**OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
CALCULATION COVER SHEET**

1. QA: QA
Page: 1 Of: 8

2. Calculation Title

Calculation: Precipitation Characteristics for Storm Water Management

3. Document Identifier (including Revision Number)

CAL-WHS-MM-000001, Rev 01

4. Total Attachments

2

5. Attachment Numbers - Number of pages in each

Attachment I - 1page, Attachment II - 4 pages

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9. Remarks

Revision History

10. Revision No.	11. Description of Revision
00	Initial Issue
01	Revision is required to more fully justify the use of the calculation method which is based on NOAA Hydrometeorological Report 49 (Hansen 1984) as applied by Bullard (1992) to the Nevada Test Site. This justification is presented as an assumption. Corrected misalignments between the list of references in the Calculation and the DIRS listing. Corrected one DIRS reference with an incorrect quality definition. Added to the Purpose section the revision of AP-3.12Q (Rev 0/ICN 2) under which the Calculation was prepared.

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1. PURPOSE

This Calculation is intended to satisfy engineering requirements for maximum 60-minute precipitation amounts for 50 and 100-year return periods at and near Yucca Mountain. This data requirement is documented in the *Interface Control Document for Support Operations to Surface Facilities Operations Functional and Organizational Interfaces* (CRWMS M&O 1998a). These developed data will supplement the information on 0.1 hour to 6-hour (in 0.1-hour increments) probable maximum precipitation (PMP) presented in the report, *Precipitation Design Criteria for Storm Water Management* (CRWMS M&O 1998b). The Reference Information Base (RIB) item, *Precipitation Characteristics for Storm Water Management* (MO9902RIB00045.000), was developed based on CRWMS M&O (1998b) and will be supplemented (via revision) with the information developed in this Calculation. The *Development Plan for the Calculation: Precipitation Characteristics for Storm Water Management* (CRWMS M&O 2000) was prepared in accordance with AP-2.13Q, *Technical Product Development Planning*. This calculation was developed in accordance with AP-3.12Q, Rev. 0/ICN 2.

2. METHOD

The method for estimating probable maximum flood-producing precipitation amounts is presented in Hydrometeorological Report 49 (HMR 49) (Hansen et al 1984). For the purpose of determining PMP over a 1 square mile area, Hansen (1984) postulated that localized thunderstorms of 6-hour duration could produce extreme or PMP-type events. These thunderstorm events tend to be intense, of shorter duration than general storms, and are more likely to produce probable maximum flooding.

The methodology developed in HMR 49 involved developing PMP estimates using empirical data from a number of notable intense local storms which occurred in the southwest U.S. Most storms were of a duration of 1-3 hours; however, a duration limit of 6 hours was used to combine the results of two or more individual storms that produce local PMP conditions. Ratios of 6-hour and 1-hour (6/1-hour) precipitation totals from PMP events were developed for the southwest U.S. (Hansen 1984, Figure 4.7, page 118).

Bullard (1992) applied the method specifically to the Nevada Test Site (NTS) to determine the PMP in this region of the western U.S. Bullard determined that the 6/1-hour ratio for the NTS to be 1.35 based on the information presented in Hansen (1984). That is,

$$\frac{\text{Extreme 6-hour precipitation amount}}{\text{Extreme 1-hour amount from same storm}} = 1.35 \quad (1)$$

Another way to express this relationship is that, for a 6-hour storm total, most of the precipitation (74 percent) falls during one hour and the remaining amount (26 percent) falls during the remaining five hours. Usually, the heaviest precipitation amount occurs

during the first one to two hours of the storm and diminishes during the storm's remaining life cycle.

This methodology was also used in CRWMS M&O (1998b) to determine incremental rainfall amounts from 0.1 to 6 hours (in 0.1-hour increments) based on a 6-hour PMP event of 5 total inches near Yucca Mountain. A 24-hour total amount of 5 inches (storm with a 6-hour duration) was determined to be realistically conservative for the Yucca Mountain region (CRWMS M&O 1997). Randerson (1997) corroborated this PMP value (5 inches in 24-hours) for the southern Nevada Test Site (NTS) in an independent study based on historical NTS precipitation data collected by the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory Special Operations Research Division (ARL/SORD). Again, the 24-hour total can be considered to have occurred within six contiguous hours because of the nature of intense thunderstorm events. Randerson (1997) also calculated a 5-inch 24-hour total to have a return period of 500 years.

This ratio (1.35) is applied in this Calculation to relate 50 and 100-year 24-hour total amounts resulting from 6-hour PMP events to 50 and 100-year 1-hour amounts. The development plan did not require special controls for source data or control of the electronic management of source data. Data were not processed electronically, therefore, AP-SV.1Q, *Control of the Electronic Management of Data*, does not apply. Calculations were performed by hand calculator throughout.

3. ASSUMPTIONS

3.1 Storm event duration and reporting. Customarily, precipitation amounts are reported as 24-hour totals for a given location. However, the storm event that produced the daily total may have had a much shorter duration. This is especially true for measurements resulting from localized summertime thunderstorm activity with much shorter durations than the general synoptic-scale wintertime storm. This is the situation in the desert southwest. Extreme accumulations usually occur from intense, isolated thunderstorms with durations of six hours or less. Such heavy storms of shorter duration can produce the most significant local flooding (Bullard 1992). Crow (1989) reported that southern Nevada flash flood-producing summer storms usually had durations of three hours or less.

Therefore, the assumption is made that extreme 24-hour precipitation totals, which are used as source data (CWRMS M&O 1997), represent extreme PMP events that began and ended within a period of six hours or less. This assumption, applied throughout this Calculation, is necessary so that the method mentioned above can be employed. This assumption does not require confirmation.

3.2. Methodology. The methodology developed in (Hansen et al. 1984) and applied by Bullard (1992) to the NTS is assumed to be valid for the intended purposes as stated in these references. It is also assumed that no further verification is needed for the

methodology since it was developed under the auspices of the National Oceanic and Atmospheric Administration (NOAA) for general use by the public and was based on data collected and verified by NOAA.

4. USE OF COMPUTER SOFTWARE AND MODELS

There are no computer programs, software routines, or models used. The Calculation was performed using a hand calculator.

5. CALCULATION

The source data for this calculation is presented in Attachment I which is modified after CRWMS M&O (1997), Table 4-3, Estimated and Observed Maximum Daily Precipitation. This table presents 24-hour 50 and 100-year precipitation extremes from a number of locations at Yucca Mountain and the surrounding region. This Calculation is based on the most conservative (highest) 50 and 100-year return 24-hour amounts estimated for the general surrounding region with the potential for occurring at Yucca Mountain.

The values selected are from the Cane Springs precipitation record and are **3.10 inches** and **3.52 inches** for 50 and 100-year returns, respectively. Cane Springs is located on the NTS, approximately 33 kilometers east of Yucca Mountain. The Cane Springs precipitation site is part of the meteorological network operated by NOAA ARL/SORD. Applying the assumption that 24-hour amounts resulting from localized PMP storms can be considered 6-hour totals and applying the ratio defined in equation (1), the following results are obtained.

For the 50-year return amount:

$$\frac{3.10 \text{ inches (6-hour extreme)}}{X \text{ inches (1-hour extreme)}} = 1.35 \quad (2)$$

$$X = 2.30 \text{ inches (50-year, 1-hour amount)}$$

Similarly, for the 100-year return amount:

$$\frac{3.52 \text{ inches (6-hour extreme)}}{X \text{ inches (1-hour extreme)}} = 1.35 \quad (3)$$

$$X = 2.61 \text{ inches (100-year, 1-hour amount)}$$

For the purpose of this Calculation, the 1-hour totals are equivalent to 60-minute totals as required by CRWMS M&O (1998a).

6. RESULTS

The results of calculations (2) and (3) are presented in Table 1. The 50 and 100-year return 60-minute PMP amounts were calculated in response to the data needs as specified in CRWMS M&O (1998a). The Cane Springs 50 and 100-year return amounts (CRWMS-M&O 1997, Table 4-3) are used because they are the most conservative data from the Yucca Mountain region. The Cane Springs data, along with the other historic NTS precipitation data (GS000200001221.002) have been designated "Accepted" in accordance with AP-SIII.2Q, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data* and are designated "N/A - Accepted Data (AMOE Approved)." No further confirmation is needed prior to use in accordance with AP-3.15Q, *Management of Technical Product Inputs*, Attachment 4. The results of this Calculation shall not be compared to design criteria and requirements, nor shall conclusions be used for recommendations for design development or program direction.

Table 1. Calculated maximum 60-minute precipitation amounts for 50 and 100-year return periods.

Location	50-Year Returns (inches)		100-Year Returns (inches)	
	24-Hour*	60-Minute	24-Hour*	60-Minute
Yucca Mountain Region (Southern NTS)	3.10	2.30	3.52	2.61
* (CRWMS M&O 1997, Table 4-3) Based on a localized storm with a duration of 6 hours.				

7. REFERENCES

7.1 PROCEDURES

AP-2.13Q, *Technical Product Development Planning*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000620.00067.

AP-3.12Q, *Calculations*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000620.0068

AP-3.15Q, *Managing Technical Product Inputs*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000218.0069.

AP-SIII.2Q, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000203.0629.

AP-SV.1Q, *Control of the Electronic Management of Data*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000512.0068.

7.2 PUBLICATIONS

Bullard, K.L. 1992. *Nevada Test Site Probable Maximum Flood Study Part of U.S. Geological Survey Flood Potential and Debris Hazard Study Yucca Mountain Site*. Denver, Colorado: U.S. Department of the Interior, Bureau of Reclamation. TIC: 205030.

Crow, L. W. 1989. *Analysis of Pertinent Weather Factors Related to the Frequency and Magnitude of Rain Storms Capable of Producing Flash Floods in Clark County, and Particularly in the Vicinity of Las Vegas, Nevada*. LWC#318. Denver, Colorado: Loren W. Crow Consultants. TIC: 233197.

CRWMS M&O 1997. *Engineering Design Climatology and Regional Meteorological Conditions Report*. B00000000-01717-5707-00066, Rev. 00. Las Vegas, Nevada: CRWMS M&O. DTN: MO9811DEDCRMCR.000. ACC: MOL.19980304.0028.

CRWMS M&O 1998a. *Interface Control Document for Support Operations to Surface Facilities Operations Functional and Organizational Interfaces*. B00000000-01717-8100-00018, Rev. 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981116.0439.

CRWMS M&O 1998b. *Precipitation Design Criteria for Storm Water Management*. B00000000-01717-1704-00001, Rev. 00. Las Vegas, Nevada: CRWMS M&O. DTN: MO9811STORMWTR.000. ACC: MOL.19990216.0207.

CRWMS M&O 2000. *Development Plan for the Calculation: Precipitation Characteristics for Storm Water Management*. Development Plan TDP-WHS-MM-000001, Rev. 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000530.0248.

Hansen, E.M.; Schwarz, F.K.; and Riedel, J.T. 1984. *Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages*. National Weather Service Hydrometeorological Report No. 49. Silver Springs, Maryland: National Oceanic and Atmospheric Administration. TIC: 220224.

Randerson, D. 1997. *Analysis of Extreme Precipitation Events in Southern Nevada*. NOAA Technical Memorandum ERL ARL-221. Silver Spring, Maryland: U. S. Department of Commerce, National Oceanic and Atmospheric Administration. TIC: 233167.

7.3 DATA

GS000200001221.002. *Precipitation Data for Nevada Test Site, 1957-1994, from Air Resources Laboratory, from National Oceanographic and Atmospheric Administration (NOAA) Precipitation Data.* Submittal date: 2/29/2000.

MO9902RIB00045.000. *Precipitation Characteristics for Storm Water Management.*
Reference Information Base item. Submittal date: 02/24/1999.

GS000100001221.001. *Earthinfo, Inc. Western US Meteorologic Station Weather Data - NCDC Summary of the Day (West 1) and NCDC Summary of the Day (West 2).*
Submittal date: 01/25/2000.

See Attachment II for the reference list of meteorological data collected at Yucca Mountain.

8.0 ATTACHMENTS

Attachment I. Modified from CRWMS M&O (1997) Table 4-3, Estimated and Observed Maximum Daily Precipitation

Attachment II. Meteorological Data Collected at Yucca Mountain – 1986 through 1997

ATTACHMENT I

Modified from CRWMS M&O (1997), Table 4-3. Estimated and Observed Maximum Daily Precipitation

Summary of Daily Precipitation Projections (Inches)				
Location	50-year Return	100-year Return	Largest recorded value	Period of Record
Site 1 ^a	2.68	3.03	1.39	1986 – 1996
Site 2 ^a	2.59	2.91	1.65	1990 – 1996
Site 3 ^a	1.91	2.14	1.33	1990 – 1996
Site 4 ^a	2.61	2.92	1.72	'90 & '92-'96
Site 5 ^a	2.05	2.30	1.63	1990 – 1996
Site 6 ^a	2.43	2.73	1.40	1993 – 1996
Site 7 ^a	2.38	2.65	1.21	1993 – 1996
Site 8 ^a	2.14	2.41	1.18	1993 – 1996
Site 9 ^a	1.60	1.79	0.90	1993 – 1996
4JA-all data ^b	2.78	3.23	3.22	1957 – 1996
4JA – 10 yrs ^b	2.92	3.33	2.04	1987 – 1996
Desert Rock ^b	2.69	3.09	3.52	10/63 – 6/96
Mercury ^b	2.77	3.19	3.63	12/68 – 12/93
Rock Valley ^b	2.84	3.24	2.98	2/63 – 12/93
Cane Springs ^b	3.10	3.52	3.47	9/64 – 12/93
Amargosa Farms ^c	2.36	2.74	2.00	1965 – 1996
Am Farms-10 yrs ^c	2.07	2.34	1.45	1987 – 1996
Beatty ^c	1.96	2.21	1.65	1948 – 1972
Beatty 8N ^c	2.32	2.64	1.90	1972 – 1996
Beatty 8N-10 yrs ^c	2.41	2.75	1.25	1987 – 1996
Las Vegas ^c	2.13	2.43	2.58	1949 – 1992

NOTES: a = Source data collected by the YMP. DTNs: (See Atch II)

b = Source data acquired from NOAA ARL/SORD at the NTS.

DTN: GS000200001221.002.

c = Source data acquired from NOAA. DTN: GS000100001221.001

ATTACHMENT II**Meteorological Data Collected at Yucca Mountain 1986 through 1997**

MO9903VALMM931.000. Validated Meteorological Monitoring Data, January - June 1993. Submittal date: 03/29/1999.

MO9903VALMM932.000. Validated Meteorological Monitoring Data, July - September 1993. Submittal date: 03/29/1999.

MO9903VALMM933.000. Validated Meteorological Monitoring Data, October - December 1993. Submittal date: 03/29/1999.

MO9903VALMM961.000. Validated Meteorological Monitoring Data, January - March 1996. Submittal date: 03/29/1999.

MO9903VALMM962.000. Validated Meteorological Monitoring Data, April - June 1996. Submittal date: 03/29/1999.

MO9903VALMM963.000. Validated Meteorological Monitoring Data, July - September 1996. Submittal date: 03/29/1999.

MO9903VALMM964.000. Validated Meteorological Monitoring Data, October - December 1996. Submittal date: 03/29/1999.

MO9905VAMMDD85.000. Validated Meteorological Monitoring Data, December 1985. Submittal date: 05/12/1999.

MO9905VMMDAJ86.000. Validated Meteorological Monitoring Data, April - June 1986. Submittal date: 05/13/1999.

MO9905VMMDAJ87.000. Validated Meteorological Monitoring Data, April - June 1987. Submittal date: 05/18/1999.

MO9905VMMDAJ88.000. Validated Meteorological Monitoring Data, April - June 1988. Submittal date: 05/18/1999.

MO9905VMMDAJ89.000. Validated Meteorological Monitoring Data, April - June 1989. Submittal date: 05/20/1999.

ATTACHMENT II (cont)**Meteorological Data Collected at Yucca Mountain 1986 through 1997**

MO9905VMMDAJ90.000. Validated Meteorological Monitoring Data, April - June 1990. Submittal date: 05/21/1999.

MO9905VMMDAJ91.000. Validated Meteorological Monitoring Data, April - June 1991. Submittal date: 05/21/1999.

MO9905VMMDAJ92.000. Validated Meteorological Monitoring Data, April - June 1992. Submittal date: 05/24/1999.

MO9905VMMDAJ94.000. Validated Meteorological Monitoring Data, April - June 1994. Submittal date: 05/29/1999.

MO9905VMMDJM86.000. Validated Meteorological Monitoring Data, January - March 1986. Submittal date: 05/13/1999.

MO9905VMMDJM87.000. Validated Meteorological Monitoring Data, January - March 1987. Submittal date: 05/13/1999.

MO9905VMMDJM88.000. Validated Meteorological Monitoring Data, January - March 1988. Submittal date: 05/18/1999.

MO9905VMMDJM89.000. Validated Meteorological Monitoring Data, January - March 1989. Submittal date: 05/20/1999.

MO9905VMMDJM90.000. Validated Meteorological Monitoring Data, January - March 1990. Submittal date: 05/21/1999.

MO9905VMMDJM91.000. Validated Meteorological Monitoring Data, January - March 1991. Submittal date: 05/21/1999.

MO9905VMMDJM92.000. Validated Meteorological Monitoring Data, January - March 1992. Submittal date: 05/24/1999.

MO9905VMMDJM94.000. Validated Meteorological Monitoring Data, January - March 1994. Submittal date: 05/29/1999.

MO9905VMMDJS86.000. Validated Meteorological Monitoring Data, July - September 1986. Submittal date: 05/13/1999.

ATTACHMENT II (cont)**Meteorological Data Collected at Yucca Mountain 1986 through 1997**

MO9905VMMDJS87.000. Validated Meteorological Monitoring Data, July - September 1987. Submittal date: 05/18/1999.

MO9905VMMDJS88.000. Validated Meteorological Monitoring Data, July - September 1988. Submittal date: 05/18/1999.

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MO9905VMMDJS92.000. Validated Meteorological Monitoring Data, July - September 1992. Submittal date: 05/24/1999.

MO9905VMMDJS94.000. Validated Meteorological Monitoring Data, July - September 1994. Submittal date: 05/29/1999.

MO9905VMMDOD86.000. Validated Meteorological Monitoring Data, October - December 1986. Submittal date: 05/13/1999.

MO9905VMMDOD87.000. Validated Meteorological Monitoring Data, October - December 1987. Submittal date: 05/18/1999.

MO9905VMMDOD88.000. Validated Meteorological Monitoring Data, October - December 1988. Submittal date: 05/20/1999.

MO9905VMMDOD89.000. Validated Meteorological Monitoring Data, October - December 1989. Submittal date: 05/20/1999.

MO9905VMMDOD90.000. Validated Meteorological Monitoring Data, October - December 1990. Submittal date: 05/21/1999.

MO9905VMMDOD91.000. Validated Meteorological Monitoring Data, October - December 1991. Submittal date: 05/21/1999.

ATTACHMENT II (cont)**Meteorological Data Collected at Yucca Mountain 1986 through 1997**

MO9905VMMDOD92.000. Validated Meteorological Monitoring Data, October - December 1992. Submittal date: 05/24/1999.

MO9905VMMDOD94.000. Validated Meteorological Monitoring Data, October - December 1994. Submittal date: 05/29/1999.

TM0000000000001.100. Validated Meteorological Data, January - March 1997. Submittal date: 04/18/1997.

TM0000000000001.104. Validated Meteorological Data, April - June 1997. Submittal date: 07/21/1997.

TM0000000000001.107. Validated Meteorological Data, July - September 1997. Submittal date: 10/22/1997.

MO98METDATA110.000. Validated Meteorological Data, October - December, 1997. Submittal date: 01/29/1998