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

Prepared in cooperation with the
FEDERAL HIGHWAY ADMINISTRATION

Geographic Information for Analysis of Highway Runoff-Quality Data on a National or Regional Scale in the Conterminous United States

Open-File Report 00-432

A Contribution to the
NATIONAL HIGHWAY RUNOFF DATA AND METHODOLOGY SYNTHESIS

U.S. Department
of Transportation

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

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By TOMAS W. SMIESZEK and GREGORY E. GRANATO

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Northborough, Massachusetts
2000

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

For additional information write to:

Chief, Massachusetts-Rhode Island District
U.S. Geological Survey
Water Resources Division
10 Bearfoot Road
Northborough, MA 01532

Copies of this report can be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225-0286

PREFACE

Knowledge of the characteristics of highway runoff (concentrations and loads of constituents and the physical and chemical processes which produce this runoff) is important for decision makers, planners, and highway engineers to assess and mitigate possible adverse impacts of highway runoff on the Nation's receiving waters. In October 1996, the Federal Highway Administration and the U.S. Geological Survey began the National Highway Runoff Data and Methodology Synthesis to provide a catalog of the pertinent information available; to define the necessary documentation to determine if data are valid (useful for intended purposes), current, and technically supportable; and to evaluate available sources in terms of current and foreseeable information needs. This paper is one contribution to the National Highway Runoff Data and Methodology Synthesis and is being made available as a U.S. Geological Survey Open-File Report pending its inclusion in a volume or series to be published by the Federal Highway Administration. More information about this project is available on the World Wide Web at http://ma.water.usgs.gov/fhwa/runwater.htm

Fred G. Bank
Team Leader
Office of Natural Environment
Federal Highway Administration

Patricia A. Cazenas, P.E., L.S.
Highway Engineer
Office of Natural Environment
Federal Highway Administration

Gregory E. Granato
Hydrologist
U.S. Geological Survey

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APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

Geographic Information for Analysis of Highway Runoff-Quality Data on a National or Regional Scale in the Conterminous United States

By Tomas W. Smieszek *and* Gregory E. Granato

Abstract

Spatial data are important for interpretation of water-quality information on a regional or national scale. Geographic information systems (GIS) facilitate interpretation and integration of spatial data. The geographic information and data compiled for the conterminous United States during the National Highway Runoff Water-Quality Data and Methodology Synthesis project is described in this document, which also includes information on the structure, file types, and the geographic information in the data files. This "geodata" directory contains two subdirectories, labeled "gisdata" and "gisimage." The "gisdata" directory contains ArcInfo coverages, ArcInfo export files, shapefiles (used in ArcView), Spatial Data Transfer Standard Topological Vector Profile format files, and meta files in subdirectories organized by file type. The "gisimage" directory contains the GIS data in common image-file formats. The spatial geodata includes two rain-zone region maps and a map of national ecosystems originally published by the U.S. Environmental Protection Agency; regional estimates of mean annual streamflow, and water hardness published by the Federal Highway Administration; and mean monthly temperature, mean annual precipitation, and mean monthly snowfall modified from data published by the National Climatic Data Center and made available to the public by the Oregon Climate Service at Oregon State University. These GIS files were compiled for qualitative spatial analysis of available data on a national and(or) regional scale and therefore should be considered as qualitative representations, not precise geographic location information.

INTRODUCTION

Geographic information is necessary for evaluating highway runoff-quality data for national or regional synthesis in terms of the availability of data that characterize the range of conditions of interest in different geographic areas. For example, climatic differences between the relatively wet Northwest and the arid Southwest would be expected to have profound impacts on the environmental cycling of trace elements and organic chemicals. In cold environments, the application of road salts and friction materials substantially increases annual loads of dissolved and suspended solids and provides a mechanism for altering local geochemical and ecological processes (Bricker, 1998). In regions with higher annual temperatures, organics may degrade and volatilize at significantly faster rates than in colder regions (Lopes and Dionne, 1998). Variation in runoff fluxes and the potential effect of highway runoff on the local aquatic environment are expected to correlate with regional factors such as climate, hydrology and ecological habitat, as well as with site specific factors such as traffic volume, extent of pavement, and right-of-way characteristics. Geographic information, therefore, can be used as explanatory variables to examine differences in the quality and quantity and effects of storm-water runoff in receiving waters.

Information about the quality and availability of existing water-quality data in different geographical, climatological, hydrologic, and ecological regions of the country is necessary to evaluate the adequacy of existing data within a region and among different regions included in a national synthesis. Geographic information systems (GIS) technology will facilitate evaluation of available water-quality data by highway engineers and decision-makers to examine characteristics of existing (or planned) study sites within the context of spatial differences between these study sites. For example, in formulating the most current model of highway-runoff constituent loads and impacts on receiving waters, Driscoll and others (1990a,b) use 9 rainfall regions to predict potential contaminant loads; 30 mean annual streamflow regions to predict potential dilution; and 23 regions of total hardness levels in surface waters to indicate potential toxic effects from metallic contaminants. Other studies also have found geographic information to be important for interpretation of results on a national or regional scale. Athayde and others (1983) indicated that rainfall characteristics, streamflow, and surface-water hardness were important for assessing the impact of urban runoff in streams during the Nationwide Urban Runoff Program (NURP). Tasker and Driver (1988) conclude that to predict runoff loads, site features, regionalized precipitation characteristics, and mean minimum January temperature could be used to formulate generalized-least-squares regression models. The U.S. Environmental Protection Agency (1992) specifies the use of a 15-zone rainfall characteristics map to plan sampling efforts and interpret stormwater-quality data collected for National Pollutant Discharge Elimination System (NPDES) permits. Therefore, national geographic information that may be used in the analysis of available runoff water-quality data is included with this report to facilitate current and future interpretations.

The GIS coverages documented herein are provided as one component of the products generated for the National Highway Runoff Water-Quality Data and Methodology Synthesis. In this synthesis, reports about highway- and urban-runoff quality are reviewed and analyzed in terms of the suitability for regional and(or) national interpretation for characterization of the quality of and potential environmental effects from runoff (Dionne and others, 1999). During this review process, the latitude and longitude of individual study sites were documented from all reports with detailed information (Dionne and others, 1999; Granato, 1999). If site maps were available, a computer program for point location and calculation of error (PLACER) was used to determine relatively precise geographic coordinates (Granato, 1999). In many cases, however, locations had to be estimated by means of geographic name search engines (Dionne and others, 1999). In any case, the review information generated by the National Highway Runoff Water-Quality Data and Methodology Synthesis may be used with the GIS coverages described in this report to examine data availability and quality with respect to geographic characteristics important to the evaluation of runoff quality.

Purpose and Scope

This document describes the geographic information and data compiled for the conterminous U.S. during the National Highway Runoff Water-Quality Data and Methodology Synthesis. This information is compiled for spatial analysis of highway runoff-quality data on a national or regional scale. This document includes information on the directory structure, file types, and the geographic information in the data files.

Disclaimer

The geographic data on this CD-ROM was prepared by the U.S. Geological Survey (USGS) in cooperation with the Federal Highway Administration (FHWA); both are agencies of the U.S. Government. This information was compiled for qualitative spatial analysis of available data on a national and(or) regional scale. Although the data have been subjected to rigorous review and are substantially complete and accurate, the geographic information was generated from original data from other sources and was digitized on the scale of the conterminous United States. Therefore, the geographic information and data and related images should be considered as qualitative representations of generalized information on a national scale, not precise geographic location information. The USGS and the FHWA reserve the right to revise the data pursuant to further analysis and review. These data and the software on the CD-ROM have been used by the USGS, and are released on condition that the USGS, the FHWA, or the U.S. Government may not be held liable for any damages resulting from their use. The use of trade or product names in this report is for identification purposes only and does not constitute endorsement by the U.S. Government. The information included in this report and the accompanying computer disk is provided solely for the purposes of private study, scholarship, or research (U.S. Copyright Office, 2000).

DIRECTORY STRUCTURE AND FILE TYPES

The "geodata" directory on the CD-ROM contains two "readme" files (one with directory information and another with general metadata), and two main subdirectories ("gisdata" and "gisimage") that store the computerized GIS maps in different formats (fig. 1). The readme files are in World Wide Web (html) format and in a generic text. The "gisdata" directory contains subdirectories for the different file formats compatible with GIS software and a subdirectory for the GIS metadata. The "gisimage" directory contains computer file formats utilized by graphics, web browser, and(or) word-processing software. The "gisdata" and "gisimage" subdirectories contain a number of subdirectories that organize files by format.

The "gisdata" Directory

The "gisdata" directory contains "readme" files and individual subdirectories containing 8 data layers (9 rain zones, 15 rain zones, precipitation, snowfall, temperature, streamflow, hardness, and ecozones) in four formats:

- ArcInfo coverages;
- ArcInfo export files;
- Shapefiles (used in ArcView); and
- Spatial Data Transfer Standard (SDTS) Topological Vector Profile files.

ArcInfo coverages were created directly from raw data that was either digitized from an image or contoured from digital data. ArcInfo coverages display attributes both as polygons and lines, according to the user needs. ArcInfo export files are coverages that have been saved as interchange files in ASCII format for

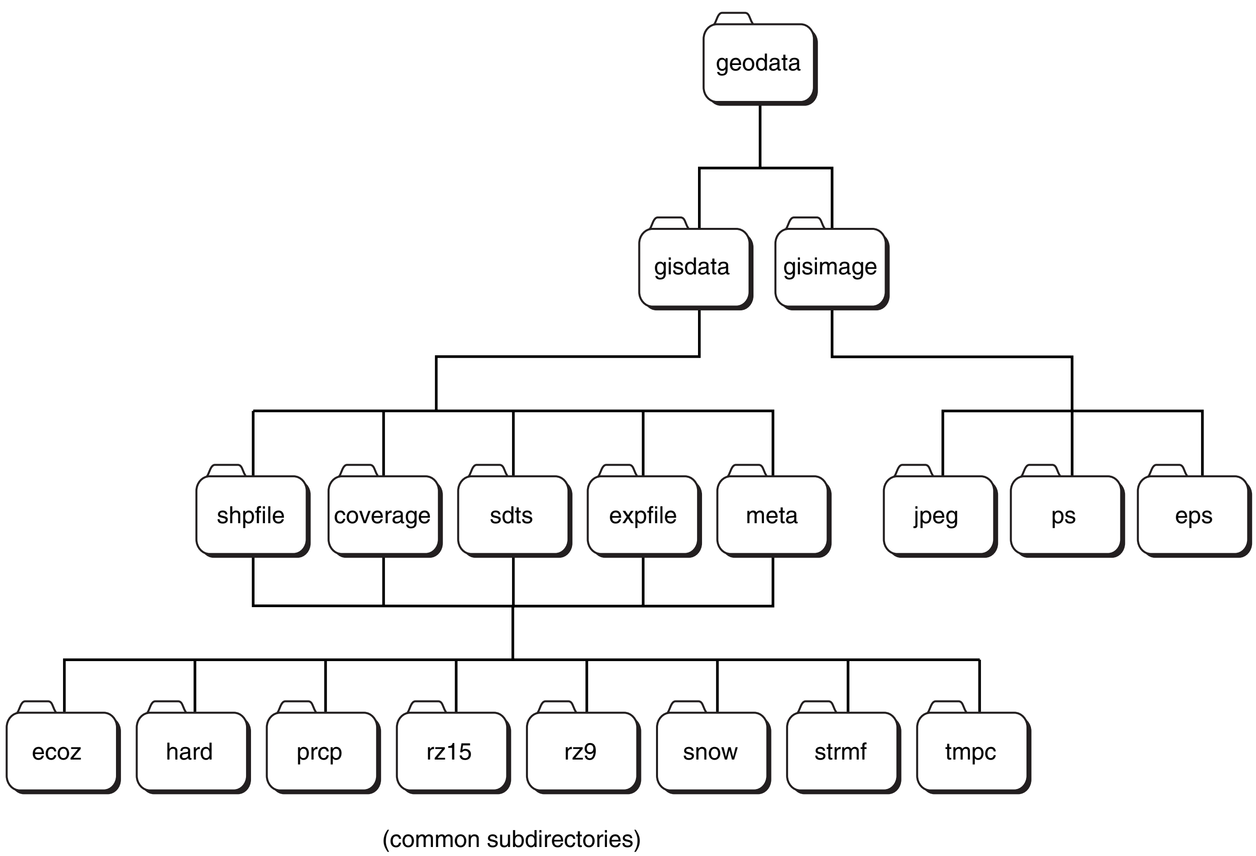

Figure 1. Directory structure within the “geodata” subdirectories.

transfer of coverages to a different computer platform that is running ArcInfo. Shapefiles (an ArcView format) were created from ArcInfo coverages with the ARCSHAPE command from the ArcInfo command prompt. Data are saved in ArcInfo and ArcView formats because they have different characteristics and the availability of both formats gives the potential user more flexibility. Shapefile formats were developed by ESRI for ArcView, but are now a GIS standard format (Environmental Systems Research Institute, Inc., 1998) that are used in other software packages. Shapefiles take up less storage space than ArcInfo coverages. In ArcView, shapefiles can be modified directly, but coverages must be converted to shapefiles before any modifications are made. Map projection information must be documented in metadata files because this information is not contained within the Shapefiles. Map projection information, however, is stored within ArcInfo coverages so tracking this projection information in separate files is not necessary. Coverages also can have multiple data types, whereas shapefiles are limited to one data type (point, line, or polygon). Therefore, two shapefiles (line and polygon) were created for every coverage (table 1).

As of 1994, all Federal spatial-data producers are obligated to supply their data in the SDTS format (National Institute of Science and Technology, 1992; USGS, 2000). SDTS provides a practical and effective way for the exchange of spatial data among different computing platforms. The SDTS was designed by a broad cross-section of government, academic, and industry experts. It is therefore more universal than formats created by individual agencies, such as the USGS digital line graph (DLG) format. The SDTS holds attributes as text in relational tables. SDTS Topological Vector Profile (TVP) transfer was created by with SDTSEXPORT command from the Arc Info prompt. The SDTS TVP files and the SDTS transfer module contents provide information needed for use of SDTS files in GIS software packages. For example, these files will indicate which command, "STDSINFO" or "SDTSLIST," is most appropriate from the Arc prompt input line.

All GIS data are stored in geographic coordinates, measured in latitude and longitude expressed as decimal degrees (not as degrees, minutes, and seconds). Spatial data stored in decimal degrees can be displayed with any of ArcView's projections, and this method is useful for other GIS applications where geographic data in an appropriate map projection is used (Environmental Systems Research Institute, 1996).

Table 1. File names for ArcView shapefiles stored in line and polygon formats

Data layer	Filename for data as lines	Filename for data as polygons
9 rain zones	rz9_ln	rz9_pl
15 rain zones	rz15_ln	rz15_pl
precipitation	prcp_ln	prcp_pl
snowfall	snow_ln	snow_pl
temperature	tmpc_ln	tmpc_pl
streamflow	strmf_ln	strmf_pl
hardness	hard_ln	hard_pl
ecoregions	ecoz_ln	ecoz_pl

Data are stored in four subdirectories (shpfile, coverage, sdts, and expfile) within the "gisdata" directory; each named according to the data layer's formats (shape files coverages, export files, SDTS, and shapefiles, respectively). Each subdirectory, in turn, includes 8 subdirectories that contain data layers, which are named according to the regional geographic data documented therein (fig. 1). An additional "info" subdirectory (within the "coverages" subdirectory) contains files necessary for use of the coverages in ArcInfo.

The "gisdata" directory also contains a subdirectory named "meta" (fig. 1). The "meta" subdirectory contains Digital Geospatial Metadata in structured text file formats, that conform to the Federal Geographic Data Committee (FGDC) metadata standard (Federal Geographic Data Committee, 1998). Metadata "data about data" is structured documentation provided with data sets to make geographic data easier to find and use. The information contained in the metadata file documents the creation of each dataset and describes the purpose of its respective geographic data. For example, data layers were acquired from the various published sources, which are identified with bibliographic references in the metadata files. These files are saved in three formats in the folder named "meta." The meta, text, and hypertext markup language (html, internet format) files have a ".met," ".txt," and ".htm" filename appendix, respectively.

The "gisimage" Directory

The "gisimage" directory contains "readme" files and two subdirectories containing geographic information in image file formats. The "readme" files briefly describe the name, content, and format of each file in the subdirectory. The GIS information recorded with the data sets is stored as Joint Photographic Experts Group (JPEG), postscript, and encapsulated postscript files (identified by the file-name suffixes: ".jpg," ".ps," and ".eps," respectively. The JPEG format is a national standard format for compressed figure files (Joint Photographic Experts Group, 2000). The JPEG format is one of the most common graphic-image file formats on the World Wide Web. The JPEG formats use a raster data type (in raster files the image resolution is proportional to file size), which is compressed with a lossy compression technique encoded in binary computer language. Postscript is a format in which the image (the text and graphic elements on a page) is described with printer commands in ASCII text. Therefore, the number and type of objects in an image rather than image resolution determine file size. The Adobe corporation developed this format in 1985 and postscript has become a computer-industry standard for printing and imaging, especially in the Unix environment. The encapsulated postscript file suffix is also an ASCII text vector-image format that the Adobe corporation developed. Many software packages use this format to incorporate images into other files, especially in the personal computer environment.

REGIONAL GEOGRAPHIC DATA

The "geodata" directory contains selected atmospheric, surface water, and ecological data for the conterminous United States. The regional geographic data and their root filenames (in parenthesis) are as follows: nine rain-zone regions (rz9); fifteen rain-zone regions (rz15); mean annual precipitation regions (prcp); mean monthly snowfall regions (snow); mean monthly temperature regions (tmpc); mean annual streamflow regions (strmf); total hardness regions (hard); and ecoregions (ecoz).

All the GIS files are derived from data in the public domain. GIS files for the two rain zone regions, the mean annual streamflow regions, and the total hardness regions were digitized from published figures in Federal guidance documents (Driscoll and others, 1990a; USEPA, 1992). The GIS files for mean annual precipitation regions, mean monthly snowfall regions, and mean monthly temperature regions are derived from federal climate data published on the Oregon State University Web site (1998). The USGS downloaded and contoured this point data to create regions based on these atmospheric variables. More specifically, atmospheric data were transformed to the GRID format with the ASCIIGRID command in ArcInfo, the atmospheric feature ranges were created in Look-up Tables (LUT), and the ArcInfo data layers were created with the LATTICEPOLY command in ArcInfo. The USGS downloaded the ecoregion files from an USEPA Web site (USEPA, 1999) reformatted these files into all the common GIS file formats, graphic formats, and created the necessary metadata files.

Nine Rain-Zone Regions (rz9)

Athayde and others (1983) and Driscoll and others (1990a,b) used the nine rain-zone regions to assess stormwater pollutant characteristics and loads. Rain-zone regions (fig. 2) were based on precipitation event statistics including annual means of total storm volume, intensity, duration, and interval between storms (table 2). The USGS digitized the boundaries of these rain zones from a printed copy of figure 2 in the FHWA report by Driscoll and others (1990a). All files in the "gisdata" and "gisimage" directories that pertain to this data set have filenames that begin with "rz9."

Fifteen Rain-Zone Regions (rz15)

Fifteen rain-zone regions are listed by the USEPA (1992) for use in planning and interpreting sampling efforts for the NPDES stormwater program (fig. 3). Regions were based on precipitation event statistics including the mean annual number of storms and total precipitation as well as mean annual values of the total storm volume, intensity, duration and interval between storm midpoints table 3. The boundaries of these rain zones were digitized from a printed copy of exhibit 2-8 in the NPDES storm water sampling guidance document (USEPA, 1992). All files in the "gisdata" and "gisimage" directories that pertain to this data set have filenames that begin with "rz15."

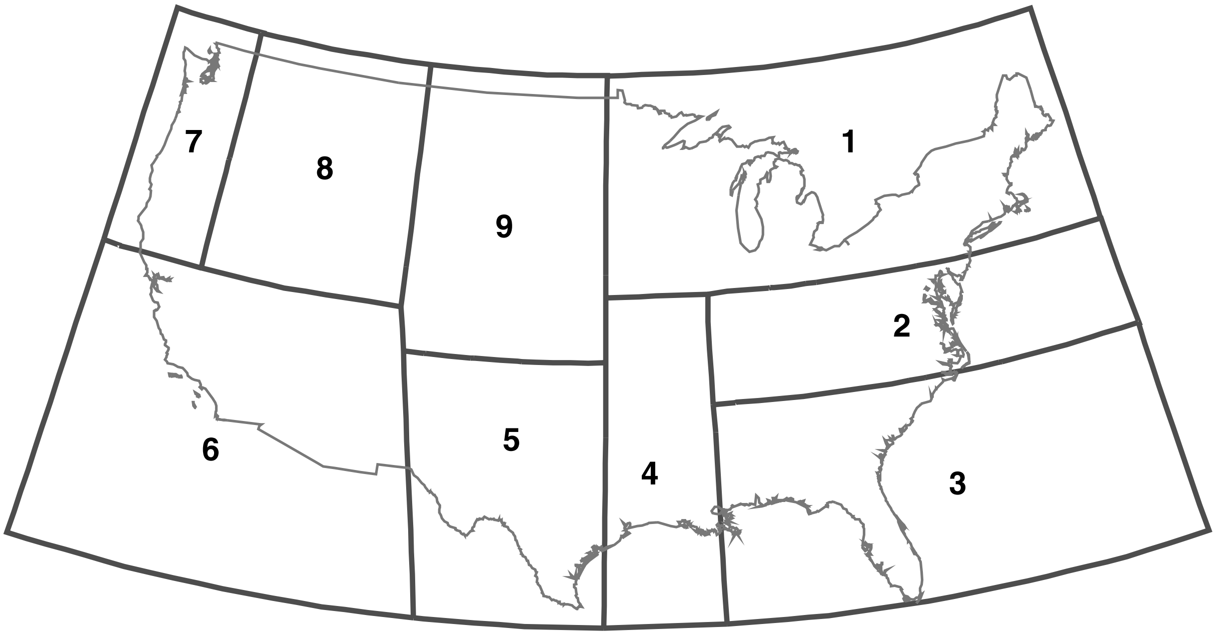

Figure 2. Nine rain zones in the conterminous United States (modified from Driscoll and others, 1990a).

Table 2. Precipitation event statistics for the nine rain zones in the conterminous United States

[From Driscoll and others (1990a). CVDP, coefficient of variation for the mean duration per event; CVIP, coefficient of variation for the mean intensity per event; CVTP, coefficient of variation for the mean time between storm midpoints per event; CVVP, coefficient of variation for the mean volume per event; MDP, mean duration per event; MIP, mean intensity per event; MTP, mean time between storm midpoints per event; MVP, mean volume per event; No., number; hr, hour; in., inch; in/hr, inches/hour]

Zone No.	Volume		Intensity		Duration		Interval	
	MVP (in.)	CVVP	MIP (in/hr)	CVIP	MDP (hr)	CVDP	MTP (hr)	CVTP
1	0.26	1.46	0.051	1.31	5.8	1.05	73	1.07
2	.36	1.45	.066	1.32	5.9	1.05	77	1.05
3	.49	1.47	.102	1.28	6.2	1.22	89	1.05
4	.58	1.46	.097	1.35	7.3	1.17	89	1.00
5	.33	1.74	.080	1.37	4.0	1.07	108	1.41
6	.17	1.51	.045	1.04	3.6	1.02	277	1.48
7	.48	1.61	.024	.84	20.0	1.23	101	1.21
8	.14	1.42	.031	.91	4.5	.92	94	1.39
9	.15	1.77	.036	1.35	4.4	1.20	94	1.24

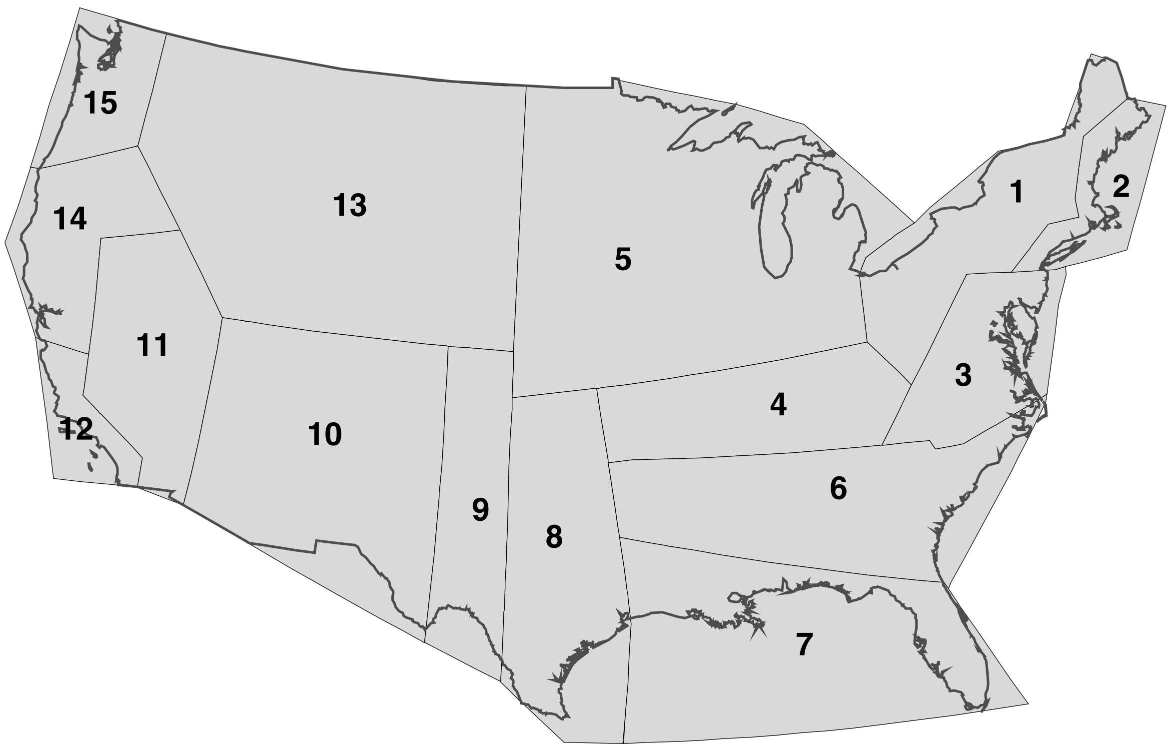

Figure 3. Fifteen rain zones in the conterminous United States (modified from USEPA, 1992).

Table 3. Precipitation event statistics for the 15 rain zones in the conterminous United States

[From USEPA (1992). COV, coefficient of variation (the standard deviation divided by the mean); CVDP, coefficient of variation for the mean duration per event; CVIP, coefficient of variation for the mean intensity per event; CVTP, coefficient of variation for the mean time between storm midpoints per event, CVVP, coefficient of variation for the mean volume per event; MIP, mean intensity per event; MDP, mean duration per event; MTP, mean time between storm midpoints per event; MVP, mean volume per event; No., number; hr, hour; in., inch; in/hr, inches/hour]

Zone		Annual number of storms		Annual precipitation		Volume		Intensity		Duration		Interval	
No.	Name	Mean	COV	Mean (in.)	COV	MVP (in.)	CVVP	MIP (in/hr)	CVIP	MDP (hr)	CVDP	MTP (hr)	CVTP
1	North East	70	0.13	34.6	0.18	0.50	0.95	0.067	1.23	11.2	0.81	126	0.94
2	North East Coastal	63	.12	41.4	.21	.66	1.03	.071	1.05	11.7	.77	140	.87
3	Midatlantic	62	.13	39.5	.18	.64	1.01	.092	1.20	10.1	.84	143	.97
4	Central	68	.14	41.9	.19	.62	1.00	.097	1.09	9.2	.85	133	.99
5	North Central	55	.16	29.8	.22	.55	1.01	.087	1.20	9.5	.83	167	1.17
6	Southeast	65	.15	49.0	.20	.75	1.10	.122	1.09	8.7	.92	136	1.03
7	East Gulf	68	.17	53.7	.23	.80	1.19	.178	1.03	6.4	1.05	130	1.25
8	East Texas	41	.22	31.2	.29	.76	1.18	.137	1.08	8.0	.97	213	1.28
9	West Texas	30	.27	17.3	.33	.57	1.07	.121	1.13	7.4	.98	302	1.53
10	Southwest	20	.30	7.4	.37	.37	.88	.079	1.16	7.8	.88	473	1.46
11	West Inland	14	.38	4.9	.43	.36	.87	.055	1.06	9.4	.75	786	1.54
12	Pacific South	19	.36	10.2	.42	.54	.98	.054	.76	11.6	.78	476	2.09
13	Northwest Inland	31	.23	11.5	.29	.37	.93	.057	1.20	10.4	.82	304	1.43
14	Pacific Central	32	.25	18.4	.33	.58	1.05	.048	.85	13.7	.80	265	2.00
15	Pacific Northwest	71	.15	35.7	.19	.50	1.09	.035	.73	15.9	.80	123	1.50

Mean Annual Precipitation Regions (prcp)

The 9- and 15-rain zone precipitation maps are generalized representations of the potential for intersite variability from region to region. Detailed spatial estimates of mean annual precipitation, however, indicate the potential for substantial intersite variability in precipitation statistics within the more generalized precipitation regions (fig. 4). There are 3,375 regions classified by eight total precipitation intervals (table 4), which are embedded in the coverage. All files in the "gisdata" and "gisimage" directories that pertain to this data set have filenames that begin with "prcp."

Table 4. Intervals used for contours of mean annual precipitation in the conterminous United States

[Interpolated from point data from the Oregon Climate Service (1998)]

Precipitation intervals	Mean annual precipitation (centimeters)	Mean annual precipitation (inches)
1	0–20	0 ~ 7.8
2	>20–40	>7.8 ~ 15.7
3	>40–60	>15.7 ~ 23.6
4	>60–80	>23.6 ~ 31.5
5	>80–120	>31.5 ~ 47.2
6	>120–160	>47.2 ~ 63.0
7	>160–200	>63.0 ~ 78.7
8	Over 200	Over 78.7

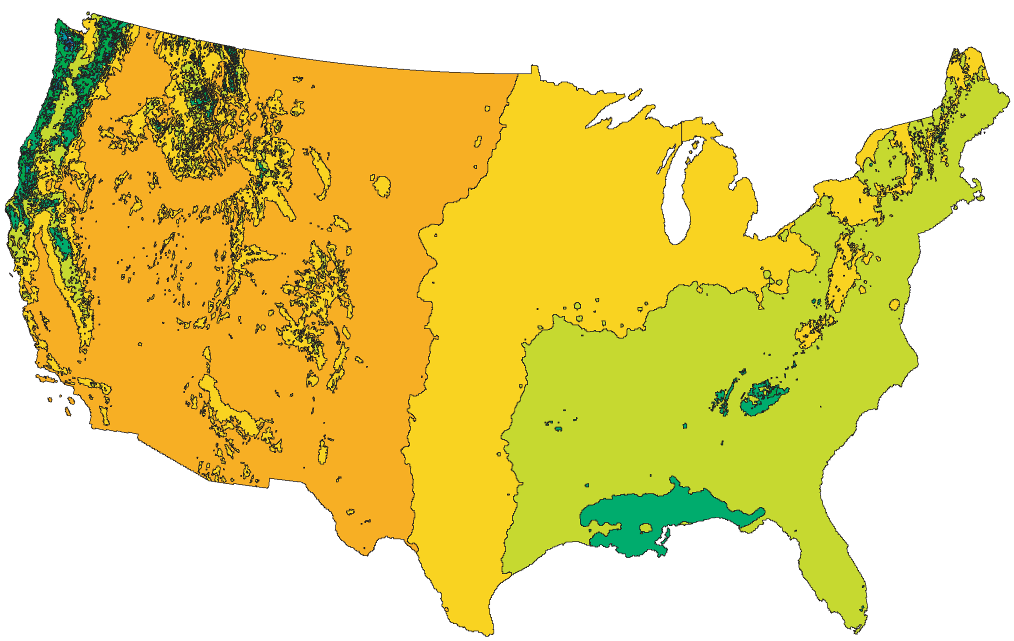

Figure 4. Mean annual precipitation in the conterminous United States, 1961–90 (data from the Oregon Climate Service, 1998).

Mean Annual Snowfall Regions (snow)

The regional estimates of mean annual snowfall indicate the potential for variability in site climate across the conterminous United States (fig. 5). Driscoll and others (1990a,b) discovered that the populations of event mean concentrations of constituents in highway runoff were significantly different for snow events than for rain events. There are 6,271 regions classified by eight total precipitation intervals (table 5), which are embedded in the coverage. All files in the "gisdata" and "gisimage" directories that pertain to this data set have filenames that begin with "snow."

Table 5. Intervals used for contours of mean annual snowfall in the conterminous United States

[Interpolated from point data from the Oregon Climate Service (1998)]

Precipitation intervals	Mean annual precipitation (centimeters of snow)	Mean annual precipitation (inches of snow)
1	0–50	0 ~ 19.6
2	>50–100	>19.6 ~ 39.3
3	>100–250	>39.3 ~ 98.4
4	>250–500	>98.4 ~ 196
5	>500–1,000	>196 ~ 393
6	>1,000–1,500	>393 ~ 590
7	>1,500–2,000	>590 ~ 787
8	Over 2,000	Over 787

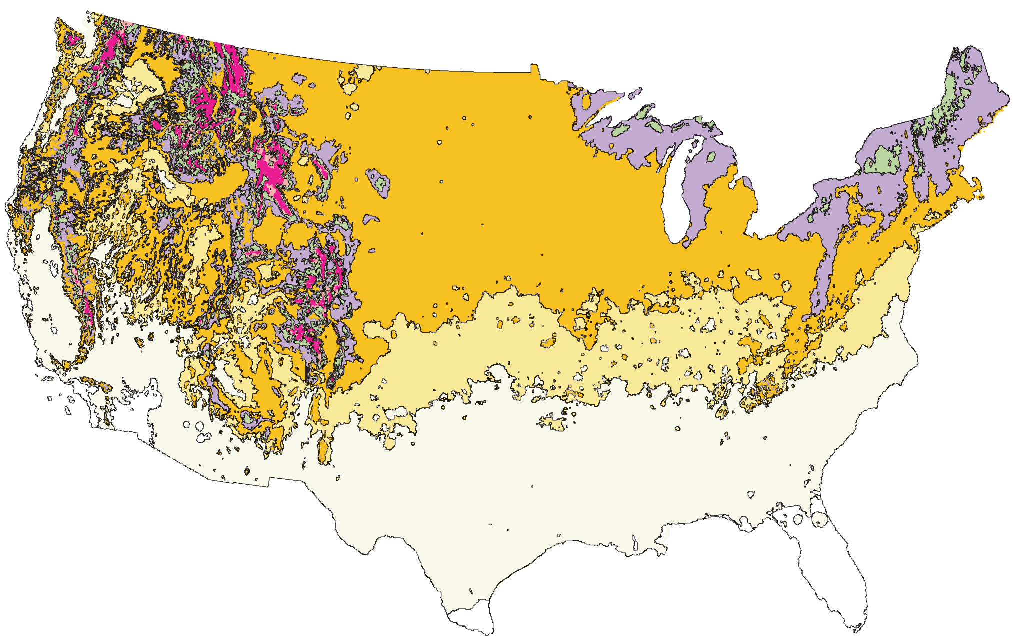

Figure 5. Mean annual snowfall in the conterminous United States, 1961–90 (data from the Oregon Climate Service, 1998).

Mean Annual Temperature Regions (tmpc)

The regional estimates of mean annual temperature also indicate the potential for variability in site climate across the conterminous United States (fig. 6). Spatial variations in mean annual temperature may affect the quality of runoff and effect of the runoff on receiving waters in different regions. Local temperature characteristics will influence factors such as the amount of deicing chemicals used, the rate of volatilization of organic chemicals, microbiological reaction rates, and the solubility of dissolved oxygen in the water column. There are 1,145 regions classified by six total temperature intervals (table 6), which are embedded in the coverage. All files in the "gisdata" and "gisimage" directories that pertain to this data set have filenames that begin with "tmpc."

Table 6. Intervals used for contours of mean annual temperature in the conterminous United States

[Interpolated from point data from the Oregon Climate Service (1998)]

Temperature intervals	Mean monthly temperature (degrees Celsius)	Mean monthly temperature (degrees Fahrenheit)
1	-5–0	23–32
2	>0–5	>32–41
3	>5–10	>41–50
4	>10–15	>50–59
5	>15–20	>59–68
6	Over 20	Over 68

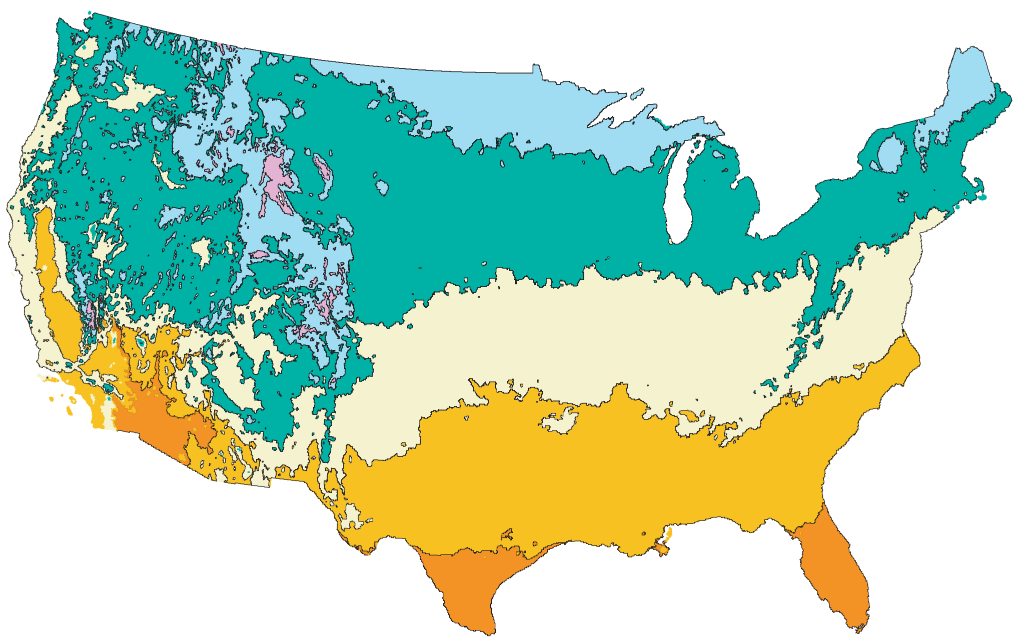

Figure 6. Mean annual temperatures in the conterminous United States, 1961–90 (data from the Oregon Climate Service, 1998).

Mean Annual Streamflow Estimates (strmf)

Driscoll and others (1990a,b) used the mean annual streamflow estimates (fig. 7) to assess potential dilution in receiving waters. Regions were based on areas with similar mean annual flow rates, which are represented by 30 unique polygons that are separated into 18 ranges, from 0.05 to 5.0 cubic feet per second per square mile of drainage area (Driscoll and others, 1990a). Each zone in the coverage is named by their respective streamflow values, which are listed in table 7 along with the number of unique polygons represented by each interval. The boundaries of these streamflow regions were digitized from a printed copy of figure 3 in the FHWA report by Driscoll and others (1990a). All files in the "gisdata" and "gisimage" directories that pertain to this data set have filenames that begin with "strmf."

Table 7. Intervals of mean annual streamflow rate in the conterminous United States and the number of unique polygons represented by each interval

[Map from Driscoll and others (1990a). Streamflow rate intervals in cubic feet per second per square mile of drainage area. No., number]

Interval No.	Streamflow rate intervals	Number of unique polygons
1	0.05	3
2	.1	1
3	.3	2
4	.4	1
5	.5	2
6	.6	1
7	.7	2
8	.8	1
9	1.0	5
10	1.1	1
11	1.2	1
12	1.4	2
13	1.5	1
14	1.7	2
15	1.9	1
16	2.0	2
17	4.0	1
18	5.0	1

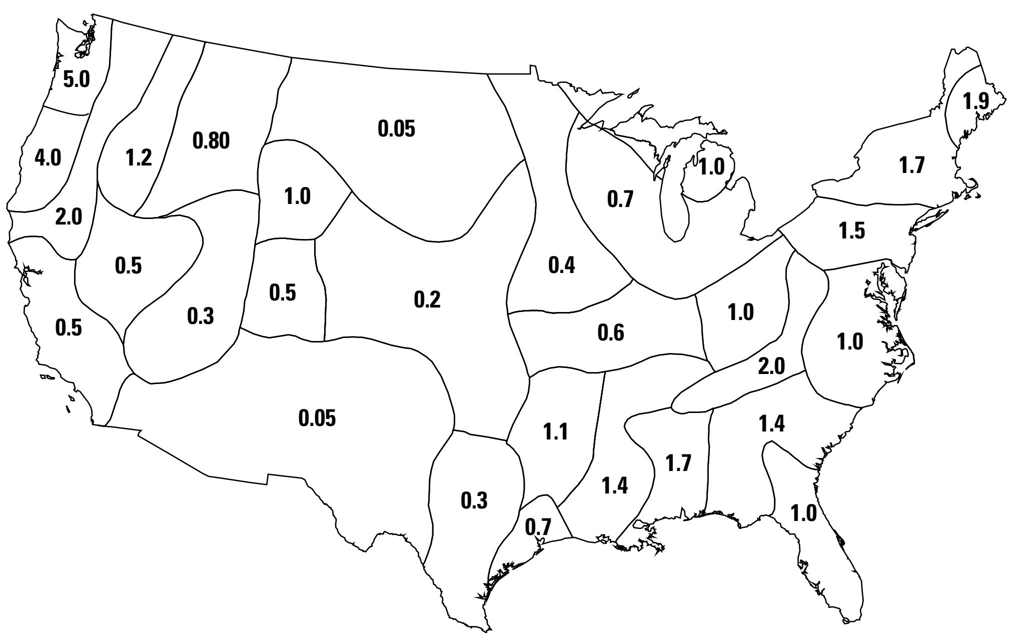

Figure 7. Regions of the conterminous United States with similar mean annual flow rates in cubic feet per second per square mile of drainage area (modified from Driscoll and others, 1990a).

Total Hardness Regions (hard)

Driscoll and others (1990a,b) used regional estimates of total hardness of surface waters to assess potential ecological effects of metals in receiving waters (fig. 8). Regions were based on areas with similar total hardness, expressed as calcium carbonate in parts per million (Driscoll and others,1990a). There are 23 regions classified by six total hardness intervals (table 8). The boundaries of these hardness regions were digitized from a printed copy of figure 4 in the FHWA report by Driscoll and others (1990a). All files in the "gisdata" and "gisimage" directories that pertain to this data set have filenames that begin with "hard."

Table 8. Intervals of total hardness of surface waters of the conterminous United States and the number of unique polygons represented by each interval

[Map from Driscoll and others (1990a). Total hardness intervals in parts per million as calcium carbonate]

Total hardness regions	Total hardness intervals as calcium carbonate	Number of unique polygons
1	Under 60	4
2	60 – <120	11
3	120 – <180	2
4	180 – <240	3
5	Over 240	4

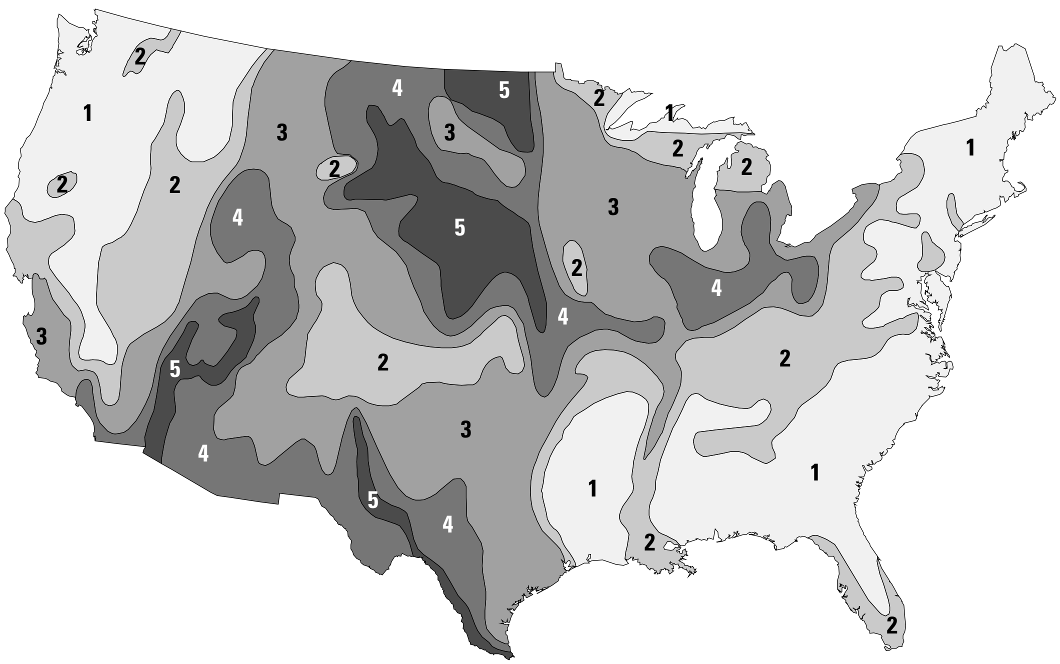

Figure 8. Regions of the conterminous United States with similar total surface-water hardness concentrations (modified from Driscoll and others, 1990a).

EcoRegions (ecoz)

Ecological regions are used to form the basis for natural resource planning and management activities such as delineating ecosystems, assessing resources, conducting environmental analyses, establishing desired future conditions, and managing and monitoring natural resources (Omernik, 1987; Bailey and others, 1994). An assessment of the potential effects of highway runoff on aquatic life and receiving waters has been identified as a primary runoff-quality research need (Transportation Research Board, 1997). Information about ecoregions (fig. 9) is, therefore, provided with the geodata products to offer a national perspective on ecological resource regions that may respond differently to a given contaminant load from a typical highway.

Ecological mapping teams of the U.S. Forest Service, USGS, and USEPA delineated the national-scale map published in the public domain by Bailey and others (1994). Ecological regions on the map are designed to group areas with similar (1) potential natural communities, (2) soils, (3) hydrologic function, (4) landform, (5) lithology, (6) climate, and (7) natural processes for cycling plant biomass and nutrients (Bailey, 1989, Bailey and others, 1994). The map was designed with the assumption that climate governs energy and moisture gradients, thereby acting as the primary control over more localized ecosystems. The ecology of receiving waters is integrated with the characteristics of the surrounding watershed through the processes of runoff, sedimentation, and migration of biotic material and chemical constituents. Aquatic sys-

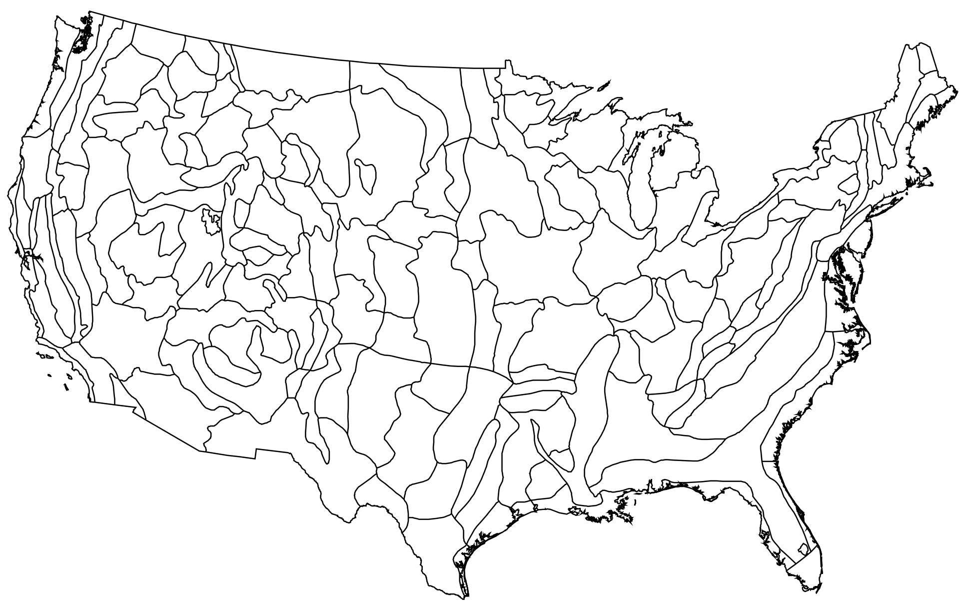

Figure 9. Ecoregions (Bailey, 1989) of the conterminous United States (data from USEPA, 1999).

tems delineated in this indirect way have many characteristics in common, including hydrology and biota, because of this interdependence of geographical components in the surrounding watershed (Frissell and others, 1986). Therefore, the potential effects of highway catchments may be examined within the context of the local watershed and the regional ecological characteristics.

There are 330 polygons (regions) classified by ecological domain, division, province, and section in the ecoregion map by Bailey and others (1994), which are defined within the GIS coverages. Originally, the boundaries of these regions were digitized from a full-scale printed copy of the ecoregions map (Bailey and others, 1994) by the NDAMS project. Later, however, a more precise electronic reproduction was made available on the World Wide Web by the USEPA (1999), and this version is included on this disk. The USEPA version was reformatted by the NDAMS project to provide the information in all the common GIS and image file formats. All files in the "gisdata" and "gisimage" directories that pertain to this data set have filenames that begin with "ecoz."

SUMMARY

Geographic information systems (GIS) facilitate interpretation and integration of spatial data on a regional or national scale with respect to local water-quality data and supporting information. The geographic information and data compiled for the conterminous United States during the National Highway Runoff Water-Quality Data and Methodology Synthesis (NDAMS) project is described in this document. The GIS data was compiled to facilitate examination of available highway runoff water-quality data in a regional and national context. It is hoped that the availability of these GIS products will facilitate current and future efforts by highway engineers, planners, and decision makers who must examine highway and urban runoff quantity in terms of the potential for adverse effects on the environment.

This document includes information on the directory structure, file types, and the geographic information in the data files. A "geodata" directory on the CD-ROM is organized into two subdirectories "gisdata" and "gisimage." The "gisdata" directory contains ArcInfo coverages, ArcInfo export files, shapefiles (used in ArcView), and Spatial Data Transfer Standard--SDTS—Topological Vector Profile format files (in respective subdirectories). The "gisimage" directory contains the GIS maps in common image file formats. The GIS data is provided in a number of formats to facilitate use, and to ensure that at least one format will be available in the future. The images are provided so that the user may preview contents of the GIS data files and to facilitate use in word-processing and graphics software.

The spatial geodata includes two rain-zone region maps and a map of national ecosystems originally published by the USEPA; regional estimates of mean annual streamflow, and water hardness as published by the Federal Highway Administration, and maps of mean monthly temperature, mean annual precipitation, and mean monthly snowfall from data published by the national climactic data center and made available to the public by the Oregon Climate Service at Oregon State University. This geographic information was compiled for qualitative spatial analysis of available data on a national and(or) regional scale and therefore should be considered as qualitative representations, not precise geographic location information.

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