northern snakehead fish (*Channa argus*), first identified in the Potomac River is now in a dozen eastern streams in 5 states and has become established in the Arkansas River (Mississippi River system) where it has survived eradication attempts.
    - On April 25, 2011, a northern snakehead was found above the Great Falls of the Potomac River near Whites Ferry. The 77-foot high falls were supposedly a HB that the fish would be unable to circumvent.
    - A giant snakehead (*Channa micropeltes*) was found dead in April 2010 in the Saint-Charles River, in Québec City (likely an aquarium release).
    - Many ANS are part of the legal or illegal aquarium trade and food imports. In May 2011, a Brooklyn fish importer was arrested for importing 350 live snakeheads into New York.
    - A fisherman caught a single snakehead in October 2004 at Burnham Harbor on Lake Michigan in Chicago (likely a single, local release).
- The first ANS salmonids in the Great Lakes were pink salmon deliberately released from the Port Arthur Hatchery at Thunder Bay on Lake Superior.
- The western Mediterranean Sea is inundated with an aggressive alga from the Pacific Ocean inadvertently released from the Oceanographic Institute in Monaco.
- Hundreds of isolated drainages and lakes in the Rocky Mountains and Sierra have non-native salmonids and *Mysis relicta* deliberately introduced by well-meaning people. In many of those systems the native Cutthroat, Golden, or Dolly Varden (Arctic char) trout have been extirpated.
- Mature catadromous Lake Michigan Lake trout were transferred by unknown means from Lewis Lake in Wyoming across the continental divide to Yellowstone Lake in 1988, circumventing the formidable HB of the 300 foot tall Lower Falls of the Yellowstone R. There they are pushing the native anadromous Cutthroat trout to extinction and changing the ecology of the Yellowstone Lake watershed.
- H. *anomala*, a recent ANS in Lake Ontario is now present in Oneida Lake 53 river km upstream from Lake Ontario, having surmounted the significant hydrologic barriers of ". . . several large rapids, locks, and dams."
- There are numerous examples of ANS in Florida wetland ecosystems that could not have come by hydrologic transfer. Many are thought to be former pets released by their owners.
- Regulations, rules, education, etc. can only go so far in preventing the transfer of species between ecosystems. Individuals sometimes release exotic species through

ignorance, for ill-conceived benefits, for spite, or for their own—sometimes irrational, reasons. While not involving ANS, the recent release of more than 50 non-native large animals—including 18 Bengal tigers, by a private, exotic pet owner in Ohio in Oct. 2011, illustrates the difficulty of trying to control or regulate the movement of species once established on a continent, education and regulations not withstanding.

- Follow-up investigations indicate that the Asian carp (AC) found in Lake Calumet in 2010 had lived there for six years or so, indicating that Asian carp can survive in the Great Lakes ecosystem. Its entry route is unknown, but a non-hydrologic transfer route is a possibility.
- Blue gills (*Lepomis macrochirus*) —a native U.S. fish, are disrupting many of Japan's freshwater ecosystems. The Bluegills were introduced to Japan as a present from Chicago mayor Richard J. Daley to Emperor Akihito when he visited Chicago as the crown prince in 1960.
- Rare or extreme hydrologic events can also lead to temporary hydrologic connections that permit the transfer of ANS. The escape of imported Bighead carp from inland fishponds in Arkansas to the Mississippi River system when flooding in 1993 overtopped the ponds is an example.
- The hydrologic separation of the Great Lakes and Mississippi River systems at Chicago is a relatively recent occurrence. As recently as about 3,500 years ago, the outlet for Lake Michigan was hydrologic corridor now occupied by the Chicago Sanitary & Ship Canal.
- Before the Chicago area was developed in the mid-1800s, aquatic species could transfer between the Des Plaines River (Mississippi River system) and the Great Lakes when the natural, hydrologic divide between these two systems–the Mud Lake region of western Chicago, was inundated with heavy spring runoff or heavy rains.
- The 'hydrologic barrier' now erected in Eagle Marsh in Ft. Wayne, an important Focus Area 2 site, is a cyclone fence. Its mesh size will allow the free passage of many ANS species and Asian carp up to 6 inches or so in length.

One need only remember that the Bighead Carp has already bypassed HB twice, first in 1972 from its native waters in China to ponds along the Mississippi R, and then in 1993 into the River itself. The first bypass was a deliberate introduction, the second was facilitated by a major flooding event. The other examples illustrate the futility of relying on HB to effect an ecological separation.

Upon completion of the GLMRIS study, the USACE will recommend a plan to prevent ANS transfer between the two hydrologic basins. Current indications are that project costs, mainly in the Chicago area will be several billions of dollars. Upon its completion, what is the chance that an inadvertent, deliberate or natural event will result in the transfer of AC or other ANS to the Great Lakes negating all of the costs and efforts put into constructing it? What is the possibility that transfer will be the result of inadvertent or deliberate human action?

Rasmussen and co-authors (2011) in considering the case for hydrologic separation, addressed this possibility. They concluded:

> "Intentional releases also pose risks that need to be addressed, primarily through education and regulations that are carefully targeted and strictly enforced. To minimize the risks of overland transfers, public education programs have been undertaken and legal prohibitions on the sale, transport and possession of live Asian carp have been enacted at the city, state and federal levels."
>
> J.L. Rasmussen et al., JGLR 2011.

Education and regulation! This statement reflects their naïvety and ignorance of the last 100 years of ANS in the United States and the examples cited above. How do they account for the hundreds of lakes, ponds and streams in the Mississippi River basin not hydrologicly connected to the river that are infested with zebra mussels; with dozens of new infestations each year; with the continuing appearance of new ANS in Florida wetland systems; and with all of this despite many regulations, boat inspections, and extensive information campaigns?

In addition, there is still a well-funded, vocal, politically active community of 'true believers' out there who put absolute faith in hydrologic barriers being the equivalent of ecological separation—in hydrologic Maginot Lines:

> As we have argued since day one: this is the *only guaranteed option for* keeping Asian carp at bay and *protecting the lakes from yet another destructive and costly invader*
>
> Alliance for the Great Lakes, 13 July 2012

> We think it is time to *devise a permanent solution* to this problem. . . . We believe . . . that it is possible *to separate the Great Lakes from the Mississippi River watershed*. It would require a significant capital investment, but the cost of not taking action is higher. It would also . . . *save the Great Lakes* from the near-certain damage from a parade of invasive species in the future.
>
> Ellen S. Alberding, Joyce Foundation, Feb 1, 2012, Chicago Tribune

> Congress mandated that GLMRIS should only consider "options and technologies available to prevent the spread" of aquatic invasive species through the waterways. *Hydrological separation would achieve this.*
>
> GLMRIS Comment ANS50021, NRDC, Feb. 14, 2012

> The Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative led a project to develop and evaluate alternatives for physically separating the Great Lakes and Mississippi River basins in the Chicago Area Waterway System *to prevent the movement of Asian carp* and other aquatic invasive species (AIS). *This report* summarizes the results of the project and *shows that separation can be achieved.*
>
> The Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative, Feb 2012.

Since the USACE is not currently authorized to do a though analysis of non-hydrologic transfer probabilities, they at least need to include the evidence for non-hydrologic transfer in their report to enable informed decisions to be made by others in this most important matter.

Should the USACE plans for a HB become a reality in the CAWS and elsewhere along the GL-MR divide, the minimum design criteria for the system are available from other ANS transfers discussed above. The hydrologic barrier needs to be taller than the Rocky Mountains, wider than the Pacific Ocean and higher than the Lower Falls of the Yellowstone R. Even then, however, a couple of ignorant or vengeful people with a boat and a big tub of water can still bypass it.

Other questions that need to be thoroughly addresses before committing to spending billions of dollars on a HB system:

1) What is the experience with the various Asian carp species, now threatening the Great Lakes in large lakes in their native Asian habitat?
2) What is the probability that any or all of the threatening Asian carp species will cause irreparable ecological damage to the Great Lakes? There are already carp in the lakes and most invasive species cause insignificant ecological damage.
3) Once an ANS has established itself in an aquatic environment in the US, what is the possibility of keeping it from invading other aquatic systems? What is the probability that the Asian carp will make it to the Great Lakes, with or without a HB in place?

What are the possible consequences of different actions?

- No billion dollar hydrologic barrier project—business as usual.
  - AC invade Lake Michigan causing major disruptions to its already troubled fishery and its tributaries, and devastate the sports fishery as feared.
  - AC invade Lake Michigan harbors and cause significant disruptions in many of its tributaries.
  - AC invade Lake Michigan with little significant effect on its ecosystem, as is true for most invasive species.
  - AC never make it to the Lake.
- A multi-billion dollar HB is constructed in the CAWS and at Phase 2 sites where necessary that prevents ANS exchange between the two hydrologic basins for more than 50 years.
  - Major changes are made in the hydrology of the CAWS.
  - Hundreds of millions of gallons of treated sewage effluent per day from one or more wastewater treatment plants now goes into the southern basin of Lake Michigan, significantly affecting its ecology and degrading its trophic state.
  - Flooding of basements and roads is more common, particularly when the water level in the lake rises.
  - Commercial shipping is disrupted.

  - Is an undisputed success.
- A multi-billion dollar HB is constructed in the CAWS and at Phase 2 sites where necessary and Asian carp successfully invade Lake Michigan within five years of its completion.
  - All of the deleterious effects noted above.
  - Major ecological and financial disaster for Lake Michigan.
  - A major PR disaster—Solyndra on the Lake, in spades.
  - Irreparable damage to the credibility of proponents and supporters of the project.

What to do?

1. Support the initial USACE policy of developing projects to reduce the risk of ANS exchange between the two basins.
2. Design containment systems at all possible transfer locations to survive the 500 year storm event (assuming five most-risky locations, and needing an overall risk of 1% per year).
3. Begin a companion project lead by qualified individuals from outside the basin, to evaluate the probability of Asian carp successfully colonizing Lake Michigan and then the other Great Lakes, with and without the construction of a major hydrologic barrier project in Focus Area 1 and Focus Area 2.
4. Consider electric barriers and other less-disruptive systems where appropriate.
5. Institute a rigorous early-warning monitoring program, using fish sampling, cDNA, and other appropriate techniques to identify invasions should they occur in time to take corrective actions before breeding populations become established.
6. Mount a thorough and well-designed information campaign modeled on those now in place for other invasive species, to minimize the risk of inadvertent ANS transfers.
7. Include a hefty reward system for information leading to information on actual or attempted ANS transfers.

The ultimate question and uncertainty here is whether it is wise to spend billions of dollars, to re-plumb the CAWS with its increased flooding risks, to discharge huge volumes of treated sewage daily into Lake Michigan and to disrupt shipping, for a project that is subject to being subverted by fishermen careless with their fish bait, by severe but infrequent natural events, by transfer mediated by other species, or by a couple of ignorant or vengeful people with a boat and a big tub of water.