LAKE TECUMSEH (Brinson Inlet Lake) WEIRS PROJECT
2012 POST WEIR MONITORING REPORT
To the Norfolk District Army Corps of Engineers

February 2013

Introduction: This report provides the 2012 vegetative monitoring results as required by special permit conditions contained in the Nationwide Permits (2) and (27), application number NAO-2006-0939, issued for the Lake Tecumseh Weirs Project in Virginia Beach, Virginia. The results from years 1 and 2 of 5 post weir monitoring and 2 years of pre weir monitoring are included.

This report also references Brinson Inlet Lake in lieu of Lake Tecumseh. The name of the lake was officially changed from Lake Tecumseh to Brinson Inlet Lake by the Virginia Beach City Council at the request of the descendants of Thomas Brinson. Mr. Brinson reportedly owned land and operated a port here in the 17th century when the lake was thought to have been an inlet to the Atlantic Ocean.

The purpose of monitoring was to document that two weirs completed in February 2011 by the U.S. Fish and Wildlife Service (Service) did not have an undesirable or unexpected secondary impact on wetlands adjacent to the lake. Undesirable effects would be a change in vegetative community type such as the conversion of vegetated wetlands to open water or the loss of one wetland type to another (e.g., forested to emergent). An exception would be the desired establishment of submerged or emergent aquatic vegetation in the open waters of the lake for the purpose of turbidity reduction and aquatic habitat for fish and waterfowl. Indices used to determine these effects included tree mortality, percent herbaceous cover, percent open water, species richness and persistence, and percent canopy closure within established permanent monitoring plots. Magnitude, frequency, and duration of flooding were also included.

The weirs were established across two non-natural drainage canals that connect Brinson Inlet Lake with Asheville Bridge Canal. The purpose of the weirs was to reduce turbidity discharge to Back Bay estuary, enhance wildlife habitat, restore wetland hydrology, and increase the number of days recreational boats could utilize the lake. Water quality and water level data from 2008 indicated the weirs would prevent the lower two-thirds of the wind tidal depth range from draining from the lake thereby preventing the release of a portion of an estimated 2,000 tons of silt discharged annually. The project also provided an estimated additional 193 days of recreational boating that otherwise were unavailable due to insufficient water depth.

All elevations in this report are to NAVD88 datum. The invert of the primary weir is at elevation +1.0 feet. The secondary weir is higher than +1.0 feet and permits water to flow around through adjacent wetlands. Prior to installation of the weirs, average high water in the lake was +1.1 feet and ranged from -0.74 to +1.8 feet with an overall mean of +0.5 feet (2008-2009 data).

The weirs had been established for 19 months when data was collected in 8 10-meter square tree plots and 24 1-meter square herbaceous plots on August 14 and 15, 2012. Data was collected in a single control plot outside the influence of the weirs as well. In addition, submerged and emergent aquatic vegetation cover in 26 1-meter square plots was collected in late October 2012

by students from the Center for Wetland Conservation at Christopher Newport University. A single factor analysis of variance (ANOVA) was used to determine if significant differences exist in tree mortality, percent herbaceous cover, and percent open water between years.

Tree Mortality: A single factor ANOVA indicated the average number of dead trees was not significantly different between years, $F(3) = 0.107$, $p = 0.955$ (Table 1). The percentage of dead trees was between 9 and 12 percent during the four years of sampling and did not increase after weir establishment. Percent canopy cover, obtained qualitatively, did not change by more than 3 points.

These results indicate no insignificant increase in tree mortality occurred and canopy cover did not change appreciably post weirs. Qualitative photographs of the 10-meter square plots are in Appendix B (attached CD).

Table 1. Average number and percent dead trees and canopy cover within 10-meter square tree plots for years 2009-2012 (n=8). Brinson Inlet Lake, Virginia Beach, Virginia. Results from control plot (n=1) appear in parentheses. ND = not determined.

TREE PLOTS	Pre-Weir		Post-Weir	
	2009	2010	2011	2012
Average Number Dead Trees	3.1	2.4	2.4	2.3
Percent Dead Trees	12.3 (3.2)	9.9 (9.1)	9.2 (9.1)	9.8 (10.3)
Percent Canopy Cover	ND	69 (85)	ND	66 (80)

Herbaceous Plant Cover: Average percent cover of herbaceous vegetation increased and percent open water decreased after establishment of the weirs (Table 2). A single factor ANOVA indicated the average percent cover of herbaceous vegetation and open water was significantly different between years, $F(3) = 23.85$, $p = 1.6E\text{-}11$; $F(3) = 18.42$, $p = 1.9E\text{-}9$, respectively. An ANOVA excluding the percent cover contributed by duckweed (*Lemna minor*) resulted in no significant differences in average percent cover indicating a significant portion of the increase in percent cover was due to the presence of duckweed $F(3) = 2.48$, $p = 0.066$. The Service concluded the weirs have not resulted in an undesired result such as an increase in open water or a decrease in herbaceous vegetation. Qualitative photographs of the 1-meter square plots are in Appendix B (attached CD).

Table 2. Average percent cover (APC) associated with herbaceous vegetation, duckweed, and open water within 1-meter subplots (n=24) for years 2009-2012. Brinson Inlet Lake, Virginia Beach, Virginia. Percentages from the control plot appear in parentheses. ND = not determined.

HERBACEOUS PLOTS	Pre-Weir		Post-Weir	
	2009	2010	2011	2012
Average Percent Cover	32	36	65	103
APC Excluding Duckweed	32 (ND)	36 (31)	52 (ND)	51 (20)
Average Percent Open Water	69 (ND)	56 (15)	38 (ND)	14 (77)

Species Richness and Persistence: A total of 30 plant species were recorded in all plots during the four years of monitoring (Table 3). Twenty-six species were recorded both pre and post weir

establishment. Six species were recorded exclusively prior to weir establishment and 5 exclusively post weirs. Two were recorded only at the control plot. The control plot had approximately half the number of species found in the treatment plots.

The majority of herbaceous cover consisted of 8 species or less. The remaining species contributed 10 percent or less each to percent cover. The most abundant herbaceous species were rice cutgrass (*Leersia oryzoides*), tearthumb (*Polygonum arifolium*), swamp loosestrife (*Decodon verticilliatus*), soft rush (*Juncus effusus*), and duckweed.

These data suggest the lake plots and control plot are dissimilar with respect to species richness indicating the control site may be most appropriate for comparing tree mortality. The Service considers herbaceous species recorded exclusively pre and post weir as insignificant with respect to the weirs because they contributed 1% or less to overall plant cover and may reflect sampling error rather than weir effects on plant cover. Exceptions are duckweed and Eurasian milfoil (*Myriophyllum spicatum*) which appear abundant since establishment of the weirs.

Submerged and Emergent Aquatic Lake Vegetation: Five species of submerged aquatic vegetation and 3 species of emergent or floating aquatic vegetation were recorded by the Christopher Newport News University Center for Wetland Conservation and the Service in September 2011 and October 2012 (Table 4). Quantitative monitoring recorded an average cover of 69% for the entire lake after establishment of the weirs in 2012. Submerged aquatic vegetation was not observed in the lake prior to establishment of the weirs. The majority of algae was present on the west side of the lake where runoff from the Hampton Roads Sanitation District farm fields is located and inflow from Red Wing Lake and a golf course was received.

Hydrology Monitoring: Lake levels were continuously recorded every three hours beginning in February 2008 using a Remote Data Systems Ecotone WM water level monitor. Prior to weir establishment approximately 15 drainage events below elevation -0.5 feet occurred annually and involved the loss of 70% or more of the lake's volume. Drainage occurred every month of the year. Water levels were seasonal with the lowest levels occurring between November and March and the highest levels between May and September. Since establishment of the weirs water levels have not been recorded below elevation 0.8 feet.

Flood frequency and duration in the lake were calculated for 24 months of continuous pre-weir data and 19 months of continuous post-weir data ending October 2012 (Table 5). These data demonstrate floods were less frequent, of lower magnitude, and of longer duration after establishment of the weirs. The median flood duration indicated 50% of floods were 2 days or more in duration pre weirs and increased to 6 days or more in duration post weirs. A 17% difference in seasonal flooding occurred with less floods during the growing season and more during the dormant season post weirs. The percentage of floods lasting 1 or more weeks increased after establishment of the weirs.

Table 3. Species presence and total number of species in plots by year. Brinson Inlet Lake, Virginia Beach, Virginia.

SPECIES PRESENCE/PERSISTENCE	All	Pre-Weir		Post-Weir	
	Control	2009	2010	2011	2012
Bald Cypress (*Taxodium distichum*)	X	X	X	X	X
Swamp Tupelo (*Nyssa sylvatica*)	X	X	X	X	X
Red Maple (*Acer rubrum*)	X	X	X	X	X
Sweet Gum (*Liquidambar styraciflua*)		X	X	X	X
Swamp Cottonwood (*Populus heterophyla*)		X	X	X	X
Wax Myrtle (*Myrica cerifera*)	X	X	X	X	X
Baccharis (*Baccharis halimifolia*)		X	X	X	X
Loblolly Pine (*Pinus taeda*)		X	X	X	
Tearthumb (*Polygonum arifolium*)		X	X	X	X
Rice Cutgrass (*Leersia oryzoides*)		X	X	X	X
Carex sp.	X	X	X	X	X
Lizard's-tail (*Saururus cernuus*)	X	X	X	X	X
Arrow Arum (*Peltandra virginica*)	X	X	X	X	X
Swamp Loosestrife (*Decodon verticilliatus*)		X	X	X	X
Marsh Fleabane (*Pluchea foetida*)		X	X	X	X
False Nettle (*Boehmeria cylindrical*)		X	X	X	X
Soft Rush (*Juncus effusus*)		X	X	X	X
Royal Fern (*Osmunda regalis*)	X	X	X	X	X
Spongeplant (*Limnobium spongia*)		X	X	X	X
Common Reed (*Phragmites australis*)	X	X	X	X	X
Pennywort (*Hydrocotyle* sp.)	X	X	X	X	X
Cattail (*Typha* sp.)		X		X	X
Smartweed (*Polygonum* sp.)		X		X	X
Virginia Day-flower (*Commelina virginica*)		X		X	X
Water Hemlock (*Cicuta maculate*)		X	X	X	
Mallow (*Malva* sp.)	X		X		X
Goldenclub (*Orontium aquaticum*)		X	X		
Primrose Willow (*Ludwigia* sp.)		X	X		
Pickerelweed (*Pontederia cordata*)				X	X
Big Cordgrass (*Spartina cynosuroides*)		X			
Three Way Sedge (*Dulichium arundinacedum*)			X		
Catbrier (*Smilax* sp.)	X				
Wild Rose (*Rosa* sp.)	X				
Poison Ivy (*Rhus toxicodendron*)		X			
Bedstraw (*Galium tinctorum*)				X	
Buttercup (*Runnunculus* sp.)				X	
Eurasian Milfoil (*Myriophyllum spicatum*)				X	
Duckweed (*Lemna minor*)				X	X
TOTAL NUMBER SPECIES	13	29	26	30	26

Table 4. Post weir observed and average percent cover of submerged and emergent aquatic species within 1-meter square plots within Brinson Inlet Lake. Virginia Beach, Virginia. Obs = qualitatively observed.

Species Cover Within Lake	2011 (n=30)	2012 (n=16)
Eurasian Watermilfoil (*Myriophyllum spicatum*)	7%	18%
Sago pondweed (*Potamogeton pectinatus*)	15%	-
Coontail *(Ceratophyllum demersum)*	25%	39%
Southern Naiad (*Najas guadalupensis*)	2%	12%
Water stargrass (*Heteranthera dubia*)	obs	-
Water Hyacinth (*Eichhoria crassipes)*	-	obs
Water Lettuce (*Pistia stratiotes*)	-	obs
American Lotus (*Nelumbo lutea*)	-	4%
Green Algae (type of spirogyra)	13%	32%
COMBINED AVERAGE COVER	62%	69%

Table 5. Descriptive statistics for pre (n=24 months) and post (n=19 months) weir flooding within Brinson Inlet Lake. Virginia Beach, Virginia. NA = not applicable.

Flood Magnitude, Frequency, and Duration	Pre-Weir	Post Weir	+/- change
Number of Flood Events Exceeding Weir Height (>1.2 feet)	36	23	NA
Flood Magnitude or Max. Depth (feet, mean sea level)	2.6	2.2	-0.4
Number Floods per Month (frequency)	1.5	1.2	-0.3
Average Flood Duration (days)	3.6	9.5	+5.9
Standard Deviation (days)	3.5	10.8	+7.3
Median Flood Duration (days)	2	6	+4
Flood Duration (range)	1-18 days	1-40 days	+22
Percent of 1-7 day Flood Duration	91.7%	73.6%	-18.1
Percent of 8-14 day Flood Duration	5.6%	21.1%	+15.5
Percent of 15-21 day Flood Duration	2.8%	15.8%	+13
Percent of 22-40 day Flood Duration	0%	10.5%	+10.5
Percentage of Floods April-October (growing season)	77.7%	60.9%	-16.8
Percentage of Floods November-March (dormant season)	22.3%	39.1%	+16.8

The Service believes the weirs and weather variability were responsible for these differences between pre and post weir flooding. The weirs restrict water movement in and out of the lake which may increase flood duration and reduce flood frequency. Flow restriction due to the weirs may also be responsible for the reduction in seasonal flooding by reducing or preventing short duration floods that normally occurred pre weirs. The reduction in flooding during the growing season would have reduced flood stress in plants and may be responsible for the increase in vegetative cover recorded.

However, local residents reported extended flooding during 2011 in multiple locations unaffected by the weirs (some up to 6 miles downstream) which the Service attributed to weather. This long duration flooding was not reported again in 2012. Weather related increases in flooding may explain the increase in flood duration recorded post weir because the weirs

permit wind driven floods to enter the lake and increased flood durations would have been captured by the monitoring device. Based upon qualitative observations and the flood study conducted prior to establishment of the weirs the Service believes weather is the greater determinant of these changes in flood frequency and duration recorded in Brinson Inlet Lake with the weirs having a smaller secondary effect.

Furthermore, flood depth or magnitude did not increase as predicted by independent flood studies conducted prior to establishment of the weirs. In fact, flood magnitude in the lake was 0.4 feet less than previous years after establishment of the weirs. This reduction in flood depth may also have been a result of weather variability however it is apparent the weirs do not increase the depth of flooding in or outside of the lake.

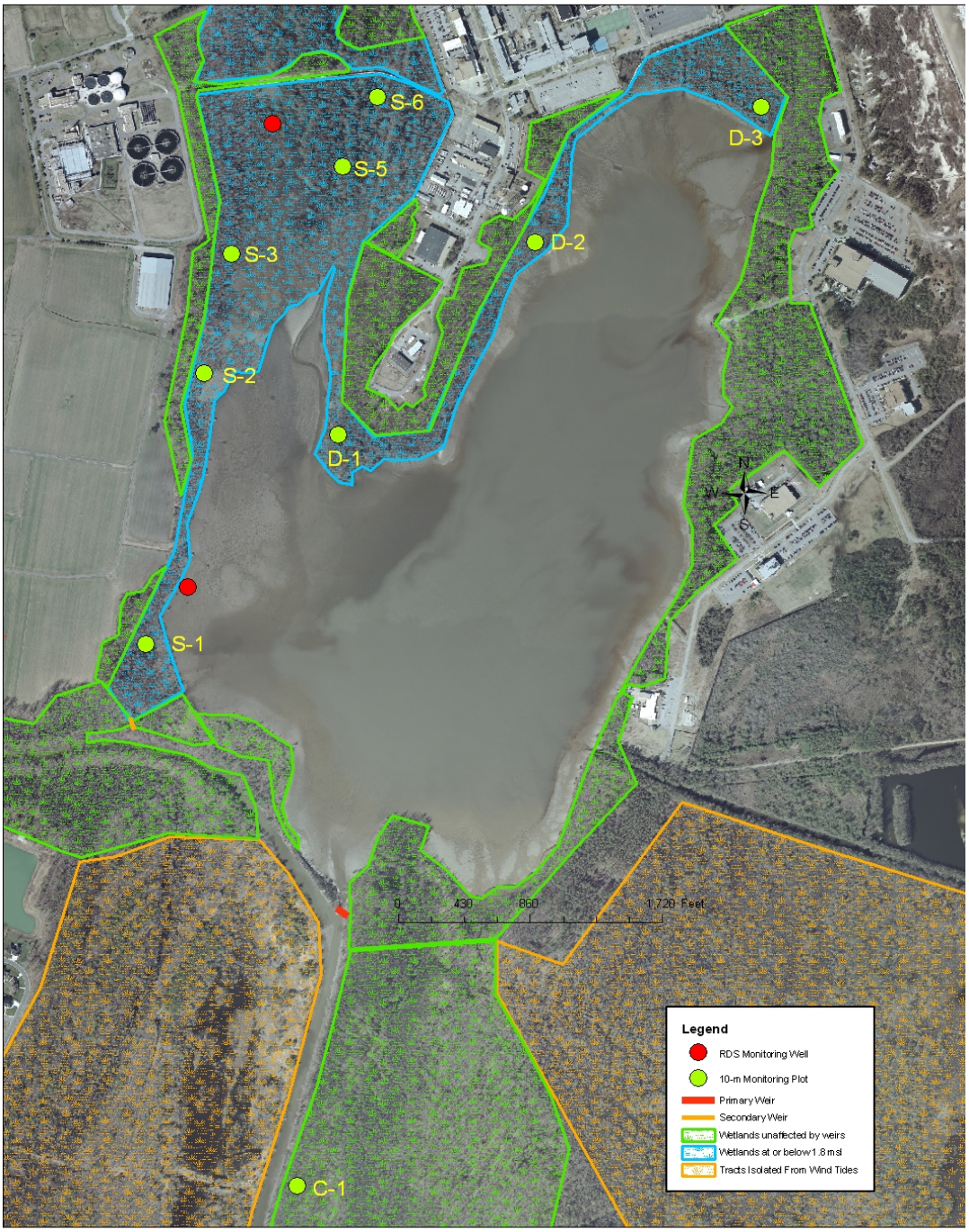
Conclusion: Since establishment of the weirs no significant differences in wetland tree mortality, herbaceous vegetation cover, percent open water, or species richness have been recorded. The Service considers the increase in submerged and emergent vegetation in the lake a desirable enhancement to aquatic life and waterfowl habitat. Flood magnitude and extent did not change or increase, as predicted by the flood studies, or cause detriment to wetlands and adjacent property. The Service concludes wetland vegetative response since the weirs' establishment has been favorable and there has been no undesirable or unexpected secondary impact to wetlands associated with Brinson Inlet Lake.

List of Appendices

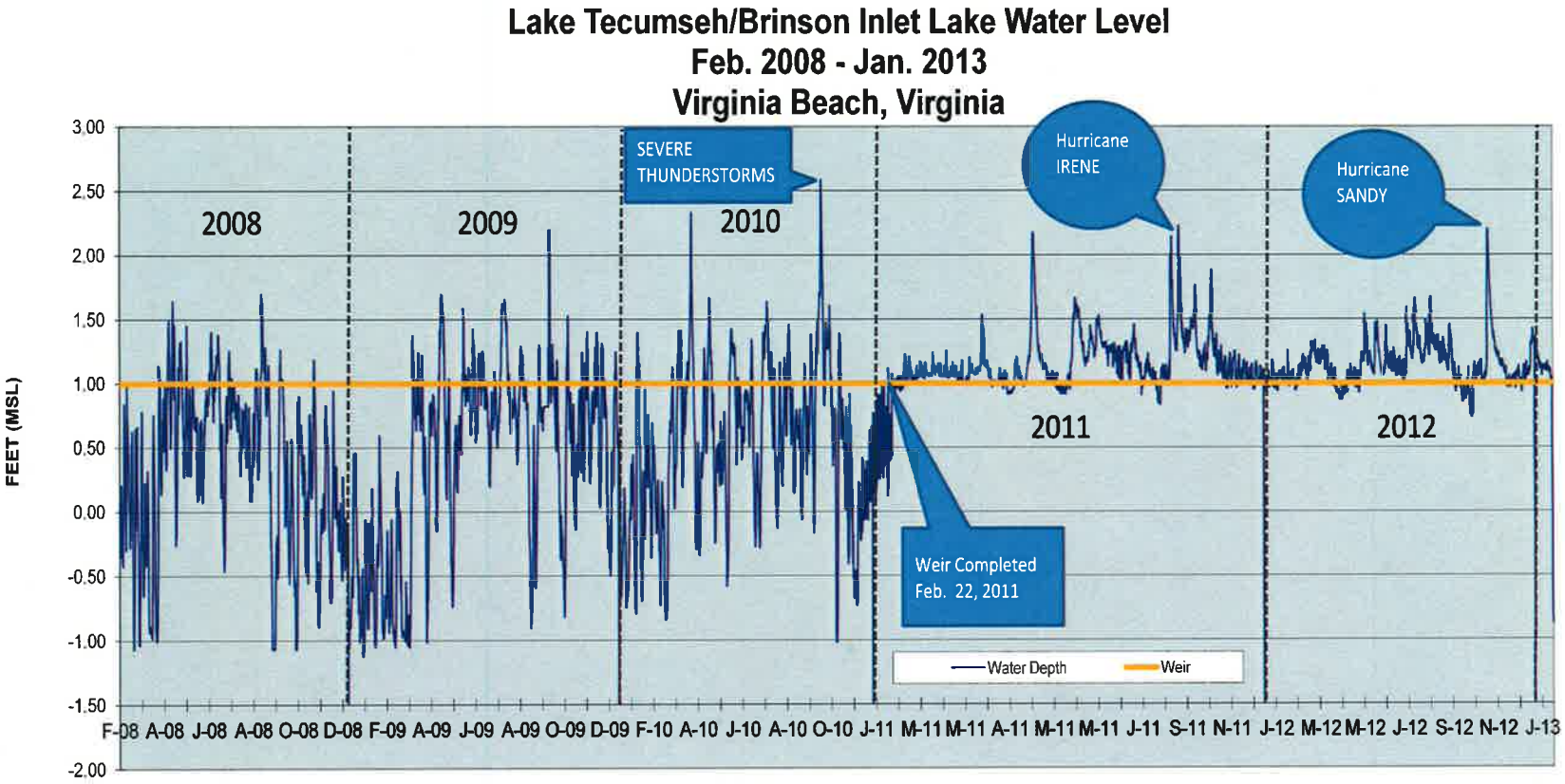
Appendix A: Monitoring plot location map.
Appendix B: Brinson Inlet Lake hydrograph 2008-2012.
Appendix C: Nationwide Permit certification with special conditions dated March 11, 2010.
Appendix D: 2012 qualitative photographs of monitoring plots on CD

Appendix A: Monitoring plot location map. Hydrology of area within blue polygon will be affected by the proposed weirs.

Wetlands Associated With Proposed Weirs
Lake Tecumseh, Virginia Beach, Virginia
Total Wetlands = 104 acres
Total Forested Wetlands = 66 acres



Appendix B: Brinson Inlet Lake hydrograph.



Appendix C: Nationwide Permit Certification

DEPARTMENT OF THE ARMY
NORFOLK DISTRICT, CORPS OF ENGINEERS
FORT NORFOLK, 803 FRONT STREET
NORFOLK, VIRGINIA 23510-1096

March 11, 2010

REPLY TO
ATTENTION OF:

Southern Virginia Regulatory Section
NAO-2006-0939 / 09-V1195 (Lake Tecumseh)

U.S. Fish and Wildlife Service
Mr. Willard Smith
6669 Short Lane
Gloucester, Virginia 23061

Dear Mr. Smith:

This is in regard to your Department of the Army permit application number NAO-2006-0939 (VMRC #09-V1195) to impact approximately 0.195 acres of subaqueous bottom with the stabilization of the eroding berm and the placement of two (2) low weirs across the main canal and a minor ditch between Lake Tecumseh and Asheville Bridge Canal in Virginia Beach, Virginia. This project also includes the installation of a boat portage rollover mechanism, which will allow boats to move between the Lake Tecumseh and Asheville Bridge Canal. The proposed impacts and work are detailed on the enclosed drawings titled "Permit Application" sheets 1-12, prepared by Langley and McDonald, Inc. dated December 14, 2009 and date stamped as received by this office on December 22, 2009.

Your proposed work as outlined above satisfies the criteria contained in the Corps Nationwide Permits (2) and (27), attached. The Corps Nationwide Permits were published in the March 12, 2007, Federal Register notice (72 FR 47) and the regulations governing their use can be found in 33 CFR 330 published in Volume 56, Number 226 of the Federal Register dated November 22, 1991.

This nationwide permit verification is contingent upon the following project specific conditions:

SPECIAL CONDITIONS:

1. **In order to ensure that there is no net loss of the 104 acres of jurisdictional wetlands that will be potentially secondarily affected with the installation of the proposed weir dams, monitoring of the existing adjacent wetlands will be required for a period of five (5) years from the date of installation. The location of the eight (8) permanent monitoring plots, each measuring ten (10) square meters, has already been established and are depicted on the attached plan titled "Wetlands Associated with Proposed Weirs, Lake Tecumseh, Virginia Beach, Virginia; Figure 1. Monitoring Plot Location Map, Lake Tecumseh, Virginia Beach, Virginia". These monitoring plots were established in the wetlands areas to be potentially affected by the weirs and are demarcated in the field with PVC poles. An additional control plot**

(C-1) was located in tidal wetlands south of Lake Tecumseh in an area that will not be affected by the weirs. The plots were sampled once before weir establishment in September 2009 and will be sampled once per year after the weirs have been installed between July and August for a period of a minimum of five (5) years. Monitoring will follow the attached monitoring plan titled "LAKE TECUMSEH WEIRS VEGETATIVE MONITORING PLAN AND PRE-WEIR ESTABLISHMENT MONITORING RESULTS" dated January 2010 and date stamped as received by this office on January 14, 2010 and will include the following:

a) **During each sampling event water depth, species, number of live and dead tree stems, and percent canopy cover will be recorded.**
b) **Herbaceous cover will be monitored by taking three replicate one-meter square sub-samples within each permanent plot for a total of twenty-four sub-plots. Percent cover and presence of dominant herbaceous species will be estimated within each meter square sub-plot.**
c) **Water depth will be recorded in the center of each subplot.**
d) **Photo documentation of all subplots and at corners of plots will be collected.**
e) **An annual written monitoring report detailing the results of the previous and current years sampling will be provided to the Norfolk District Corps of Engineers Regulatory Office and posted to the U.S. Fish and Wildlife Service Lake Tecumseh webpage within 90 days of completing data collection.**

If the Corps deems it necessary, additional monitoring beyond five years may be required. However, the additional monitoring will be dependent upon the results of the previous five years of monitoring.

2. **The Nationwide Permit 27 requires that any activities authorized result in the net increase of aquatic resource function and services. Therefore, you are required to report any and all positive increases in aquatic resource function and services associated with the installation of the weir dams. This information should be included in the yearly monitoring reports.**

3. **If it is determined that the installation of the weir dams in the main canal and/or minor ditch between Lake Tecumseh and Asheville Bridge Canal is causing the flooding of adjacent private properties, the weirs must be immediately retrofitted (i.e. notched to increase water flow in and out of the Lake) and/or removed completely in order to prevent any further degradation of private property surrounding Lake Tecumseh. The appropriate level of action will be determined accordingly after a thorough investigation has determined the exact cause of the flooding.**

4. **The boat portage rollover mechanism must be properly maintained and remain in working order at all times to allow proper navigable access between Lake Tecumseh and Asheville Bridge Canal. The repair and maintenance of the boat portage will be the sole responsibility of the U.S. Fish and Wildlife Service Back Bay National Wildlife Refuge (Service). Sign(s) will be posted at the portage mechanism that**

provide contact information and phone number(s) for individuals (caller) to notify the Service in the event that repair or maintenance is needed. Within 48 hours of receiving notification, the Service will conduct an assessment of the problem and contact the caller and the Corps with the results and time to repair. Repairs will be made as soon as possible but no more than five (5) business days after the initial assessment unless extenuating circumstances occur such as inclement weather, parts not immediately available, or major repairs required. The Service shall notify the caller and the Corps upon repairs being completed. The Service will inspect and perform regular preventative maintenance of the portage mechanism at a minimum of every four (4) months. Common parts needed for periodic maintenance and minor repairs of the structure shall be kept in stock by the Service. Any variance from these conditions will be communicated to the Corps and the caller immediately. The Service will be financially responsible for repairs made by others should the Service fail to reasonably meet these conditions for responsiveness and repair.

5. **Proper warning signage and/or any safety lights and signals, prescribed by the U.S. Coast Guard through regulations or otherwise, must be installed and maintained at the permittee's expense at the location of the two weir structures in navigable waters of the United States. The warning sign and beacon detail is depicted on Sheet 12 of 12 on the attached project plans.**

Provided the project specific conditions (above) and the Nationwide Permit General Conditions (enclosed) are met, an individual Department of the Army Permit will not be required. In addition, the Virginia Department of Environmental Quality has provided unconditional §401 Water Quality Certification for Nationwide Permit Number (2) and conditional §401 Water Quality Certification for Nationwide Permit Number (27) (see the "Section 401 Water Quality Certification" section of the attached enclosure). Furthermore, a permit may be required from the Virginia Marine Resources Commission and/or the City of Virginia Beach Wetlands Board, and this verification is not valid until you obtain their approval, if necessary. This authorization does not relieve your responsibility to comply with local requirements pursuant to the Chesapeake Bay Preservation Act (CBPA), nor does it supersede local government authority and responsibilities pursuant to the Act. You should contact your local government before you begin work to find out how the CBPA applies to your project.

Enclosed is a "compliance certification" form, which must be signed and returned within 30 days of completion of the project, including any required mitigation. Your signature on this form certifies that you have completed the work in accordance with the nationwide permit terms and conditions.

This NWP verification is valid for two years from the date of this letter. If this verification letter expires before the NWP itself expires, the activity continues to be authorized until the expiration date of the NWP, and it is not necessary to obtain a new verification. Project specific conditions listed in this letter continue to remain in effect after the NWP verification expires, unless the district engineer removes those conditions. All of the existing NWPs are scheduled to be modified, reissued, or revoked prior to March 18, 2012. We will issue a special public notice

announcing any changes to the nationwide permits when they occur; however, it is incumbent upon you to remain informed of changes to the NWPs. Pursuant to 33 CFR 330.6(b), activities which have commenced (i.e. are under construction) or are under contract to commence in reliance upon an NWP will remain authorized provided the activity is completed within twelve months of the date of an NWP's expiration, modification, or revocation, unless discretionary authority has been exercised on a case-by-case basis to modify, suspend, or revoke the authorization in accordance with 33 CFR 330.4(e) and 33 CFR 330.5 (c) or (d). Activities completed under the authorization of an NWP which was in effect at the time the activity was completed continue to be authorized by that NWP.

If you have any questions, please contact Katy Damico, of my staff, either via telephone at (757) 201-7121 or via email at katy.r.damico@usace.army.mil .

Sincerely,

R E Henderson Fo
J. Robert Hume, III
Chief, Regulatory Office

Enclosures

Cc: Mr. Tom Langley of Langley and McDonald, Inc., agent
Mr. Curtis Davey, Department of Environmental Quality
Mr. David O'Brien, NOAA Fisheries Service
Mr. Ron Grayson, Virginia Department of Historic Resources
Mr. Justin Worrell, Virginia Marine Resources Commission

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