Freshwater Swimming Beach Monitoring Sampling and Analysis Project Plan

May 2005

King County

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Freshwater Swimming Beach Monitoring: Sampling and Analysis Project Plan

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1.0. INTRODUCTION

Beginning in 1996, a number of public swimming beaches on Lake Sammamish, Lake Washington, and Green Lake have been monitored during the summer months to determine presence and levels of bacterial pollution and relative human health risks. Prior to this survey little data on bacterial levels at any local public swimming beaches existed. Substantial amounts of bacterial data are collected in lakes Sammamish and Washington from the King County Major Lakes program. However, these data are collected to monitor overall lake water quality and integrity of the sewage collection system, and are not collected within designated swimming beaches. Low counts of fecal coliform bacteria; e.g., less than 50 colony-forming units per 100 milliliters of water (CFU/100 mL), are routinely found in high quality water. Typical fecal coliform bacteria counts from the middle of lakes Washington and Sammamish during the summer are less than 20 CFU/100 mL. Public perception of the source of high bacteria counts at swimming beaches is often directed at the sewage collection and conveyance system, whether this is the source of the pollution or not. This makes synoptic sampling of the beaches, lakes, and streams necessary to identify or rule out a specific source of bacterial pollution, and propose appropriate corrective measures to address pollution sources when necessary.

Fecal coliform bacteria are routinely sampled as an indicator of sewage pollution in water and as an indicator of the associated pathogenic bacteria that may impact human health risk from swimming in contaminated waters. Elevated counts of fecal coliform bacteria always occur when sewage is present in the waters. However, high bacteria counts do not necessarily indicate human sewage pollution because many other mammals, birds and even vegetation can contribute this type of bacteria to the water. According to Chapter *173-201A, WAC WATER QUALITY STANDARDS FOR SURFACE WATERS OF THE STATE OF WASHINGTON*, 'extraordinary primary contact' criteria state freshwaters shall not have fecal coliform levels exceeding 50 colonies/100 mL and not have more than 10% of all samples exceeding 100 colonies/100 mL. The criterion for 'primary contact' is 100 colonies/100 mL and less than 10% of all samples exceeding 200 colonies/100 mL (see Appendix A). These concentrations are often exceeded in urban streams in King County, and frequently at the public swimming beaches. *Escherichia coli* is a better indicator of human health risks associated with fecal contamination, but the State of Washington water quality standards have not yet been updated to use *E.coli* as a more effective bacterial indicator, so both *E.coli* and fecal coliform are sampled in this program.

A supporting technique that has been used to identify sources of fecal bacteria is matching or ribotyping the genetic material RNA (ribonucleic acid) from the bacteria. This provides information on the species of animal which added the bacteria to the water. A study using this RNA method conducted in Piper's Creek in Seattle's Carkeek Park (SPU, 1993) identified domestic cats as the major source of bacteria. A subsequent study at Juanita Beach (King County 1998) identified ducks and geese as the major source of fecal coliform pollution, with seagulls and dogs as secondary sources. These RNA tests are expensive and time consuming, taking weeks to obtain the data. While the results are valuable in designing our long term water quality protection programs, the results are currently not available quickly enough to use this technique for routine monitoring of the beaches or the sewer system. Fecal coliform and *E. coli*

testing (without RNA analysis) takes less than 48 hours, allowing a much faster response to potential problems.

The Swimming Beach Monitoring Program sampling design and logistics are prepared and implemented by the King County Department of Natural Resources and Parks (KCDNRP). Samples are collected by King County Science and Technical Support (KCSTS) and the King County Environmental Laboratory (KCEL). Analysis results are transmitted to the Public Health Department of Seattle & King County (PHS&KC). PHS&KC determines the public health implications of the bacterial data collected from this program, and conveys this information to elected officials, other jurisdictions and the public. KCSTS is responsible for posting data to an internet webpage.

1.1 Project Organization

Project team members and their responsibilities are summarized in Table 1. All team members are staff of the King County Department of Natural Resources and Parks (KCDNRP), Water and Land Resources Division (WLRD) or Public Health Department of Seattle & King County (PHS&KC). Several individuals from different parks departments are associated with this program as well and are identified in Appendix B.

Table 1. Project Team Members and Responsibilities

name/telephone/email/title	Affiliation	Responsibility
Jonathan D. Frodge (206) 296-8018 Jonathan.frodge@metrokc.gov Sr. Limnologist/Program Manager	WLRD, Science and Technical Support Unit	Project manager for the swimming beach monitoring program. Data analysis
Robert Brenner (206) 296-8060 Bob.brenner@metrokc.gov Water Quality Planner	Science and Technical Support Unit	field sampling and data analysis
Katherine Bourbonais (206) 684-2382 Katherine.bourbonais@metrokc.gov Laboratory Project Manager	Environmental Laboratory	Coordination of analytical activities, lab QA/QC, and data reporting.
Robin Revelle, (206) 684-9160 Robin.revelle@metrokc.gov Microbiologist	Environmental Laboratory	Sample and Bacterial data analysis
Judith Ochs (206) 684-2347 Judy.ochs@metrokc.gov Environmental Scientist	Environmental Laboratory	Coordination of sampling activities, field QA/QC, and field analyses.
Daniel Smith (206) 263-6343 Daniel.smith@metrokc.gov Water Quality Planner	WLRD, Science and Technical Support Unit	Data reporting and website support
Fred Bentler (206)296-8050 Fred.bentler@metrokc.gov Information Systems Professional	KCDNRP, WLRD	Web support back-up for Daniel Smith
Colin Elliott (206) 684-2343 Colin.elliott@metrokc.gov KCEL Quality Assurance Officer	Environmental Laboratory	Overall project QA/QC.
Eileen Hennessy (206)205-3489 eileen.hennessy@metrokc.gov Technical Support Senior	Public Health-Seattle & King County	Public Health response
Logan Harris (206)263-6550 Logan.harris@metrokc.gov Media Relations Coordinator	KCDNRP, Director's Office	Public Affairs, media contact coordination

1.2 Study Design

The main purpose of the beach monitoring program is to protect public health by providing timely information about the water quality at public swimming beaches on lakes Sammamish, Washington and Green Lake. The primary method used to accomplish this is by routinely sampling *E.coli* and fecal coliform bacteria, and sampling for cyanobacterial toxins (beginning 2005 for two years) during bloom events. The program also provides additional data that can be used to help identify the source of bacteria, whether from bathers, animals or overflow from the sewage collection and conveyance system. This program implements a plan to coordinate roles of inter-departmental agencies involved in water testing, public health assessments, beach closures and media response. The bacterial data are collected weekly during the swimming season (mid-May through mid-September) and are posted on the King County swimming beach web page. http://dnr.metrokc.gov/wlr/waterres/lakes/bacteria.htm

The swimming beaches selected for this survey are public swimming beaches with officially designated swimming areas. In cooperation with PHS&KC's drowning prevention program, beaches with lifeguards are selected when possible, and all but the Lake Sammamish State Park has posted lifeguards during the swimming season. The beaches are selected to provide a wide geographic coverage of swimming beaches in lakes Sammamish and Washington, with Green Lake providing a high use small lake comparison. No private swimming beaches are sampled as part of this program. However, KCSTS will analyze and post bacterial data collected by jurisdictions that are not part of this program's sampling to the KC webpage, providing data are collected using the protocols defined in this SAP and analyzed at an accredited laboratory.

1.3 Goals and Objectives Protocol for Swimming Beach Monitoring

- Protect public health by providing timely and accessible information on regional bacterial water quality at public swimming beaches in lakes Sammamish, Washington and Green Lake.

- The beach monitoring program is conducted as a cooperative effort of the King County Department of Natural Resources, Science and Technical Support Unit (KCSTS), KC Environmental Laboratory (KCEL), multiple park districts, and Public Health Seattle & King County Department (PHS&KC).

- Approximately twenty public freshwater swimming beaches are sampled weekly from mid May through mid September as part of the routine monitoring program.

- All verified bacterial data are immediately transferred to PHS&KC. The Public Health Department makes all determinations on public health and contacts the local jurisdictions and parks departments on possible beach closures.

- Data from the beach monitoring program is used by the PHS&KC to close beaches by officially posting warning signs at the beach when fecal coliform counts exceed the ***Ten State Standard*** used by the PHS&KC *(geometric mean <200 cfu/100ml and no one*

sample >1000 cfu/100ml). Subsequent testing is conducted to determine if bacteria counts are below the standard before the beach is reopened.

- Preliminary analysis of cyanobacteria toxicity is carried out when bloom events of species capable of producing toxins are identified by field personnel during routine monitoring.

- KCSTS posts data weekly on the KC website http://splash.metrokc.gov/wlr/waterres/lakes/bacteria.htm

1.4 Sampling Locations

Table 2. 2004 Swimming Beach Sampling Locations.

Description	Site	Xplan	Yplan
Idylwood Park	0602SB	1327966	236634
Idylwood Creek	A620	1327254	236932
Lake Sammamish State Park west	0615SB	1334687	205515
NE 130TH PL street end	0805ASB	1289635	264271
OO Denny Park	0805BSB	1291408	261542
Juanita Beach	0806SB	1300025	259865
Juanita Creek	O446	1299812	260125
Luther Burbank	SD017SB	1297194	217536
Matthews Beach south	0817SSB	1286289	256489
Mathews Beach Park	0818SB	1285991	257467
Thornton Creek	A434	1285981	257146
Magneson Park	0826SB	1292290	251401
Madison Park	0852SB	1284654	235167
Mount Baker Park	0820SB	1281623	216172
Madrona Park	SD007SB	1282939	225430
Andrews Bay	0813SB	1288682	204375
Yarrow Bay	0825SB	1299140	240880
Meydenbauer Bay Park	0834SB	1300926	225707
Newcastle Beach	083930SB	1305139	209276
Gene Coulon Park	0828SB	1301896	187039
East Green Lake	A734SB	1271868	251768
Echo Lake	A764SB	1269635	285528
Hidden Lake	0207SB	1262436	278147

Sampling locations are subject to change based on sampling resources, presence or absence of lifeguards, or other program modifications determined prior to the annual swimming season. Samples will be pre-logged and collected as determined by the field collection crew based on workload allocation and efficiency of driving time and sampling.

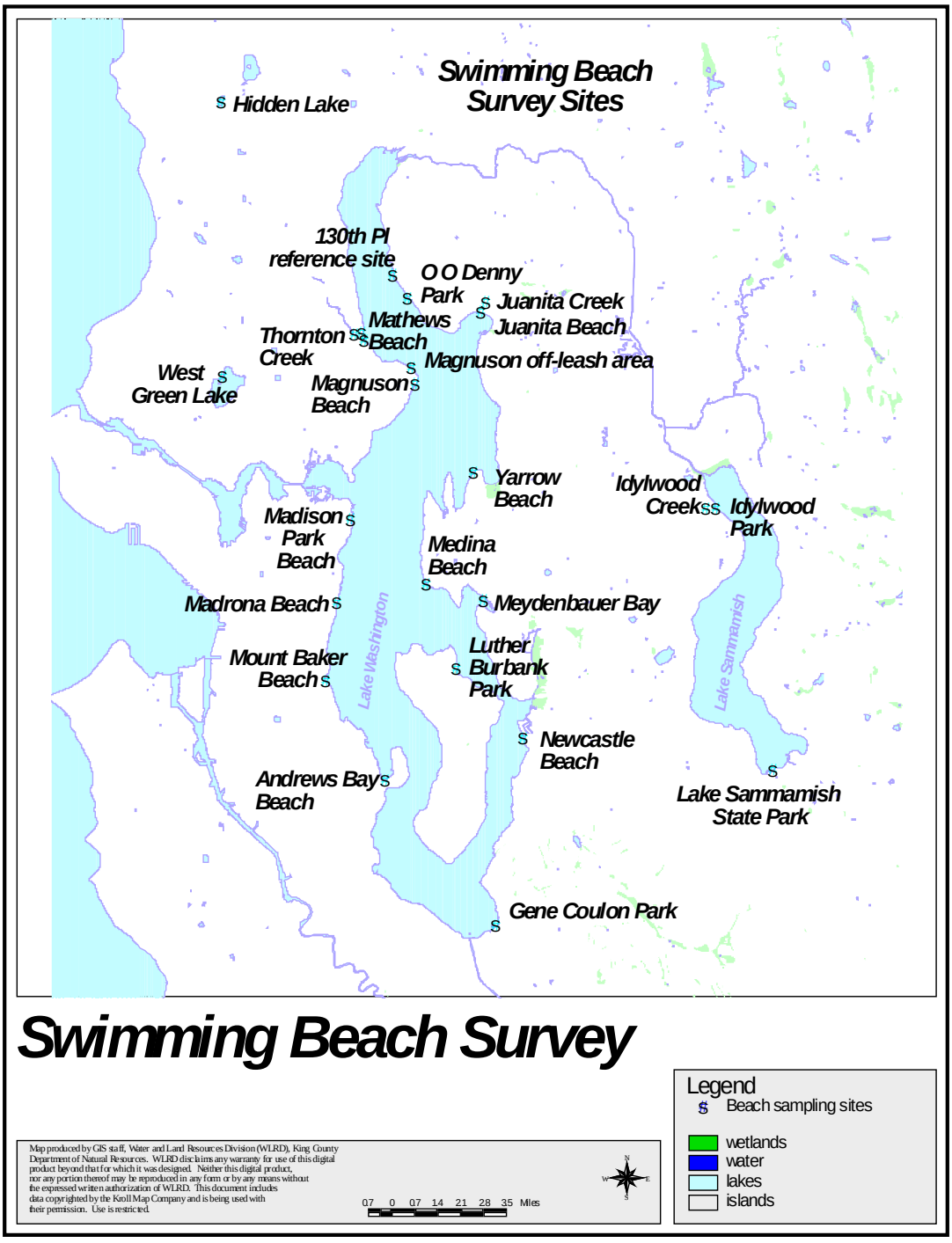

Figure 1. Swimming Beach sampling locations for 2005.

2.0. ROUTINE WATER TESTING

2.1 Location of Sampling

Single grab samples will be collected from near the middle of the officially designated beach area (laterally along the shoreline) at the control rope that designates the shallow "kiddie" portion from the deeper open water area. If there is no rope to designate the shallow area, samples will be collected where the water depth is between three to six feet. The assumption is this is the area where maximum loading and exposure would occur, as it is occupied by younger swimmers, and transited by anyone going into deeper water.

2.2 Frequency of Sampling and Rationale for Re-sampling

Swimming beaches are sampled on a weekly basis from mid-May through mid-September by collecting a single grab sample. Time of day of sampling is determined by field and lab requirements. If the bacterial results from the initial sampling at a beach is above the criteria for closing a beach (geometric mean >200 cfu/100ml or single sample >1000 cfu/100ml), an additional sample will be immediately collected from the same location using the same sampling protocols.

The rationale for immediate re-sampling is based on lack of statistical sampling power with a single grab and the possibility of collecting a false high count from a small localized source not representative of the overall bacterial water quality or human health concern. If the re-sampled value is within the water quality standards, the second sample is used for determining the geometric mean and bacterial water quality of the beach for that week. If the source of the bacteria is not small and isolated but rather a sewage spill or other large persistent source, the re-sampled count will also be high, as the possibility of obtaining a low bacterial count from water polluted by sewage is negligible.

Reliance on a single grab sample is not in compliance with the sampling protocols used by the WDOE Marine Beach Sampling Program funded by the USEPA (minimum of three samples per sampling event), but is a compromise designed to maximize the number of swimming beaches monitored with the sampling capacity available. This approach apparently works, as sewage spills and leaks have been detected at Andrews Bay in 1999 and Meydenbauer Bay in 2004. It is unknown if this sampling approach has missed potentially harmful public health events. If/when WDOE changes the indicator bacteria from fecal coliform to *E. coli* as has been suggested by the USEPA, all of the beach samples could be replicated with no additional increase in the cost of the program.

2.3 Sample Collection, Containers, Preservation and Storage

Grab samples are collected from within one foot of the surface of the water where the swimming area is three to six feet deep. Samples are collected using the dip method. Care must be taken to avoid contamination of the samples. Sampling staff will use either polyvinyl chloride (PVC) or latex gloves. Polypropylene (PP) or high density polyethylene (HDPE) bottles must be autoclaved and identified as sterile with autoclave tape before being used for sample collection. Containers must be filled such that a minimum of 1 inch of headspace is present. Bottles should NOT be rinsed with sample as part of the collection procedure.

Sampling personnel should walk from the dry beach area to the sample site wearing all proper gear including gloves. If a beach has been closed because of high bacterial counts personnel should also wear hip boots or chest waders. Prior to entering the water, the water quality sampler determines the direction of wind, current and effects of wave action. The sampler enters the water down-current or down-wind of the collection site and wades in a manner to avoid disturbing the water with sediment disruption. The sampler removes the cap, tips the sample container downward at a 45 degree angle and plunges the container so that the mouth is at least 5 inches below the surface. In one continuous motion, the sample container is turned upward so it begins filling with ambient water, it is then brought above the surface of the water, in a manner to provide a 1" headspace and the cap replaced. This continuous motion is an arc away from the sampler's body. If the bottle is overfilled, the neck of the bottle is snapped smartly to create a headspace if one does not exist, and the cap replaced. The sample container is then placed into an ice chest packed with ice.

During this process, atmospheric exposure should be kept to a minimum. The sampler must try to avoid collecting any debris, including sticks, seaweed, leaves, feathers, obvious waterfowl droppings, etc. This process is repeated until all sample containers for this site are filled. All sample containers are transported to the laboratory on ice. See the following KCEL Standard Operating Procedure (SOP) for further discussion. SOP for Clean Sampling for Ultra Trace Metals, Trace Organics, Microbiology and Conventional Chemistry Parameters using Surface Grabs, SOP #02-02-13000 (February, 2000). Samples must be stored at 4^{o}C and may be held for up to 24 hours following collection. See SOP for Fecal Coliforms in Environmental Water by Membrane Filtration SOP # 05-03-001-000 (10/15/2002), Supersedes SOP: Microbiology QA Manual Section 6.1.

2.4 Phytoplankton

A qualitative and quantitative grab sample of phytoplankton (2 total) and one for microcystin toxin will be collected when a bloom event is identified by the sampler. A bloom will be defined as an easily noticeable increase in phytoplankton concentrations from the previous sampling event, an obvious high concentration of phytoplankton, the presence of a surface scum or the visual identification of the presence of cyanobacteria. Phytoplankton sampling is a grab sample, typically a skimmed surface sample, but always targeting recovery of the visible algal bloom. The sample is collected and preserved with eight drops of Lugol's Iodine for a 60 mL foil

wrapped glass sample container (Standard Methods 20th Edition, Method 10200B.2). The sample bottle for toxin analysis is not preserved.

Samples will be returned to the KCEL for qualitative identification. If the cyanobacteria are identified as *Aphanizomenon*, *Microcystis*, *Anabaena*, or other cyanobacteria (blue-green algae), an Enzyme Linked Immunosorbent Assay (ELISA) toxicity test for microcystins will be run on the samples (250 ml AWM bottle). The aliquot collected for quantitative phytoplankton analysis will be archived for possible future analysis. Designation of a 'bloom' is at the discretion of the sampler.

2.5 Field Observations and Measurements

2.5.1 Temperature/Number of Swimmers/Number of Waterfowl

Water temperature of the swimming beach will be collected at each sampling event using a certified hand-held, digital thermometer. A count of waterfowl and swimmers (anyone in the water) should be made before completing water sampling. A visual inspection of the swimming area, including both the water and up-land area should be conducted and field notes taken if appropriate.

3.0. SAMPLE ANALYSIS

3.1 Microbiology

Microbiology parameters analyzed on a routine basis will include *Escherichia coli* and other fecal coliform bacteria. Special sampling of phytoplankton blooms for toxicity may be conducted during sampler identified bloom events.

Table 3. Microbiology and Toxicology Parameters and Containers

Analyte	Container	Holding Times
Escherichia coli	500 mL PP or HDPE, sterile	24 hours
Fecal coliforms	500 mL PP or HDPE, sterile (same container as *E. coli*)	24 hours
Qualitative and quantitative phytoplankton identification (Cyanobacteria)	2 x 60 mL Glass wrapped in foil, preserved with Lugol's solution	355 days
Microcystins by ELISA	250 mL AWM	24 to 48 hours, then freeze

Notes:

1. Collect a single bottle for *E. coli* and fecal coliforms.

2. Qualitative phytoplankton analysis is done at the KCEL. Quantitative analysis if needed is subcontracted to WATER Environmental, Inc. When collected, archive one (1) 60 mL foil wrapped bottle for possible future quantitative analysis.

3.2 Method

The method used at the KCEL for fecal coliform testing by membrane filtration (MF) is Standard Method 9222 D, Standard Methods for the Examination of Water and Wastewater, 20th Edition. Dilutions are selected to provide a targeted recovery range of between 1 and 6,000 cfu/100ml.

The method used at the KCEL for *E. coli* testing by membrane filtration (MF) is Standard Method 9213D.3, (Standard Methods for the Examination of Water and Wastewater, 20th Edition), the mTEC method. Dilutions are selected to provide a targeted recovery range of between 1 and 6,000 cfu/100ml.

The qualitative method used at the KCEL for phytoplankton identification is sedimentation followed by visual taxonomic evaluation by an experienced microscopist familiar with algal taxonomic reference texts. A standardized 1.0 ml volume is viewed in a Sedgewick-Rafter slide and the dominant and subdominant species are determined based on size and prevalence (Standard Method 10200B, C and E (Standard Methods for the Examination of Water and Wastewater, 20th Edition).

Table 4. Suggested Volumes for Fecal Coliform Analyses by MF

Project	Volume Analyzed (mL)								
	10^{2}	10^{1}	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
Streams (routine)	x	x	x						
Streams (storms)	x	x	x	x					
Lake Wash.	x	x							
Lake Samm.	x	x							
Lake Union	x	x							
Beaches (Lakes)	x	x	x						
Sewage (raw)					x	x	x	x	x
CSO		x	x	x	x	x	x		
Trouble Call (water)		x	x	x	x	x	x		
Stormwater	x	x	x	x	x	x			
WP Offshore	x								
Renton Offshore	x								
Beaches * (Marine)	x	x							

* Volumes routinely analyzed are 10, 30 and 100 mL.

3.3 Roles and Responsibilities

The KCEL has the primary role of coordinating resources to collect and analyze swimming beach samples each week. KCSTS, in cooperation with KCEL, will provide data interpretation, immediately post data on the KC website and provide limnological consultative services to PHS&KC and local parks departments.

KCEL will process samples and e-mail a spreadsheet with the weekly testing data results, a running geomean and a five day (sampling event) geometric mean (Table 5), typically within 24 - 48 hours of sampling to KCSTS for analysis and transmission to PHS&KC. Samples will be collected on Tuesdays and results transmitted to PHS&KC as soon as the data have passed the KCEL QA/QC requirements. This schedule is designed to provide time to review the data, make a determination about the bacterial quality of the swimming beaches, and potentially consult with involved parties (the KCEL, Parks, the media etc.) prior to the determination and posting of a weekend beach closure. PHS&KC is responsible for officially transmitting the data to parks departments and the local municipalities. KCSTS will post verified data on the web site.

Table 5. Example of the spreadsheet created by KCEL Microbiology with weekly bacteria data and running geometric means.

RowId	WorkGrp	AnalDate	SampNum	Type	A734WSB, W.Green Lake	A734WSB Mean	0826SB, Magnuson Beach	0826SB Mean	0818SB, Matthews	0818SB Mean	0852SB, Madison	0852SB Mean	SD007SB, Madrona	SD007SB Mean	0820SB, Mt. Baker	0820SB Mean	0813SB, Andrews	0813SB Mean	4903SB, Pritchard	4903SB Mean	0828SB, Gene Coulon
248	WG76027	24-Aug-04	L32797	Reg	190	12	400	23	200	122	420	44	200	26	14	18	100	14		0	214
247	WG76027	24-Aug-04	L32797	Dup																	
246	WG76027	24-Aug-04	L32797	Dup					130												
245	WG75925	17-Aug-04	L32669	Reg	11	10	22	19	150	119	32	38	32	23	12	18	110	12		0	370
244	WG75925	17-Aug-04	L32669	Dup																	
243	WG75925	17-Aug-04	L32669	Dup																	
242	WG75948	12-Aug-04	L32848	Reg		10		19		118		38		22		18		10		0	
241	WG75771	10-Aug-04	L32652	Reg	29	10	350	19	240	118	80	38	44	22	41	18	350	10		0	360

4.0. BEACH CLOSURE

In accordance with WAC 248-98-070 "No bathing beach shall be maintained or operated when such water is determined by the health officer to be so polluted or subject to pollution as to constitute a menace to health if used for bathing. " Any beach closure determination and subsequent action will be under the authority of the Seattle King County Health Department.

4.1 Water Quality Standards for Beach Closure

The State Health Department (DOH) standard for bacteriological water quality will be used to determine when to close a beach. The current standard being used is the "*Ten State Standard*", (Health Education Service 1990, Appendix A) for fecal coliform calculated on a geometric mean with a maximum safe level of a geometric mean of 200 CFU per 100 milliliters, or when the fecal coliform density of any sample exceeds 1,000 CFU per 100 milliliters.

As an alternative to criteria based on fecal coliform counts, the U.S. Environmental Protection Agency has suggested that *E.coli* organisms be used instead as indicator of fecal contamination and associated human health risk. A geometric mean of five samples should not exceed 126 *E.coli* CFU per 100 milliliters. A single sample should not exceed 235 *E.coli* CFU/100ml (Health Education Service 1990). The PHS&KC in communication with the parks department(s) will make a determination on public health risks and whether results of the sampling should lead to beach closure. Parks will inform the supervisor of the swimming beach about the results of the bacteriological analysis and PHS&KC recommendations for closure.

4.2 Media Contact When There is a Closure

PHS&KC, KCSTS, and the parks departments will discuss beach closure prior to releasing the information to the media or posting the beach. Parks will prepare a press release in consultation with PHS&KC and KCSTS to include the name of the beach closed, the address of the beach, date of closure, general reasons for the closure. The beach will remain closed until the bacteriological levels meet standards as determined by PHS&KC. PHS&KC will coordinate with the media specialists in their departments, the affected parks departments, and KCDNRP about the press release. Parks will send the press release to appropriate media contacts.

4.3 Media Contacts:

- All questions on public health are directed to the PHS&KC.
- Technical questions on sampling, data and limnology are answered by KCSTS or KCEL staff and reported to public outreach.
- Staff does not initiate contact with the media. If staff are contacted by the media they are to notify the KCDNRP Media Relations Coordinator, Logan Harris (296-6550) prior to responding to the information request.

4.4 Beach Closure Posting

PHS&KC determines if a beach is to be posted and, based on subsequent data, the duration of the closure. The beach should be posted to inform the public of possible risks of illness and to advise against swimming or water contact. An example posting is included in Appendix B. Parks staff will post the beach as soon as a determination has been made to close the beach. Signs should be posted in a conspicuous area visible to swimmers before they enter the water and where they can be easily read. PHS&KC is responsible for official posting of beach closures. The individual parks departments are responsible for removing postings when directed to do so by PHS&KC. All beach closure notices will be immediately posted to the KC web site as a prominent headline.

4.5 Follow-up Testing

Follow-up water testing will be conducted when the beach is closed to determine the source of bacterial pollution and when bacterial levels are again acceptable such that the beach can be reopened. Bathing beaches may be reopened if a satisfactory sanitary survey is completed, or if the daily averaged fecal coliform density in each of two consecutive daily sets of samples is <200CFU/100ml. These surveys will be conducted by KCEL, KCSTS or PHS&KC staff, and reimbursement to KCEL for the resampling will be the responsibility of the jurisdiction that owns and operates the swimming beach or park. Sampling will continue on a daily basis until bacteriological sample results are low enough to reopen the beach (<200CFU/100ml), with a minimum of three replicates collected within the swimming area (Health Education Service 1990). Replicates should be taken at the usual sampling location and 10 - 15 m on either side of the usual location. Any additional samples that the sampler deems necessary should be collected at this time (i.e. storm drains, stream mouths, etc.). All samples should be described accurately in the field notes, coordinate data collected. New sampling locations will be located as a shapefile in a GIS project by KCEL and KCSTS staff, using the wtrbdy.shp and the image files in the KCGIS system. Copies of the GIS files and maps will be sent by KCSTS to PHS&KC and other jurisdictions or parks departments responsible for the closed beach. .

4.6 Reopening Beaches

PHS&KC will make a determination to reopen a beach if follow-up test results show a decline in fecal coliform to acceptable levels, and if the beach no longer poses a public health risk. PHS&KC and Parks will discuss reopening the beach prior to releasing this information to the media and removing warning signs.

4.7 Media Contact and Removing Warning Signs

Once it has been determined that a beach is to be reopened, the warning signs will be removed by Parks and the notice will be removed from the KC website. The goal is to remove signs as soon as it's been determined by sampling results that the risk to public health has been diminished and the water samples are at acceptable levels. PHS&KC and Parks will inform the media specialists in PHS&KC and KCDNRP about the reopening. The media specialist in

KCDNRP will verify that the beach warning closure notice on the KC website is removed, as there have been problems in the past with the beach closure notice remaining on the KC web site after the swimming beach has been reopened. The appropriate jurisdictional Parks Department will also inform the swimming beach supervisor that the beach may be reopened to swimmers. After consultation with PHS&KC and KCDNRP, the Parks Department will send a press release to the media that the beach has been reopened.

4.8 Cooperation with Other Jurisdictions to Expand the Swimming Beach Monitoring Program

In order to expand the regional freshwater swimming beach monitoring program within the current budget, KCSTS will provide an incentive training program for jurisdictions within the King County service area. This program provides initial sample collection by KCSTS and KCEL staff, microbiological analysis by KCEL, and data analysis by KCSTS. A local jurisdiction participating in this program will designate a staff member(s) who will cooperate with KC staff to select appropriate swimming beach data collection sites and will be trained by KCEL staff to collect the swimming beach data according to the protocols in this SAP. The local jurisdiction will take over sampling after a two to three week training period, and will be responsible for collecting data on the appropriate day and transporting the samples to the KCEL. KCEL will continue to analyze the bacteria samples for the entire first season that the jurisdiction participates in the program.

If the jurisdiction chooses to participate in the program after the first year, the jurisdiction is responsible for sample collection and contracting sample analysis at an accredited laboratory. KCSTS will continue to analyze the data as part of the over all swimming beach monitoring program and post the data on the KC website. The data will be identified as being produced by a different laboratory. The jurisdiction is responsible for the timely transmittal of data to KCSTS.

Examples of this approach are the collection and analysis of data by Seattle Public Utilities at Rattlesnake Lake and participation by the City of Shoreline in the 2004 swimming beaches monitoring program (Appendix C). The KCDNRP swimming beach program will reserve sufficient sampling capacity to bring one additional jurisdiction on under this program each year. If a jurisdiction already has the capacity to collect and analyze samples and collection protocols meet or exceed the protocols in this SAP, those data can be posted to the KC website and analyzed as part of the KC swimming beach program.

5.0. DATA QUALITY OBJECTIVES

Data quality objectives typically involve specifications of the required precision, accuracy and tolerable bias of the analytical data. Discussion is also provided that describes the methods used to ensure that data are representative of the population targeted for sampling and comparable to other similar studies. Methods and procedures used to minimize the loss of usable data are also described.

While a minimum of three replicates are called for in the Washington State Draft Standards for Recreational Water and Beaches (Appendix D), the KC freshwater swimming beach monitoring program collects only a single grab sample. The KC program has a different set of data quality issues stemming from the need to cover a broad geographic area with a limited budget that is available. The scope of the sampling effort and resulting lack of statistical power is directly related to the available budget. Funding for other swimming beach monitoring, such as the USEPA funded sampling at marine beaches in King County, is restricted to marine swimming beaches only. A summary of inconsistencies between the KC swimming beach protocols and those developed by Washington State and USEPA is presented in Appendix D.

5.1 Precision

Data precision is the degree of agreement among repeated measurement of the same sample (laboratory replicate) or of separate samples collected as close as possible temporally and spatially (field replicate). A measure of precision gives an indication how consistent and reproducible field and/or laboratory methods are. However, precision does not reflect how "true" or accurate the results are. Typically, precision is monitored by the analysis of replicate samples. Replicating the analysis of a subset of field samples will assess the precision of the data. Approximately 4 percent of the field and laboratory samples will be analyzed in duplicate to provide a means of assessing analytical precision. One field replicate will be collected at a swimming beach randomly selected by KCEL staff during every sampling event.

Sampling precision will be estimated by calculating the Relative Percent Difference (RPD) of the replicate sample results:

$$RPD = \frac{|X_1 - X_2|}{(X_1 - X_2)/2} 100$$

Analytical precision is determined by performing a duplicate analysis on the same sample and comparing the results. Laboratory duplicates by the membrane filtration method are performed by removing aliquots from the sample bottle as two separate sub-samples, and duplicating all steps including preparation of dilutions. Duplicate sample results are evaluated by method 9020B.4 prescribed in Standard Methods for the Examination of Water and Wastewater, 20th ed., 1998. Briefly, this requires that the log-transformed difference between the two duplicate results be compared to the mean of the log-transformed differences for the previous 15 sample

pairs. The acceptance criterion is to be within 3 standard deviations of this latter value. Failure to meet the criterion is cause to evaluate the entire sample batch for compliance and applicability of the calculation, before qualifying or rejecting the data set.

5.2 Accuracy and bias

Accuracy is a measure of confidence in the analytical results. The smaller the difference between the measured value and the "true" value, the more accurate the results. The pattern of these differences (typically higher or lower) indicates the amount of bias in the results. Results with high precision and low bias are more accurate than results with high bias and precision or high bias and low precision. Results may still be accurate if they have low bias and precision, but there will tend to be a random scatter of replicate results around the true value. Because we plan to take a single sample to estimate the "true" bacterial counts, it is important that our results have low bias and high precision.

Following standard field protocols for the collection and preservation of the samples will ensure the accuracy and bias of the data. Accuracy and bias of phytoplankton identifications may also be assessed by independently verifying the results reported by the phytoplankton specialist. This will involve a review of wet-mount slides (or photographs) by a second phytoplankton specialist. It is recommended that a minimum of two samples be selected for independent verification.

5.3 Representativeness

Representativeness is the extent to which measurements actually depict the true population under evaluation.

Field and laboratory sampling techniques proposed for this study should provide data that are representative of bacterial quality at the sampled swimming beaches.

5.4 Comparability

Comparability is the extent to which data from one study can be compared directly to either historical data or data being collected in another project.

The objective of this study is to provide data that are comparable to historical lake and stream bacteria data. However, measures described above to evaluate the quality of the data should provide supporting information that may be used to assess the suitability of the data for comparison to historical information or data collected currently by other investigators.

5.5 Completeness

Completeness is a measure of the number of samples you must take to be able to use the information, as compared to the number of samples you originally planned to collect.

Ideally, implementation of this plan will result in collection of usable data for each proposed sample. Generally, sample and data tracking systems in place at the laboratory should ensure that all samples are collected, transported, logged in and analyzed in an acceptable manner. However, where data are not complete, decisions regarding re-sampling and/or re-analysis will be made by a collaborative process involving both data users and data generators.

6.0. PROJECT DELIVERABLES

Data will be compiled on a weekly basis by KCSTS staff and put on the web site by noon on Fridays. This requires timely collection and analysis of samples. The KCEL needs to transmit final data by close of business (COB) on Thursdays so the web site can be updated. If a given beach(es) needs to be resampled any resulting, subsequent data will be analyzed when it is verified. Updating the KC web site is the responsibility of the KCSTS staff (Bob Brenner and Daniel Smith). If the individual responsible for updating the web is unavailable, Fred Bentler (296-8050) will provide backup. It is the responsibility of the KCSTS staff to coordinate with backup support if they are unable to carry out the task.

6.1 Timeline

Data and associated documentation descried in this SAP will be transmitted from the KCEL microbiology laboratory to KCSTS (Bob Brenner, Jonathan Frodge) and PHS&KC (Eileen Hennesey) by COB Thursday. KCSTS will update the KC web site by COB on Fridays.

7.0. REFERENCES

American Public Health Association. 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edition.

Chorus, I, I.R. Falconer, H.J. Salas, and J. Bartram. 2000. Health risks caused by freshwater cyanobacteria in recreational waters. J. Toxicol. Environ. Health B. Crit. Rev. 4:323-347.

Health Education Service 1990. Recommended Standards for Bathing Beaches, Policies for the review and approval of plans and specifications for public bathing beaches. 1990 Edition. A Report of the Committee of the Great Lakes – Upper Mississippi River Board of State Public Health and Environmental Managers. Members and Province: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Ontario, Pennsylvania, Wisconsin.

KCDNR&P. 2002. Sampling and Analysis Plan for the Toxic Cyanobacteria in King County Lakes Study. King County Department of Natural Resources and Parks (KCDNR&P), Water and Land Division, Seattle, WA.

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Appendix A. Regulations and Policy

The following are the portions of the Washington Administrative Code showing the purpose and authority of Washington Department of Heath (WA-DOH) for Bathing Beaches

WAC 246-260-001 Purpose and authority. (1) The purpose of this chapter is to protect the health, safety, and welfare of users of water recreation facilities (WRF). This chapter is established per RCW 70.90.120.

WAC 246-260-180 Bathing beaches. No bathing beach shall be maintained or operated when such water is determined by the health officer to be so polluted or subject to pollution as to constitute a menace to health if used for bathing. Where bathhouse and toilet facilities are provided for use of bathers they shall be constructed, maintained and operated in a sanitary manner approved by the health officer.

[Statutory Authority: RCW 43.20.050. 91-02-051 (Order 124B), recodified as § 246-260-180, filed 12/27/90, effective 1/31/91; Regulation .98.070, effective 3/11/60.]

The following are the portions of the Washington Administrative Code showing the water quality criteria used by the Washington Department of Ecology (WDOE) for primary and extraordinary primary contact, including bathing beaches

WAC 173-201A-200 Fresh water designated uses and criteria

(2) **Recreational uses.** The recreational uses are extraordinary primary contact recreation, primary contact recreation, and secondary contact recreation.

(a) **General criteria.** General criteria that apply to fresh water recreational uses are described in WAC 173-201A-260 (2)(a) and (b), and are for:

(i) Toxic, radioactive, and deleterious materials; and

(ii) Aesthetic values.

(b) **Water contact recreation bacteria criteria.** Table 200 (2)(b) lists the bacteria criteria to protect water contact recreation in fresh waters.

Table 200 (2)(b)

Water Contact Recreation Bacteria Criteria in Fresh Water

Category	Bacteria Indicator
Extraordinary Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.
Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies /100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies /100 mL.
Secondary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 200 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 400 colonies /100 mL.

(i) When averaging bacteria sample data for comparison to the geometric mean criteria, it is preferable to average by season and include five or more data collection events within each period. Averaging of data collected beyond a thirty-day period, or beyond a specific discharge event under investigation, is not permitted when such averaging would skew the data set so as to mask noncompliance periods. The period of averaging should not exceed twelve months, and should have sample collection dates well distributed throughout the reporting period.

(ii) When determining compliance with the bacteria criteria in or around small sensitive areas, such as swimming beaches, it is recommended that multiple samples are taken throughout the area during each visit. Such multiple samples should be arithmetically averaged together (to reduce concerns with low bias when the data is later used in calculating a geometric mean) to reduce sample variability and to create a single representative data point.

(iii) As determined necessary by the department, more stringent bacteria criteria may be established for rivers and streams that cause, or significantly contribute to, the decertification or conditional certification of commercial or recreational shellfish harvest areas, even when the preassigned bacteria criteria for the river or stream are being met.

(iv) Where information suggests that sample results are due primarily to sources other than warm-blooded animals (e.g., wood waste), alternative indicator criteria may be established on a site-specific basis by the department.

Recommended Standards for Bathing Beaches, Policies for the review and approval of plans and specifications for public bathing beaches. 1990 Edition. A Report of the Committee of the Great Lakes – Upper Mississippi River Board of State Public Health and Environmental Managers. Members and Province: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Ontario, Pennsylvania, Wisconsin. Published by: Health Education Service, PO Box 7126, Albany, NY 12224. phone: (518)439-7286.

Water Quality Standards

4.0 Water Quality Standards

4.1 Bacterirological Quality

4.1.1 The bathing beach shall be closed when the fecal coliform density from the last five consecutive daily sets of samples collected on five different days within a 30 day period exceeds a geometric mean of 200 (cfu) per 100 ml or when the fecal density of any sample exceeds 1,000 (cfu) per 100 ml. The fecal density of a daily set of samples shall be the arithmetic mean fecal coliform density of all samples collected that day.

4.1.2 Daily sets of samples shall be collected and analyzed while the bathing beach is closed. The beach may be reopened if the fecal coliform density in a daily set of samples is less than 200 (cfu) per 100 ml and a satisfactory sanitary survey has been conducted or if the fecal coliform density in each of two consecutive daily sets of samples is less than 200 per 100 ml.

4.1.3 As an alternative to 4.1.1 above the United States Environmental Protection Agency (USEPA) has suggested that *E. coli* be used instead of fecal coliform as indicators of contamination. A geometric mean of five samples should not exceed 126 e. coli organisms per 100 ml or 33 enterococcus organisms per 100 ml. A single sample should not exceed 235 e. coli or 61 enterococcus organisms per 100 ml.

4.4 Biological Quality

4.4.1 Algae and aquatic vegetation shall be controlled so that no hazard to bathers results.

4.4.2 Where schistosome dermatitis (swimmer's itch) is known to exist, appropriate measures shall be taken to protect bathers. Such measures may include posting of warning signs, chemical treatment, or closing the beach.

4.4.3 Chemical used for water treatment shall be acceptable to the regulatory agency and shall be applied by properly trained applicators. Any chemical used, when properly applied, shall not be capable of creating toxic reactions, including skin or membrane irritations when the beach is in operation.

Appendix B. Lake Water Quality Team

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Appendix C. Scope of Work for City of Shoreline participation in King County Swimming Beach Monitoring Program

Echo Lake Swimming Beach Sampling

Under this Scope of Work, the King County Water and Land Resources Environmental Lab will provide services to the City to evaluate water samples from the Echo Lake Swimming Beach for fecal coliforms and *E. coli* (both by the membrane filtration method). Sampling will take place between 18 May 2004 and 21 September 2004. City staff will be trained in sample collection so that they may collect the samples themselves. King County will provide sample bottles, labels and fieldsheets.

- King County field science staff will train City of Shoreline staff on-site in proper sample collection techniques and documentation of observed field conditions. Training will take place during the course of collecting the first two samples.
- Thereafter, City of Shoreline staff will collect the weekly samples and deliver them to the Environmental Laboratory for evaluation. Sample delivery time must be coordinated with the laboratory.
- Analysis results will typically be available within 48 hours of collection, and are reported by the Environmental Laboratory to the Seattle King County Public Health Department, who will in turn transmit data to the parks and municipalities as needed so that beach closures if required can be effected before the weekend. King County Natural Resources and Parks Department will post results to the Swimming Beach Monitoring Program website.
- The Environmental Laboratory will prepare a Comprehensive Data Report for the City of Shoreline (Excel spreadsheet, standard laboratory format), and transmit file electronically within 30 days of sample collection. A separate report will be prepared and transmitted for each weekly sampling event.
- King County will provide a case narrative describing analytical anomalies, if and when any occur. Case narratives will be transmitted as part of the data report.
- Total cost of conducting the program as described above will be $1,500, including sample collection during 2 events, training of City staff and analysis of samples collected during all 19 weekly events.
- If there are elevated counts (e.g., a single sample with fecal coliform counts >1000cfu/100 mL) or beach closure is required by the Public Health Department, additional samples will be collected by King County staff so that rising and falling contamination levels can be monitored. Additional sampling events will be charged at $145 per event. An event is considered to include collection of one sample, and analysis for fecal coliforms and *E. coli* , both by the membrane filtration method.

Appendix D. Inconsistencies between Washington State and USEPA Protocols and KC Swimming Beach Monitoring Program Protocols

- The "Washington State Draft Standards for Recreational Water and Beaches" state that the operator should collect a set of bacteriological samples at least five times per month. Additional samples may be collected as the need for bacteriological surveillance becomes apparent. On the day of testing, a minimum of two samples should be collected from representative locations throughout the bathing area. As stated, KC has field and lab capacity to collect and analyze a single sample in the nearshore swimming area.
- The Draft Standards state one sample will be taken from the shallow portion of the beach several feet from the water's edge. KC collects a sample at or near the rope designating the shallow area.
- The Draft Standards state the second sample will be collected farther out than the first sample, in deeper water. As stated, KC currently does not have the field or lab capacity to collect and analyze this additional sample. Also, collection of this second, deeper sample would require a boat at most or all of the sites included in the program.
- The Draft Standards state that to assure that the samples are representative of the bathing water, they should be collected in an area where the bottom of the lake hasn't been stirred up and in an area that is free of floating debris or isolated evidence of duck or other animal droppings. The KC written protocols may have to be expanded to (ensure?) assure consistent sampling. If samples are collected during periods of peak usage, then the bottom will likely be disturbed. And short of watching the animals defecate, it is impossible to tell if one has done so in the immediate vicinity of the sampling site.