

Conference Report on Chicago Workshop

Workshop Title:

Climate Change and the Great Lakes Water Levels: What Are the Potential Impacts, and What Can We Do?

March 30, 2001

The U.S. Environmental Protection Agency, the Great Lakes Regional Assessment, and the National Wildlife Federation are sponsoring a series of workshops following the release of a major scientific assessment of the potential consequences of climate change for the Great Lakes region. The five workshops are intended to focus on issues of interest to stakeholders and citizens in the region. The first, entitled Climate Change and the Great Lakes Water Levels, was held Friday March 30, 2001 in Chicago.

The Chicago workshop attracted strong public and media attention, reflecting the importance of the lakes as the foundation of the region's industrial strength and multibillion-dollar tourist industry. The *Chicago Tribune*, *Detroit News*, *The Milwaukee Journal Sentinel*, and *The Times Northwest Indiana* ran stories, and the ABC affiliate in Chicago covered the event.

Gary Gulezian, director of EPA's Great Lakes Program Office, welcomed 90 participants that included marina owners, academics, private citizens, and owners from the marine transport industry, as well as representatives of environmental organizations, shipping associations, state and local environmental agencies, and federal agencies. "We have a responsibility to protect this magnificent resource for this and future generations," Gulezian said as he opened the meeting.

Peter Sousounis, director of the Great Lakes Regional Assessment, outlined the objectives of the meeting:

- To inform stakeholders about the latest findings of the Great Lakes Regional Assessment;
- To provide participants with a forum for discussing how the potential impacts of climate change might affect their respective interests;
- To elicit from stakeholders what their information and research needs are;
- And, to share ways for the stakeholders to become actively involved in the assessment.

The presentations in the morning session focused on the science of climate change and how it could affect water levels in the Great Lakes, and how changes in the Lakes could affect the economy and lifestyles of the region. The talks provided a glimpse of the potential socio-economic consequences that could result from lower lake levels associated with climate change. The afternoon session focused on water management and mitigation strategies. Both morning and afternoon talks were followed by a question and answer session.



Themes that emerged included the need for better understanding of the short-term impacts of climate variability; the importance of mitigation as well as adaptation; and the tendency of the political issues that govern lake levels to complicate attempts to address the impacts of climate change. **To view all of the speakers' presentations, see <http://geo.msu.edu/gla/>**

Morning Presentations

Brent Lofgren, a physical scientist with the National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory, gave a brief overview on the science of climate change. He also explained NOAA's work, which involved applying Global Circulation Models (GCMs) to develop scenarios of possible changes in water levels in the Lakes. We know with "virtual certainty" that greenhouse gases in the atmosphere are increasing, an enhanced greenhouse effect is occurring, and the Earth's climate exhibits natural variability. "Very probable" is an increase in evaporation and precipitation. "Less well-substantiated" are local impacts, such as changes in ice break-up dates.

Lofgren went on to describe the two computer models that project climate change that were used for the U.S. National Assessment—the Canadian GCM and the United Kingdom's Hadley Center GCM. After the talk, in response to a question from the audience, Lofgren cautioned, "The Canadian model does not recognize the existence of the Great Lakes. And the Hadley model does so, but in a crude fashion."

To develop projections of water levels under climate change, NOAA simulated the lake levels resulting from actual observations of meteorological variables such as temperature and precipitation over the past 50 years. Then, using the same variables as projected by the climate models, they projected lake levels for the near and more distant future.

Using scenarios derived from the Canadian model, NOAA found that water levels might drop more than 3 feet by 2090, due to a hotter, drier climate. Under the Hadley model, which projects smaller temperature increases and more precipitation, levels would not change significantly and might even increase slightly.

Most other models agree that future climate change will lead to lower Great Lakes levels. “Drops of nearly 5 feet are possible,” Lofgren concluded, “and recent low lake levels provide an analog that may give a taste of what we can expect.”

A Dramatic Impact on Commercial Shipping

To discuss the potential impacts of those changes in lake levels, speakers from different aspects of the shipping and boating industry offered their perspectives on the current lake levels, and the possibility of longer term changes.

Impact of Lower Water Levels on Great Lakes Commercial shipping and the Industries They Serve George Ryan, President of the Great Lakes Carriers' Association

“Let’s look at water levels from the captain’s perspective,” George Ryan, president of Great Lakes Carriers’ Association, told the workshop. “The greater the depth that a captain can load a vessel, the more cargo it can carry.”

For each inch of carrying capacity lost to lower water levels, a thousand-foot-long ship can carry 270 fewer tons. The ship owners are paid on the basis of the tonnage they carry, but their operating costs are fixed, so they face decreased revenues if they have to off-load freight.

Although it might seem appropriate to pass along the costs to shippers, the major shipper on the Great Lakes is the steel industry, which faces severe competition from imported steel.

If low water levels persist, there may be cause for concern about whether the nation has enough vessels to make the additional trips needed, given reduced cargo per trip. If cargo is shifted to land transport, traffic congestion and environmental consequences will increase—whether the cargo is carried on trucks or trains. A ship carries the equivalent of six 100-railcar trains. Switching the cargo to trains means increased delays at rail crossings, more noise and air pollution, and possibly increased rail crossing fatalities.

The shipping industry recommends dredging channels and ports deeper and extending the shipping season by utilizing existing icebreakers.

The industry also recommends improving real-time communication to the captains about water depths. “They need to know how much water will be under the keel at all times,” Ryan said, suggesting that data be updated every six minutes so that they can load and navigate their vessels cost-effectively.

Canadian Shipping’s Perspective

Wayne Smith, Vice President, Seaway Marine Transport.

Wayne Smith is Vice President of Seaway Marine Transport, one of the largest commercial shipping companies operating in the Great Lakes St. Lawrence Seaway. He briefed the participants on the physical, economic, and political factors that influence shipping in the region.

The depth of the waters ships travel through limits ship traffic. Until the past year, the 26’3” draft of the St. Lawrence Seaway has been the constraining variable on the \$4 billion Canadian-U.S. marine transportation industry, said Wayne Smith. “Now it’s the lake levels of Huron and Michigan,” he pointed out.

The St. Lawrence River Board of Control is responsible for maintaining sufficient depth and velocity for hydropower and navigation, while protecting the shoreline from flooding. A study of the feasibility of deepening the seaway’s channel by 3 inches is now underway.

A new study by Canada and the United States (see the Galloway talk on page 10) will be the first comprehensive assessment of the system in nearly 50 years. This study will consider environmental impacts, review existing regulations, and examine potential climate change impacts.

“It is ironic that global warming could hurt marine transportation,” said Smith, “because studies show that it is the most environmentally friendly transportation mode.” Moreover, he said, the costs are lower than truck and rail transport, marine shipping is the safest mode, and adequate infrastructure and capacity already exist. He concluded by noting that Europeans are encouraging modal shifts from truck to rail and from rail to water.

Marine Assistance in Low Water Conditions

Don Biganeiss, CEO of American Rescue Services

Don Biganeiss is CEO of American Rescue Services, Inc., a Michigan company that renders assistance to pleasure craft. That assistance ranges from helping boaters who have run out of fuel or gotten lost to dealing with boats that have run aground, capsized, caught fire, or collided with others, as well as the associated environmental cleanup.

In addition to shallow water leading to more groundings, more boats are crowding into the deep parts of the lakes, increasing the likelihood of collisions. In 1999, the company received 865 calls – the most rescue calls in one year according to Biganeiss. Although, in the summer of 2000, the number decreased to 400, many were more serious than in the past: 60 percent involved sinkings and hard groundings with hull breaches.

Biganeiss feels that the decreased number of calls may also be due to the “media scaring people about the low water” and gas prices were high.

Low water led the company to change its operations in a number of ways. The company’s rescue boats used to carry a maximum of 600 feet of line for towing grounded boats. Now they carry 1,500 to 3,000 feet to keep the rescue boats themselves from grounding.

The number of damaged propellers in rescue boats has tripled because of low water. The company is considering switching to flatter craft with a shallower draft and jet drives instead of propellers, and lighter line.

Biganeiss offered four recommendations from the marine assistance perspective: (1) Decrease media sensationalism, (2) Increase public awareness of lower water depths, (3) Teach navigation to boaters, and (4) Update marine charts every two or three years.

Effects of Low Lake Levels on Recreational Boaters and Marina Owners

Jeff Henderson, Owner, Harrison Marine

With half the registered U.S. recreational boaters living in the Great Lakes region, the economic impacts of low water are enormous. More than one-third of the region’s commercial marinas could not rent some of their slips in 2000 because of the water levels. His own marina lost more than \$10,000 in revenue.

One-fourth of the marinas had to do unscheduled dredging. The average cost currently is running \$20 to \$22 per cubic yard, not including the cost of disposal of dredged material. Disposal costs are rising “because of the possibility of PCBs, mercury, pesticides, and other toxins in the sediment,” Henderson noted.

Other impacts include increased boat damage, greater congestion in deepwater areas, more accidents, boats that cannot be launched because their hoists can no longer reach the water, refueling ports that become inaccessible, and sailboats forced to leave shallow homeports.

More than 50 percent of the region’s marinas were negatively affected by low water in 1999, with a total estimated revenue loss of \$11 million.

Henderson offered five recommendations: (1) Educate, without sensationalization, (2) Explore tax credits for marinas, similar to those that farmers receive in crop damage years, (3) Increase the number of classes in navigation, (4) Streamline the dredging permit process, and (5) Maintain sufficient depth in state-run harbors and waterways.

Socio-Economic Impacts on Shipping and Boating
George Albercook, is a senior project scientist the
Center for Environmental, Policy, Economics, and Sciences

By 2030, the Canadian climate model, the Great Lakes shipping vessels will carry 12.6 percent less cargo per trip due to lower lake levels. By 2090, they will carry 24.3 percent less. “Few businesses can tolerate a reduction in efficiency of one-fourth. These scenarios would mean the end of Great Lakes shipping as we know it,” Albercook noted.

The traffic would shift to alternate modes that are less fuel-efficient. Consider the distance that one gallon of fuel can move one ton of cargo: ships on the Great Lakes consume 1 gallon of fuel for each 1 ton of cargo moved 607 miles. Rail moves that same ton only 204 miles, and trucks only 60 miles. Greater fuel use would increase air emissions.

If the Sault Locks close, the 87 million tons currently moved by ship would require different transportation methods. If half of it went to rail, an additional 4,350 trips by 100-car trains would be required. “It is doubtful that enough railcars exist in the United States,” Albercook said. If the other half went by truck, an additional 1.9 million truck trips (or an additional 800-mile trip by every tractor trailer in the nation)—with associated environmental impacts—would be required.

Under the Canadian model, dredging costs for federal harbors and channels could increase from less than \$6 million annually to \$75 to \$125 million per year. Only two of the existing approved disposal sites left by 2006 will have room for contaminated dredge material.

Low water under the Canadian model would disable the Chicago Sanitary and Ship Canal, posing a serious health risk. Much of the 30-mile Chicago Diversion runs through rock, so dredging would be expensive.

Question and Answer Panel Discussion: Morning Session

During an hour-long question-and-answer session, the workshop participants focused on adaptation measures, such as increased dredging, fleet changes, and an extended shipping season.

Question 1: Sharon Hanshue, of the Michigan Department of Natural Resources, asked how to manage public expectations about changing water levels and get away from media sensationalism.

Response: One panelist commented that the media only report bad news, but no real solution or alternative was suggested.

Question 2: Katherine Silverthorne, of the World Wildlife Fund, noted that while much attention is paid to the potential costs of mitigating climate change, little is paid to those sectors and industries that may suffer because of climate change, such as shipping or recreation industries. She inquired whether carriers have attempted to “get the message out about the economic impacts on their industry.”

Response: George Ryan replied that we are telling the shippers and the government about the severe impact of lower lake levels.

Question 3: Cameron Davis, of the Lake Michigan Federation, asked whether increased dredging would result in more water being lost from the lake system.

Response: Dave Schweiger, of the U.S. Army Corps of Engineers (USACE), replied that dredging historically did result in a permanent lowering of Lakes Michigan and Huron.

Question 4: Questions about adapting the shipping fleet and ice-breakers came from Ned Dikmen, publisher of the Great Lakes Boating Magazine, and Virginia Reiner, a freelance writer.

Response: George Ryan replied that the new multi-mission icebreaker would have a shallower draft. Wayne Smith noted that the Great Lakes fleet is aging, and new freighters will be built only if adequate returns on capital investments are received. He added that policy makers should compare the full environmental costs of marine, rail, and truck shipping.

Question 5: Tim Eder, of the National Wildlife Federation, noted that the environmental impacts of extending the shipping season need to be taken into account.

Response: George Ryan replied that any extension would not happen overnight. “All parties—federal, state, local, and tribal—will be consulted during the environmental impact analysis. With global warming, a longer shipping season is a natural adaptation.”

Question 6: Arthur Brooks, of the University of Wisconsin-Milwaukee, and two other participants asked about control structures and construction of new locks for wider vessels as an alternative to dredging.

Response: Ryan pointed out that both environmentalists and the shipping industry historically have opposed new control structures. With respect to the proposed new lock size, he said it would be wide enough.

Question 7: John Lenters, of University of Wisconsin-Madison, and another participant asked about smaller-scale effects of climate change and how to model them, given the coarseness of the GCMs

that Lofgren described. Another participant asked when new model results for the Great Lakes region might be available.

Response: Peter Sousounis replied that the present models, despite their coarse resolution, still provide "large-scale patterns from which we can get some idea of short-term impacts."

As to when we can expect model results for the Great Lakes to become available, Brent Lofgren replied, "Within 1.5 years." Sousounis added that the next generations of the Hadley model "may be more in line with the Canadian model."

Question 8: Phil Keillor, of Wisconsin Sea Grant, asked whether climate change might increase the risk of structural damage to ships that hit bottom during loading at docks.

Response: Smith and Ryan noted that hulls are always at or near the bottom during loading, and the problem of improper loading is not a new one. In addition, the shipping industry is working with NOAA and the USACE to improve communication so that ship captains will know when barometric changes and wind shifts displace the water. In Lake Erie, Ryan added, "with a strong northwest or westerly wind you can have an extra 9 feet of water in Buffalo and 9 feet less water in Toledo."

Question 8: Amy Hennen, of the Izaak Walton League of America, raised the issue of reducing greenhouse gas emissions.

Response: Smith replied that the Canadian government has become more involved in mitigation, and Don Biganeiss noted that manufacturers of personal watercraft are switching to cleaner four-cycle engines.

The session concluded with the comments of Lee Botts, of the Indiana Dunes Environmental Learning Center: "Don't we all—industry and environmentalists—have a common interest in trying to reduce greenhouse gas emissions? The only good thing about the climate change debate is that everyone has a stake in getting beyond our immediate interests and looking at the big picture."

Afternoon Presentations

Water Management and Mitigation Strategies.

Scott Vowinkel of the U.S. Army Corps of Engineers spoke about dredging and toxic sediments.

The Great Lakes has about 24 percent of the nation's commercial harbors and 12 percent of the recreational ones. U.S. Army Corps of Engineers Civil Engineer Scott Vowinkel told the conference that the Corps' budget for navigational projects on the lakes runs \$82-\$89 million annually, of which \$16-\$24 million is spent on dredging.

The Corps recently received authority to dredge deeper than the project depth, but cost, environmental issues, and coordination with the states need to be addressed before the new authority can be exercised.

The Corps gives priority to commercial harbors. Because of funding and disposal problems, some recreational harbors that had shoaling problems in 2000 were not dredged.

Disposal in open water is the preferred option, and the second choice is beneficial re-uses such as beach nourishment, habitat restoration, road construction, and landfill covers. But the trend is toward use of the last choice—confined disposal facilities (CDFs).

Half of the existing disposal facilities are either filled or inactive, while the rest are rapidly filling up. The Corps now has the authority to pay a tipping fee to use private disposal facilities, such as at Green Bay Harbor, Wisconsin. The useful life of existing CDFs is being extended through improved consolidation by draining water from dredged material.

The quality of dredged material also is improving. "The more we dredge," said Vowinkel, "the more we get the pollutants out."

Finally, Vowinkel concluded, lower lake levels increase the impact of prop wash, stirring up the sediments and suspending the toxic materials in the water column.

Regulating Great Lakes Water Use

Gerry Galloway, Secretary of the United States Section, International Joint Commission

The International Joint Commission (IJC), established by the Boundary Waters Treaty of 1909, regulates actions that cause changes in the flows or levels of the Great Lakes. Humans can modify channels, regulate flows, and remove or add waters. Nevertheless, IJC Secretary Gerald Galloway told the workshop's participants, "Human control over the Great Lakes is relatively minor compared with what nature does."

The Boundary Waters Treaty established an order of precedence for competing uses of Great Lakes water:

1. Domestic and sanitary uses
2. Navigation
3. Hydropower
4. Riparian uses

IJC regulations involve a systematic balancing of these uses, as well as upstream, local, and downstream conditions. In addition, the IJC establishes maximum and minimum flow limits and rules that govern winter operations.

Decades have passed since the IJC has modified its regulations, but in that time use by recreational boaters has increased. In addition, we have come to recognize environmental constraints, such as the need for extremes in water levels to permit fish spawning and restore habitat.

In December 2000, in response to the growing importance of recreational boating and recognition of environmental needs, Canada and the United States initiated a five-year, \$20 million study to review its regulations and explore new factors, such as climate change, that may severely stress current regulatory regimes.

“Because of uncertainty in the future, we need to be cautious about taking water out of the Great Lakes,” he concluded “We need principles to govern removals and consumptive uses. There is no surplus water.”

Madison Takes Action on Climate Change

Jayne Somers, Climate Protection Engineer, City of Madison Engineering

To date, Madison is the only city in Wisconsin to develop a climate change action plan to reduce greenhouse gas emissions. Jayne Somers, the city’s climate protection engineer, explained that the plan, approved in 2000, sets a target of reducing Madison’s carbon dioxide emissions by 7 percent below 1990 levels by the year 2010.

Madison Gas & Electric (MG & E), which supplies 90 percent of the city’s electricity, will phase out its nuclear power plant by 2005. At present, nuclear supplies one-fourth of MG&E’s energy mix, so the impact on greenhouse gas emissions will be significant.

Because Wisconsin has no fossil fuel resources of its own, the state now spends \$6 billion importing from other states. When Somers gives presentations in Madison, she emphasizes that implementing the plan will save money and produce jobs in the energy-efficiency and renewable energy industries.

A number of measures are already in place. In addition to 100 miles of bicycle trails and lanes, 75 vanpools, and the nation’s oldest curbside recycling program, Madison has a new green power program. The program is the largest wind project east of the Mississippi River, sold out faster than any other green power program in the United States, and now has a waiting list.

“Key factors in approval of the climate action plan,” Somers told the workshop, “are that an alderperson championed it, we had support from the mayor and city council, and the climate resolution contains no funding commitment. Instead of a major review, each measure will be reviewed individually.”

Water Management under a Changed Climate

Frank H. Quinn, Senior Research Hydrologist, Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration

“We’ve had 30 years of high lake levels, but we have *no* equivalent experience of low water levels,” said Frank Quinn, senior research hydrologist with NOAA’s Great Lakes Environmental Research Laboratory. We know the flooding damage that occurs with high water, but the low water levels of the mid-1960s “didn’t last long enough to provide a good analog,” Quinn noted.

The years of 1998-1999 represent the largest one-year drop on record for May and June. And 1998-2000 had the largest two-year drop.

Water management goals in the face of climate change include sustainable development, equity (balancing competing interests), regional economic development, reduction of vulnerability, and minimization of risks and economic losses.

Management options include letting nature take its course, additional regulation, placing sills (a submerged ridge located at the bottom of the channel) in rivers to hold water levels up, and importing additional water from Canada. Additional regulation will still result in a reduction of flow in connecting channels, while diverting water can lead to importation of invasive species.

Quinn asked what would happen if we have 30 years of low water levels. We know what it would mean for electricity production, but not for marinas, commercial shipping, and wildlife habitats. “If we have another three or four years of low water,” he concluded, “I hope that meetings like this will lead to all interests coming together.”

Concluding Comments

Peter Sousounis, Director, Great Lakes Regional Assessment

Peter Sousounis, director of the Great Lakes Regional Assessment, outlined the objectives of the meeting and summarized the themes that emerged. The goals were to inform stakeholders about the latest findings of the U.S. National Assessment and ways to become actively involved in the assessment.

“Collaboration is the key,” Sousounis continued. “We need to share concerns, ideas, models, data, expertise, and results.” He urged participants to attend four additional workshops, the first scheduled for June 15, 2001, in Milwaukee, Wisconsin. “We hope this is the beginning of a long-term relationship,” he concluded.

Question and Answer Panel Discussion: Afternoon Session

Question 1: Ned Dikmen, publisher of Great Lakes Boating Magazine, about the information used to develop regulations,

Response: Gerald Galloway noted, "As opposed to 1977 or 1950, it is clear that we have considerably more technical backup, such as information technology, databases, and remote sensing, to help in decision-making."

Question 2: Peter Annin, of the Institute for Journalism and Natural Resources, asked for clarification of the impact of dredging on lake levels.

Response: Frank Quinn noted that maintenance dredging does not affect the levels. But dredging to deepen the draft in the connecting channels would lower upstream water levels unless compensating structures such as dikes are used to retard the flow.

Question 3: Bill Andresen, chairman of the Great Lakes Coalition, inquired why the Corps is slow to release information about beach replenishment.

Response: Scott Vowinkel replied that priorities change during the year because of funding constraints linked to increasing fuel costs and contractor availability.

Question 4: When asked about the capability of the dredging fleet, he noted that the contractors would be available if the demand is there. Rochelle Sturtevant, a Sea Grant extension agent, asked about using dredge material to reclaim mine sites, and Vowinkel noted that the Corps has authority for beneficial re-uses.

Question 5: Philip Keillor, of the Wisconsin Sea Grant, noted that public infrastructure such as pumping stations, water treatment plants, and municipal wastewater treatment plants are designed to a specific range of water levels. Quinn said that a committee is looking at infrastructure issues as part on an ongoing International Joint Commission Lake Ontario study.

Question 6: Tim Eder, of the National Wildlife Federation, asked about growth in demand for consumptive uses. Galloway noted that the IJC study found a potential for demand from nearby communities, though not from far away. Quinn added that impacts on tributary flows are a concern that has not yet been addressed.

Question 7: There was a question about Madison's use of electricity for lighting versus heating, Jayne Somers noted that surprisingly the city's use peaks in the summer. Power used for air-conditioning is greater than energy used for heating. When asked whether Madison should retain

nuclear in its energy mix, Somers cited economic and public relations reasons for eliminating the use of nuclear power.

Question 8: Jo Sandin, an environmental reporter with *The Milwaukee Journal Sentinel*, asked whether the Chicago Diversion is “an idea whose time is past?”

Response: Quinn replied that, because of climate change and low water levels, it might become necessary for the Corps to explore that question.

In response to a question from Keillor about information needs posed by climate change, Quinn said that we need better understanding of the impacts of land use on hydrology. “Right now we don’t have the tools and models to integrate the GCMs with the impacts of changing levels on ecosystems such as wetlands,” he said. “It is important to maintain funding so that we can maintain existing data and obtain better data for policymaking and engineering.”

Question 9: Reg Gilbert, of Great Lakes United, asked about the impacts on water movement and ecosystems. Quinn replied that we know that climate change will decrease ice cover, which will affect some species. Galloway added that the IJC study contains an appendix on cumulative impacts of temperature differentials. Moderator Patty Glick, of the National Wildlife Federation, added that the June 15 workshop in Milwaukee will address the impacts of climate change on water ecology.

Question 10: George Stone, of Milwaukee Area Technical College, asked how much lower lake levels need to go before they would be unique in the historical record. Quinn replied that another 8-inch drop would set a new record “and if it lasts another two or three years, we will be in the area of a new record in terms of duration.”

Speakers and Moderators

George Albercook, Senior Project Scientist, Resource Recycling Systems

Don Biganeiss, CEO, American Rescue Services, Inc.

Gerry Galloway, Secretary of the United States Section, International Joint Commission

Patty Glick, Climate Change and Wildlife Program Coordinator, National Wildlife Federation

Jeff Henderson, President, Harrison Marine Inc.

Brent Lofgren, Physical Scientist, Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration

Frank H. Quinn, Senior Research Hydrologist, Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration

George Ryan, President, Great Lakes Carriers' Association

Wayne Smith, Vice-President and General Manager, Seaway Marine Transport

Jayne Somers, Climate Protection Engineer, City of Madison Engineering

Peter Sousounis, Director, Great Lakes Regional Assessment

Scott G. Vowinkel, Civil Engineer, U.S. Army Corps of Engineers

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