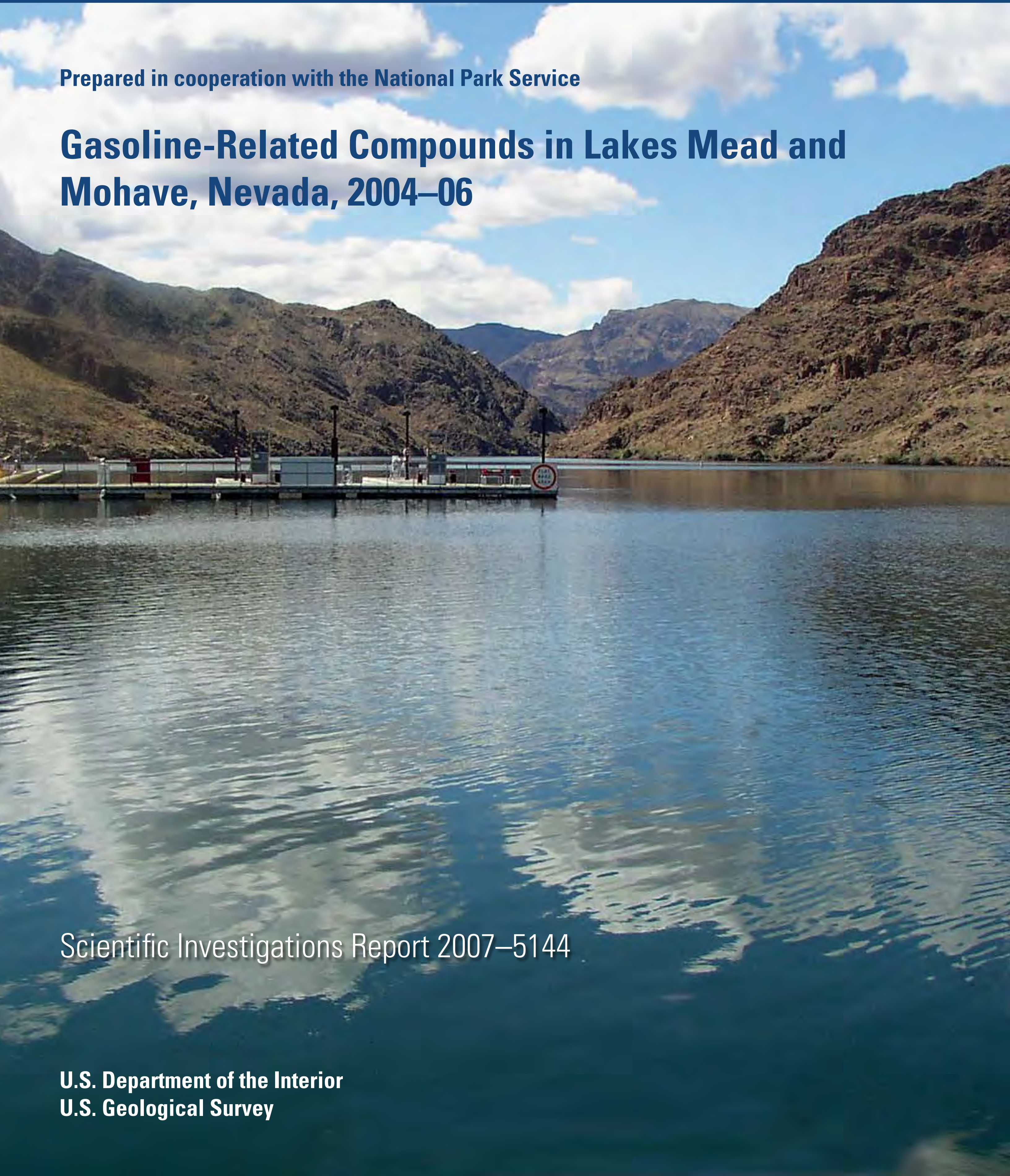
Prepared in cooperation with the National Park Service

Gasoline-Related Compounds in Lakes Mead and Mohave, Nevada, 2004–06



Scientific Investigations Report 2007–5144

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph of the Colorado River looking downstream from Willow Beach, Arizona.
Photograph taken by Michael S. Lico, U.S. Geological Survey, March 20, 2006.

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Contents

Figures

Tables

Conversion Factors and Datum

Conversion Factors

Multiply	By	To obtain
centimeter (cm)	0.3937	inch (in.)
cubic meter (m^3)	35.714	cubic foot (ft^3)
cubic meter (m^3)	264.2	gallon (gal)
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)
kilometer (km)	0.6214	mile (mi)
liter (L)	61.02	cubic inch (in^3)
liter (L)	0.2642	gallon (gal)
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	1.057	quart (qt)
meter (m)	3.281	foot (ft)
meter (m)	1.094	yard (yd)
millimeter (mm)	0.03937	inch (in.)
square kilometer (km^2)	0.3861	square mile (mi^2)
square meter (m^2)	0.0002471	acre

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32)/1.8.$$

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Datum

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

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Gasoline-Related Compounds in Lakes Mead and Mohave, Nevada, 2004–06

By Michael S. Lico and B. Thomas Johnson

Abstract

The distribution of man-made organic compounds, specifically gasoline-derived compounds, was investigated from 2004 to 2006 in Lakes Mead and Mohave and one of its tributary streams, Las Vegas Wash. Compounds contained in raw gasoline (benzene, toluene, ethylbenzene, xylenes; also known as BTEX compounds) and those produced during combustion of gasoline (polycyclic aromatic hydrocarbon compounds; also known as PAH compounds) were detected at every site sampled in Lakes Mead and Mohave.

Water-quality analyses of samples collected during 2004–06 indicate that motorized watercraft are the major source of these organic compounds to the lakes. Concentrations of BTEX increase as the boating season progresses and decrease to less than detectable levels during the winter when few boats are on the water. Volatilization and microbial degradation most likely are the primary removal mechanisms for BTEX compounds in the lakes. Concentrations of BTEX compounds were highest at sampling points near marinas or popular launching areas. Methyl *tert*-butyl ether (MTBE) was detected during 2004 but concentrations decreased to less than the detection level during the latter part of the study; most likely due to the removal of MTBE from gasoline purchased in California.

Distribution of PAH compounds was similar to that of BTEX compounds, in that, concentrations were highest at popular boating areas and lowest in areas where fewer boats traveled. PAH concentrations were highest at Katherine Landing and North Telephone Cove in Lake Mohave where many personal watercraft with carbureted two-stroke engines ply the waters. Lake-bottom sediment is not a sink for PAH as indicated by the low concentrations detected in sediment samples from both lakes. PAH compounds most likely are removed from the lakes by photochemical degradation.

PAH compounds in Las Vegas Wash, which drains the greater Las Vegas metropolitan area, were present in relatively high concentrations in sediment from the upstream reaches. Concentrations of PAH compounds were low in water and sediment samples collected farther downstream, thus the bottom sediment in the upstream part of the wash may be an effective trap for these compounds.

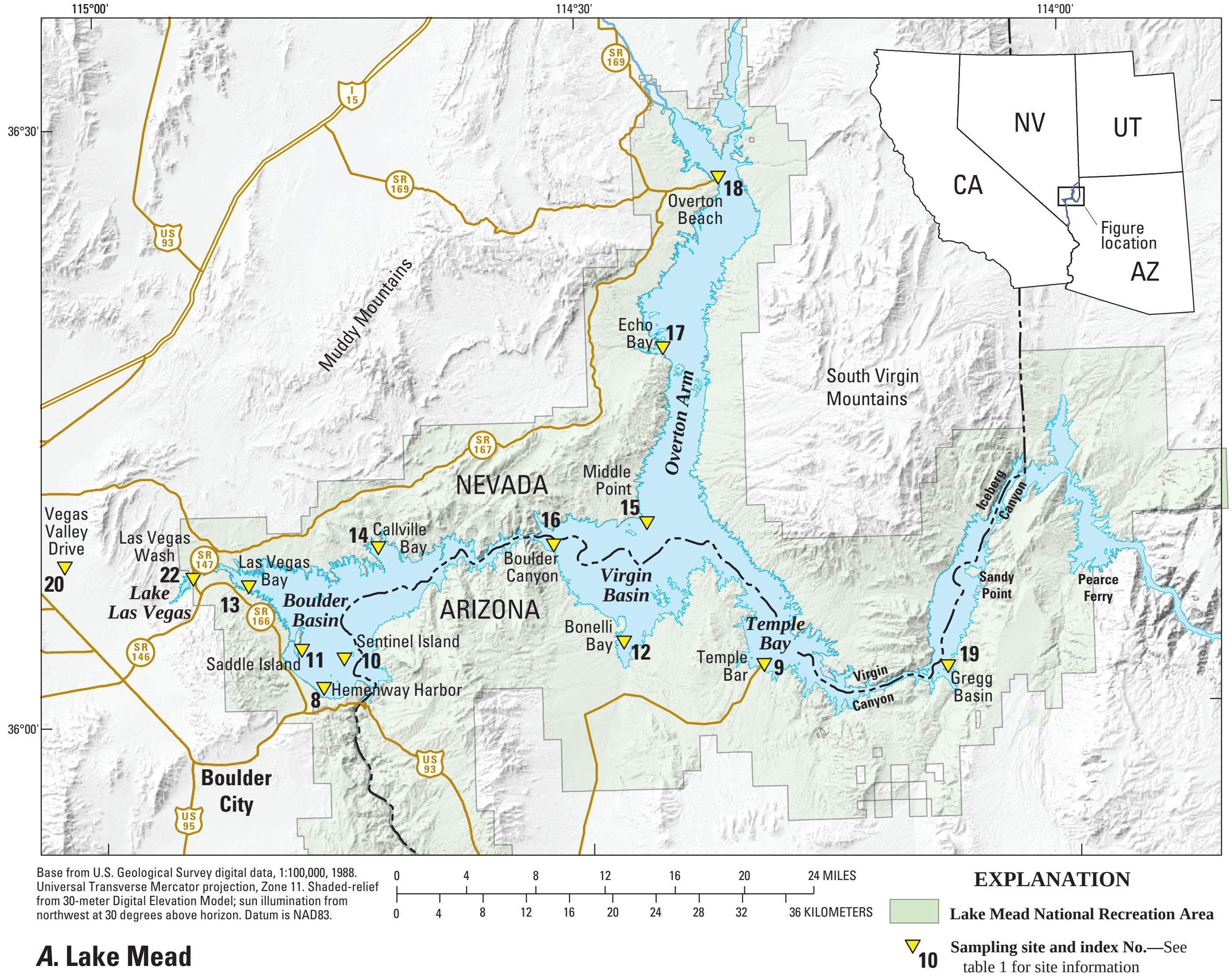
Bioavailable PAH compounds were present in all samples as determined using the Fluoroscan method. Microtox acute toxicity profiles indicated that Callville Bay in Lake Mead and the two Lake Mohave sites had only minor evidence that toxic compounds are present.

Introduction

Emissions from watercraft engines represent a potential chronic or acute toxic threat to aquatic wildlife at Lake Mead National Recreation Area (fig. 1), which includes Lakes Mead and Mohave and the Colorado River between the two reservoirs. Lakes Mead and Mohave are used intensively by many types of watercraft. Watercraft engines release uncombusted gasoline and oil to the water and air. Two-stroke carbureted engines, typically used on many older boats and on larger numbers of personal watercraft, are estimated to discharge as much as 30 percent of their fuel and oil during operation (California Environmental Protection Agency, Air Resources Board, 1999).

Gasoline contains such compounds as benzene, toluene, ethylbenzene, and xylene (BTEX) and oxygenated additives such as methyl *tert*-butyl ether (MTBE) that are known to have adverse effects on human health and aquatic life. Watercraft engines also can emit polycyclic aromatic hydrocarbon (PAHs) compounds. These compounds are formed by combustion of oil and are composed of two or more fused benzene rings and can have any combination of alkyl or aromatic functional groups attached to the molecule. PAHs can occur as low molecular weight compounds, such as naphthalene, or as high molecular weight compounds, such as coronene.

The toxicity of PAHs generally increases as the molecular weight increases (Agency for Toxic Substances and Disease Registry, 1994; Moring, 1996). High molecular weight PAHs, however, are not acutely toxic in concentrations generally detected in the environment partly because of their low solubility in water. Many PAHs may have adverse effects on aquatic organisms because of their high lipid solubilities. High molecular weight PAHs or their metabolites can be carcinogenic. High molecular weight PAHs can be produced



Base from U.S. Geological Survey digital data, 1:100,000, 1988. Universal Transverse Mercator projection, Zone 11. Shaded-relief from 30-meter Digital Elevation Model; sun illumination from northwest at 30 degrees above horizon. Datum is NAD83.

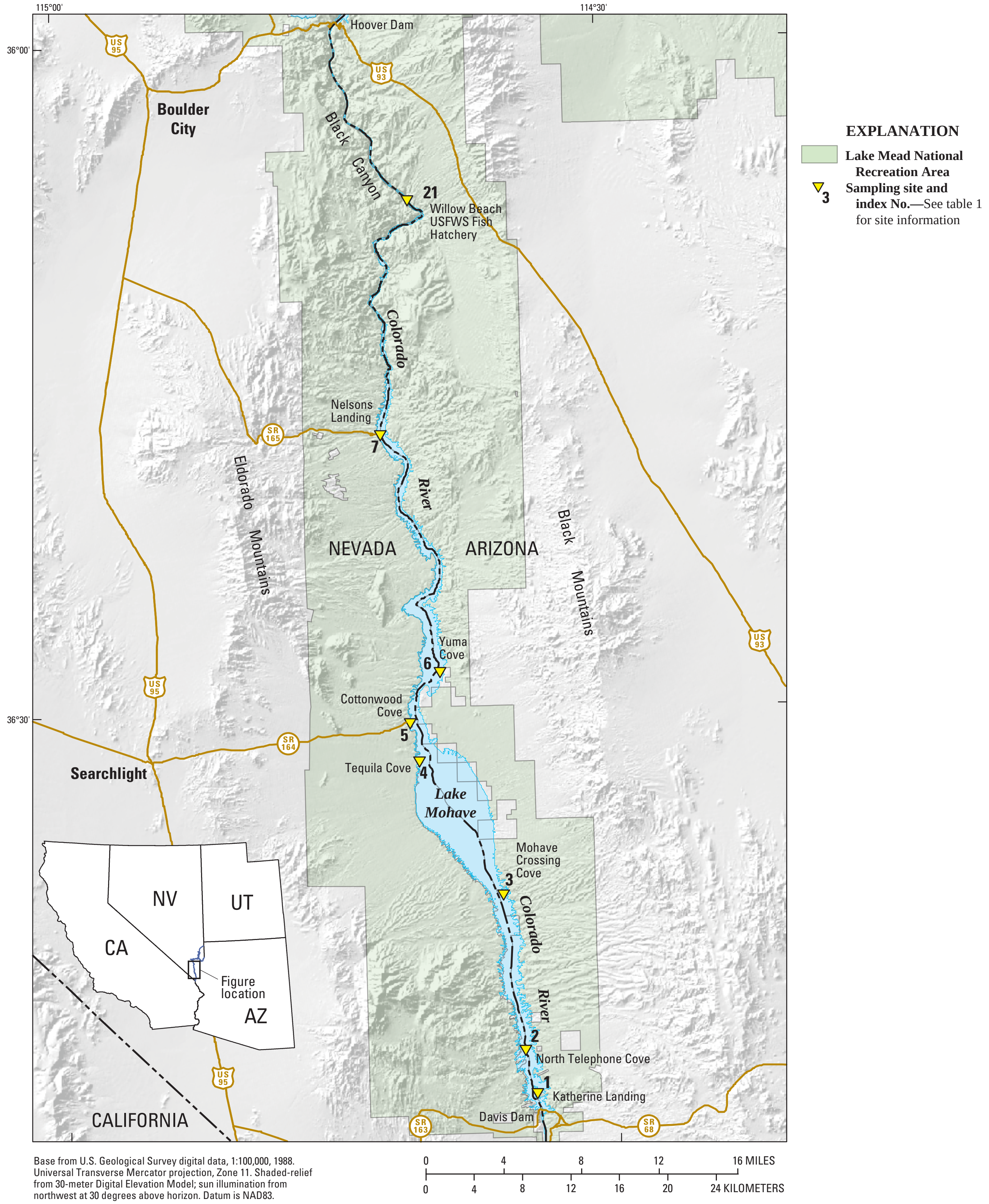
***A*. Lake Mead**

Figure 1. Location of study area and sampling sites, Lakes Mead and Mohave, Nevada.

by the incomplete combustion of fuels, during forest fires or incineration of waste materials, and as part of industrial manufacturing (Mill and others, 1981; Kochany and Maguire, 1994).

Exposure to ultraviolet solar radiation, termed photoactivation, can cause increased toxicity, but only to certain compounds (Kochany and Maguire, 1994). Compounds with one benzene ring, such as the BTEX compounds, commonly are acutely toxic when exposed to ultraviolet radiation, whereas those compounds with many rings (PAHs) are chronically toxic when exposed to ultraviolet radiation. The intensity of ultraviolet solar radiation and the depth of penetration into the water also are factors effecting the photoactivation and PAH toxicity.

Only minor reliable scientific data are available on the effects of watercraft emissions on major use recreational desert lakes or impoundments such as Lakes Mead and Mohave. In June 1999, five water samples were collected at 1-meter depths from both lakes. Analysis of these samples indicates that BTEX compounds and MTBE were detected at all sampling sites on both lakes (Jones and others, 1999). Bevans and others (1996) detected numerous PAHs in bottom-sediment samples and in the water column at several sites in Boulder Basin of Lake Mead with semipermeable membrane devices (SPMDs). The detection of these compounds was associated with discharge of wastewater from Las Vegas Valley. Covay and Beck (2001) detected numerous PAHs and other semivolatile compounds in intervals from lake-sediment cores collected at several sites in Las Vegas Bay and Overton Arm. Studies at Lake Tahoe evaluated the occurrence and distribution of gasoline-related compounds (Lico and Pennington, 1999; Lico, 2003 and 2004) and the toxicity of PAHs to fish and zooplankton (Oris and others, 1998).



Base from U.S. Geological Survey digital data, 1:100,000, 1988.
Universal Transverse Mercator projection, Zone 11. Shaded-relief from 30-meter Digital Elevation Model; sun illumination from northwest at 30 degrees above horizon. Datum is NAD83.

***B*. Lake Mojave**

Figure 1.—Continued

Hydrologic Setting

Lake Mead was created in 1935 by construction of Hoover Dam on the Colorado River. Lake Mead is the largest reservoir by volume in the United States (LaBounty and Burns, 2005). The major surface-water inflows to Lake Mead are the Colorado, Virgin, and Muddy Rivers, and Las Vegas Wash with the Colorado River providing about 97 percent of the annual inflow (LaBounty and Burns, 2005). Las Vegas Wash has the most potential for delivering contaminants to Lake Mead because of intensive urban development and discharge of treated sewage effluent.

Davis Dam, 67 mi downstream of Hoover Dam, was completed in 1953 (Bureau of Reclamation website: http://www.usbr.gov/lc/region/pao/brochures/davis.html, last accessed Jan. 22, 2007) forming Lake Mohave. Aside from ephemeral streams, some perennial springs, and scant rainfall, releases of water from Hoover Dam are the only source of water for Lake Mohave.

Use of Resource

Lakes Mead and Mohave are popular recreation areas used by many people from Las Vegas, southern California, Arizona, and elsewhere. Activities generally are concentrated near developed marinas and popular beaches on the lakes. Lake Mead National Recreation Area (includes both Lakes Mead and Mohave) was the fifth most visited National Park in the country during 2005. Some of the more common activities people come to Lakes Mead and Mohave for are boating, fishing, scuba diving, hiking, and relaxing.

Another major asset of Lakes Mead and Mohave is the important habitat they provide for populations of several endangered species; including the Razorback sucker (*Xyrauchen texanus*), Bony tailed chub (*Gila elegans*), Virgin River chub (*Gila seminuda*), and the Woundfin (*Plagopterus argentissimus*).

Purpose and Scope

The purpose of this report is to document concentrations of organic compounds related to the use of gasoline-powered engines on Lakes Mead and Mohave. Organic compounds are BTEX, oxygenates, degradation products of oxygenates, and PAH. In all, water, SPMD, and bottom-sediment samples were collected from 22 sites (table 1) in the study area (water, 20 sites; SPMDs, 9 sites; and bottom sediment, 10 sites). Samples were collected in 2004, 2005, and 2006, generally during the boating season (May–September) and once during early spring 2006.

Table 1. Information for sampling sites in Lakes Mead and Mohave, Nevada.

[Location of site Nos. are shown in figure 1. USGS, U.S. Geological Survey; deg, degrees; min, minutes; sec, seconds]

Site No. (fig. 1)	USGS site identification No.	Site name	Latitude (deg, min, sec)	Longitude (deg, min, sec)
1	351308114335501	Lake Mohave at Katherine Landing	35° 13' 08"	114° 33' 55"
2	351359114341101	Lake Mohave at North Telephone Cove	35° 13' 59"	114° 34' 11"
3	352000114352001	Lake Mohave at Mohave Crossing	35° 20' 00"	114° 35' 20"
4	352831114404601	Lake Mohave at Tequila Cove	35° 28' 31"	114° 40' 46"
5	352936114405601	Lake Mohave at Cottonwood Cove	35° 29' 36"	114° 40' 56"
6	353123114391501	Lake Mohave at Yuma Cove	35° 31' 23"	114° 39' 15"
7	354235114422801	Lake Mohave at Nelsons Landing	35° 42' 35"	114° 42' 27"
8	360149114462701	Lake Mead at Hemenway Harbor	36° 01' 49"	114° 46' 27"
9	360228114185701	Lake Mead at Temple Bar Marina	36° 02' 28"	114° 18' 57"
10	360314114450501	Lake Mead at Sentinel Island QW Platform	36° 03' 14"	114° 45' 05"
11	360344114474201	Lake Mead at Saddle Island	36° 03' 44"	114° 47' 42"
12	360547114264801	Lake Mead at Bonelli Bay	36° 05' 47"	114° 26' 48"
13	360700114505101	Lake Mead at Las Vegas Bay QW Platform	36° 07' 00"	114° 50' 51"
14	360745114414901	Lake Mead at Callville Bay	36° 07' 45"	114° 41' 49"
15	360852114270101	Lake Mead off Middle Point Island	36° 08' 52"	114° 27' 01"
16	360901114321001	Lake Mead at Virgin Basin QW Platform	36° 09' 01"	114° 32' 10"
17	361806114244401	Lake Mead at Echo Bay	36° 18' 06"	114° 24' 44"
18	362601114204501	Lake Mead at Overton QW Platform	36° 26' 01"	114° 20' 45"
19	360908114045801	Lake Mead at Gregg Basin	36° 09' 08"	114° 04' 58"
20	94196784	Las Vegas Wash at Vegas Valley Drive	36° 08' 13"	115° 02' 16"
21	9421900	Colorado River at Willow Beach	35° 52' 10"	114° 39' 40"
22	9419800	Las Vegas Wash below Lake Las Vegas	36° 07' 20"	114° 54' 15"

Sample Collection and Analytical Methods

Sample Collection

Water

Water samples for gasoline-related volatile organic compounds (VOCs) were collected using a stainless-steel hand sampler (fig. 2*A*) that was lowered to the desired depth (1 meter) on either a stainless-steel cable or nylon rope (Shelton, 1997). The sampler holds four 40-mL glass vials that are flushed with approximately seven volumes of water before being filled by the final 40 mL. Immediately upon retrieval of the sampler, the sampler was opened and each vial was removed, preserved with 1:1 hydrochloric acid, capped, placed on ice, and shipped overnight to the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) in Lakewood, Colo.

Detection of PAHs in water samples is problematic because of their low solubility in water and their transient nature, leading to low concentrations. Semipermeable membrane sampling devices (SPMDs) were used to sample these organic compounds in the water column. SPMDs consist of a flat low-density polyethylene tube filled with triolein (lipid) and are deployed in stainless-steel canisters (fig. 2*B*) suspended in the water column (Huckins and others, 1990 and 1993). These devices are effective in sequestering hydrophobic organic compounds from water and are useful in assessing the bioavailability of these compounds to the biota (Bevans and others, 1996).

During May–June 2004, SPMDs were placed at three locations in Lake Mead, two locations in Lake Mohave, and one location in Las Vegas Wash. During May–June 2006, SPMDs were placed at four locations in Lake Mead and two locations in Lake Mohave. The SPMDs were placed by suspending the canisters 3-meters below the water surface from a platform or buoy chain. When the SPMDs were retrieved, they were placed on ice and shipped overnight to Environmental Sampling Technologies (sole vendor of SPMDs) in St. Joseph, Missouri, for processing.

Bottom Sediment

Lake-bottom sediment samples were collected from a boat using a small Ponar dredge (fig. 2*C*), which was lowered to the bottom on a nylon rope. The dredge typically sampled the upper few centimeters of lake-bottom sediment. The dredge was retrieved and then placed in a cleaned stainless steel tray where the sediment was exposed by opening the dredge. Sediment was placed into a pre-cleaned (washed with detergent, rinsed with deionized water, and baked at 450 °C) 1-liter glass jar with a Teflon® spatula and the jar was sealed and placed on ice. The samples were frozen as soon as possible after collection, packed on ice, and sent to the USGS NWQL.

A. Stainless steel hand sampler used to collect water samples.

B. Semipermeable membrane device (SPMD) used to collect organic compound samples.

C. Small ponar dredge used to collect lake-bottom sediment samples.

Figure 2. Equipment used for collection of samples from Lakes Mead and Mohave, Nevada.

Laboratory Analyses of Samples

Water

Water samples were analyzed for volatile organic compounds (VOCs) at the USGS NWQL. Compounds specifically targeted were BTEX (benzene, toluene, ethylbenzene, and xylene isomers), oxygenates (diisopropyl ether, ethyl *tert*-butyl ether, methyl *tert*-butyl ether, and methyl *tert*-pentyl ether), and degradation products of oxygenates (acetone, methyl acetate, *tert*-amyl alcohol, and *tert*-butyl alcohol). The individual compounds were quantified using a heated purge and trap followed by gas chromatography and mass spectrometry (Rose and Sandstrom, 2003). Laboratory reporting limits for BTEX and other VOC compounds analyzed are shown in table 2.

Semipermeable Membrane Devices (SPMDs)

Compounds were recovered from the SPMDs by dialysis and gel-permeation chromatography, extracted into hexane, and sealed in glass ampoules. These samples were sent to the USGS NWQL for analysis. The hexane extracts were analyzed for PAHs using gas chromatography and mass spectrometry (Furlong and others, 1996). Individual PAH compounds that were analyzed in SPMD extracts and their laboratory reporting limits are shown in table 3.

Table 2. Laboratory reporting limits for BTEX and other volatile organic compounds analyzed for in water samples from Lakes Mead and Mohave, Nevada, 1999–2006.

[**Abbreviations**: µg/L, microgram per liter]

Compound	Reporting limit (µg/L)
Benzene	0.01
Toluene	0.01
Ethylbenzene	0.03
m-, p-xylene	0.07
o-xylene	0.01–0.04
Diisopropyl ether	0.04–0.08
Ethyl *tert*-butyl ether	0.04–0.1
Methyl *tert*-butyl ether	0.05
Methyl *tert*-pentyl ether	0.05
Methyl acetate	0.4–2
tert-amyl alcohol	0.4–1
tert-butyl alcohol	1.0–2.0
Acetone	1.0

Samples collected from five sites (three from Lake Mead and two from Lake Mohave) were dialyzed with hexane, transferred to DMSO (dimethylsulfoxide) and were shipped under ice to the Microbiology Laboratory at the Columbia Environmental Research Center (CERC) for analyses. All samples were handled under subdued lighting pursuant to CERC Standards. A hand-held Picofluor® dual channel fluorometer (Turner Designs, Sunnyvale, CA) monitored SPMD extracts for bioavailable PAHs. PAHs with three or more rings are known to fluoresce. The environmental contaminant pyrene was used as the standard to estimate the concentrations of fluorescent PAHs in unknown samples. A pyrene index was developed to estimate the presence and concentrations of PAHs detected in each SPMD dialysate. The fluorescence of individual PAHs varies widely, so this method serves as an approximation of the relative concentrations and presence or absence of PAHs in the sample. The index used the linear range where the concentration range in the readout of the Picofluor® is directly proportional to the concentration range for the fluorophore. Samples were recorded as µg PAH per SPMD dialysate.

The DMSO extracts also were used to determine relative toxicity of the PAHs in the samples. Microtox bioassays were conducted according to the standard protocol for the basic test described in the Microtox Manual, Volume III (Microbics, 1992) to determine the acute toxicity of compounds detected in water from the sites. Validation of the Microtox Toxicity Assay in single and complex mixtures of pesticides, polychlorinated biphenyls (PCBs), petroleum products, and PAH has been previously reported by Johnson and Long (1998) and Kaiser and Palabrica (1991). Suspensions of a selected strain of luminescent bacteria *(Vibrio fischeri*, Azur Environmental, Inc. Carlsbad, CA) were exposed to each test substance in a standard four-tube plus controls 1:2 dilution series. Samples were incubated at 17^{o}C in a temperature-controlled incubator; light emissions were measured after 5 minutes with a luminometer (Azur Analyzer 500). Phenol and DMSO were the assay's standard positive and negative controls, respectively; carrier solvent (DMSO) did not exceed 5 percent of the sample volume. The standard dose-response curve method was used to determine the concentration that caused a 50-percent loss of light production in the bacteria. To calculate the effective concentration (EC50) values of the test samples, supporting computer software used a standard log-linear model and expressed the mean value of three replicates with confidence intervals (mg SPMD per mL carrier solvent).

Table 3. Organic compounds analyzed for in SPMD (semipermeable membrane device) extracts and associated laboratory reporting limits.

[**Abbreviations**: µg/kg, microgram per kilogram; NA, compound not analyzed for in 2006 samples]

Compound	Laboratory reporting limit (µg/kg)	
	2004	2006
Polycyclic aromatic hydrocarbon compounds		
2-chloronaphthalene	250	95
2-ethylnaphthalene	250	95
2,6-dimethylnaphthalene	250	95
1,6-dimethylnapthalene	250	95
Naphthalene	250	95
Acenaphthylene	250	95
1,2-dimethylnaphthalene	250	95
Acenaphthene	250	95
2,3,6-trimethylnaphthalene	250	95
9H-Fluorene	250	95
1-methyl-9H-fluorene	250	95
Phenanthrene	250	95
Anthracene	250	95
Acridine	250	95
Phenanthridine	250	95
2-methylanthracene	250	95
4,5-methylenephenanthrene	250	95
1-methylphenanthrene	250	95
Fluoranthene	250	95
Pyrene	250	95
1-methylpyrene	250	95
Benz(a)Anthracene	250	95
Chrysene	250	95
Benzo(b)fluoranthene	250	95
Benzo(k)fluoranthene	250	95
Benzo(a)pyrene	250	95
Indeno(1,2,3-c,d)pyrene	250	95
Dibenzo(a,h)anthracene	250	95
Benzo(g,h,i)perylene	250	95
Phthalate compounds		
dimethylPhthalate	250	95
diethylphthalate	250	95
di-n-butylphthalate	250	95
butlybenzylphthalate	250	95
bis(2-ethylhexyl)phthalate	250	95
di-n-octylphthalate	250	95

Compound	Laboratory reporting limit (µg/kg)	
	2004	2006
Other organic compounds		
Phenol	250	95
bis(-2-Chloroethyl) Ether	250	95
2-Chlorophenol	250	95
1,3-Dichlorobenzene	250	95
1,4-Dichlorobenzene	250	95
1,2-Dichlorobenzene	250	95
bis(2-Chloroisopropyl)Ether	250	95
N-nitros-Di-n-propylamine	250	95
Hexachloroethane	250	NA
p-cresol	250	95
Nitrobenzene	250	95
Isophorone	250	95
c8-alkyl-Phenol	250	95
bis(-2-Chloroethoxy) Methane	250	95
3,5-dimethylphenol	250	95
2,4-dichlorophenol	250	95
1,2,4-trichlorobenzene	250	95
2,4,6-trimethylphenol	250	NA
Hexachlorobutadiene	250	NA
Quinoline	250	95
Isoquinoline	250	95
4-chloro-3-methylphenol	250	95
Hexachlorocyclopentadiene	250	NA
2,4,6-trichlorophenol	250	NA
2,6-dinitrotoluene	250	95
2,4-dinitrophenol	250	NA
4-nitrophenol	250	NA
2,4-dinitrotoluene	250	95
4-chlorophenyl-phenylether	250	95
4,6-dinitro-2-methylphenol	250	NA
N-nitrosodiphenylamine	250	95
Azo-benzene	250	95
4-bromophenyl-phenylether	250	95
Hexachlorobenzene	250	95
Pentachloroanisol	250	95
Dibenzothiophene	250	95
Pentachlorophenol	250	95
Pentachloronitrobenzene	250	95
9H-carbazol	250	95
benzo-C-quinoline	250	95
anthraquinone	250	95
2,2’-biquinoline	250	95
2-Nitrophenol	250	NA

Samples were designated “toxic” when their EC50 values were significantly less than the EC50 value of the trip blank (TB). The lower the EC50 value the higher the acute toxicity. A toxicity index (TI) was calculated by dividing the mean phenol control EC50 value by the exposed SPMDs EC50 value (TI = TB/unknown sample).

Bottom Sediment

The PAH compounds were extracted from the sediment samples by solvent extraction followed by partial separation using gel-permeation chromatography. The compounds were identified and quantified using capillary-column gas chromatography and mass spectrometry (Olson and others, 2004). The individual PAH compounds analyzed for in sediment samples and their laboratory reporting limits are shown in table 4.

Quality Assurance

Several measures were taken to ensure the procedures used for sample collection, processing, transport, and analysis did not affect the concentrations of compounds of interest in the samples. Types of quality assurance used during this study included using materials, samplers, and methods known to be appropriate for analytes of interest, collecting blanks and replicate samples in the field, and a high level of laboratory quality assurance (Pirkey and Glodt, 1998; Maloney, 2005).

Table 4. Laboratory reporting limits for PAH (polycyclic aromatic hydrocarbon) compounds in sediment samples.

[**Abbreviations**: µg/kg, micrograms per kilogram]

PAH compound	Laboratory reporting limit (µg/kg)
anthracene	11–50
benzo(a)pyrene	11–100
fluoranthene	11–100
naphthalene	11–26
phenanthrene	11–50
pyrene	11–100
1-methyl naphthalene	25
2-methyl naphthalene	25
2,6-dimethylnaphthalene	16–42

For VOC samples, field blanks were collected during each major sampling trip and consisted of pouring nitrogen-purged VOC-free water into the VOC sampler containing four VOC vials, letting the water contact the sampler for 5 minutes, then processing the samples as if they were environmental samples. Reproducibility of sample collection, processing, and analysis was assured by collecting one replicate sample during each sampling trip. These replicate samples were collected sequentially, that is, they were collected one after the other. The results of the blank and replicate samples show that contamination was not introduced by the materials and methods used for sample collection and the methods provided a reproducible sample. The results of the field blanks and replicate samples are listed in tables 5 and 11 (at back of report), respectively.

For SPMD samples, field, dialysis, and laboratory blanks were collected and processed for each deployment (2004 and 2006). Field blanks were collected at each site during 2004 and at two sites during 2006 (one site for each lake). A field blank consisted of exposing an SPMD to the atmosphere during the time the SPMDs that were placed into the water were exposed to the atmosphere (typically 1 to 2 minutes). This was done during deployment and retrieval of the SPMDs. The exposed SPMDs were sealed in tin cans and accompanied the environmental samples to the laboratory. Dialysis blanks were a check on whether any contamination was introduced during the extraction procedure of the SPMDs, and laboratory blanks assured the sample processing and analysis at the laboratory did not introduce contaminants to the sample. Duplicate SPMD samples were collected at two sites during the 2004 collection by placing them in separate stainless-steel containers attached side-by-side to the buoy chains. Unexposed SPMDs spiked with PAH compounds in the laboratory (laboratory spikes) were analyzed to determine the recoverability of PAH compounds during the extraction and analysis of the SPMD samples. The results of the blank and duplicate samples are shown in table 6 and show that minor contamination was present in field blanks during the 2006 collection period. The compounds detected in both field blanks were alkyl naphthalenes, naphthalene, and phenanthrene; pyrene and fluoranthene also were detected in one field blank. The concentrations, however, were far less than those reported for the environmental samples. The dialysis blank had detectable concentrations of the same compounds as the field blanks at concentrations near those detected in the field blanks, thus, the dialysis process likely did not contaminate samples. PAH compounds were not detected in field blanks collected in 2004, however, the laboratory reporting limits

Table 5. Concentrations of BTEX, oxygenate, and degradation products in field blank water samples, Lakes Mead and Mohave, Nevada, 2004–06.

[Concentrations are expressed in micrograms per liter, unless indicated otherwise. **Abbreviations**: <, less than; E, estimated concentration; M, result deleted due to highly variable analytical results]

Compound — Sample type:	Field blank					
Date:	06-23-2004	03-23-2006	05-31-2006	07-07-2006	08-21-2006	09-05-2006
Time:	1030	0715	1305	0805	1115	0700
Benzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethylbenzene	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
m-, p-Xylene	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
o-Xylene	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Toluene	<0.01	<0.01	<0.01	E0.01	<0.01	<0.01
Diisopropyl ether	<0.08	<0.04	<0.06	<0.06	<0.06	<0.06
Ethyl *tert*-butyl ether	<0.1	<0.04	<0.1	<0.1	<0.1	<0.1
Methyl *tert*-butyl ether	<0.08	<0.04	<0.05	<0.05	<0.05	<0.05
Methyl *tert*-pentyl ether	<0.07	<0.03	<0.05	<0.05	<0.05	<0.05
Methyl acetate	<0.4	<1	<1	<1	<1	<1
tert-amyl alcohol	<0.4	<1	<1	<1	<1	<1
tert-butyl alcohol	<1	<2	<2	<2	<2	<2
Acetone	<1	<1	M	<1	<1	<1
Isobutyl alcohol-d6 surrogate percent recovery[1]	95.5	88.1	129	109	104	96
1,2-Dichloroethane-d4 surrogate percent recovery[1]	98.6	101	109	112	113	104
1-Bromo-4-fluoro benzene surrogate percent recovery[1]	97.9	96.7	81.4	83.8	98.5	99.1
Toluene-d8 surrogate percent recovery[1]	99.3	100	100	105	115	99.4

[1] Values represent amount of surrogate compound recovered from sample by analytical procedure. These compounds are added to the samples and are not present in the environment.

were much higher (250 µg/kg) as compared to those in 2006 (95 µg/kg). Laboratory blanks were consistently without detections and laboratory spikes had recoveries that generally were between 70 and 90 percent (table 6).

Lake-bottom sediment was quality assured using a laboratory blank, spike recovery, and several duplicate samples (table 7). The estimated concentration of naphtathalene in the laboratory blank was 4.81 µg/kg, which was subtracted from the concentrations detected in the environmental samples. Laboratory spike recoveries ranged from 43 to 108 percent. The same compounds generally were detected in duplicate samples but the concentrations were sometimes different by a factor of two.

Overall, the results of the quality assurance indicate that the collection, processing, and analysis of samples collected during this study produced samples that were free of gross contamination and representative of the water or sediment sampled. Contamination was minor and always far less than the concentrations detected in environmental samples. The reproducibility of VOC samples was very good and that of the SPMD and sediment samples was slightly more variable, but reasonably good.

Table 6. Quality-assurance data associated with collection and analysis of SPMDs (semipermeable membrane devices) for PAHs (polycyclic aromatic hydrocarbons), Lakes Mead and Mohave, Nevada, 2004 and 2006.

[Concentrations are expressed in micrograms per kilogram unless indicated otherwise. Site numbers are shown in figure 1. **Abbreviations**: <, less than; NA, not applicable]

Compound	Sample type:	Lab blank		Lab spike (percent recovered)		Field blank							Dialysis blank
	Date:	2004	2006	2004	2006	05-25-2004	06-16-2006	05-25-2004	05-24-2004	06-13-2006	05-24-2004	05-25-2004	06-13-2006
	Site number:					1	1	2	8	10	13	14	
Naphthalene		<50	<50	85.10	60.83	<250	18.2	<250	<250	11.7	<250	<250	26.9
2-ethylnaphthalene		<50	<50	86.35	73.44	<250	11	<250	<250	8.55	<250	<250	11.6
2,6-dimethylnaphthalene		<50	<50	86.87	75.14	<250	17.8	<250	<250	11.5	<250	<250	18.7
1,6-dimethylnapthalene		<50	<50	86.59	74.62	<250	14.1	<250	<250	10.9	<250	<250	14.2
Acenaphthylene		<50	<50	85.67	70.83	<250	<95	<250	<250	<95	<250	<250	<95
1,2-dimethylnaphthalene		<50	<50	87.38	74.14	<250	8.16	<250	<250	7.11	<250	<250	8.25
Acenaphthene		<50	<50	85.12	72.11	<250	5.23	<250	<250	4.63	<250	<250	5.03
2,3,6-trimethylnaphthalene		<50	<50	87.43	80.58	<250	11.2	<250	<250	9.49	<250	<250	11
9H-Fluorene		<50	<50	85.61	75.91	<250	<95	<250	<250	<95	<250	<250	<95
1-methyl-9H-fluorene		<50	<50	88.84	85.09	<250	<95	<250	<250	<95	<250	<250	<95
Phenanthrene		<50	<50	82.63	78.12	<250	14.7	<250	<250	9.88	<250	<250	14.3
Anthracene		<50	<50	82.55	79.10	<250	<95	<250	<250	<95	<250	<250	<95
2-methylanthracene		<50	<50	83.19	83.62	<250	<95	<250	<250	<95	<250	<250	<95
4,5-methylenephenanthrene		<50	<50	82.84	84.79	<250	<95	<250	<250	<95	<250	<250	<95
1-methylphenanthrene		<50	<50	83.74	83.93	<250	<95	<250	<250	<95	<250	<250	<95
Fluoranthene		<50	<50	82.92	77.62	<250	8.41	<250	<250	<95	<250	<250	8.66
Pyrene		<50	<50	83.01	78.23	<250	7.15	<250	<250	<95	<250	<250	7.13
1-methylpyrene		<50	<50	83.91	84.76	<250	<95	<250	<250	<95	<250	<250	<95
Benz(a)Anthracene		<50	<50	85.05	72.19	<250	<95	<250	<250	<95	<250	<250	<95
Chrysene		<50	<50	86.69	71.73	<250	<95	<250	<250	<95	<250	<250	<95
Benzo(b)fluoranthene		<50	<50	88.18	76.56	<250	<95	<250	<250	<95	<250	<250	<95
Benzo(k)fluoranthene		<50	<50	85.91	75.70	<250	<95	<250	<250	<95	<250	<250	<95
Benzo(a)pyrene		<50	<50	86.12	76.42	<250	<95	<250	<250	<95	<250	<250	<95
Indeno(1,2,3-c,d)pyrene		<50	<50	83.74	83.00	<250	<95	<250	<250	<95	<250	<250	<95
Benzo(g,h,i)perylene		<50	<50	84.35	78.58	<250	<95	<250	<250	<95	<250	<250	<95
SUM OF PAH		<50	<50	NA	NA	<250	115.95	<250	<250	73.76	<250	<250	125.77

Table 7. Concentrations of PAH (polycyclic aromatic hydrocarbon) compounds detected in lake- and stream-bottom sediment samples, Lakes Mead and Mohave, Nevada, 2004–06.

[Concentrations are expressed in micrograms per kilogram. Site numbers are shown in figure 1. **Abbreviations**: %, percent; <, less than; E, estimated concentration; NA, not analyzed]

Compound Date:	Lab spike % rec.	Lab blank	11-02-2006	11-02-2006	11-02-2006	03-30-2006	03-29-2006	03-29-2006	03-30-2006	04-05-2006	03-29-2006	03-02-2006	04-04-2006	03-29-2006	03-29-2006
Time:			0925	0950	1040	1500	1024	1115	1200	0950	1115	1120	0840	1450	1500
Site number:			1	2	4	10	13	13	18	19	20	20	21	22	22
benzo(a)pyrene	43	<100	<17	<11	<26	<100	<100	<100	<100	<100	181	366	<100	<100	<100
fluoranthene	101	<100	E6.9	<11	<26	<100	<100	<100	<100	<100	125	287	116	<100	<100
naphthalene[1]	65	E4.81	<13	<11	<26	E0.13	E0.7	E0.32	<25	E0.43	E2.52	E1.15	E0.25	<25	E0.09
phenanthrene	84.4	<50	E1.3	<11	<26	<50	<50	<50	<50	<50	E43	E35.7	32.5	<50	<50
pyrene	97	<100	E7.1	<11	<26	<100	<100	<100	<100	<100	107	256	103	<100	<100
2-methyl naphthalene	74.2	<25	NA	NA	NA	<25	<25	<25	<25	<25	E17.4	<25	<25	<25	<25
2,6-dimethylnaphthalene	83.4	<25	81.8	21.5	134.0	34.5	<25	40	30.5	30.7	37.7	35.4	36.5	34.9	32.5
1,6-dimethylnaphthalene	NA	NA	<13	<11	E21.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Perylene	NA	NA	<13	E5.9	<26	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SUM OF PAH	NA	4.81	97.1	27.4	155.2	34.63	0.7	40.32	30.5	31.13	513.62	981.25	288.25	34.9	32.59
Surrogate Recovery															
naphthalene-d8[2]	69.1	31.3	69.73	58.04	70.20	46.4	43.5	45.7	46.3	52.1	47.2	44.1	37.2	41.2	33.5
Acenaphthalene-d10[2]	79.2	67.3	68.60	70.21	82.80	62.0	47.9	44.1	55.5	62.3	59.0	56.8	43.8	56.2	42.5
Chrysene-d12[2]	108	112	84.57	89.89	89.17	93.76	90.9	93.2	91.4	83.7	100.6	95.37	82.2	93.7	77.34

[1] Concentrations reported for environmental samples are corrected for contamination by subtracting blank concentration from environmental sample concentrations.

[2] Values represent amount of surrogate compound recovered from sample by analytical procedure. These compounds are added to the samples and are not present in the environment.

Gasoline-Related Compounds

The results of this study indicate that the use of motorized watercraft on Lakes Mead and Mohave has added organic compounds to the waters of those lakes. During operation and fueling of watercraft, organic compounds, such as BTEX, oxygenates, and PAHs, can be introduced to the water through direct spills into the water and unburned fuel and PAHs exhausted through the engine. The engine type plays an important role in the amount of raw fuel and PAHs that are emitted through the exhaust. Marine engines do not have the emission controls found on most automobiles and thus emit large amounts of hydrocarbons compared to an automobile. Certain marine engines (carbureted two-stroke) are especially dirty and can release as much as 30 percent of their fuel unburned out the exhaust (California Environmental Protection Agency, Air Resources Board, 1999). The manufacturers of marine engines have advanced the technology of how fuel is injected into the two-stroke engines to reduce emissions. These cleaner-burning engines are gradually replacing the older carbureted two-stroke engines and the hydrocarbon load to waters should be decreased concurrently.

BTEX Compounds (Benzene, Toluene, Ethylbenzene, and Xylene Isomers)

Virtually all boats operated on Lakes Mead and Mohave use gasoline increasing the potential for the volatile components of gasoline (BTEX and other additives, such as oxygenates) to enter the water. BTEX compounds were detected at all sample locations in the lakes (fig. 3). Oxygenates (MTBE, ETBE, TAME, and DIPE) and their degradation products (methyl acetate, *tert*-amyl alcohol, and *tert*-butyl alcohol) were either not detected or detected at low concentrations throughout the study area (table 11). Acetone, a degradation product of oxygenates, commonly was detected at all sites.

Median BTEX concentrations in the lakes range from 0.17 µg/L at Bonelli Bay in Lake Mead to 7.52 µg/L at Katherine Landing in Lake Mohave (fig. 3). Of the BTEX compounds, toluene generally was the highest concentration at most sites with the xylene isomers being the second highest (table 11). The highest single concentration of BTEX (23.5 µg/L) sampled was at Katherine Landing on June 24, 2004. Another extremely high BTEX concentration of 22.4 µg/L was documented on June 24, 2004 at North Telephone Cove. Both of these sites are at the southern end of Lake Mohave and are very busy during the boating season. Examination of figure 3 reveals that all of the highest BTEX concentrations were detected at locations where there are launching facilities and marinas. These sites include Katherine Landing and Cottonwood Cove in Lake Mohave and Hemenway Harbor, Temple Bar, Callville Bay, and Echo Bay in Lake Mead. Interestingly, a marina is located on the Colorado River at Willow Beach and the BTEX concentrations were low (median = 0.16 µg/L; fig. 3), probably because the flow in the river moves most gasoline compounds downstream. The other anomaly seen in figure 3 is the high median BTEX concentration measured at North Telephone Cove (second highest median concentration of all sites; 5.6 µg/L), which is not a developed marina, but is a major launching area for personal watercraft.

Several mechanisms exist that can release gasoline components into the lakes at or near launching facilities. All marinas have fueling facilities where the potential for gasoline spillage into the lakes can occur. Fuel can be introduced to the lakes by overfilling boat fuel tanks by careless pump operators, leaking hoses, nozzles, or storage tanks, and pumpage from bilges. At North Telephone Cove, personal watercraft users sometimes refuel their machines right at the shoreline, which could lead to fuel spillage into the lake. Gross contamination that would be associated with a leaking fuel tank was not observed during this study.

Distributions of concentrations of volatile gasoline-related compounds were different in the sites sampled during this study. BTEX concentrations, in general, were much higher in Lake Mohave than in Lake Mead (fig. 4). Median concentrations of BTEX compounds in Lakes Mohave and Mead were 2.2 and 0.7 µg/L, respectively. Concentrations were highest in samples from Lake Mohave and the maximum value was 23.5 µg/L. BTEX concentrations were relatively low in samples collected from the Colorado River at Willow Beach with a median value of 0.2 µg/L (fig. 4). Median BTEX concentration in water samples collected from Las Vegas Wash was 0.05 µg/L.

The concentrations of BTEX compounds detected in water samples collected from Lakes Mead and Mohave show a common variation with time of year. Concentrations are low or less than the detection limit during the non-boating season as seen in the samples collected during March 2006 (table 11). As the boating season progresses during the summer months, concentrations of BTEX increase and reach a maximum value in mid-summer then decrease as the boating season draws to an end. This typical temporal trend in BTEX concentrations can be seen clearly in figure 5 for data collected from North Telephone Cove in Lake Mohave.

Oxygenates, like MTBE, and their degradation products, with the exception of acetone, have not been detected in the lakes since summer 2004 (table 11). Prior to 2005, MTBE was the only oxygenate detected in Lakes Mead and Mohave.

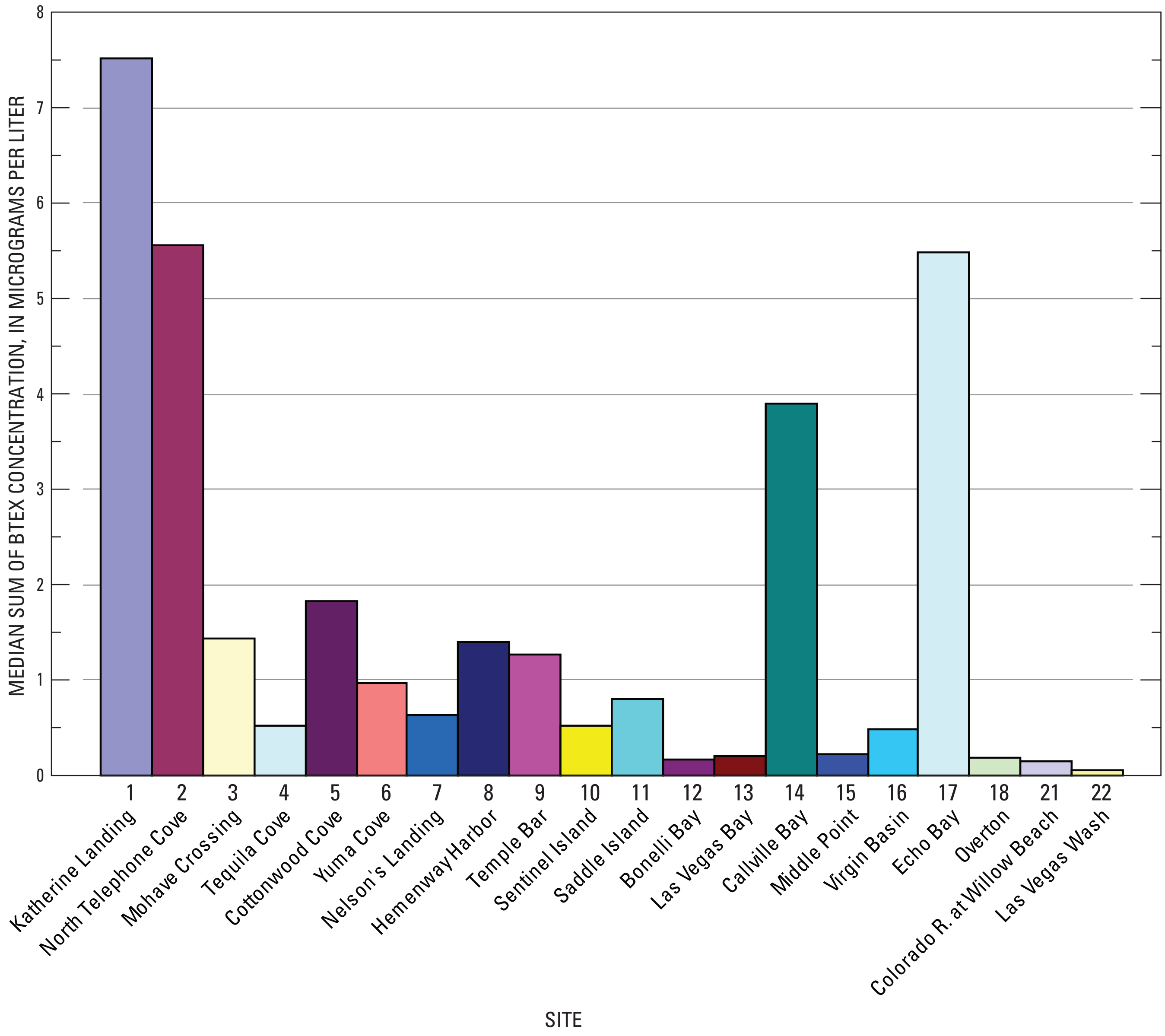


Figure 3. Median sum of BTEX concentrations for sites where water samples were collected from Lakes Mead and Mohave, Nevada, 2004–06.

A likely explanation for the disappearance of MTBE is a change in the formulation of gasoline in California, which removed MTBE as an oxygen source at the end of 2004. Acetone has been routinely detected at all sampling sites, except for the Colorado River at Willow Beach. Acetone has been documented as a product of MTBE degradation in the environment (National Science and Technology Council, 1997). Apparently, acetone does not persist through the winter non-boating season as evidenced by the lack of detectable concentrations during the March 2006 sampling (table 11). The source of acetone is in Lakes Mead and Mohave is unknown. After 2004, MTBE was not present in gasoline sources and thus could no longer produce acetone by degradation processes. One possible source of acetone is Las Vegas Wash (median concentration of 2 µg/L) but that does not explain the detection of acetone farther upstream in Lake Mead at sites like Bonelli Bay (site 12, fig. 1).

Several lines of evidence indicate that boats are the major source of BTEX compounds detected in Lakes Mead and Mohave. Concentrations of BTEX are greater in areas where the number of boats is greater, such as Katherine Landing, North Telephone Cove, Callville Bay, and Echo Bay. Three

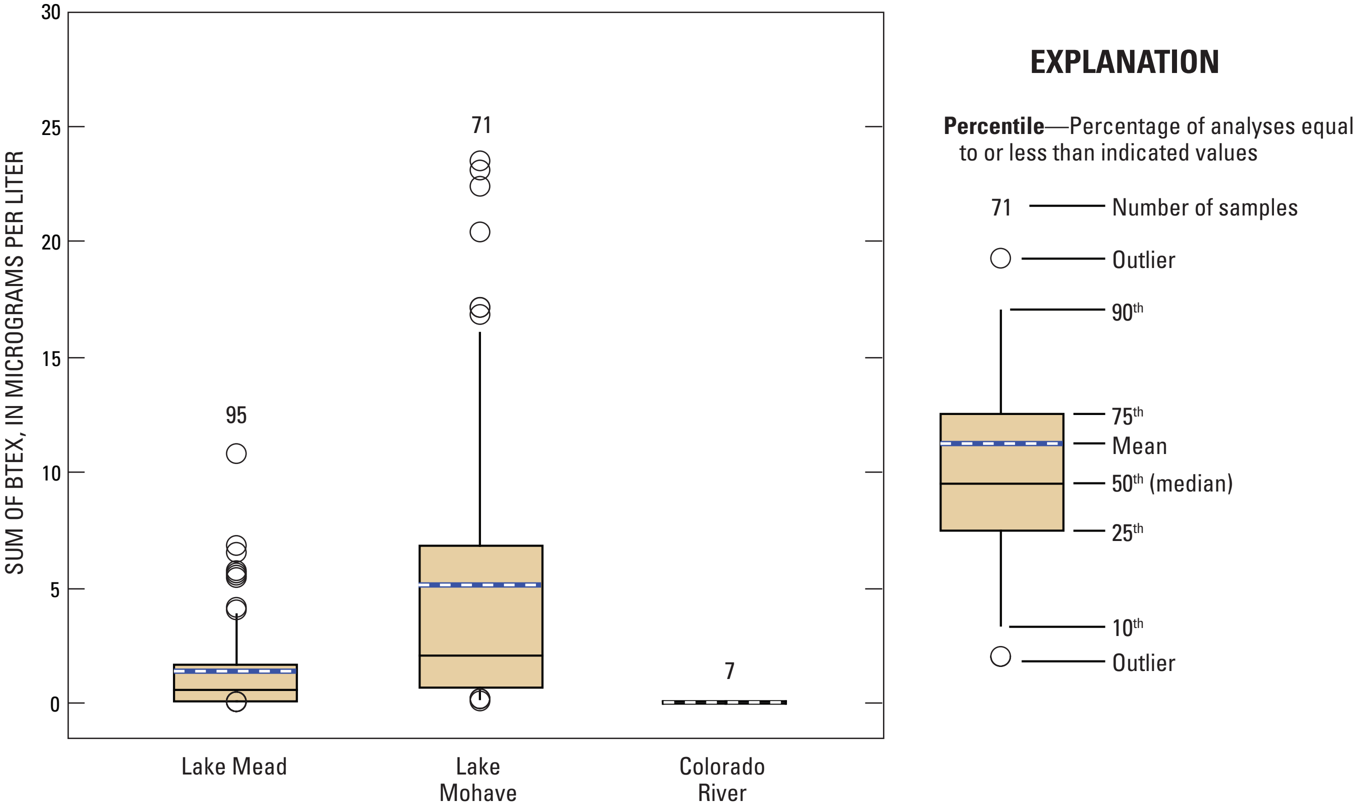


Figure 4. Distribution of BTEX concentrations for samples collected from Lakes Mead and Mohave and Colorado River at Willow Beach, Nevada, 2004–06.

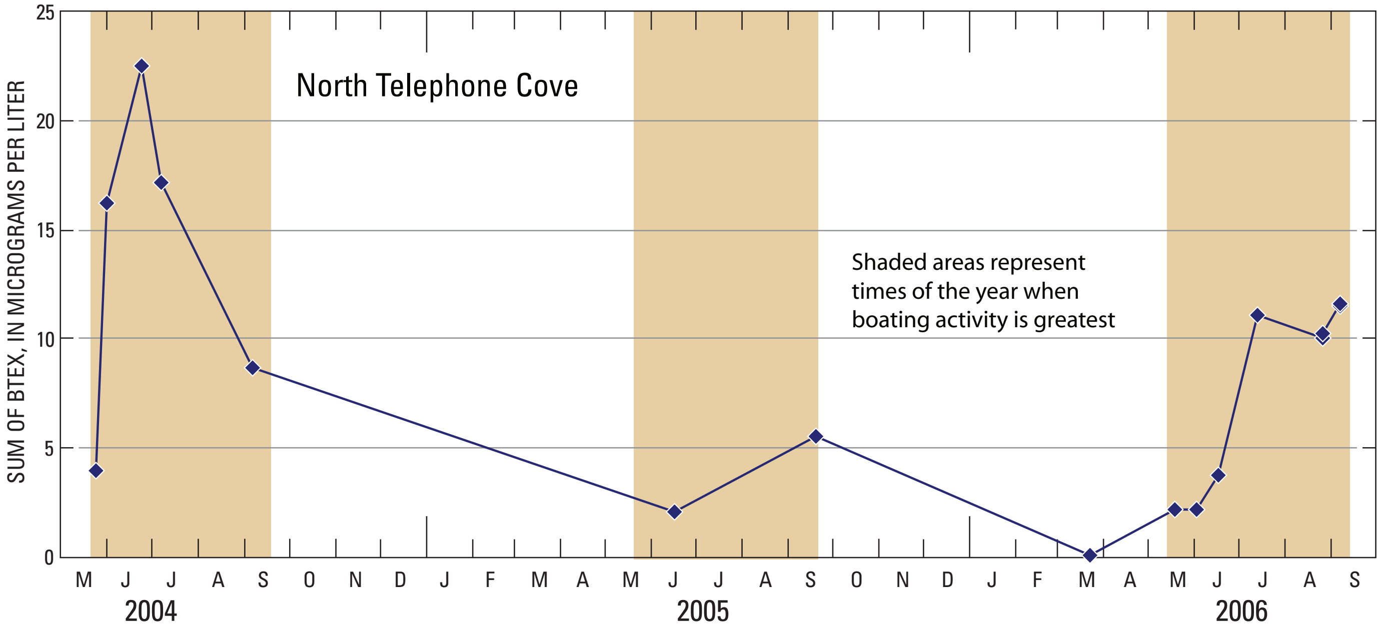


Figure 5. Concentrations of BTEX and time at Telephone Cove sampling site, Lake Mohave, Nevada, 2004–06.

of these sites have marinas with boat docking, launching, and fueling facilities (Katherine Landing, Callville Bay, and Echo Bay). The other site, North Telephone Cove, is a popular drive-to launching area for personal watercraft. In areas where few boats travel, such as Tequila Cove, Nelson's Landing, Bonelli Bay, and the Virgin Basin, the BTEX concentrations were much less than in the popular areas mentioned above. Concentrations of BTEX compounds were very low after the boats are put away for the winter as seen in the results of the March 2006 sampling (table 11). Volatilization and microbial degradation most likely are the primary removal mechanisms for BTEX compounds from the lakes (Rathbun, 1998). Inputs from tributary streams to Lakes Mead and Mohave do not appear to contribute large amounts of BTEX to the lakes. BTEX concentrations were very low in Las Vegas Wash (contains urban runoff and seepage from the Las Vegas area and treated sewage effluent), the Colorado River at Willow Beach (reflects input from the Colorado River to Lake Mohave), near Overton (reflects inputs from the Muddy and Virgin Rivers), and Middle Point (near the confluence of the Virgin and Colorado River and indicative of concentrations in those two sources). The concentrations of BTEX near marinas that have fueling facilities indicates no grossly contaminated (milligram per liter concentrations) areas around fueling docks from leaking tanks or pipes. Finally, MTBE concentrations decrease to less than detection levels when MTBE was removed from gasoline although BTEX concentrations did not change much.

PAH Compounds (Polycyclic Aromatic Hydrocarbons)

Several potential sources of PAH exist within the study area and include motorized watercraft, direct spills of gasoline into the lakes by leaking tanks and lines or spillage into the lakes during fueling, urban runoff from the greater Las Vegas metropolitan area and other smaller towns near the lakes, atmospheric deposition or runoff from combustion of natural vegetation in wildfires or gasoline and oil in automobiles, and industrial sources (Bertilsson and Widenfalk, 2002). PAH compounds were determined in the aqueous phase by deploying SPMDs in the lakes and in Las Vegas Wash. The PAH concentrations presented in this report are expressed as micrograms per kilogram of compound in the lipid within the SPMDs.

PAHs were detected in all SPMDs deployed on Lakes Mead and Mohave and in Las Vegas Wash (table 8). The amounts of PAHs, both concentration and number of compounds, were not the same at all sampling sites (fig. 6 and table 8). PAH concentrations in samples from two sites in Lake Mohave were much higher than sites sampled in Lake Mead and Las Vegas Wash. Concentrations of PAH were highest (about 6,400 µg/kg) in a sample from Katherine Landing in Lake Mohave, where more than 20 compounds were greater than detectable levels (table 8). PAH concentrations were lower in a duplicate sample from the same site (about 40 percent), but had the same compounds in the same relative concentrations. The highest concentration detected in Lake Mead was at Callville Bay where 930 µg/kg of PAH (15 compounds) was present in the SPMD extracts. The amounts of PAH detected in Las Vegas Wash and Las Vegas Bay were quite low (average concentrations about 100 µg/kg) compared to most other sites sampled in this study.

The most commonly detected PAH compounds were fluoranthene and pyrene, which were detected in all SPMD extracts and are indicative of emissions from internal combustion engines. Naphthalenes also were commonly detected and were quantified in all SPMD extracts from the lakes, except for the 2004 sample collected at Las Vegas Bay. Naphthalenes were not detected in a sample collected from Las Vegas Wash. Most of the PAH compounds generated in Lakes Mead and Mohave probably have a very short existence in the water column. A study of the photochemical degradation of PAH in freshwaters indicated that the half lives of anthracene, phenanthrene, and naphthalene were 1, 20.4, and greater than 100 hours, respectively, in surface waters (Bertilsson and Widenfalk, 2002). During the boating season, a daily load of PAHs enters the lakes from boating activity but these compounds generally do not reach large concentrations due to their short half lives. PAH compounds are not expected to persist throughout the winter (non-boating season) because the major source of these compounds is not present.

PAH concentrations in samples collected during 2004 from Lake Mohave were much higher than those collected during 2006 (fig. 6). The two sites on Lake Mohave where this occurred are very popular with users of personal watercraft. The reason for the decrease in PAH concentrations between 2004 and 2006 may be due to cleaner-technology (four-stroke) engines being used as carbureted two-stroke engines are retired from service.

Las Vegas Wash drains the urban area of Las Vegas and also contains treated effluent from sewage-treatment plants in the Las Vegas Valley. PAH concentrations were low in SPMD extracts at the sampling site downstream of Lake Las Vegas (fig. 6). Water flowing from the treatment plants serving the Las Vegas area apparently is not the principle source of PAH.

Table 8. Concentrations of PAH (polycyclic aromatic hydrocarbon) compounds in SPMD (semipermeable membrane device) extracts, Lakes Mead and Mohave, Nevada, 2004 and 2006.

[Concentrations are expressed in micrograms per kilogram of lipid in SPMD. Site numbers are shown in figure 1. **Abbreviations**: <, less than; E, estimated value; deg C, degrees Celsius]

Compound Date:	05-25-2004	05-25-2004	06-16-2006	05-25-2004	06-16-2006	05-24-2004	05-24-2004	06-13-2006	05-24-2004	06-13-2006	05-24-2004	06-14-2006	06-14-2006	05-26-2004
Time:	1232	1233	0845	1332	1000	1222	1223	0929	1342	0820	1112	1110	0900	1155
Site number:	1	1	1	2	2	8	8	10	13	13	14	16	18	22
Naphthalene	<250	<250	6.40	<250	14.1	<250	<250	26.7	<250	14.1	<250	29.2	7	<250
2-ethylnaphthalene	E63.8	E205	12.50	E127	26.7	E26.4	E27.5	8.95	<250	4.15	E22.6	8.45	3.55	<250
2,6-dimethylnaphthalene	E196	600	31.80	400	65.8	E44.1	E52.2	19.7	<250	11.3	E39.1	22.2	8.5	<250
1,6-dimethylnapthalene	E110	338	15.20	E217	33.1	E31.8	E37.6	10.7	<250	5.2	E24.5	10.7	4.5	<250
Acenaphthylene	E33.6	E90.9	11.40	E49.6	14.8	<250	<250	<95	<250	<95	<250	9.2	<95	<250
1,2-dimethylnaphthalene	E34.4	E106	6.04	E69.2	11.94	<250	<250	3.49	<250	1.73	<250	3.29	1.39	<250
Acenaphthene	<250	<250	0.56	<250	2.09	<250	<250	1.7	<250	0.61	<250	1.28	0.4	<250
2,3,6-trimethylnaphthalene	E147	407	22.40	E214	32.9	E40.0	E35.4	8.51	<250	4.11	E43.7	6.51	3.41	<250
9H-Fluorene	E54.4	E142	14.30	E80.3	20.9	<250	<250	10.3	<250	7.82	<250	9.64	7.85	<250
1-methyl-9H-fluorene	E79.5	E209	18.00	E97.0	23	<250	<250	11.7	<250	10.1	<250	9.58	9.14	<250
Phenanthrene	E235	588	37.90	314	66.5	E50.7	E52.1	17.12	<250	7.92	E51.1	15.72	9.32	<250
Anthracene	<250	<250	11.50	<250	15.7	<250	<250	<95	<250	<95	<250	<95	<95	<250
2-methylanthracene	E34.4	E94.0	15.80	E47.4	20.2	E23.5	E26.1	<95	<250	<95	<250	<95	<95	<250
4,5-methylenephenanthrene	E121	319	32.30	E121	40.6	<250	<250	17.5	<250	13.1	E39.6	14.4	12.3	<250
1-methylphenanthrene	E111	285	24.70	E127	35.9	E23.6	E21.8	<95	<250	9.35	E36.5	<95	<95	<250
Fluoranthene	516	1400	93.59	509	120.59	E117	E116	47.8	E43.3	21.1	252	31.6	24.5	E39.8
Pyrene	E194	517	58.05	E240	75.65	E64.3	E69.4	15.3	E28.0	15.4	E136	14.5	13.2	E49.4
1-methylpyrene	<250	<250	<95	E23.5	<95	<250	<250	<95	<250	<95	<250	<95	<95	<250
Benz(a)anthracene	E64.0	E160	12.60	E71.8	17	E27.7	E29.6	<95	<250	<95	E35.4	<95	<95	<250
Chrysene	E127	338	26.20	E117	31.9	E40.2	E46.9	10	<250	<95	E77.4	9.66	<95	<250
Benzo(b)fluoranthene	E66.2	E144	17.80	E55.2	22.4	<250	<250	<95	<250	<95	E55.1	<95	<95	<250
Benzo(k)fluoranthene	E68.5	E192	9.94	E68.3	11.8	<250	<250	<95	<250	<95	E32.7	<95	<95	<250
Benzo(a)pyrene	E47.6	E122	<95	E49.3	9.9	<250	<250	<95	<250	<95	E42.4	<95	<95	<250
Indeno(1,2,3-c,d)pyrene	E78.8	<250	<95	E74.8	<95	<250	<250	<95	<250	<95	<250	<95	<95	<250
Benzo(g,h,i)perylene	E55.3	E136	8.47	E54.6	9.17	<250	<250	<95	<250	<95	E42.7	<95	<95	<250
SUM OF PAH	2437.5	6392.90	487.45	3127	722.64	489.30	514.6	209.47	71.3	125.99	930.8	195.93	105.06	89.2
Water Temperature (deg C)	23	23	20	23	19	23	23	23	26	24	24	23	24	27
Days Deployed	31	31	30	31	30	31	31	29	31	29	31	29	29	30
Number of Compounds	21	20	22	22	23	12	11	14	2	14	15	15	13	2

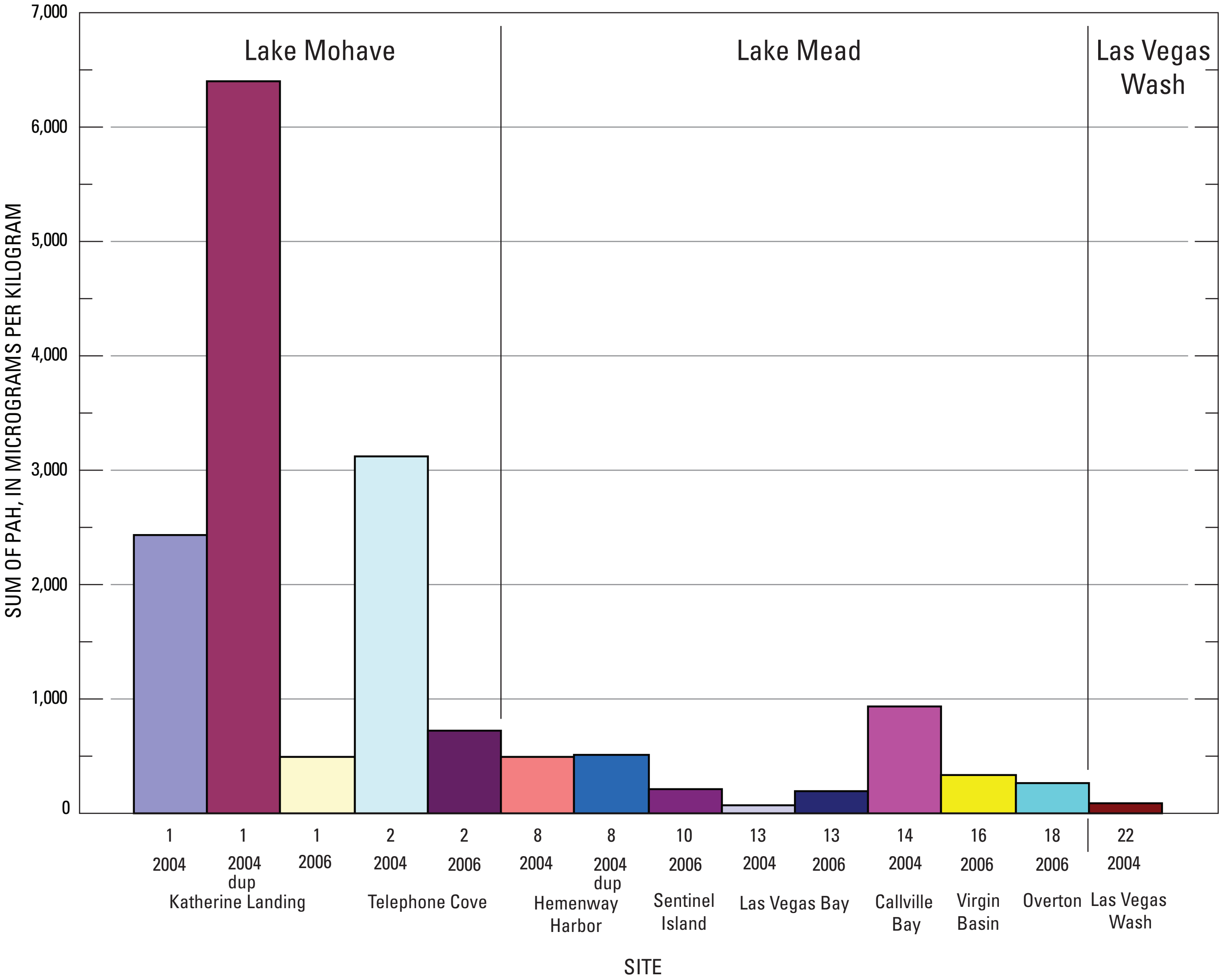


Figure 6. Sum of PAH (polycyclic aromatic hydrocarbon) concentrations for sites where SPMDs (semipermeable membrane devices) were emplaced in Lakes Mead and Mohave, Nevada, 2004–06.

PAH concentrations were low in most lake- and stream-bottom sediment samples and are not a likely sink or source of PAH to the water (fig. 7). Concentrations of PAH compounds were highest in Las Vegas Wash upstream of the input of treated sewage effluent (average of about 750 µg/kg) of all-sites that were sampled (table 8). The source of this water is urban runoff from the greater Las Vegas metropolitan area. The two samples collected from the Las Vegas Wash site had an abundance of the larger PAH compounds (benzo(a)pyrene, phenanthrene, pyrene, and fluoranthene), which are indicative of combustion sources, and far smaller amounts of the two-ringed PAHs (naphthalenes). Many potential sources exist for the compounds detected in the sediment samples and include runoff from asphalt areas, automobile exhaust, and other industrial sources. The smaller flow volumes upstream of the discharge of treated sewage effluent into Las Vegas Wash may allow more contact of the water containing PAHs with the sediment allowing the compounds to be sorbed more readily than occurs with higher flows downstream in the wash. The Colorado River at Willow Beach (site 21, fig. 1) had the second highest concentration of PAH compounds (about 290 µg/kg), also with a dominance of the larger compounds.

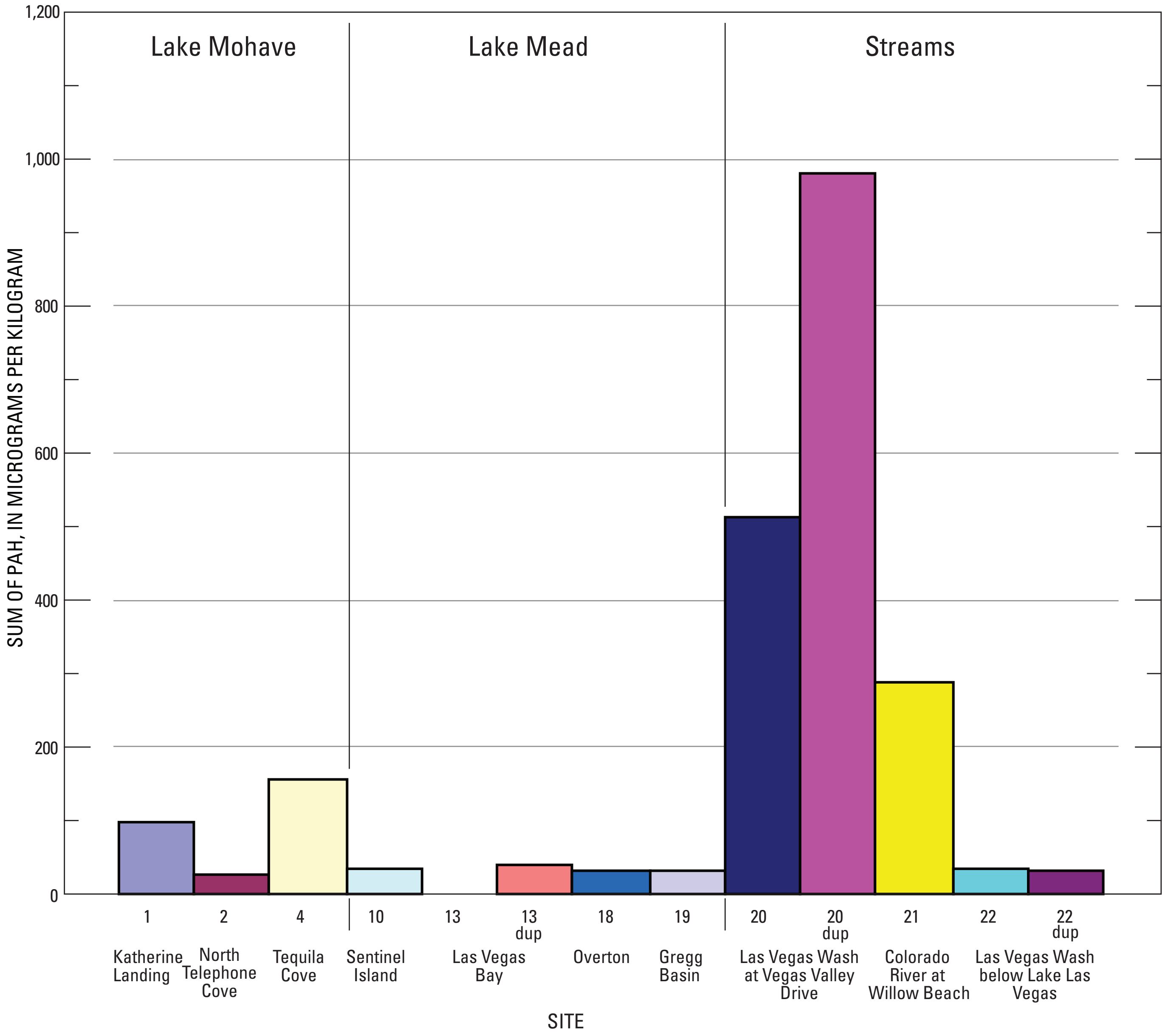


Figure 7. Sum of PAH (polycyclic aromatic hydrocarbon) concentrations for sites where lake-bottom sediment samples were collected from Lakes Mead and Mohave, Nevada, 2004–06.

Among the lake sites where bottom-sediment samples were collected, PAH compounds were highest at two sites in Lake Mohave (Katherine Landing and Tequila Cove) (fig. 7), although not as high as the stream sites. In the lake sediment, the dominant compounds were naphthalenes and a few detectable concentrations of the larger PAH compounds (pyrene, fluoranthene, and phenanthrene). One possible explanation for the occurrence of naphthalenes in the sediment is their longer half life in water as compared to the larger PAH compounds, allowing more time for the compounds to be sorbed onto sediment before degradation. The naphthalene compounds are most likely from unburned fuel, either exhausted into the lakes by carbureted two-stroke engines or spilled directly into the lakes.

Microtox (EC50) and Toxicity Index

The three sites sampled at Lake Mead (Callville Bay, Hemenway Harbor, and Las Vegas Bay) and two sites at Lake Mohave (Katherine Landing and North Telephone Cove) all showed evidence of bioavailable PAH compounds in the water column (fig. 8 and table 9). As determined by the Fluoroscan method, the two Mohave sites contained about 3,000 µg/SPMD of PAH although the Lake Mead sites ranged from 750 to 1,380 µg/SPMD. A dialysate control had a PAH concentration less than the level of quantitation. The relative amounts of PAH determined by the Fluoroscan method were in general agreement with the results determined by the SPMDs and subsequent extraction with GC-MS analysis of individual PAHs (figs. 6 and 8; tables 7 and 9).

The Microtox EC50 and Toxicity Index values of all sample sites as well as the EC50 values of the dialysate and trip blank (TB) controls are shown in table 10. The Callville Bay and Lake Mohave sites showed only minor evidence that toxic compounds are present with TI values greater than 10. Dialysates from Las Vegas Bay and Hemenway Harbor sites did not indicate the presence of toxic compounds. The fluoroscan screening of SPMD sequestered samples revealed the presence of significant aromatic organic compounds not seen in the acute toxicity bioassay. The low acute toxicity and the uniform evidence of PAHs suggested that multiple-ringed-substituted PAHs, probably of petrogenic (derived from petroleum) or pyrogenic (derived from combustion) origin, were bioavailable as waterborne agents. These observations indicate that PAH compounds are present but not at concentrations high enough to cause toxicity to organisms in the lakes.

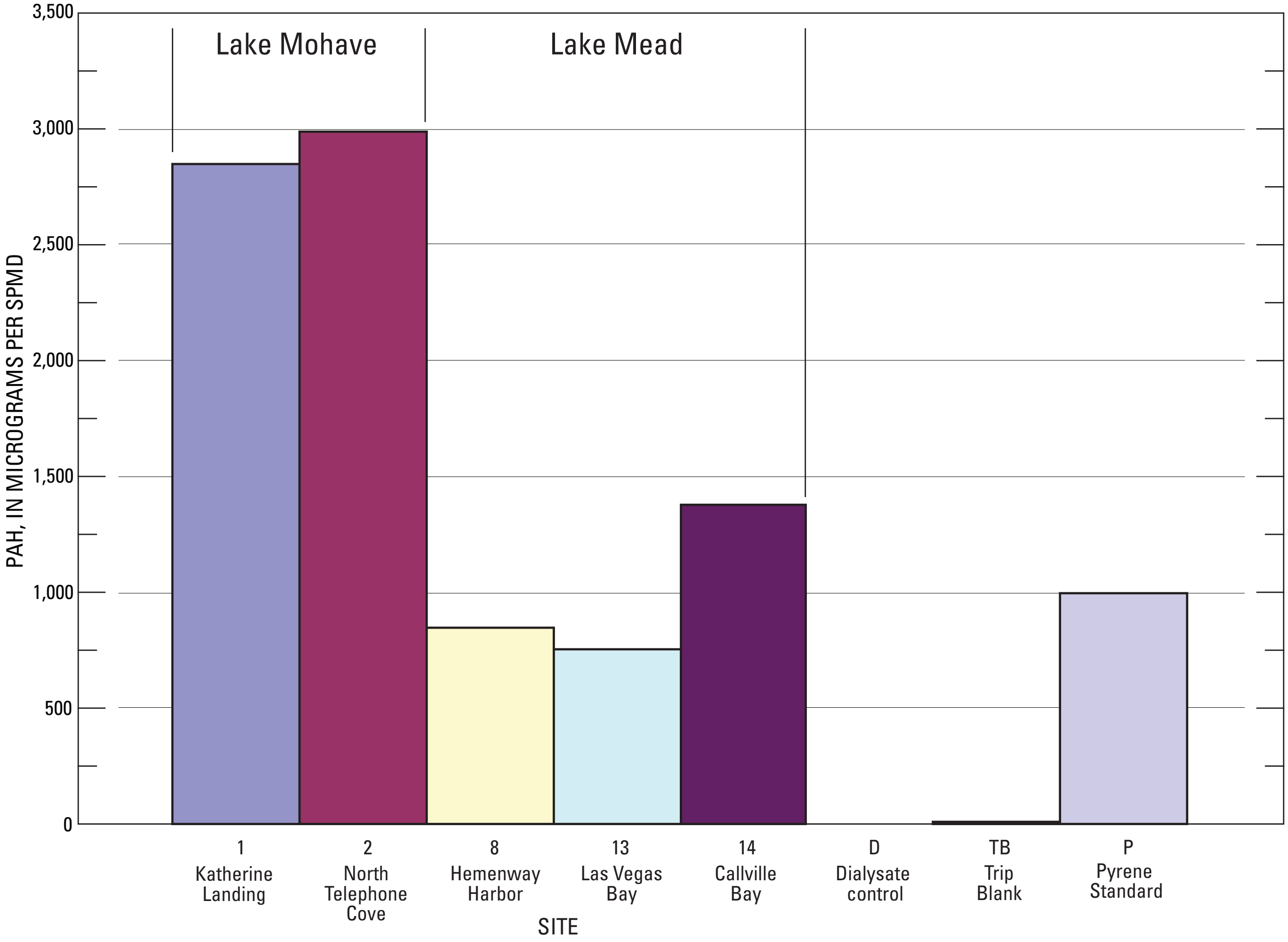


Figure 8. PAH (polycyclic aromatic hydrocarbon) concentrations determined using Fluoroscan in SPMD (semipermeable membrane device) samples collected from Lake Mead, Nevada, 2004–06.

Table 9. Estimated concentrations of PAH (polycyclic aromatic hydrocarbon) compounds in SPMD (semipermeable membrane device) dialysates using Fluoroscan, Lakes Mead and Mohave, Nevada.

Site No. (fig. 1)	Site name	PAH micrograms per SPMD
	Lake Mohave	
1	Katherine Landing	2,850
2	North Telephone Cove	2,990
	Lake Mead	
8	Hemenway Harbor	850
13	Las Vegas Bay	750
14	Callville Bay	1,380
	Controls	
	Dialysate Control	0
	Trip Blank	5
	Pyrene Standard	1,000

Table 10. Microtox acute toxicity profile of chemicals sequestered with SPMDs (semipermeable membrane devices), Lakes Mead and Mohave, Nevada, 2004.

[**Abbreviations**: >, greater than]

Site No. (fig. 1)	Site name	EC50	Toxicity Index (TI)
	Lake Mohave		
1	Katherine Landing	14.9	59.6
2	North Telephone Cove	13.5	54
	Lake Mead		
8	Hemenway Harbor	30	120
13	Las Vegas Bay	30	120
14	Callville Bay	11.55	46.2
	Controls		
	Phenol	25	100
	Dialysate Control	>50	>130

Conclusions

Several lines of evidence indicate that motorized watercraft are the principal source of BTEX and PAH in Lakes Mead and Mohave. All of the highest BTEX concentrations were detected at locations where there are launching facilities and marinas—areas of heaviest boat traffic. In areas where few boats travel, such as Tequila Cove, Nelson’s Landing, Bonelli Bay, and the Virgin Basin, the BTEX concentrations were much less. Concentrations are low or less than detection levels during the non-boating season as seen in the samples collected during March 2006. As the boating season progresses during the summer months, concentrations of BTEX increase and reach a maximum value in mid-summer then decrease as the boating season draws to an end. BTEX concentrations, in general, were much higher in Lake Mohave than in Lake Mead, most likely due to a larger number of boats within a smaller area.

Inputs from tributary streams to Lakes Mead and Mohave do not appear to contribute large amounts of BTEX to the lakes. BTEX concentrations were very low in Las Vegas Wash (contains urban runoff and seepage from the Las Vegas area and treated sewage effluent), the Colorado River at Willow Beach (reflects input from the Colorado River to Lake Mohave), near Overton (reflects inputs from the Muddy and Virgin Rivers), and Middle Point (near the confluence of the Virgin and Colorado River and indicative of concentrations in those two sources). The concentrations of BTEX near marinas that have fueling facilities indicates no grossly contaminated areas around fueling docks from leaking tanks or pipes. Finally, MTBE concentrations fall to below detection levels after it was taken out of gasoline in California (December 31, 2004) while BTEX concentrations changed little. Volatilization most likely is the primary removal mechanism for BTEX compounds from the lakes.

The distribution of PAHs in Lakes Mead and Mohave generally parallel that for BTEX compounds. PAHs were detected in all SPMDs deployed on Lakes Mead and Mohave and in Las Vegas Wash. The more popular boating areas had the highest concentrations and number of PAH compounds, whereas, the less trafficked parts of the lakes had low concentrations. The highest concentrations were at the south end of Lake Mohave where an abundance of personal watercraft ply the waters. The major source of PAH in the lakes is combustion of gasoline and oil in boat engines. The most commonly detected PAH compounds were fluoranthene, pyrene, and naphthalenes, which were detected in almost all SPMD extracts. Water from the Las Vegas metropolitan area sampled with SPMDs downstream of the release of treated sewage effluent in Las Vegas Wash had low concentrations of PAH and thus is not a major source of these compounds to Lake Mead.

Sediment samples from Lakes Mead and Mohave and Las Vegas Wash did not show the same distribution pattern of PAH concentrations as BTEX and PAH concentrations in water. Relatively high concentrations of PAH were detected in sediment from Las Vegas Wash upstream of the release of treated sewage effluent suggesting PAHs are generated in the Las Vegas metropolitan area, but are sorbed onto the sediment and not released into Lake Mead.

Bioavailable PAH was present at all five sites using the Fluoroscan method. PAH concentrations are relatively non-toxic as determined by EC50 and Toxicity Index calculations with samples from Katherine Landing and North Telephone Cove in Lake Mohave and Callville Bay in Lake Mead having slightly more toxicity than Hemenway Harbor and Las Vegas Bay in Lake Mead.

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Table 11. Concentrations of BTEX, oxygenate, and degradation products in water samples collected from Lakes Mead and Mohave, Las Vegas Wash, and the Colorado River, Nevada, 1999–2006.

[Concentrations are expressed in micrograms per liter, unless indicated otherwise. **Abbreviations**: <, less than; E, estimated concentration; M, result deleted due to highly variable analytical results; NA, not analyzed]

Site No. (fig. 1)	Date	Time	Sum of BTEX	Benzene	Ethyl-benzene	m-, p-Xylene	o-Xylene	Toluene	Diiso-propyl ether	Ethyl *tert*-butyl ether	Methyl *tert*-butyl ether	Methyl *tert*-pentyl ether	Methyl acetate	*tert*-Amyl alcohol	*tert*-Butyl alcohol	Acetone	Isobutyl alcohol-d6 surrogate percent recovery[1]	1,2-Dichloro-ethane-d4 surrogate percent recovery[1]	1-Bromo-4-fluoro-benzene surrogate percent recovery[1]	Toluene-d8 surrogate percent recovery[1]
Lake Mohave Sites																				
1	19990602	1400	14.46	1.25	1.01	4.19	1.83	6.18	<0.10	<0.05	4.2	E0.08	NA	NA	NA	NA	NA	102	81.4	96.6
	20040525	1245	6.35	0.55	0.5	2.1	0.83	2.37	<0.08	<0.1	0.23	<0.07	<2.0	<0.4	<1	1	91.7	98	98.2	99.7
	20040602	1125	17.19	1.41	1.33	5.78	2.32	6.35	<0.08	<0.1	0.43	<0.07	<2.0	<0.4	<1	E1	93.2	100	101	101
	20040624	1115	23.47	1.73	1.88	7.74	3.23	8.89	<0.08	<0.1	0.5	<0.07	<0.4	<0.4	<1	1	92.2	98	105	102
	20040624	1135	23.15	1.68	1.84	7.68	3.2	8.75	<0.08	<0.1	0.52	<0.07	<0.4	<0.4	<1	E1	93.3	97.3	103	100
	20040707	1043	16.82	1.36	1.37	5.17	2.43	6.49	<0.08	<0.1	0.47	<0.07	<0.4	<0.4	<1	2	94.3	103	97.6	96.9
	20040907	1004	7.52	0.62	0.61	2.4	1.04	2.85	<0.08	<0.1	0.13	<0.07	<0.4	<0.4	<1	2	88.1	98	103	102
	20050617	0856	6.26	0.53	0.47	2.15	0.87	2.24	<0.04	<0.04	E0.07	<0.03	<1.0	<1.0	<2	M	98.4	106	106	104
	20050919	1134	6.01	0.48	0.47	1.97	0.8	2.29	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	3	106	102	103	100
	20060322	0850	0.92	0.08	0.07	0.29	0.12	0.36	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	103	106	98.4	99
	20060518	0920	5.09	0.35	0.37	1.74	0.7	1.93	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	96.5	111	117	108
	20060601	0824	3.18	0.23	0.21	0.96	0.36	1.42	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	118	109	114	102
	20060616	0845	2.66	0.2	0.2	0.77	0.32	1.17	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	104	112	122	115
	20060712	0840	20.47	1.68	1.95	4.22	3.57	9.05	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	147	117	160	122
	20060824	0850	16.08	1.27	1.36	5.11	2.33	6.01	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	87.2	110	104	99.7
	20060905	0930	14.48	1.33	1.2	4.49	1.93	5.53	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	8	85.5	109	102	100
2	19990602	1440	1.67	0.14	0.11	0.48	0.2	0.74	<0.10	<0.05	0.6	<0.11	NA	NA	NA	NA	NA	109	93	101
	20040525	1345	4.01	0.32	0.31	1.31	0.52	1.55	<0.08	<0.1	0.16	<0.07	<2.0	<0.4	<1	1	85.4	97.8	97	99.9
	20040602	1100	16.17	1.08	1.31	5.56	2.28	5.94	<0.08	<0.1	0.35	<0.07	<2.0	<0.4	<1	E1	95.4	97.5	98.3	100
	20040624	1302	22.44	1.46	1.81	7.43	3.17	8.57	<0.08	<0.1	0.55	<0.07	<0.4	<0.4	<1	1	94.8	99.1	105	101
	20040707	1211	17.18	1.26	1.42	5.34	2.56	6.6	<0.08	<0.1	0.57	<0.07	<0.4	<0.4	<1	2	97.1	102	97.6	96.5
	20040907	1037	8.71	0.65	0.71	2.85	1.22	3.28	<0.08	<0.1	0.16	<0.07	<0.4	<0.4	<1	2	80.9	94.7	104	102
	20050617	0942	2.04	0.19	0.15	0.64	0.24	0.82	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	E1	99.4	106	103	102
	20050919	1203	5.55	0.41	0.45	1.83	0.74	2.12	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	3	107	100	103	101
	20060322	0920	0.09	E0.01	<0.03	E0.03	E0.01	E0.04	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	101	111	95.5	98.6
	20060518	1000	2.22	0.17	0.17	0.72	0.28	0.88	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	93.6	109	112	107
	20060601	0853	2.19	0.15	0.16	0.62	0.26	1	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	125	108	108	99.8
	20060616	1000	3.79	0.25	0.28	1.26	0.52	1.48	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	104	111	132	116
	20060712	0900	11.11	0.74	0.9	3.25	1.65	4.57	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	84.3	109	140	116
	20060824	0905	10.01	0.8	0.87	3.06	1.4	3.88	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	84	110	102	99.5
	20060905	0945	11.61	0.97	0.96	3.63	1.54	4.51	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	5	84.7	109	103	100
3	20050617	1035	1.43	0.14	0.1	0.44	0.15	0.6	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	1	101	106	104	103
	20050919	1246	1.05	0.13	0.07	0.27	0.1	0.48	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	3	97.5	100	95.5	100
	20060322	1030	0.01	<0.01	<0.03	<0.07	<0.04	E0.01	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	102	108	95	99.5
	20060601	0924	0.33	E0.04	E0.03	E0.08	E0.03	0.15	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	122	106	86.6	101

Table 11. Concentrations of BTEX, oxygenate, and degradation products in water samples collected from Lakes Mead and Mohave, Las Vegas Wash, and the Colorado River, Nevada, 1999–2006. —Continued.

[Concentrations are expressed in micrograms per liter, unless indicated otherwise. **Abbreviations**: <, less than; E, estimated concentration; M, result deleted due to highly variable analytical results; NA, not analyzed]

Site No. (fig. 1)	Date	Time	Sum of BTEX	Benzene	Ethyl-benzene	m-, p-Xylene	o-Xylene	Toluene	Diiso-propyl ether	Ethyl *tert*-butyl ether	Methyl *tert*-butyl ether	Methyl *tert*-pentyl ether	Methyl acetate	*tert*-Amyl alcohol	*tert*-Butyl alcohol	Acetone	Isobutyl alcohol-d6 surrogate percent recovery[1]	1,2-Dichloro-ethane-d4 surrogate percent recovery[1]	1-Bromo-4-fluoro-benzene surrogate percent recovery[1]	Toluene-d8 surrogate percent recovery[1]
Lake Mohave Sites—Continued																				
3	20060712	0930	3.55	0.27	0.28	1.1	0.44	1.46	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	82.6	107	128	114
	20060824	0940	4.54	0.38	0.37	1.4	0.62	1.77	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	82.1	110	102	100
	20060905	1015	3.01	0.29	0.24	0.89	0.34	1.25	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	86.8	110	102	100
4	19990602	1050	2.08	0.16	0.14	0.66	0.26	0.86	<0.10	<0.05	0.4	<0.11	NA	NA	NA	NA	NA	107	90.9	102
	20050617	1128	0.28	E0.04	E0.02	E0.06	E0.02	0.14	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	E1	93.5	104	100	104
	20050919	1338	0.48	0.07	E0.03	0.11	E0.04	0.23	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	108	103	103	100
	20060322	1130	0.02	<0.01	<0.03	E0.01	<0.04	E0.01	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	95	101	95.8	98.8
	20060601	0954	0.61	0.08	E0.05	0.15	0.06	0.27	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	127	109	96.5	103
	20060712	1020	0.56	0.07	E0.05	0.15	0.05	0.24	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	144	111	96.5	107
	20060824	1030	0.61	0.07	E0.06	0.15	0.07	0.26	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	155	96	108	111
	20060905	1045	0.44	0.06	E0.03	0.1	E0.03	0.22	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	86	110	100	99.1
5	19990602	1020	2.96	0.24	0.19	0.91	0.4	1.22	<0.10	<0.05	0.8	<0.11	NA	NA	NA	NA	NA	107	91	100
	20050617	1642	1.93	0.22	0.13	0.57	0.22	0.79	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	E1	103	106	104	102
	20050909	1330	1.36	0.19	0.07	0.27	0.08	0.75	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	99.2	101	99	102
	20060322	1250	0.16	E0.02	E0.01	E0.05	E0.02	0.06	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	99.7	104	96.4	98.1
	20060601	1040	1.73	0.2	0.12	0.46	0.2	0.75	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	121	108	106	103
	20060712	1100	3.54	0.34	0.28	1.07	0.38	1.47	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	86.6	109	146	118
	20060824	1115	1.22	0.13	0.11	0.3	0.14	0.54	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	156	103	108	109
	20060905	1115	2.65	0.27	0.21	0.79	0.3	1.08	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	87.3	108	100	99
6	19990602	1000	3.15	0.25	0.21	1.11	0.5	1.08	<0.10	<0.05	0.7	<0.11	NA	NA	NA	NA	NA	109	88.7	99.9
	20050617	1204	0.95	0.09	0.07	0.25	0.09	0.45	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	100	107	100	103
	20050909	1253	0.66	0.12	E0.02	E0.08	E0.01	0.43	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	109	104	106	101
	20060322	1210	0	<0.01	<0.03	<0.07	<0.04	<0.01	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	98.6	103	96.5	99.7
	20060601	1015	0.33	0.06	E0.02	E0.08	E0.03	0.14	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	124	107	88	100
	20060712	1035	1.16	0.12	0.1	0.3	0.12	0.52	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	83.1	108	109	113
	20060824	1055	1	0.1	E0.10	0.26	0.12	0.42	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	149	97.8	112	110
	20060905	1100	1.4	0.15	0.1	0.39	0.14	0.62	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	86.5	111	101	99.9
7	20050617	1535	0.24	0.07	E0.01	E0.05	E0.02	0.09	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	1	111	105	99.5	103
	20050909	1127	0.53	0.11	E0.01	E0.05	E0.01	0.35	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	101	101	100	99.7
	20060321	950	0.05	E0.01	<0.03	E0.02	<0.04	E0.02	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	97.7	107	94.4	99.6
	20060530	835	1.41	0.13	0.1	0.39	0.19	0.6	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	129	106	104	102
	20060712	1245	0.63	0.07	E0.06	0.17	0.07	0.26	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	134	106	107	111
	20060821	1240	1.65	0.21	0.17	0.46	0.17	0.64	<0.06	<0.1	<0.05	<0.05	E.4	<1.0	<2	5	107	111	127	123
	20060905	1315	0.88	0.12	0.06	0.21	0.07	0.42	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	6	90.4	112	102	99.4

Table 11. Concentrations of BTEX, oxygenate, and degradation products in water samples collected from Lakes Mead and Mohave, Las Vegas Wash, and the Colorado River, Nevada, 1999–2006. —Continued.

[Concentrations are expressed in micrograms per liter, unless indicated otherwise. **Abbreviations**: <, less than; E, estimated concentration; M, result deleted due to highly variable analytical results; NA, not analyzed]

Site No. (fig. 1)	Date	Time	Sum of BTEX	Benzene	Ethyl-benzene	m-, p-Xylene	o-Xylene	Toluene	Diiso-propyl ether	Ethyl *tert*-butyl ether	Methyl *tert*-butyl ether	Methyl *tert*-pentyl ether	Methyl acetate	*tert*-Amyl alcohol	*tert*-Butyl alcohol	Acetone	Isobutyl alcohol-d6 surrogate percent recovery[1]	1,2-Dichloro-ethane-d4 surrogate percent recovery[1]	1-Bromo-4-fluoro-benzene surrogate percent recovery[1]	Toluene-d8 surrogate percent recovery[1]
Lake Mead Sites																				
8	20040524	1240	4.3	0.35	0.33	1.44	0.57	1.61	<0.08	<0.1	E0.09	<0.07	<2.0	<0.4	<1	2	83	98.2	97.4	101
	20040524	1250	2.04	0.17	0.16	0.68	0.28	0.75	<0.08	<0.1	E0.04	<0.07	<2	<0.4	<1	2	86.2	99.1	97.1	101
	20040601	1130	1.5	0.15	0.11	0.46	0.2	0.58	<0.08	<0.1	<0.08	<0.07	<2.0	<0.4	<1	3	91.9	98.7	95.3	101
	20040623	1101	1.45	0.12	0.12	0.46	0.19	0.56	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	3	91	97.7	101	101
	20040623	1110	1.14	0.11	0.09	0.34	0.14	0.46	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	2	92.4	99.1	102	101
	20040706	1114	1.54	0.16	0.12	0.46	0.19	0.61	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	3	105	105	98.6	98.2
	20040908	900	1.03	0.13	0.06	0.21	0.07	0.56	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	3	96	98.4	99.1	101
	20050616	1244	0.9	0.1	0.07	0.27	0.11	0.35	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	104	105	103	104
	20050908	1111	1.6	0.18	0.09	0.36	0.13	0.84	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	82.3	104	101	101
	20060323	730	0.78	0.05	0.07	0.28	0.12	0.26	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	<1	103	105	99	99.7
	20060531	1310	2.3	0.19	0.15	0.64	0.27	1.05	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E3	112	109	110	104
	20060707	815	1.39	0.14	0.13	0.29	0.15	0.68	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	101	116	105	111
	20060823	815	0.94	0.11	E0.08	0.19	0.08	0.48	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	97.9	108	95.9	108
	20060907	905	0.86	0.1	0.05	0.23	0.07	0.41	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	84.4	111	96.3	98.4
9	20050615	1020	0.37	0.05	E0.03	E.10	E0.04	0.15	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	3	96.8	104	101	103
	20050907	1317	0.38	0.06	E0.02	E0.07	E0.02	0.21	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	3	79.4	103	103	101
	20060323	1250	0.21	E0.03	E0.02	E0.06	E0.02	0.08	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	100	110	95.4	98.6
	20060531	936	2.2	0.22	0.15	0.61	0.25	0.97	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E2	129	109	107	101
	20060711	1000	1.26	0.14	0.11	0.33	0.13	0.55	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	81.9	106	110	112
	20060822	1010	2.17	0.21	0.18	0.57	0.24	0.97	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	99.4	108	112	107
	20060906	1350	1.76	0.23	0.12	0.45	0.16	0.8	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	84.8	109	99.8	99
10	20060516	840	0.57	0.07	E0.04	0.14	E0.05	0.27	<0.06	<0.06	<0.05	<0.05	<1.0	<1.0	<2	2	95	109	99.8	107
	20060613	930	0.46	0.07	E0.03	E.10	E0.03	0.23	<0.06	<0.06	<0.05	<0.05	<1.0	<1.0	<2	3	108	111	94.1	112
11	19990601	1215	2.61	0.25	0.16	0.71	0.26	1.23	<0.10	<0.05	0.3	<0.11	NA	NA	NA	NA	NA	108	91.7	99.2
	20050616	1204	0.72	0.08	0.05	0.22	0.09	0.28	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	93.6	106	105	104
	20050908	1048	0.72	0.12	E0.03	E0.08	E0.02	0.47	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	84.7	107	102	101
	20060323	750	0.21	E0.02	E0.02	E0.06	E0.03	0.08	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	<1	103	108	94.2	98.1
	20060531	1332	1.26	0.12	0.09	0.33	0.14	0.58	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E3	114	106	98.8	103
	20060707	930	1.12	0.12	0.1	0.24	0.11	0.55	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	97	118	104	113
	20060823	945	0.79	0.09	E0.07	0.18	0.07	0.38	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	94.7	105	92.8	106
	20060907	1440	0.79	0.09	E0.05	0.2	0.07	0.38	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	78.3	113	102	99.5
12	20050615	1127	0.07	E0.01	<0.03	E0.02	E0.01	E0.03	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	2	104	104	102	104
	20050907	1426	0.09	E0.02	<0.03	E0.02	<0.04	0.05	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	3	87.6	104	102	101
	20060323	1340	0	<0.01	<0.03	<0.07	<0.04	<0.01	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	103	112	94.9	99.5

Table 11. Concentrations of BTEX, oxygenate, and degradation products in water samples collected from Lakes Mead and Mohave, Las Vegas Wash, and the Colorado River, Nevada, 1999–2006. —Continued.

[Concentrations are expressed in micrograms per liter, unless indicated otherwise. **Abbreviations**: <, less than; E, estimated concentration; M, result deleted due to highly variable analytical results; NA, not analyzed]

Site No. (fig. 1).	Date	Time	Sum of BTEX	Benzene	Ethyl-benzene	m-, p-Xylene	o-Xylene	Toluene	Diiso-propyl ether	Ethyl *tert*-butyl ether	Methyl *tert*-butyl ether	Methyl *tert*-pentyl ether	Methyl acetate	*tert*-Amyl alcohol	*tert*-Butyl alcohol	Acetone	Isobutyl alcohol-d6 surrogate percent recovery[1]	1,2-Dichloro-ethane-d4 surrogate percent recovery[1]	1-Bromo-4-fluoro-benzene surrogate percent recovery[1]	Toluene-d8 surrogate percent recovery[1]
Lake Mead Sites—Continued																				
12	20060531	1047	0.06	E0.02	<0.03	<0.07	<0.04	E0.04	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E2	124	104	83.1	98.9
	20060711	1100	0.1	E0.02	<0.03	E0.04	<0.04	E0.04	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	139	109	95.8	109
	20060822	1050	0.11	E0.02	<0.03	E0.04	<0.04	E0.05	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	95.4	103	88.5	109
	20060906	1450	0.22	E0.04	E0.01	E0.05	E0.02	0.1	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	84.9	112	99.4	99.3
13	20040524	1400	0.22	E0.03	E0.02	E0.07	E0.03	0.07	<0.08	<0.1	<0.08	<0.07	<2.0	<0.4	<1	2	95.2	97.5	94.9	99.7
	20040601	1340	0.04	E0.02	<0.03	E0.01	<0.04	E0.01	<0.08	<0.1	<0.08	<0.07	<2.0	<0.4	<1	E1	94.5	97.9	95.1	99.5
	20040623	1400	0.12	E0.04	<0.03	E0.03	E0.01	E0.04	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	E1	89.8	97.4	99.5	101
	20040706	1437	1.98	0.16	0.15	0.7	0.3	0.67	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	2	98	102	98.5	99.1
	20040908	1055	0.11	E0.03	<0.03	E0.03	E0.01	E0.04	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	<1	97.5	99	99.6	101
	20050616	1106	0.05	E0.02	<0.03	E0.01	E0.01	E0.01	<0.04	<0.04	<0.04	<0.03	M	<1.0	<2	2	110	105	97.9	103
	20050908	1015	0.58	0.06	E0.04	0.18	0.07	0.23	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	<1	86.6	107	103	101
	20060323	820	0.05	E0.01	<0.03	E0.02	<0.04	E0.02	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	104	102	95.4	99
	20060516	1100	0.2	E0.03	E0.02	E0.06	E0.03	0.06	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	103	111	93.5	108
	20060531	1228	0.05	E0.02	<0.03	<0.07	<0.04	E0.03	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	124	108	81.9	105
	20060613	820	0.33	0.06	E0.03	E.10	E0.04	0.1	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	109	110	95.3	113
	20060706	1140	0.57	0.06	E0.06	0.16	0.08	0.21	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	99.8	113	94.9	113
	20060823	925	0.34	0.06	E0.03	E0.09	E0.04	0.12	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	99.6	105	88.1	106
	20060907	1415	0.31	0.07	E0.02	E0.08	E0.03	0.11	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	80.3	113	99.3	98.5
14	19990601	1045	6.88	0.69	0.47	1.97	0.76	2.99	<0.10	<0.05	0.8	<0.11	NA	NA	NA	NA	NA	109	88.3	98.3
	20040524	1125	3.32	0.36	0.24	1.02	0.41	1.29	<0.08	<0.1	E0.05	<0.07	<2.0	<0.4	<1	3	89.3	97.7	96.2	99.9
	20040601	1255	10.81	1.06	0.7	3.88	1.59	3.58	<0.08	<0.1	0.2	<0.07	<2.0	<0.4	<1	3	93.2	99.1	98.6	101
	20040623	1215	3.92	0.4	0.26	1.39	0.56	1.31	<0.08	<0.1	0.18	<0.07	<0.4	<0.4	<1	3	90.9	97.5	102	98.5
	20040706	1310	5.55	0.53	0.43	1.72	0.72	2.15	<0.08	<0.1	E0.06	<0.07	<0.4	<0.4	<1	3	96.5	103	97.5	98
	20040908	955	5.79	0.76	0.37	1.47	0.65	2.54	<0.08	<0.1	E0.06	<0.07	<0.4	<0.4	<1	2	101	99.5	103	102
	20050616	1015	1.9	0.2	0.13	0.61	0.23	0.73	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	93.2	106	104	103
	20050908	936	2.68	0.46	0.14	0.47	0.15	1.46	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	89.3	106	102	102
	20060323	905	0.25	E0.04	E0.02	E0.07	E0.03	0.09	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	99.4	111	95	98
	20060531	1152	4.08	0.41	0.22	1.23	0.42	1.8	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E3	119	110	115	106
	20060706	1100	3.86	0.45	0.26	1	0.41	1.74	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	7	110	117	124	115
	20060823	850	2.73	0.31	0.18	0.64	0.24	1.36	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	101	107	108	110
	20060907	1345	3.9	0.47	0.27	1.13	0.4	1.63	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	87.1	112	102	100
15	20050615	1445	0.28	E0.04	E0.02	E0.07	E0.03	0.12	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	3	101	105	102	104
	20050907	1500	0.24	E0.03	E0.01	E0.05	E0.02	0.13	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	E3	88.3	105	102	101

Table 11. Concentrations of BTEX, oxygenate, and degradation products in water samples collected from Lakes Mead and Mohave, Las Vegas Wash, and the Colorado River, Nevada, 1999–2006. —Continued.

[Concentrations are expressed in micrograms per liter, unless indicated otherwise. **Abbreviations**: <, less than; E, estimated concentration; M, result deleted due to highly variable analytical results; NA, not analyzed]

Site No. (fig. 1)	Date	Time	Sum of BTEX	Benzene	Ethyl-benzene	m-, p-Xylene	o-Xylene	Toluene	Diiso-propyl ether	Ethyl *tert*-butyl ether	Methyl *tert*-butyl ether	Methyl *tert*-pentyl ether	Methyl acetate	*tert*-Amyl alcohol	*tert*-Butyl alcohol	Acetone	Isobutyl alcohol-d6 surrogate percent recovery[1]	1,2-Dichloro-ethane-d4 surrogate percent recovery[1]	1-Bromo-4-fluoro-benzene surrogate percent recovery[1]	Toluene-d8 surrogate percent recovery[1]
Lake Mead Sites—Continued																				
15	20060323	1220	0.04	E0.01	<0.03	E0.01	<0.04	E0.02	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	97.9	104	96.8	98.5
	20060531	1022	.4	E0.03	E0.04	0.11	0.05	0.17	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E2	123	109	89.7	102
	20060711	1040	3.53	.19	0.27	1.14	0.43	1.5	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	5	81.7	109	127	111
	20060822	1115	.15	E0.02	E0.02	E0.04	<0.04	0.07	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	97.8	107	83.1	106
	20060906	1425	.13	E0.02	E0.01	E0.03	E0.01	0.06	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	83.1	111	98.8	99
16	20050616	913	.36	E0.05	E0.03	E0.09	E0.04	0.15	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	4	110	106	102	104
	20050908	852	1.12	.22	E0.04	0.15	E0.03	0.68	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	3	81.5	104	98.4	100
	20060323	950	.04	E0.01	<0.03	E0.01	<0.04	E0.02	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	<1	96.8	104	96.8	100
	20060517	800	.47	.06	E0.04	0.13	0.05	0.19	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	86.6	108	97.4	107
	20060531	1106	.17	E0.02	E0.02	E0.05	E0.02	0.06	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E2	121	107	83.2	101
	20060614	1110	.48	.08	E0.03	E.10	E0.03	0.24	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	3	106	113	94.3	113
	20060711	1130	1.49	.14	0.13	0.41	0.15	0.66	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	5	81.1	107	110	112
	20060822	1140	.48	.07	E0.05	0.11	E0.05	0.2	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	98.9	105	90.5	107
	20060907	1000	.61	.09	E0.04	0.14	E0.04	0.3	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	81.2	113	101	99.2
17	20050615	1348	1.27	.13	0.08	0.44	0.17	0.45	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	100	106	105	104
	20050907	1049	3.13	.27	0.22	0.79	0.28	1.57	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	E2	77.9	103	101	100
	20060323	1050	.98	.08	0.08	0.35	0.14	0.33	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	104	107	98.7	98.8
	20060531	840	5.64	.3	0.35	1.91	0.73	2.35	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	130	110	117	104
	20060711	840	5.49	.37	0.38	1.7	0.63	2.41	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	4	77.2	106	132	115
	20060822	912	6.56	.48	0.46	2.05	0.78	2.79	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	99.9	110	128	110
	20060906	1300	5.67	.49	0.42	1.76	0.64	2.36	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	86.8	110	101	99.6
18	20050615	1255	.52	.06	E0.04	0.15	0.07	0.2	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	E1	103	105	104	105
	20050907	1143	.08	E0.02	<0.03	E0.02	<0.04	E0.04	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	<1	74.7	105	99.4	101
	20060323	952	.02	E0.01	<0.03	<0.07	<0.04	E0.01	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	<1	106	111	94.2	97.9
	20060517	1120	.02	E0.01	<0.03	<0.07	<0.04	E0.01	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	92.8	107	92.8	106
	20060606	930	.69	.08	E0.05	0.22	0.1	0.24	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	2	91	109	99.4	110
	20060614	900	.19	E0.03	E0.02	E0.06	E0.02	0.06	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	1	106	110	91.7	111
	20060705	1100	.39	.07	E0.03	E0.08	E0.03	0.18	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E2	97.1	117	88.7	109
	20060822	1230	.29	E0.04	E0.04	E0.08	E0.04	0.09	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	E1	97.9	104	110	103
	20060906	1010	.07	E0.01	<0.03	E0.02	E0.01	E0.03	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	85.9	112	100	99.5

Table 11. Concentrations of BTEX, oxygenate, and degradation products in water samples collected from Lakes Mead and Mohave, Las Vegas Wash, and the Colorado River, Nevada, 1999–2006. —Continued.

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Site No. (fig. 1)	Date	Time	Sum of BTEX	Benzene	Ethyl-benzene	m-, p-Xylene	o-Xylene	Toluene	Diiso-propyl ether	Ethyl *tert*-butyl ether	Methyl *tert*-butyl ether	Methyl *tert*-pentyl ether	Methyl acetate	*tert*-Amyl alcohol	*tert*-Butyl alcohol	Acetone	Isobutyl alcohol-d6 surrogate percent recovery[1]	1,2-Dichloro-ethane-d4 surrogate percent recovery[1]	1-Bromo-4-fluoro-benzene surrogate percent recovery[1]	Toluene-d8 surrogate percent recovery[1]
Stream and River Sites																				
21	20050617	1420	0.18	E0.03	E0.01	E0.04	E0.02	0.08	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	99.8	107	100	102
	20050909	946	.13	E0.02	E0.01	E0.04	E0.01	0.05	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	<1	107	102	100	100
	20060320	1600	.07	E0.02	<0.03	E0.02	<0.04	E0.03	<0.04	<0.04	<0.04	<0.03	<1.0	<1.0	<2	M	112	109	95	97.9
	20060530	1012	.16	E0.02	E0.02	E0.04	E0.02	0.06	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	130	106	82	99.8
	20060713	900	.1	E0.02	<0.03	E0.04	<0.04	E0.04	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	<1	128	110	91.2	108
	20060821	1430	.12	E0.03	<0.03	E0.05	<0.04	E0.04	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	<1	102	108	96.4	104
	20060908	915	.09	E0.02	<0.03	E0.02	E0.01	E0.04	<0.06	<0.1	<0.05	<0.05	<1.0	<1.0	<2	M	80.1	113	98	98.5
22	20040526	1010	.06	<0.01	<0.03	<0.07	<0.04	0.06	<0.08	<0.1	<0.08	<0.07	<2.0	<0.4	<1	2	108	98.9	94.9	99.7
	20040603	1230	.05	<0.01	<0.03	<0.07	<0.04	0.05	<0.08	<0.1	<0.08	<0.07	<2.0	<0.4	<1	2	104	98.5	93.2	100
	20040624	1715	.06	<0.01	<0.03	<0.07	<0.04	0.06	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	2	91.4	98.1	100	103
	20040707	1450	.05	<0.01	<0.03	<0.07	<0.04	0.05	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	2	96.6	104	98.1	99.5
	20040907	1425	.02	<0.01	<0.03	<0.07	<0.04	E0.02	<0.08	<0.1	<0.08	<0.07	<0.4	<0.4	<1	2	96.6	99.1	102	103

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[1] Values represent amount of surrogate compound recovered from sample by analytical procedure. These compounds are added to the samples and are not present in the environment.

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