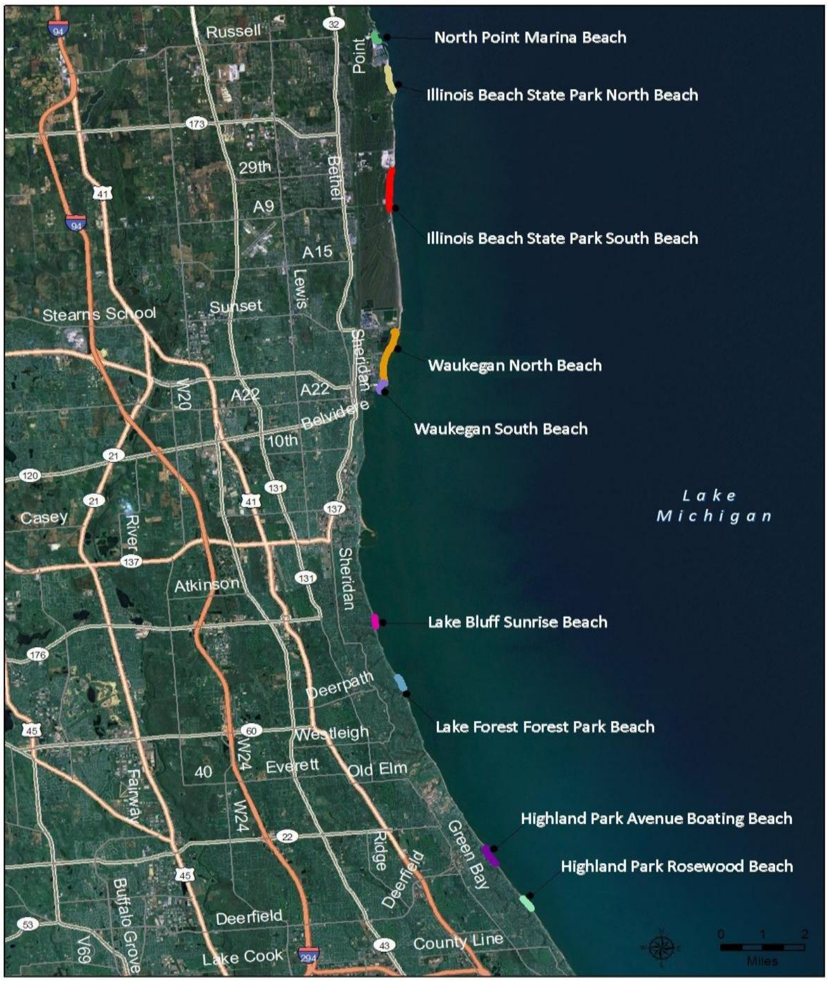
Total Maximum Daily Load

Shoreline Segments in Lake County, Illinois

9 Segments from North Point Marina Beach to Highland Park Rosewood Beach

Pathogen Indicators (*Escherichia coli*)



Illinois Environmental Protection Agency

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Lake Michigan Beaches Bacteria TMDL and Implementation Plan. Phase II

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List of Acronyms

BAV	Beach Action Value
BEACH Act	Beaches Environmental Assessment and Coastal Health Act
BMP	Best Management Practice
BPA	Beach Protection Area
BSS	Beach Sanitary Survey
cfu	colony forming unit
CPD	Chicago Park District
CSO	combined sewer overflow
CWA	Clean Water Act
E. coli	Escherichia coli
EAOC	Extended Area of Concern
FIB	fecal indicator bacteria
GI	green infrastructure
GIS	geographic information systems
GLCFS	Great Lakes Coastal Forecasting System
GLOCS	Great Lakes Observation System
GLFER	Great Lakes Fishery & Ecosystem Restoration
GLRI	Great Lakes Restoration Initiative
GM	geometric mean
HY	hatch year
IBSP	Illinois Beach State Park
IDNR	Illinois Department of Natural Resources
IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
km	kilometer
K-S test	Kolmogorov–Smirnov test
LA	load allocation
LC	loading capacity
LCHD	Lake County Health Department
LIDAR	Light Detection And Ranging
m	meter
m/s	meters per second

MGD	million gallons per day
mL	Milliliters
MLR	multiple linear regression
MOS	margin of safety
MS4	Municipal Separate Storm Sewer System
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSSD	North Shore Sanitary District
PRAWN	U.S. EPA’s Program tracking, beach Advisories, Water quality standards, and Nutrients
RC	reserve capacity
REML	Restricted Maximum Likelihood Estimator Deviance
RWQC	Recreational Water Quality Criteria
SSM	Single Sample Maximum
SSO	sanitary sewer overflow
STORET	U.S. EPA’s STOrage and RETrieval system
STP	Sewage Treatment Plant
STV	Statistical Threshold Value
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
Tukey’s HSD	Tukey’s Honestly Significant Difference
U.S. EPA	U.S. Environmental Protection Agency
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WLA	wasteload allocations
WQS	water quality standard

1. Introduction

Lake Michigan beaches and their coastal waters are a highly valued societal and ecological resource. These beaches are widely popular, highly used, and frequently monitored by stakeholders and local government to ensure that water quality conditions support safe and healthy recreation. This Total Maximum Daily Load (TMDL) document addresses 9 of the 51 Lake Michigan shoreline segments (10-digit HUC 0404000205) that are located in Lake County, IL, and were identified by the Illinois Environmental Protection Agency (IEPA) to be in nonattainment of their designated use, primary contact recreation. The remaining 42 segments will be addressed in two companion TMDL documents addressing the Lake Michigan shoreline segments that are in Cook County, IL.

From May through September, the various municipalities, through their beach management units, sample Lake Michigan beaches 5 to 7 days a week for bacteria. The Illinois Department of Public Health (IDPH) and the beach management authorities use these monitoring data to establish the day-to-day operational status of Lake Michigan beaches for swimming. In Lake County, swim bans occur when Escherichia coli (*E. coli*) bacteria exceed the water quality standard (WQS) of 235 colony-forming units (cfu) per 100 milliliters (mL).

The IEPA uses the number and duration of beach closures (i.e., swim bans) to assess whether the beaches are supporting use designations for primary contact recreation. Within Illinois, Lake Michigan Beaches are found to be "not supporting" of primary contact use when, on average, over a 3-year period, (1) there is one bathing area closure (i.e., swim advisory where no swimming is advised or swim ban) per year of less than 1 week's duration or (2) there is one bathing area closure per year of greater than 1 week's duration or more than one bathing area closure per year. Based on IEPA's methodology, these 9 segments in Lake County, IL, were not supporting primary contact use and were first included on Illinois' Section 303(d) list in 2006.

The Clean Water Act (CWA) and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop TMDLs for all waters on the Section 303(d) lists. A TMDL is the sum of the allowable amount of a pollutant that a water body can receive from contributing point and nonpoint sources and still meet WQSs. These 9 shoreline segments on Illinois' 303(d) list span a range of conditions from suburban beaches with hardened shorelines to more natural, undisturbed beaches in the Illinois Beach State Park (IBSP).

In this study, "shoreline segment" is used in place of "beach" because not all 51 segments are considered beaches as defined by the local management agencies. Beach managers monitor licensed beaches for public health concerns, yet some of the segments included in these TMDL documents do not have swimming access, and, therefore, are not monitored for swim advisory decisions by beach managers. However, all Lake Michigan nearshore waters have a designated use for primary contact recreation (77 Ill. Adm. Code 820.400); therefore, IEPA assesses any shoreline segment with available monitoring data at the time of the assessment to determine if they are supporting their designated use. For the segments without swimming access, although they are not currently monitored regularly, there was historical data available that indicated the segment was not supporting the designated use.

1.1 Priority Ranking

In accordance with U.S. EPA regulations, states develop a priority ranking to help prioritize waters for TMDL completion. The prioritization of Illinois' Section 303(d) list is done on a watershed basis instead of on individual water body segments. IEPA watershed boundaries are based on U.S. Geological Survey (USGS) 10-digit hydrologic units (HUC10).

In 2008 and 2010, prioritization was accomplished through the following steps:

- **Step 1.** The first step in the prioritization process is based on use designations, establishing a High, Medium and Low Priority for specific uses.
  - High Priority – watersheds containing one or more waters that are Not Supporting public and food processing water supply use.
  - Medium Priority – watersheds containing one or more waters that are Not Supporting aquatic life use, fish consumption use, or primary contact (swimming) use.
  - Low Priority – watersheds containing waters that are Not Supporting aesthetic quality use only.
- **Step 2.** The second step in the prioritization process is based on the overall severity of pollution.

The 51 Lake Michigan shoreline segments were grouped under a single entry for Lake Michigan (HUC 0404000205) and were assigned a lower priority relative to the remaining waters on the 303(d) list. States are not required to complete TMDLs in priority order, and where other factors, such as funding availability or existing complementary work, exist in a watershed with impairments, it may result in developing TMDLs other than those with highest priority.

1.2 Framework for Illinois Shoreline Segments TMDL Development

The 51 shoreline segments are addressed in three separate TMDL documents; one for Lake County, one for suburban Cook County, and one for Chicago. Each document contains descriptions for each beach, statistical models of *E. coli* concentrations, a table providing TMDLs for the addressed segments, and corresponding Implementation Plans by segment. Given the large geographical area to cover in the TMDL study and the varying amount of information available for the 51 different segments, a methodology was proposed where beaches could be grouped and analyzed together when they showed similar water quality conditions in response to factors that affect bacteria in beach waters (e.g., physical characteristics, potential sources). The segments in a group are examined in the same statistical analysis to leverage information between the segments. The methods used for this analysis were designed to consider multiple segments in one consistent format, while still ultimately providing individual TMDLs and implementation options.

This document provides the background information, calculation methods, and TMDLs for the 9 segments within Lake County. These segments are highlighted within **Table 1-1** out of all 51 listed segments. Since beaches can be known by various names, this document will attempt to use the IDPH name (i.e., the name used by local beach managers) as much as possible to avoid confusion. This table acts as a cross-reference from IDPH to Assessment and Local names.

Table 1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List

The segments were first listed in 2006 and also appear on subsequent 303(d) lists

Assess-ment Unit ID	Beach ID	IDPH Name	Assessment Beach Name	Name Note[1]	Length (meters)[2]	Monitoring County/ Organization
IL_QH-01	IL913512	North Point Marina Beach	North Point Beach		317	Lake/ LCHD
IL_QH-03	IL677426	Illinois Beach State Park North Beach	IL Beach State Park North		977	Lake/ LCHD

(continued)

Table 1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List (continued)

Assess-ment Unit ID	Beach ID	IDPH Name	Assessment Beach Name	Name Note[1]	Length (meters)[2]	Monitoring County/ Organization
IL_QH-04	IL087773	Waukegan Beach (North segment)	Waukegan North Beach	LCHD considers the Waukegan Beaches to be a single beach	2219	Lake/ LCHD
IL_QH-05	IL234945	Waukegan Beach (South segment)	Waukegan South Beach	LCHD considers the Waukegan Beaches to be a single beach	339	Lake/ LCHD
IL_QH-09	IL215601	Illinois Beach State Park South Beach	IL Beach State Park South		5648	Lake/ LCHD
IL_QI-06	IL195441	Lake Bluff Sunrise Beach	Lake Bluff Beach (Sunrise)		406	Lake/ LCHD
IL_QI-10	IL634222	Lake Forest Forest Park Beach	Lake Forest Beach (Forest Park)		809	Lake/ LCHD
IL_QJ	IL730475	Highland Park Rosewood Beach	Rosewood Beach		292	Lake/ LCHD
IL_QJ-05	IL782704	Highland Park Avenue Boating Beach	Park Avenue Beach		204	Lake/ LCHD
IL_QK-04	IL942128	Glencoe Park Beach	Glencoe Beach (Glencoe Park Beach)		172	Cook/ Glencoe Park District
IL_QK-06	IL108354	Winnetka Tower Beach	Tower Beach (Winnetka Tower Beach)		167	Cook/ Winnetka Park District
IL_QK-07	IL595016	Winnetka Lloyd Park Beach	Lloyd Beach (Winnetka Lloyd Park Beach)		172	Cook/ Winnetka Park District
IL_QK-08	IL750698	Winnetka Maple Park Beach	Maple Beach (Winnetka Maple Park Beach)		76	Cook/ Winnetka Park District
IL_QK-09	IL928218	Winnetka Elder Park Beach	Elder Beach (Winnetka Elder Park Beach)		121	Cook/ Winnetka Park District
IL_QL-03	IL984895	Kenilworth Beach	Kenilworth Beach		122	Cook/ Kenilworth Water & Light Dept.
IL_QL-06	IL637664	Wilmette Gillson Park Beach	Gillson Beach (Wilmette Gillson Park Beach)		445	Cook/ Wilmette Park District
IL_QM-03	IL505764	Evanston Greenwood Beach	Greenwood Beach (Evanston Greenwood Beach)		372	Cook/ Evanston Health Dept.
IL_QM-04	IL327651	Evanston Lee Beach	Lee Beach (Evanston Lee Beach)		222	Cook/ Evanston Health Dept.

(continued)

Table 1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List (continued)

Assess-ment Unit ID	Beach ID	IDPH Name	Assessment Beach Name	Name Note[1]	Length (meters)[2]	Monitoring County/ Organization
IL_QM-05	IL291926	Evanston Lighthouse Beach	Lighthouse Beach (Evanston Lighthouse Beach)		253	Cook/ Evanston Health Dept.
IL_QM-06	IL287401	Northwestern University Beach	Northwestern University Beach		272	Cook/ Evanston Health Dept.
IL_QM-07	IL601796	Evanston Clark Beach	Clark Beach (Evanston Clark Beach)		213	Cook/ Evanston Health Dept.
IL_QM-08	IL636205	Evanston South Beach	South Boulevard Beach (Evanston South Beach)		245	Cook/ Evanston Health Dept.
IL_QN-01	IL705276	Leone Beach	Touhy (Leone) Beach (Loyola Beach)	Considered part of Leone Beach by CPD	881	Cook/ CPD
IL_QN-02		Loyola Beach	Loyola (Greenleaf) Beach	Considered part of Leone Beach by CPD		Cook/ CPD
IL_QN-03	IL923491	Kathy Osterman Beach	Hollywood/ Osterman Beach (Kathy Osterman Beach)		525	Cook/ CPD
IL_QN-04	IL228136	Foster Avenue Beach	Foster Beach		297	Cook/ CPD
IL_QN-05	IL132842	Montrose Beach	Montrose Beach		837	Cook/ CPD
IL_QN-06	IL748682	Juneway Terrace Beach	Juneway Terrace (Juneway Terrace Park Beach)		57	Cook/ CPD
IL_QN-07	IL621748	Rogers Beach	Rogers Beach (Rogers Avenue Park Beach)		53	Cook/ CPD
IL_QN-08	IL120964	Howard Beach	Howard Beach (Howard Street Park Beach)		80	Cook/ CPD
IL_QN-09	IL603994	Jarvis and Fargo Beaches	Jarvis Beach (Jarvis Avenue Park Beach)	Considered 2 separate beaches, but sampled together by CPD	217	Cook/ CPD
IL_QN-10	IL259912	Hartigan North Beach	Pratt Beach (Pratt Blvd and Park Beach)	Considered Hartigan Beach by CPD	193	Cook/ CPD
IL_QN-11	IL274491	Hartigan North Beach	North Shore/ Columbia (North Shore Avenue Beach)	Considered Hartigan Beach by CPD	235	Cook/ CPD
IL_QN-12	IL798802	Hartigan South Beach	Albion Beach	Considered Hartigan Beach by CPD	61	Cook/ CPD

(continued)

Table 1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List (continued)

Assess-ment Unit ID	Beach ID	IDPH Name	Assessment Beach Name	Name Note[1]	Length (meters)[2]	Monitoring County/ Organization
IL_QN-13	IL586992	Thorndale or George Lane Beach	Thorndale Beach	Considered part of Kathy Osterman Beach by CPD	58	Cook/ CPD
IL_QO-01	IL666876	North Avenue Beach	North Ave. Beach		1691	Cook/ CPD
IL_QO-02	IL103378	Fullerton Shoreline	Fullerton Beach (Fullerton [Theater on the Lake])	Fullerton St. Shoreline (No swimming access)[3]	208	Cook/ CPD
IL_QO-03		North Avenue Beach	Webster Beach	Considered North Avenue Beach by CPD		
IL_QO-04		North Avenue Beach	Armitage Beach	Considered North Avenue Beach by CPD		
IL_QO-05	N/A	Schiller Avenue Shoreline	Schiller Beach	Schiller Ave. Shoreline (No swimming access)[3]	N/A	No Data Available
IL_QP-02	IL296528	Oak Street Beach	Oak St. Beach		338	Cook/ CPD
IL_QP-03	IL926480	Ohio Street Beach	Ohio St. Beach		171	Cook/ CPD
IL_QQ-01	IL820929	12th Street	12th St. Beach		325	Cook/ CPD
IL_QQ-02	IL461767	31st Street Beach	31st St. Beach		275	Cook/ CPD
IL_QR-01	IL865711	49th Street Shoreline	49th St. Beach	49th St. Shoreline (No swimming access)[3]	N/A	Cook/ CPD
IL_QS-02	IL118596	63rd Street Beach	Jackson Park/63rd St. Beach		666	Cook/ CPD
IL_QS-03	IL814025	Rainbow Beach	Rainbow		546	Cook/ CPD
IL_QS-04	IL589159	57th Street Beach	57th St. Beach		241	Cook/ CPD
IL_QS-05	IL288152	67th Street Shoreline	67th St. Beach	67th St. Shoreline (No swimming access)[3]	286	Cook/ CPD
IL_QS-06	IL581683	South Shore Beach	South Shore Beach		212	Cook/ CPD
IL_QT-03	IL376700	Calumet South Beach	Calumet Beach (Calumet South Beach)		404	Cook/ CPD

1 This column provides information on how individual segments are related to actual monitored beaches according to Chicago Park District (CPD).

2 "N/A" indicates that the beach is not indexed or monitored by IDPH; blank cells indicate that the beach is part of a larger beach for which a length is provided.

3 Although there is no swimming access at these segments, a TMDL is completed for these sites because the entire Lake Michigan shoreline is designated for primary contact recreation by the State of Illinois.

2. Overview of Impaired Segments

Lake County is located just south of the Illinois/Wisconsin border along Lake Michigan and is the northeastern-most county in the state of Illinois. The shoreline of Lake County is divided into 7 municipalities, each of which contains at least one impaired beach. These impaired beaches are, from north to south, North Point Marina Beach; IBSP North Beach; IBSP South Beach; Waukegan North Beach; Waukegan South Beach; Lake Bluff Sunrise Beach; Lake Forest Forest Park Beach; Highland Park Park Avenue Boating Beach; and Highland Park Rosewood Beach (**Figure 2-1**). The impaired segments from North Point Marina Beach southward to Waukegan South Beach are located on the Zion beach-ridge plain, which is an extensive coastal sand plain that extends from near Kenosha, WI, to North Chicago, IL. The landscape on the plain is composed of alternating dune sand ridges and marshy swales that were formed by coastal migration over time. The Zion plain supports a variety of habitats, including beach, foredune, coastal black oak sand savanna, sand prairie, fen, marsh, interdunal pond, and globally rare coastal wetland communities called panne (Illinois Department of Natural Resources [IDNR], 2011a). The Ravine/Bluff region stretches from Waukegan Harbor southward to Winnetka, IL, and includes Lake Bluff Sunrise Beach southward through Highland Park Rosewood Beach. In this area, bluffs run parallel to the shoreline and are cross cut by relatively small, closely grouped ravines hosting intermittent streams that drain into Lake Michigan (IDNR, 2011b).

The Lake Management Unit of the LCHD monitors *E. coli* levels in water from the Lake County beaches no less than 4 days a week during swimming season, approximately from Memorial Day to Labor Day. These measurements are used to issue beach advisories and swim bans at most Lake County beaches or to verify model predictions at the County's SwimCast beaches. SwimCast, a regression-based model, provides prediction of daily *E. coli* concentrations for several beaches in Lake County, IL. It relies on explanatory variables that include air and water temperature, wind speed and direction, precipitation, relative humidity, wave height, lake stage, insolation (light energy), and other water quality parameters.

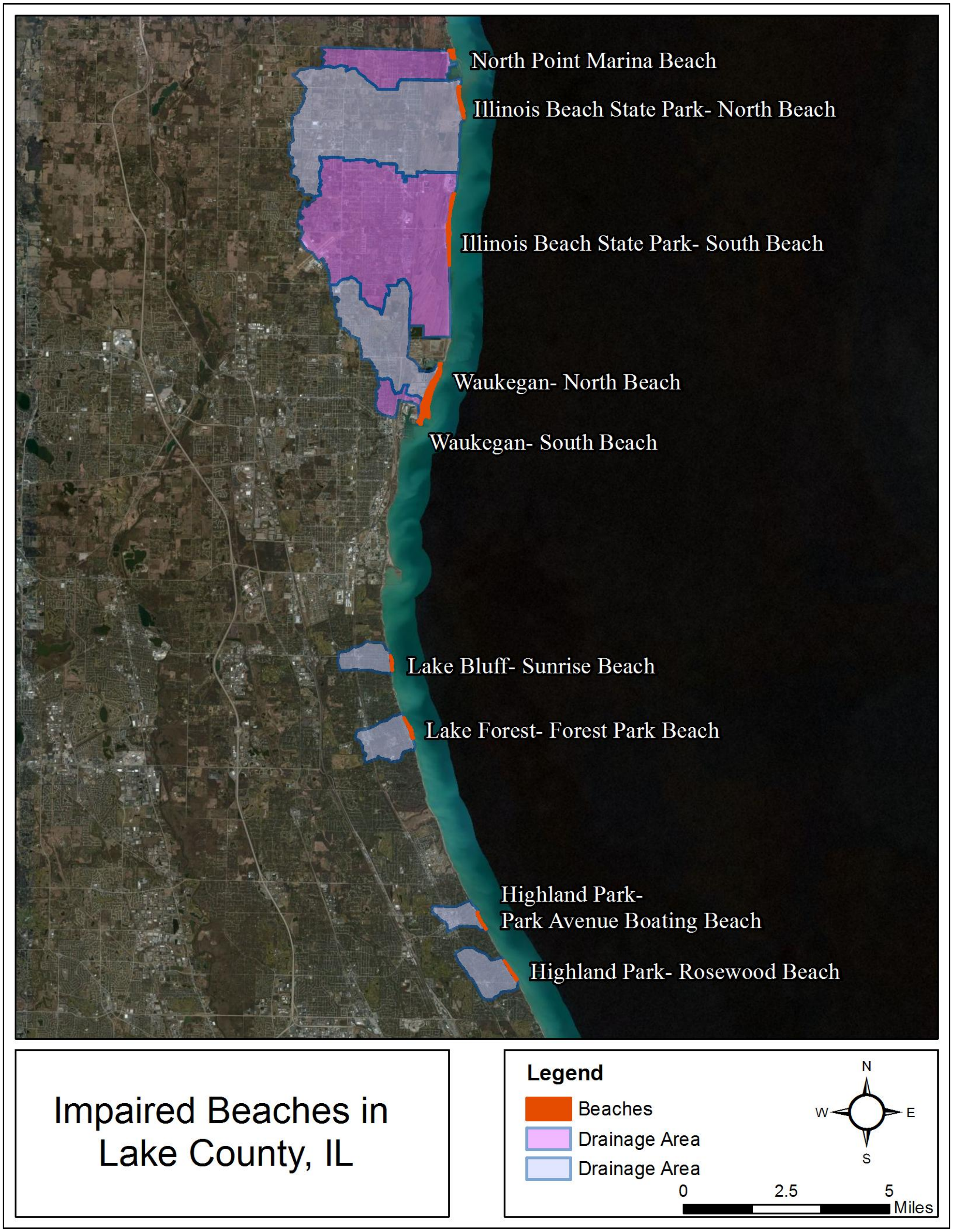


Figure 2-1. Drainage Areas for Impaired Beaches in Lake County, Illinois

2.1 Watershed Characterization

Along the Illinois shoreline there are very few stream outlets to Lake Michigan aside from the Chicago River and Calumet River in Cook County. The streams that drain the shoreline to the north are small in scale, ranging up to 10 kilometers (km) in length with a drainage area of up to 14.2 km^2. Ravines exist along the shoreline in the northern areas of the study region (i.e., Lake County) and tend to be the more likely conduits for delivery of point-source loads to the shoreline rather than free-flowing streams (Alliance for the Great Lakes, 2009). The "beachsheds," or watershed areas that contribute surface water flow to the impaired segment area, contain both surface drainage areas based on coastal ravines and some smaller tributary streams and a direct drainage area where overland runoff drains directly on to the beach. Drainage to the ravines and/or tributaries is defined based on both topography and any identified stormwater management systems, which may alter the natural hydrology of the region and transport stormwater runoff through pipes into the ravines and tributaries. The direct drainage area was determined through a geographic information systems (GIS) analysis using Light Detection And Ranging (LIDAR) remote sensing data. A bare earth elevation grid (i.e., influences of buildings removed) developed from the LIDAR data was used to define the portions of the grid that slope toward the defined beach area.

The primary source of bacterial contamination at beaches in Lake County, IL, has previously been identified as the gull population (Lake County Health Department [LCHD], 2003). Several of the municipalities along the coast have Municipal Separate Storm Sewer Systems (MS4s) and discharge stormwater to Lake Michigan, either through direct runoff or via surface water flow (e.g., discharge to coastal ravines). The ravines and tributaries may also contain other local stormwater outfalls or intersect aging sanitary sewer infrastructure, potentially introducing contamination to the beach. Industrial and other individual potential point sources of bacteria have been identified and are discussed in the following sections. No concentrated animal feeding operations are located within the Lake County beach drainage areas. An area extending 500 meters (m) along the shore from each end of the beach and 500 m from the beach into the lake is designated the "Beach Protection Area" (BPA). This distance has been identified as an area within which point-source discharges may be especially influential to the surrounding Lake Michigan shoreline (Scopel et al., 2006). Outside of this region, the lake effects are more likely to attenuate the effects of a point source so that a corresponding change in water quality could not be distinctly detected at a distance 500 m from the discharge. Therefore, the BPA is the focus area for identification of sources of bacteria along the shore and within the lake for each segment. The beachsheds are the focus area for identification of sources of bacteria inland.

2.1.1 North Point Marina Beach

North Point Marina Beach is located within the Kellogg Creek watershed in northern Lake County near Winthrop Harbor, IL. North Point Marina Beach is located in Zion beach-ridge plain. Southward migration of the coastline continues in the area of the North Point Marina Beach due to the net southerly transport of sediment from the Illinois/Wisconsin border toward the entrance of Waukegan Harbor (IDNR, 2011a).

The North Point Marina Beach is about 10.8 acres in size (**Figure 2-2**), and the land use is classified as Parks, Arboretums, and Botanical Gardens. The drainage catchment (as defined in the Kellogg Creek Watershed Plan [Lake County Stormwater Management Commission (LCSMC), 2008]) spans about 2 square miles; drains to North Point Marina Beach; and includes large areas of residential land, parks, and transit systems. The catchment also contains smaller areas of cropland, grassland, forest, and wetlands. Dead Dog Creek flows from the northwest corner of the drainage catchment toward the southeast and empties into Lake Michigan through a channel just north of the beach. A second Lake Michigan tributary also drains the suburban areas of Kenosha, WI, and Winthrop Harbor, IL, before discharging into the same channel. Dead Dog Creek has been channelized since early industrial development and no longer meanders with intermittent wetland flooding, as it would without channelization (IDNR, 2011a). The Lake County Stormwater Commission has nearly completed Phase 1 of a restoration at Dead Dog Creek in order to reduce channelization and increase stream meandering and connectivity to the riparian zone (Phase 2 is described in Table 5-1). There are no point-source discharges within the drainage catchment. However, the Kellogg Creek Watershed-Based Plan indicates that "surface water flow that enters Spring Bluff Nature Preserve via Dead Dog Creek tends to spread throughout the wetlands during storm events rather than staying within the creek channel, which may be contributing pollutants to the wetland communities as well as modifying hydrologic conditions of those communities. Culvert obstruction is exacerbating this condition by forcing water out of its channel prematurely" (LCSMC, 2008).

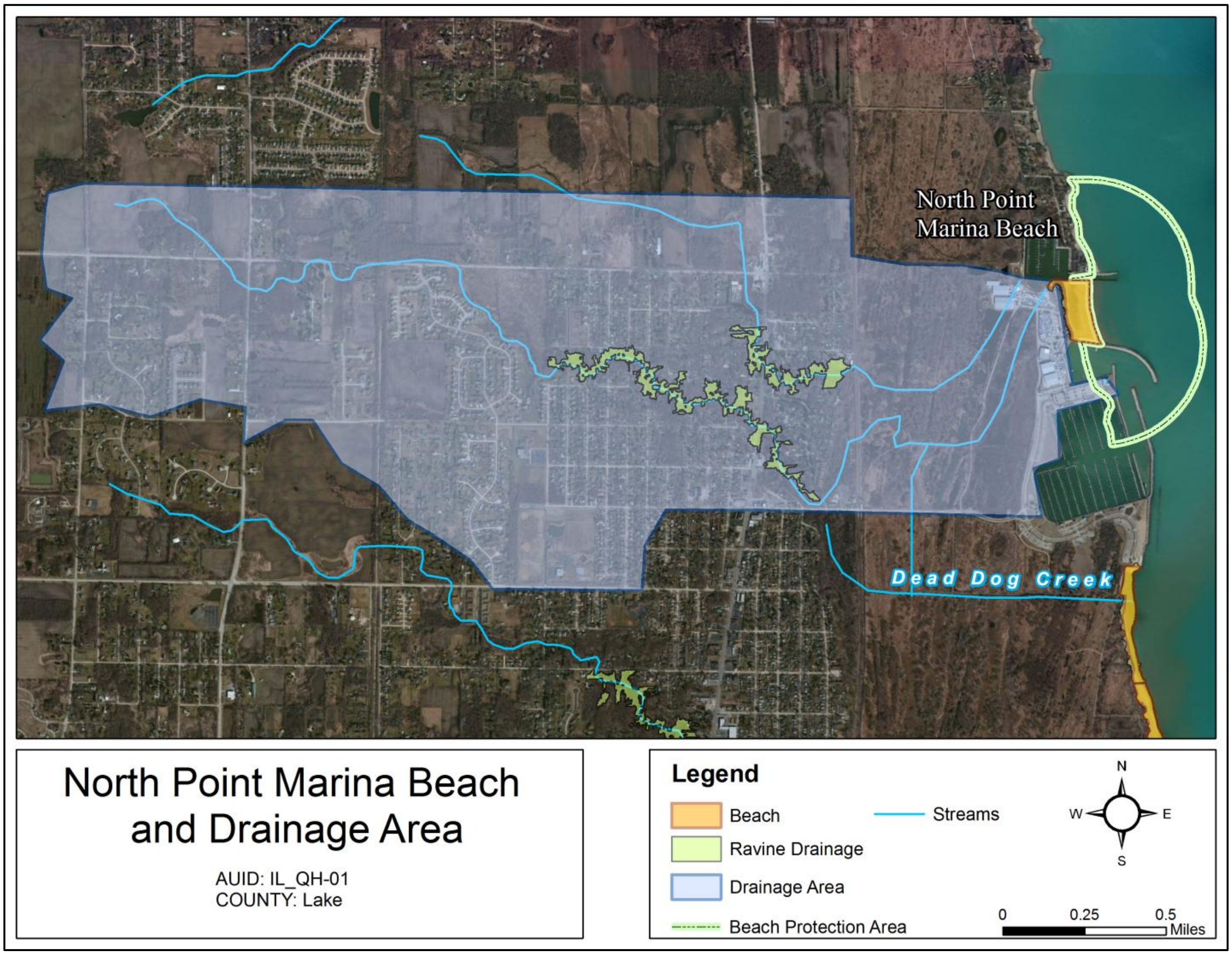


Figure 2-2. North Point Marina Beach and Drainage Catchment within Illinois

The east-facing embayment at North Point Marina Beach is flanked by two jetties—a small one to the north and a longer one to the south that protects the entrance to North Point Marina, located directly to the south of the beach. The southern rubble-mound jetty constructed in 1987–1988 creates a partial barrier to the net-southerly transport of sediment along the coastline. Sand accumulates along this partial barrier, contributing to shallower water depths in this area and allowing wave action to move sand southward around the north breakwater and into the area near the marina entrance (IDNR, 2011a).

Table 2-1 shows information about beach monitoring and closures for the past 5 years as reported in the U.S. EPA's eBeaches system. The LCHD studied possible sources of *E. coli* contamination at the North Point Marina Beach in 2002. The study showed that gulls were the primary source (51%) of bacterial contamination at the time, followed by unidentified sources (28%), human/sewage sources (14%), and deer/raccoon/sheep (7%) (Soucie and Pfister, 2003). Gulls favor open sand, and the accumulation of sand along the jetty bordering the southern boundary of North Point Marina Beach has increased the amount of open sand and the number of gulls on the beach over time. The sandy beach area increased from 1½ acres in 1990 to almost 9 acres in 2011 (Abderholden, 2011). In addition, the beach is directly adjacent to the largest marina on the Great Lakes. The marina contains a floating dock system of 1,500 boat slips, whose rentals include sanitary pump-outs among other amenities (IDNR, 2012b).

North Point Marina Beach is owned by the State of Illinois and managed by the Illinois Department of Natural Resources (IDNR). Together with the IBSP beaches and the North Point Marina, the North Point Marina Beach is designated as part of the Adeline Geo-Karis Complex. The Lake Management Unit of the LCHD monitors *E. coli* levels in water from this beach 4 days a week during swimming season, from Memorial Day to Labor Day. Swim bans are issued if *E. coli* concentrations in the water samples are greater than 235 cfu/100 mL. Beach advisories (i.e., notice to beachgoers to avoid swimming) may also be issued for 48 hours after a large rain event (LCHD, 2012a).

Table 2-1. Monitoring and Single Sample Maximum WQS Exceedances for North Point Marina Beach in the Past 5 Years

Assessment Units Mapped to Indexed Beaches				BEACH[1] Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	STORET[2] Station ID	Impaired Segment Name	Years	Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	Gull Counts
IL_QH-01	NORTHPT	North Point Beach	2007	8	9.9	5/23/2007	9/1/2007	104	County	X		X	X	X	X	X		X
▪ Source detection study in 2003 - major sources = avian/gulls and human/sewage			2008	19	2.7	5/27/2008	8/28/2008	126	STORET	X		X	X	X	X	X		X
			2009	4	22	5/26/2009	9/8/2009	115	STORET	X		X	X	X	X	X		X
			2010	9	7.7	5/27/2010	9/4/2010	108	STORET	X		X	X	X	X	X		X
			2011	12	2.8	5/20/2010	9/1/2011	114	STORET	X		X	X	X	X	X		X

[1] BEACH = Beaches Environmental Assessment and Coastal Health

[2] STORET = U.S. EPA's STOrage and RETrieval system

2.1.2 Illinois Beach State Park – North Beach

The IBSP is located about a mile and a half south of North Point Marina Beach in northern Lake County and is divided into North and South (described below) units, each with a beach (i.e., IBSP North Beach and IBSP South Beach). The units are separated by a strip of land that is part of Zion, IL, and contains Hosah Park and the decommissioned Zion Nuclear Power Station (IDNR, 2011a). The Zion Nuclear Power Station is a former nuclear generating facility that has been converted into an electrical grid voltage stabilizing facility and is operated by Exelon Generating Company. The North Unit is located directly south of North Point Marina between the municipalities of Winthrop Harbor and Zion and consists of land that includes former residential housing, limited former commercial and industrial land, and Camp Logan, a historic military training facility (IDNR, 2011a). IBSP North Beach is part of the Kellogg Creek Watershed on the Zion beach-ridge plain.

IBSP North Beach spans 8 acres in size and drains a catchment of approximately 9 square miles. The land use at IBSP North Beach is classified as Parks, Arboretums, and Botanical Gardens. The drainage catchment (**Figure 2-3**) contains mostly residential land, parks, transit, and cropland. There are also small areas of wetland and forest, as well as utility/waste facilities, a landfill, and land in industrial/commercial use. Two creeks flow through the IBSP North Beach drainage catchment: an unnamed tributary (with a north-south canal connection to Dead Dog Creek) and the more substantial Kellogg Creek. Kellogg Creek, a perennial stream, flows through most of the IBSP North Beach drainage catchment and empties into Lake Michigan about a quarter mile south of IBSP North Beach within the eroded bluff/ravine system in IBSP just outside the IBSP North Beach BPA (IDNR, 2011a). The channel bottom of Kellogg Creek within IBSP is sand and, in some locations, muck with low stability substrates. It is likely that this condition is caused by sediments eroded from upstream portions of the watershed settling out or collecting here in the low-gradient IBSP (LCSMC, 2008). The creek has been channelized since early industrial development and no longer meanders with intermittent wetland flooding as it would without channelization. The Kellogg Creek connection to Lake Michigan can become obstructed by a sand bar dam created by littoral drift, which is broken during high river flows (LCSMC, 2008). Runoff drains directly into Kellogg Creek along a 2.5-mile stretch about halfway from the headwaters in the center of the IBSP North Beach drainage catchment.

IBSP North Beach has an unarmored shoreline and is subject to severe shoreline recession. This process is exacerbated by the partial barrier to southward sediment transport formed by the North Point Marina jetties to the north. Beach replenishment of sand is routine at the northern end of IBSP North Beach (IDNR, 2011a).

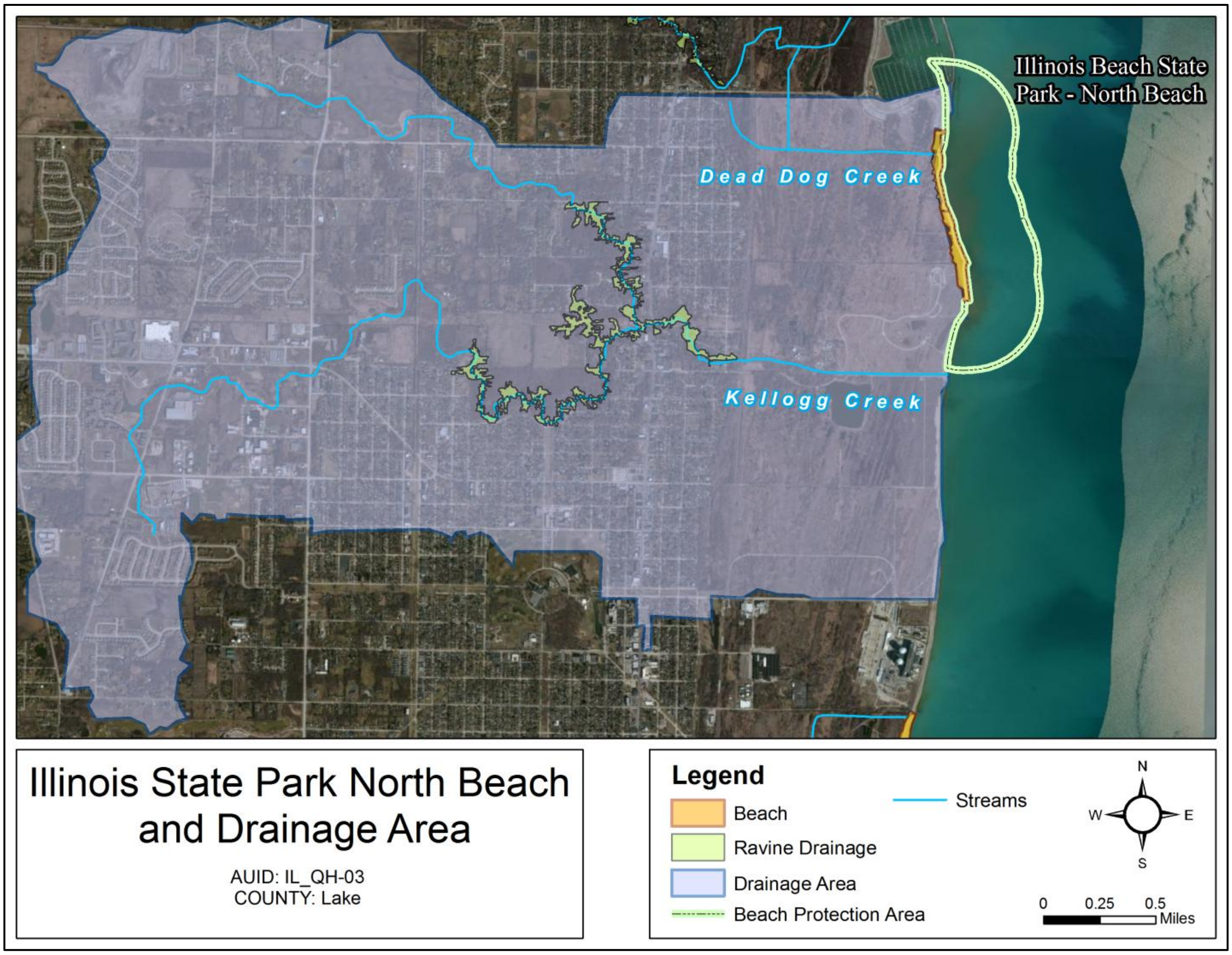


Figure 2-3. IBSP North Beach and Drainage Catchment

Table 2-2 shows information about beach monitoring and closures for the past 5 years. Although LCHD has not conducted an analysis specific to IBSP North Beach, gulls are generally the primary source of bacterial contamination at beaches in Lake County, IL (LCHD, 2003). In addition, the beach is directly adjacent to the largest marina on the Great Lakes. The marina contains a floating dock system of 1500 boat slips, whose rentals include sanitary pump-outs among other amenities (IDNR, 2012b). A 2003 study of algal mats at the IBSP showed that algal mats may be a secondary source of bacteria in beach water. *E. coli* can exist on dry algal mats for 6 months, potentially reintroducing the bacteria to the water body upon rewetting (Whitman et al., 2003). The Cities of Zion and Winthrop Harbor have separate sanitary and stormwater sewer systems. Both municipalities have MS4 permits that allow stormwater runoff to drain to Kellogg Creek.

IBSP North Beach is owned by the State of Illinois and managed by the IDNR as part of the Adeline Geo-Karis Complex. The Lake Management Unit of the LCHD monitors *E. coli* levels in water from this beach 4 days a week during swimming season from Memorial Day to Labor Day. Swim bans are issued if *E. coli* concentrations in the water samples are greater than 235 cfu/100 mL. Beach advisories may also be issued for 48 hours after a large rain event (LCHD, 2012a).

Table 2-2. Monitoring and Single Sample Maximum WQS Exceedances for IBSP North Beach in the Past 5 Years

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	STORET Station ID	Impaired Segment Name	Years	Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	Gull Counts
IL_QH-03	ILBEACHN	IL Beach State Park North	2007	10	1.6	5/23/2007	9/1/2007	194	STORET	X		X	X	X	X	X		X
▪ Olyphant (2005) developed multiple regression models relating hydrometeorological data to *E. coli* concentrations			2008	8	1.1	5/27/2008	8/28/2008	128	STORET	X		X	X	X	X	X		X
			2009	6	2.3	5/26/2009	9/3/2009	111	STORET	X		X	X	X	X	X		X
			2010	5	1	5/28/2010	9/3/2010	102	STORET	X		X	X	X	X	X		X
			2011	5	2.8	5/20/2011	9/1/2011	109	STORET	X		X	X	X	X	X		X

2.1.3 Illinois Beach State Park – South Beach

IBSP South Beach is about 2 miles south of IBSP North Beach in the Dead River watershed on the Zion beach-ridge plain. IBSP South Beach is part of the South Unit of the IBSP in Zion, IL. The South Unit was the original IBSP established in 1953 in response to expanding industrial land uses to the south, including the former Johns Manville manufacturing plant (now a Superfund site) and Waukegan Generating Station (IDNR, 2011a).

IBSP South Beach is a long, thin beach about 41 acres in size with a drainage catchment of approximately 8.5 miles (**Figure 2-4**). The land use at IBSP South Beach is classified as Parks, Arboretums, and Botanical Gardens. The drainage catchment contains mostly residential land, roadways, parks, and an airport with smaller areas of forest, wetlands, utility/waste facilities, and commercial/industrial businesses. The largest stream in the drainage catchment is Bull Creek, which flows east from the western edge of the drainage catchment. Runoff from surrounding land drains into Bull Creek along a 1.25-mile segment of the stream in the center of the IBSP South Beach drainage catchment. Bull Creek is a perennial stream that drains to Lake Michigan Park through an eroded bluff/ravine system. A portion of Bull Creek becomes Dead River once it descends from the uplands, turns southward, and begins to traverse the sand plain covered by the IBSP. The Dead River is an unaltered natural tributary to Lake Michigan that flows through coastal wetlands (IDNR, 2011a). A portion of Bull Creek also travels north through the sand plain and enters Lake Michigan at the north end of IBSP South Beach.

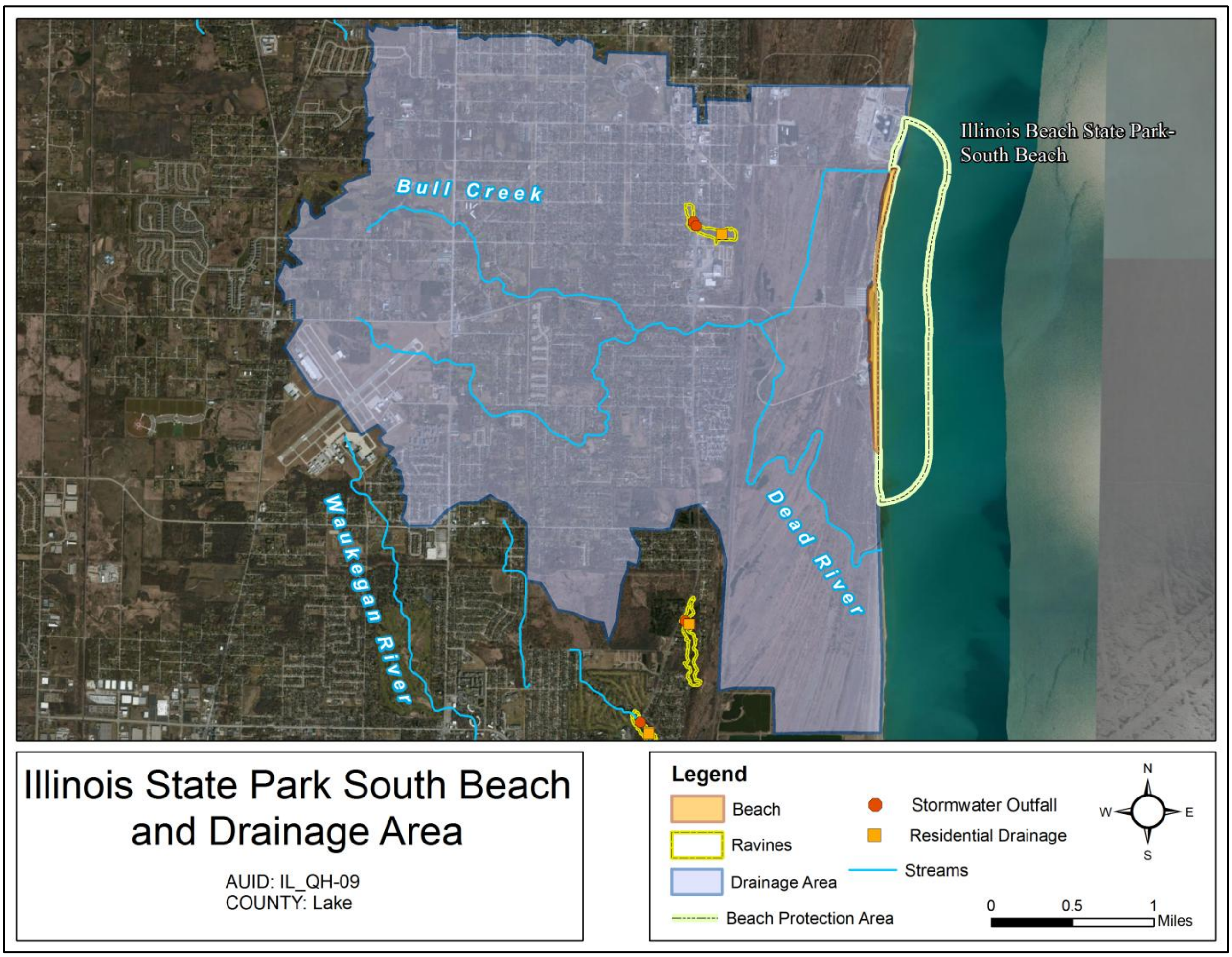


Figure 2-4. IBSP South Beach and Drainage Catchment

IBSP South Beach has an unarmored shoreline. Shoreline recession is less along this beach than along the IBSP North Beach. Erosion processes are most severe south of the North Point Marina jetties and decrease southward to the mouth of the Dead River. Beach replenishment of sand is occasional at the northern end of IBSP South Beach (IDNR, 2011a).

Table 2-3 shows information about beach monitoring and closures for the past 5 years. The LCHD studied possible sources of *E. coli* contamination at South Beach in 2003. The study showed that birds were the primary source (53%) of bacterial contamination at the time, followed by human/sewage sources (26%), unidentified sources (15%), and dog/rodent (6%) (Soucie and Pfister, 2003). A campground is located in the South Unit of IBSP and includes sanitary facilities and a sanitary dump station (IDNR, 2012a). A 2003 study of algal mats at the IBSP showed that algal mats may be a secondary source of bacteria in beach water. *E. coli* can exist on dry algal mats for 6 months, potentially reintroducing the bacteria to the water body upon rewetting (Whitman et al., 2003).

North of Bull Creek is a small ravine, which discharges to the wetlands within IBSP, with three stormwater outfalls. Less than a quarter mile north of South Beach are 3 point-source discharges from National Pollutant Discharge Elimination System (NPDES) permit holder Exelon Generating Company. Another point discharge from the same company is located about three-quarters of a mile inland. The Exelon Generating Company discharges an average of 1,815 million gallons of water to Lake Michigan each day; however, this discharge made up mostly of industrial cooling water is not expected to constitute a source of bacteria or pathogens.

IBSP South Beach is owned by the State of Illinois and managed by the IDNR as part of the Adeline Geo-Karis Complex. The Lake Management Unit of the LCHD monitors *E. coli* levels in water from this beach 4 days a week during swimming season from Memorial Day to Labor Day (LCHD, 2012a). Swim bans are issued if *E. coli* concentrations in the water samples are greater than 235 cfu/100 mL. Beach advisories may also be issued for 48 hours after a large rain event (LCHD, 2012a).

Table 2-3. Monitoring and Single Sample Maximum WQS Exceedances for IBSP South Beach in the Past 5 Years

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	STORET Station ID	Impaired Segment Name	Years	Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	Gull Counts
IL_QH-09	ILBEACHS	IL Beach State Park South	2007	17	1.4	5/23/2007	9/1/2007	95	County			X	X	X	X	X		X
▪ Source detection study in 2003 - major sources = avian/gulls and human/sewage; some contributions from dog and rodent sources as well			2008	9	1.7	5/27/2008	8/28/2008	134	STORET			X	X	X	X	X		X
			2009	8	2.5	5/26/2009	9/8/2009	119	STORET			X	X	X	X	X		X
			2010	3	5	5/27/2010	9/3/2010	107	STORET			X	X	X	X	X		X
			2011	5	1.8	5/20/2011	9/5/2011	100	STORET			X	X	X	X	X		X

2.1.4 Waukegan Beaches

The beaches in the city of Waukegan are located about 2.25 miles south of IBSP South Beach in the Dead River Watershed on the Zion beach-ridge plain. The Waukegan beaches include Waukegan North Beach and Waukegan South Beach. Both Waukegan beaches are in the city of Waukegan. The beaches are bordered by the Midwest Generation, LLC, coal-fired power plant; the North Shore Sanitary District (NSSD) Sewage Treatment Plant (STP); and the City of Waukegan North Beach Park. The Johns Manville Superfund site is located to the north, and the Outboard Marine Corporation Superfund site is located to the west. Both beaches are located within the Waukegan Harbor Area of Concern (Environmental Consulting & Technology, Inc. [ECT], 2008).

Waukegan North Beach is much larger (103 acres) than the adjacent Waukegan South Beach (11 acres) (**Figure 2-5**). Waukegan North Beach is classified as about 30% beach, about 25% park, and about 20% wetlands; lakes, streams, and indeterminate vegetation account for the last 25% of land use. The drainage catchment for Waukegan North Beach is about 3.5 square miles and contains mostly residential land, roadways, utility/waste facilities, and parks, with smaller areas of wetlands, golf courses, forest/grassland, and land in commercial/industrial use.

Waukegan South Beach's land use is classified as Parks, Arboretums, and Botanical Gardens. The drainage area around Waukegan South Beach is slightly more than 0.5 square miles and contains mostly residential land, transit, and vacant land available for redevelopment. There are also smaller areas of parks, grassland, wetlands, utility/waste facilities, and commercial/industrial development. This half-square mile area does not drain directly to Waukegan South, but to the channel west of the beach, which is still within the BPA. This drainage area also contains one small ravine.

A south-facing jetty extends into Lake Michigan from the southern tip of North Beach. Waukegan South Beach is a southeast-facing embayment flanked by 2 jetties (one facing south, and the other facing northeast). These beaches are part of a sediment transport cell that transports sediment from the Illinois/Wisconsin border southward to Waukegan Harbor. Both beaches are located in the portion of the cell that has conditions favorable for the accumulation of sand (IDNR, 2011a).

Table 2-4 shows information about beach monitoring and closures for the past 5 years. The LCHD studied possible sources of *E. coli* contamination at Waukegan South Beach in 2002. The study showed that gulls were the primary source (55%) of bacterial contamination at the time, followed by unidentified sources (34%), human/sewage sources (7%), and deer/cow/pig (4%) (Soucie and Pfister, 2003). Gulls can be attracted to beaches by garbage, and the Waukegan beaches have had comments about uncollected trash bins during non-swim season (IDNR, 2011b).

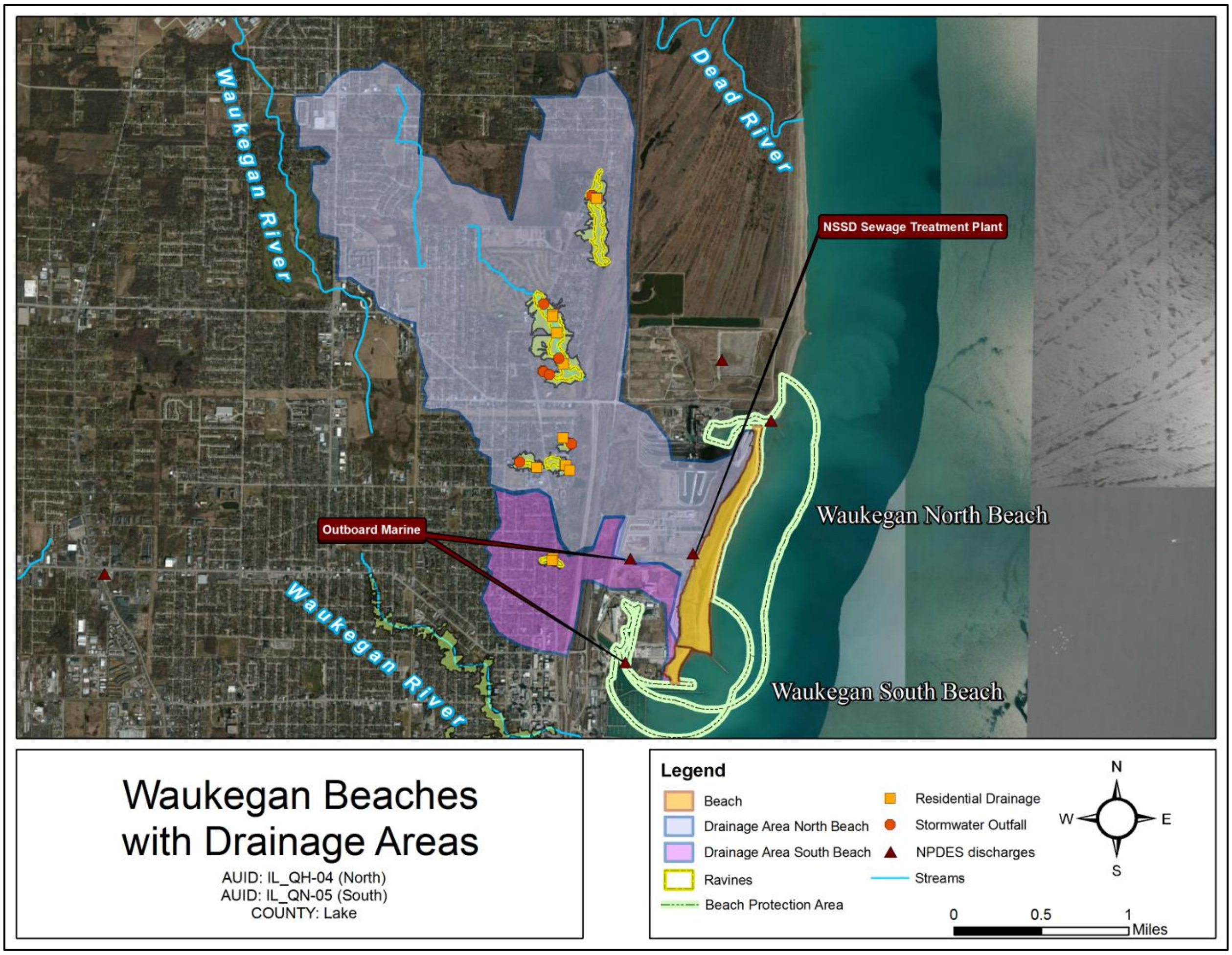


Figure 2-5. Waukegan Beaches and Drainage Catchments

Historically, cross connections between the City of Waukegan's stormwater and sanitary sewer lines resulted in beach closures. Since 1990, the City has worked to correct sanitary sewer overflows (SSOs) and cross connections as they are discovered. Some illicit discharges and cross connections have been found in recent years (ECT, 2008). In addition, excess flow discharge from the NSSD outfall has resulted in algae blooms along the shoreline (IDNR, 2011c). Algae blooms can serve as a secondary source for *E. coli* bacteria by providing suitable conditions for bacteria growth (Whitman et al., 2003).

The City of Waukegan has an MS4 permit that discharges stormwater to the Waukegan River. The Waukegan North Beach drainage catchment also contains three ravines that have several stormwater outfalls. The Waukegan North Beach drainage catchment contains two point-source discharges; the NSSD STP discharge point is directly adjacent to North Beach, and discharge from Outboard Marine Corporation is less than half a mile inland. Although the NSSD STP primarily discharges effluent to the Des Plaines River, occasional discharge to Lake Michigan during periods of extreme high flows into the treatment facility will occur through this outfall. Any flow to Lake Michigan is partially treated and is termed "Excess Flow" by IEPA. The NSSD STP has discharged flow to Lake Michigan between 1 and 5 days per year over the last 5 years. Flows have ranged from approximately 0.05 to 2 million gallons per day. Fecal coliform is monitored in the discharged water, and the facility holds a permit with daily maximum and monthly mean fecal coliform limits for during these periods of "excess flow". Outboard Marine (Bombardier) discharges stormwater and roof drainage to Waukegan Harbor and a ditch draining to Lake Michigan. Two other point discharges are located just north of Waukegan North Beach. Midwest

Generation, LLC and Johns Manville discharge industrial process water and are not considered sources of bacteria.

Both beaches are managed by the City of Waukegan. The Lake Management Unit of the LCHD monitors *E. coli* levels in water from these beaches 4 days a week during swimming season from Memorial Day to Labor Day (LCHD, 2012a). A SwimCast system is installed at the Waukegan South Beach to collect real-time measurements of air and water temperature, wind speed and direction, precipitation, relative humidity, wave height, lake stage, insolation (light energy), and other water quality parameters. The system helps predict when *E. coli* levels are low enough to indicate safe swimming conditions, or high enough to call for a swim ban (LCHD, 2012b). If SwimCast-predicted levels of *E. coli* are high enough to warrant a swim ban at Waukegan South Beach, Waukegan North Beach is also closed for the day. The monitoring results are used as modeling verification of SwimCast system. Beach advisories may also be issued for 48 hours after a large rain event (LCHD, 2012a).

Table 2-4. Monitoring and Single Sample Maximum WQS Exceedances for Waukegan Beaches in the Past 5 Years

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	**STORET Station ID**	**Impaired Segment Name**	**Years**	**Number of Closures (#)**	**Average Duration of Closures (days)**	**Monitoring Start Date**	**Monitoring End Date**	**Number of Samples**	**Source**	**Replicate Samples**	**Multiple Samples/ Times per Day**	**Wind Direction**	**Wind Speed**	**Air Temp**	**Water Temp**	**Wave Category**	**Wave Height**	**Gull Counts**
IL_QH-04	WAUKN	Waukegan North Beach	2007	18	1.6							X	X	X	X	X		X
			2008	14	1.2	5/27/2008	8/28/2008	65	STORET			X	X	X	X	X		X
			2009	3	1	5/26/2009	9/3/2009	62	STORET			X	X	X	X	X		X
			2010	91		5/27/2010	6/11/2010	8	STORET			X	X	X	X	X		X
			2011	1	1	5/20/2011	9/1/2011	57	STORET			X	X	X	X	X		X
IL_QH-05	WAUKS	Waukegan South Beach	2007	20	1.6	5/23/2007	9/1/2007	160	County		X	X	X	X	X	X	X	X
▪ Source detection study in 2003 - major sources = avian/gulls and human/sewage. ▪ SwimCast Beach			2008	14	1	6/2/2008	8/28/2008	102	STORET		X	X	X	X	X	X	X	X
			2009	11	1	6/1/2009	9/3/2009	93	STORET		X	X	X	X	X	X	X	X
			2010	9[1]		5/28/2010	9/5/2010	154	STORET		X	X	X	X	X	X	X	X
			2011	11	1	5/20/2011	9/5/2011	100	STORET		X	X	X	X	X	X	X	X

[1] Closure data were absent in PRAWN [Program tracking, beach Advisories, Water quality standards, and Nutrients] and were supplied by LCHD

2.1.5 Lake Bluff Sunrise Beach

Lake Bluff Sunrise Beach is located in the Ravine/Bluff region about 5.5 miles down shore from Waukegan South Beach. Sunrise Beach is within the village of Lake Bluff.

The thin, 4.5-acre beach contains three circular embayments that face east (**Figure 2-6**). The land use for Sunrise Beach is classified as about 65% park, 20% lake, 10% utility/waste facility, and 5% beach. The catchment that drains to Sunrise Beach is about 0.75 square miles and contains mostly residential land and roadways, with some smaller areas of parks, forest, recreational trails, and pasture.

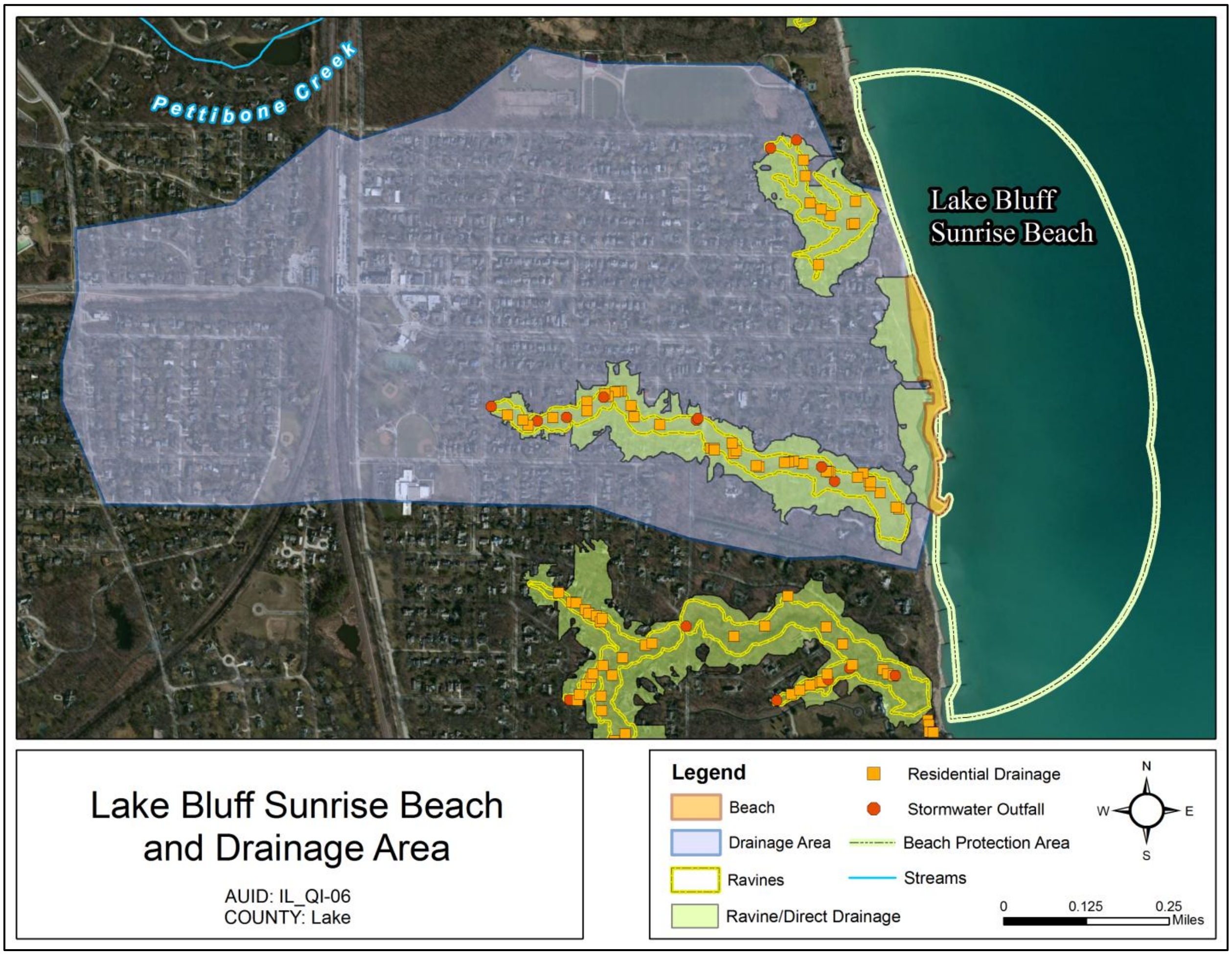


Figure 2-6. Lake Bluff Sunrise Beach and Drainage Catchment

In Lake County south of Waukegan Harbor, the Zion beach-ridge plain is absent, and beaches are located at the toe of bluffs running along the shoreline. Armoring techniques are commonly employed at beaches in this area to prevent erosion (IDNR, 2011b). Lake Bluff Sunrise Beach has three hardened breakwater structures.

Table 2-5 shows information about beach monitoring and closures for the past 5 years. Although LCHD has not conducted an analysis specific to Lake Bluff Sunrise Beach, gulls are generally considered the primary source of bacterial contamination at beaches in Lake County, IL (LCHD, 2003). Lake Bluff Sunrise Beach is adjacent to Lake Bluff Dog Beach, which makes up the far north end of the beach. Dogs are allowed on leash throughout the beach, but are allowed off leash only within the designed "dog friendly beach" area. All dog owners using either beach are required to complete a Dog Responsibility Contract, which ensures that waste products will be picked up (Lake Bluff Park District, 2012).

An NSSD pumping station is also located on Sunrise Beach (Surkamer, 2012). The Village of Lake Bluff has an MS4 permit that allows stormwater runoff to drain to Lake Michigan and has separate sanitary and stormwater sewer systems. The beachshed contains two ravines with many identified stormwater outfalls (Alliance for the Great Lakes, 2009). However, there are no additional permitted point-source discharges in the drainage catchment or in the surrounding area.

Lake Bluff Sunrise Beach is managed by the Lake Bluff Park District. The Lake Management Unit of the LCHD monitors *E. coli* levels in water from the beach 4 days a week during swimming season, from Memorial Day to Labor Day (LCHD, 2012a). Swim bans are issued for *E. coli* concentrations if the water samples are greater than 235 cfu/100 mL. Beach advisories may also be issued for 48 hours after a large rain event (LCHD, 2012a).

Table 2-5. Monitoring and Single Sample Maximum WQS Exceedances for Lake Bluff Sunrise Beach in the Past 5 Years

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	**STORET Station ID**	**Impaired Segment Name**	**Years**	**Number of Closures (#)**	**Average Duration of Closures (days)**	**Monitoring Start Date**	**Monitoring End Date**	**Number of Samples**	**Source**	**Replicate Samples**	**Multiple Samples/ Times per Day**	**Wind Direction**	**Wind Speed**	**Air Temp**	**Water Temp**	**Wave Category**	**Wave Height**	**Gull Counts**
IL_QI-06	SUNRISE	Lake Bluff Beach	2007	6	1.5	5/23/2007	8/29/2007	14	County			X	X	X	X	X		X
▪ Dog beach adjacent. Sampling for 2004-2007 reported as Lake Bluff Dog Beach. Weekly sampling completed for those years.			2008	6	1	5/27/2008	8/28/2008	59	STORET			X	X	X	X	X		X
			2009	2	6	5/26/2009	9/3/2009	59	STORET			X	X	X	X	X		X
			2010	4	1.8	5/20/2010	9/3/2010	53	STORET			X	X	X	X	X		X
			2011	1	1	5/20/2011	9/1/2011	51	STORET			X	X	X	X	X		X

2.1.6 Lake Forest Park Beach

Lake Forest Park Beach, located in the Ravine/Bluff region in the city of Lake Forest, is a thin beach with an area of about 9 acres (**Figure 2-7**). The beach is bordered by a 29+-acre city park (The City of Lake Forest, 2012). The land use at Lake Forest Park Beach is classified as about 80% parks, 13% beach, and 7% lake. The drainage catchment for Lake Forest Beach is roughly 1 square mile and includes mostly residential land, transit, and educational facilities, with some smaller areas of forest, parks, and commercial/industrial businesses.

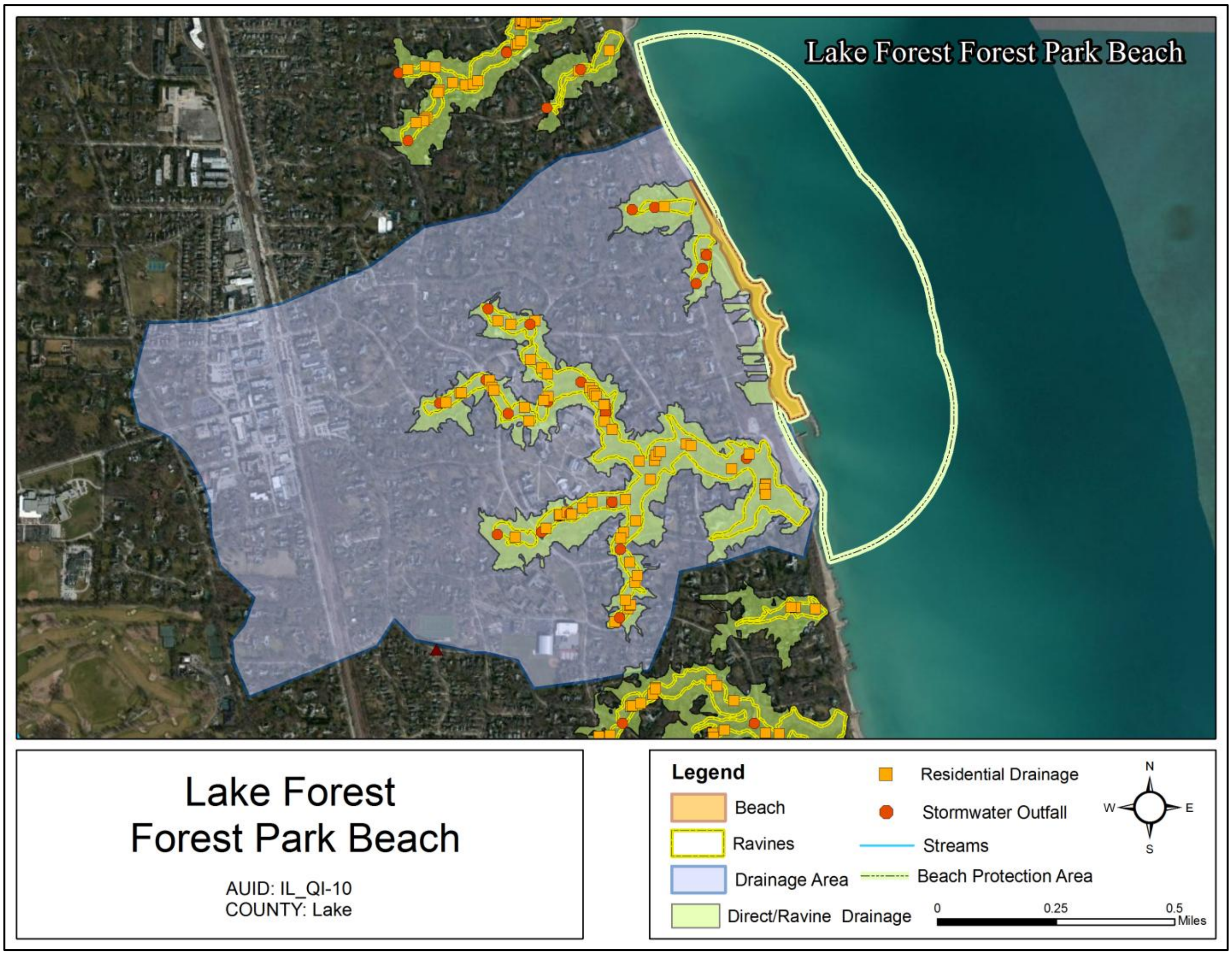


Figure 2-7. Lake Forest Park Beach and Drainage Catchment

The beach contains five hardened breakwater structures that have created four circular embayments (two east-facing and two northeast-facing). The presence of the breakwaters and the shape of the embayments limit the exchange of freshwater between the embayments and Lake Michigan (Fawcett, 2009).

Table 2-6 shows information about beach monitoring and closures for the past 5 years. The LCHD studied possible sources of *E. coli* contamination at Lake Forest Park Beach in 2002 and 2003. The 2002 study showed that gulls were the primary source (49%) of bacterial contamination at the time, followed by unidentified sources (34%), human/sewage sources (11%), and raccoon/pig (6%). The 2003 study showed that avian species were the primary source (68%) of bacterial contamination at the time, followed by human/sewage sources (18%) and unidentified sources (14%) (Soucie and Pfister, 2003). The City of Lake Forest has separate sanitary and stormwater sewer systems as well as an MS4 permit, but does not identify the receiving waters. The drainage catchment contains a large ravine with many stormwater outfalls. The beach is adjacent to another smaller direct drainage area, which contains 2 small ravines with a total of 6 stormwater outfalls. There are no NPDES-permitted point-source discharges within the beachshed drainage area.

Lake Forest Park Beach is managed by the City of Lake Forest. The Lake Management Unit of the LCHD monitors *E. coli* levels in water from this beach 4 days a week during swimming season, from Memorial Day to Labor Day (LCHD, 2012a). In addition, a SwimCast system is installed at the beach to collect real-time measurements of air and water temperature, wind speed and direction, precipitation, relative humidity, wave height, lake stage, insolation (light energy), and other water quality parameters. The system helps predict when *E. coli* levels are low enough to indicate safe swimming conditions, or high enough to call for a swim ban (LCHD, 2012b). Swim bans are issued for SwimCast-predicted *E. coli* concentrations greater than 235 cfu/100 mL. The monitoring results are used as modeling verification of SwimCast system. Beach advisories may also be issued for 48 hours after a large rain event (LCHD, 2012a).

Table 2-6. Monitoring and Single Sample Maximum WQS Exceedances for Lake Forest Beach in the Past 5 Years

Assessment Units Mapped to Indexed Beaches			Years	BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						Gull Counts
ID305B Unit ID	STORET Station ID	Impaired Segment Name		Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	
IL_QI-10	LFFOREST	Lake Forest Beach	2007	16	1.7	5/23/2007	9/1/2007	96	STORET		X	X	X	X	X	X	X	X
▪ Source detection study in 2003 - major sources = avian/gulls and human/sewage; some contributions from dog and rodent sources as well. Olyphant (2005) developed multiple regression models relating hydrometeorological data to *E. coli* ▪ SwimCast Beach			2008	9	1.1	6/2/2008	8/28/2008	60	STORET		X	X	X	X	X	X	X	X
			2009	8	1.4	6/3/2009	9/4/2009	91	STORET		X	X	X	X	X	X	X	X
			2010	4[1]		5/27/2010	9/5/2010	160	STORET		X	X	X	X	X	X	X	X
			2011	6	2	6/4/2011	9/5/2011	94	STORET		X	X	X	X	X	X	X	X

[1] Closure data were absent in PRAWN and were supplied by LCHD.

2.1.7 Highland Park Beaches

The Highland Park beaches consist of Park Avenue Boating Beach and Rosewood Beach. The beaches are located in the Ravine/Bluff region in southern Lake County. The Park Avenue Boating Beach is a fishing beach, boat-launch, and dry boat storage facility composed of concrete and sand launching ramps, parking lots, and boat storage areas; swimming and wading are not allowed. The beach is also home to the North Shore Yacht Club (Park District of Highland Park [PDHP], 2012a). Rosewood Beach is a swimming beach that is surrounded by an 11-acre park (PDHP, 2012b). Rosewood Beach is scheduled to undergo restoration as part of the U.S. Army Corps of Engineers (USACE) Great Lakes Fishery & Ecosystem Restoration (GLFER) Program (U.S. Army Corps of Engineers, 2011). The Park District of Highland Park is also planning to make improvements to Rosewood Beach (PDHP, 2012b).

Park Avenue Boating Beach is a small (5 acres), thin, northeast-facing beach (**Figure 2-8**). Park Avenue Beach is classified as 75% beach, 13% lake, and 12% park. The drainage catchment is roughly 0.5 square miles and contains mostly residential land, roadways, and commercial/industrial development, with some smaller areas containing educational facilities, parks, and forested land. The drainage catchment contains two ravines. One ravine drains to the lake slightly north of the beach. A second, smaller ravine drains directly to the center of Park Avenue Beach. Both ravines have identified numerous non-permitted stormwater outfalls. There are no permitted point-source discharges near the beach or within the drainage catchment.

Rosewood Beach is located less than 1 mile south of Park Avenue Beach. Rosewood Beach is also a small, thin, northeast-facing beach, but is slightly larger than Park Avenue Beach with an area of about 5.75 acres (Figure 2-8). The land use at Rosewood Beach is roughly 50% beach, 40% park, and 10% lake. The beachshed that drains to Rosewood Beach is roughly 1 square mile and includes mostly residential land and transit systems with smaller areas of forest, parks, and recreational trails. Rosewood Ravine covers roughly one quarter of the drainage area and drains directly to Rosewood Beach. A second smaller ravine drains to the northern part of Rosewood Beach.

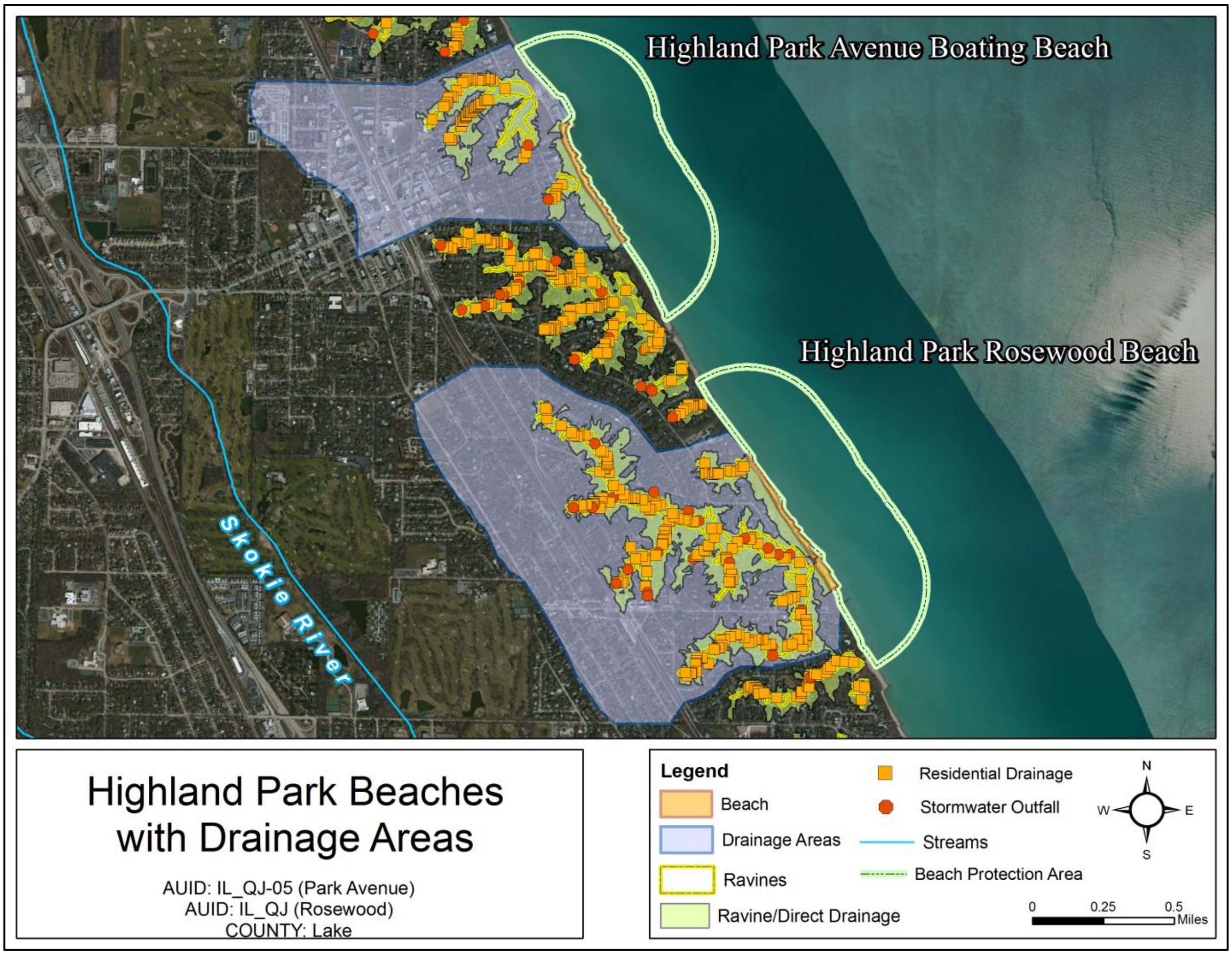


Figure 2-8. Highland Park Beaches and Drainage Catchments

Both beaches are currently armored with metal groyne structures. Park Avenue Beach has 11 groynes and a concrete boating ramp. Rosewood Beach has 12 groyne structures. Planned improvements for Rosewood Beach include the removal of all 12 groyne structures and the installation of breakwater structures similar to those at Lake Forest Beach (PHDP, 2012b).

Table 2-7 shows information about beach monitoring and closures for the past 5 years. The LCHD studied possible sources of *E. coli* contamination in 2002 and 2003. The 2002 study at Rosewood Beach and Ravine showed that gulls were the primary source (46% at the beach and 49% in the ravine) of bacterial contamination at the time, followed by unidentified sources (24% at the beach and 21% in the ravine), human/sewage sources (17% at the beach and 21% in the ravine), and deer/raccoon/cow/pig (11% at the beach and 8% in the ravine). The 2003 study at Rosewood Beach showed that avian species were the primary source (73%) of bacterial contamination at the time, followed by human/sewage sources (9%), unidentified sources (9%), canine sources (5%), and rodent sources (5%) (Soucie and Pfister, 2003). Rosewood Ravine and Beach were assessed as part of the 2007 Beach Sanitary Survey Great Lakes Pilot Project (U.S. EPA, 2008a). The survey reported that the most likely sources of pollution to the beach came from exposed sanitary sewer, stormwater, and other drainage pipes in the ravine, which carry the pollution to the beach and Lake Michigan during rainfall events. Several old sanitary lines were repaired as a result of the survey. Currently, Rosewood Park and Beach is not equipped with permanent restroom facilities; portable restrooms are rented by the season. Park improvements, including permanent restroom facilities, are scheduled to begin in late 2012 (PDHP, 2012b). The City of Highland Park has separate sanitary and stormwater sewer systems as well as an MS4 permit allowing stormwater runoff to drain to Skokie River, which enters Lake Michigan south of Rosewood Beach far outside of the BPA, and therefore outside of the expected area of influence for the beach.

The Highland Park beaches are managed by the Park District of Highland Park. The Lake Management Unit of the LCHD monitors *E. coli* levels in water from these beaches 4 days a week during swimming season, from Memorial Day to Labor Day (LCHD, 2012a). In addition, a SwimCast system is installed at Rosewood Beach to collect real-time measurements of air and water temperature, wind speed and direction, precipitation, relative humidity, wave height, lake stage, insolation (light energy), and other water quality parameters. The system helps predict when *E. coli* levels are low enough to indicate safe swimming conditions, or high enough to call for a swim ban (LCHD, 2012b). Swim bans are issued for SwimCast-predicted *E. coli* concentrations greater than 235 cfu/100 mL. Beach advisories may also be issued for 48 hours after a large rain event (LCHD, 2012a).

Table 2-7. Monitoring and Single Sample Maximum WQS Exceedances for Highland Park Beaches in the Past 5 Years

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	**STORET Station ID**	**Impaired Segment Name**	**Years**	**Number of Closures (#)**	**Average Duration of Closures (days)**	**Monitoring Start Date**	**Monitoring End Date**	**Number of Samples**	**Source**	**Replicate Samples**	**Multiple Samples/ Times per Day**	**Wind Direction**	**Wind Speed**	**Air Temp**	**Water Temp**	**Wave Category**	**Wave Height**	**Gull Counts**
IL_QJ-05	PARKAVE	Park Ave. Beach	2007	12	1.2	5/23/2007	9/1/2007	95	County			X	X	X	X	X		X
			2008	3	1	5/27/2008	8/28/2008	82	STORET			X	X	X	X	X		X
			2009	2	4	5/27/2009	9/3/2009	56	STORET			X	X	X	X	X		X
			2010	5	2.2	5/27/2010	9/3/2010	53	STORET			X	X	X	X	X		X
			2011	4	3.2	5/20/2011	9/1/2011	53	STORET			X	X	X	X	X		X
IL_QJ	ROSEWOOD	Rosewood Beach	2007	11	1.3	5/23/2007	9/1/2007	151	County		X	X	X	X	X	X	X	X
▪ Source detection study in 2003 - major sources = avian/gulls and human/sewage; some contributions from deer sources as well. ▪ SwimCast beach ▪ Rosewood Ravine enters Lake Michigan to north of beach ▪ Sanitary survey conducted in 2007			2008	9	1.3	6/2/2008	8/28/2008	106	STORET		X	X	X	X	X	X	X	X
			2009	6	1.3	6/1/2009	9/3/2009	99	STORET		X	X	X	X	X	X	X	X
			2010	5[1]		5/27/2010	9/5/2010	159	STORET		X	X	X	X	X	X	X	X
			2011	9	1.7	6/2/2011	9/5/2011	129	STORET		X	X	X	X	X	X	X	X

[1]Closure data were absent in PRAWN and were supplied by LCHD.

2.2 Current E. coli Conditions

All 9 impaired shoreline segments/beaches within Lake County are monitored on weekdays (at least 4 days) by LCHD, from approximately Memorial Day until the beginning of September. The daily *E. coli* concentration measures are compared to the single sample maximum (SSM) and geometric mean (GM) WQS in **Table 2-8**. **Figure 2-9** provides a visualization of monitored *E. coli* levels versus the SSM across five beach seasons for the impaired segments. Corresponding beach closures/swim bans were presented in Tables 2-1 through 2-7 in terms of number of closures and average duration of the closures.

All shoreline segments addressed in this TMDL have experienced exceedances of the SSM in the last 5 years. Five years are assessed to provide a range of interannual variation such as wet and dry years and to more fully characterize source interactions. In addition, in Lake County all the impaired segments have been monitored for hydrometeorologic conditions and presence of gulls on days with water quality monitoring since at least 2006. In general, the trend has been in the direction of decreased number of SSM exceedances except for Waukegan North Beach and the beaches in Highland Park. However, correspondence to the actual number of closures, which are typically based on single daily samples, instituted at each beach is somewhat mixed. There are a number of reasons for this lack of relation, including the time delay in sampling for *E. coli* and the reporting of the concentration (typically 18 hours), the practice of putting an advisory or closure in place after sustained rainfall regardless of monitoring, and multi-day closures that may cover any number of SSM exceedances.

Exceedances of the GM differentiate more easily between the highly impaired beaches, such as North Point Marina Beach, and the beaches with less prevalent water quality issues, such as IBSP North Beach and Lake Bluff Sunrise Beach. Use of the GM gives less weight to a few elevated concentration values and differentials between sporadic exceedances and sustained water quality issues. The GM is more suited to assess long-term use impairment, while the SSM measures public health risk on a daily increment. This distinguishes water quality targets needed for TMDL development and restoring designated uses from targets needed for daily beach management focused on the public.

Table 2-8. 5-year Monitored Exceedances of the WQSs

Beach	Year	Count of Single Samples	SSM Exceedances	Count of 30-day GM Calculations	GM Exceedances
North Point Marina Beach	2007	104	**85**	69	**69**
	2008	63	**51**	40	**40**
	2009	63	**48**	38	**38**
	2010	63	**43**	39	**39**
	2011	115	**0**	31	**0**
IBSP - North Beach	2007	96	**17**	69	**0**
	2008	68	**9**	41	**0**
	2009	60	**7**	38	**0**
	2010	57	**6**	39	**0**
	2011	64	**0**	22	**0**
IBSP - South Beach	2007	95	**23**	67	**23**
	2008	71	**15**	41	**9**
	2009	59	**13**	38	**0**
	2010	58	**13**	39	**0**
	2011	42	**0**	21	**0**

(continued)

Table 2-8. 5-year Monitored Exceedances of the WQSs (continued)

Beach	Year	Count of Single Samples	SSM Exceedances	Count of 30-day GM Calculations	GM Exceedances
Waukegan - North Beach	2007	96	**28**	68	**26**
	2008	65	**17**	41	**6**
	2009	56	**5**	38	**0**
	2010	55	**9**	38	**3**
	2011	65	**43**	22	**19**
Waukegan - South Beach	2007	159	**50**	68	**45**
	2008	105	**31**	41	**15**
	2009	105	**20**	38	**9**
	2010	55	**14**	38	**18**
	2011	70	**12**	42	**0**
Lake Bluff - Sunrise Beach	2007	95	**8**	69	**0**
	2008	59	**6**	40	**0**
	2009	57	**2**	38	**0**
	2010	55	**5**	38	**0**
	2011	53	**3**	41	**0**
Lake Forest - Forest Park Beach	2007	94	**28**	66	**16**
	2008	63	**10**	41	**0**
	2009	52	**12**	33	**5**
	2010	57	**8**	39	**0**
	2011	54	**0**	26	**0**
Highland Park - Park Avenue Boating Beach	2007	94	**15**	66	**0**
	2008	63	**3**	67	**0**
	2009	56	**4**	41	**0**
	2010	55	**5**	38	**0**
	2011	54	**7**	39	**0**
Highland Park - Rosewood Beach	2007	150	**23**	66	**0**
	2008	109	**16**	41	**0**
	2009	106	**10**	38	**0**
	2010	56	**7**	39	**0**
	2011	54	**26**	42	**18**

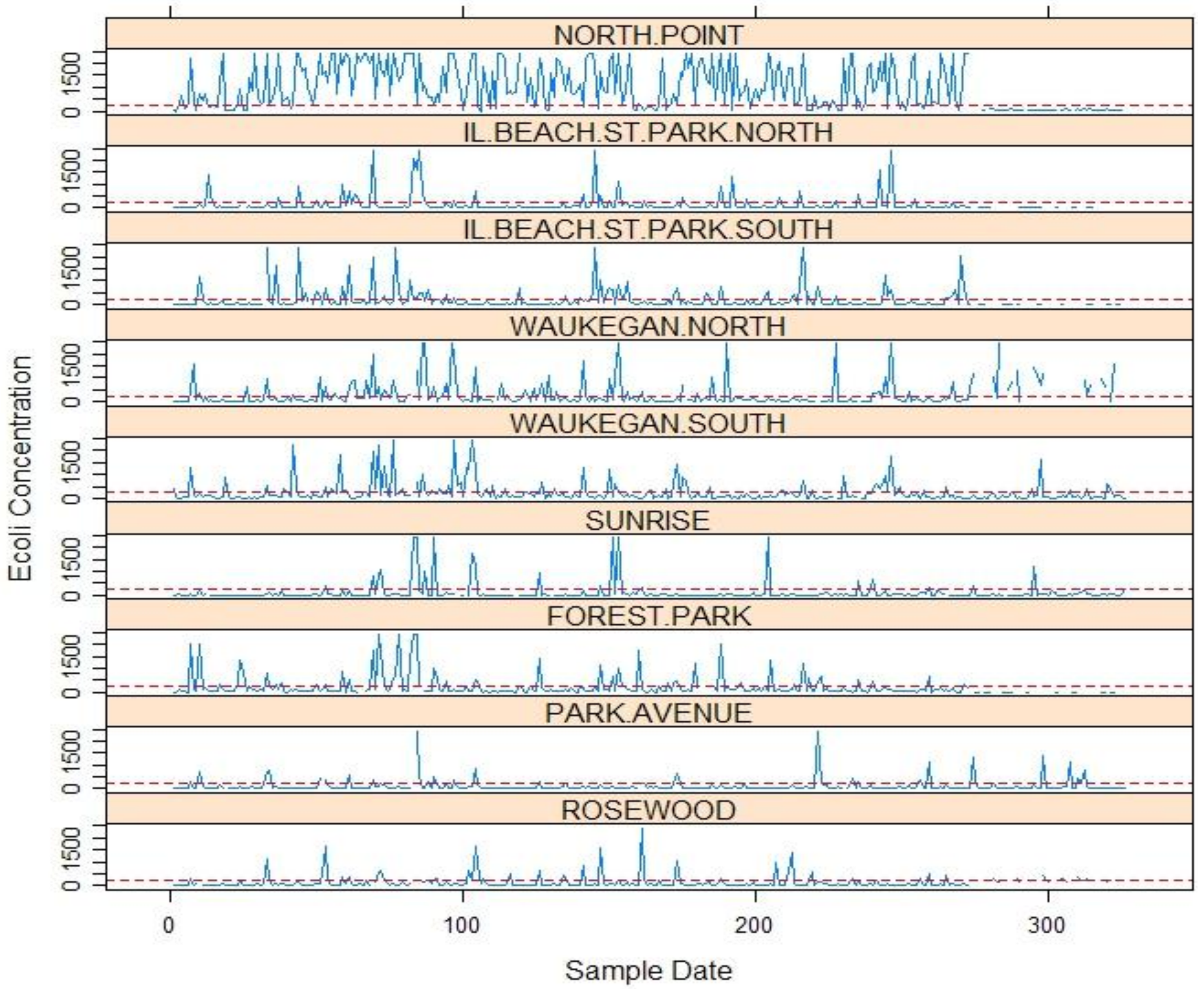


Figure 2-9. Monitored *E. coli* Levels in Lake County as Compared to the SSM WQS (red line) for May 2007 (day 0) – August 2011

3. Problem Statement

All 9 of the Lake County impaired segments are in non-attainment of their designated use of primary contact recreation. According to Illinois WQS, "primary contact" means ... *any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing*" (35 Ill. Adm. Code 301.355). All shoreline segments in this TMDL have a designated use of primary contact recreation.

The Illinois 303(d) list report describes the guidelines for assessing attainment of primary contact use at Lake Michigan beaches. A Lake Michigan beach is *listed as impaired* if, over a three-year period:

1. On average, one or more beach closures occurred per year lasting less than a week, or
2. On average, less than one beach closure occurred per year, but the average closure duration was one week or greater.

For beaches identified as not-supporting primary contact use, *E. coli* is identified as. the pollutant causing recreational impairment if at least one of the bathing beach closures per year is due to an observed *E. coli* concentration above the WQS (as opposed to closures from dangerous swimming conditions, for example) (**Table 3-1**).

Table 3-1. Guidelines for Identifying Potential Causes of Impairment of Primary Contact (Swimming) Use in Lake Michigan Beaches and Open Waters[1]

Potential Cause	Basis For Identifying Causes - Numeric Standard[2]
Escherichia coli	On average at least one bathing beach closure per year based on *E. coli* bacteria

[1] Excerpt from the Draft 2010 Illinois Integrated Report (IEPA, 2010).

[2] Department of Public Health Bathing Beach Code (77 Ill. Adm. Code 820.400): An *E. coli* count of 235 cfu/100 mL in each of two samples collected on the same day shall require closing the beach. Note: beaches in Lake County are closed when one sample exceeds 235 cfu/100 mL. The 235 cfu/100 mL value is also consistent with the federal water quality standards for Coastal and Great Lakes Recreation Waters.

Swim bans implemented by beach authorities are not equivalent to IEPAs definition of beach closure when IEPA assesses attainment. A *swim ban* or *advisory* occurs when *E. coli* exceeds 235 cfu/100 mL in each of two samples collected on the same day. In Lake County swim bans occur when one sample exceeds 235 cfu/100 mL. IEPA considers a *beach closure* as the consecutive number of days that swim bans are in place. Thus, in some instances, the SSM can be exceeded at a beach by some amount and still be in full support of the primary contact use under IEPAs listing methodology.

IEPA looked at swim bans and their duration according to their assessment methodology and found that all beaches met criteria to be listed as impaired. A summary of swim ban data, from Tables 2-1 through 2-7, collected for the TMDL illustrate that individual swim bans occur at a high enough rate for the waters to be listed as impaired on IEPAs 303(d) list (**Table 3-2**).

Table 3-2. Swim Ban Statistics for Impaired Segments Based on Reporting to U.S. EPA's PRAWN System

Impaired Segment Name	Metric	Year	Number
North Point Marina Beach	5-Year Average	N/A	10.4
	Minimum	2009	4
	Maximum	2008	19
IBSP - North Beach	5-Year Average	N/A	6.8
	Minimum	2010 & 2011	5
	Maximum	2007	10
IBSP - South Beach	5-Year Average	N/A	8.4
	Minimum	2010	3
	Maximum	2007	17
Waukegan - North Beach	5-Year Average	N/A	9
	Minimum	2011	1
	Maximum	2007	18
Waukegan - South Beach	5-Year Average	N/A	13
	Minimum	2010	9
	Maximum	2007	20
Lake Bluff - Sunrise Beach	5-Year Average	N/A	3.8
	Minimum	2011	1
	Maximum	2007 & 2008	6
Lake Forest - Forest Park Beach	5-Year Average	N/A	8.6
	Minimum	2010	4
	Maximum	2007	16
Highland Park - Park Avenue Boating Beach	5-Year Average	N/A	5.2
	Minimum	2009	2
	Maximum	2007	12
Highland Park - Rosewood Beach	5-Year Average	N/A	8
	Minimum	2010	5
	Maximum	2007	11

3.1 WQS and TMDL Targets

There are both fecal and *E. coli* water quality criteria that are in place to protect recreational users of Lake Michigan Beaches within Illinois (**Table 3-3**). There are also two values for each of these parameters, one is a measure of central tendency (a GM), and the second is an upper limit (SSM). IEPA considered all of these criteria and selected the GM for *E. coli* over a 30-day rolling period as the TMDL target. The bacteria criteria and the rationale for this selection are discussed further below.

Table 3-3. Applicable Water Quality Standards for Bacteria at Lake Michigan Beaches in Illinois

Bacteria Water Quality Standards	
State Standard (From IL Admin. Code Sec. 302.505)	
Fecal Coliform (cfu/100 mL)	▪ Must not exceed a geometric mean of 200 cfu/100 mL ▪ More than 10% of the samples during any 30-day period shall not exceed 400 cfu/100 mL.
Federal Standard (From 40 CFR Part 131 Part II. Final Rule. Water Quality Standards for Coastal and Great Lakes Recreation Waters. 16 Nov 2004.)	
E. coli (cfu/100 mL)	▪ Must not exceed a geometric mean of 126 cfu/100 mL[1] ▪ Single sample maximum of 235 cfu/100 mL (for designated bathing beaches)[2]

[1] The duration of time is not specified in the Federal Rule, but the U.S. EPA's 1986 bacteria criteria document, from which these values were taken, indicates that generally not less than five samples evenly spaced over a 30-day period should be used to calculate the geometric mean. From the Federal Rule (at Page 67224), "EPA expects from current practice by States and Territories that they will compute the geometric mean on either a monthly or recreation season basis."

[2] The single sample maximum values are intended for use in making beach notification and closure decisions (at P. 67225 of Federal Rule). The SSM may, but need not, also play a role in implementing other Clean Water Act programs.

State criteria for fecal coliform for non-open waters in Lake Michigan are found in Illinois Administrative Code Title 35 Section 302.505. Federal criteria for *E. coli* were promulgated for Great Lakes coastal recreation waters in 2004 in the *Final Rule for Water Quality Standards for Coastal and Great Lakes Recreation Waters* and are codified in 40 CFR 131.41 Subp. D. The 2004 Federal *E .coli* criteria apply to the Illinois Lake Michigan beaches (and other coastal and Great Lakes waters) that are designated for swimming, bathing, surfing, or similar water contact activities. The federally promulgated standards also apply to existing State bacteria standards for recreation waters. While both standards in Table 3-3 apply to the Lake Michigan shoreline segments addressed in this TMDL, IEPA selected the *E. coli* criteria for use in developing the TMDL.

The *E. coli* standard was selected for the TMDL for multiple reasons. First, beach managers monitor for and make swim ban decisions based on Federal *E. coli* standards. Second, the fecal coliform and *E. coli* numeric criteria are based on detectable effects between decreasing water quality and increasing risk to gastrointestinal illness. When the 1986 criteria values were developed for *E. coli* the illness rate associated with the GM was determined to be 8 out of 1000. However, studies indicate illness rates are more accurately predicted by *E. coli* than fecal coliform (Dufour, 1984). Lastly, it can be reasonably assumed that corrective actions to reduce bacteria at beaches will reduce both *E. coli* as well as fecal coliform counts, given that *E. coli* is one of many fecal bacteria comprising the fecal coliform group. There is one exception where an intermittent discharge from a single facility is given a wasteload allocation (WLA) for fecal coliform. Monitoring of fecal coliform and *E. coli* at this facility could ensure that equivalent levels of health protection are protected.

Next, in selecting how to apply the *E. coli* criteria as a target for the TMDL, IEPA considered both the SSM and the GM (assuming a 30-day period) criteria. The GM was selected as the target for the TMDL. Under this target some percent of samples might exceed the SSM and still meet the GM over a 30-day period; based on data collected at these beaches, it was estimated that the SSM would not be exceeded by more than 10% of samples collected. IEPA selected this approach because it provides illness rate protection that is equivalent to what was intended by the bacteria criteria when they were developed, and it is consistent with the U.S. EPA's position as described in its promulgated federal criteria (Pages 67224-5 of Federal Register Notice, November 16, 2004).

The GM and SSM bacteria criteria applicable to these beaches were promulgated by U.S. EPA in 2004 and are based on EPA's 1986 criteria values. When the 1986 criteria values were developed, a GM of 126 cfu/100 mL was the GM of the water quality distribution that showed a significant correlation between decreasing water quality and increasing risk to gastrointestinal illness. The illness rate associated with the GM was estimated to be 8 out of 1000. An upper limit was also calculated as part of the standard in order to reduce the chance of an unnecessary beach closure based on a single sample. This upper limit was 235 cfu/100 mL and represents the 75% confidence interval from the dataset whose GM was 126 cfu/100 mL[1]. Thus the SSM and GM are linked to the same dataset and same illness rate, but the SSM provides a value to base beach closure decisions on a single sample with a given level of confidence in that decision.

The TMDL target for the Illinois Lake Michigan Beaches TMDL was set at the GM criterion with a given level of SSM exceedance, on the basis that the GM criterion is the more relevant measure to develop allocations and that SSM was not necessarily intended for use as a never to exceed value in TMDLs. This is consistent with EPA's 2004 promulgation of bacteria criteria, which clarified U.S. EPA's expectations regarding the use of SSM: "geometric mean is the more relevant value to protect and improve water quality because it is a more reliable measure, being less subject to random variation...." [2] Also, a TMDL based on the SSM as a never to exceed criterion could lead to unnecessarily restrictive allocations, as it may be possible that exceedance of the SSM can occur and a water could achieve the same level of health protection if bacteria levels met a GM of 126 cfu/100 mL (8 out of 1000 illness rate). Using a GM as the target may allow for large spikes in *E. coli* to occur, but the TMDL would still be met if these spikes occurred at a low enough frequency that the GM is not exceeded; this is a function of the way a GM is calculated (as evidenced in Table 2-8). This allows for a TMDL to be written that results in achievable reduction strategies and will still meet standards that are applicable to "other Clean Water Act applications" (Page 67224 of the Final Rule).

Use of the GM for the TMDL does not change, or in any way undermine, current beach monitoring efforts. Beach monitoring is conducted by local entities (e.g., IDPH, LCHD, and CPD) and makes use of the SSM to help identify public health risks related to swimming on a particular day, whereas the TMDL study is undertaken to assess sources and assign allocations in order to improve water quality and restore designated uses.

In November 2012 U.S. EPA released recommendations for Recreational Water Quality Criteria (2012 RWQC). The Beach Act directs States and Tribes to adopt and submit to U.S. EPA the RWQC for Beach Act waters. Although the Illinois Lake Michigan beaches TMDL target was based on the 2004 Federal *E. coli* criteria, which was the applicable criteria at the beginning of the assessment, the target still provides at least equivalent protection as would be provided by the 2012 RWQC. The 2012 RWQC recommend that *E. coli* should meet a GM of 126 cfu/100 mL over a 30-day period and that an upper statistical threshold value (STV) of 410 cfu/100 mL is not to be exceeded by more than 10% of the samples. The TMDL target, by comparison, is set so that the GM of 126 cfu/100 mL is met over a 30-day period, and where the 30-day GM is achieved, the Illinois Lake Michigan beaches were estimated to be greater than the SSM of 235 cfu/100 mL by no more than 10% of the samples. Thus when bacteria criteria based on the 2012 RWQC become applicable to these waters, this TMDL would still provide at least the equivalent level of health protection. This does not indicate that the 2012 RWQC provide less protection than the 2004 and 1986 bacteria criteria; in this instance, site-specific data are being used to estimate how often the SSM would be exceeded, and the SSM was not intended to be a value not to be exceeded by 10% (i.e., it was calculated as the 75th confidence interval about the GM criteria). In the 2012 RWQC a beach action value (BAV) replaces the concept of the SSM in the 2004/1986 criteria. BAVs are provided

[1] The 2012 recommendations use a 90th confidence interval, which is 410 cfu/100 mL

[2] Pages 67224-5 of Federal Register Notice, November 16, 2004

for informational purposes only and for use in beach notification decisions if the state chooses. If, in the future, it becomes apparent that the TMDL does not provide equivalent protection according to newly adopted criteria, the TMDL may be modified.

Employing a margin of safety (MOS), a required element of the TMDL, within the allocation calculation is one way to demonstrate how the probability of exceeding the SSM will also be lowered when using the GM as the TMDL target. This selected target applies on any given day, relying on the previous 30 days of water quality measures to form a GM, to assure achievement of the bacteria whenever the WQS are in effect (i.e., swimming season). An MOS may be implicit or explicit based on the selected application and method of calculation.

Although a TMDL is typically defined in terms of a loading (mass per day) instead of a concentration (mass per volume), IEPA believes that for bacteria along the Lake Michigan shoreline the concentration-based TMDL is the most useful format for guiding both remediation and protection efforts at these impaired segments. Also, a concentration target is more readily understandable to the public, and allows interested citizens and/or watershed groups to determine easily whether any particular source is exceeding its allocation.

3.2 Linkage Analysis

In order to identify the sources of bacteria to the impaired segments, as no sources are immediately identified in the 303(d) listing, research was conducted into studies of beach contamination in the area and over swimming beaches in general. Then, any data on identified potential sources was gathered from the available site-specific data provided by local beach managers, federal data repositories, and beach monitoring groups (e.g., Alliance for the Great Lakes' Adopt-a-Beach program). These data were screened to provide a daily time series of any available monitored source or other environmental parameter with a corresponding bacteria measurement. The environmental parameters include measurements that may be considered a surrogate measure of a potential bacteria source, such as magnitude of precipitation is a surrogate for stormwater. Finally, these time series were used in a statistical method (described in **Section 4.8**) to determine which monitored sources or other environmental parameters were best correlated with the daily monitored bacteria concentration.

Direct linkages between sources of bacteria and pathogens and water quality along the shoreline are typically unclear due to the highly dispersed nature of the shoreline hydrology and varied overland drainage surrounding a beach/shoreline segment. For the logical, implied sources such as wildlife and stormwater, there is often little published information on actual quantifiable impacts. There is also often a lack of quantified and monitored point-source discharges or other easily identifiable sources directly along the shoreline where water quality is an issue. When available, studies on sources of bacterial water quality impairments to bathing beaches are often highly site-specific, although the findings may be generalized to a larger number of locations. For instance, studies at the embayed 63rd Street beach in Chicago point to entrainment of bacteria and water under certain lake current conditions leads to greatly reduced water quality (Ge et al., 2010). A similar finding can likely be extrapolated to other embayed beaches.

Use of published literature enabled the identification of a number of potential bacteria sources for the shoreline areas. Several studies along the shoreline in Wisconsin provided guidance on how to examine the source of bacteria along the Illinois shoreline in the absence of source tracking studies for all sites. In one study, McLellan and Salmore (2003) conducted a detailed monitoring study of a public beach within Milwaukee that included both dry and wet weather sampling across multiple shoreline and offshore sites for *E. coli*. Their findings indicate that, for both wet and dry conditions, shoreline sites had significantly higher *E. coli* levels than offshore regions where the shoreline samples exceeded the SSM WQS 66% of the time. They also found that these high levels coincided with the presence of birds and stormwater at the swimming beaches, but that the high levels were not correlated with *E. coli* levels in a connecting harbor. The authors concluded that local, persistent contamination is likely the major source of high *E. coli* levels over regional sources. Similarly, Scopel and others (2006) determined that the major water quality impacts at a local beach in Bayview, WI, were from delivery of pollutants from the adjacent shore following rain events rather than from a combined sewer overflow (CSO) to the north of the beach. Combining knowledge gained in the intensive study of the Wisconsin shoreline, it has been proposed by local experts that a point source of bacteria can impact water quality along the shoreline within a distance of approximately 500 m of the discharge (i.e., the BPA). Outside of this boundary, lake dynamics lead to dispersal and mixing of pollutants, rarely allowing a specific source beyond this range to be identified among the other sources as a contributor to poor water quality at the shoreline segment of interest (Scopel et al., 2006).

Given this information, this TMDL analysis has attempted to gather and quantify any potential source variables or surrogate variables identified within 500 m along shore/into the lake (i.e., the BPA) and within the beachshed or to a channel that discharges within the BPA or the beachshed. **Figure 3-1** provides a map illustrating the 500-m distance along the shoreline as the BPAs. **Table 3-4** lists the different source variables and surrogate variables identified in the analysis. Surrogate variables are measurable values that can be used to quantify or qualify a source of bacteria or a factor that may contribute to increases or decreases in bacteria concentrations along the shoreline.

The following sections provide information on the data sources used to quantify and identify each of the potential sources of bacteria or surrogate variables.

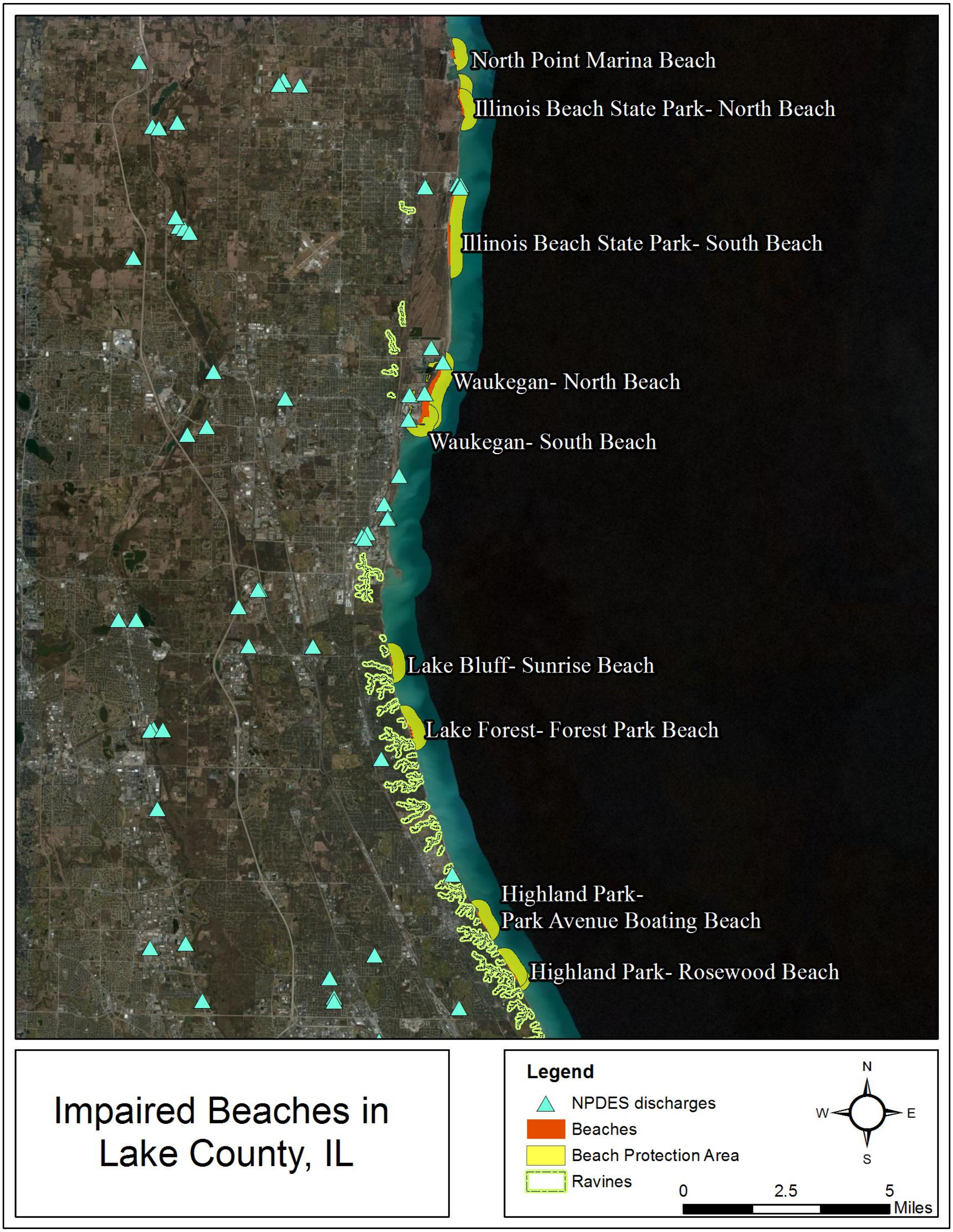


Figure 3-1. BPA/500-meter Buffer on Lake County Beaches

Table 3-4. Example Source Parameters Examined in the Multilevel Modeling for TMDL Development and Potential Management Methods

Surrogate	Metric	Surrogate For	Manageable Parameter	Method
Known/Assumed Sources				
Number of gulls	Count	Bacteria in bird fecal matter	X	Egg oiling; dog patrol
Number of beach goers	Count	Human sources; Disturbance of sediments	X	Fees; restrictions?
Area of specific land use class (e.g., area of high density residential land)	Area	Depending on land use bacterial sources	X	Sewering; Best Management Practices (BMPs); Ravine restoration
Point-source loading	Magnitude	Direct source loading	X	Load reductions
River reversal events (i.e., locks opening after large storm event)	Type or Magnitude	Direct source loading; accounted for in monitored water quality when available		Other actions; Operated by USACE
Physical Influences				
Beach slope	Magnitude	Potential for greater swash zone	X	Grading
Embayment	Type	Effects of hydrodynamics	X	Alteration of jetties, walls, etc.
Substrate	Type	Potential for bacterial attachment and growth	X	Beach supplementation
Hydrometeorological Influences				
Precipitation magnitude (e.g. previous 24 hours)	Magnitude	Washoff	X	Green infrastructure such as porous pavement and rain gardens. Stormwater BMPs
Hours since rain event	Temporal	Buildup	X	Stormwater BMPs, street sweeping, and beach grooming
Air and water temperature	Magnitude	Bacterial growth and die-off		
Wind speed	Magnitude	Proxy for wave energy		
Wind direction	Type	Influence of Lake Michigan off-shore waters		
Lake Influences				
Wave height	Magnitude	Resuspension from slosh zone		
Current velocity	Magnitude	Influence of Lake Michigan off-shore waters		
Current direction	Type	Influence of Lake Michigan off-shore waters		

3.2.1 The Great Lakes Coastal Forecasting System

To estimate the lake effects on beach water quality such as wave action and current directions, model estimates from the National Oceanic and Atmospheric Administration's (NOAA's) Great Lakes Coastal Forecasting System (GLCFS) were used. The GLCFS is a numerical model that calculates waves, currents, and temperatures for each of the Great Lakes based on available observational data systems (e.g., buoys). The GLCFS Nowcast runs four times per day and provides estimates of conditions at the time the model is run. The GLCFS Forecast runs twice per day and predicts conditions 60 hours into the future. GLCFS data is stored on the Great Lakes Observation System THREDDS server after each run of the model. Archives of Nowcast results are created for each completed calendar year beginning with 2006.

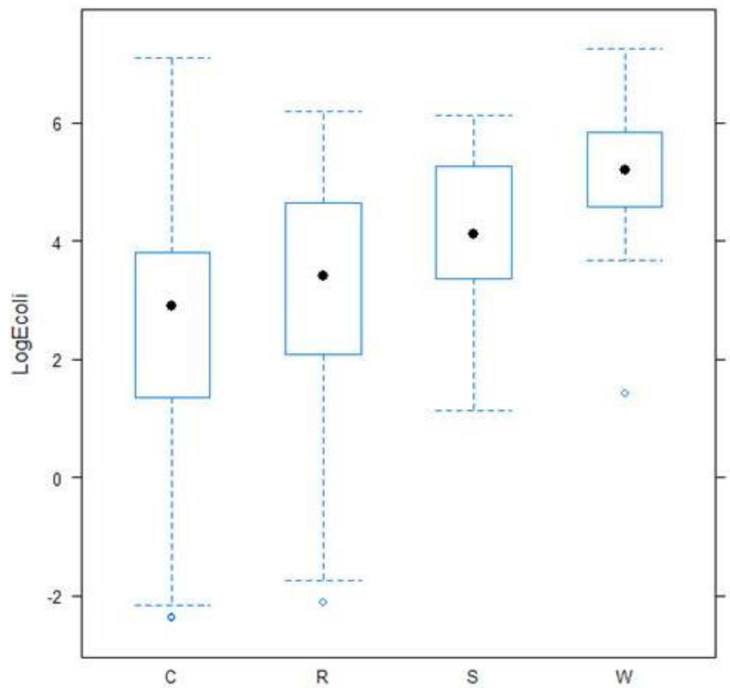
Two sets of model results are created during each run, one defining conditions on the surface (two-dimensional) and one that defines circulation within the lake (three-dimensional). Within Lake Michigan, results are produced on a 2-km grid scale. For this analysis a latitude and longitude point nearest each beach was identified within the interior of the local GLCFS grid cell. Each point was then used within the GLCFS data download point query available through NOAA's website to obtain all available data for the corresponding grid cell. **Table 3-5** identifies the parameters utilized from the GLCFS download. Although the available data are reported in 15-minute intervals every day, the values for the 15-minute interval closest to the *E. coli* sampling time is used as the corresponding measure to the water quality sample.

Table 3-5. Fields in GLCFS Data

GLCFS Parameter
Bathymetry (m)
Model Water Level (m)
Eastward Water Velocity at Surface (m/s)
Northward Water Velocity at Surface (m/s)
Water Velocity at Surface (m/s)
Water Velocity at Surface Direction (degree)
Significant Wave Height (m)
Wave Direction (degree)
Wave Period (s)

m/s = meters per second

One example of the lake effects on water quality at a swimming beach is illustrated in **Figure 3-2** using log-normalized *E. coli* concentrations (i.e., the log-normalized SSM WQS is 5.5, while the log-normalized GM WQS is 4.8). Using a compilation of data from Lake County beaches, the influence of wave action on *E. coli* concentrations is clear—increasing wave action can be correlated with higher *E. coli* concentrations along the shoreline. Other impacts from water velocity and wave activity are also shown to have some impact on the bacterial water quality at the impaired segments as described later in this document.



C=calm, R=ripples, S=severe, W=whitecaps

Figure 3-2. *E. coli* Concentrations by Wave Condition

3.2.2 Precipitation

Precipitation in itself is not a cause of water quality impairment by bacteria. However, when precipitation falls on the land surface, it gathers bacteria that have built up during dry weather and the water flows downhill toward a receiving water. Along the Illinois shoreline, the receiving water may be a stormwater catchment basin, a stream, a ravine, or even the shoreline itself. To account for this stormwater influence, hourly precipitation measures from several local weather stations were gathered and analyzed to determine precipitation conditions corresponding to each *E. coli* water sample available. Three different precipitation measures were assessed for their correlation to water quality:

- Hourly amount
- Past 24-hour total
- Hours since last rain event.

As noted earlier, stormwater has been demonstrated to contribute to impaired water quality at numerous beaches in the Great Lakes. In a general analysis of all Lake County beaches, the *E. coli* concentrations on days with rain (right panel, **Figure 3-3**) were greater than on days with no rain (left panel, Figure 3-3). In addition, the impacts of precipitation may be compounded on those beaches with hardened structures either by focusing and exacerbating the stormwater impact or by sheltering the beach from what could otherwise be larger stormwater impacts.

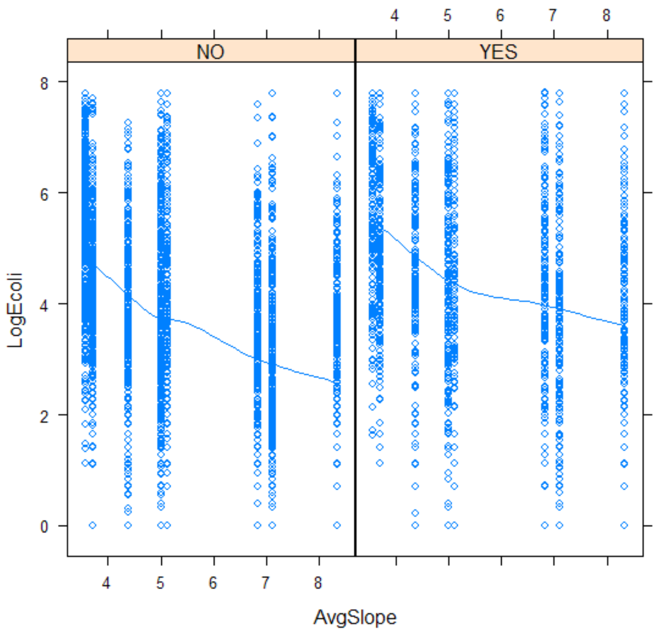


Figure 3-3. Influence of Precipitation and Slope on Water Quality

3.2.3 Land Use

The 2005 land use data set layer is based on the 2000 land use inventory data set for Lake County, IL. Most definitions from 2000 have been retained, but some land use types have been modified in the 2005 layer. There are eight major land use classifications and over 80 specific land cover classifications. All land cover greater than 0.25 acres was included in the database. **Table 3-6** describes the major land use and land cover classifications in the database. A few of the major land use classifications have been broken down into more specific categories and can be viewed in **Figure 3-4**.

Table 3-6. Major Land Use and Land Cover Classifications in the 2005 Data Set Layer

Major Land Use Classification	Major Land Cover Classifications
Urban and Built-up Land	Various residential, Mixed commercial
Institutional	Universities, Hospitals, Religious facilities, Prisons, Other government facilities
Industrial, Warehousing, Wholesale Trade	Mineral extraction, Manufacturing, Distribution center
Transportation, Communication, Utilities	Various roadways, railways, other transit, communications, landfills, utilities and waste facilities
Agricultural Land	Cropland, Orchards, Pasture, Equestrian facilities
Open Space	Parks, Golf courses, Nature preserves, Game lands, Athletic fields, swimming beaches, campgrounds
Forest, Grassland, Wetlands	Land not developed for human purposes, undeveloped land, forest and grasslands not in a park or preserve
Water	Rivers, Streams and Canals >5 feet wide; Reservoirs, lagoons and lakes > 0.25 acres

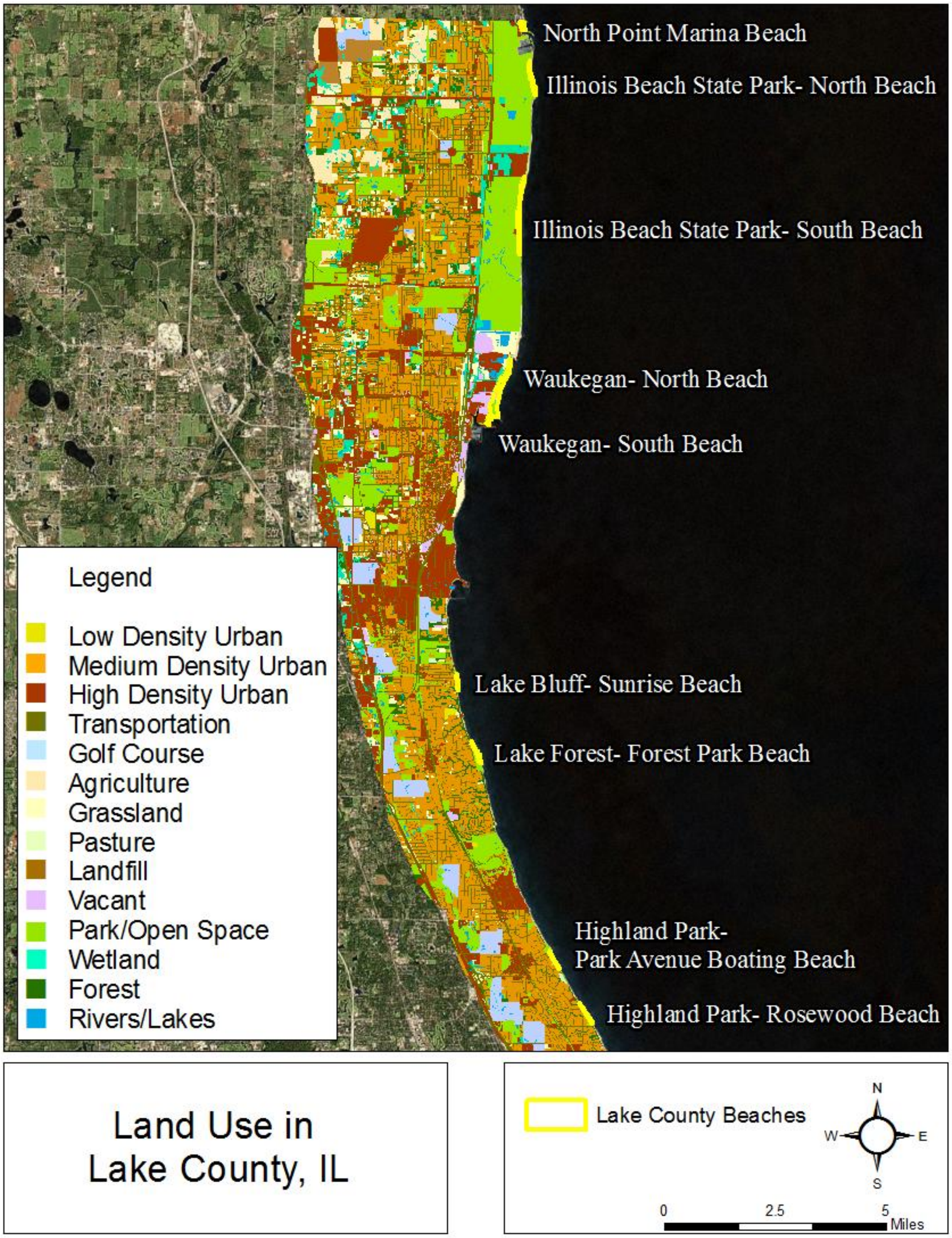


Figure 3-4. Land Use along the Shoreline in Lake County

3.2.4 Substrate

Spatial coverages of macro- and micro-substrate within southwestern Lake Michigan were compiled by Creque and others (2010) using information gathered over 72 years for Illinois waters. The researchers used sediment data for 1682 sites within a GIS and applied natural neighbor interpolation to predict sediment type in areas lacking data. Sediment data points were most concentrated within the nearshore area.

Figure 3-5 displays the micro-substrate along the Illinois shoreline. Substrate types vary from pebble to coarse and medium sands near the impaired shoreline segments. Comparison of monitored *E. coli* levels in Lake County support findings in peer-reviewed research that finer substrates are more likely to harbor and allow buildup of bacteria than coarser, looser substrates.

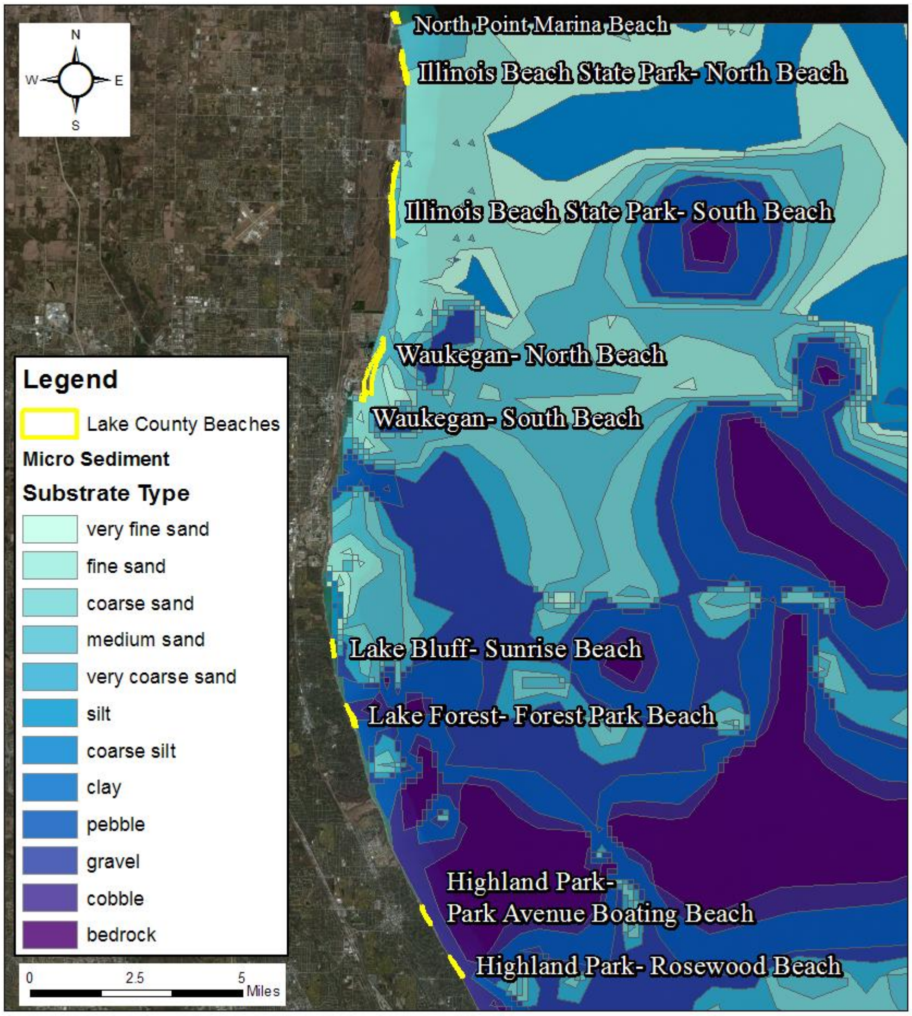


Figure 3-5. Substrate along the Shoreline

3.2.5 Shoreline Physical Characteristics

The physical characteristics of an impaired segment can vary greatly from one another, and these characteristics have varying impacts to beach water quality. Along the Illinois shoreline the impaired segments under study vary from unprotected straight segments to curved segments with barriers on each end. **Figure 3-6** provides an aerial look at two of the different structures of interest to this analysis because of the way these features permit or block the circulation of water, sediment, and bacteria from entering and staying within the impaired water areas.

Figure 3-6. Example of Physical Structures at Shoreline Segments

Therefore, to understand the impacts of the different physical features of each segment, satellite imagery from Google Earth was used to examine each segment in detail. The following determinations were applied where applicable:

- Embayment morphology refers to a beach with a "C" shape enclosure (generally due to hardened structures such as jetties, groynes, etc.) that isolates the site from long shore currents.
- "Channel" indicates if there is a tributary/ravine discharging directly to the beach. Whether the channel was to the north, south, or on either end of a segment was noted.
- General hardened structures (e.g., groynes) were identified and located (north, south, along, segmenting) within each segment.

In an analysis separate from review of aerial images, we also used LIDAR to determine the average slope of each shoreline segment.

3.2.6 Ravines

The ravine structures in Lake County have developed over time due to the unique geology of the Lake Border Upland region near the coast of Lake Michigan. The ravines were created gradually as rainwater eroded the land along the bluffs as it traveled toward the lake. Eventually, the gradual erosion caused by rainwater was balanced by the establishment of trees and plants whose root systems helped to stabilize the banks. The shape and location of the ravines have created a unique microclimate that supports tree and plant species that are usually found in colder, moister, and more northern climates.

More recently, the ravines have been affected by the growing urban development that surrounds them. Urban regions have large areas of impervious surface that generate great volumes of runoff during a rain event. The high volume and velocity of surface water runoff has increased erosion along the ravine banks and has inhibited the establishment of tree and plant species. Furthermore, numerous stormwater outfalls from both residential properties and stormwater transmission systems directly drain to ravines, and this additional quantity of water compounds the rate of bank erosion. Typically, residential drainages are small pipes 6 inches or less in diameter that are unpermitted and drain properties surrounding the ravine banks. The stormwater outfalls can be 12 inches or larger in diameter and may transmit stormwater from any large areas of the lands in the vicinity of the ravine. The resulting rapid bank erosion threatens the establishment and well-being of the rare tree and plant species that make these ravine ecosystems so unique (Alliance for the Great Lakes, 2009).

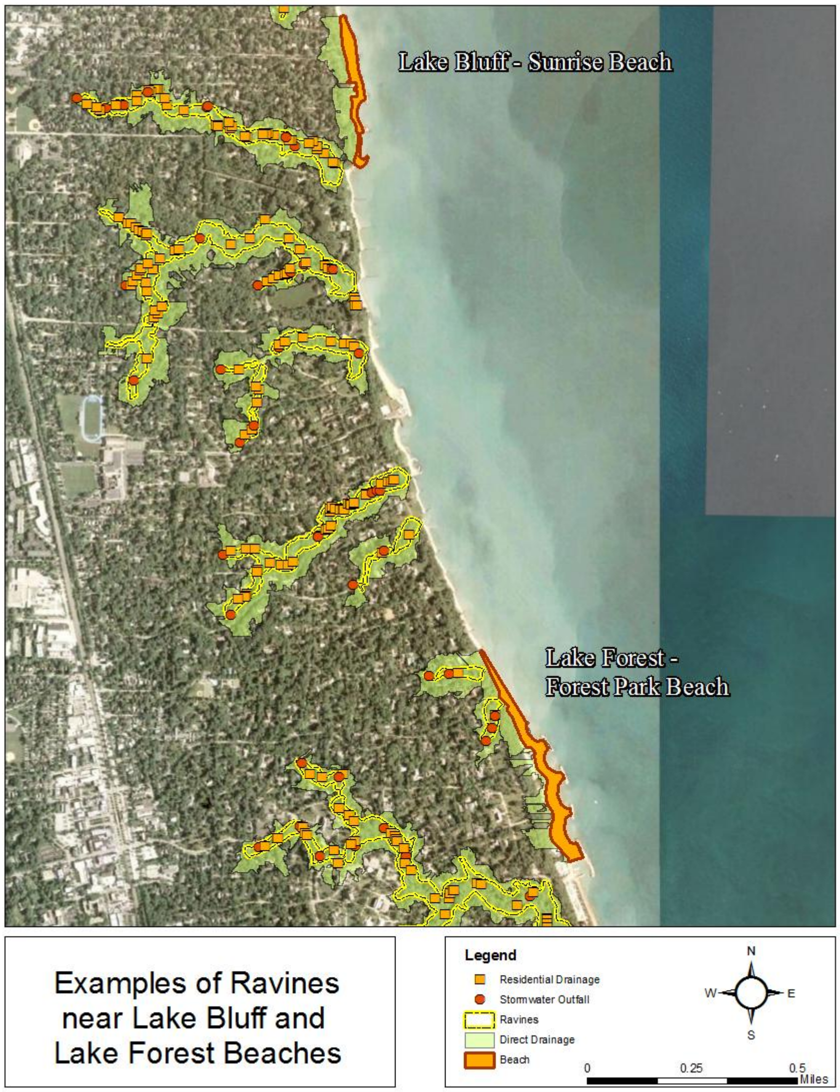


Figure 3-7. Ravines along the Shoreline in Lake County

3.3 Loading Capacity and Existing Load

Development of TMDLs for the shoreline of Lake Michigan presents differences compared to the typical determination of a loading capacity for an impaired segment corresponding to a lake or stream. First, the impaired shoreline segments do not have a single identifiable flow regime. These segments are under the influence of three-dimension currents and tides. Second, there is no defined point in the geography over which the volume of water may be measured to compute a reliable loading off of the concentration measures available from monitoring. Finally, loadings of bacteria, which depend on a volume of flow, are less likely to directly correlate with measured concentrations at a beach due to the high variability in the bacterial water quality over time and between sources. For these reasons, the loading capacity used to develop these TMDLs is concentration-based and set at the WQS.

In simplified terms, the standard formula changes to

TMDL = Loading Capacity = Water Quality Standard

With this decision for the loading capacity, the TMDL/WQS is then applied to the WLA for allowable regulated sources as well. Point sources must now meet the WQS at the point of discharge. This WLA does not account for mixing, die-off, and lake effects on that source once it enters the nearshore waters. Thus, the bacteria TMDLs represent conservative TMDL target-setting, which provides some implicit MOS as well as a high level of confidence that the TMDLs established are consistent with WQSs.

4. Total Maximum Daily Loads

The loading capacity (LC) is the total amount of a pollutant that can be assimilated by the receiving water while still achieving WQSs. The loading capacity is composed of the sum of individual WLAs for regulated sources and load allocations (LAs) for unregulated sources and natural background levels. In addition, the TMDL must include a MOS, either implicitly or explicitly, and a reserve capacity (RC). The MOS accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. The RC allows for further development that may occur within the watershed. Conceptually, this is defined by the equation:

$$TMDL = \sum WLA + \sum LA + MOS + RC$$

When prepared for conventional pollutants, such as phosphorus or suspended sediment, the LC is expressed as a load (i.e., pounds per day). However, bacteria are not a conventional pollutant that can be expressed in terms of mass. Bacteria are expressed in terms of colony forming units per unit volume rather than in mass per unit volume. In addition, the impaired waterbodies associated with this TMDL are shoreline segments, not lakes or streams. Therefore, total volume cannot be quantified with sufficient certainty due to the variability of in-lake hydrodynamic impacts at each individual beach.

As such, the TMDLs for Lake County are expressed in terms of concentrations. Concentration-based LC, WLA, and LA allow for easier implementation because they

- Provide a direct link to existing water quality conditions and numeric WQSs;
- Apply to a range of flow and environmental conditions;
- Minimize the uncertainty associated with determining the volume of water contributing to the loading of bacteria to the beaches along Lake Michigan, which in turn minimizes the uncertainty in load allocation and reduction strategies; and
- Are more meaningful to beach managers and other stakeholders who may play a role in meeting the WLAs and LAs.

As described in **Section 3.1**, the water quality target selected for the LC for each impaired segment is 126 cfu/100 mL based on the GM WQS.

4.1 Pollutant Source Assessment

The potential sources of *E. coli* impacting the impaired segments are partially treated flow from STPs and urban stormwater runoff impacted by illicit or failing sewer connections; pet, avian, and wildlife feces; and contaminated sediment. Other *E. coli* sources potentially impacting the impaired segments and occurring at the beach are direct deposition of feces from gulls, pets, and bathers, and resuspended sand in the swash zone.

There are several traditional *E. coli* sources that are not relevant to the impaired segments: untreated CSOs, SSOs, failing septic systems, and impact from agricultural sources. There are no untreated CSOs or SSOs discharging to Lake Michigan or its tributaries. (Note that river reversals are considered separately from CSOs.) There are minimal septic systems in the beachsheds (Adam, 2012) and no agricultural land uses. Therefore, these sources are not considered further in this TMDL.

As authorized by the federal CWA, the NPDES permit program controls water pollution by regulating wastewater and stormwater discharges from industrial and municipal facilities to waters of the United States. The impaired waters are potentially impacted by wastewater discharged by sewage treatment plants and stormwater discharged from municipal and industrial storm sewers. These sources are described in detail in the following sections.

4.1.1 Sewage Treatment Plants

There are two STPs that are relevant in this TMDL: NSSD's Gurnee and Waukegan STPs as shown in **Table 4-1**. Although these plants primarily discharge effluent to the Des Plaines River, they occasionally discharge to Lake Michigan during periods of extreme high flows into the treatment facilities. Any flow to Lake Michigan is partially treated and is termed "Excess Flow" by IEPA. This partially treated effluent undergoes screening, settling, and disinfection before discharging to the Lake and is permitted for fecal coliform according to their NPDES permits. Between 2007 and 2011, the Gurnee plant had no excess flow discharges. The list of excess flow discharges for the Waukegan plant is included as **Table 4-2** (IEPA, 2011).

Table 4-1. Sewage Treatment Plants Potentially Contributing *E. coli* to the Impaired Segments

Facility Name	Outfall	Description	Receiving Water	Permit No.	Beachshed
NSSD-Waukegan STP	0020	Excess Flow to Lake Michigan	Lake Michigan	IL00030244	Waukegan North Beach, Waukegan South Beach
NSSD Gurnee STP	0200	Excess Flow To Lake Michigan	Lake Michigan	IL00035092	None – Located south of Waukegan South Beach and north of Lake Bluff Sunrise Beach

Table 4-2. Discharge Data from the NSSD Waukegan Facility during Periods of Excess Flow: 2007–2011

Date	Flow (Million gallons/month)	Fecal Coliform[1] (cfu/100 ml)
Aug 2007	7.72	< 9
Mar 2008	12.69	116
Apr 2008	49.22	320
Jun 2008	2.09	9
Sept 2008	29.79	13,300
Dec 2008	37.23	200
Mar 2009	31.11	1,040
Apr 2009	35.38	13
May 2009	1.75	< 2
Jun 2009	61.11	> 20,000
Dec 2009	7.83	3
May 2010	9.75	3
May 2011	3.32	<2

[1]Daily maximum

4.1.2 Stormwater

Stormwater may also be impacting the impaired beach segments. Surface runoff may be impacted by *E. coli* sources, including pet, avian, and wildlife feces and contaminated sediment. In addition, connections intended for sanitary sewers may exist within storm sewer systems, or ex-filtration from improperly maintained sanitary sewers may leach into surface waters.

Stormwater from the beachsheds and BPAs is captured by 16 systems, each covered by a NPDES MS4 permit (**Table 4-3**). MS4 permits require municipalities to implement measures to reduce pollutants in stormwater from illicit discharges and construction sites, to provide public education and allow public participation, to minimize pollutants from municipal operations, and to address post-construction runoff. The determination of which municipalities are required to obtain MS4 permits involves a combination of population; proximity to large, urbanized areas; and the water quality of receiving streams. All of the municipalities within the Lake County beachsheds are permitted MS4s. No discharge data was available; however, researchers have found *E. coli* values as high as 250,000 cfu/100 mL at stormwater outfalls near beaches in Wisconsin (McLellan, 2012).

Table 4-3. MS4 Permitted Discharges within Impaired Lake County Beachsheds and BPAs

Permittee	Permit No.	Receiving Water	Beachshed/BPA
Beach Park Village	ILR400164		IBSP North and South Beaches
East Skokie Drainage District	ILR400491	Skokie River	Waukegan North Beach, Waukegan South Beach
Highland Park, City of	ILR400352	Skokie River, Lake Michigan	Highland Park Avenue Beach, Rosewood Beach and Waukegan North Beach, Waukegan South Beach

(continued)

Table 4-3. MS4 Permitted Discharges within Impaired Lake County Beachsheds and BPAs (continued)

Permittee	Permit No.	Receiving Water	Beachshed/BPA
Highwood, City of	ILR400353		Highland Park Avenue Beach, Rosewood Beach
Illinois Department of Transportation	ILR400493		Multiple
Lake Bluff, Village of	ILR400366	Lake Michigan	Lake Bluff Sunrise Beach
Lake County	ILR400517		Multiple
Lake Forest, City of	ILR400367		Lake Forest Forest Park Beach
North Chicago, City of	ILR400402		Lake Bluff Sunrise Beach
Shields Township	ILR400123		Lake Bluff Sunrise Beach, Lake Forest Forest Park Beach
Union Drainage District Middle Fork	ILR400518		
Waukegan Township	ILR400148		Waukegan North Beach, Waukegan South Beach
Waukegan, City of	ILR400465	Waukegan River	Waukegan North Beach, Waukegan South Beach
West Skokie Drainage District Middle Fork	ILR400490	Skokie River	Waukegan North Beach, Waukegan South Beach through SSO at NSSD STP
Winthrop Harbor, Village of	ILR400477	Kellogg Creek	North Point Marina Beach, IBSP North Beach
Zion, City of	ILR400482	Kellogg Creek	IBSP North and South Beaches

In addition, the region contains two industrial facilities with a NPDES permit for stormwater discharges as shown in **Table 4-4**. Similar to MS4s, runoff from these facilities may be impacted by *E. coli*.

Table 4-4. Permitted Industrial Stormwater Discharges within the Impaired Beachsheds and BPAs that May Contribute *E. coli* to Coastal Waters

Facility Name	Outfall[1]	Receiving Water	Permit No.	Beachshed/BPA
Abbott Labs-N Chicago	0010, 0020, 003s, 0030	Lake Michigan, Grassy Area Tributary to Lake Michigan	IL0001881	None – Located south of Waukegan South Beach and north of Lake Bluff Sunrise Beach
Outboard Marine (Bombardier-Waukegan)	002-005, 015, 016	North Ditch Tributary to Lake Michigan, Waukegan Harbor	IL0002267	Waukegan North Beach, Waukegan South Beach

[1]One or more outfall discharges stormwater from each facility

Although not a direct source of *E. coli*, runoff from construction sites can contain sediment that may harbor *E. coli* in storm sewers. During the period of 2007–2011 there were four stormwater permits for construction activities issued within the study area (**Table 4-5**). During rain events, contaminated sediment can be resuspended and discharged to Lake Michigan. Because MS4 permits require municipalities to reduce pollutants from construction sites, an independent WLA was not needed for construction sites for bacteria. Furthermore, construction activity during the project period is low in the drainage areas relevant to the beaches. If stormwater prevention practices onsite fail and sediment (that could harbor bacteria) leaves the construction site, stormwater within this project area would drain to the MS4 conveyance or to streams. Sources of bacteria via these pathways are covered in this TMDL by the MS4 WLA and through the model used to generate LAs. If construction activity is found to be a persistent and readily identifiable source of bacteria impairments at the beaches, the TMDL may be modified.

Additional permitted discharges that are not sources of bacteria are listed in **Appendix I**.

Table 4-5. Applicable Construction Stormwater Permits in Lake County from 2007 to 2011

Construction Address	City	County	Acres	Completion Date	Receiving Water
Garrick Ave and Lee Ave	Waukegan	Lake	1.5	06/27/07	Unnamed Tributary to the North Branch Waukegan River
351 Skokie Highway	Lake Bluff	Lake	6.34	07/14/07	Skokie River
East of Rt 41 and South of Rockland Rd	Lake Bluff	Lake	1.85	07/17/07	Skokie River
One ZB Way - 21st St and Kenosha Rd	Zion	Lake	2	06/01/07	Kellogg Creek

4.1.3 Gulls and Other Sources

For the impaired shoreline segments in Lake County, waste from gulls at the shore is the primary source of bacterial contamination (LCHD, 2003). Other potential *E. coli* sources at impaired beach segments include

- Feces from dogs and other wildlife,
- Bather load
- Wave action against beach sands in the swash zone and subsequent resuspension of resident *E. coli* populations (Alm et al., 2003; Skalbeck et al., 2010), and
- Transport of *E. coli* from outside the beachshed by lake currents.

4.2 Pollutant Allocations

Two allocations of pollutant sources are evaluated in TMDL development: WLAs and LAs. The WLA is the allowable amount of the pollutant that can be assigned to regulated sources. For this TMDL, regulated sources include sewage treatment facilities and municipal and industrial stormwater discharges. Regulated entities that discharge within the beachshed/drainage area or within the BPA will receive a WLA.

The LA is the allowable amount of the pollutant that can be assigned to unregulated sources. For this TMDL, unregulated sources include direct fecal input from gulls, dogs, and wildlife; resuspended sand in the swash zone, and *E. coli* transported from outside the beachshed by lake currents.

4.2.1 Wasteload Allocations

The WLA for the Waukegan and Gurnee STPs is 400 fecal cfu/100 mL as a daily maximum (**Table 4-6**). This WLA is based on fecal coliform rather than *E. coli* and is consistent with the existing NPDES permits for each facility. Achievement of the fecal limit is expected to be consistent with the *E. coli* WQS as discussed in **Section 3.1**.

Municipal stormwater permittees were assigned a WLA if their jurisdiction fell within the beachshed/ drainage area or BPA. Municipal stormwater permittees were given a WLA of 126 *E. coli* cfu/100 mL as a GM (Table 4-6).

The Outboard Marine/Bombardier-Waukegan and Abbott Labs-N Chicago facilities were given a WLA of 126 *E. coli* cfu/100 mL as a GM (Table 4-6).

The construction stormwater permits are considered a negligible source of bacteria to the beaches and are not given a specific WLA because they are not considered to be a direct source of *E. coli*. Additionally, these sites would have existing coverage if the MS4 permit in which they fall if stormwater migrates from the construction site.

Table 4-6. WLAs for Lake County

NPDES Permittee	Permit No.	WLA (cfu/100 mL)[1]
Wastewater		
NSSD-Waukegan STP		400[1]
Gurnee STP		400[1]
Municipal Stormwater		
Beach Park Village	ILR400164	126
East Skokie Drainage District	ILR400491	126
Highland Park, City of	ILR400352	126
Highwood, City of	ILR400353	126
Illinois Department of Transportation	ILR400493	126
Lake Bluff, Village of	ILR400366	126
Lake County	ILR400517	126
Lake Forest, City of	ILR400367	126
North Chicago, City of	ILR400402	126
Shields Township	ILR400123	126
Union Drainage District Middle Fork	ILR400518	126
Waukegan Township	ILR400148	126
Waukegan, City of	ILR400465	126
West Skokie Drainage District Middle Fork	ILR400490	126
Winthrop Harbor, Village of	ILR400477	126
Zion, City of	ILR400482	126
Industrial Stormwater		
Outboard Marine (Bombardier-Waukegan)	IL0002267	126
Abbott Labs-N Chicago	IL0001881	126

[1] Fecal WLAs are based on a daily maximum, while *E. coli* WLAs are based on a geometric mean.

The goal of the TMDLs is to ensure compliance with the bacteria water quality criteria at the point of discharge for point sources in order to meet WQSs at the nearby beaches/impaired segments. In this setting, point-source discharges are impacting the impaired segment on a different time scale than the predictor variables identified in the model (e.g., precipitation, wave action, gulls counts); their contributions to the *E. coli* impairment are assumed to occur on an infrequent, nondaily time scale (i.e., when storms occur). Inclusion of these point sources into the model used to assess reductions for nonpoint sources (**Section 4.8**) would have introduced uncertainty into model results due to the difference in data availability and the time and scale at which these sources contribute. Therefore, to account for all sources and ensure that point sources will not cause or contribute to an exceedance at the beach, the WLA for point sources would be equal to the GM WQS as shown in the table above.

4.2.2 Load Allocations

The LA for this TMDL is set as a GM of 126 *E. coli* cfu/100 mL. This covers discharges from unregulated sources, including direct deposition from gulls, dogs, and wildlife; resuspended beach sand; and possible transport from long shore currents, e.g., nonpoint sources of *E. coli* that do not have localized points of release to the shoreline segment.

LAs are set as the WQS because there is no direct monitoring that provides the concentration and/or load of *E. coli* directly related to each of these sources. For nonpoint sources hypothesized to contribute to the impairment, surrogate variables were used within the multilevel analysis to determine any correlation between the source and the *E. coli* concentration and to provide the reduction required from each source to achieve the TMDL.

4.3 Margin of Safety

The MOS, which may be explicit or implicit, accounts for uncertainty that the resultant allocations in the TMDL will result in attaining WQSs. Uncertainty can stem from a lack of supporting information or data to link the allocated sources with the water quality impairment. By using a concentration-based TMDL, there is an implicit MOS because all sources are set to less than or equal to the WQS, and any mixing, dilution, settling, or die-off impacts are excluded from the allocations. Therefore, the allocations and any load reductions calculated from the allocations are conservative.

An additional element of the implicit MOS arises from the methodology used to determine the reductions in nonpoint sources (**Section 4.8**). Using a modeling method that simulates the distributions of monitored *E. coli* levels, the load reductions were calculated by shifting the predicted distributions until there was a negligible probability that the estimated GM or SSM (depending on the analysis) would exceed the WQS. With this method, all ranges of concentrations experienced within the existing monitoring data (and therefore it is assumed all beach conditions) are accounted for and lowered to WQS levels by instituting the calculated reductions. Requiring all point sources to meet the WQS (i.e., the WLA) further assures that the TMDL will be met.

4.4 Seasonal Variation

The federal promulgated *E. coli* standard is being used to develop the TMDL, but an explicit time period for the recreation season was intentionally not promulgated in the federal rule. (This acknowledges and allows states to select recreation seasons that are applicable to their climate and geographic area). To determine which season is applicable for this TMDL, IEPA examined their state WQSs. IL Title 35 Section 302.309 describes general use WQSs for fecal coliform as applicable from May to September. Therefore, it was reasonably assumed that the federal *E. coli* standards for this TMDL could be applied for a recreation season from May to September. In the future, if nonrecreation season water quality exceedances become a routine public health issue, which may demonstrate that primary contact recreational use is not being supported, then the TMDL may be modified. It is assumed that the variation over the summer season can currently be modeled to adequately address seasonal variation that occurs within the recreation season and thus addresses TMDL requirements.

Inter-seasonal variation was also accounted for by considering *E. coli* concentrations across the years 2006 to 2011 recreation seasons. Drier summer seasons in 2006 and 2008 bordered a wetter summer season in 2007, whereas precipitation totals for 2009 to 2011 were more similar based on rain gauge data in Zion, Waukegan, Lake Forest, and Highland Park (**Table 4-7**).

Table 4-7. May–September Lake County Precipitation, Average of Four Stations

Year	Average Rainfall Sum (in)
2006	12.6
2007	21.7
2008	17.5
2009	20.8
2010	19.2
2011	21

4.5 Critical Conditions

As specified in the CWA, critical conditions must be considered in the TMDLs. Critical conditions refer to periods in which the greatest reductions are needed. Critical conditions are those that can be anticipated to generate the poorest water quality conditions and also conditions that lead to the greatest pollutant loading. Due to the complex hydrology associated with a beach, there is no one single critical condition for these TMDLs. Analysis of existing monitoring data shows that exceedances occurred under a variety of conditions due to a variety of sources, all of which are considered by basing reduction goals on the full range of monitored conditions. However, the period of record for the data set used in this study contains many extreme observed values that reflect 'critical conditions'; these observations, which co-occur with measured *E. coli* concentrations at or near the upper detection limit, have been documented at all impacted beach segments (**Table 4-8**). Variables representing critical conditions include high gull counts (nonpoint source); wave energy and period (resuspension of resident *E. coli* populations in swash zone); and 24-hour rainfall total (transport of *E. coli* in surface runoff from near-beach environment). Since the modeling process incorporates data from conditions that are expected to be critical, the final modeled distributions can reasonably be described as accounting for critical conditions.

Table 4-8. Examples of Critical Conditions at Lake County Beaches

Beach	Wind Direction	Wind Speed (mph)	Gull Count	Wave Height (m)	Wave Direction (degree)	Wave Period (s)	Previous 24-hr Rainfall Total (in)	*E. coli* (cfu/100 mL)
North Point Marina Beach	W	5	850	0.1205	75.3	1.33	0	2419
IBSP North Beach	SE	10	0	1.281	295.75	4.7	2.19	2419
IBSP South Beach	S	2.5	400	0.4995	205.4	3.1	0	2419
Waukegan North Beach	NE	20	0	2.2164	227.35	6.078	1.44	2419
Waukegan South Beach	E	5	226	0.2638	290	2.5169	0	2755
Sunrise Beach	NE	15	0	0.5087	226.0	2.9969	1.82	2419
Forest Park Beach	N	20	20	0.8317	212.4	3.7921	0.16	2187
Park Avenue Boating Beach	E	5	0	0.9375	290	4.74	2.51	2419
Rosewood Beach	E	5	0	0.9375	290	4.74	2.51	4352

4.6 Reserve Capacity

RC represents some *E. coli* allocation that has been set aside to accommodate future growth and development rather than allocating it to existing sources. The RC for each impaired segment is zero. Application of the WQS as the WLA and LA requires that any changes within the contributing area (e.g., urban development within an MS4 municipality that discharges to a beach) must maintain discharges that meet the WQS and therefore the TMDL.

4.7 TMDLs

To summarize, if the source of the bacteria load is allowable, the WLA or LA is set equal to the applicable WQS for bacteria in the receiving water. If the source of the bacteria load is prohibited or reductions cannot be achieved from that source or surrogate source, then the WLA and LA are set to zero. For example, discharges of untreated wastewater to any surface water from sources such as illicit discharges to stormwater systems, boats, and failed septic systems are prohibited and would receive bacteria load allocations of zero. **Table 4-9** provides the WLAs and LAs by category of source for the TMDLs for the nine impaired segments of interest in this study.

The underlying assumption in setting a concentration-based TMDL for bacteria is that if all sources are less than or equal to the WQS, then the concentration of bacteria within the receiving water will attain WQS. This methodology implies a goal of meeting bacteria standards at the point of discharge for all sources.

Table 4-9. Summary of Allocations by Category

NPDES Permittee	Allocation/Indicator (cfu/100 mL)
Waste Load Allocations	
Wastewater	400 fecal
Municipal Stormwater	126 *E. coli*
Industrial Stormwater	126 *E. coli*
Untreated wastewater	0
Load Allocations	
Gulls, dogs, wildlife, resuspended beach sand, long shore currents, and other nonspecific loading sources to nearshore waters (i.e., river reversals)	126 *E. coli*

4.8 Load Reduction Calculation Methods

In order to utilize all the available monitoring data from each of the beaches managed within Lake County (which correspond with the impaired segments), a statistical framework was employed to calculate the impacts of each of the source and surrogate variables available on *E. coli* concentrations. For nonpoint sources hypothesized to contribute to the impairment, surrogate variables were used within a statistical analysis to determine any correlation between the source and the *E. coli* concentration and to estimate the source reductions required to achieve the TMDL. The method is explained through three steps beginning with initial data exploration and ending with calculating the reductions needed to meet the WQS in the different parameters used in the model. Further details on the method used can be found in **Appendix II**.

4.8.1 Step 1: Data Collection and Initial Analysis

Measured *E. coli* concentrations for Lake County beaches were obtained for the years 2004 to 2011. Where present, the average daily concentration (from two samples taken at the same time) was chosen as the daily *E. coli* value for each beach. In some cases, only a single measurement was reported.

Information that might predict *E. coli* concentrations at Lake County beaches (predictor variables) was then collected from a number of different sources. These variables were chosen based on information in the scientific literature and stakeholder input. Examples of predictor variables tested in this analysis include information on lake conditions, precipitation, beach characteristics, watershed characteristics, and gull counts.

The data were then examined to check model assumptions and to look for relationships between *E. coli* concentrations and the predictor variables. Both visual methods (graphs) and formal statistical tests were used.

4.8.2 Step 2: Initial Model Fitting

The variables identified in Step 1 were then used as the starting point for a multilevel regression model. This model was used to estimate relationships between the predictor variables and *E. coli* concentrations at Lake County Beaches. Predictor variables were added to the model in a stepwise manner, and the explanatory power of the model was evaluated. All variables were tested, and the selection of variables in the final model was based on explanatory power and statistical significance (**Table 4-10**).

Once fitted, statistical assumptions were checked to make sure the use of the model was appropriate.

4.8.3 Step 3: Simulation

Both manageable and non-manageable variables were included in the final model (Table 4-10). Manageable variables are those that can be influenced by beach managers (i.e., gulls) while non-manageable variables are those that cannot be easily changed (i.e., wave height), but which still impact water quality. Reductions for sources necessary to meet the TMDL were therefore limited to variables representing manageable sources. The relationships between these predictor variables and *E. coli* concentrations were quantified in Step 2. Because there is uncertainty associated with these estimated relationships, statistical simulation was used to identify the impact of changing a manageable variable (i.e., keeping the number of gulls below a certain threshold). In model simulation, many predictions are made and the ‘average’ predicted value for a specific combination of predictor variable values is obtained. Manageable variables in the model were then manipulated until all average predicted values were below the TMDL water quality target. The predictor variable thresholds required to meet the target were then used as the recommended management goals.

More specific information on methodology and statistical approaches can be found in **Appendix II**, while final model parameter values can be found in **Appendix III**.

4.9 Final Reductions

The predictor variables in the final Lake County model were chosen for explanatory value, physical interpretation, and management value (Table 4-10). Most, but not all, of the variables achieved statistical significance; variables that did not meet the standard 5% p-value statistical significance threshold were included if they greatly enhanced the explanatory power of the model.

The physical interpretation of the model is consistent with the view that beach *E. coli* concentrations are influenced by local conditions—wave conditions, rainfall, physical structures, and gull presence. In general, watershed-level variables such as land use, impervious surface, or ravine data were not found to be as influential as local conditions. One important finding is that the impact of hardened structures at beaches depends on prevailing weather. For instance, hardened structures oriented to the northeast are associated with lower levels of *E. coli*. Based on the literature, one interpretation of this finding is that these structures help protect the beach from wave energy associated with storms and/or longshore currents; there is, therefore, less wave energy available for resuspending any resident environmental *E. coli* bacteria living in beach sand (Alm et al., 2003; Skalbeck et al., 2010). The same protective phenomenon is evident in the case of embayment and severe wave conditions. However, hardened structures are associated with average or above average *E. coli* conditions when rain is considered. Again, based on the literature, this result is likely due to the prevention of nearshore flushing by longshore currents (Ge et al., 2012). Precipitation may increase water column concentrations either by washing source loads (e.g., gulls feces, trash) to the beach through stormwater runoff or by percolating into beach sands and transporting resident *E. coli* colonies into the water column. The negative correlation between average beach slope and *E. coli* concentration may be due to faster shedding of stormwater or reduced area exposed to wave energy in the swash zone.

4.9.1 Distributional Groups

An important consideration when analyzing data from units that differ on spatial (physical locations) and/or temporal (time of observations) dimensions is whether the distribution of the variable of interest (in this case, *E. coli* concentration) is similar across different units. There are at least two reasons to examine this issue. First, we need to verify that the distribution of *E. coli* at each beach meets the requirements of the parametric regression approach used in this study. Second, in terms of prediction and simulation, we do not want to apply relationships based on an average *E. coli* concentration to beaches that are statistically above or below the average; this approach is likely to result in predictions that are below or above the observed patterns at these sites, respectively. When comparing distributions, we want to examine both mean values as well as the ‘tail’ regions (i.e., probabilities associated with observing a value that is much higher or much lower than the average).

In order to compare mean values, a stepwise multiple comparison (Tukey’s Honestly Significant Difference [HSD]) analysis was used to contrast mean *E. coli* concentrations across all sampling locations. This comparison indicates which beaches have *E. coli* distributions with similar mean values. The results of the analysis revealed that several pairwise beach comparisons exhibit statistically significant differences in mean *E. coli* concentration. However, Tukey’s HSD examines differences in mean value only. Beaches that have similar average *E. coli* concentrations can differ greatly in the probabilities of very high or very low concentration values. For this reason, a non-parametric test that considers the probabilities of all concentration values was also calculated (Kolmogorov-Smirnov [K-S] test). The most significant result of this analysis was to show that four beaches—Forest Park, Rosewood, IBSP South, and Waukegan North Beaches—have statistically similar *E. coli* distributions for the period 2006–2011 (**Figure 4-1**). In comparison to the other sites, this four-beach group is close to the overall “average” distribution. A second group comprised of Park Avenue Boating and IBSP North Beaches was also found to have statistically similar *E. coli* distributions; these two beaches can be characterized as being slightly below the Lake County average in term of observed concentrations. The remaining beaches—Sunrise, Waukegan South, and North Point Marina—could not be grouped with other sites on the basis of observed *E. coli* measurements. These beaches can be described, respectively, as follows: Sunrise had the overall lowest observed distribution; Waukegan South was slightly above average; and North Point Marina had the highest observed distribution for the data period 2006–2011.

Table 4-10. Final Lake County Predictor Variables

Variable	Statistically Significant	Impact on Predicted Concentrations	Correlation with *E. Coli* Concentration	Physical Interpretation	Manageable Parameter
Embayment	Yes	High	Positive	Prevents flushing of near-shore loading	Potential, but unlikely
Wave Category (Intensity)	Dependent on level	Moderate to high	Positive	High-energy waves resuspend bacteria located in swash zone	No
Gulls	Yes	Low	Positive	Loading from fecal material	Yes
Previous 24-hour Rainfall	Yes	Moderate	Positive	Transport mechanism for near-shore loading	Yes
Hardened Structures based on location relative to beach	Dependent on level	Moderate to high	Dependent on structure location	Structures oriented to the north and northeast block long shore current wave energy	Potential, but unlikely
Significant Wave Height	Yes	Moderate	Positive	Direct measure of wave energy	No
Wind Direction	Dependent on level	Low	Dependent on direction (negative)	Winds from the west, northwest, and southwest assist in flushing	No
Wind Category (Intensity)	No	Low	Dependent on intensity	Strong wind proxy for storm events	No
Average Beach Slope	Yes	Low	Negative	Higher average slopes may have smaller swash zones; less attractive to gulls; may shed surface runoff	Yes
Interaction: Embayment and Wave Category	Dependent on level	None to high	Dependent on combination	Embayment is protective against high energy waves; however, embayment also prevents flushing of near-shore loading during calm conditions	No
Interaction: Previous 24-hour Precipitation and Hardened Structures	Dependent on level	Moderate	Dependent on combination	Structures that may be productive during intense wave activity may also prevent flushing of near-shore loading	Potential, but unlikely

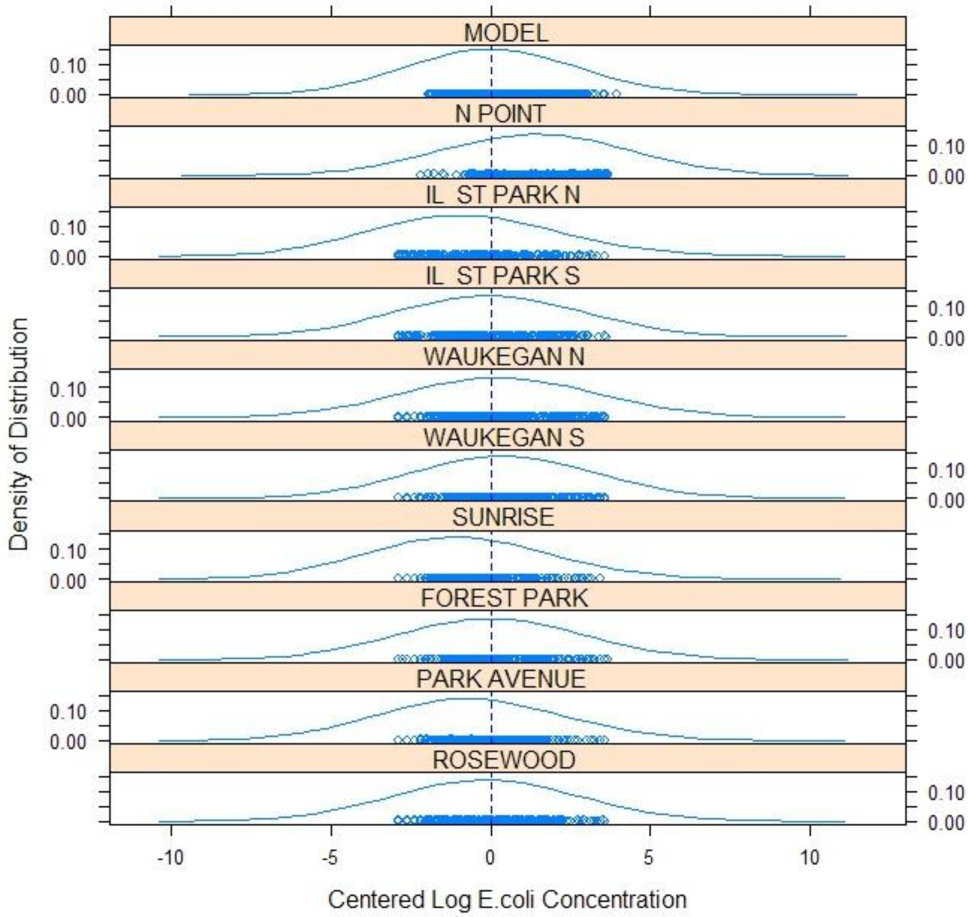


Figure 4-1. Predicted Distributions of *E. coli* at All Segments (top panel) Versus Monitored Distributions at Individual Segments (lower panels)

4.9.2 Analysis

Of the predictor variables included in the final model, three were considered to be readily manageable: gull count, previous 24-hour rainfall, and average beach slope. As described in **Section 4.8.3**, these variables were subset in iterative statistical simulations to provide a predicted daily *E. coli* distribution that achieves either the SSM or the GM WQS in successive analyses (**Table 4-11**). The TMDL target is set at the GM; however, the SSM was also examined when estimating load reductions for informational purposes as the SSM values are used for making beach notification and closure decisions based on public health concerns. GM TMDL targets are designed to consistently achieve the GM with some predicted percent of SSM exceedance. SSM informational targets are designed so that a SSM is not exceeded.

As a general rule, the management action that would be necessary to meet a SSM standard would be more stringent than what is required to meet a GM-based standard. Because the GM is based on an average value (30-day moving average), individual exceedances of the SSM WQS can occur even if the GM WQS is still met. Table 4-11 presents the thresholds of the three manageable variables that must be met in order to achieve concentrations at or below the SSM throughout the beach season and, alternatively, to achieve a 30-day GM. The thresholds are determined using the distributional groups previously described, so that the same variable adjustments are required to attain the WQS for beaches in the same group.

Table 4-11. Manageable Variable Thresholds Required to Meet the Load Allocation

Beach/Distributional Group	SSM Informational Target[1]			GM TMDL Target			
	Reduce 24-hour Rainfall Below (inches)[1]	Reduce Daily Gull Count Below	Increase in Slope Required (%)	Reduce 24-hour Rainfall Below (inches)[2]	Reduce Daily Gull Count Below	Increase in Slope Required (%)	Predicted Percent of SSM Exceedances when GM Is Attained
Group 1: Forest Park, Rosewood, IBSP South, Waukegan North	0.4	30	3	1	50	1	8%
Group 2: Park Avenue Boating, IBSP North	0.7	35	3	1.5	60	—	7%
Sunrise	1	45	2	2	65	—	8%
Waukegan South	0.1	5	6	0.2	25	3	4%
North Point Marina[3]	N/A	N/A	N/A	0.2	40	2	4%

[1] The SSM targets provided in this series of tables are for informational purposes only. The GM targets correspond to the thresholds needed to meet the TMDL LAs.

[2] Reduction in rainfall below a certain amount equates to capturing any rainfall in excess of that amount through stormwater BMPs so that runoff and other surface flows (e.g., ravine discharge) do not directly impact the beach.

[3] Because of high observed *E. coli* concentrations, attainment of the SSM WQS could not be attained through adjustments to the manageable variables at this beach.

When comparing the thresholds required to attain the SSM and those required to attain the GM, greater actions are required to achieve the SSM as expected. For instance, at the relatively less impaired Sunrise Beach, managers must arrange for stormwater management when rainfall is above 1inch, keep daily gull counts below 45 birds, and regrade the beach to achieve a 2% greater slope in order to attain the SSM. If they aim to achieve the GM, they will experience approximately 8% SSM exceedances; however, they need to manage stormwater only when rainfall is above two inches and keep the gull count below 65 per day. A 8% chance of exceeding the SSM equates to approximately 8 days with a exceedance during the beach season (assuming a 100-day beach season). Conversely, North Point Beach ranked as the sampling site with the highest overall average *E. coli* concentration. Because of this high observed concentration, modeling based on the SSM was not able to achieve a predicted level of no exceedances. To achieve the GM, beach managers must control for stormwater during most rainfall events (greater than 0.2 inches in magnitude), keep the gull count below 40 birds per day, and regrade the beach to increase the slope by 2%. With those management options, achieving the GM still allows for approximately 4 exceedances of the SSM WQS during a 100-day beach season (4%).

To assess the magnitude of the required changes, the thresholds can be compared to the observed values of these variables over the study period 2006–2011 (**Table 4-12**). Attempts were made when modeling to determine the thresholds to keep them within observed limits so that implementation activities could likely be used to achieve the required levels. For instance, an increase in slope by 4% for Waukegan South would be necessary to help achieve the GM WQS. Although 4% is a large increase in terms of slope, the existing slope at the beach is only 3.7%. With the increase in slope, the beach would still be within the limits observed at other beaches throughout Lake County.

Table 4-12. Observed Gull and 24-hour Rainfall Data Summaries by Predictive Group

Beach/Distributional Group	Gulls			Previous 24-hour Rainfall			Average Slope (%)
	Median	Mean	Max	Median	Mean	Max	
Group 1: Forest Park, IBSP South, Waukegan North, Rosewood	5	35	2000	0	0.12	3.29	4.4 – 6.8
Group 2: IBSP North, Park Avenue Boating	0	9	550	0	0.1	3.13	7.1, 8.3
Sunrise	0	4	70	0	0.12	3.29	9.4
Waukegan South	65	91	2110	0	0.1	2.7	3.7
North Point Marina	200	217	1000	0	0.15	3.6	3.6

In order to provide a point of reference for the 24-hour rainfall thresholds presented as load reduction scenarios, the last 10 years (2002–2011) of recreation season rainfall events were examined from the 4 rainfall monitoring stations used in the analysis: Zion (2007–2011 only), Waukegan, Lake Forest, and Highland Park. These years cover wet years (17.2 inches total rainfall in 2007), dry years (3.2 inches in 2005), and average years (11.8–11.9 inches in 2009, 2010, and 2011). **Table 4-13** presents the average percentage of rainfall events that fall above each threshold value across these years.

Table 4-13. Relative Occurrence of Rainfall Events Reaching Proposed Reduction Thresholds[1]

Threshold for Previous 24-hour Rainfall (in)	Percent of Rainfall Events	Percent of All Recreation Season Days
0.1	51	16
0.2	40	13
0.4	25	8
0.7	14	4.5
1	8.2	2.6
1.5	4.8	1.5
2	2.5	0.8

[1] Percentages based on recreation season (approximated by Julian days 146 through 247) averages for the years 2002–2011 from three climate stations and for 2007–2011 for one climate station

5. Implementation and Monitoring Recommendations

5.1 Implementation Plan

Based on modeling results and input from local beach managers, birds (i.e., seagulls), beach slope, and precipitation are the primary manageable factors impacting *E. coli* concentrations at the Lake County beaches. Gulls add *E. coli* directly to the beach via fecal droppings. If the droppings are buried in the beach sand, for instance, by wind action, beachgoers, or wave action, *E. coli* can be trapped in the sand, survive, and be resuspended by runoff or wave action. Reducing the number of gulls at the beach has been correlated with reduced *E. coli* levels in the water column (Engeman et al., 2012). Standing water at the beach will keep sand moist, which can positively influence *E. coli* concentrations in the water column. Pools of water also provide an area for gulls to congregate. Regrading the beach to create a steeper swash zone and reduce ponding will reduce the amount of *E. coli* found in beach sand, which will reduce *E. coli* concentrations in the water column presumably due to resuspended beach sand (Koski and Kinzelman, 2010). Runoff, driven by precipitation, will pick up bacteria from the land areas, such as parking lots, ponded areas, and beach sand, and transport it down gradient to the beach or percolate into the sand and release resident bacteria to the water column. Minimizing runoff at or near the beach will reduce *E. coli* concentrations.

Each of these factors (seagull count, beach slope, and precipitation) can be managed by local, state, or federal agencies provided that the appropriate funding is available. Other factors were also shown to impact *E. coli* conditions, such as beaches being located in embayed areas, wind direction, and wave energy, but these factors were considered not manageable and therefore are not directly addressed in this implementation plan.

A list of Best Management Practices (BMPs) for reducing *E. coli* concentrations at a beach was developed based on controlling (1) the contributing factors (gulls, rainfall, and beach slope) and (2) those variables that could not be modeled due to lack of information. These unmodeled variables include stormwater quality impacts from improperly disposed pet waste, resuspended sediment from eroded stream banks, illicit connections to storm drains, or exfiltration from sanitary sewers. Although these variables were not modeled, they are typically present in urbanized areas and therefore are included in this discussion.

Several beach managers have in the past or are currently implementing some of the listed BMPs through pilot projects funded by the U.S. EPA. Through these projects, researchers and beach managers are determining the effectiveness of these BMPs on reducing *E. coli* concentrations. For example, a study in the Chicago area was just completed that showed that the number of gulls found at several beaches was reduced after eggs found at two nesting sites were oiled over a 3-year period. The egg oiling was likely a beneficial factor in the improved *E. coli* conditions found at several area beaches (Engeman et al., 2012). In another study, a bioretention cell was installed in an urban area of Charlotte, North Carolina, to capture and infiltrate stormwater. In this case, researchers observed *E. coli* reductions of 71% (n=14) during several small storm events (precipitation < 42 mm) when comparing treated and untreated flow (Hunt et al., 2008). Other BMP case studies can be found in *A Review of Best Management Practices Benefiting Great Lakes Recreational Waters: Current Success Stories and Future Innovations* (Koski and Kinzelman, 2010).

In addition, the U.S. EPA has produced a video demonstrating the utility of Beach Sanitary Surveys (BSSs) in identifying pollution sources affecting beaches. The DVD highlights nine beach restoration projects that have been undertaken in Wisconsin to control *E. coli* and improve beach water quality. The video provides examples of several BMPs, including rain gardens to retain surface runoff and stormwater, and manufactured dunes and vegetation enhancements to create barriers to prevent sand migration and decrease the width of the beach in areas where gulls tend to congregate. A copy of the DVD can be obtained at no charge by contacting the U.S. EPA at Wirick.Holiday@epa.gov or viewed https://www.youtube.com/user/EPARegion5Training/feed?feature=context-cha.

5.1.1 Descriptions of BMPs

Based primarily on the experiences of others in the Great Lakes Region, the most appropriate BMPs for mitigating these factors have been identified as shown in **Table 5-1**. These BMPs focus on both source control and mitigation of *E. coli* present in the environment and are divided into the following categories: source assessment, stormwater management, gull management, beach management, public education, and ordinances. Descriptions of several of the listed BMPs are provided after Table 5-1. These descriptions include the level of effort in terms of hours or cost and the recommended frequency for many of the BMPs.

Table 5-1. Best Management Practices to Address *E. coli* Impairments

Best Management Practice	Corresponding Contributing Factor
Source Assessments	
Conduct beach sanitary surveys	Not modeled
Conduct illicit discharge surveys	Not modeled
Stormwater Management (at the beach or in the upstream drainage area)	
Infiltration basins, install and maintain	Rain
Bioretention/Rain gardens, install and maintain	Rain
Vegetated swales/Bioswales, install and maintain	Rain
Pervious pavement, install and maintain	Rain
Install green infrastructure, not sure type	Rain
Redirect runoff away from beach	Rain
Stabilize ravine banks	Not modeled
Buffer/Filter strips, install and maintain	Not modeled
Stormwater filter devices in storm sewer, install and maintain	Not modeled
Gull Management	
Utilize harassment measures such as border collies, predator models or calls	Gulls
Create natural areas to discourage gulls	Gulls
Conduct egg oiling to reduce hatchlings	Gulls
Beach Management	
Employ deep beach grooming measures	Gulls, Slope
Increase slope of the swash zone	Slope
Waste receptacles, supply and maintain	Gulls
Restrooms, supply and maintain	Not modeled
Pet waste stations, install and maintain	Not modeled
“Don’t Feed the Birds” signage, install	Gulls
Public Education – Personal Habits	
Support/prepare print ads, handouts, websites, signage regarding wildlife feeding	Gulls
Support/prepare print ads, handouts, websites, signage regarding littering	Gulls
Support/prepare print ads, handouts, websites, signage regarding pet waste cleanup	Not modeled
Support/prepare print ads, handouts, websites, signage regarding illegal dumping	Not modeled
Ordinances	
Implement/enforce local ordinance regarding wildlife feeding	Gulls
Implement/enforce local ordinance regarding littering	Gulls
Implement/enforce local ordinance regarding pet waste cleanup	Not modeled
Implement/enforce local ordinance regarding illicit discharge elimination	Not modeled

5.1.1.1 Source Assessments

Two types of source assessments are discussed: BSSs and illicit discharge surveys.

Beach Sanitary Survey. As the name implies, BSSs are conducted at the beach to identify the potential sources and magnitude of fecal pollution impacting beach water quality. The type of data collected by a BSS includes number/type of birds at the beach, slope of the beach, location and condition of bathrooms, and amount of algae on the beach, tributary land use, location of storm water outfalls, surface water quality, etc. Microbial source tracking can be utilized as part of an expanded BSS, especially if bacterial sources are elusive. The U.S. EPA has developed survey forms to allow for consistent collection of data in a well-organized format. One form is used for routine surveys and the other is used for annual surveys (U.S. EPA, 2008a). These surveys are typically conducted by beach managers. More information can be found in the U.S. EPA's *Great Lakes Beach Sanitary Survey User Manual* (U.S. EPA, 2008b): http://water.epa.gov/type/oceb/beaches/sanitarysurvey_index.cfm.

Annual survey
Effort: 20 hours Frequency: once a year

Routine survey
Effort: 30–60 minutes Frequency: each time water quality samples are collected

Illicit Discharge Survey. An illicit discharge survey should be conducted on storm sewers and surface waters discharging to Lake Michigan. Priority should be given to those discharges occurring within 500 meters of the beach along shore or within the lake (i.e., the BPA) or within the beachshed. This survey is typically conducted by municipal public works personnel or a consultant. The survey involves a systematic screening of stormwater outfalls to determine the presence of an illicit discharge and is required by Illinois' General Permit for Discharges from Small MS4s. The screening includes a physical inspection of the outfall, surrounding area and discharge, and sampling of the discharge for pollution indicators. Following the outfall survey, follow-up investigations are conducted in the stormwater conveyance system to narrow down and locate the source of the illicit discharge. Follow-up investigations can include visual observations, sampling, microbial source tracking, televised sewer inspections, smoke testing, or dye testing. More information can be found in the Center for Watershed Protection's *Illicit Discharge Detection and Elimination Manual:* http://cfpub.epa.gov/npdes/stormwater/idde.cfm.

Outfall Survey
Effort: 15–30 minutes/outfall Frequency: once a year (IEPA, 2009)

Follow-up Investigations
Effort: variable Frequency: as needed, immediately following the outfall survey

5.1.1.2 Stormwater Management

Stormwater management relies on the use of various BMPs to intercept rainfall and snow melt and allow for some treatment prior to discharge to surface waters. Many stormwater BMPs call for the use of green infrastructure (GI), also called low impact development—techniques to infiltrate, evapotranspirate, and reuse stormwater on the land where it is generated. These techniques include the use of infiltration basins, bioretention/rain gardens, vegetated swales/bioswales, and pervious pavement. A brief description of select GI techniques follows to aid managers in determining the best approach for their beach. More information on these techniques can be found on the U.S. EPA's website: http://water.epa.gov/polwaste/green/index.cfm, while detailed design criteria can be found in the *Low Impact Development Manual for Michigan: A Design Guide for Implementers and Reviewers*:

http://www.semcog.org/LowImpactDevelopment.aspx. In order to make design cost estimates, the Center for Neighborhood Technology has developed an online tool for use by engineers and planners. The Green Values® Stormwater Management Calculator can be found at http://greenvalues.cnt.org.

Infiltration Basins. Infiltration basins are subsurface areas located in permeable soils that capture, store, and infiltrate runoff into the surrounding soils. These basins are typically used for drainage areas between 5 and 50 acres with land slopes less than 20%. Pretreatment of runoff in some areas may be necessary in order to minimize clogging of the soils.

Cost: Variable depending on excavation size, plantings and piping (Southeast Michigan Council of Governments [SEMCOG], 2008)

Bioretention. Bioretention areas (also called rain gardens) are shallow surface depressions planted with specifically selected vegetation (preferably native plants) to capture and treat stormwater runoff from impervious surfaces. These areas allow stormwater to temporarily pool then infiltrate to reduce the transport of pollutants, including *E. coli* found in runoff. Like all GI techniques, bioretention areas require routine maintenance with more intensive efforts needed prior to plant establishment.

Cost: $5–$7/cubic foot of storage (construction only) (SEMCOG, 2008)

Vegetated Filter Strips. Vegetated filter strips are permanent, maintained strips of vegetation designed to slow runoff velocities and filter out stormwater pollutants. They are gentle sloping areas that use grasses and other dense vegetation to treat sheet flow. They are used to treat runoff from parking lots, roadways, and other impervious surfaces and are often used in conjunction with other BMPs.

Cost: $0 to $50,000/acre depending on site conditions (SEMCOG, 2008)

Vegetated Swales. Vegetated swales (also called bioswales) are shallow surface channels that are densely planted with grasses, shrubs, and/or trees and are designed to slow, filter and infiltrate runoff. They can treat up to a 5-acre area with slopes less than 6%. Swales provide less treatment than other infiltration BMPs, but can be usefully especially in lieu of concrete pipe. Periodic maintenance is required to remove built-up sediments and reestablish the drainage slope.

Cost: $4.50–$20/linear foot (construction only) (SEMCOG, 2008)

Pervious Pavement. Pervious pavement (including porous asphalt, pervious concrete, permeable pavers, and reinforced turf) is another infiltration technique that uses infiltration through structural surfaces, subsurface storage, and uncompacted soils to capture and treat stormwater runoff. This technique is well suited for parking lots, alleys, playgrounds, and sidewalks. These systems require periodic cleaning, potentially using a vacuum sweeper, to maintain their effectiveness.

Cost: Porous Asphalt without infiltration bed: $4–$5/square foot or 15–25% higher than standard asphalt (SEMCOG, 2008)
Pervious Concrete without infiltration bed: $4–$6/ square foot (SEMCOG, 2008)

The Delaware Department of Natural Resources and Environmental Control gathered information on the effectiveness of BMPs in bacteria concentrations. It should be noted that lower levels of efficiency are seen when incoming bacterial concentrations are low. This information is summarized in **Table 5-2** (Boyer, 2012).

Table 5-2. Bacteria Reduction from Stormwater BMPs

BMP	Bacteria Reduction (%)
Bioretention/Rain gardens	>99
Buffer Strips	43–57
Constructed Wetlands	78–90
Sand Filters	36–83
Wet Detention Ponds	44–99

Stormwater Treatment Devices. Various commercially available stormwater treatment devices have been developed to treat nonpoint-sources pollutants, and a few of them are reported to remove bacteria. These devices can be installed within storm sewers or catch basins to treat piped or overland flow. They vary in size and function, but all utilize some form of settling, filtration using specially designed media, or hydrodynamic separation to remove trash, sediment, oil, and other pollutants. Those designed to be installed in catch basins are easy to retrofit in urban areas (SEMCOG, 2008). However, the effectiveness of these BMPs in removing fecal indicator bacteria (FIB) should be carefully evaluated and possibly field tested before purchased.

Cost: $250 and up per catch basin insert; much higher costs for inline treatment devices

Streambank Stabilization. Ravine banks along the Lake Michigan shoreline should be stabilized to reduce the impact of erosion on proximal beaches. The stabilized ravines will decrease the potential for sanitary sewer exflow caused by undermining of the soils. In addition, soils tend to harbor FIB that when resuspended could cause water quality issues if transported to the beach. Lessening the stormwater flows impacting the ravines could be accomplished with the use of green infrastructure, including stormwater capture and reuse at individual lots (e.g., cisterns and rain barrels).

Cost: Variable

5.1.1.3 Gull Management

Gull Harassment. Multiple techniques are available to reduce beach water quality impacts caused by excessive gull populations. These techniques include active and passive harassment measures and population reduction measures. Active harassment measures include the use of dogs, animal models, predator calls, or pyrotechnics to prevent gulls from loafing or roosting on the beach. Many of these measures work for a period of time, until the birds become conditioned to them. The use of multiple techniques and moving the location of the models can increase effectiveness. Noise calls, used in a study conducted in Ontario, were initially effective; however, the gulls returned after a short period of time (Koski and Kinzelman, 2010).

In another study, gulls were chased from a Lake Michigan beach using specially trained dogs, and water quality improvements were quantified. Average daily gull counts fell from 665 before to 17 during intervention. *E. coli* densities were also significantly reduced during gull control ($p = 0.012$). Linear regression results indicate that a 50% reduction in gulls was associated with a 29% decrease in *E. coli* density. Potentially human pathogenic bacteria were significantly reduced ($p = 0.005$) with the bacteria detected on 64% of days prior to gull control and absent during gull intervention. This study demonstrates that dog harassment can be a highly successful measure to improve beach water quality impacted by gulls (Converse et al., 2012).

Cost: $17,000 for the Lake Michigan study mentioned above, which covered 15 days, night-time laser sweeps, and dawn-to-dusk dog presence (Converse, 2012).

Generally speaking, the cost is variable based on site conditions (terrain, hours, and type and extent of bird problem).

Flight interruption devices may also be an effective gull management measure. These rotating devices reflect sunlight in a manner that disorients birds in flight by limiting their vision. This causes birds to change their flight pattern. Once such flight interrupting device, the Eagle Eye, claims an 80% deterrent rate and has a range of 150 feet horizontally and 30 feet vertically. It can be powered by wind, solar, or standard 110 volt outlet and requires periodic maintenance (http://www.eagleeyebird.com).

Eagle Eye Flight Interrupter

Source: www.eagleeyebird.com

Cost: ~$1,200 for a solar unit plus installation.

Naturalized beach areas have also been used as a passive gull exclusion measure. Gulls will not loaf near areas with dune grass due to fear of predation. Daily bird counts were significantly less along beach transects near naturalized areas when compared to those transects in open beach areas (Koski and Kinzelman, 2010). A 10.4 acre dune was installed at Chicago's 63rd Street Beach, and an evaluation of impacts to bird count and water quality is under way.

Egg Oiling. Gull population reduction measures, such as egg oiling, have also been successfully employed to improve beach water quality. Egg oiling was conducted at two Chicago gull colonies to reduce production and the influx of hatch-year (HY) gulls using Chicago's beaches. From 2007 to 2009, 52%, 80%, and 81% of nests at the two primary nest colonies had their eggs rendered unviable by corn oil application. HY counts declined at all 10 surveyed beaches from the initial year (52% nests with oiled eggs) to subsequent years with 80% of nests oiled. Overall, HY gulls numbers on beaches decreased 86% from 2007 to 2009. Decreases in beach usage by after-HY gulls were not detected. Compared to pretreatment, the number of beaches with improved water quality test rates increased each year through the course of the study. The frequency of water quality tests showing bacterial exceedances compared to 2006 declined at 18 of 19 beaches by 2009. Egg oiling resulted in fewer HY gulls using Chicago's beaches and was likely a beneficial factor for reduced frequencies of swim advisories and swim bans (Engeman et al., 2012).

Cost: $250,000 via Great Lakes Restoration Initiative (GLRI) grant.

5.1.1.4 Beach Management

Beach Grooming. "Beach grooming is practiced at many locations to provide aesthetics by removing waste left by previous beach goers and to help remove potentially dangerous object from the sand (glass, metal and wood debris). Not only does beach grooming improve ambiance, but it can have additional benefits such as the removal of food sources for nuisance wildlife and potentially reduce the amount of bacteria in beach sand. In Racine, WI, deep grooming (7–10 cm) without leveling and compacting of the beach sand was shown to decrease bacteria content when sediments were described as wet to moist (Kinzelman et al., 2004). Multiple factors may be responsible for this decrease in FIB, including increased UV exposure and increased amount of sand surface area exposed to the atmosphere, reducing sand drying times. Fecal indicator density in beach sands has been shown to be a function of moisture content (Beversdorf et al., 2006; Yamahara et al., 2009). Shallow beach grooming has been shown to positively influence FIB densities in sand; it is uncertain if this is an artifact of mechanical perturbation of FIB sources in the sediments, such as seagull fecal material being more amalgamated or if conditions are made more hospitable for FIB survival (Kinzelman et al., 2003). The CPD has developed mechanical beach grooming equipment improvements in conjunction with manufacturer H. Barber based on the

Racine, WI study. Dubbed the "Chicago Rake," this modification allows for deeper grooming (30 cm) and increases the amount of sand exposed to the sun" (Koski and Kinzelman, 2010).

Beach Grading. "Beach grade improvements are used to prevent standing water from being retained on the shore. Standing water keeps sediments moist, which can positively influence bacteria in beach sands. It is also a potential area for wildlife to congregate, which can contribute to direct fecal loading. Water retained in swales or depressions on beach sands does not circulate and can have elevated levels of FIB made available for transport to nearshore waters via precipitation events or wave encroachment. Sources of standing water can vary, including water trapped behind the berm crest from intense wave action, stormwater outlets, and capillary rise from groundwater (Land and Water Magazine, 2009). Beach sand nourishment programs or reengineering of the beach slope may serve to remove depressed areas in which water accumulates. Naturalized beach mitigation measures, including beach grade improvements, have been proposed for Egg Harbor, Wisconsin" (Koski and Kinzelman, 2010).

The availability and maintenance of various beach facilities should help control direct fecal inputs from beachgoers, dogs, and wildlife, which will be beneficial for water quality. These facilities include

- Public restrooms,
- Covered waste receptacles to reduce the supply of food sources for gulls and other wildlife, and
- Pet waste stations at beaches that allow dogs.

5.1.1.1 Public Education

A robust public education campaign should be implemented to educate citizens on how their actions can impact beach water quality. Such a campaign could include signage, public service announcements, and print advertisements to discourage wildlife feeding, littering, and illegal dumping and encourage pet waste cleanup as appropriate for individual beaches. The Watershed Center of Grand Traverse Bay, in cooperation with Michigan State University, implements a well-executed public education campaign to improve beach water quality. Their Healthy Beach campaign targets littering, waterfowl feeding, and pet waste management—all of which are relevant for the Lake Michigan beaches. One of their radio public service announcements aimed at waterfowl feeding can be found at http://www.gtbay.org/wp-content/uploads/2010/09/Dont_Feed_the_Ducks.mp3.

Source: The Watershed Center of Grand Traverse Bay

More information on their program can be found at http://www.gtbay.org/our-programs/healthy-beaches/ Local ordinances should also be enacted and enforced to discourage/encourage these activities. The effectiveness of these public education BMPs has not been documented. Nonetheless, there is sufficient anecdotal evidence to suggest that they should be instituted as part of a multi-tiered approach to improve water quality (Koski and Kinzelman, 2010).

5.1.2 Management Strategy

In general, BSSs (routine and annual) should continue and improve as long as the source of the water quality impairment is unknown. The BSSs should be summarized on an annual basis and include an interpretation of the findings. The results of the sanitary surveys should be shared with local municipal staff (e.g., public works, beach managers, maintenance staff) at least on an annual basis, so they can understand their role in keeping the beaches open.

If stormwater is a suspected *E. coli* source at a beach—as it is at all of the Lake County segments, illicit discharge surveys should be conducted annually for those discharges occurring within the beachshed and BPA. If potential human sewage discharges are identified, follow-up investigations should be initiated immediately and resolved as soon as practical. An annual beach coordination meeting could be a forum to share the illicit discharges identified/corrected. Alternatively, quarterly meetings may be desired if more real-time communication is needed.

Gull management efforts should be conducted at most of the Lake County beaches. The slanted metal roof of the old gypsum plant located near Waukegan Harbor serves as one known nesting site and Waukegan South Beach has been a historical nesting area, but locating other nesting areas has been a challenge. The local communities and/or Lake County should continue their coordination with the U.S. Department of Agriculture and/or the IDNR to conduct population control measures, such as locating additional nesting sites and oiling eggs to reduce the number of gull hatchlings. Harassment measures could also be undertaken to reduce the number of gulls loafing at the beaches.

Public education efforts should be improved throughout the county to limit littering and the feeding of gulls, geese, and other wildlife at all of the Lake County beaches. This could include signage at the beach, awareness and enforcement of local ordinances, and print and Internet outreach. These efforts should focus on the connection between wildlife feeding/litter and beach closures.

Based on the modeling results and local input, known and suspected sources of the water quality impairments were identified, and BMPs were suggested for each of the impaired segments as described below.

5.1.3.1 North Point Marina Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from Dead Dog Creek. (k)
- Gull populations have increased as the beach area has grown from 1.9 to 9.2 acres between 1999 and 2008. The increase in beach area is due to the deposition of sand behind the breakwater and decreasing water levels in Lake Michigan. (k)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in Dead Dog Creek.
- Mitigate stormwater flow to Dead Dog Creek by using green infrastructure measures.
- Improve the function of the bioswales already in place.
- Dredge sand from the beach to increase the slope of the beach as described in the IDNR’s GLRI grant application, *Lake Bottom Restoration at Illinois Beach State Park* (IDNR, 2010).
- Conduct gull harassment or population reduction measures.
- Conduct deep beach grooming.
- Improve beach drainage to minimize saturated areas.
- Continue the supply and maintenance of pet waste stations and improve enforcement of the associated local ordinance.
- Improve “Don’t Feed the Birds” signage.
- Improve public education campaign aimed at wildlife feeding, littering, and pet waste cleanup.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste cleanup.

5.1.2.2 IBSP North Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from Dead Dog Creek. (k)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in Dead Dog Creek.
- Mitigate stormwater flow to Dead Dog Creek by using green infrastructure measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste cleanup.

5.1.2.3 IBSP South Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from Bull Creek and Dead River. (s)
- Excessive gull populations. (k)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby tributaries.
- Mitigate stormwater flow to nearby tributaries by using green infrastructure measures.
- Conduct gull harassment or population reduction measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste cleanup.

5.1.2.4 Waukegan North Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from the Waukegan River, other tributaries, and storm sewers. (s)
- Illegal dumping into the Waukegan River. (k)
- Excessive gull populations. (k)

Suggested solutions:

- Develop a stormwater and sanitary sewer master plan as redevelopment of the Superfund site located just north of the beach is considered.
- Conduct illicit discharge investigations for sewage sources in nearby tributaries.
- Mitigate stormwater flow to nearby tributaries by using additional green infrastructure measures.
- Improve the function of the infiltration basins, bioswales, and filter strips already on site.
- Consider the use of pervious pavement for the parking area.
- Research the use of stormwater filtration devices.
- Create/Improve dune grass areas to discourage gull loafing.
- Conduct gull harassment or population reduction measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, pet waste cleanup, and illicit discharge elimination.

5.1.2.5 Waukegan South Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from the Waukegan River, other tributaries, and storm sewers. (s)
- Shallow beach slope that collects standing water. (k)
- Excessive gull populations and a historic nesting area. (k)

Suggested solutions:

- Consider the use of pervious pavement and other green infrastructure practices.
- Improve on the filter strips already in place.
- Improve deep grooming of the beach sand.
- Possibly dredge the beach in collaboration with dredging Waukegan Harbor.
- Conduct illicit discharge investigations for sewage sources in nearby tributaries and storm sewers.
- Mitigate stormwater flow to nearby tributaries by using green infrastructure measures.
- Research the use of stormwater filtration devices.
- Conduct gull harassment or population reduction measures.
- Create additional dune grass areas to discourage gull loafing. Target the area along the north side of the southern jetty, if sand is added here.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, pet waste cleanup, and illicit discharge elimination.

5.1.2.6 Lake Bluff Sunrise Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater drainage to and from nearby ravines. (s)
- Sanitary sewer overflow at nearby lift station. (known, but infrequent)
- Drainage from neighboring dog beach. (s)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby ravines and storm sewers.
- Mitigate stormwater flow to nearby ravines by using green infrastructure measures.
- Conduct adequate maintenance at the sanitary sewer lift station to prevent overflows.
- Improve the filter strips already onsite.
- Create/Improve dune grass areas to discourage gull loafing.
- Conduct gull harassment while investigating population control measures.
- Improve deep grooming of the beach sand.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at littering, pet waste cleanup, and illicit discharge elimination.
- Enforce pet waste cleanup and access rules at the beach.

5.1.2.7 Lake Forest Forest Park Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater drainage from ravines and directly connected impervious areas. (k)

- Excessive gull populations. (k)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby ravines and storm sewers.
- Redirect runoff away from the beach using the appropriate green infrastructure techniques and improve existing filter strips.
- Mitigate stormwater flow to nearby ravines by using green infrastructure measures.
- Research the use of stormwater filtration devices.
- Create/Improve dune grass areas to discourage gull loafing.
- Conduct gull harassment while investigating population control measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at pet waste cleanup and illicit discharge elimination.

5.1.2.8 Highland Park Avenue Boating Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater drainage from ravines and directly connected impervious areas. (k)
- Improper disposal of septage from boats. (s)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby ravines and storm sewers.
- Redirect runoff away from the beach using the appropriate green infrastructure techniques, including filter strips.
- Mitigate stormwater flow to nearby ravines by using green infrastructure measures.
- Research the use of stormwater filtration devices.
- Encourage proper disposal of boater septage by ensuring ease of access to and proper use of pumpout stations.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at pet waste cleanup and illicit discharge elimination.

5.1.2.9 Highland Park Rosewood Beach

The Park District of Highland Park has plans to improve the beach and neighboring park. These improvements include the installation of permanent bathrooms, day lighting the ravines, and installing breakwaters.

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater drainage from ravines and directly connected impervious areas. (k)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby ravines and storm sewers.
- Redirect runoff away from the beach using the appropriate green infrastructure techniques.
- Monitor beach improvement plans to account for the impact to water quality at the beach. Some suggestions include balancing the need for water circulation with the need for breakwaters, the use of green infrastructure, and regular maintenance of the bathrooms. Consider the use of filter strips and stormwater filtration devices as well.

- Conduct deep grooming of the beach sand.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at pet waste cleanup and illicit discharge elimination.

5.1.3 Implementation

A schedule for implementation of the suggested measures is not appropriate in this document. The impaired beaches are managed by various entities, and there are practical, political, and financial limitations that potentially need to be considered and overcome by the local beach managers before some of the BMPs are undertaken. Nonetheless, it is recommended that each community prioritize their beaches and the recommended strategies to determine the most feasible options at the most impacted beaches. If deemed helpful for the community, a community beach improvement plan should be developed if not already incorporated into a community's master planning documents.

Through IEPA's Resource Management Mapping Service (http://www.rmms.illinois.edu), a tracking tool is being developed to measure TMDL implementation successes. This tool will track the BMPs that are implemented to reduce pollutant loads to impaired waters with established TMDLs. During the first stage of development, nitrogen, phosphorus, and total suspended solid load reductions will be tracked for BMPs implemented to control nonpoint-source pollution (i.e., LAs). During future upgrades to the tool, additional parameters will be added and load reductions associated with point sources (i.e., WLAs) will be tracked.

5.1.4 Funding Sources

The most likely funding sources to implement the BMPs described previously are the Great Lakes Restoration Initiative (http://greatlakesrestoration.us/index.html), the Illinois Green Infrastructure Program for Stormwater Management (www.epa.state.il.us/water/financial-assistance/igig.html) and Nonpoint Source Section 319 grants (http://www.epa.state.il.us/water/financial-assistance/non-point.html). However, multiple other programs can aid in funding measures to reduce *E. coli*, as shown in **Table 5-3**.

Table 5-3. Funding Opportunities for Implementing Selected Options to Achieve the TMDLs

Funding Opportunity	Description
U.S. Environmental Protection Agency	
Clean Water Act Section 319 Grants	This funds various projects, including a program area aimed at improving beach water quality.
Five Star Restoration Challenge	This brings together community groups to restore streambanks and wetlands.
Priority Lake and Watershed Implementation Program	This funds implementation of protection/restoration practices that improve water quality.
U.S. Department of Agriculture, Natural Resource Conservation Service	
Streambank Stabilization Restoration Program	This develops and demonstrates vegetative, stone-structure and other low-cost bio-engineering techniques for stabilizing streambanks
U.S. Department of the Interior, Fish and Wildlife Service	
Land and Water Conservation Fund	This provides funds to states and localities for park and recreational land planning, acquisition, and development.

(continued)

Table 5-3. Funding Opportunities for Implementing Selected Options to Achieve the TMDLs (continued)

National Oceanic and Atmospheric Administration	
Coastal Zone Management Program	This assists states in implementing Coastal Zone Management programs approved by NOAA. Funding for watershed projects in Illinois is expected in upcoming years, following program adoption and establishment by the state.
Coastal Services Center Cooperative Agreements	These provide technical assistance and project grants through arrange of programs and partnering arrangements, all focused on protecting and improving coastal environments.
U.S. Department of Transportation	
Transportation Enhancement Program	This funds projects that may include control technologies to prevent polluted highway runoff from reaching surface water bodies, scenic easements, pedestrian and bicycle trails, and wetland mitigation efforts.
Illinois Environmental Protection Agency	
Illinois Green Infrastructure Program for Stormwater Management	Grants are available to local units of government and other organizations to implement green infrastructure BMPs to control stormwater runoff for water quality protection in Illinois. Projects must be located within a MS4 or CSO area. Funds are limited to the implementation of BMPs.
Nonpoint Source Section 319 Grants	Grants are available to local units of government and other organizations to protect water quality in Illinois. Projects must address water quality issues relating directly to nonpoint source pollution. Funds can be used for the implementation of watershed management plans, including the development of information/ education programs and for the installation of BMPs.
Illinois Department of Natural Resources	
Conservation 2000	This supports nine conservation programs across three state agencies and provides financial and technical support to groups (ecosystem partners) that seek to maintain and enhance ecological and economic conditions in key watersheds of Illinois.
Water Resources Small Projects Fund	This provides assistance to rural and smaller urban communities to reduce stormwater-related damages by alleviating local significant drainage and flood problems.
Illinois Department of Agriculture	
Streambank Stabilization & Restoration Program	This supports naturalized stream bank stabilization practices in rural and urban communities.
Lake County	
Lake County SMC Watershed Management Board Fund	Funding for Watershed Management Board members in good standing with the National Flood Insurance Program and comply with SMC policies.
Other Funding Sources	
The Great Lakes Basin Program for Soil Erosion and Sediment Control	This supports projects that protect Great Lakes water quality, such as by controlling erosion and sedimentation.
Coastal Services Center Cooperative Agreements	These provide technical assistance and project grants through a range of programs and partnering arrangements, all focused on protecting and improving coastal environments.

5.2 Reasonable Assurance

The U.S. EPA requires reasonable assurance that TMDLs will be achieved and WQS will be met. Reasonable assurance that the WLAs will be implemented is provided by regulatory actions. According to 40 CFR 122.44(d)(1)(vii)(B), NPDES permit effluent limits must be consistent with assumptions and requirements of all WLAs in an approved TMDL. IEPA implements its stormwater and NPDES permit programs and is responsible for making the effluent limits consistent with the WLAs in this TMDL. Effluent and instream monitoring is reported to IEPA and should provide reasonable assurance that WQSs will be met. This will be undertaken for the excess flow facilities identified in this study as well as revisiting the other NPDES-permitted discharges.

The primary strategy for attaining WQSs along the Illinois Lake Michigan shoreline is to implement BMPs aimed at reducing stormwater runoff to the beaches themselves and to the surface ravines and tributaries transmitting water the lake on or within a half km of the beaches along the shoreline. BMPs will be used to address the stormwater and physical beach characteristics that were identified as large contributors to the WQS exceedances at the beaches.

A number of watershed and beach-specific activities exist or are under way along the shoreline thanks to funding from the GLRI (**Table 5-4**). Several of these activities directly relate to the identified nonpoint sources in the TMDL analysis (e.g., gulls).

For this TMDL analysis, an additional level of reasonable assurance is provided by making the statistical models for load reductions based on measurable parameters available to the beach managers through a software program. The graphical user interface for this program is intended to provide beach managers with a tool that will allow them to examine the impact of various mitigation strategies on predicted *E. coli* concentrations. Users will be able to vary both manageable and non-manageable variables while selecting from preset scenarios for average or critical conditions to assess the range and sensitivity in results. For instance, managers could predict the impact of restricting gull counts to a specific number or examine how varying 24-hour precipitation amounts alter predicted *E. coli* concentrations under average or critical conditions. As model variables are changed, the appropriate beach-specific model will recalculate predicted concentrations; this function will allow users to compare the impact of mitigation strategies under a range of different conditions.

In addition, a survey on preferred and available implementation options was distributed to local beach managers, municipal stormwater engineers, and other applicable parties so that the options most likely to be implemented were included in the segment-specific plans developed for this TMDL. Beach managers and local stormwater officials were able to identify projects that they were favorable, able, or planning to put into place in their managed areas. Therefore, the implementation plans are based on current state of practice and consider local conditions and managerial climates.

Table 5-4. Existing Activities Within the Lake Michigan Shoreline Watershed that Support Attainment of the WQS

Project Title	Abstract	Recipient Organization or Lead Agency	GLRI Award Amount	Fiscal Year
Ring-billed Gull Management for Lake Michigan Beach Health	The objectives of the Chicago Ring-billed Gull Damage Management Project were to reduce the local production of ring-billed gulls, to evaluate the affects limiting gull production has on gull use of beaches, and to reduce the severity of conflicts with gulls, including the issuance of swim advisories and swim bans. Between 2007 and 2009, we applied corn oil to 52%–80% of nests in 2 large gull colonies in Chicago and successfully reduced hatching success and subsequent fledging of 18,000–42,000 gulls per year without causing colony abandonment.	Chicago Department of Environment	$250,236	2010
A Comprehensive Communications Program for Chicago Beaches	This project will implement a comprehensive beach communications program that is designed to improve public understanding of beach water quality and beach health and to increase public notification of swimming bans and advisories for 21 of the 24 Chicago Beaches in Lake Michigan. The project will include signage, expanded electronic communications, staff training, and a new volunteer beach ambassadors program.	Chicago Park District	$99,340	2010
Modification of 63rd Street Beach to Improve Water Quality	CPD will use this grant to install a culvert through an existing pier on the south end of the 63rd Street Beach. The culvert will improve water circulation and reduce bacterial contamination levels at the beach, resulting in fewer beach closures and advisories and improved protection of public health.	Chicago Park District	$182,500	2011
A Protective Barrier to Improve Beach Safety in Chicago	CPD will install a protective barrier at Montrose Beach or Rainbow Beach to prevent nonpoint sources of pollution from outside the beach basin from impacting beach water quality in the swimming area. CPD will also conduct 45 days of intensive sampling and analysis of water and sand inside and outside the barrier area to determine the effectiveness of reducing bacteriological, algal and chemical contamination concentrations in the beach swimming area.	Chicago Park District	$243,465	2011
Development of SwimCast Models at Four Chicago Beaches	CPD proposes to begin development of new predictive models using SwimCast monitoring stations at Montrose Beach, Foster Beach and Calumet Beach. In addition, the Chicago Park District will continue to refine the existing predictive models at 63rd Street Beach. Technical assistance in analyzing data for the development of the models will be provided by the USGS. The USGS will use the data collected from the SwimCast stations to further work on a regional model.	Chicago Park District	$245,420	2010
Sanitary Surveys and Stormwater Impacts at Chicago Beaches	CPD proposes to conduct sanitary surveys at every Chicago beach and the catchment areas of storm drains that discharge into Lake Michigan. Samples will be collected directly from the stormwater outfalls to determine whether storm drains and urban runoff are contributing to fecal indicator bacteria levels at nearby Chicago beaches. Sources of fecal indicator bacteria will be characterized and will be used to develop evaluation and assessment protocols that can be used by beach managers in similar Great Lakes settings.	Chicago Park District	$250,000	2010

(continued)

Table 5-4. Existing Activities Within the Lake Michigan Shoreline Watershed that Support Attainment of the WQS (continued)

Project Title	Abstract	Recipient Organization or Lead Agency	GLRI Award Amount	Fiscal Year
Enhancing Beach Management for Beach Safety in Chicago	CPD will reduce bacterial contamination from ring-billed gulls, litter, and organic material. CPD will groom twenty four Chicago beaches seven days a week to reduce bacteria from sand and will begin a beach ambassador program to educate beachgoers and day camp children about beach health. CPD will collect data on algae mats and detritus to evaluate grooming effectiveness.	Chicago Park District	$749,121	2011
Illinois Lake Michigan Implementation Plan	IDNR will collaborate with the Alliance for the Great Lakes, Chicago Wilderness, and the Biodiversity Project to develop and implement an Illinois Lake Michigan Implementation Plan to guide resource allocations to protect the Illinois Lake Michigan watershed. The result will be improved prioritization and implementation of on-the-ground restoration projects in the Lake Michigan watershed and coastal zone and an increase in the number and diversity of stakeholders participating in Lakewide Management Plan priorities.	Illinois Department of Natural Resources	$226,950	2011
Illinois Beach Sanitary Surveys	IDPH will perform detailed surveys of swimming beaches and associated watersheds to identify sources of pollution contributing to water quality exceedances at 10 Lake Michigan beaches. The department will identify ways to eliminate pollution and disseminate findings.	Illinois Department of Public Health	$245,000	2010
Waukegan Harbor AOC-Glen Flora Tributary Hydrology Study	This project will include a detailed hydrologic study to identify existing flow patterns of water entering the Waukegan Harbor Extended Area of Concern (EAOC) from Glen Flora Tributary. By (1) identifying inundation frequency, inundation depth, and direction and quantity of flow into and through the EAOC; (2) determining the respective quantity of water in each flow path; and (3) determining the influence of Glen Flora Tributary on the hydrology of the EAOC, the project will form the basis of restoration and management decisions for wetlands and native plant communities for wildlife habitat in the EAOC and nearby buffer area.	Lake County Stormwater Management Commission	$118,500	2010
Dead Dog Creek Ravine/Stream Restoration Phase 2	The Lake County Stormwater Management Commission will implement the second and final phase of Dead Dog Creek stream restoration. Dead Dog Creek is a ravine system tributary to coastal wetlands and Lake Michigan. The restoration will implement in-stream, streambank, and riparian buffer water quality and sediment control on 3,950 feet of Dead Dog Creek. This restoration will prevent 67 tons of sediment and 73 pounds of phosphorus from reaching Lake Michigan.	Lake County Stormwater Management Commission	$675,401	2011
Kellogg Watershed-Dead Dog Creek/Water Quality BMPs Project	This project will implement in-stream, streambank, and riparian buffer water quality and sediment control bioengineering practices on Dead Dog Creek in Winthrop Harbor, Illinois. In addition, residential and business demonstration sites will be created with run-off reduction and water quality improvement practices. This project will restore hydrology and stabilize stream channels by reducing urban stormwater flows to Dead Dog Creek.	Lake County Stormwater Management Commission	$832,850	2010

(continued)

Table 5-4. Existing Activities Within the Lake Michigan Shoreline Watershed that Support Attainment of the WQS (continued)

Project Title	Abstract	Recipient Organization or Lead Agency	GLRI Award Amount	Fiscal Year
Restoring Native Diversity to Aquatic Ravine Ecosystems	This project will restore natural stream conditions to improve fish habitat in Ravine Number 7L at Millard Park (a tributary of Lake Michigan, located in Highland Park, Illinois) to make it more suitable for the return of desirable cold-water fish such as brook trout, brown trout, lake chub and white sucker. A restored stream, with successfully reproducing stocks of native fish, will enhance the overall desirability of the Park, improve Great Lakes fish habitat and water quality, and provide a model of fish habitat restoration for future projects in the Lake Michigan ravine ecosystems.	Park District of Highland Park	$200,000	2010
63rd St. Beach and Dune Construction	The United States Army Corps of Engineers (USACE) has initiated construction of this project that will restore 21 acres of dune and swale habitat along Lake Michigan in Chicago, IL.	U.S. Army Corps of Engineers	$800,000	2010, 2011
Illinois Beach State Park Southern Buffer Restoration	This project will: 1) restore and expand a green buffer to preserve vital habitat and water quality for nearshore species; 2) gather baseline biological data for the Waukegan Extended Area of Concern; 3) prevent erosion and sedimentation in the riparian nearshore, wetland and upland reaches of the Dead River watershed; and 4) provide greater infiltration and stabilization of at least 160 acres riparian inflows to Lake Michigan.	Waukegan Harbor Area of Concern Citizens Advisory Group	$1,433,350	2010
Dune and Beach Restoration for Lake Michigan Beach Health	LCHD will decrease gull habitat and increase biodiversity at North Point Marina in Lake County, Illinois. LCHD will restore and expand the dune and beach area, remove all invasive species, plant native species, monitor water levels, assess vegetation, and educate lifeguards about beach and dune health. This project is expected to reduce bacteria and other pathogens, improve water quality, and reduce swimming bans at North Point Marina.	Lake County Health Department and Community Health Center	$349,934	2011

5.3 Monitoring Recommendations to Track TMDL Effectiveness

BEACH Act funding currently supports water quality monitoring by local beach authorities at Lake Michigan Beaches. If this funding is maintained, then pre- and post-water quality data sets will be available to track the effectiveness of the TMDL. Water quality monitoring for *E. coli* concentrations at the impaired beach segments is expected to continue during future swim seasons to ensure public health and verify models. The LCHD is also expected to continue to utilize SwimCast in setting swim bans, and the CPD is currently developing its own SwimCast models. It is also assumed and recommended that the hydrometeorological parameters monitored at each of the current beaches will continue. Monitoring of this nature will allow for determination of the attainment of the WQS.

Additional monitoring not routinely conducted, except under specific BSSs, which would provide high levels of information to the tracking of the TMDL status, focuses on identifying and quantifying stormwater loadings of bacteria. Identifying those locations that contribute stormwater runoff directly to the beaches or to one of the surface water tributaries/ravines will allow for event-based sampling to narrow down the locations at which stormwater with elevated *E. coli* concentrations originates. This process will help focus the suggested BMPs in the Implementation Plans.

Finally, while the NSSD maintains a discharge permit based on fecal coliform, it is suggested that a monitoring program, which includes *E. coli* and fecal coliform should be put into place during excess flow periods to ensure that equal levels of protection exist from using the permitted requirement 400 cfu/100 mL of fecal coliform as would exist if an *E. coli* standard was used instead.

6. Public Participation

A Technical Advisory Committee (TAC) was established that includes the project team (U.S. EPA, IEPA, and the contractor) and local stakeholders (CPD, LCHD, IDPH, Metropolitan Water Reclamation District of Greater Chicago [MWRDGC], local municipalities, and nonprofit groups). Regular participating members in the TAC are listed in **Table 6-1**. Input was sought from the TAC to 1) help the TMDLs and implementation plans best reflect local conditions, 2) ensure that the TMDLs rely on the best available data, 3) build consensus amongst the stakeholders, and 4) determine how any ongoing or planned stakeholder activities can be leveraged in TMDL development or Implementation Plan guidance. The project team interacted with the local stakeholders by submitting data requests associated with the ongoing BSSs and to review beach characterizations.

Four stakeholder meetings were held during TMDL development to present data analysis and project status and to allow stakeholders an opportunity to provide feedback:

- April 2011 – Review of project plan and available data
- March 2012 – Review of initial findings and required assumptions
- October 2012 – Discussion of implementation options and draft TMDL results
- January 2013 – Review of public notice draft TMDLs
- April 2013 – User interface demonstration

Table 6-1. Participating Members of the TAC

Contact	Agency
Holiday Wirick	U.S. EPA
Cathy Breitenbach	Chicago Park District
Mike Adam	Lake County Health Department
Geeta K. Rijal, Ph.D., NRCM	Metropolitan Water Reclamation District of Greater Chicago
Justin Dewitt, P.E., LEED AP	IL Department of Public Health
Lyman Welch	Alliance for the Great Lakes
Carl Caneva	Evanston Park District

In addition to the meetings with the TAC, two public notice meetings were held in Chicago and Lake Forest, IL. The first meeting in March 2012 outlined the project objectives, basic methods, and reliance on monitoring data. The second meeting, to be held in February 2013 during the public notice period, will review WLAs, LAs, load reductions, and implementation plans.

The U.S. EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). Before TMDLs are finalized, the public is notified that a comment period is open for at least 30 days. IEPA's public notices to comment on draft TMDLs are also distributed via mail and electronic mail to major stakeholders in the watershed or other potentially impacted parties. After the comment period closes, IEPA reviews all comments, edits the TMDL as is appropriate, writes a Summary of Response to Comments, and includes this in their TMDL submission to the U.S. EPA for final review. **Appendix IV** of this document contains the response to public comments received during the public notice period.

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Appendix I: Lake County NPDES Discharges Not Expected to Contribute *E. coli*

Table A.I-1. Lake County NPDES Dischrages not Expected to Contribute *E. coli* to Receiving Waters

Permit Number	FACILITY Name	DSDG	DESCRIPTION	Receiving Water	LAT	LONG	STATUS
IL0001881	ABBOTT LABS-N CHICAGO	002Q	Quarterly noncontact cooling water	Lake Michigan	421943	-874953	A
IL0001881	ABBOTT LABS-N CHICAGO	001Q	Quarterly noncontact cooling water	Lake Michigan	421943	-874953	A
IL0002763	EXELON GENERATING COMPANY-ZION	0010	House service water	Lake Michigan	422641	-874755	A
IL0002763	EXELON GENERATING COMPANY-ZION	0020	Unit 2 condenser cooling water	Lake Michigan	422644	-874754	A
IL0049883	HIGHWOOD WTP	0010	Reclaim basin decant overflow	Lake Michigan	421213	-874758	A
IL0069809	JOHNS MANVILLE	0010	Recycle system overflow	Lake Michigan based on GIS location	422318	-874842	A

Appendix II: Load Reduction Calculation Methods

In order to utilize all the available monitoring data from each of the beaches managed within Lake County (which correspond with the impaired segments), a statistical framework is employed to calculate the impacts of each of the source and surrogate variables available on *E. coli* concentrations. The method is explained through four steps beginning with initial data exploration and ending with calculating the reductions in the different parameters used in the model that are needed to meet the WQS.

A.1 Step 1: Exploratory Data Analysis – Response Variable

Purpose: Characterize distribution of *E. coli* concentrations in Lake County; examine censored observations; check for temporal and/or spatial autocorrelation.

Measured *E. coli* concentrations for Lake County beaches were obtained for the years 2004 to 2011. Where present, the average daily concentration (from two samples taken at the same time) was chosen as the daily *E. coli* value for each beach. In some cases, only a single measurement was reported. Less frequently, a single beach had two or more samples taken at discrete periods during the same day; in these cases, the daily average concentration was calculated.

In order to be modeled using common regression techniques, the response variable must meet specific distributional requirements. Environmental concentrations frequently exhibit a log-normal distribution. Lake County *E. coli* concentrations were log-transformed and examined for approximate normality using both formal and graphical means. The results indicate that the log-transformed values of *E. coli* concentrations across all beach sites are approximately normal.

Approximately 7% of the reported concentrations fell outside of the analytical reporting limits set by standard laboratory procedures. These limits are 1 and 2419.2 cfu/100 mL, respectively. Various methods have been proposed for dealing with so-called ‘censored observations’ (Gilliom, 1986; Helsel, 2005). The overall goal of these methods is to avoid adding or removing information that might bias the results of subsequent modeling. To this end, censored observations were initially modeled by fitting a theoretical log-normal distribution to the non-censored observations. However, it was discovered that the modeled observations did not substantially alter the results of subsequent modeling; in addition, the modeled observations appeared to add an unjustifiable amount of skew to the right tail of the *E. coli* distribution. The censored observations were therefore removed from the analysis.

Another important consideration is whether the response variable exhibits either temporal or spatial autocorrelation—in other words, whether knowing a concentration at a specific time and/or point in space provides information about concentrations at a different time and/or point in space. If autocorrelation is present, corrective steps must be taken to ensure accurate modeling. Temporal autocorrelation is generally assessed using the residuals (errors) of a fitted model. However, spatial autocorrelation can be checked by comparing the variances of *E. coli* concentrations at different sites as a function of the distance between sampling sites. Spatial autocorrelation was assessed using monthly average values for randomly selected months and years at all beach sites. The resulting plots, called semivariograms, did not indicate any consistent spatial correlation between *E. coli* concentrations at Lake County beaches.

A.2 Step 2: Exploratory Data Analysis – Predictor Variables

Purpose: Derive additional predictor variables associated with *E. coli* concentrations; identify likely predictor variables; make initial estimate of correlations and magnitudes.

Predictor variables investigated during exploratory analysis were collected from a number of sources (Table 3-4). Derived variables were chosen based on information in the scientific literature and stakeholder input. Variables were also selected to cover a wide range of spatial and temporal scales, from relatively static watershed-level variables to beach-specific meteorological conditions that varied on a daily or hourly time step. Once collected, graphical approaches such as scatter plots, box and whisker plots, conditional plots, and time series plots were used to look for general trends, correlations, conditional responses, and interactions between the predictor variables and measured *E. coli* concentrations. Data mining techniques such as Classification and Regression Tree models and Random Forest partitioning algorithms were also used to identify important predictor variables.

Once important predictor variables were identified, a stepwise linear regression was used to examine the significance, magnitude, and exploratory power of each variable. A single ordinary least squares linear regression model with a single predictor was fitted for each variable under consideration and the p-value, adjusted r-squared, and estimated coefficient for each model were recorded and compared. The p-value of a test statistic is the probability of an observed result occurring by chance, assuming that the null hypothesis—in this case, that there is no relationship between a predictor variable and the response—is true. The accepted threshold for a statistically significant relationship is a p-value at or below 5%. However, predictor variables that do not meet the 5% threshold can be included in a model: this decision is generally guided by the overall goals and objectives of the study. The adjusted r-squared is a conservative estimate of how much of the variation observed in the response variable can be explained by the predictor variables included in a regression model. The coefficient of a predictor variable is the estimated impact of that variable on the response variable.

The goal of these analyses is to identify likely starting points for the main modeling exercise. Given the nature of the TMDL, as many manageable variables as possible were selected for inclusion based on statistical trends discovered during the exploratory analysis. Current scientific understanding as documented in peer-reviewed journal articles on freshwater beaches and *E. coli* concentrations were also used to guide variable selection and interpretation.

A.3 Step 3: Initial Model Fitting

Purpose: Estimate relationships between predictor variables and measured *E. coli* concentrations; interpret model output; check model assumptions.

A range of modeling options are available for log normal-response variables. One of the most commonly applied predictive statistical models for *E. coli* concentrations is multiple linear regression (MLR). This approach is well suited for single site studies using predictor variables that occur at the same spatial and temporal scale as the response variable. However, the literature on *E. coli* fate and transport at freshwater beaches indicates that larger-scale phenomena—such as precipitation patterns and nearshore lake conditions—may drive pathogen indicator concentrations. In other words, *E. coli* concentrations may be driven by variables that occur at the same temporal and spatial scale as well as by variables that occur at different temporal and spatial scales. The context of the *E. coli* measurement—i.e., a sample nested within a beach, nested within a stretch of shoreline, nested within a particular nearshore watershed—therefore becomes critically important. However, when multiple measurement sites are included in order to increase sample size and characterize nuances in larger-scale predictor variable behavior, MLR techniques run into at least two statistical issues. First, model errors across all sites are pooled in a single error term. This is an issue because sites with similar contexts are likely to have correlated errors, which violates one of the key assumptions of linear regression. Second, the inability to include group-level context results in a model that treats all regression coefficients as applying equally to sites that may have very different contexts. ANOVA or ANCOVA approaches to modeling address some of these issues, but other problems can remain (Luke, 2004; Qian, 2009). For these reasons, a multilevel regression was chosen to analyze the data from Lake County beaches.

Multilevel models allow researchers to explicitly account for context by the specification of group-level variables; these group-level variables can help account for interdependent hierarchical (nested) relationships in data. In statistical terms, a multilevel model allows the user to vary the intercept and/or slope of the model by group level variables. For example, a researcher might allow the model's intercept to vary by the name of each sampling site, which effectively establishes a different baseline concentration for each site.

Variable selection in regression modeling is most often based on statistical significance and model explanatory power, although professional judgment and the overall use of the model also inform the process. For instance, models optimized for prediction frequently include variables that are not statistically significant, but which increase the predictive ability of the model. If the goal is to identify possible causal linkages, then statistical significance is likely to take precedence. Many models are designed to broadly accommodate both goals.

In multilevel modeling, variable selection is largely based on physical interpretation (do the estimated relationships between predictor and response variables make sense within the context of current scientific understanding?) and increases in explanatory power as measured by criteria such as the Bayesian Information Criteria or reductions in the Restricted Maximum Likelihood Estimator Deviance (REML). Based on the exploratory data analysis described above, likely predictor variables were added in a stepwise fashion to the Lake County model, and the physical interpretation and explanatory power of the model were evaluated. Variables that were not identified as predictive during exploratory analysis were also added and evaluated. Finally, interactions and group-level variables were specified based on the findings from exploratory data analysis and scientific literature.

Once the final model was fitted, various model assumptions were checked, including collinearity, residual normality, and temporal autocorrelation. Collinearity was assessed using three measures: kappa, variance inflation factor, and the degree of correlation among fixed effects. One note: In multilevel modeling, correlations can often be reduced by centering and/or scaling the response and/or predictor variables. These transformations were therefore applied as needed to reduce collinearity in the final model.

Model residuals were checked for normality using both graphical (histogram and density plots) and formal (non-parametric K-S test) methods.

Finally, the possibility of temporal or seasonal impacts was assessed with a time series plot of model residuals. With this plot, any consistent seasonal trend in model error will be visible as a recurring pattern. In other words, does knowing the date of a sample provide any information on model performance? If the answer appears to be yes, then additional adjustments are required.

A.4 Step 4: Simulation for Load Reduction

Purpose: Model uncertainty in estimation; use modeled relationships to predict daily concentrations; shift distribution of predicted daily concentrations to meet WQS.

The impact of a predictor variable on a response variable has two components: central tendency, or the average impact, and some measure of uncertainty. The estimated coefficient of a predictor variable is the average impact of that variable on the response. For example, a coefficient of 0.5 for predictor X1 indicates that, on average, the response variable increases by 0.5 units for every unit increase in predictor X1. Uncertainty regarding the impact of the predictor variable is estimated as standard error. In practical terms, this means that sometimes predictor X1 will have an above average or below average impact on the response. When using a statistical model to make predictions, it is important to account for this uncertainty in estimated response. We do this via the process of simulation.

In simulation, we create many thousands of predictions for a given set of observed variables and then average the results. The idea here, known as the law of large numbers, is that the results of many trials will approximate the expected or long run average outcome. For example, think of the difference between flipping a coin 5 times versus 1,000 times; the proportion of heads after 1,000 coin flips should be close to the expected value of 50%, whereas the proportion of heads after 5 coin flips is likely to be much different. Once averaged, the matrix of predictions can be used to create a statistical distribution that reflects the predicted daily *E. coli* concentration as a function of the statistical relationships found in the observed data. Since a single multilevel model was fitted for all sampling sites, this predicted distribution characterizes daily concentration values for all sites, with a mean that reflects the average value across all samples. However, beach-specific distributions may markedly vary from this overall distribution, just as the distribution of observed concentrations at a beach with many WQS exceedances will differ from the distribution of observed concentrations at a beach with no WQS exceedances. Using the overall predicted distribution to model these beaches, then, will tend to underpredict values at the beach with above average concentrations and overpredict values at the beach with below average concentrations. To correct this issue, the observed distributions of daily *E. coli* samples can be compared on a beach-by-beach basis to discover if any beaches share a similar distribution; beaches with comparable observed distributions can be modeled together. Two methods of pairwise multiple comparisons were used: Tukey's HSD and the K-S test statistic. Tukey's HSD requires a normality assumption and compares the means of distribution. The K-S test makes no distributional assumptions and tests for differences in both location and shape of distributions.

Once distributional groups were determined, the predicted distribution was shifted to the left by subsetting manageable variables in the original data set and refitting the multilevel model. The idea here is that by removing the upper values of manageable variables with positive correlations—or removing the lower values of manageable variables with negative correlations—we can model the impact of various management strategies on the predicted daily concentration. For example, the original data set could be limited to only those observations where the gull count is less than 60. Refitting the model and recreating the predicted distribution with this subset data set enables the prediction of the impact of keeping gull counts below 60. Because the subset data set contains fewer observations, we can bootstrap—or sample with replacement—in order to retain a robust sample size for both data subset by manageable variable and data subset by distributional group. Using a combination of distributional group-specific manageable variables, we can shift the predicted distribution to the left so that the probability of exceeding the WQS becomes very small within each distributional unit. We estimate this exceedance probability by sampling the predicted distribution many thousands of times and computing the number of predicted observations that exceed the WQS. Both the SSM and GM can be modeled with this methodology.

Once a predicted distribution meets the WQS, we use the range of the subset manageable variables to set management targets.

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Appendix III: Supplemental Model Parameter Information

Table A.III-1 provides estimates of the parameter coefficients calculated for fixed-effects in the Lake County multilevel-model (i.e., looking at all beaches together). The table also includes standard errors, or uncertainty estimates, for each parameter. A t-value greater than 2 or less than -2 indicates statistical significance at the 0.05 threshold. The significance of a given predictor variable extends to all beaches included in the model. Beach specific differences were considered using a variety of techniques. Two interaction terms were included in the model to capture interactions between predictor variables; the predicted impact depends on the characteristics of individual beaches. In addition, the coefficients of variables marked with a '*' were allowed to vary on a beach by beach basis; these are known as 'random effects' and should be considered predictions of how the impact of a variable may change based on a group level variable (in this case, beach location).

Table A.III-2 provides the metadata for the observational data and GIS-derived beach characterizations used to provide model parameters.

Table A.III-1. Parameter Estimates (average impact) and Standard Errors (uncertainty) for Fixed-Effects in Lake County Multilevel-Model

Variable	Estimate	Std. Error	t value
Intercept	-0.435	0.277	-1.571
Embayment - Yes	1.255	0.256	4.909
Wave-Ripples	0.049	0.076	0.638
Wave-Whitecaps	0.562	0.088	6.397
Wave-Severe	0.840	0.136	6.196
Gull Count	0.003	0.000	11.616
Significant Wave Height*	0.869	0.094	9.218
Previous 24 hour precipitation	0.758	0.154	4.933
Hardened Structure-North	-0.114	0.165	-0.694
Hardened Structure-Northeast	-1.165	0.221	-5.262
Hardened Structure-Northwest	0.249	0.094	2.635
Hardened Structure-South	0.460	0.127	3.606
Sample Month-June*	0.197	0.141	1.401
Sample Month-July*	0.467	0.154	3.040
Sample Month-August*	0.499	0.183	2.732
Sample Month-September*	-0.012	0.394	-0.031
Wind Direction-North	-0.015	0.091	-0.166
Wind Direction-Northeast	-0.133	0.086	-1.550
Wind Direction-Northwest	-0.393	0.103	-3.826
Wind Direction-South	-0.189	0.083	-2.262
Wind Direction-Southeast	-0.029	0.098	-0.296
Wind Direction-Southwest	-0.235	0.109	-2.150
Wind Direction-West	-0.289	0.082	-3.543
Wind Category-Low	-0.110	0.073	-1.504
Wind Category-Moderate	0.013	0.089	0.145
Wind Category-High	-0.295	0.261	-1.134
Average Slope	-0.147	0.031	-4.803
Interaction: Embayed:Wave-Ripples	0.388	0.135	2.879
Interaction: EmbayedYes:Wave-Whitecaps	0.005	0.146	0.032
Interaction: EmbayedYes:Wave-Severe	-1.087	0.261	-4.160
Interaction: Previous 24 hour precipitation:Hardened Structure-North	-0.318	0.199	-1.597
Interaction: Previous24 hour precipitation:Hardened Structure-Northeast	0.261	0.246	1.060
Interaction: Previous24 hour precipitation:Hardened Structure-Northwest	0.625	0.197	3.176
Interaction: Previous24 hour precipitation:Hardened Structure-South	0.290	0.240	1.208

Table A.III-2. Metadata for Model Parameters

Data Set	Source Description	Variables	Coverage	Source/Availability
Lake County Beach Sanitary Survey Data	Surveys of 10 beaches across several swimming seasons for meteorology, lake conditions, and gull counts on a mostly daily basis	Rain (Y/N), Wind Direction, Wind Category, Wind Speed, Air Temperature, Water Temperature, Wave Condition, *E. coli*, Gull Count, Sample Date, Month, Year, and Time	June 2004 through September 2011	Lake County Department of Public Health
Chicago Parks Department *E. coli* Monitoring	Daily bacteria monitored at CPD beaches	*E. coli*, Sample Date, Month, Year, and Time	May 2006 through September 2011	http://www.epa.gov/ storet/
Cook County *E. coli* Monitoring	Daily bacteria monitored at suburban Cook County beaches	*E. coli*, Sample Date, Month, and Year	May 2007 through September 2011	http://www.epa.gov/ storet/
City of Chicago Beach Sanitary Survey Data	Surveys of 15 beaches during the 2011 swimming season for factors that can impact bacteria concentrations and public health concerns on a mostly daily basis	Turbidity, Wave Intensity, Wave Height, Floating debris, Algae in Water, Bird Count, Dog Count, Litter on Beach, Algae on Sand, Bather Load	June 2011 through September 2011	Chicago Park District
City of Evanston Beach Sanitary Survey Data	Surveys of 7 beaches across several swimming season for factors that can impact bacteria concentrations and public health concerns on a mostly daily basis.	AM/PM *E. coli*, Air Temperature, Wind Speed, Wind Direction, Rainfall, Rain Intensity, Weather Condition, Wave Intensity, Wave Height	June 2009 through June 2012	City of Evanston, Evanston Park District
Great Lakes Coastal Forecasting System (GLCFS)	The GLCFS is a numerical model that calculates waves, currents and temperatures for each of the Great Lakes based on available observational data systems.	Bathymetry, Model Water Level, Eastward Water Velocity at Surface, Northward Water Velocity at Surface, Water Velocity at Surface, Water Velocity at Surface Direction, Significant Wave Height, Wave Direction, Wave Period	2007 through 2011	http://www.glerl.noaa.gov/res/glcfs/
Lake County Land Use Data	2005 land use data set layer based on the 2000 land use inventory data set for Lake County, IL	8 major land cover classifications to characterize beach drainage areas	2005	Lake County Planning, Building and Development (PB&D)
National Land Cover Database 2006	Land Cover for Cook County (including Chicago) on a 30 by 30 meter grid	Digested into 11 land cover classifications (from 28 specific land cover classifications) to characterize beach drainage areas	2006	http://www.mrlc.gov/nlcd06_data.php

Data Set	Source Description	Variables	Coverage	Source/Availability
NOAA's Digital Coast 2008 USACE Great Lakes: Lake Michigan, Illinois Light Detection And Ranging (LIDAR) remote sensing data	Used to derive average slope and direct drainages	Average slope and direct drainage areas	2008	http://csc.noaa.gov/htdata/lidar1_z/geoid12a/data/563/2008_USACE_IL_metadata.html
Lake County Stormwater Management Commission Precipitation Monitoring Stations	Four rain gauges were assigned to the Lake County beaches by location (Zion, Waukegan, Lake Forest, Highland Park)	Sub-daily precipitation measures summarized to total daily precipitation	2007 through 2011	http://www.lakecountyil.gov/Stormwater/RainGauges/Pages/RainData.aspx
NOAA National Climatic Data Center (NCDC) Meteorological Stations	Six meteorological stations from the NCDC used to assess daily precipitation in Cook County (Glencoe 0.1/Chicago Botanical, Evanston 1.4, Evanston 1.2, Chicago 6.8, Chicago 4.7, Chicago 5.5)	Total daily precipitation measures were linked by sample date and geography. 48- and 24-hour total and number of hours since a precipitation event were calculated	2007 through 2011	http://www.ncdc.noaa. gov/
Alliance for the Great Lakes Ravines Data	Ravine location and extent; ravine pipe locations and descriptions	Ravine locations and extents for use in drainage area definitions and locating potential point sources	2009	Alliance for the Great Lakes. 2009. Stresses and Opportunities in Illinois Lake Michigan Watersheds Strategic Sub-Watershed Identification Process (SSIP) Report. Prepared for the Lake Michigan Watershed Ecosystem Partnership. Available at: http://www.greatlakes.org/Page.aspx?pid=881.
Geographic Information Systems (GIS) with ArcGIS map services World Imagery layer	Satellite imagery to hand digitize beach area and impervious surface within beach area	Beach areas, drainage areas, impervious areas	circa 2011	http://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9

Data Set	Source Description	Variables	Coverage	Source/Availability
Macro and micro substrate GIS data	Interpolated characterization of the macro and micro substrates along the Illinois Lake Michigan shoreline	Average substrate characteristics by beach	Compilation of 72 years of data	Creque, S.M., K.M. Stainbrook, D.C. Glover, S.J. Czesny, and J.M. Dettmers. 2010. Mapping bottom substrate in Illinois waters of Lake Michigan: Linking substrate and biology. Journal of Great Lakes Research 36:780–789.
Illinois National Pollutant Discharge Elimination System (NPDES) Permits	Listing of active NPDES permits with Illinois that may contribute bacteria to Lake Michigan	Permit type and location	N/A	IEPA
Illinois Municipal Separate Storm Sewer System (MS4)	Listing of active MS4 permits for municipalities that are located along the Lake Michigan Shoreline	Name of municipality and, potentially, listing of receiving water	N/A	IEPA

Appendix IV: Response to Public Comments

1. TMDL is not precise enough to satisfy applicable water quality standards to support designated uses, and therefore to lead to eventual designation of the waters along these beaches as Category 1 or Category 2 segments in Illinois' integrated water quality report and section 303(d) list.

Response: TMDLs are required to meet applicable water quality standards. Each TMDL contains a LA and WLA for nonpoint and point sources, respectively, at each beach. Those allocations were set at a level that will achieve the applicable water quality standards. The allocations were derived from models that were developed utilizing standard statistical methods, which were tested to ensure that the methods met standard statistical assumptions (i.e., normality and variance). The confidence levels associated with these models have been added in **Appendix III** for Lake County TMDL and **Appendix II** in Suburban Cook County and Chicago TMDL documents. The allocations provided in the TMDL reports are designed to support recreational use and meet applicable water quality standards.

2. The draft Final TMDL improperly diverges from the WQS

A. **The draft final TMDL calibrates goals for bacteria concentrations based solely on a 30 day rolling maximum geometric mean ("GM") of 126 cfu/100 ml for *E. coli***

Response: The TMDL considers both the GM and SSM and provides allocations that will result in being at or below the GM as a rolling 30-day value, and predicts that the SSM will not be exceeded by more than 4–10% as presented in **Section 4.9.2** in each TMDL document (i.e., Lake County, Suburban Cook County, and City of Chicago). This is consistent with the applicable water quality criteria for this TMDL given that the GM must be met and the SSM (or an upper limit for fecal coliform) is not specified as a never to exceed value in the 2004 Federal *E. coli* criteria.

However in order to clarify the TMDL, we are providing information below to supplement **Sections 4.8** and **4.9** in each TMDL document, which discuss the comprehensive analysis completed to develop the model and derive the TMDL. The figures and tables below point out the difference between historical conditions and predicted TMDL conditions. The figure illustrates both the observed *E. coli* conditions from 2007–2011 (green curve in **Figure A.IV-1**) and expected *E. coli* conditions when achieving TMDL conditions (blue curve color in **Figure A.IV-1**). The allocations were derived by reducing bacteria source variables in the validated statistical model until that model predicted the *E. coli* conditions (blue curve) that would consistently achieve the GM and exceed the SSM only infrequently. The figures and tables below demonstrate the improvement in water quality that are expected to occur by achieving the TMDL. **Table A.IV-1** reports expected water quality improvements by comparing SSM and GM exceedance frequencies that occurred at the beaches during 2007–2011 to the SSM and GM exceedance (or non-exceedance) expected to be achieved under the TMDL.

In further detail, Figure A.IV-1 provides a visualization of the distribution of the 30-day GMs calculated from observed *E. coli* concentrations at Waukegan North Beach, from 2007–2011 (green curve) as compared to the 30-day GMs of predicted *E. coli* concentrations when achieving the management targets prescribed by the IL Beaches TMDL study (blue curve). This beach is characterized by a relatively high number of observed GM exceedances in the observed concentrations.

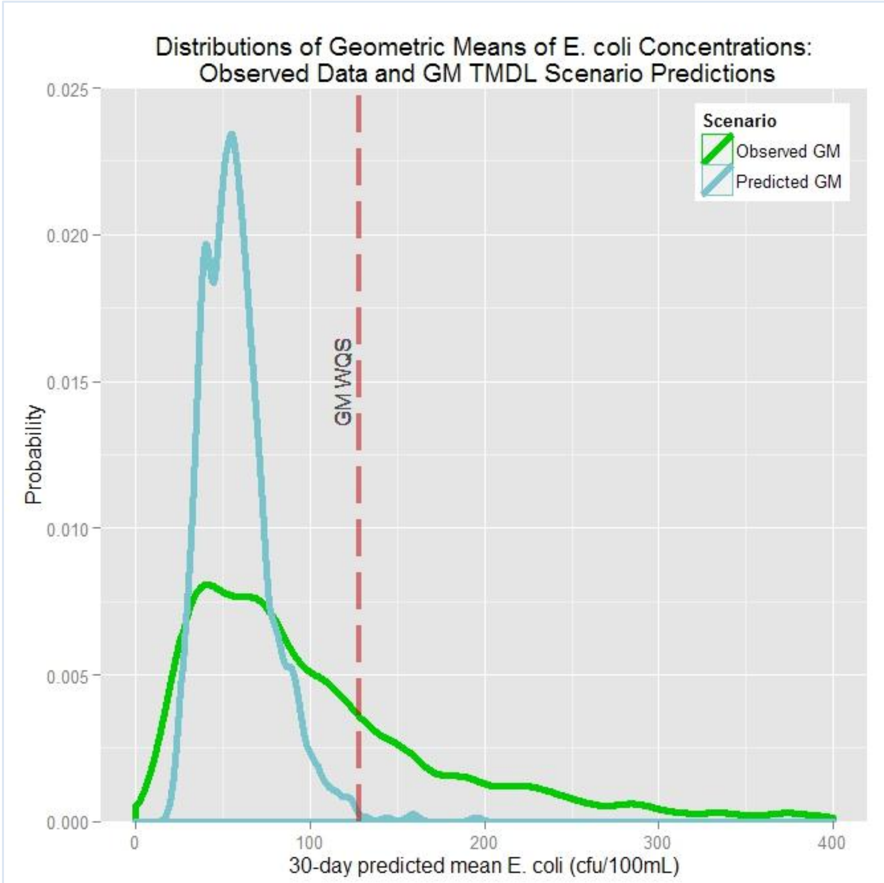

Figure A.IV-1. Comparison of 30-day GM Distributions at Waukegan North Beach

Table A.IV-1 provides a summary of observed and predicted concentrations for Waukegan North Beach. Observed data represent 30-day GMs of all reported *E. coli* values obtained for the beach from 2007 to 2011. Predicted values are simulated from the distribution expected after implementation of recommended GM management targets. The GM exceedance rate for the observed data is 26 %; the predicted GM exceedance rate after implementation of the recommended GM management targets prescribed by the IL Beaches TMDL study is <1%. Although these management recommendations target the GM WQS, implementation also greatly reduces the predicted SSM exceedance rate, which declines from 30 % in the observed data to a predicted 9 % under the GM management target scenario.

Table A.IV-1. Summary Values of Observed and Predicted *E. coli* Concentrations at Waukegan North Beach

	30-day GM of Observed Waukegan North Beach *E. coli* Data (2007-2011)	Predicted Values under GM TMDL Management Targets
Mean GM Value	108	90
Median GM Value	82	88
% SSM exceeded	30	9
% GM exceeded	26	<1

Figure A.IV-2 provides a visualization of the distribution of the 30-day GMs calculated from observed *E. coli* concentrations at Evanston Lee Beach, from 2008–2011 (green curve) as compared to the 30-day GMs of predicted *E. coli* concentrations when achieving the recommended GM management targets prescribed by the IL Beaches TMDL study (blue curve). This beach is characterized by a very low number of observed GM exceedances.

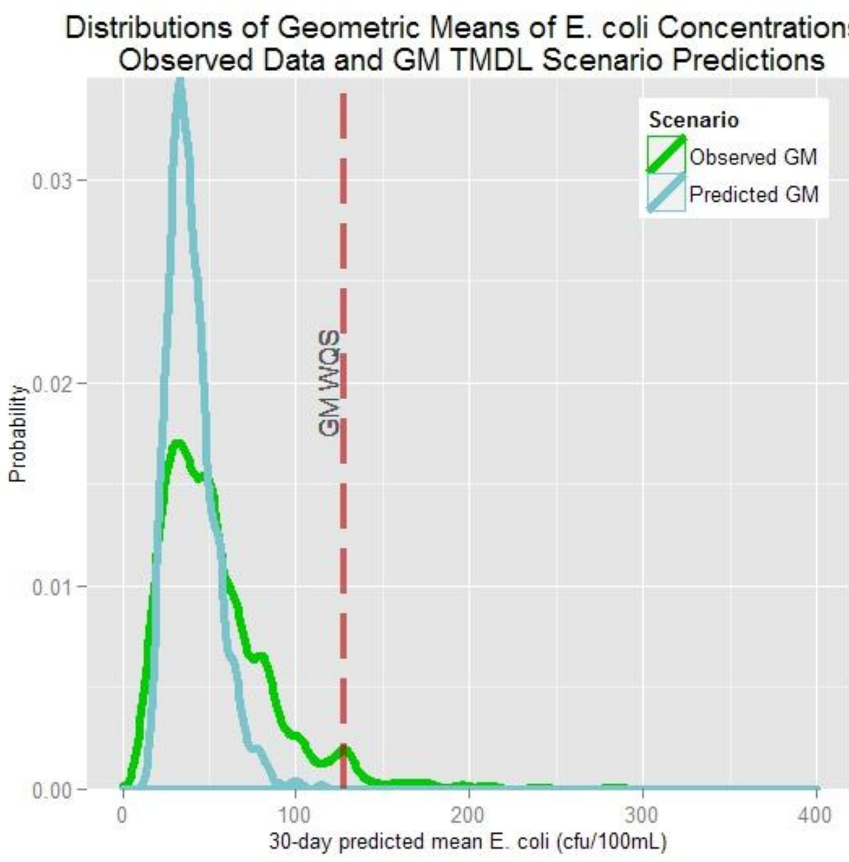

Figure A.IV-2. Comparison of 30-day GM Distributions at Evanston Lee Beach

Table A.IV-2 provides a summary of observed and predicted concentrations for Evanston Lee Beach. Observed data represent 30-day GMs of all reported *E. coli* values obtained for the beach from 2008 to 2011. Predicted values are simulated from the distribution expected after implementation of targets prescribed by the TMDL. The GM exceedance rate for the observed data is 1%; the predicted GM exceedance rate after implementation of the recommended GM management targets prescribed by the IL Beaches TMDL study is <1%. Although these management recommendations target the GM WQS, implementation also reduces the predicted SSM exceedance rate, which declines from 12% in the observed data to a predicted 8% under the GM management target scenario.

Table A.IV-2. Summary Values of Observed and Predicted *E. coli* Concentrations at Evanston Lee Beach

	30-day GM of Observed Evanston Lee Beach *E. coli* Data (2008–2011)	Predicted Values under GM TMDL Management Targets
Mean GM Value	54	40
Median GM Value	47	37
% SSM exceeded	12	7–8
% GM exceeded	1–2	<1

Figure A.IV-3 provides a visualization of the distribution of the 30-day GMs calculated from observed *E. coli* concentrations at Rainbow Beach, from 2007–2011 (green curve) as compared to the 30-day GMs of predicted *E. coli* concentrations when achieving the recommended GM management targets prescribed by the IL Beaches TMDL study (blue curve). This beach is characterized by a high number of observed GM exceedances as displayed the large area under the green curve to the right of the GM WQS.

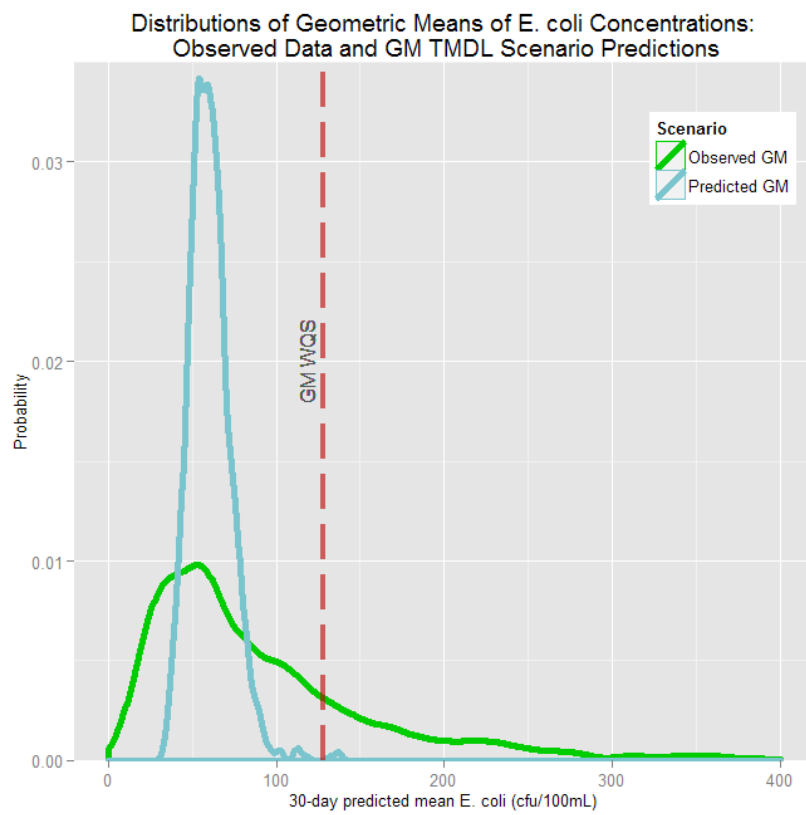

Figure A.IV-3. Comparison of 30-day GM Distributions at Rainbow Beach

Table A.IV-3 provides a summary of observed and predicted concentrations for Rainbow Beach. Observed data represent 30-day GMs of all reported *E. coli* values obtained for the beach from 2007 to 2011. Predicted values are simulated from the distribution expected after implementation of targets prescribed by the TMDL. The GM exceedance rate for the observed data is 17%; the predicted GM exceedance rate after implementation of the recommended GM management targets prescribed by the IL Beaches TMDL is <1%. Although these management recommendations target the GM WQS, implementation also reduces the predicted SSM exceedance rate, which declines from 18% in the observed data to a predicted 8% under the GM management target scenario.

Table A.IV-3. Summary Values of Observed and Predicted *E. coli* Concentrations at Rainbow Beach

	30-day GM of Observed Evanston Lee Beach *E. coli* Data (2008–2011)	Predicted Values under GM TMDL Management Targets
Mean GM Value	91	62
Median GM Value	57	59
% SSM exceeded	18	8
% GM exceeded	17	<1

B. No part of the design incorporates the SSM or STV components from the state or federal standards

Response: The design explicitly considers the rate at which the SSM criterion would be exceeded and when the GM criterion is met through implementation of the TMDL. This value is reported for each beach group and is found in **Section 4.9.2** of the TMDL document (**Table 4-11** of Lake County, **Tables 4-15 through 4-17** of Suburban Cook County, and **Tables 4-13 through 4-15** of Chicago TMDL documents). For more detail see the response in 2A of this appendix as well as **Section 4.9.2** of the TMDLs.

C. The data reported by IEPA in the draft final TMDL seems to indicate that the actual historic SSM exceedance rate is substantially higher than 10% at many beaches

Response: This is correct and identifies part of the reason the beaches were classified as Not Supporting recreational use. Beaches on the Illinois shoreline have exceeded the SSM by more than 10% and the corresponding attainment of the GM WQS varied during the period of 2007 through 2011. Although these data characterize the historical condition, the data represent conditions that would be much different from the conditions that would exist when a TMDL is achieved. When the TMDL was set, the sources of bacteria were adjusted in the statistically verified model until the distribution of *E. coli* at a beach would be at or below the GM. Based on the statistically valid and verified relationships built using historical data, the TMDL study predicted that the amount of reduction required to achieve the GM would result in *E. Coli* concentrations exceeding the SSM by no more than 4–10% depending on the beach.

D. At the very least, the TMDL draft should disclose all of the underlying data and should include a comprehensive analysis supporting these assertions

Response: All of the data are publicly available. The raw data used are too extensive to include in print format (e.g., the *E. coli* data alone comprise approximately 18,000 rows of data), but a table has been added in **Appendix III** for Lake County TMDLs and **Appendix II** for Suburban Cook County and Chicago TMDLs, which contains the metadata for each variable used in the model domain including where those data can be accessed.

E. Possible concerns about the practicality and cost of a combined GM and SSM (or STV) appear misguided.

Response: The TMDL considers both the GM and SSM and provides allocations that will result in being at or below the GM as a rolling 30-day value. The modeling also predicts that when meeting the TMDL the SSM will not be exceeded more than 4–10% of the time over the long-term as presented in **Section 4.9.2** in the TMDL document. However, concerns were raised about the practicality of meeting a TMDL designed to never exceed the SSM.

IEPA selected the management actions designed to consistently achieve the GM, while allowing for some exceedance of SSM, on the basis that the level of protection intended by the promulgated federal criteria could be met with some SSM exceedances. The 2004 Federal *E. coli* criteria illustrate this point with an example calculation (Water Quality Standards for Coastal and Great Lakes Recreation Waters. EPA, Federal Register, Vol. 69, No. 220, November 16, 2004, Page 67225). Meeting the level of protection for primary contact use that the bacteria criteria were designed to provide does not require that the SSM never be exceeded.

As noted in written comments, the Lake St. Clair (MDEQ, 2007) and Indiana beach (Tetra Tech, 2004) TMDLs include targets that both the GM and SSM are not to be exceeded, while IEPA's TMDL allows for some SSM exceedances. IEPA notes that EPA's 2004 *E. coli* criteria do not specify upper limit values as never to be exceeded. By contrast Michigan WQSs (Michigan Public Health Code and Rule 323.1062(1) of the Part 4. Water Quality Standards [Promulgated pursuant to Part 31 of the Natural Resources and Environmental Protection Act, 1997 PA 451, as amended]) do specify that upper limit values cannot be exceeded. Indiana WQSs (327 IAC 2-1.5-8 (e)) specify that, with some exceptions described at 327 IAC 2-1.5-8(e)(3)(B), upper limit values cannot be exceeded. The SSM can be exceeded in 10% of samples where there are at least 10 samples in a 30-day period, the exceedances are incidental and attributed to a discharge of treated wastewater, and the GM criterion is still met.

For informational purposes, the IL Beaches TMDL study identifies actions necessary to manage beaches such that the SSM is never exceeded (**Section 4.9.2** of the TMDL documents). These actions, compared to those designed to meet the TMDL (i.e., consistently meet a GM with some limited SSM exceedance) would be expected to require additional costs and maintenance whereas the TMDL targets already provide the level of protection required to meet the criteria. These management actions are compared in **Table A.IV-4** and in the TMDL documents (See **Table 4-11** in Lake County, **Tables 4-15 through 4-17** in Suburban Cook County, and **Tables 4-13 through 4-15** in Chicago TMDL documents).

For example (**Table A.IV-4**), in Lake County the group of beaches comprising Forest Park, Rosewood, IBSP South, and Waukegan North would be subjected to thresholds of reducing rainfall below 0.4 inches, keeping gulls below 30, and increasing the slope of the beaches by 3% if the SSM were never to be exceeded. While to achieve the GM rainfall above 1 inch would need to be captured, gulls could reach a count of approximately 50, and the slope of the beaches would only need to be increased by 1%. Examining rainfall for the last 10 years, only 8% of rainfall events reached 1 inch in depth, whereas closer to 25% of events were at least 0.4 inches in depth. Considering that at these beaches the mean count of gulls experienced during the study period was 35, keeping the gull counts below 50 would be a feasible goal. Finally, the slopes of the beaches in this group range from 4.4 to 6.8%. Requiring an increase of 3% would require maintenance of beach slopes near the maximum slope observed at all Lake County beaches (9.4%), whereas an increase of 1% would keep the beaches within the mid-range of slopes that have been observed.

Table A.IV-4. Example Manageable Variable Thresholds[1]

Beach/Distributional Group	SSM Informational Target			GM TMDL Target			
	Reduce 24-hour Rainfall Below (inches)	Reduce Daily Gull Count Below	Increase in Slope Required (%)	Reduce 24-hour Rainfall Below (inches)[1]	Reduce Daily Gull Count Below	Increase in Slope Required (%)	Predicted Percent of SSM Exceedance when GM Is Attained
Group 1: Forest Park, Rosewood, IBSP South, Waukegan North	0.4	30	3	1	50	1	8%

[1] SSM informational targets are designed so that a SSM is not exceeded. GM TMDL targets are designed to consistently achieve the GM with some predicted percent of SSM exceedance.

F. In addition, the draft final TMDL does not on its face ensure compliance with the applicable Illinois WQC for fecal coliform […] As such, we ask that the TMDL explain the relationship between *E. coli* and fecal coliform in more depth and explain how achieving the *E. coli* target will also achieve compliance with Illinois WQC for fecal coliform.

Response: The fecal coliform criteria were first proposed by the National Technical Advisory Committee (NTAC) to the Federal Water Pollution Control Administration in 1968. The NTAC used epidemiological data collected by the United States Public Health Service (USPHS) from 1948–1950 to develop criteria for recreational bathing waters. In 1986, new bacteria criteria were promulgated for *E. coli* due, in part, from a need to improve the certainty in the relationship between indicator bacteria levels and illness rate. Studies used to develop the criteria examined illness rates in swimmers (and non-swimmers as a control) as it related to three bacteria criteria indicators: fecal coliform, *E. coli*, and enterococci. The study found *E. coli* and enterococci were most closely related to illness rates (Dufour, A.P. 1984. Health effects criteria for fresh recreational waters, EPA-600/1-84-004).

The TMDL allocations to reduce *E. coli* are reasonably expected to reduce fecal coliform loads to a level where water quality is associated with an illness rate that supports primary recreational use. Both *E. coli* and fecal coliform are used as bacteria indicators, yet *E. coli* is part of the parent fecal coliform group. Where *E. coli* is reduced, fecal coliform concentrations that are comprised of *E. coli* will consequently decrease. Due to the widespread and consistent availability of *E. coli* data across beaches and years, but the absence of fecal coliform data, the TMDL considered *E. coli* data and relied on the reasonable assumptions that reduced *E. coli* would consequently reduce fecal coliforms, and that reduced bacteria levels would protect water quality at a level that supports primary contact recreational use.

3. Implementation for new sources, such as planned additional MS4 outfalls, must be clarified.

Response: The TMDL will be incorporated into the Illinois MS4 General Permit (Permit No. ILR40) by reference once the TMDL is approved. The MS4 General Permit's current expiration date is March 31, 2014. The existing wastewater treatment plants must continue to comply with their permits to be consistent with the WLA provided in the TMDL. All existing and new MS4 Permittees are expected to meet the requirements of the Storm Water General Permit ILR40 and the TMDL WLA, i.e., 126 cfu/100 mL as the 30-day GM of *E. coli* as discussed in this report. The current General Permit Part III- Special Conditions (C) requires the MS4 Permittee to review their storm water management plan and determine whether the Permittee is meeting the TMDL allocation or approved watershed management plan. If they are not meeting the TMDL allocations, they must modify their storm water management program to implement the TMDL or watershed management plan within eighteen months of notification by the Agency of the TMDL or watershed management approval.

4. The draft final TMDL insufficiently considers designated uses.

Response: The TMDLs sufficiently consider designated uses and were designed to provide protection at a level equivalent to the applicable criteria. The bacteria criteria are designed to protect the public from illness related to primary contact use (e.g., swimming). The *E. coli* GM of 126 cfu/100 mL is associated with the accepted illness rate of 8 out of 1000 recreators. When the criteria were set, the SSM was determined as the upper 75th confidence interval of the GM of 126 cfu/100 mL. A confidence interval describes a range that is expected to contain the true population parameter (in this case, the mean) over repeated observations; the upper 75th confidence interval of the GM denotes a value that is expected to be at or above the true GM 75 percent of the time. The promulgation of *E. coli* criteria in 2004 clarified that the SSM was not intended for use as a never to exceed value for other CWA purposes, and doing so would result in a level that is more stringent than the level of protection provided by the criteria. That is, the GM is the basis for the illness rate and the SSM is an upper boundary, determined from the GM, which is used when making an immediate beach closure decision. Regardless, both of these criteria are considered in the TMDL. While the allocations were designed to consistently meet the GM, the corresponding rate that the SSM would be exceeded was also predicted. This provides a measure for how often a beach could exceed the SSM within a season and be expected to meet the GM and thus the level of protection that supports primary contact use. Reductions were assigned to the sources of bacteria (i.e., allocations) at a level that achieves these conditions.

5. The draft final TMDL is inconsistent with Illinois impairment listing standards

Response: A TMDL must be written to meet applicable WQSs. Illinois' impairment listing methodology is a process used to assess impairment status, rather than a codified and EPA-approved standard. The TMDLs were designed to be protective of the designated primary contact use and meet the applicable water quality criteria that were designed to protect this use. Furthermore, obtaining the TMDL is expected to reduce the frequency that SSM is exceeded and thereby expected to reduce the number of beach closures (See **Tables A.IV-1 through A.IV-3** in this appendix).

The Illinois EPA impairment listing methodology is based on the number of closures a particular beach experiences in a given time frame. These closures are based on the Beach Management Authority obtaining a sample on a daily basis during the swimming season and comparing the results of the sample to the Federal criteria for beaches.

6. Implementation schedules for TMDL measures should be included.

Response: NPDES permits must be consistent with the WLA and the assumptions used to derive them. Existing Wastewater Treatment Plants that discharge to Lake Michigan are expected to meet effluent limits that are outlined in their respective NPDES permits.

Current NPDES Permits will remain in effect until the permits are reissued; provided that IEPA receives the NPDES permit renewal application prior to the expiration date of the existing NPDES permit. The WLAs will be incorporated into the permits upon reissuance. The following is a list of permitted facilities along with their current permit expiration dates:

- North Shore Sanitary District – Waukegan WWTP (NPDES Permit No. IL0030244) renewal request received Nov. 2011. Current expiration 4/30/2012.
- North Shore Sanitary District – Gurnee WWTP (NPDES Permit No. IL0035092). Renewal request received June 2011. Current expiration 11/30/2011
- Abbot Labs (NPDES Permit No. IL0001881). Expiration date is 9/30/2016
- Outboard Marine (NPDES Permit No. IL0002267). Permit expired 6/1/1992. Permit will not be renewed. Awaiting No Further Remediation letter.
- Winnetka Water and Electric (NPDES Permit NO. IL0002364). Permit expired on 1/31/09. Permit renewal is in progress.

The MS4 communities are covered under the General NPDES Permit No. ILR40 that expires on March 31, 2014. The TMDL will be incorporated into the MS4 General Permit by reference. The General Permit will remain in effect until a new General Permit is reissued (pending new Storm Water Regulations). The current General Permit Part III- Special Condition (C) requires the MS4 Permittee to comply with the WLA when a TMDL is developed for that particular watershed within eighteen months of notification by IEPA of the TMDL.

Implementation of the LA is voluntary. However, IEPA has demonstrated reasonable assurance that the TMDL target will be met.

References

MDEQ (Michigan Department of Environmental Quality). 2007. Total Maximum Daily Load for *E. coli* for Lake St. Clair Metropolitan and Memorial Beaches Macomb County.

Tetra Tech. 2004. Lake Michigan Shoreline TMDL for E. coli Bacteria. Submitted to Indiana Department of Environmental Management. Indianapolis, IN.