DESIGN RECURRENCE INTERVALS STUDY
Rocky Flats Plant Site

Task 9
As a Part of
Zero-Offsite Water-Discharge Study

Prepared For:

EG&G ROCKY FLATS, INC.
FACILITIES ENGINEERING
PLANT CIVIL-STRUCTURAL ENGINEERING
P.O. BOX 464
GOLDEN, CO 80402-0464

EG&G JOB NUMBER 401009
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Purchase Order No. BA

Prepared By:

ADVANCED SCIENCES, INC.
405 URBAN STREET, SUITE 401
LAKEWOOD, CO 80228

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DISCLAIMER

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EXECUTIVE SUMMARY

This report is one of several addressing the Zero-Offsite Water-Discharge Study prepared in response to Item C.7 of the Agreement in Principle between the Colorado Department of Health (CDH) and the U.S. Department of Energy (DOE) (ASI, 1990a). The CDH/DOE Agreement Item C.7 states "Source Reduction and Zero Discharges Study: Conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and ground water. This review should include a source reduction review." The purpose of this report is to provide information from which a decision can be made regarding the design recurrence interval(s) flood event(s) which should be used for Rocky Flats Plant (RFP) surface-water conveyance and storage structures (ASI, 1990b). The decision of which design recurrence interval(s) is(are) appropriate and will be used at the RFP will be made upon completion of another Zero-Offsite Water-Discharge Study, Task 6, "Storm-Runoff Quantity for Various Design Events."

Design criteria of agencies with jurisdictional or structure-inspection and rating duties at the RFP were reviewed in greater detail. These agencies include the DOE, the U.S. Army Corps of Engineers (COE), and the Colorado Division of Water Resources, Office of the State Engineer. In the documents SC-109, "Standard for Storm Sewer Design Criteria," (DOE, 1986) and 6430.1A, "Design Criteria Manual," (DOE, 1989), DOE requires that the storm drainage system at the RFP be able to remove at least the 25-year, 6-hour duration rainfall event. Larger events, up to the 100-yeqr, 6-hour duration event should be evaluated.

In reviewing and evaluating design flood criteria used by various agencies, comparisons need to be made to conditions applicable to the RFP and the purposes of surface-water control there. Storage structures currently in place at the RFP are rated "minor" to

"intermediate" in size and Class II to Class IV according to Colorado State Engineer criteria. For Class II, Class III and Class IV structures, in case of dam or spillway failure, no loss of life is anticipated. Downstream damage to structures where people live, work or recreate is expected in case of failure of Class II dams, but such damage is not expected if Class III dams fail. Damage is expected to be limited to the dam owner's property in case of failure of Class IV structures. Reservoir C-2 has the only Class II rated dam at the RFP.

Similarly, the COE rates the water-storage structures currently existing at the RFP. The COE rates RFP dams as "small" to "intermediate" in size with mainly "low" downstream risk potential. Downstream risk potential is rated as "significant" for Reservoir C-2, because there could be minimal to appreciable damage to roadway structures and a few buildings in the event that the dam should fail. Spillways of RFP dams have been judged by the COE as adequate in ability to pass their respective, appropriate design flood.

The recurrence intervals for design-storms/floods as presented by various other Federal, State and local agencies and entities range from two years to the Probable Maximum Flood (PMF). For small structures where capacity exceedance has minimal consequences in terms of loss of human life or property damage, the two-year event is the design-storm/flood. For structures whose failure could result in loss of human life or extensive property damage, the PMF is used as the design flood. Also, the U. S. Nuclear Regulatory Commission (NRC) recommends use of the PMF for design of erosion protection covers for stabilization of uranium mill tailings sites. The 100-year flood is often used for design purposes where loss of human life and damage to structures and public facilities are not expected as a result of failure. The CDH requires that, upon closure of a waste-disposal facility, permanent surface-water structures be designed for the 100-year event.

DESIGN RECURRENCE INTERVALS STUDY
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1.0 INTRODUCTION

This report is prepared for one of several studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan for Rocky Flats Plant (RFP) in response to Item C.7 of the Agreement in Principle between the Colorado Department of Health (CDH) and the U.S. Department of Energy (DOE) (ASI, 1990a). The CDH/DOE Agreement Item C.7 states " Source Reduction and Zero Discharges Study: Conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and ground water. This review should include a source reduction review." This report only addresses zero discharge of water at the RFP. Specifically, the purpose of this report is to provide information on which to base a decision regarding the design recurrence interval(s) storm event(s) for surface-water conveyance and storage structures at the RFP (ASI, 1990b). The decision of which design recurrence interval(s) is(are) appropriate and will be used at the RFP will be made upon completion of another Zero-Offsite Water-Discharge Study, Task 6, "Storm-Runoff Quantity for Various Design Events."

If storm runoff is to be captured from the controlled area and/or parts of the buffer zone at the RFP, a management decision will be made as to the extreme precipitation event or combination of rainfall and snowmelt for which hydraulic structures will be designed. This is especially critical for storage structures such as reservoirs.

The design storm/flood used for sizing hydraulic structures to transport or store runoff at the RFP is of great importance, given the RFP's location upstream from certain domestic water supplies in the Denver metropolitan area. The decision as to which design storm or flood to use will be made based on the probability of

failure of a given structure and the cost of the consequences of such a failure. The design storm/flood decision cannot always be made using quantifiable engineering analyses, because the consequences of failure of some structures include loss of human life. Therefore, the design storm/flood decision will consider philosophical arguments. This study attempts to put the design-storm/flood question in perspective by examining design-storm/flood criteria proposed by Federal, State, and local regulatory agencies for other hydraulic structures and facilities.

The design-storm/flood events discussed in this report are used interchangeably. That is, it is assumed that a 100-year average recurrence-interval rainfall would produce the 100-year average recurrence-interval flood. This assumption is used when a runoff model calculates the resulting flood from an input storm event. This hydrometeorological approach is used because streamflow records are of such short duration that statistical analyses thereof do not provide reliable bases for estimates of extreme flood events.

Several terms are used in this report, the definitions of which will aid in understanding the concepts discussed. These are presented in Appendix A, "Definitions".

2.0 DESIGN-STORM/FLOOD CRITERIA

The following discussion briefly reviews design-storm/flood criteria that relate to the RFP. The design-storm/flood criteria used by several jurisdictional agencies and entities for a variety of structures and facilities are discussed. A summary of design-storm/flood criteria is given in tabular form in Appendix B, "Summary of Design-Storm/Flood Criteria."

2.1 Rocky Flats Plant

2.1.1 U.S. Department of Energy (DOE)

The document SC-109, "Standard for Storm Sewer Design Criteria," (DOE, 1986), established the storm-frequency design criteria for use at the RFP. Rainfall and runoff data presented by the Denver Regional Council of Governments (DRCOG) document "Urban Storm Drainage Criteria Manual," (Urban Drainage and Flood Control District, 1969 revised in 1984) were used in preparing SC-109. According to document SC-109, the storm drainage system at the RFP is to be designed for complete removal of a 25-year frequency rainfall, and the potential flood damage from a 100-year event is to be evaluated. A more severe storm than the 25-year event is to be used for design purposes if it is warranted, based on flood damage evaluation studies. In 1989, in "Design Criteria Manual" (DOE, 6430.1A, 1989), the design criteria were further refined to state "... Stormwater management systems shall be designed for not less than the 25-year, 6-hour storm. The potential effect of larger storms (up to the 100-year, 6-hour storm) shall also be considered. With the approval of the cognizant DOE authority, lesser design storms may be used where a large expenditure for flood protection cannot be economically justified."

The DOE is also directed in 10 CFR 1022 - "Compliance With Floodplain/Wetlands Environmental Review Requirements" to exercise leadership and take action to avoid to the extent possible long- and short-term adverse impacts associated with the destruction, occupancy, modification and development of floodplains and wetlands. The policies and procedures set forth in 10 CFR 1022 apply to all organizational units of DOE except the Federal Energy Regulatory Commission (FERC), and are intended to accommodate requirements of Executive Orders 11988 and 11990 ("Floodplain Management" and "Protection of Wetlands", respectively) through applicable DOE National Environmental Policy Act (NEPA) procedures. The "base floodplain" is defined as the 100-year floodplain, and the "critical action floodplain" is defined as the 500-year floodplain.

2.1.2 U.S. Army Corps of Engineers

Dams and reservoirs are classified according to size and hazard potential by the U.S. Army Corps of Engineers (COE, 1978). "Small" reservoirs are those with storage less than 1,000 acre feet (ac-ft) and with dam heights less than 40 ft. "Intermediate" reservoirs contain between 1,000 and 50,000 ac-ft of storage and have dam heights between 40 and 100 ft, and "large" reservoirs have storage capabilities greater than 50,000 ac-ft with dams exceeding 100 ft in height.

Hazard potential criteria are the potential for loss of life and the potential for economic loss. "Low" hazard potential is assumed where no loss of life is expected as a result of structure failure, and potential for economic loss is minimal. Hazard potential is considered to be "significant" when a few lost lives and appreciable loss of agriculture, industry or structures are anticipated. Hazard potential is "high" when more than a few lives would be lost and economic loss would be excessive. Design-flood criteria range from the 50- to 100-yr event for "small" dams with

"low" hazard potential to the Probable Maximum Flood (PMF) for "large" dams regardless of the hazard potential. Storm duration is not given as a specific spillway design flood criterion by the COE, (1978). However, at the RFP the 16-hour duration Probable Maximum Precipitation (PMP) event was used to model flood peaks and volumes in the analysis of dam storage and spillway capabilities.

The COE , based on a contractual arrangement, inspects the water-storage structures at the RFP on an annual basis. According to their most recent report (COE, 1989), the RFP dams are rated "small" to "intermediate" in size and "low" to "significant" in hazard potential. Reservoir C-2 has been rated as having "significant" hazard potential in the event of dam failure. It is estimated that there would be no loss of life; however, there could be minimal to appreciable damage to roadway structures and a few buildings.

RFP's reservoirs are listed in Appendix C, "RFP Reservoir Information", along with COE ratings. According to the aforementioned COE annual inspection report, the spillways of all RFP dams are adequately sized.

2.1.3 Colorado Division of Water Resources, State Engineer

The State of Colorado, through the Office of the State Engineer, has classified reservoir dams according to hazard potential and size (Colorado State Engineer, 1988). For reservoirs where dam failure could result in loss of human life, the PMP may be required when determining the inflow design flood (IDF). Dams whose failure would not result in loss of human life may use, as the IDF, events expressed as a fraction of the PMP or specific recurrence interval events such as the 100-year flood. The 25-year flood is the minimum IDF required and is applicable for spillways of "minor" or "small" dams where loss of human life due to failure is not expected, and damage will occur only to the dam owner's property.

In general, the State Engineer recommends use of the 24-hour duration rainfall event when spillway design requires use of the 25-, 50-, or 100-year IDF. The 72-hour duration rainfall event is used for the PMF.

The State Engineer also inspects RFP surface-water storage facilities annually and has classified the RFP reservoirs as "minor" to "intermediate" in size and Class II, Class III or Class IV in risk potential. RFP reservoir classifications according to the Colorado State Engineer are given in Appendix C.

State Engineer "minor" dams do not exceed 20 ft. in vertical height and 100 ac-ft. in capacity. A "small" dam is greater than 20 ft. in vertical height but equal to or less than both 40 ft. and 1,000 ac-ft. in capacity, or is greater than 100 ac-ft. in capacity but equal to or less than both 1,000 ac-ft. in capacity and 40 ft. in vertical height. "Intermediate" dams are greater than 40 ft. in vertical height but equal to or less than both 100 ft. and 50,000 ac-ft. in capacity, or greater than 1,000 ac-ft. in capacity but equal to or less than both 50,000 ac-ft. in capacity and 100 ft. in vertical height. "Large" dams exceed the maximum criteria for "intermediate" dams.

Failure of a Class I dam would potentially result in loss of life and extensive property damage. Their spillways are required to pass the PMP for all dam sizes except a "minor" dam, the spillway of which must pass 0.50 PMP. No structures at RFP are rated as Class I.

A Class II dam is a dam for which significant damage is expected to occur, but no loss of human life is expected in the event of failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, or public or private facilities exclusive of unpaved roads and picnic areas. The required IDF design precipitation for spillway design

for a "small", Class II dam is 0.50 PMP. A Class III dam is one for which loss of human life is not expected and damage to structures and public facilities, as defined for a Class II dam, is not expected in the event of failure of the dam. Spillways of "small" to "large" dams must pass the 100-year flood, whereas "minor" Class III dam's spillways must be capable of passing the 50-year flood. Class IV dams are those for which no loss of human life is expected, and damage will occur only to the dam's owner's property in the event of failure of the dam. "Minor" and "small" Class IV dams must pass the 25-year flood, and "intermediate" and "large" dam's spillways must pass the 50-year flood.

The C-2 Reservoir has been rated as Class II by the State Engineer. All other RFP reservoirs are rated Class III or Class IV.

2.2 Design-Storm/Flood Criteria of Other Agencies

2.2.1 Denver Regional Council of Governments

The Denver region's urban-runoff design criteria have been documented in the Urban Storm Drainage Criteria Manual (Urban Drainage and Flood Control District, 1969, revised 1984). Denver region's storm-drainage design recognizes two separate and distinct storm-drainage systems: (1) the initial drainage system, and (2) the major drainage system.

The initial drainage system includes the underground storm sewer-system and street gutters. Its purpose is to reduce street maintenance costs, to provide protection from regularly recurring damage from storm runoff, and to direct storm runoff into the major drainage system. The design storm for the initial drainage system ranges from a 2-year recurrence interval event to a 10-year recurrence interval event.

The major drainage system consists primarily of open channels designed to transport major runoff events. For this system, the 100-year recurrence interval event commonly is used as the design storm.

2.2.2 Colorado Department of Highways

Criteria used by the Colorado Department of Highways in selecting the design flood frequency for their structures include construction costs, probable property and highway damage, traffic delays, availability of alternate routes, intangible considerations (such as loss of emergency supply and evacuation routes and potential loss of life), and budgetary constraints (Colorado Department of Highways, 1987). Thus, their design-flood recurrence interval ranges from 2 years, for some side drains and minor storm-sewer systems, to 100 years for bridge foundation scour, cross drainage for major urban-area roads, and major storm-sewer systems.

2.2.3 U.S. Federal Highway Administration

Similar to the Colorado Department of Highways, the U.S. Federal Highway Administration designs their hydraulic structures considering such factors as risk to traffic, potential property damage and failure as a result of floods (Federal Highway Administration, 1988). For rural roads, the recommended design flood ranges from a 5-year recurrence interval for curbs and ditches to a minimum recurrence interval of 50 years for bridges. The 100-year flood should be investigated and considered for bridges. Additionally, at least one foot of clearance is allowed for bridge design, and, when ice or wooded debris is a factor, additional clearance may be necessary.

In urban areas, Federal Highway Administration structures should cause no more than one foot rise in elevation of the 100-year

runoff event (Federal Highway Administration, 1986). Also, a minimum design flood frequency of 10 years is used for all urban drainage systems, including ditches.

2.2.4 U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation has selected the PMF as the IDF for proposed storage dams in those cases where the potential hazard area is or is expected to be occupied by permanent human habitation (Bureau of Reclamation, 1981). In these instances, loss of human life and/or extensive property damage can reasonably be expected if failure occurs. If it can be demonstrated conclusively that the potential hazard area downstream from the proposed dam is unoccupied by permanent human habitation, and is unlikely to be so occupied in the future, a flood of lesser magnitude may be selected. The magnitude of the flood selected is based on economic and financial considerations which specifically include protection of the investment and the impact of disrupting water-related services. The lesser magnitude flood usually is expressed as a percent of the PMF or as a flood of specific frequency.

2.2.5 U.S. Soil Conservation Service

The U.S. Soil Conservation Service (SCS) classifies structures into three category groups (Ogrosky, 1964):

(a) Structures located in rural or agricultural areas where failure might damage farm buildings, agricultural land, or township or county roads;

(b) Structures located in predominantly rural or agricultural areas where failure might damage isolated homes, main highways or minor railroads, or cause interruption of use or service of relatively important public utilities; or

(c) Structures located where failure might cause loss of life, serious damage of homes, industrial and commercial buildings, important public utilities, main highways, or railroads.

For these different classifications, the spillway design and the freeboard pool design floods range from the 100-year event, through a flood series including the 100-year event plus a fraction of the PMP, to the PMP (see Appendix B for more details). The SCS uses a 6-hour duration event unless the time of concentration exceeds 6 hours. In those cases where the time of concentration exceeds 6 hours, adjustments are made to the 6-hour storm depth to account for the greater amounts of direct runoff during a longer period of time.

2.2.6 Jefferson County, Colorado

Jefferson County's landfill policies are not specific with respect to surface-water runoff (Jefferson County, 1983). Their site-development policy regarding runoff is general and contains directives that surface runoff should be diverted in a manner that minimizes contact with the working face of the fill, other disturbed areas, or stockpiled soil materials. However, the design and operation plan for a recently proposed Jefferson County landfill used the 100-year, 6-hour duration storm for sizing surface-water diversion structures (ICI, 1986).

2.2.7 Colorado Department of Health

Siting and closure criteria for solid-waste facilities in Colorado define the 100-year recurrence interval flood as the "base flood" (Colorado Department of Health, 1987). Design standards for closure of solid waste disposal facilities require that permanent surface-water diversion structures control runon and runoff from the 100-year event.

The Colorado Department of Health (CDH) requires that hazardous-waste disposal sites be designed to prevent adverse effects on surface-water quality but gives no specific design-flood guidance. Reasonable assurance must be given that the hazardous wastes are isolated and away from natural environmental pathways that could expose the public within a 1,000 year period of time. In a joint study with the Colorado Geological Survey and the CDH (Hynes and Sutton, 1980), it was recommended that hazardous waste disposal sites be located outside any area subject to the PMF, and that site should be evaluated for the impact of the PMP. Also, mitigation procedures should be considered and designed based on PMP calculations.

2.2.8 U. S. Environmental Protection Agency

In the criteria recommended by the U. S. Environmental Protection Agency (EPA, 1988) for municipal solid waste landfills, federal regulations require that a runon system should prevent flow onto the active portion of the landfill during the peak discharge from a 25-year storm. Additionally, a runoff system for the active part of the landfill must collect and control the water volume resulting from a 24-hour duration, 25-year storm.

Surface-water runoff considerations for hazardous waste sites administered by EPA as a result of the Resource Conservation and Recovery Act of 1976 (RCRA) or the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) regulations are general in nature. EPA establishes design criteria on a case by case basis (verbal communication, 1990). However, if leachate or runoff from a waste pile is a hazardous waste, then the same runon and runoff requirements as described previously for municipal solid waste landfills apply.

2.2.9 U. S. Nuclear Regulatory Commission

The U. S. Nuclear Regulatory Commission (NRC) has issued a draft staff technical position concerning the design of erosion protection covers for stabilization of uranium mill tailings disposal sites (NRC, 1990). Federal regulations set forth in 40CFR 192.02 and 10CFR 40, Appendix A require that uranium mill-tailings stabilization designs provide reasonable assurance of control of radiological hazards for a 1,000-year period, to the extent practicable, but in any case, for a minimum of 200 years. According to this NRC staff-position paper, the design flood or precipitation event on which to base the stabilization plan should be one for which there is reasonable assurance of non-exceedance during the 1,000-year design life. The 1,000-year flood has about a 63 percent chance of being equalled or exceeded during the 1,000-year design life, and is therefore unacceptable. Because there is low likelihood of exceedance of the PMF during the 1,000-year design life, the PMF is the event preferred by NRC staff for design purposes.

3.0 OTHER DATA AND INFORMATION

3.1 Standley Lake and Great Western Reservoir

Downstream from the RFP are two reservoirs utilized as municipal water supplies: Great Western Reservoir on Walnut Creek and Standley Lake on Woman Creek. Great Western Reservoir, owned by the City of Broomfield, is rated by the State Engineer as "Intermediate", Class I. Its dam height is 70 ft. and reservoir storage capacity is 3,250 ac-ft. As a Class I reservoir, its spillway should be designed to pass the flood caused by the PMP. The 1989 State Engineer's Inspection Report noted that Great Western Reservoir's spillway is undersized and indicated that it would require enlargement within three years.

Standley Lake, owned in part by the City of Westminster, is larger than Great Western Reservoir, with a dam height of 113 ft. and a storage capacity of 42,380 ac-ft. It is classified as a "Large", Class I reservoir. Its spillway is designed to adequately pass the PMF.

3.2 Design Precipitation Values

A table of precipitation values at the RFP is given in Appendix D. Recurrence intervals range from the 2-year event to the PMP. Storm durations range from 5 minutes to 72 hours. Two-year through 100-year values for 1-, 6-, and 24-hour durations were taken from isohyetal contour maps prepared by the National Weather Service (Miller, Frederick and Tracey, 1973). Five-minute through 30-minute duration values presented in Appendix D were taken from SC-109 (DOE, 1986). Values presented in SC-109 were taken from the DRCOG document, "Urban Storm Drainage Criteria Manual," (Urban Drainage and Flood Control District, 1969 revised in 1984). The 72-hour duration storm values for 2- through 100-year recurrence intervals were determined by extrapolating log-log plots of

precipitation versus storm duration. These plots are also presented in Appendix D (Figure D-1). PMP values presented in Appendix D were taken from National Weather Service document HMR-55A (Hansen and others, 1988).

3.3 Historical Precipitation Events

The PMP is almost theoretical in nature. Yet, there is precedence in Colorado and in the Front Range area for large magnitude events of the same order of magnitude as the PMP (Colorado State Engineer, 1989). Although it has not been quantified as a percentage of the PMP, a maximum point value of 12.5 inches of rain fell within four hours on July 31, 1976 near Estes Park in the Big Thompson River basin (Maddox and others, 1977 and Miller and others, 1988).

In 1985 in Cheyenne, Wyoming, greater than 6 inches of rain fell, estimated by some to exceed the 500-year storm (Colorado State Engineer, 1989).

The so-called Southwest Colorado Flood, which occurred in 1970, was caused by a storm estimated to be 88 percent of the 6-hour duration 100 sq. mi. general storm PMP (Colorado State Engineer, 1989). This storm equalled 69 percent of the 1-hour, 10-sq. mi. local storm PMP.

In 1965, greater than 10 inches of rain fell at many locations within the Plum Creek basin, with the greatest localized rainfall amount being recorded 18.1 inches (Colorado State Engineer, 1989).

On May 30-31, 1935, heavy convective-storm rainfall occurred at several locations along a line from the foothills of the Rocky Mountains of eastern Colorado east-northeastward to the Kansas border. Point rainfall amounts as high as 24 inches in 6 hours were recorded (Hansen and others, 1988).

These examples give evidence of the excessive precipitation and runoff events that can and do occur in and around the RFP site, the Denver metropolitan area and Colorado. Other examples are described in detail in the National Weather Service document HMR-55A (Hansen and others, 1988).

4.0 ACKNOWLEDGEMENTS

This report was prepared under the direction of Mr. Michael G. Waltermire, P.E., Project Manager, of Advanced Sciences, Inc. (ASI). Mr. Stephen J. Playton, P.H., subconsultant to ASI, prepared this report, and it was reviewed by Dr. James R. Kunkel, P.E., P.H., Senior Hydrologist, ASI, and by Dr. Timothy D. Steele, P.H., Group Director, Physical Sciences, ASI. This study report is submitted in partial fulfillment of the Zero-Offsite Water-Discharge study being conducted by ASI on behalf of EG&G, Rocky Flats Plant, Inc. EG&G's Project Engineer was R. A. Applehans of EG&G Rocky Flats, Inc. Facilities Engineering, Plant Civil/Structural Engineering.

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APPENDIX A
DEFINITIONS

X-Year Flood: The flood whose magnitude will be equalled or exceeded, on the average, at least once in the next X years.

X-Year Storm: Same as X-year flood except for rainfall.

Probable Maximum Precipitation: The precipitation based upon the maximized intensity-duration values for a given storm type and variation, with respect to location, areal coverage, and duration. The worst-case meteorological conditions are assumed. The PMP is not associated with a recurrence interval.

Probable Maximum Flood: The largest flood that can reasonably be expected to occur from a drainage basin, based upon the worst meteorological and drainage basin conditons that can occur. The PMF is not associated with a recurrence interval.

Storm Duration: The time that rainfall occurs over a drainage basin. Common durations used in design range from the 1-hour for small drainage basins where peak discharges are of interest, to several days for large drainage basins where water storage is of interest.

Peak Discharge: The highest instantaneous discharge during a flood from a given drainage basin. Of interest in design of open channels, spillways and culverts.

Runoff Volume: The total amount of runoff from a flood from a given drainage basin. Of interest in design of reservoirs.

APPENDIX B

SUMMARY OF DESIGN-FLOOD CRITERIA

AGENCY OR ENTITY	STRUCTURES OR FACILITIES	DESIGN-FLOOD CRITERIA
Dept. of Energy, Rocky Flats Plant	Storm Sewers	25-yr flood, 6-hr duration evaluate 100-yr flood damage
U.S. Army Corps of Engineers	Dams and Spillways	Hazard / Size / Design Flood Low / Small / 50 to 100 yr / Intermediate / 100 yr to 0.5 PMF / Large / 0.5 PMF to PMF Significant / Small / 100 yr to 0.5 PMF / Intermediate / 0.5 PMF to PMF / Large / PMF High / Small / 0.5 PMF to PMF / Intermediate / PMF / Large / PMF
Colorado State Engineer	Dams and Spillways	Dam Class / I / II / III / IV Large / PMP / .75PMP / 100 yr / 50 yr Intermediate / PMP / .50PMP / 100 yr / 50 yr Small / PMP / .50PMP / 100 yr / 25 yr Minor / .50PMP / 100 yr / 50 yr / 25 yr PMP based on 72-hr duration Others based on 240hr duration
Urban Drainage and Flood Control District	Denver Region storm drainage system	Land Use / Initial Storm / Major Storm Residential / 2 yr / 100 yr High Val. Comm'l / 5 yr / 100 yr Public Bldg / 5 yr / 100 yr Airports / 2-5 yr / 100 yr Major Airport Terminals / 5-10 yr / 100 yr Downtown Bus. Areas / 5-10 yr / 100 yr
Colo. Dept. of Highways	State Highway facilities	Cross Drainage Multi-lane roads in urban areas: 100 yr in rural areas: 50 yr 2-lane roads in urban areas: 100 yr in rural areas where q50 >4000cfs: 50 yr q50 <4000cfs: 25 yr Culvert scour protection: 10 yr Bridge foundation scour: 100 yr Side drains: 2-10 yr Storm sewers major system: 100 yr minor system residential: 2-3 yr commercial: 2-5 yr

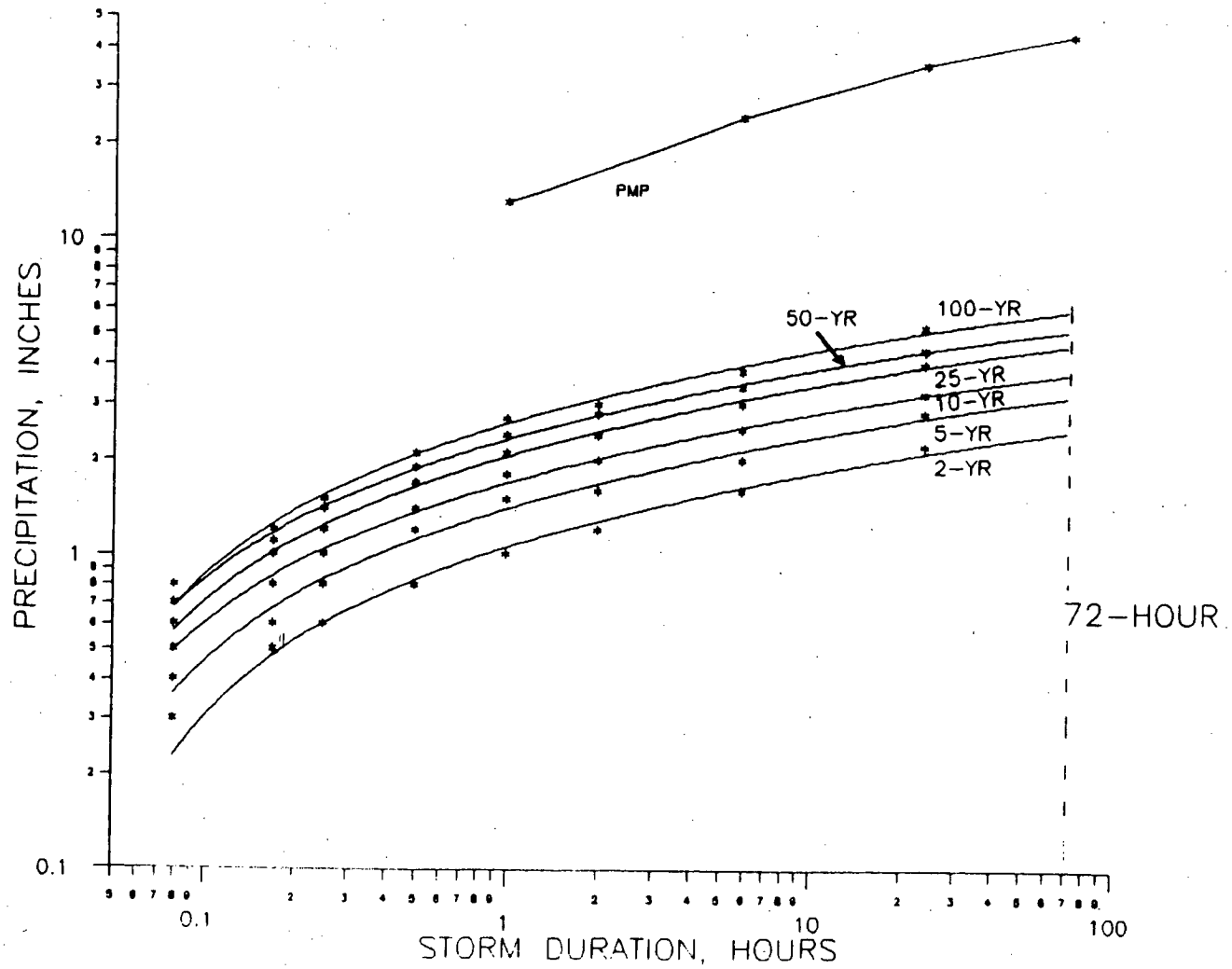
SUMMARY OF DESIGN FLOOD CRITERIA

AGENCY OR ENTITY	STRUCTURES OR FACILITIES	DESIGN-FLOOD CRITERIA
Federal Highway Administration	Federal highway facilities	Rural roads curbs and ditches 5-10 yr Culverts & embankments 25-50 yr Small streams(q10<50 cfs) 10-25 yr Large streams(q10>50 cfs) 50 yr Bridges min 50 yr Urban areas & floodplains all drainage systems min 10 yr raise 100-yr flood level < 1 ft
Bureau of Reclamation	Dams and Spillways	Downstream hazard area human occupied - PMF Downstream hazard area not human occupied - evaluated on case by case basis
Soil Conservation Service	Dams and Spillways	Dam Class — Spillway Design (a) — 100 yr (b) — 100 yr + 0.12(PMP-100 yr) (c) — 100 yr + 0.26(PMP-100 yr) based on 6-hr duration
Jefferson County Colorado	Landfills	not specific, but have used 100-yr, 6-hr duration event
Colorado Dept. of Health	Landfills Hazardous waste sites	closure requires protection from 100-yr event Public not exposed for 1000 yr - PMF
Environmental Protection Agency	Municipal Landfills Hazardous waste sites	Active portion of landfill - 24-hr duration, 25 yr Evaluated on case by case basis - hazardous leachate from piles same as for landfills
Nuclear Regulatory Commission	Uranium mill tailings	Public not exposed for 1000 yr - PMF

APPENDIX C
RFP RESERVOIR INFORMATION

DRAINAGE BASIN	RESERVOIR NAME	DAM HEIGHT (ft)	MAXIMUM POOL CAPACITY (ac-ft)	SPILLWAY CREST CAPACITY (ac-ft)	COE DAM SIZE RATING	COE HAZARD RATING	COLO. SIZE RATING	COLO. HAZARD RATING	SPILLWAY DESIGN FLOOD
N. Walnut Creek	A-1	17	12.3	4.9	Small	Low	Minor	Class IV	> 50 yr
	A-2	29	31.4	19.0	Small	Low	Small	Class IV	> 50 yr
	A-3	37.5	76.0	43.0	Small	Low	Small	Class IV	> 50 yr
	A-4	46	153.5	94.0	Intermed.	Low	Intermed.	Class III	>100 yr
S. Walnut Creek	B-1	16	8.0	3.1	Small	Low	Minor	Class IV	> 50 yr
	B-2	26	14.9	7.5	Small	Low	Small	Class IV	>100 yr
	B-3	18	6.0	2.2	Small	Low	Minor	Class IV	>100 yr
	B-4	19	5.7	1.8	Small	Low	Minor	Class IV	> 50 yr
	B-5	54	120.0	79.3	Intermed.	Low	Intermed.	Class III	0.6 PMF
Woman C.	C-1	15	17.1	5.9	Small	Low	Minor	Class IV	> 50 yr
	C-2	35.5	173.5	70.7	Small	Signif.	Small	Class II	0.8 PMF
N. Walnut Creek	Landfill	40.5	43.5	28.0	Intermed.	Low	Intermed.	Class III	0.4 PMF

Information taken from COE (1989) and State Engineer inspection reports.



PRECIPITATION VERSUS STORM DURATION

ROCKY FLATS PLANT
DESIGN RECURRENCE INTERVALS STUDY

PROJECT NO.208.0109
FIGURE No.D-1

APPENDIX D
TABLE OF PRECIPITATION VALUES
AT ROCKY FLATS PLANT

RECURRENCE INTERVAL
(Probability of Occurrence)

DURATION	2-yr (50%)	5-yr (20%)	10-yr (10%)	25-yr (4%)	50-yr (2%)	100-yr (1%)	PMP(L)	PMP(G)
	Precipitation, inches							
5-min storm	0.3	0.4	0.5	0.6	0.7	0.8	- -	- -
10-min storm	0.5	0.6	0.8	1.0	1.1	1.2	- -	- -
15-min storm	0.6	0.8	1.0	1.2	1.4	1.5	- -	- -
30-min storm	0.8	1.2	1.4	1.7	1.9	2.1	- -	- -
1-hr storm	1.0	1.5	1.8	2.1	2.4	2.7	10.7	13
2-hr storm	1.2	1.6	2.0	2.4	2.8	3.0	- -	- -
6-hr storm	1.6	2.0	2.5	3.0	3.4	3.8	14.5	24
24-hr storm	2.2	2.8	3.2	4.0	4.4	5.2	- -	35
72-hr storm	2.9	3.3	3.8	5.0	5.5	6.3	- -	43

PMP(L) = Local Storm PMP
PMP(G) = General Storm PMP

For 2-yr through 100-yr recurrence-interval storms:

5-min, 10-min, 15-min and 30-min duration values from SC-109 (DOE, 1986).

1-hr, 6-hr and 24-hr duration values from NOAA Atlas 2 Miller, Frederick and Tracey, 1973).

72-hr duration values extrapolated from log-log plot of 1-hr to 24-hr duration values (Figure D-1).

PMP's from National Weather Service HMR-55A (Hansen and others, 1988).

Rainfall intensity (in/hr) = (Precipitation (in) * 60) / Duration (min)