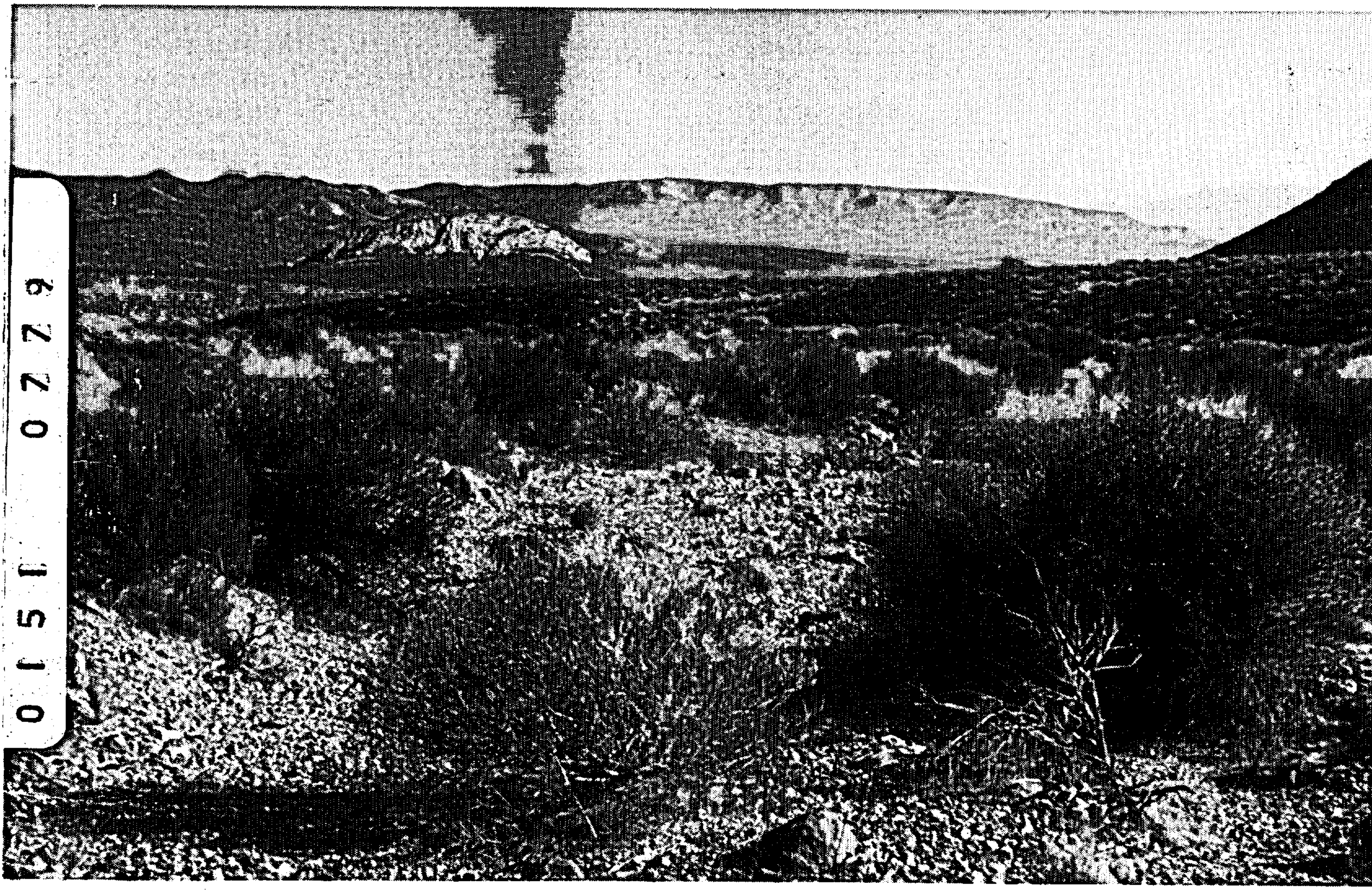
FLOOD POTENTIAL OF FORTYMILE WASH AND ITS PRINCIPAL SOUTHWESTERN TRIBUTARIES, NEVADA TEST SITE, SOUTHERN NEVADA



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 83-4001

Prepared in cooperation with the

U.S. DEPARTMENT OF ENERGY

Flood Potential Of Fortymile Wash And Its Principal Southwestern Tributaries, Nevada Test Site, Southern Nevada

By Robert R. Squires and Richard L. Young

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 83-4001

Prepared in cooperation with the
U.S. DEPARTMENT OF ENERGY

Carson City, Nevada
1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

U.S. Geological Survey
Room 227, Federal Building
705 North Plaza Street
Carson City, NV 89701

Copies of this report may be purchased from:

Open-File Services Section
U.S. Geological Survey
Box 25425, Federal Center
Denver, CO 80225

Call (303) 234-5888 for ordering information

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS AND ABBREVIATIONS

Inch-pound units of measure used in this report may be converted to International System (metric) units by using the following factors:

Multiply	*By*	*To obtain*
Cubic feet per second (ft^3/s)	0.02832	Cubic meters per second (m^3/km)
Cubic feet per second per square mile [$(ft^3/s)/mi^2$]	0.01093	Cubic meters per second per square kilometer [$(m^3/s)/km^2$]
Feet (ft)	0.3048	Meters (m)
Feet per second (ft/s)	0.3048	Meters per second (m/s)
Inches (in.)	25.40	Millimeters (mm)
Miles (mi)	1.609	Kilometers (km)
Square feet (ft^2)	0.0929	Square meters (m^2)
Square miles (mi^2)	2.590	Square kilometers (km^2)

Temperatures may be converted from degrees Fahrenheit (°F) to degrees Celsius (°C) by using the following equation: $°C = 0.5556\ (°F - 32)$.

ALTITUDE DATUM

The term "National Geodetic Vertical Datum of 1929" (abbreviation, NGVD of 1929) replaces the formerly used term "mean sea level" to describe the datum for altitude measurements. The NGVD of 1929 is derived from a general adjustment of the first-order leveling networks of both the United States and Canada. For convenience in this report, the datum also is referred to as "sea level."

FLOOD POTENTIAL OF FORTYMILE WASH AND ITS PRINCIPAL SOUTHWESTERN TRIBUTARIES, NEVADA TEST SITE, SOUTHERN NEVADA

By Robert R. Squires and Richard L. Young

ABSTRACT

Flood hazards for a 9-mile reach of Fortymile Wash and its principal southwestern tributaries--Busted Butte, Drill Hole, and Yucca Washes--were evaluated to aid in determining possible sites for the storage of high-level radioactive wastes on the Nevada Test Site.

Data from 12 peak-flow gaging stations adjacent to the Test Site were used to develop regression relations that would permit an estimation of the magnitude of the 100- and 500-year flood peaks (Q_{100} and Q_{500}), in cubic feet per second. The resulting equations are:

$$Q_{100} = 482A^{0.565} \text{ and } Q_{500} = 2,200A^{0.571},$$

where A is the tributary drainage area, in square miles. The estimate of the regional maximum flood was based on data from extreme floods elsewhere in Nevada and in surrounding states.

Among seven cross sections on Fortymile Wash, the estimated maximum depths of the 100-year, 500-year, and regional maximum floods are 8, 11, and 29 feet, respectively. At these depths, flood water would remain within the deeply incised channel of the wash. Mean flow velocities would be as great as 9, 14, and 28 feet per second for the three respective flood magnitudes.

The study shows that Busted Butte and Drill Hole Washes (9 and 11 cross sections, respectively) would have water depths of up to at least 4 feet and mean flow velocities of up to at least 8 feet per second during a 100-year flood. A 500-year flood would exceed stream-channel capacities at several places, with depths to 10 feet and mean flow velocities to 11 feet per second. The regional maximum flood would inundate sizeable areas in central parts of the two watersheds.

At Yucca Wash (5 cross sections), the 100-year, 500-year, and regional maximum floods would remain within the stream channel. Maximum flood depths would be about 5, 9, and 23 feet and mean velocities about 9, 12, and 22 feet per second, respectively, for the three floods.

Estimated peak discharges at the farthest downstream cross sections in the study area are as follows:

Wash	Drainage area (square miles)	Peak flood discharge (cubic feet per second)		
		100-year	500-year	Regional maximum
Fortymile	312	12,000	58,000	540,000
Busted Butte	6.6	1,400	6,500	44,000
Drill Hole	15.4	2,300	10,000	86,000
Yucca	16.6	2,400	11,000	92,000

INTRODUCTION

Engineering and environmental studies on the Nevada Test Site and vicinity are being made by the U.S. Geological Survey to aid in determining possible sites for the storage of high-level radioactive wastes. Knowledge of flood potential is necessary in planning the location of a storage facility because of the risk of (1) flood damage to the facility itself and (2) flood transport of radioactive materials away from the facility. The study discussed in this report was made to locate and delineate floodflow boundaries in the Yucca Mountain area, a candidate site. Specifically, the study dealt with the three eastward drainages from Yucca Mountain to Fortymile Wash and a 9-mile reach of the wash from a point 1-1/2 miles upstream from the uppermost of the three tributaries to a point 2-1/2 miles downstream from the lowermost tributary (figure 1).

This study was made in cooperation with the U.S. Department of Energy through an interagency agreement (DE-A108-78ET44802). The work was supported by the Department of Energy's Nevada Nuclear Waste Storage Investigations Project.

Other related studies within this area include a preliminary assessment of the seismic hazards of the Nevada Test Site region by Rogers and others (1977) and an evaluation of the topographic, geomorphic, and geologic features of the southwestern part of the Test Site by Hoover and others (1978). In addition, a report by Christensen and Spahr (1980) defines flood boundaries in the Topopah Wash drainage adjacent to and east of Fortymile Wash.

Purpose of Study

The purpose of the study discussed herein was to provide information regarding the probable characteristics of the 100-year, 500-year, and regional maximum floods and the resulting areas of probable inundation along Fortymile Wash and its southwestern tributaries. The study and the resulting report have three specific objectives:

1. Identify reaches of Fortymile Wash and its three southwestern tributaries where flooding could affect potential waste-disposal facilities in the study area;

2. Estimate the peak flow magnitudes, average flow velocities, and depths that might be expected during the 100-year, 500-year, and regional maximum floods; and

3. Determine maximum flood-inundation limits that may be expected during those floods.

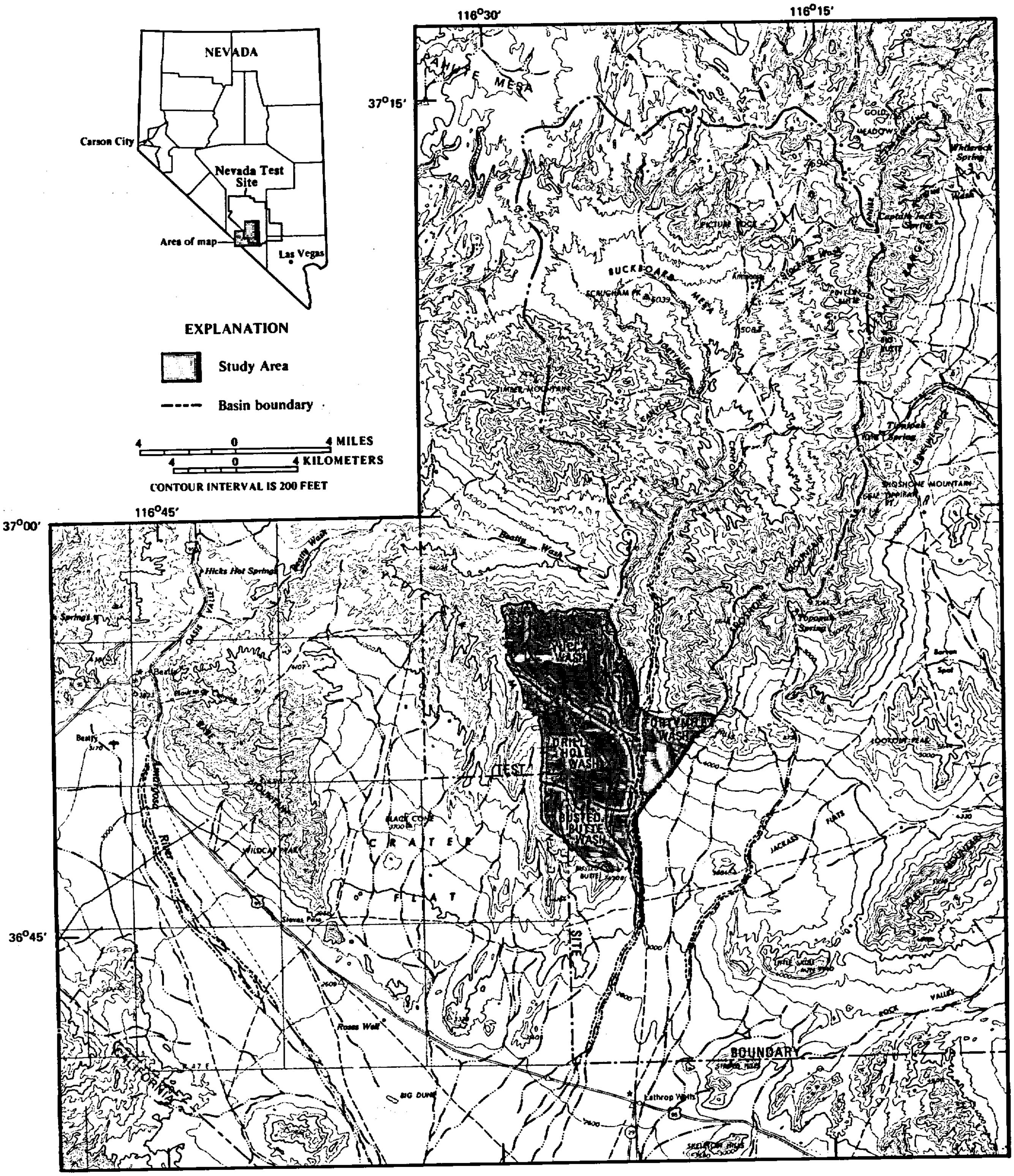
Description of Study Area

Fortymile Wash is the major drainage channel in the western part of the Nevada Test Site. The drainage area tributary to Fortymile Wash is bordered by Yucca Mountain on the southwest, Timber Mountain on the northwest, Pahute Mesa on the north, Shoshone Mountain on the east and northeast, and Jackass Flats on the southeast (figure 1). The wash and its tributaries are normally dry streambeds that contain flow only after rainstorms or during snowmelt.

The study area covers only part of the Fortymile Wash drainage (figure 1). In this area, the wash has three major tributaries that locally are called Busted Butte Wash, Drill Hole Wash, and Yucca Wash, in order from south to north. All three flow southeasterly and join Fortymile Wash at distances of about 10, 12, and 15 miles upstream from U.S. Highway 95. Fortymile Wash drains southward to join the Amargosa River southwest of Lathrop Wells, Nev. Within the study area, altitudes range from about 6,700 feet above sea level at the headwaters of the Yucca Wash tributary to about 3,010 feet where Fortymile Wash leaves the study area.

Surveyed cross sections on Forytmile Wash are numbered FM-1 through FM-7 (plate 1). The tributary cross sections are numbered BB-1 through BB-9 on Busted Butte Wash, DH-1 through DH-11 on Drill Hole Wash, and Y-1 through Y-5 on Yucca Wash. Figure 2 shows longitudinal profiles of the main drainage channels within the study area.

The channel of Fortymile Wash within the study area is well defined and is incised to a depth ranging from 50 to 70 feet; the bed of the wash is 1,000 to 1,500 feet wide. An ephemeral stream course meanders across the channel between the walls of the wash. At cross-section FM-7, the channel bed is comprised of boulders and coarse gravel; downstream, the grain size gradually decreases to mostly gravel and sand at cross-section FM-1.



Base from U.S. Geological Survey
Goldfield 1:250,000, 1962, and
Death Valley 1:250,000, 1966

FIGURE 1.--Location of Fortymile Wash and the study area.

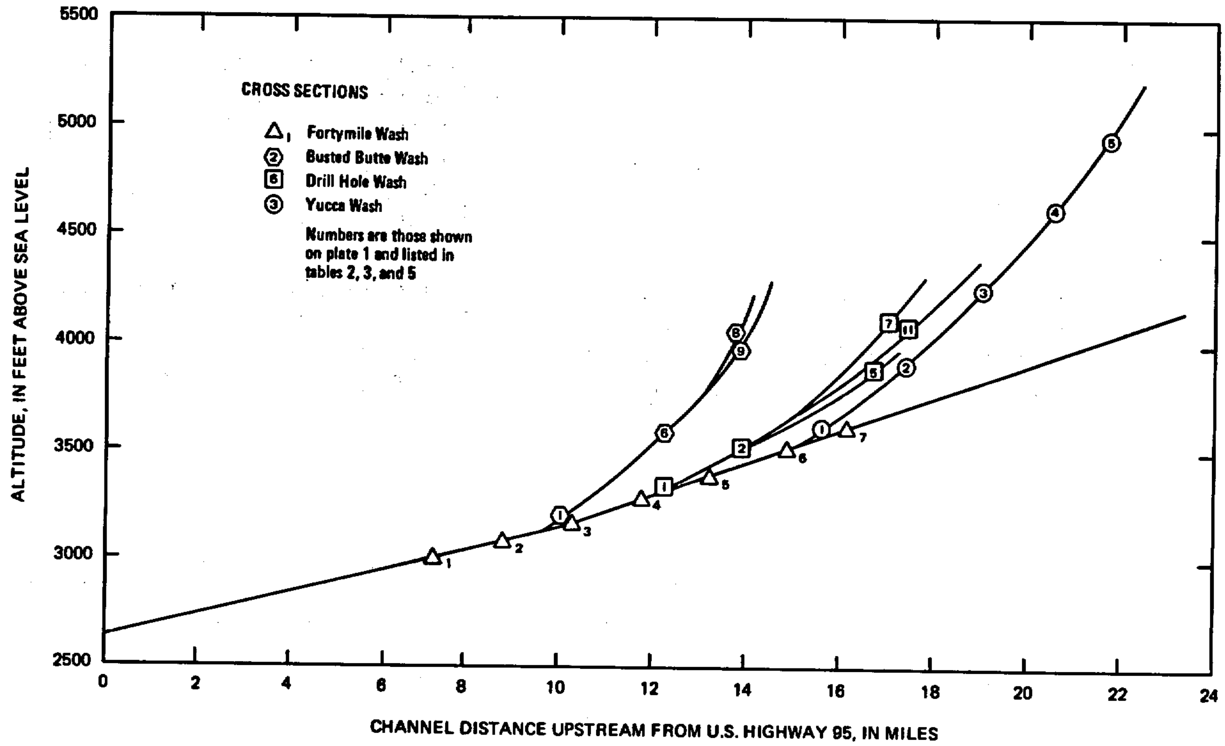


FIGURE 2.--Longitudinal profiles of main drainage channels in the study area.

The physiography of the Busted Butte Wash drainage varies from a low-gradient valley with meandering ephemeral channels to a deeply incised channel at its junction with Fortymile Wash. Channel deposits are gravel and sand; materials in the headwater area are the coarsest.

The Drill Hole Wash drainage is characterized by deep canyons in the upper reaches. Near the middle part of the basin, the flow channels become generally wide and braided, with poorly defined banks and multiple channels around alluvial islands. During flood flows, the braided channels presumably are unstable, change their alignment rapidly, and carry large quantities of sediment. Near its confluence with Fortymile Wash, the channel of Drill Hole Wash is incised in alluvium within a winding canyon.

The Yucca Wash channel is about 800 feet wide and is incised 45 feet near its confluence with Fortymile Wash; the channel is 350 feet wide and is incised 20 feet about 6 miles upstream, at cross-section Y-5. The channel bed comprises boulders and coarse gravel.

Vegetation is generally sparse throughout the study area. Several varieties of sage (generally 1 to 2 feet high), creosote brush (mostly 2 to 4 feet high), and other desert vegetation predominate. General views of vegetation and channel character in the basins are shown in figures 3-11.

Climatically, the Nevada Test Site has four well-defined seasons. The summer extends from June to September, with daytime temperatures as high as 110°F. The spring and fall seasons are relatively short, and daytime temperatures are usually in the 70's. In winter, daytime temperatures usually are in the 50's, and night-time lows in January and February are near or below freezing. The average annual daily temperature is about 60°F.

Mean annual precipitation in the study area is only about 4 to 5 inches (Geraghty and others, 1973, plate 2). Despite that fact, flooding--especially the rare torrential runoff events--can be severe. Localized convective-type storms can produce downpours that cause major flash floods.

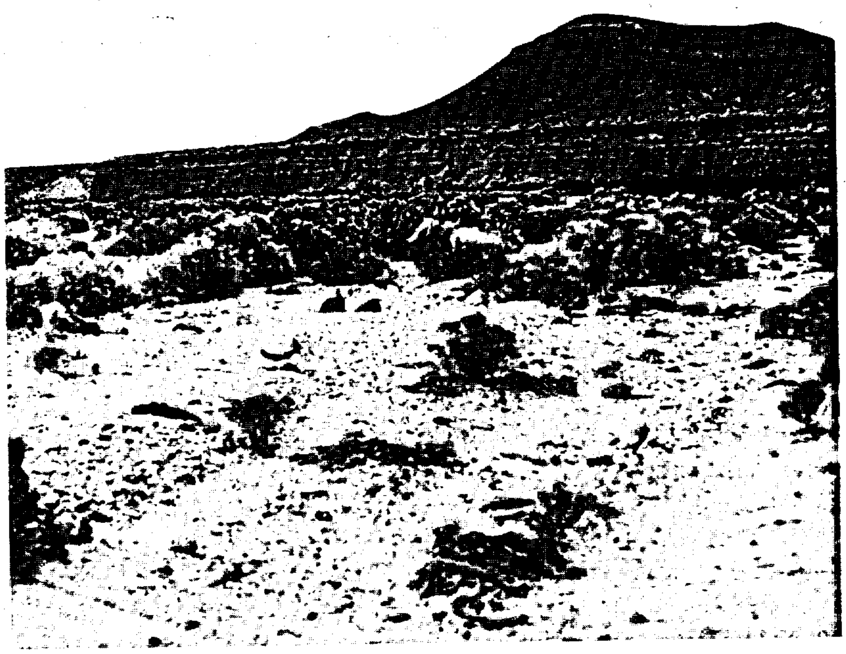


FIGURE 3.--Typical flow channel, streambed material, and vegetation along Fortymile Wash. View is downstream at cross-section FM-4, November 12, 1981.

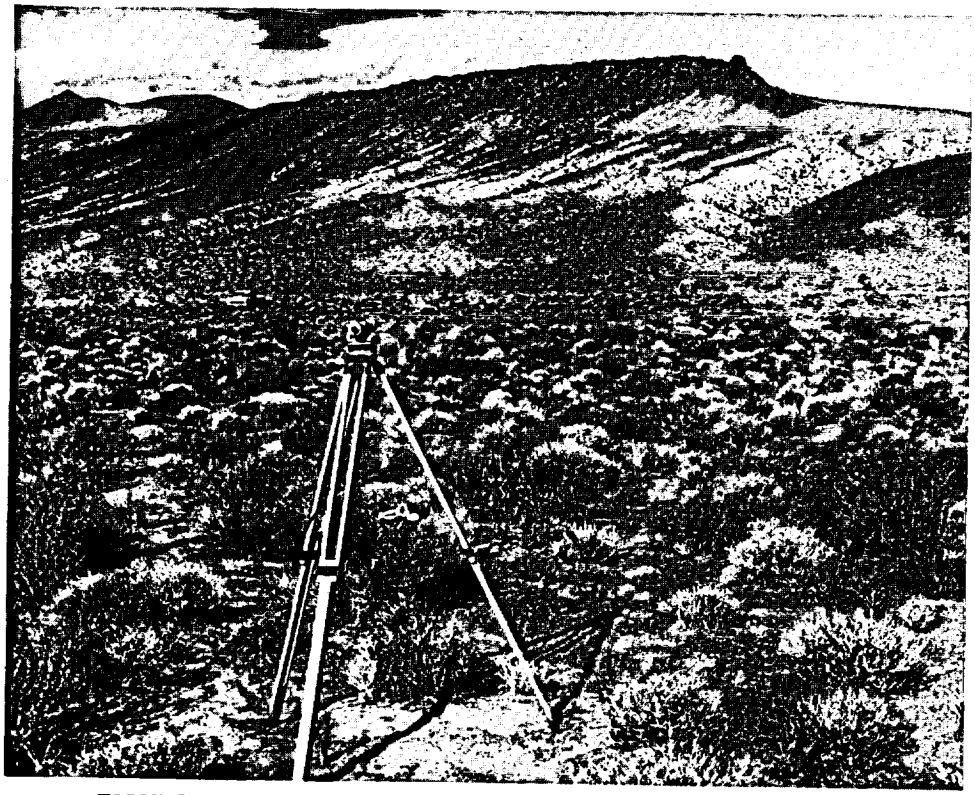


FIGURE 4.--Typical flow channel, streambed material, and vegetation of Busted Butte Wash. View is from right to left at cross-section BB-2, November 16, 1981.

FIGURE 5.--Typical flow channel, streambed material, and vegetation of Busted Butte Wash. View is downstream at cross-section BB-8, November 16, 1981.

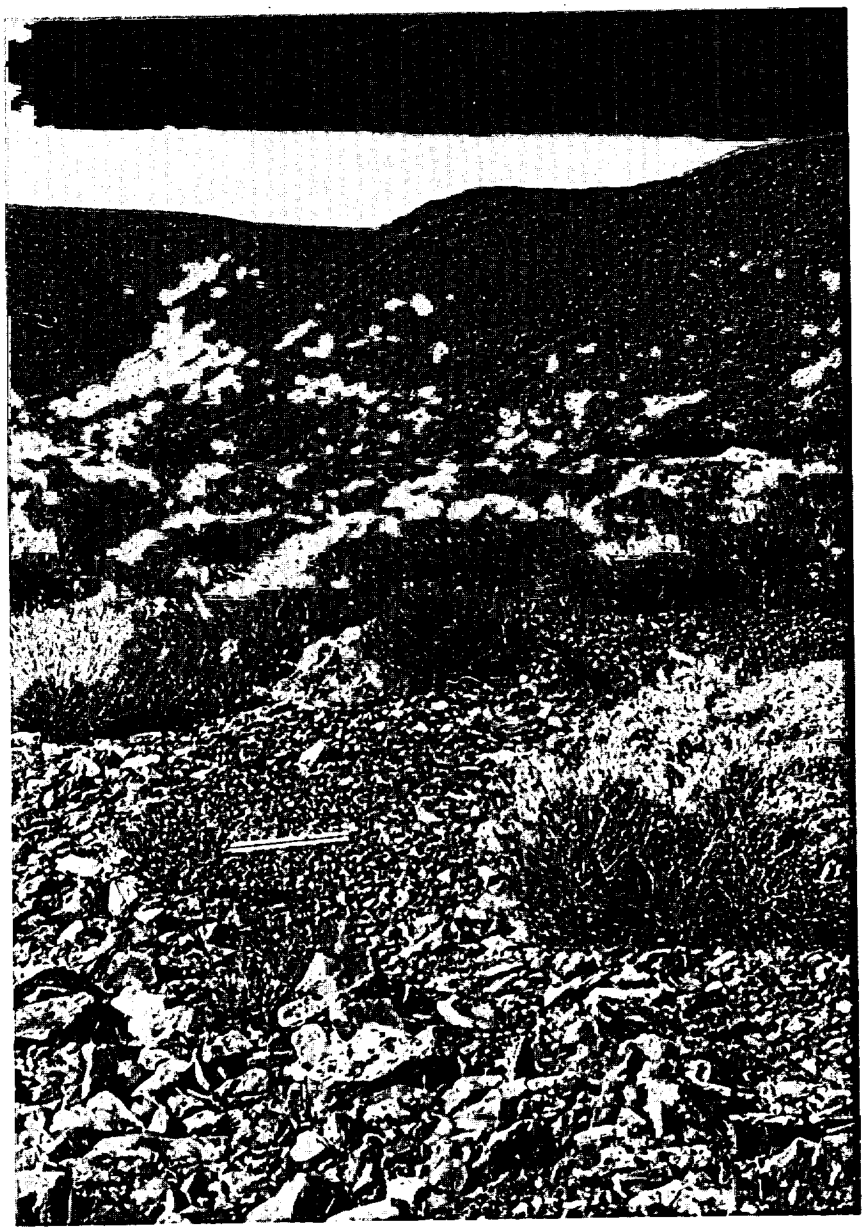


FIGURE 6.--Typical flow channel, streambed material, and vegetation of Busted Butte Wash. View is upstream at cross-section BB-8, November 16, 1981.

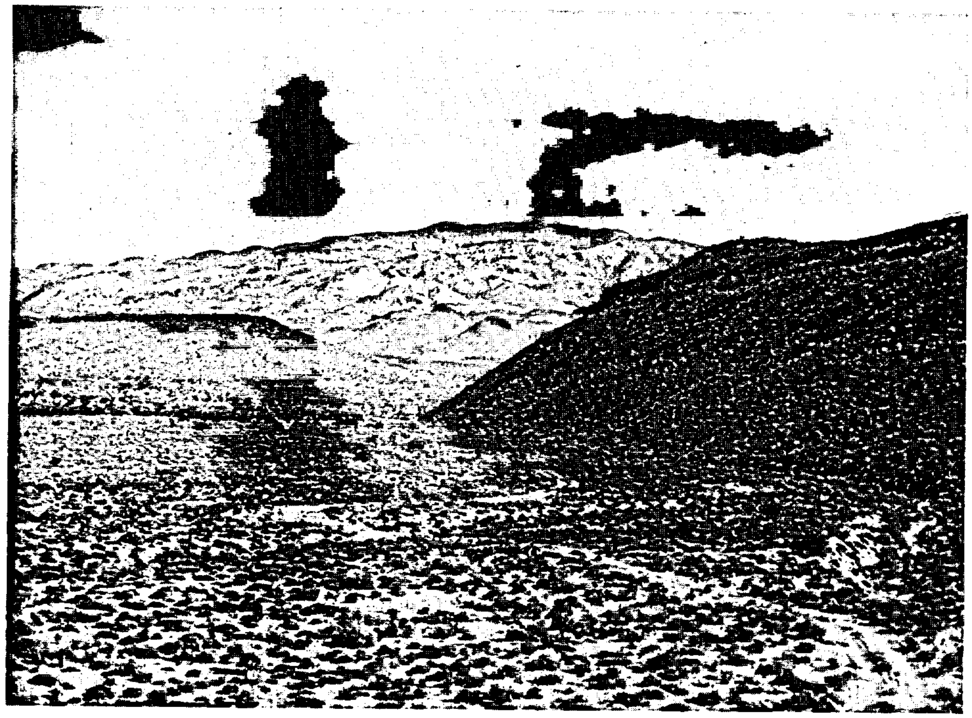


FIGURE 7.–Typical flow channel, streambed material, and vegetation of Drill Hole Wash. View is downstream at cross-section DH-3, November 14, 1981.

FIGURE 8.–Typical flow channel, streambed material, and vegetation of Drill Hole Wash. View is downstream at cross-section DH-6, November 14, 1981.

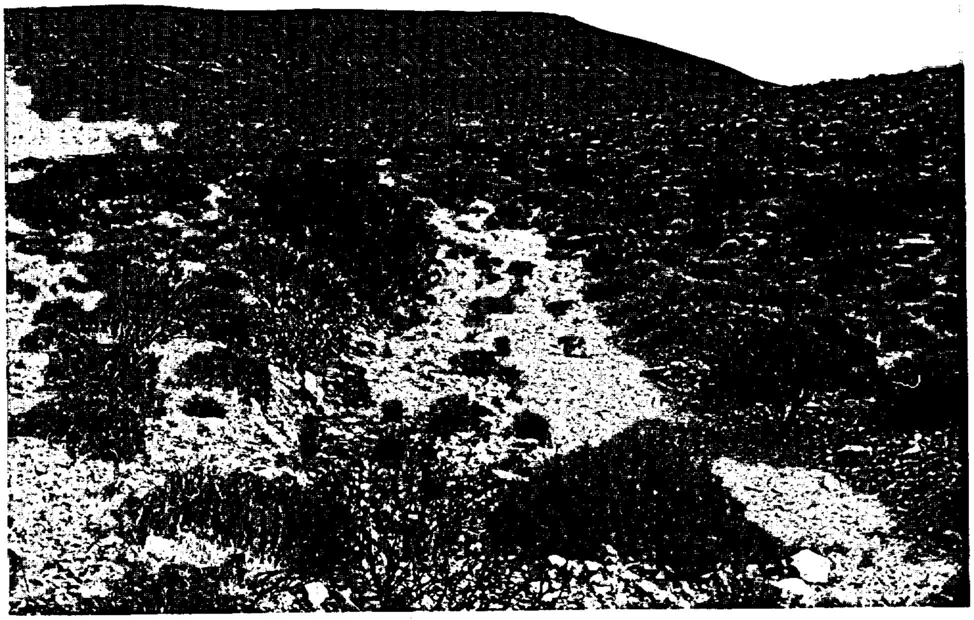


FIGURE 9.--Typical flow channel, streambed material, and vegetation of Drill Hole Wash. View is downstream at cross-section DH-10, November 14, 1981.

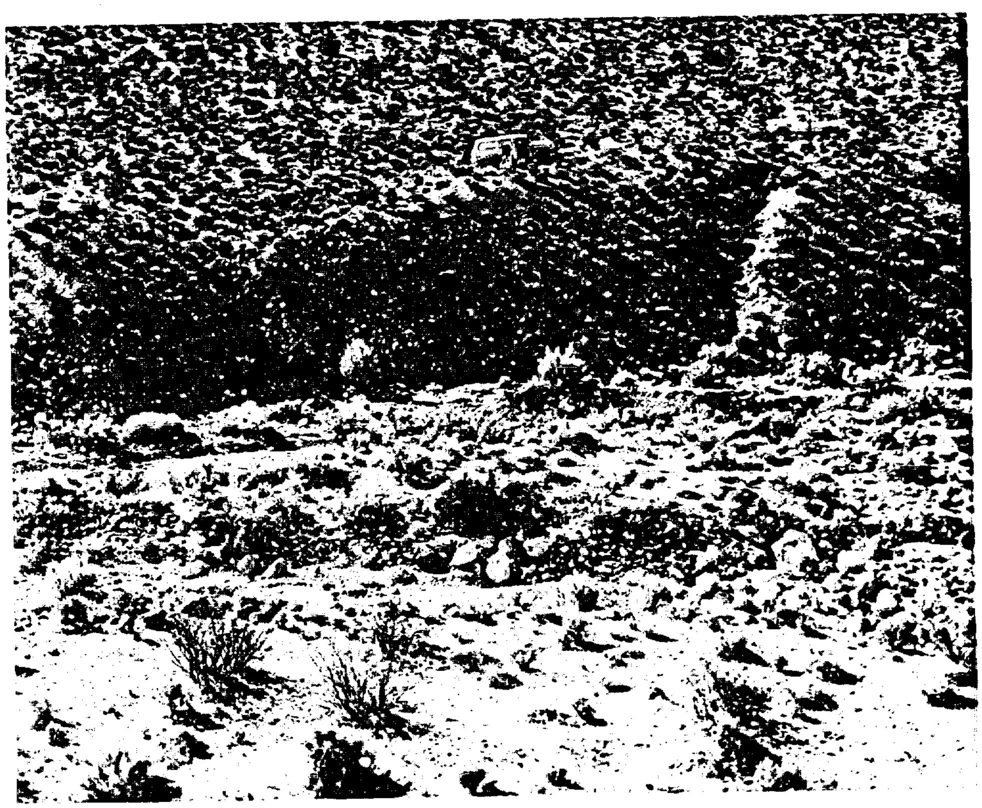


FIGURE 10.--Typical flow channel, streambed material, and vegetation of Yucca Wash. View is left bank to right at cross-section Y-2, November 17, 1981.

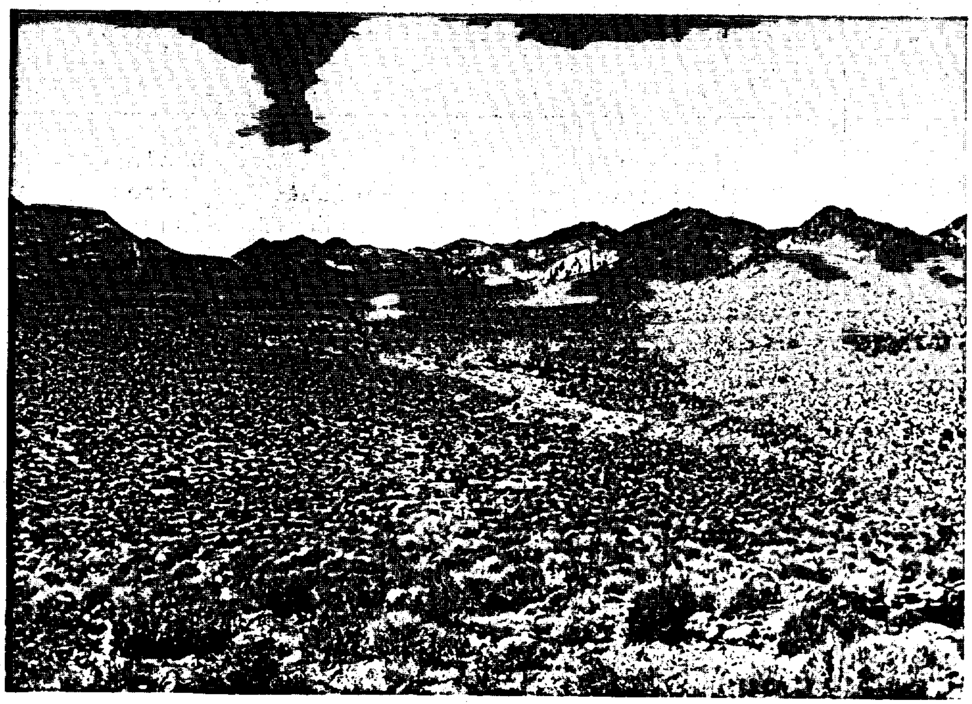


FIGURE 11.– Typical flow channel, streambed material, and vegetation of Yucca Wash. View is upstream at Y-2, November 17, 1981.

Principal Flood Problems

Localized convective-type storms that produce downpours and resulting flash floods can occur at any place in southern Nevada and are likely on Fortymile Wash and its tributaries, according to Darryl Randerson (National Weather Service, oral commun., 1982) and Harold H. Klieforth (Atmospheric Sciences Center, Desert Research Institute, written commun., 1982). Surface-water data on nearby drainages and knowledge of climatic characteristics of the region also indicate that the potential for flooding exists in the study area.

No flood-peak information is known to have been collected prior to this study on Fortymile Wash and its tributaries in the Nevada Test Site. However, the U.S. Geological Survey has systematically collected data on peaks resulting from major floods on many similar ephemeral washes near the Nevada Test Site since the early 1960's. Five of the most notable floods are listed below along with pertinent basin characteristics for comparison.

Site	Maximum discharge (cubic feet per second)	Date	Latitude and longitude	Drainage area (square miles)	Range in altitude (feet above sea level)
Amargosa River tributary near Mercury	3,400	Aug. 1968	36°34' 116°06'	110	3,000-6,080
Amargosa River near Beatty	16,000	Feb. 1969	36°52' 116°46'	470	3,100-7,450
Fortymile Wash near Lathrop Wells[1]	3,300	Feb. 1969	36°40' 116°26'	325	2,700-7,700
California Wash near Moapa	52,000	Aug. 1981	36°33' 114°37'	208	1,700-5,000
Overton Wash near Valley of Fire	24,000	Aug. 1981	36°31' 114°32'	17	1,800-3,280

1 Six miles downstream from study area.

Geomorphic studies on the Nevada Test Site by David L. Hoover (U.S. Geological Survey, oral commun., 1981) have indicated that some of the alluvial surfaces along Fortymile Wash are thousands of years old. Such ages might imply that the surfaces have not been flooded since they were formed several thousand years ago. However, distinct high-water marks were observed along Fortymile Wash in the vicinity of cross-section FM-4 during the current study. From these marks and data on the cross-sectional area and channel slope, a peak flow of about 20,000 ft^3/s is estimated. Documentation of similar flooding in nearby washes indicates that this flood peak probably occurred during February 1969. The remnant high-water marks are unmistakable and indicate that the alluvial surfaces along Fortymile Wash were inundated. The survival of those alluvial surfaces may be explained by an observation of John E. Costa (University of Denver, written commun., 1982) that a flash flood in Colorado during 1976 left high-water marks 5 feet over the top of an old, fine-grained alluvial surface, and the surface was virtually unaffected.

ENGINEERING EVALUATION

Standard hydrologic and hydraulic methods were used to determine areas of potential flood hazard for this study. Floods of a magnitude that is expected to be equaled or exceeded once, on the average, during any 100- or 500-year period (which is known as the recurrence interval) were selected as having special significance for flood-plain management. These magnitudes have a 1- and 0.2-percent chance, respectively, of being equaled or exceeded during any year. The 100- and 500-year floods and the regional maximum flood (discussed below) would pose significant hazards to facilities located in areas of potential inundation.

The recurrence interval is defined specifically as the long-term average interval of time within which a given flood will be equaled or exceeded once (Langbein and Iseri, 1960, page 16). Although the recurrence interval represents the long-term average period between floods of a specific magnitude, extreme floods could occur at short intervals or even within the same year.

The "regional maximum flood" is estimated on the basis of data for floods of unusually large magnitude in a five-State region that includes Fortymile Wash, without reference to recurrence interval (Crippen and Bue, 1977, page 2). The region comprises Arizona, California, Nevada, New Mexico, and Utah.

The analyses reported here reflect flooding potential based on conditions existing in the study area at the time of the field surveys (November 1981). Any future environmental or land-surface changes may affect conclusions presented in this report.

Hydrologic Analyses

The magnitude and frequency of peak discharges for ungaged streams generally are estimated either by applying a synthetic rainfall-runoff relation or by developing statistical relationships between floodflow characteristics and significant characteristics of the basin. Because of a lack of available data for the study area with which to determine adequately (1) the areal distribution of rainfall, (2) the rate at which rainfall will infiltrate into the ground, (3) the magnitude of stream-channel losses, and (4) the proper calibration of a rainfall-runoff model, a synthetic rainfall-runoff relation was not used. Instead, a procedure using a regional analysis of streamflow records was selected to estimate the 100-and 500-year discharges in the study area.

Twelve long-term, peak-flow data sites operated by the U.S. Geological Survey were selected for 100- and 500-year flood analyses. The sites are shown in figure 12, and information on them is presented in table 1.

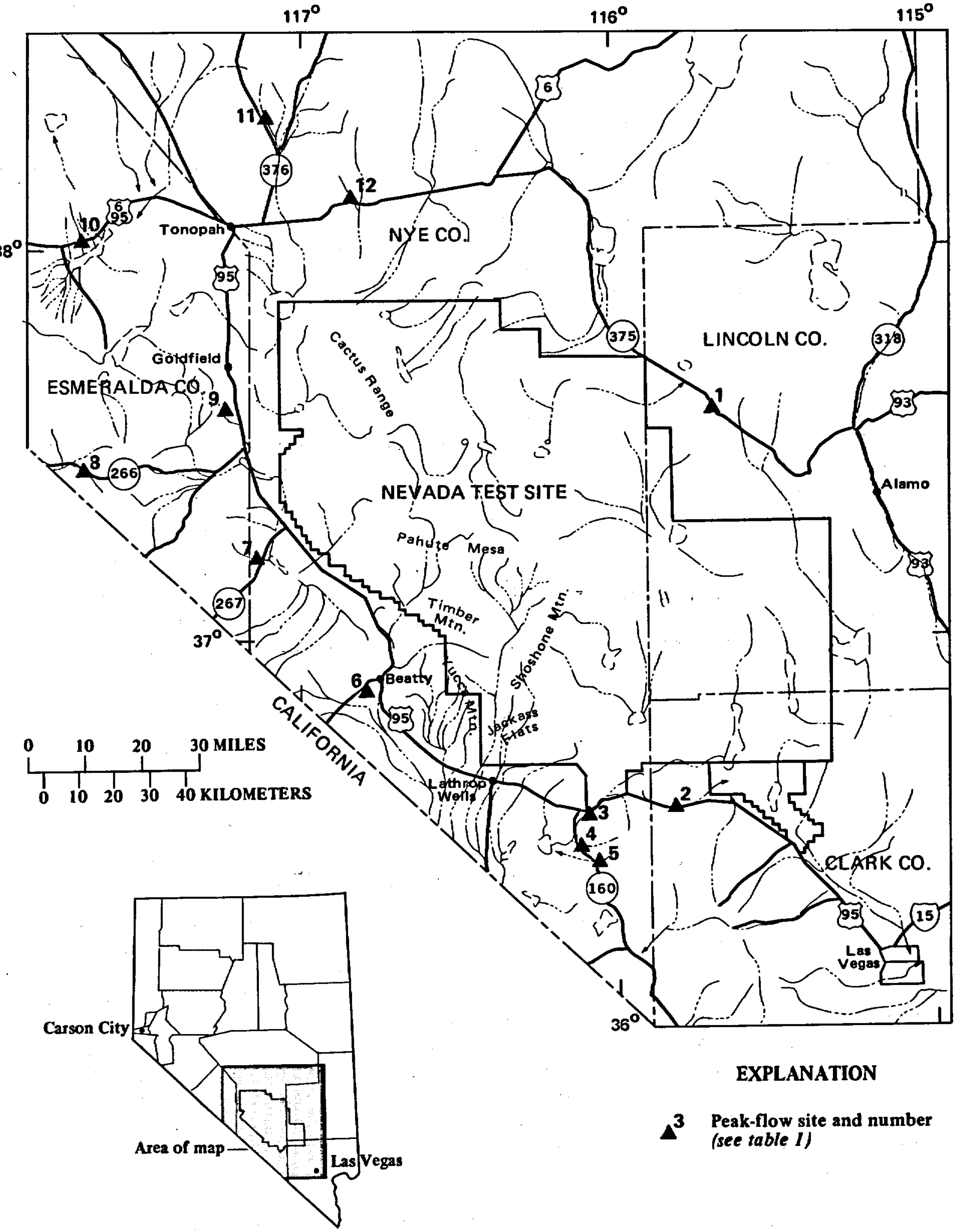


FIGURE 12.--Peak-flow data sites listed in table 1.

TABLE 1.—*Information for selected gaging stations near the study area*

Site number in figure 12	Station number	Station name	Location	Drainage area (square miles)	Period of record
1	10247860	Penoyer Valley tributary near Tempiute, Nev.	Lat 37°35'07", long 115°40'48", in SE¼ NE¼ sec. 21, T. 4 S., R. 56 E., Lincoln County, on left bank, upstream side of culvert on State Highway 375, 1 mile northwest of Coyote Summit and 5.3 miles south of Tempiute.	1.48	1964-80
2	10248490	Indian Springs Valley tributary near Indian Springs, Nev.	Lat 36°34'00", long 115°48'40", in NW¼ NW¼ sec. 16, or SW¼SW¼ sec. 9, T. 16 S., R. 55 E., Clark County, at culvert on U.S. Highway 95, 8 miles west of Indian Springs.	29.0	1964-80
3	10251270	Amargosa River tributary near Mercury, Nev.	Lat 36°33'40", long 116°06'00", in sec. 14, T. 16 S., R. 52 E., Nye County, at culvert on U.S. Highway 95, 9 miles southwest of Mercury.	110	1963-80
4	10251271	Amargosa River tributary No. 1 near Johnnie, Nev.	Lat 36°27'36", long 116°06'28", in NE¼SE¼ sec. 22, T. 17 S., R. 52 E., Nye County, at culvert on State Highway 160, 3.5 miles northwest of Johnnie.	2.21	1967-80
5	10251272	Amargosa River tributary No. 2 near Johnnie, Nev.	Lat 36°26'09", long 116°04'28", in W¼NE¼ sec. 36, T. 17 S., R. 52 E., Nye County, at culvert on State Highway 160, 1.2 miles north of Johnnie.	2.49	1968-80
6	10251220	Amargosa River near Beatty, Nev.	Lat 36°52'06", long 116°45'34", in NW¼ NE¼ sec. 30, T. 12 S., R. 47 E., Nye County, on left bank 170 feet downstream from airport road, 2.8 miles south of Beatty.	470	1964-79
7	10249050	Sarcobatus Flat tributary near Springdale, Nev.	Lat 37°13'18", long 117°07'35", T. 8 S., R. 43 E., Nye County, at culvert on State Highway 267, at Bonnie Clare and 24 miles northwest of Springdale.	37.1	1961-80
8	10249850	Palmetto Wash tributary near Lida, Nev.	Lat 37°26'30", long 117°41'25", in SW¼SE¼ sec. 6, T. 6 S., R. 39 E., Esmeralda County, at culvert on State Highway 266, 7 miles west of Lida Summit and 11 miles west of Lida.	4.73	1967-80
9	10248970	Stonewall Flat tributary near Goldfield, Nev.	Lat 37°35'40", long 117°12'35", in SE¼NE¼ sec. 13, T. 4 S., R. 42 E., Esmeralda County, at culvert on U.S. Highway 95, 8 miles south of Goldfield.	.53	1964-79
10	10249680	Big Smoky Valley tributary near Blair Junction, Nev.	Lat 38°01'52", long 117°42'35", Esmeralda County, at culvert on U.S. Highway 6 and 95, 3.5 miles east of Blair Junction.	11.4	1961-79
11	10249135	San Antonio Wash tributary near Tonopah, Nev.	Lat 38°19'37", long 117°07'25", in SE¼SW¼ sec. 35, T. 6 N., R. 43 E., Nye County, at culvert on State Highway 376, 19 miles north of Tonopah.	3.42	1965-80
12	10249180	Salsbury Wash near Tonopah, Nev.	Lat 38°07'30", long 116°48'30", in S¼SW¼ sec. 10, T. 3 N., R. 46 E., Nye County, at culvert on U.S. Highway 6, 23 miles east of Tonopah.	56.0	1962-80

The data sites are on the perimeter of the Nevada Test Site and the Nellis Air Force Gunnery Range. No systematically collected long-term flood data are available within that perimeter. Because of the proximity of the sites to the Nevada Test Site, and the similarity of physiographic characteristics of basins inside and outside the Test Site, flood data collected at the long-term sites shown in figure 12 are judged to be representative of data for the Test Site in general and for the Fortymile Wash study area in particular.

Statistical values for the magnitude and frequency of floods at each of the 12 long-term sites were based on log-Pearson Type-III analyses, as outlined by the U.S. Water Resources Council (1981). A multiple-regression analysis was made using the derived flood magnitudes and frequencies and the calculated basin characteristics for each site. The resulting equations for estimating the 100- and 500-year floods are:

$$Q_{100} = 482A^{0.565} \quad (1)$$

and

$$Q_{500} = 2{,}200A^{0.571}, \quad (2)$$

where Q_{100} = the 100-year flood, in cubic feet per second;
Q_{500} = the 500-year flood, in cubic feet per second; and
A = the drainage area, in square miles.

The standard errors of estimate for the two equations are 0.70 and 0.77 log units and the independent variable A is significant at the 0.03 and 0.06 levels, respectively.

The standard error of estimate is a measure of how well the observed data agree with a regression relation; the standard error is computed from the differences (residuals) between observed data and values calculated from the regression equation. The relatively large values of the standard error of estimate, 0.70 and 0.77, result primarily from the short period of record—15 to 20 years—and the extreme areal variability of floodflows in arid climates. However, the regression approach, which is based on data from nearby streams, is believed to be the best available method for peak-discharge determinations. Other methods—such as rainfall-runoff modeling—may give results that are not qualified as to their statistical reliability. These other methods are not believed to be inherently better than the method used in this study, which allows a reliability evaluation and is based on nearby flood data.

The previous flood-potential study on the adjacent Topopah Wash drainage (Christensen and Spahr, 1980) used unpublished statewide flood-frequency relations developed by U.S. Geological Survey personnel in Carson City, Nev. New relationships were developed for the current study because the statewide data (1) are limited to drainage areas of 70 square miles or less, (2) did not use all the sites listed in table 1, and (3) did not include relationships for a 500-year recurrence interval.

Calculated values of 100-year peak discharges using the relation developed for the Fortymile Wash study, the statewide relations, and the U.S. Soil Conservation Service (SCS) rainfall-runoff method (1975, page 4-1) for several selected cross-section sites in the Fortymile basin are tabulated below.

Site[1]	Latitude and longitude	Drainage area (square miles)	Mean altitude (feet)	100-year peak discharge (cubic feet per second)		
				Fortymile Wash study	Statewide relations	SCS[2]
Fortymile Wash, FM-1	37°03', 116°24'	312	5,310	12,000	14,000	—
Fortymile Wash, FM-7	37°05', 116°23'	256	5,580	11,000	12,000	—
Yucca Wash, Y-3	36°55', 116°25'	8.1	5,180	1,600	2,100	—
Drill Hole Wash, DH-10	36°52', 116°25'	.9	3,760	450	1,000	700
Busted Butte Wash, BB-5	36°49', 116°25'	.5	3,750	330	760	470

[1] Sites are shown on plate 1.

[2] Data from U.S. Soil Conservation Service, for drainage areas less than 2,000 acres.

Rainfall amounts for the SCS method were obtained from Miller and others (1973, page 43). The comparison indicates that all three methods produce estimates of similar magnitude at the selected cross sections.

Estimated discharges for the 100- and 500-year floods on Fortymile Wash and its three southwestern tributaries, calculated by using equations 1 and 2, are listed in tables 2 and 3. The estimated discharges are accurate to no more than two significant figures.

TABLE 2.--*Characteristics of the 100-year flood peak at cross sections*

Stream and cross section: Stream name and cross-section number shown on plate 1. Cross sections for each individual stream are listed in downstream order.
Drainage area: Contributing drainage area above cross section, in square miles.
Discharge: Estimated peak discharge, in cubic feet per second, rounded to two significant figures.
Area: Cross-sectional area below water surface, in square feet.
Width: Cross-sectional distance between channel banks at water surface, in feet.
Mean velocity: Estimated discharge divided by cross-sectional area, in feet per second.
Maximum depth: Vertical distance from water surface to lowest point in cross section, in feet.

Stream and cross section	Drainage area	Discharge	Area	Width	Mean velocity	Maximum depth
Fortymile Wash						
FM-7	256	11,000	1,530	[a]865	7.2	4.1
FM-6	280	12,000	1,470	[a]728	8.2	3.9
FM-5	283	12,000	1,390	[a]650	8.6	3.5
FM-4	301	12,000	1,980	1,010	6.1	5.2
FM-3	302	12,000	1,400	[a]632	8.6	7.2
FM-2	311	12,000	1,740	828	6.9	4.6
FM-1	312	12,000	1,960	[a]1,020	6.1	5.8
Busted Butte Wash						
BB-9	0.9	450	74	65	6.1	2.3
BB-8	.4	290	52	44	5.8	2.1
BB-7	2.0	710	91	49	7.8	3.0
BB-6	2.8	860	144	123	6.0	2.2
BB-3	3.4	960	169	151	5.7	3.3
BB-5	.5	330	51	39	6.5	2.6
BB-4	1.9	690	99	62	7.0	2.7
BB-2	.6	360	68	65	5.3	2.0
BB-1	6.6	1,400	295	273	4.7	3.2
Drill Hole Wash						
DH-11	0.5	330	61	54	5.4	1.9
DH-8	.8	420	68	55	6.2	1.5
DH-9	4.5	1,100	280	[a]431	4.0	2.5
DH-10	.9	450	76	59	5.9	2.1
DH-7	1.9	690	143	[a]209	4.8	2.5
DH-5	1.1	510	93	100	5.5	1.6
DH-6	4.2	1,100	229	269	4.7	2.9
DH-4	1.7	650	136	[a]147	4.8	1.7
DH-3	2.6	830	128	58	6.5	3.0
DH-2	13.5	2,100	334	[a]263	6.3	2.9
DH-1	15.4	2,300	323	[a]190	7.0	4.0
Yucca Wash						
Y-5	1.5	610	110	106	5.5	3.4
Y-4	4.0	1,100	184	[a]177	5.7	3.4
Y-3	8.1	1,600	216	96	7.3	3.0
Y-2	12.7	2,000	249	[a]117	8.2	5.1
Y-1	16.6	2,400	373	[a]326	6.3	3.5

[a] Total width includes multiple channels.

TABLE 3.—*Characteristics of the 500-year flood peak at cross sections*

Stream and cross section: Stream name and cross-section number shown on plate 1. Cross sections for each individual stream are listed in downstream order.
Discharge: Estimated peak discharge, in cubic feet per second, rounded to two significant figures.
Area: Cross-sectional area below water surface, in square feet.
Width: Cross-sectional distance between channel banks at water surface, in feet.
Mean velocity: Estimated discharge divided by cross-sectional area, in feet per second.
Maximum depth: Vertical distance from water surface to lowest point in cross section, in feet.

Stream and cross section	Discharge	Area	Width	Mean velocity	Maximum depth
Fortymile Wash					
FM-7	52,000	4,430	1,000	11.7	7.1
FM-6	55,000	4,230	730	13.0	6.7
FM-5	55,000	3,970	673	13.8	7.3
FM-4	57,000	4,870	1,050	11.7	8.0
FM-3	57,000	4,210	789	13.5	10.7
FM-2	58,000	4,500	841	12.9	7.9
FM-1	58,000	5,290	1,190	11.0	8.7
Busted Butte Wash					
BB-9	2,100	285	153	7.3	4.3
BB-8	1,300	171	97	7.6	3.9
BB-7	3,300	450	[a]278	7.3	5.8
BB-6	4,000	438	[a]178	9.0	4.3
BB-3	4,400	564	279	7.8	5.0
BB-5	1,500	211	[a]129	7.0	4.4
BB-4	3,200	384	189	8.3	5.3
BB-2	1,600	205	106	8.0	3.6
BB-1	6,500	745	289	8.3	4.7
Drill Hole Wash					
DH-11	1,500	190	95	7.8	3.7
DH-8	1,900	248	[a]127	7.8	4.0
DH-9	5,200	950	843	5.5	3.5
DH-10	2,100	245	91	8.4	4.3
DH-7	3,200	483	351	6.6	3.7
DH-5	2,300	292	141	7.9	3.3
DH-6	5,000	675	355	7.4	4.3
DH-4	3,000	416	[a]271	7.2	3.0
DH-3	3,800	422	115	9.0	6.6
DH-2	9,700	1,180	577	8.2	4.9
DH-1	10,000	1,020	316	10.3	9.5
Yucca Wash					
Y-5	2,800	330	126	8.4	5.3
Y-4	4,900	612	289	7.9	5.1
Y-3	7,300	748	242	9.7	7.0
Y-2	9,400	800	172	11.7	8.6
Y-1	11,000	1,240	485	8.8	5.6

[a] Total width includes multiple channels.

Maximum floodflows from small basins are generally caused by intense, commonly short-duration storms over a small area. Maximum floods from large basins, on the other hand, are generally caused by storms of several days duration over large areas. Regardless of the amount of rainfall that has caused the highest known flow in a stream or wash, a greater or more intense rainfall may eventually cause an even greater floodflow than the maximum known value. To determine a reasonable regional maximum flood (page 13) for Fortymile Wash and its tributaries within the study area, data were used from maximum floods that have been observed at other sites which exhibit similar characteristics and flood potentials.

Crippen and Bue (1977) selected, compiled, and analyzed maximum observed flood peaks nationwide through September 1974. Data from 883 sites having drainage areas of less that 10,000 square miles were grouped into geographically regional sets. The maximum discharges for major floods from each region were plotted against the respective drainage areas, and upper "boundary" curves were drawn. These curves provide estimates of peak discharges on the basis of maximum known floods. The "boundary" curve developed by Crippen and Bue (1977, page 15) for the five-State region that includes the study area was used to estimate the discharges of regional maximum floods for Fortymile Wash and its tributaries. The curve is shown in figure 13, and the data upon which the curve is based are listed in table 4. The probability of occurrence for the regional maximum flood can be determined only by geomorphic and geologic techniques.

The regional maximum flood discharges for selected sites in the study area are listed in table 5. Floods of that magnitude are large enough to be beyond the possibility of control with conventional flood-mitigation works. The curve showing discharge versus drainage area for regional maximum floods (figure 13), which is taken from Crippen and Bue (1977, figure 18), gives discharge values that are conservatively high compared to all events recorded by Crippen and Bue (their table 1) for drainage areas similar in size to that of Fortymile Wash (about 300 square miles). Nonetheless, estimates of the regional maximum flood for Fortymile Wash (table 5, plate 1, figure 14) are based on Crippen and Bue's curve. This provides a margin of safety that should help to offset the limitations inherent in applying relatively short-term historical data to long-term predictions at Fortymile Wash.

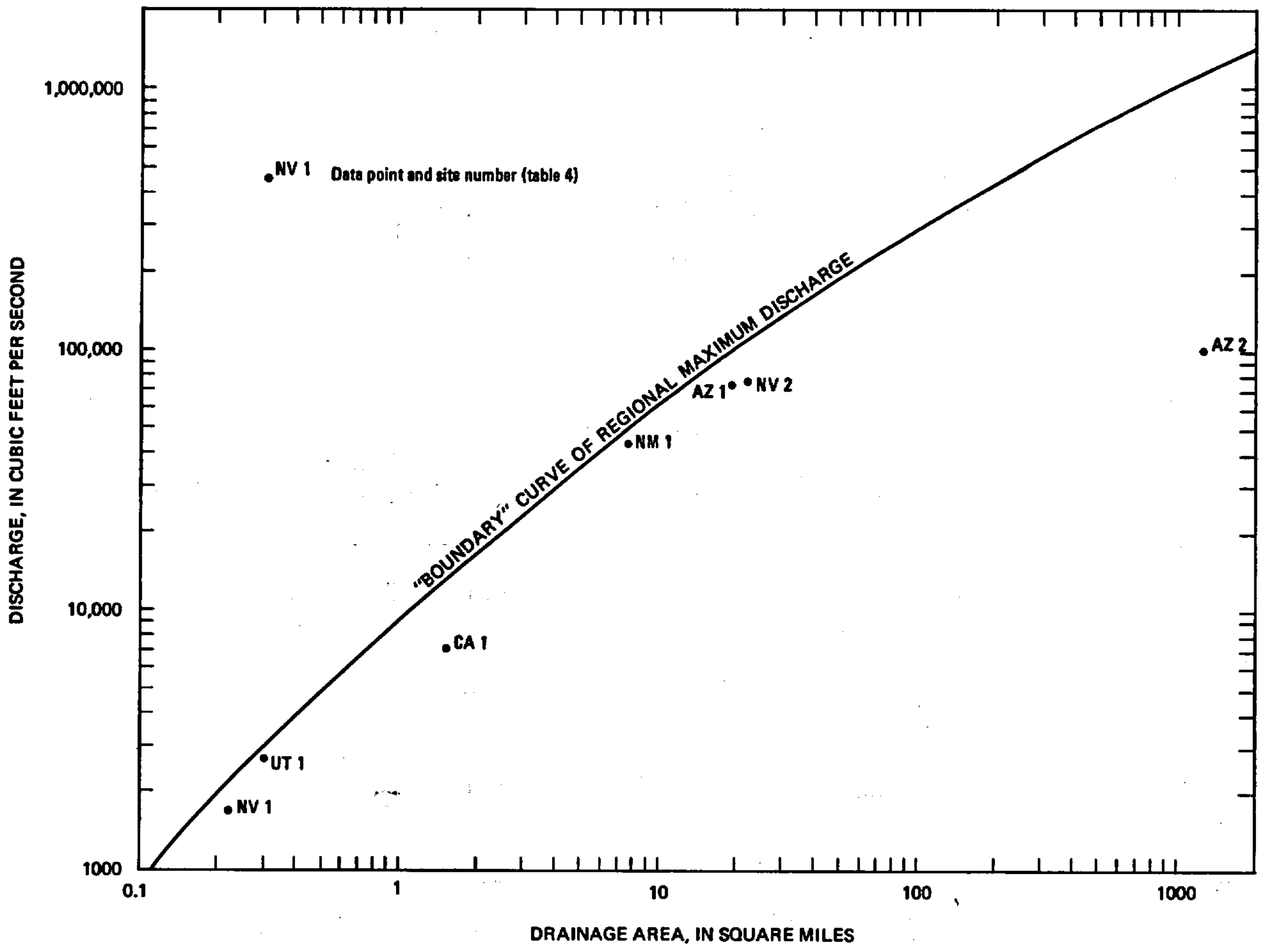


FIGURE 13.--Regional maximum discharge versus drainage area. "Boundary" curve was developed by Crippen and Bue (1977, figure 18) for maximum observed discharges in the flood region that includes the study area.

Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding within the study area were made to provide estimates of the water-surface altitudes of peak flows for the 100-year, 500-year, and regional maximum floods along the principal channels.

Cross-section dimensions at selected sites on Fortymile, Busted Butte, Drill Hole, and Yucca Washes were obtained by field surveys using laser and self-leveling instruments. Locations of the cross sections are shown on plate 1. The hydraulic analyses were based on natural flow conditions. Thus, manmade improvements such as road embankments, levees, dams, excavated or earth-filled areas, and local drainage channels (none of which existed at the time of the survey) are not considered.

TABLE 4.—*Peak discharge at seven selected sites in Arizona, California, Nevada, New Mexico, and Utah*[1]

Site designation in figure 12	Location	Drainage area (square (miles)	Date	Peak discharge	
				Cubic feet per second	Cubic feet per second, per square mile
AZ 1	Bronco Creek near Wikieup, Ariz.	19.0	8-18-71	73,500	3,870
AZ 2	San Pedro River at Charleston, Ariz.	1219	9-28-26	98,000	80
CA 1	Arch Creek near Earp, Calif.	1.52	8-19-71	7,160	4,710
NV 1	Lahonton Reservoir Tributary No. 3 near Silver Springs, Nev.	.22	7-20-71	1,680	7,640
NV 2	Eldorado Canyon, Nev.	22.8	9-14-74	76,000	3,300
NM 1	El Rancho Arroyo near Pojoaque, N. M.	6.7	8-22-52	44,000	6,570
UT 1	Little Pinto Creek Tributary near Old Irontown, Utah	.30	8-11-64	2,630	8,770

[1] From Crippen and Bue (1977, pages 17, 18, 33, 35, 47), except data for Eldorado Canyon, Nev., which are from Glancy and Harmsen (1977, page 12).

TABLE 5.—*Characteristics of the regional maximum flood peak at cross sections*

Stream and cross section: Stream name and cross-section number shown on plate 1. Cross sections for each individual stream are listed in downstream order.
Discharge: Estimated peak discharge, in cubic feet per second, rounded to two significant figures.
Area: Cross-sectional area below water surface, in square feet.
Width: Cross-sectional distance between channel banks at water surface, in feet.
Mean velocity: Estimated discharge divided by cross-sectional area, in feet per second.
Maximum depth: Vertical distance from water surface to lowest point in cross section, in feet.

Stream and cross section	Discharge	Area	Width	Mean velocity	Maximum depth
Fortymile Wash					
FM-7	490,000	19,700	1,110	24.9	21.5
FM-6	510,000	20,300	1,230	25.1	21.8
FM-5	510,000	18,400	780	27.7	27.3
FM-4	530,000	23,000	1,400	23.0	22.5
FM-3	530,000	19,800	960	26.8	28.6
FM-2	540,000	20,900	1,120	25.8	24.5
FM-1	540,000	21,900	1,260	24.7	22.0
Busted Butte Wash					
BB-9	8,000	840	[a]289	9.5	7.0
BB-8	4,100	458	[a]177	9.0	6.0
BB-7	16,000	1,810	[a]694	8.8	8.4
BB-6	22,000	2,450	[a]929	8.9	8.4
BB-3	25,000	1,790	[a]305	14.0	9.2
BB-5	4,900	636	[a]352	7.7	6.5
BB-4	16,000	1,200	231	13.2	9.2
BB-2	6,000	724	339	8.3	6.4
BB-1	44,000	2,750	320	16.0	11.2
Drill Hole Wash					
DH-11	4,500	492	[a]170	9.1	6.0
DH-8	7,700	910	[a]390	8.5	6.5
DH-9	32,000	3,120	905	10.4	6.0
DH-10	8,500	700	149	12.1	8.0
DH-7	16,000	1,470	[a]404	10.7	6.3
DH-5	10,000	964	276	10.4	6.3
DH-6	30,000	2,530	564	11.9	8.4
DH-4	14,000	1,350	376	10.8	5.7
DH-3	20,000	(*b*)	(*b*)	(*b*)	(*b*)
DH-2	79,000	5,000	620	15.8	11.3
DH-1	86,000	(*b*)	(*b*)	(*b*)	(*b*)
Yucca Wash					
Y-5	13,000	1,320	[a]343	9.5	10.3
Y-4	29,000	2,060	321	14.1	9.8
Y-3	52,000	3,100	339	16.8	15.0
Y-2	75,000	3,540	248	21.2	22.4
Y-1	92,000	5,870	705	15.7	12.5

[a] Total width includes multiple channels.
[b] Not determined.

Channel-roughness factors known as "Manning's n" values (Linsley and Franzini, 1972, page 270), which are used in the hydraulic computations, were chosen by engineering judgment on the basis of field observations and measurements of the channels and flood-plain areas. Roughness values for Fortymile Wash ranged from 0.032 to 0.045 for the three flood magnitudes used. The roughness values for channels and flood plains along Busted Butte, Drill Hole, and Yucca Washes ranged from 0.030 to 0.055.

Water-surface altitudes for floods of the three selected magnitudes were estimated for each cross section by using a procedure commonly known as a slope-conveyance computation. This procedure requires cross-section characteristics that are determined by field surveying. The mathematical equation used in this procedure combines the Manning formula (Linsley and Franzini, 1972, page 270) and the continuity equation to provide the relationship between discharge and depth at a selected cross section. The combined equation is:

$$Q = \frac{1.49}{n} A \, R^{2/3} \, S^{1/2} \ , \qquad (3)$$

where Q = discharge for a given flood depth, in cubic feet per second;
n = the roughness coefficient, in dimensionless units;
A = cross-section area for a given flood depth, in square feet;
R = hydraulic radius (cross-section area divided by wetted perimeter), in feet; and
S = slope of the energy-grade line, in feet per foot, which is assumed to be equivalent to the slope of the water surface and channel bottom under conditions of uniform flow.

At each cross section, a depth-discharge relation was developed by computing discharges for several depths that span the range of values for the 100-year, 500-year, and regional maximum floods. From this relation, the depth of flow was determined and converted to a water-surface altitude for each of the three flood discharges. Typical cross sections are shown in figures 14-17.

The main sources of uncertainty in the use of this procedure are the estimates of slope and channel roughness. The flow regime may not be uniform at all cross sections; thus, the slope of the energy-grade line may not everywhere coincide with that of the water surface or channel bottom. The impact of this uncertainty has not been evaluated. The roughness coefficient n is inversely proportional to discharge. Therefore, because the average value of n for natural channels is about 0.03, an error of 0.003 in n represents only a 10 percent error in the estimated discharge--well within the accuracy limits of this study.

Characteristics of floodflow (discharge, area, width, mean velocity, and maximum depth) that were estimated at channel cross sections for the 100-year, 500-year, and regional maximum floods are listed in tables 2, 3, and 5, respectively. Any significant manmade channel modifications in the future could change the estimated floodflow characteristics and inundation boundaries given in this report.

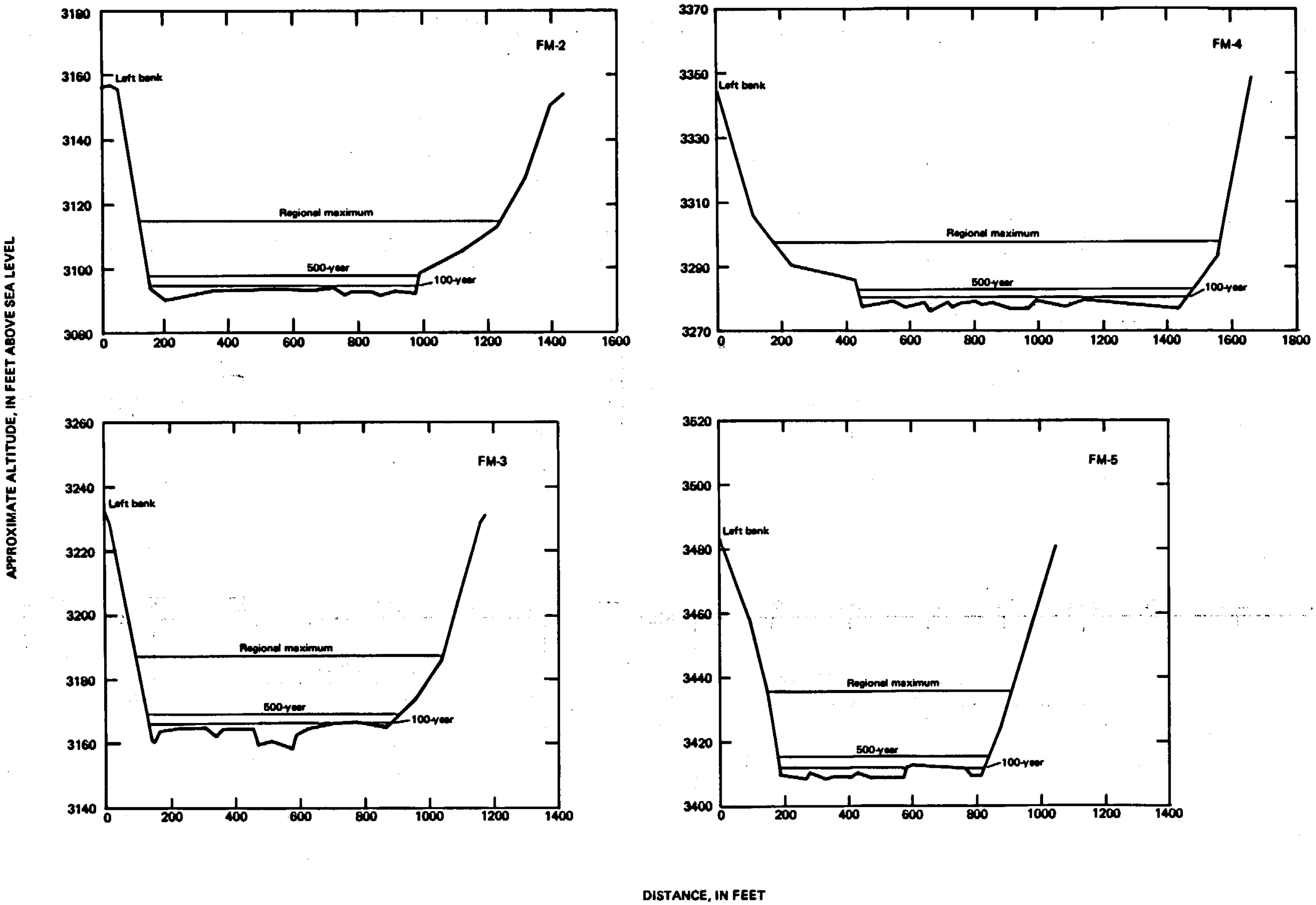


FIGURE 14.--Water surfaces for the 100-year, 500-year, and regional maximum floods at Fortymile Wash cross-sections FM-2, FM-3, FM-4, and FM-5.

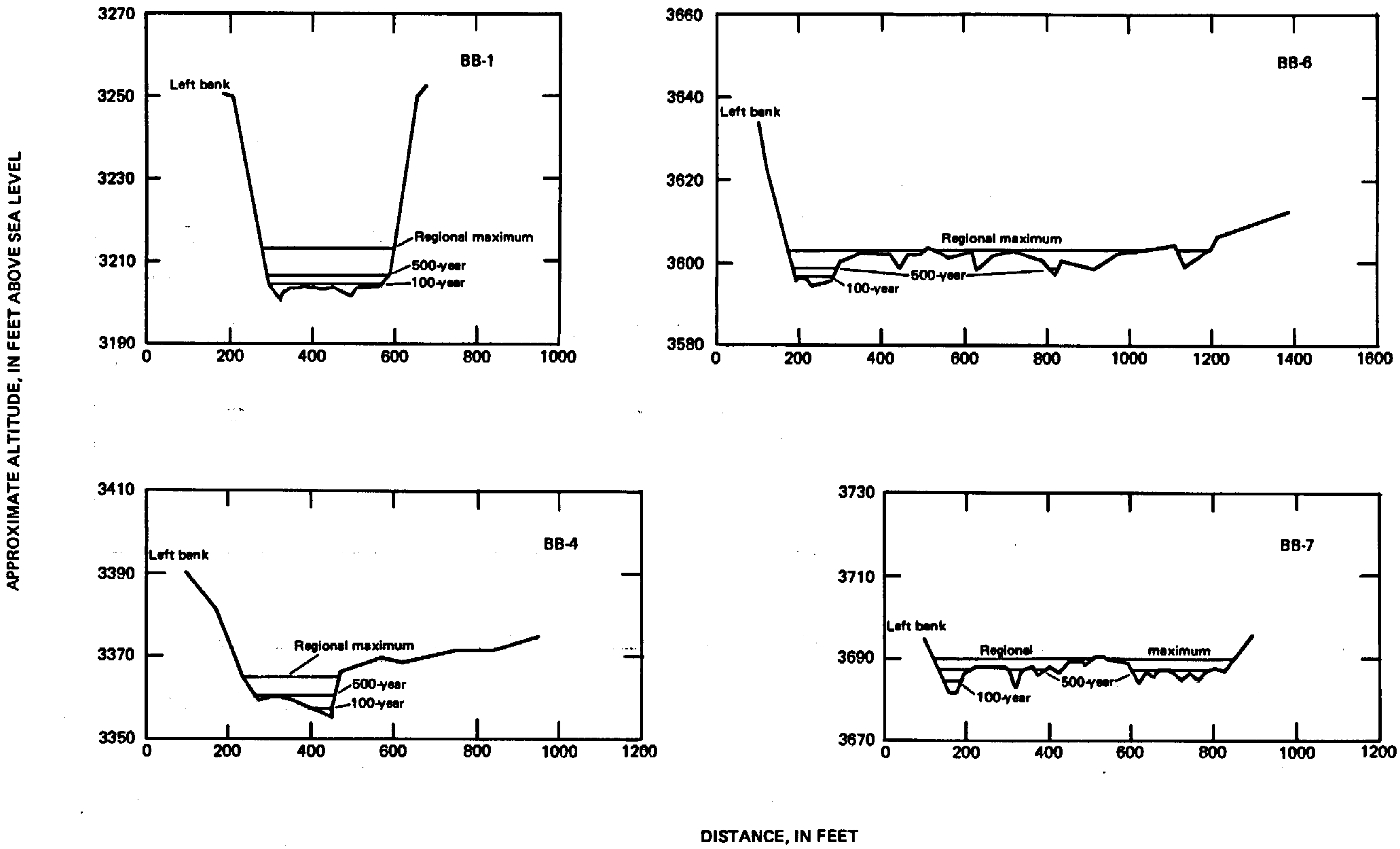


FIGURE 15.–Water surfaces for the 100-year, 500-year, and regional maximum floods at Busted Butte Wash cross-section BB-1, BB-4, BB-6, and BB-7.

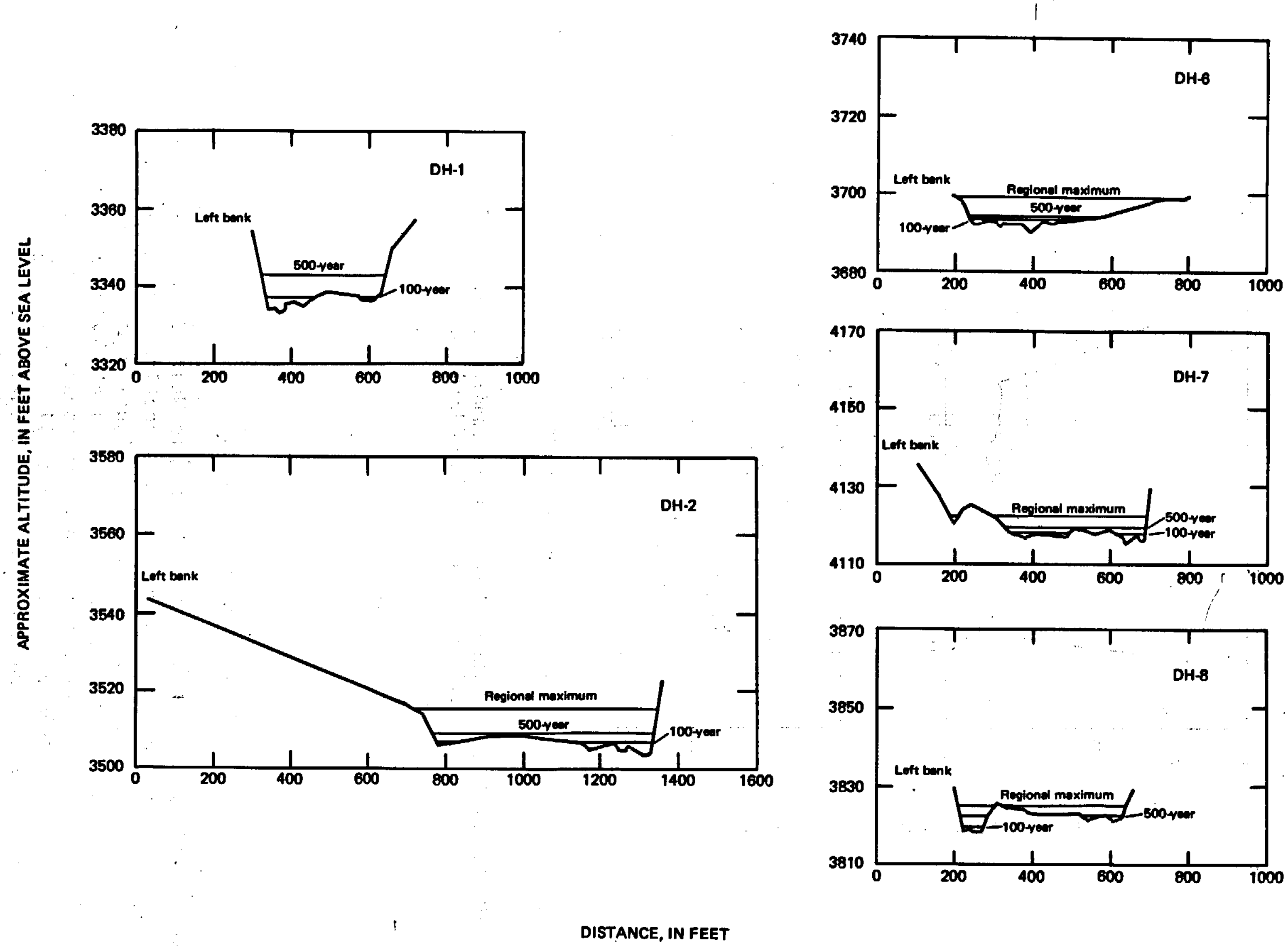


FIGURE 16.–Water surfaces for the 100-year, 500-year, and regional maximum floods at Drill Hole Wash cross-sections DH-1, DH-2, DH-6, DH-7, and DH-8.

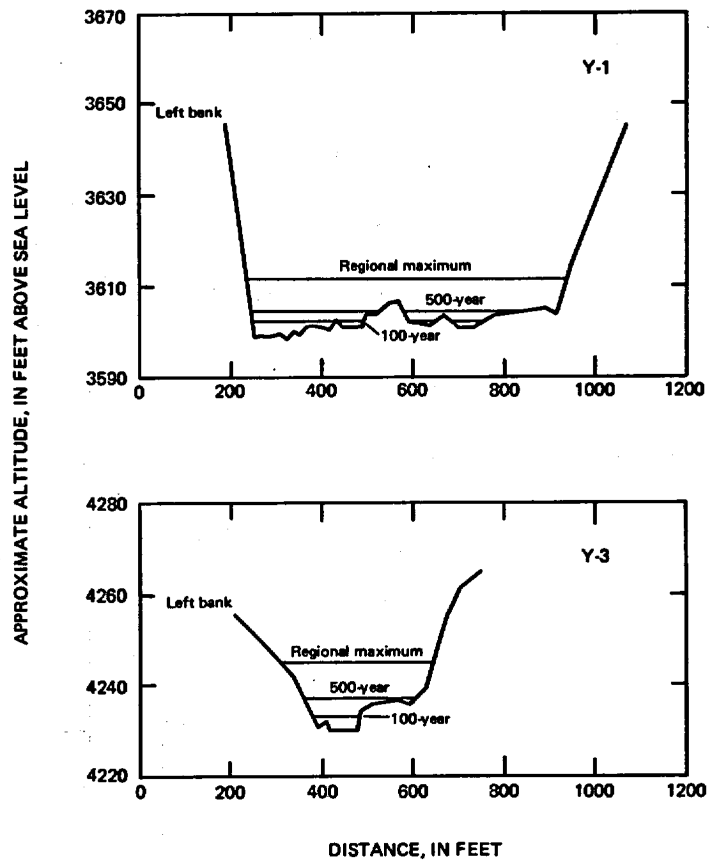


FIGURE 17.--Water surfaces for the 100-year, 500-year, and regional maximum floods at Yucca Wash cross-sections Y-1,and Y-3.

Flood Characteristics

The estimated flow conditions along Fortymile Wash within the study area were based on data collected at seven cross-sections and detailed field investigations. The 100-year, 500-year, and regional maximum floods as interpreted herein would remain within the confines of Fortymile Wash Canyon. Estimated maximum flood depths at the channel cross-sections would range from 3 to 8 feet during the 100-year flood, from 6 to 11 feet during a 500-year flood, and from 21 to 29 feet during the regional maximum flood. The estimated mean velocities at the seven surveyed cross-sections ranged from 6 to 9 ft/s for the 100-year flood, from 11 to 14 ft/s for the 500-year flood, and from 23 to 28 ft/s for the regional maximum flood.

The interpreted characteristics of flooding for Busted Butte and Drill Hole Washes were based on 9 and 11 surveyed cross sections, respectively. These washes are physiographically unique in the study area: both are characterized by steep incised channels in the upstream reaches and shallow to indiscernible channels on alluvial fans in the central parts of the drainage areas. Between the two alluvial valleys and Fortymile Wash, Busted Butte and Drill Hole Washes apparently have downcut through a north-trending mountain block. Estimated maximum flood depths at surveyed cross sections along Busted Butte and Drill Hole Washes would range from 1 to 4 feet, and mean velocities would range from 4 to 8 ft/s, during the 100-year flood. The 500-year flood would produce maximum depths ranging from 3 to 10 feet and mean velocities of 5 to 11 ft/s. The regional maximum flood would result in depths between 5 and at least 12 feet and mean velocities between 7 and at least 16 ft/s. The regional maximum flood would inundate all flat alluvial-fan areas in these watersheds.

Five cross sections were surveyed in the Yucca Wash drainage, the northernmost tributary to Fortymile Wash in the study area. The three selected flood peaks would remain within the banks of the incised channel. Maximum flood depths at surveyed cross sections would range from 3 to 5 feet for a 100-year flood, from 5 to 9 feet for a 500-year flood, and from 9 to 23 feet for the regional maximum flood. The mean velocities associated with these floods would range from 5 to 9, 8 to 12, and 9 to 22 ft/s, respectively.

The quantitative extent of erosion and sediment movement caused by floodflows in ephemeral channels of the study area is unknown. Qualitatively, however, erosion of or deposition in channels and flood plains probably would be significant in parts of the study area during the 100-year flood, and could be severe during the 500-year and regional maximum floods.

An approximate guide to the erodibility of differing bed materials, as related to the roughness coefficient ("*n*" value) and the velocity of clear and turbid water, has been developed by Fortier and Scobey (Chow, 1959, page 165):

		Maximum permissible velocity (feet per second)[1]	
Material	"*n*" value	Clear water	Water transporting "colloidal silt"
Fine sand	0.020	1.5	2.5
Fine gravel	.020	2.5	5.0
Coarse gravel	.025	4.0	6.0
Cobbles	.035	5.0	5.5

[1] For straight, stable channels of small slope.

The maximum permissible velocity is the greatest mean velocity that will not cause erosion of the channel-bed material. In general, old and well-established channels will resist erosion at much higher velocities than new ones, because the bed is usually better stabilized. When other conditions are the same, a deep channel will convey water at a higher mean velocity without erosion than a shallow one.

Any significant channel erosion of, or deposition in, the existing streambeds would alter the floodflow characteristics of cross-sectional area, width, mean velocity, and maximum depth listed in tables 2, 3, and 5, and shown in figures 14-17. The effect of the erosion or deposition on floodflow characteristics would vary from cross section to cross section. Because most of the velocities listed in tables 2, 3, and 5 exceed the maximum permissible velocities listed above, channel erosion and deposition appear likely. In fact, evidence of extensive erosion and deposition was noted in places during the field surveys.

Flood Boundaries

All streams in the study area are ephemeral, which means that they contain flow for only short periods of time in response to heavy rainfall or snowmelt. Ephemeral-channel systems generally undergo significant changes in depth, width, alignment, and stability with time, particularly during large floods of long recurrence interval. Accordingly, areas that would be inundated by the 100-year, 500-year, and regional maximum floods shown on plate 1 are only approximate. For each channel studied, the boundaries have been delineated on the basis of (1) information determined at each cross section and (2) flood profiles. Between cross sections, the boundaries were interpolated from topography shown on plate 1 at a scale of 1:24,000 and with a contour interval of 20 feet. By convention, in places where boundaries of two or all three of the floods are too close together to distinguish on plate 1, only the lesser magnitude boundary is shown. Within the mapped flood boundaries, small islands doubtless would protrude above the flood and, therefore, would not be subjected to flooding; owing to limitations of the map scale, however, such areas are not shown. Small tributary channels that would become flooded are not shown either, because of map-scale limitations.

SUMMARY

Most flood-producing storms at the Nevada Test Site are a result of convective precipitation. Some past flooding events, however, have also resulted from snowmelt.

Estimates of the 100-year, 500-year, and regional maximum floods were made at selected sites on Fortymile Wash and its three principal southwestern tributaries—Busted Butte, Drill Hole, and Yucca Washes. Data from 12 U.S. Geological Survey gaging stations on ephemeral streams adjacent to the Test Site were used to develop equations for estimating the 100-year and 500-year flood magnitudes applicable to streams in the study area. The equations are as follows:

$$Q_{100} = 482A^{0.565}$$

and

$$Q_{500} = 2{,}200A^{0.571},$$

where Q is the peak-flow discharge, in cubic feet per second, and A is the tributary drainage area, in square miles. The "boundary" curve of Crippen and Bue (1977, page 15) was used to estimate the magnitude of the regional maximum floods.

Estimated peak discharges at the farthest downstream cross sections in the study area are as follows:

Wash	Drainage area (square miles)	Peak flood discharge (cubic feet per second)		
		100-year	500-year	Regional maximum
Fortymile	312	12,000	58,000	540,000
Busted Butte	6.6	1,400	6,500	44,000
Drill Hole	15.4	2,300	10,000	86,000
Yucca	16.6	2,400	11,000	92,000

Floodflow characteristics of the stream channels under natural-flow conditions were evaluated at 32 cross sections by the slope-conveyance procedure, using the following measured and estimated data: discharges for the 100-year, 500-year, and regional maximum floods; channel-roughness coefficients; cross-section areas; hydraulic radii; and energy-grade-line slopes.

Estimated ranges of maximum depth, in feet, and mean velocity, in feet per second, for the peak flood flows are as follows:

Wash	100-year flood		500-year flood		Regional maximum flood	
	Maximum depth	Mean velocity	Maximum depth	Mean velocity	Maximum depth	Mean velocity
Fortymile	3-8	6-9	6-11	11-14	21-29	23-28
Busted Butte and Drill Hole	1-4	4-8	3-10	5-11	5-12	7-16
Yucca	3-5	5-9	5-9	8-12	9-23	9-22

Along the 9-mile study area of Fortymile Wash, the flood flows would remain within the incised channel. In the Busted Butte and Drill Hole Wash drainages, the 500-year flood would exceed stream-channel capacities at several places, and the regional maximum flood would inundate sizeable areas in the central parts of the watersheds. At Yucca Wash, flood flows of all three magnitudes would remain within the stream channel.

Significant erosion of, or deposition in, channels and flood plains would probably occur in parts of the study area during the 100-year flood, and could be severe during the 500-year and regional maximum floods.

REFERENCES CITED

Chow, V. T., 1959, Open-channel hydraulics: New York, McGraw-Hill, 680 p.

Christensen, R. C., and Spahr, N. E., 1980, Flood potential of Topopah Wash and tributaries, eastern part of Jackass Flats, Nevada Test Site, southern Nevada: U.S. Geological Survey Open-File Report 80-963, 22 p.

Crippen, J. R., and Bue, C. D., 1977, Maximum floodflows in the conterminous United States: U.S. Geological Survey Water-Supply Paper 1887, 52 p.

Geraghty, J. J., Miller, D. W., van der Leeden, Fritz, and Troise, F. L., 1973, Water atlas of the United States: Port Washington, N.Y., Water Information Center publication, 122 plates.

Glancy, P. A., and Harmsen, Lynn, 1975, A hydrologic assessment of the September 14, 1974, flood in Eldorado Canyon, Nevada: U.S. Geological Survey Professional Paper 930, 28 p.

Hoover, D. L., Eckel, E. B., and Ohl, J. P., 1978, Potential sites for a spent unreprocessed fuel facility (SURFF), southwestern part of the Nevada Test Site: U.S. Geological Survey Open-File Report 78-269, 18 p.

Langbein, W. B., and Iseri, K. T., 1960, General introduction and hydrologic definitions: U.S. Geological Survey Water-Supply Paper 1541-A, 29 p.

Linsley, R. K., and Franzini, J. B., 1972, Water-resources engineering: New York, McGraw-Hill, 690 p.

Miller, J. F., Frederick, R. H., and Tracey, R. J., 1973, Precipitation-frequency atlas of the western United States: U.S. National Oceanic and Atmospheric Administration Atlas 2, v. VII-Nevada, 43 p.

Rogers, A. M., Perkins, D. M., and McKeown, F. A., 1977, A preliminary assessment of the seismic hazard at the Nevada Test Site region: Seismology Society of America Bulletin, v. 67, no. 6, p. 1587-1606.

U.S. Soil Conservation Service, 1975, Urban hydrology for small watersheds: Technical Release 55, 97 p.

U.S. Water Resources Council, 1981, Guidelines for determining flood flow frequency: Hydrology Committee Bulletin 17B, 183 p.

CENTRAL RECORDS FACILITY
SPECIAL INSTRUCTION SHEET

Y-AD-062
10/88

THIS SHEET IS USED TO IDENTIFY A RECORD THAT IS NOT ENCLOSED FOR ONE OF THE FOLLOWING REASONS:

[ ] ONE-OF-A-KIND RECORD

[X] SPECIAL PROCESSED

[ ] OTHER: ______

ATT NNA.19870519.0060

THE FOLLOWING INFORMATION IDENTIFIES THE RECORD. THE LOCATION OF THE RECORD CAN BE DETERMINED BY THE TYPE OF MEDIA ON WHICH IT RESIDES.

ACCSN NUM: Attachment to NNA.890511.0110

DETAIL DESC: DWG (Oversized Drawing)

MEDIA TYPE: Aperture Card

REVISION NUM: —

RECORD DATE:

RECORD TITLE: Plate 1 - Map showing approximate flood prone areas, Fortymile Wash and its Principal Southwestern Tributaries, NTS, Southern Nevada. From Water Resources Investigation Report 83-4001

9015180819

PUBLISHED REPORT PACKAGE

JQS.19880517.1933

This accession number contains the color images for the record with accession number: HQS.19880517.1933

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Prepared in cooperation with the
UNITED STATES DEPARTMENT OF ENERGY

WATER RESOURCES INVESTIGATION REPORT 83–4001
PLATE 1

MAP SHOWING APPROXIMATE FLOOD PRONE AREAS, FORTYMILE WASH AND ITS PRINCIPAL SOUTHWESTERN TRIBUTARIES, NEVADA TEST SITE, SOUTHERN NEVADA