DOE/NV/25946--2448

# RCRA PART B PERMIT APPLICATION

# NEVADA NATIONAL SECURITY SITE (NNSS)

# FOR WASTE MANAGEMENT ACTIVITIES AT THE NNSS MIXED WASTE DISPOSAL UNIT (MWDU)

OCTOBER 2015

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# Acronyms

| | |
|---|---|
| ac | acre(s) |
| AEA | *Atomic Energy Act* |
| AMEM | Assistant Manager for Environmental Management |
| ASTM | American Society for Testing and Materials |
| BLM | Bureau of Land Management |
| CAP | Corrective Action Plan |
| CAR | Corrective Action Request |
| CAU | Corrective Action Unit |
| CFR | Code of Federal Regulations |
| cm | centimeter(s) |
| DoD | U.S. Department of Defense |
| DOE | U.S. Department of Energy |
| DOT | U.S. Department of Transportation |
| EODU | Explosive Ordnance Disposal Unit |
| EPA | U.S. Environmental Protection Agency |
| EPIP | Emergency Plan Implementing Procedure |
| FEMA | Federal Emergency Management Agency |
| FFACO | *Federal Facility Agreement and Consent Order* |
| FIRM | Flood Insurance Rate Map |
| ft | foot (feet) |
| $ft^2$ | square foot (feet) |
| $ft^3$ | cubic foot (feet) |
| gal | gallon(s) |
| ha | hectare(s) |
| HEC | Hydrologic Engineering Center |
| HWSU | Hazardous Waste Storage Unit |
| in. | inch(es) |
| kg | kilogram(s) |
| km | kilometer(s) |
| $km^2$ | square kilometer(s) |
| L | liter(s) |
| lb | pound(s) |
| LDR | land disposal restriction |
| LLMW | low-level mixed waste |
| LLW | low-level waste |
| m | meter(s) |
| $m^2$ | square meter(s) |

## Acronyms (continued)

| | |
|---|---|
| $m^3$ | cubic meter(s) |
| mi | mile(s) |
| $mi^2$ | square mile(s) |
| mrem | millirem(s) |
| MWDU | Mixed Waste Disposal Unit |
| MWSU | Mixed Waste Storage Unit |
| NAC | Nevada Administrative Code |
| NDEP | Nevada Division of Environmental Protection |
| NNSA/NFO | U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office |
| NNSS | Nevada National Security Site |
| NNSSWAC | Nevada National Security Site Waste Acceptance Criteria |
| NRS | Nevada Revised Statutes |
| NSTec | National Security Technologies, LLC |
| PCB | polychlorinated biphenyl |
| PLO | Public Land Order |
| PPE | personal protective equipment |
| QA | quality assurance |
| QC | quality control |
| RCRA | *Resource Conservation and Recovery Act* |
| RCT | Radiological Control Technician |
| RTR | real-time radiography |
| RWMC | Radioactive Waste Management Complex |
| RWMS | Radioactive Waste Management Site |
| RWO | Radioactive Waste Operations |
| SDS | Safety Data Sheet |
| TCLP | Toxicity Characterization Leaching Procedure |
| TID | tamper-indicating device |
| TSDF | treatment, storage, and disposal facility |
| UHC | underlying hazardous constituent |
| UR | use restriction |
| USGS | U.S. Geological Survey |
| WAP | Waste Analysis Plan |
| $yd^3$ | cubic yard(s) |

## B.1 Mixed Waste Disposal Unit [40 CFR 270.14(b)(1)]

This permit application provides facility information on the design, processes, and security features associated with the Cell 18 Mixed Waste Disposal Unit (MWDU). Onsite and offsite containerized low-level mixed waste (LLMW) that has an approved U.S. Department of Energy (DOE) nexus, DOE non-radioactive classified hazardous waste, U.S. Department of Defense (DoD) and other government agency non-radioactive classified hazardous waste (hereafter called waste) are disposed in the unit. Classified waste is the only non-radioactive waste accepted for disposal and is required to meet waste acceptance criteria for radioactive waste.

The MWDU is located in the southeast portion of the Nevada National Security Site (NNSS) at the Area 5 Radioactive Waste Management Complex (RWMC). The RWMC includes transuranic waste storage units, breaching and re-packaging facilities, and the Area 5 Radioactive Waste Management Site (RWMS). The RWMS is an active disposal site for waste. Polychlorinated biphenyls (PCBs) and friable and non-friable asbestos are accepted for disposal as described in Section B.3.a.

Table 1 lists metric conversion factors used in this application. Table 2 lists existing permits.

**Table 1. Metric Conversion Factors**

| Unit | Equals |
|---|---|
| 1 ha | 2.471 ac |
| 1 cm | 0.394 in. |
| 1 kg | 2.205 lb |
| 1 L | 0.264 gal |
| 1 m | 3.281 ft |
| 1 $m^2$ | 10.76 $ft^2$ |
| 1 $m^3$ | 35.32 $ft^3$ |
| 1 $m^3$ | 1.308 $yd^3$ |
| 1 km | 0.621 mi |
| 1 $km^2$ | 0.386 $mi^2$ |
| 1 metric ton | 1.102 short tons |
| The actual value (or real value), which is in metric units, is converted to the corresponding value in English units using the conversion factors listed above. The converted value is then rounded in the following manner. | |
| **Numerical Range** | **Rounded to the Nearest…** |
| 0–10 | 0.10 |
| 10–100 | 1 |
| 100–5,000 | 5 |
| 5,000–10,000 | 10 |
| 10,000–500,000 | 100 |
| 500,000–1,000,000 | 1,000 |
| >1,000,000 | 10,000 |

**Table 2. List of Existing Permits**

| Number | Type, Area, Location |
|---|---|
| NY-1054 | Septic System, Area 3, Waste Management Office |
| NY-1069 | Septic System, Area 18, 820th Red Horse Squadron |
| NY-1077 | Septic System, Area 27, Baker Compound |
| NY-1106 | Septic System, Area 5, Building 5-8 |
| NY-1079 | Septic System, Area 12 (U12g Tunnel) |
| NY-1080 | Septic System, Area 23, Building 1103 |
| NY-1081 | Septic System, Area 6, CP-170 |
| NY-1082 | Septic System, Area 22, Building 22-1 |
| NY-1083 | Septic System, Area 5, Radioactive Material Management Site (RWMS) |
| NY-1084 | Septic System, Area 6, Device Assembly Facility |
| NY-1085 | Septic System, Area 25, Central Support Area |
| NY-1086 | Septic System, Area 25, Reactor Control Point |
| NY-1087 | Septic System, Area 27, Able Compound |
| NY-1089 | Septic System, Area 12 Camp |
| NY-1090 | Septic System, Area 6, LANL Construction Campsite |
| NY-1091 | Septic System, Area 23, Gate 100 |
| NY-1103 | Septic System, Area 22, Desert Rock Airport |
| NY-1110-HAA-A | Individual Sewage Disposal System, A-12, Bldg. 12-910 |
| NY-1112 | Commercial Sewage Disposal System, U1a, Area 1 |
| NY-1113 | Commercial Sewage Disposal System, Area 1, Building 121 |
| NY-1124 | Commercial Individual Sewage Disposal System, Area 6 |
| NY-1128 | Area 6 Yucca Lake Project |
| NY-1130 | Commercial Individual Sewage Disposal System, Area 6, Fire Station #2 |
| NY-17-06839 | Septic Tank Pumping Contractor (5 units) |
| GNEV93001 | Water Pollution Control General Permit |
| NEV96021 | Water Pollution Control for E-Tunnel Waste Water Disposal System and Monitoring Well ER-12-1 |
| 31297 | NNSS Hazardous Materials Permit |
| 31304 | Nonproliferation Test and Evaluation Complex Hazardous Materials Permit |
| NEVHW0101 | NNSS Hazardous Waste Management Permit (RCRA) |
| AP9711-2557 | NNSS Class II Air Quality Operating Permit |
| AP9711-2659 | UGTA Surface Area Disturbance Permit ER-EC-13 and ER-EC-15 |
| AP9711-2824 | UGTA Surface Area Disturbance Permit ER-EC-14 |
| NY-0360-12NTNC | Public Water System Area 23 and Area 6 |
| NY-4098-12TNCWS | Public Water System Area 25 |
| NY-4099-12TNCWS | Public Water System Area 12 |
| NY-0835-12NP | NNSS (Water Hauler) #84846 |
| NY-0836-12NP | NNSS (Water Hauler) #84847 |
| SW 532 | Area 5 Asbestiform Low-Level Solid Waste Disposal Site |
| SW 13 097 02 | Area 6 Hydrocarbon Disposal Site |
| SW 13 097 03 | Area 9 U10c Solid Waste Disposal Site |
| SW 13 097 04 | Area 23 Solid Waste Disposal Site |
| UNEV2012203 | NNSS Underground Injection Control Permit |

### B.1.a MWDU Background

National Security Technologies, LLC (NSTec), will continue to receive and dispose of DOE and DoD waste at the currently permitted disposal unit. The MWDU has been compliantly operating since January 26, 2011, and approximately 60 percent of its capacity has been used for disposal.

In addition to the requirements of the *Resource Conservation and Recovery Act* (RCRA), the MWDU is also subject to DOE orders, U.S. Department of Transportation (DOT) regulations (for receipt of offsite waste), and State requirements. General information and hazardous waste codes identified for disposal at the MWDU are described in Section B.2. State-only designated hazardous waste may also be received at the NNSS as hazardous waste.

This section provides as-built drawings of the Cell 18 MWDU and a facility overview of the RWMC.

#### B.1.a.1 NNSS General Facility Description

The NNSS is a U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) installation comprising approximately 3,561 square kilometers ($km^2$) (1,375 square miles [$mi^2$]) of federally owned land located in southeastern Nye County, Nevada. Located approximately 105 kilometers (km) (65 miles [mi]) northwest of Las Vegas, Nevada, the NNSS is accessed from U.S. Highway 95, which roughly forms the southern boundary of the site. The site is bordered to the west, north, and east by the Nevada Test and Training Range, another government-owned, restricted-access area. Public land to the south of the NNSS is managed by the Bureau of Land Management (BLM). Surrounding areas are predominantly rural, undeveloped public desert lands used for grazing and agriculture. The NNSS is well buffered from public access. Las Vegas is the closest major population center. Smaller, rural communities near the NNSS include Amargosa Valley and Pahrump.

The NNSS varies from 46 to 57 km (28 to 35 mi) in the east/west direction and from 65 to 90 km (40 to 55 mi) in the north/south direction. Elevation varies from 915 to 2,345 meters (m) (3,000 to 7,700 feet [ft]) above sea level. The terrain is characteristic of the Basin and Range Physiographic Province in Nevada, Arizona, and Utah, which is a province of nearly parallel intervening valleys and ranges. Numerous north to northeast trending mountain ranges are separated by gently sloping linear valleys and broad flat basins. The principal valleys are Frenchman Flat, Yucca Flat, and Jackass Flats. The principal highlands are Pahute Mesa, Rainier Mesa, Timber Mountain, and Shoshone Mountain. Large portions of the NNSS are within one or two elevation ranges from 915 to 1,220 m (3,000 to 4,000 ft) in the valleys to the south and east to 1,675 to 2,225 m (5,500 to 7,300 ft) in the high country to the north and west.

The Mercury base camp is located in the southeast corner of the site, approximately 6.5 km (4.0 mi) north of U.S. Highway 95. Mercury has administrative and maintenance structures that currently support a working population of approximately 1,000 workers and a residential capacity of approximately 350. NNSS areas outside of Mercury were used for many activities. In Area 5, the Frenchman Flat vicinity was designated for atmospheric testing, hazardous materials spill testing, underground testing, and radioactive waste management. Yucca Flat and Rainier Mesa were used for underground tests, and Yucca Flat was used for atmospheric nuclear tests. The Pahute Mesa vicinity was used for higher-yield underground tests.

Historically, the primary mission of the NNSS was to conduct nuclear weapons tests. Since the moratorium on nuclear testing began in October 1992, this mission has changed to maintaining readiness to conduct tests if so directed. Because of its favorable environment and infrastructure, the NNSS supports national security-related research, development, and testing programs, as well as waste management activities. Numerous government and/or research organizations use the NNSS for a variety of research activities and/or programs because of its specialized facilities, favorable climate, remote location, and controlled access. The research and testing activities comprising these programs are directly supported by NNSA/NFO.

NSTec, the Management and Operations Contractor, provides a number of services including designing and operating the functioning hazardous waste management units at the NNSS. The contractor also provides onsite medical services and operates the NNSS Fire and Rescue Department. Additionally, NNSA/NFO maintains separate contracts for 24-hour security services (armed patrol and access control), while the Nye County Sheriff’s Office provides law enforcement support on the NNSS.

Figure 1, “General Location Map,” Figure 2, “Topographic Features and Infrastructure,” Figure 3, “NNSS Land Use Map,” and Figure 4, “Aerial Photograph of the RWMC,” provide additional information to support this Part B Application.

**Figure 1. General Location Map**

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NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA FIELD OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 05A
RCRA UNITS

GENERAL LOCATION MAP

| DRAWN | PREPARER | CHECKER | PROJECT ENGINEER | APPROVER / USER |
|---|---|---|---|---|
| S. Plural 4-21-15 | J. Sarola 4/21/15 | N/A | G. Clifford 4/21/15 | N/A |

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DRAWING NUMBER / WORK ORDER NUMBER: SK-01327-C-1001
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**Figure 2. Topographic Features and Infrastructure**

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NATIONAL NUCLEAR SECURITY ADMINISTRATION

NEVADA FIELD OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 05A

RCRA UNITS

# TOPOGRAPHIC FEATURES & INFRASTRUCTURE

| DRAWN | PREPARER | CHECKER | PROJECT ENGINEER | APPROVER / USER |
|---|---|---|---|---|
| S. Pluhl 4-21-15 | J. Szerla 4/21/15 | N/A | [signature] 4/21/15 | N/A |

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ENGINEERING NO. 01327

ORIGINAL SIGNATURES ON FILE

DRAWING NUMBER / WORK ORDER NUMBER: SK-01327-C-1002

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**Figure 3. NNSS Land Use Map**

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**Figure 4. Aerial Photograph of the RWMC**

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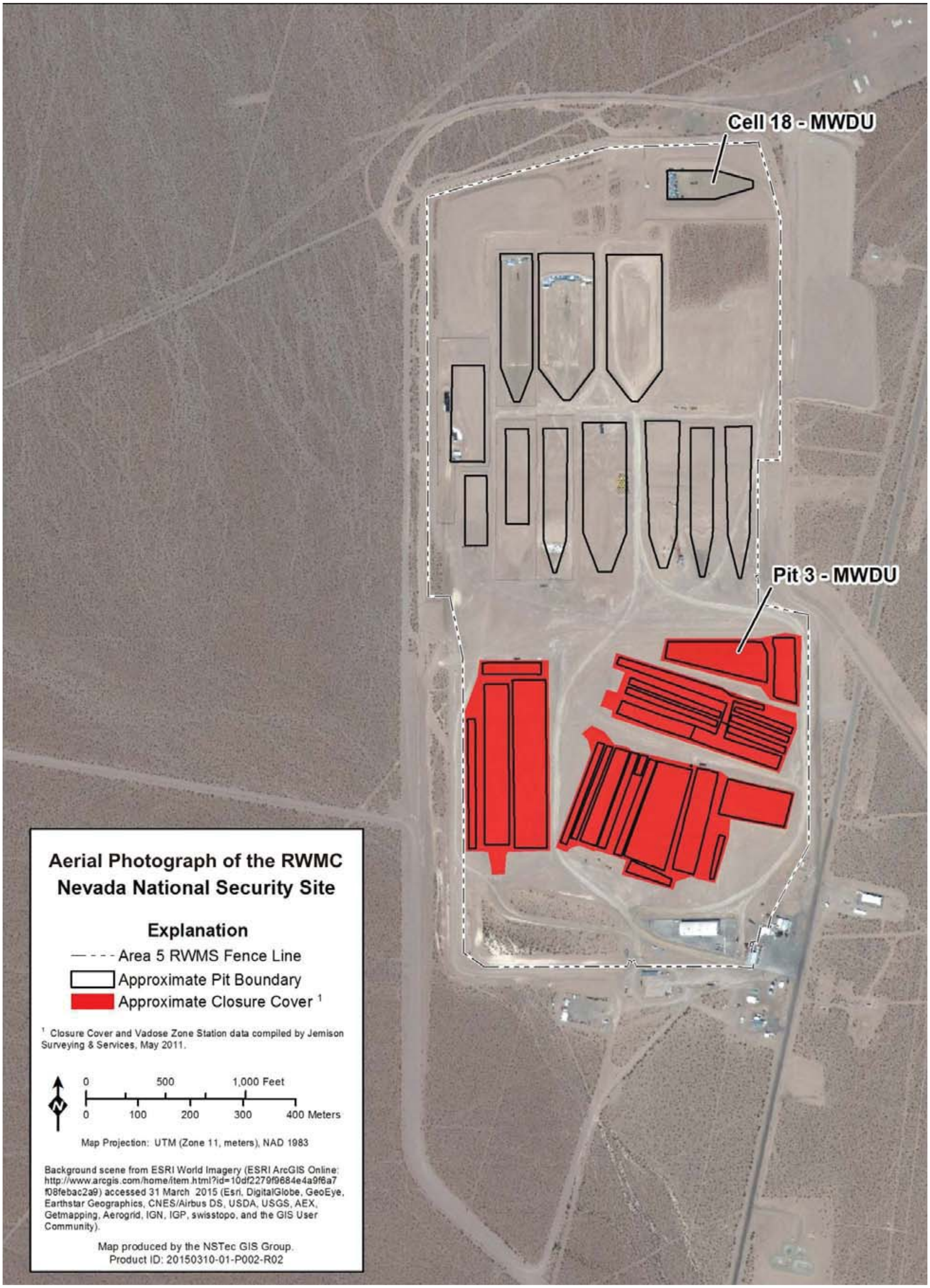
Cell 18 - MWDU
Pit 3 - MWDU
Aerial Photograph of the RWMC
Nevada National Security Site
Explanation
Area 5 RWMS Fence Line
Approximate Pit Boundary
Approximate Closure Cover [1]
[1] Closure Cover and Vadose Zone Station data compiled by Jemison Surveying & Services, May 2011.
0 500 1,000 Feet
0 100 200 300 400 Meters
N
Map Projection: UTM (Zone 11, meters), NAD 1983
Background scene from ESRI World Imagery (ESRI ArcGIS Online: http://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9) accessed 31 March 2015 (Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community).
Map produced by the NSTec GIS Group.
Product ID: 20150310-01-P002-R02

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### B.1.a.2 RCRA Permit Application History

In 1985 and 1987 DOE submitted Parts A and B, respectively, of the RCRA Permit Application to the U.S. Environmental Protection Agency (EPA) Region 9 and the State of Nevada. The application provided detailed information on the disposal of LLMW at the Area 5 Pit 3 MWDU and the treatment of non-radioactive waste at the Area 11 Explosives Ordnance Disposal Unit (EODU). In September 1987, the Nevada Division of Environmental Protection (NDEP) concurred that the Pit 3 MWDU and the EODU met the regulatory requirements of interim status. In 1992, DOE resubmitted the Part B Application with the addition of the Hazardous Waste Storage Unit (HWSU). From June 1992 through May 1995, DOE provided subsequent revisions to the application, including an additional proposal in January 1995 for a MWSU. In May 1995, NDEP issued a RCRA Part B Permit to DOE for the operation of the Area 5 HWSU for storage of non-radioactive hazardous waste and for the Area 11 EODU for treatment of non-radioactive waste explosives. The permit was renewed in November 2000 and 2005. In 2005, DOE requested accelerated closure of the Pit 3 MWDU and submitted a closure plan to NDEP. LLMW shipments for Pit 3 ended in November 2010. Permit NEV HW0101 was issued in December 2010, and LLMW acceptance into the Cell 18 MWDU began on January 26, 2011.

### B.1.a.3 Summary of RCRA Operational Units

Figure 1 and Table 3 provide the location and status of each RCRA operational unit on the NNSS. Specific information for the Cell 18 MWDU, the Area 11 EODU, the Area 5 HWSU, and the Area 5 Mixed Waste Storage Unit (MWSU) can be found in the RCRA Part B Permit Application for each unit and the NDEP Permit for a Hazardous Waste Management Facility (NEV HW0101).

**Table 3. Operational Unit Locations and Regulatory Status**

| Unit Name | Location | Regulatory Status | Permit | Effective Date |
|---|---|---|---|---|
| MWSU | Area 5 RWMC | Permitted | NEV HW0101 | December 2010 |
| Cell 18 MWDU | Area 5 RWMC | Permitted | NEV HW0101 | December 2010 |
| EODU | Area 11 | Permitted | NEV HW0101 | December 2010 |
| HWSU | Area 5 | Permitted | NEV HW0101 | December 2010 |

**Cell 18 MWDU**

Cell 18 MWDU is a fully compliant, RCRA-permitted landfill that disposes of onsite and offsite containerized LLMW from an approved DOE nexus. The permitted capacity of the unit is 25,485 cubic meters ($m^3$) (33,300 cubic yards [$yd^3$]).

**EODU**

The Area 11 EODU is an 8.1-hectare (ha) (20-acre [ac]) permitted thermal treatment unit for explosive waste. Explosive waste is stored in a magazine, which serves as a satellite accumulation area. The unit has an annual estimated capacity of 1,875 kilograms (kg) (4,130 pounds [lb]). The process design capacity is 45 kg per hour (100 lb per hour).

**HWSU**

The Area 5 HWSU is a permitted storage unit for hazardous non-radioactive waste generated on the NNSS. It is located immediately to the east of the Area 5 RWMC. The storage design capacity of the HWSU is approximately 61,600 liters (L) (16,300 gallons [gal]).

**MWSU**

The Area 5 MWSU is a permitted storage unit for onsite and offsite containerized LLMW from an approved DOE nexus. It is located within the Area 5 RWMC and uses existing facilities at the RWMC to store LLMW.

### B.1.b General Dimensions and Structural Description

The Cell 18 MWDU is an existing landfill located at the RWMC. Low-level waste (LLW) disposal cells are located in the 92-Acre Area and Expansion Area at the RWMC. Until 2001, all disposal activities at the RWMC were within the 92-Acre Area. LLW disposal operations have since been ongoing north of the 92-Acre Area in the Expansion Area. The 92-Acre Area is closed.

#### B.1.b.1 Cell 18 Design

Cell 18 is approximately 46 by 91 by 6.1 m (150 by 300 by 20 ft) with an approximate design capacity of 25,000 $m^3$ (33,000 $yd^3$). The disposal cell is double-lined (**40 CFR 264.301[c]**) with leachate collection and removal systems located above the top liner and between the top and bottom liners. The removal system between the liners serves as a leak detection system. The leachate collection and removal system above the top liner is designed, constructed, operated, and maintained so that the leachate depth over the liner does not exceed 30.5 centimeters (cm) (12 inches [in.]). Design drawings are provided in Exhibit 1.

The following features of the Cell 18 leachate collection and removal system satisfy the requirements of **40 CFR 264.301**:

- Constructed with a bottom slope greater than one percent
- Drainage materials composed of synthetic material with a minimum transmissivity of 3 x $10^{-5}$ square meters per second (3.6 x $10^{-5}$ square yards per second) and a clay liner of granular drainage material with a minimum hydraulic conductivity of 0.01 cm per second (0.004 in. per second) and a minimum thickness of 30.5 cm (12 in.)
- Constructed of materials that are chemically resistant to the waste managed in the landfill and the leachate expected to be generated, and of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and equipment used at the landfill
- Designed and operated to minimize clogging during the active life and post-closure period
- Constructed with sumps and liquid removal methods of sufficient size to collect and remove liquids from the sump and prevent liquids from backing up into the drainage layer
- Designed to provide a method for measuring and recording the volume of liquids present in the sump and of liquids removed

The leakage rate for the landfill was determined by the final design parameters (**40 CFR 264.302**). RWMC personnel inspecting and monitoring the leak detection system record the amount of liquid removed from the sump during the unit's active life and closure period. During post-closure, amounts of liquids will be monitored and recorded at least monthly, or as dictated by levels of leachate in the sump (**40 CFR 264.303[c][1]** and **[2]**).

Tank 18-T1 (LPW-TNK-001) contains leachate. The tank capacity is 11,400 L (3,000 gal). The tank is constructed of materials compatible with the leachate expected to be generated. Leak detection monitoring is used for both the tank and the tank's secondary containment. The tank is located adjacent to (west of) Cell 18. Underground piping components of the tank are constructed of double-walled fiberglass/fiberglass-reinforced plastic. Collected leachate is accumulated in the tank pending treatment and disposal. Tank operations are automated; a sensor in the sump detects the liquid level and automatically pumps the leachate to the storage tank when pre-programmed set points are reached. The tank is equipped with an automated feed cut-off to prevent overfilling. The tank has a digital fill gauge that indicates the liquid level in the tank.

### B.1.b.2 Storm Water Run-On and Runoff Control [40 CFR 270.21(b)(2)]

#### *Run-On Protection*

The MWDU is protected from flooding from upstream watersheds by two flood control channels (west and east of the RWMC) and berms. The berms extend along the western, northern, and eastern sides of the RWMC. The channels are designed to divert the peak flow from a 25-year, 24-hour storm event, evaluated using the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) HEC-2 model. The 25-year flood peaks were derived using a HEC-1 model developed for the 100-year floodplain mapping that assumed that floodwater from the entire Barren Wash drainage basin would pass through the west channel. Therefore, the channel design is highly conservative. The flood control channels divert storm water around the RWMC and onto Frenchman Flat.

A 25-year flood event was documented at the RWMC on February 23 and 24, 1998 (French and Curtis, 1999). The observed flow depth in the west channel during this storm was a few inches. The channel is designed for 242 $m^3$ per second (316 $yd^3$ per second). The modeled peak for the event was 96 $m^3$ per second (126 $yd^3$ per second), and the estimated flow rate corresponding to observed water depth in the channel was less than 1.5 $m^3$ per second (2.0 $yd^3$ per second).

#### *Runoff Protection*

Runoff is not anticipated because of the construction of run-on controls and the slope of the MWDU.

#### *Erosion Protection*

Erosion from precipitation on the floor of the Cell 18 MWDU is repaired to maintain the soil layer needed to protect the geomembrane liner from the impacts of equipment and vehicles operating in the cell. Side slopes are protected by a sacrificial layer of high-density polyethylene liner and by repairs to soil cover materials.

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## EXHIBIT 1. Cell 18 MWDU Design Drawings

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## B.2 Chemical and Physical Analysis [40 CFR 270.14(b)(2)]

### B.2.a Volume and Composition of Hazardous Waste [40 CFR 264.13(a)]

Table 4 provides general information3 on waste codes and design capacity of the unit.

**Table 4. General Information – Cell 18 MWDU**

| | |
|---|---|
| Process Code | D80 (Landfill Disposal) |
| Waste Codes | D004 through D043 |
| | F001 through F011, and F039 |
| | P001 through P018, P020 through P024, P026 through P031, P033, P034, P036 through P051, P054, P056 through P060, P062 through P078, P081, P082, P084, P085, P087 through P089, P092 through P099, P101 through P106, P108 through P116, P118 through P123, P127, P128, P185, P188 through P192, P194, P196 through P199, and P201 through P205 |
| | U001 through U012, U014 through U039, U041 through U053, U055 through U064, U066 through U099, U101 through U103, U105 through U138, U140 through U174, U176 through U194, U196, U197, U200, U201, U203 through U211, U213 through U223, U225 through U228, U234 through U240, U243, U244, U246 through U249, U271, U278 through U280, U328, U353, U359, U364, U367, U372, U373, U387, U389, U394, U395, U404, and U409 through U411<br>Polychlorinated biphenyls (PCBs) – state hazardous waste |
| Process Design Capacity | 25,485 $m^3$ (33,300 $yd^3$) (Estimated) |

### B.2.b Compatibility of Waste with Containers [40 CFR 264.172]

General requirements for waste containers include the following:

- Incompatible wastes or incompatible wastes and materials shall not be placed in the same container.
- Waste containers of 450 L (119 gal) or less must be marked with the hazardous characteristics of the waste.
- Waste packages must be 90 percent full.
- A tamper-indicating device (TID) may be employed on packages that are inspected offsite as part of verification. The number of the TID must be recorded on the verification documentation. Some waste packaging does not allow for the application of TIDs (e.g., welded boxes).
- Intermodal containers that are emptied and returned to the generator are prohibited.

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## B.3 Waste Analysis Plan [40 CFR 270.14(b)(3)]

NNSA/NFO's MWDU Waste Analysis Plan (WAP) includes requirements for waste certification programs, characterization, traceability, prohibited items, waste profiling, waste forms, and packaging and shipment of waste. The WAP provides examples of expected waste streams, waste descriptions and sources, waste characteristics, characterization/acceptable knowledge requirements, sampling and analysis protocols, physical and chemical screening methods, prohibited waste, notification/certification requirements, and waste generator approval process.

The Nevada National Security Site Waste Acceptance Criteria (NNSSWAC) establishes the requirements generators shall meet to dispose of waste at the NNSS. It includes requirements for waste certification programs, characterization, traceability, prohibited items, waste profiling, waste form, and packaging and shipment of waste. The NNSSWAC outlines the requirements for generators to receive NNSA/NFO Assistant Manager for Environmental Management (AMEM) approval to ship LLW and LLMW to the NNSS. Applicable portions of this WAP are incorporated into the NNSSWAC. This WAP applies to LLMW disposed at the MWDU. References are made throughout this plan to EPA regulations regarding waste analysis requirements for hazardous waste management facilities. These requirements are generally found in **40 CFR 264, Subpart B**, and unless otherwise stated have been adopted by reference in the Nevada Administrative Code (NAC).

### B.3.a Waste Description and Sources

Accepted wastes are generated from DOE and NNSA/NFO activities, including routine waste generation, remediation, and decontamination and decommissioning. Wastes may include contaminated soil and debris, pond sludge, personnel protective equipment (PPE), spill residue, decontamination effluent, lead debris and shielding, and other forms of contaminated media. The final treated waste forms may include incinerator ash, stabilized ash, debris, macro-encapsulated debris and lead, and soil. NNSA/NFO may also accept wastes treated by equivalent technologies, provided NDEP has approved the technologies. Acceptable hazardous waste codes are provided in Table 4.

### B.3.b Waste Characteristics

The LLMW disposed at the MWDU contains both radioactive and hazardous material components as defined by the *Atomic Energy Act* (AEA), RCRA, Nevada Revised Statutes (NRS), and NAC. LLMW accepted at the MWDU for disposal may carry only the EPA hazardous waste numbers listed in Table 4 and must meet the NNSSWAC. Waste must also meet land disposal restriction (LDR) treatment standard requirements in **40 CFR 268.40** and **268.45**, including applicable standards for underlying hazardous constituents (UHCs). Waste meeting the alternative LDR treatment standard for contaminated soil (**40 CFR 268.49**) or equivalent treatment technologies (**40 CFR 268.42[b]**) approved by NDEP may also be accepted. State-only designated hazardous waste may be received at the NNSS as hazardous waste. PCBs that meet the requirements for disposal in a permitted hazardous waste landfill as specified in **40 CFR 761** and **NAC 444.9452** are also accepted.

LLMW received from generators may include waste containing metals, solvents, organics, and/or listed constituents; or waste from specific processes regulated by **40 CFR 261**.

### B.3.c Waste Identification Parameters [40 CFR 264.13(b)(1)]

NNSS onsite generators, DOE offsite generators, and the treatment, storage, and disposal facilities (TSDFs) sending DOE waste for disposal at the MWDU are referred to as "generators." The operating organization is required to test certain LLMW, depending on the treatment standard, to ensure that the waste or treatment residual complies with applicable LDR requirements. Testing is performed at the frequency specified in this WAP. Characterization data are developed under **40 CFR 261**. Data may be obtained from acceptable knowledge and/or sampling and analysis.

When demonstrating that the concentration-based LDR treatment standards in **40 CFR 268.40** have been met, a representative sample of the waste is taken by the generator and submitted to a laboratory accepted under Section B.3.l.4. When demonstrating that a treatment technology standard has been met, an LDR certification is submitted.

### B.3.d Waste Form and Containers

#### B.3.d.1 Prohibited Waste Forms

The following waste forms are prohibited:

1. RCRA D, F, P, K, or U waste numbers other than those listed in Table 4
2. Wastes that contain only a hazardous component, unless the waste is classified
3. Non-LDR (**40 CFR 268**) compliant waste
4. Pathogens, infectious wastes, or other etiologic agents
5. Compressed gases (Aerosol cans must be punctured and valve mechanisms removed from expended gas cylinders.)
6. Free liquids (Free liquids must be absorbed, stabilized, or otherwise removed from the waste. Containerized free liquids such as ampules and small articles that contain free liquids required for the article to function are acceptable. Provisions for additional sorbent should be made when significant temperature and atmospheric differences exist between the generating site and the disposal site.)
7. Non-biodegradable sorbents (**40 CFR 264.314[e]**)
8. PCBs not classified as bulk product waste (**40 CFR 761.62**) or remediation waste (**40 CFR 761.61**)
9. Chelating or complexing agents in amounts greater than 1 percent of the waste unless stabilized or solidified

#### B.3.d.2 LLMW Containers

Containers must meet the following requirements:

1. Incompatible wastes or incompatible wastes and materials shall not be placed in the same container if such placement results in any of the following:
    a. Generates extreme heat or pressure, fire or explosion, or violent reaction
    b. Produces uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to threaten human health

   c. Produces uncontrolled flammable fumes or gases in sufficient quantities to pose a risk of fire or explosion
   d. Damages the structural integrity of the device containing the waste
2. LLMW containers of 450 L (119 gal) or less must be marked with the hazardous characteristics of the waste. Containers must be marked with all of the following:
   a. The words "HAZARDOUS WASTE – FEDERAL LAW PROHIBITS IMPROPER DISPOSAL. If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency."
   b. Generator's name and address
   c. Manifest Document Number
3. LLMW container marking must be:
   a. Durable
   b. In English
   c. Printed on or affixed to the surface of a package or on a label, tag, or sign
   d. Displayed on a background of sharply contrasting color
   e. Unobscured by other labels or attachments
   f. Located away from any marking that could substantially reduce its effectiveness
4. LLMW packages must be at least 90 percent full (**40 CFR 264.315[a]**).
5. A TID may be employed on packages that are inspected offsite as part of verification. The number of the TID must be recorded on the verification documentation. Some waste packaging does not allow for the application of TIDs (e.g., welded boxes).
6. Intermodal containers that are emptied and returned to the generator are prohibited.

### B.3.e LDR Notification and Certification

**40 CFR 268.7(a)** requires each generator to evaluate waste to determine if it is restricted from land disposal. As applicable, wastes containing specific hazardous characteristics must be evaluated for UHCs reasonably expected to be in the waste. LLMW destined for disposal at the MWDU must meet LDR requirements prior to shipment to the NNSS. LDR notification and certification forms must be submitted per **40 CFR 268.7**. The information on the notification (i.e., manifest number, EPA waste code[s], waste constituents to be monitored, category of waste, and waste analysis data) is compared with accompanying shipment documentation. If a certification statement is missing or unsigned and the discrepancy cannot be resolved, the waste shipment is not accepted and will be returned to a generator-specified facility.

Generators are required to perform hazardous waste determinations including evaluating LDR treatment standard requirements on their waste streams. Generators are required to test the waste to ensure compliance with applicable concentration-based treatment standards. On the waste profile, generators identify the applicable treatment standard, and whether the waste meets the standards as generated, is excluded, or requires treatment before disposal.

When shipping waste to the MWDU, generators are required to submit all information, notifications, and certifications described in **40 CFR 268.7** to the operating organization. If the waste information changes, the generator must submit a new notification and certification.

### B.3.f Waste Profile and Data Quality Assurance Process

Characterization data must be sufficient to verify compliance with the NNSSWAC, ensure safe management, identify UHCs, and verify that waste meets LDR treatment standards prior to disposal. The waste profile shall provide a clear picture of the radiological, physical, and chemical characteristics; regulatory classification; and packaging. Generator-supplied data are the primary means by which NNSA/NFO demonstrates compliance with **40 CFR 264.13(a)** and **264.13(b)(5)** for obtaining detailed chemical, physical, and radiological analysis.

Generators shall determine the appropriate analysis (total vs. Toxicity Characterization Leaching Procedure [TCLP]) to use when performing hazardous waste determinations and identifying UHCs.

Waste characterization data must be based on samples collected using methods specified in EPA SW-846 or other equivalent methods.

#### B.3.f.1 General Waste Profile Requirements

Waste profiles are submitted to NNSA/NFO for review and approval.

Changes to approved waste streams may be submitted at any time. Depending on the significance of the change, the approval to ship may be temporarily suspended until the changes are reviewed and approved.

Waste profiles shall have annual expiration dates if not recertified by the generator.

Generators shall notify NNSA/NFO in writing when terminating an approved waste profile.

#### B.3.f.2 Specific Waste Profile Requirements

The following information shall be included:

1. EPA waste codes
2. Applicable State waste codes
3. Sorbent(s) used and certification of the use of non-biodegradable sorbents
4. Chemical, physical, radiological, and general characteristics and properties
5. Compliance with NNSSWAC item-prohibitions
6. Container type, size, weight, dose rate, and approximate number
7. Demonstration of compliance with LDR standards including compliance with Universal Treatment Standards, if applicable
8. Supplemental attachments consisting of container drawings, process flow information, analytical data, etc., if necessary
9. Visual inspection forms, analytical results or log books, and/or procedures or treatability test results, as necessary

### B.3.g Pre-Acceptance Approval Process

The NNSSWAC establishes the requirements generators shall meet to dispose of waste at the NNSS. It includes requirements for waste certification programs, characterization, traceability, prohibited items, waste profiling, waste form, and packaging and shipment of waste. The NNSSWAC outlines the process requirements for generators to receive NNSA/NFO AMEM approval to ship LLW and LLMW to the NNSS. Applicable portions of this WAP are incorporated into the NNSSWAC. Approval flow diagrams are provided in Exhibit 2.

The NNSSWAC establishes a facility evaluation system (audit and surveillance) to approve the generator's shipment of waste to the NNSS. These evaluations, conducted by the operating organization, include rigorous attention to the characterization, certification, and quality assurance (QA) programs at the generator site. The evaluations are conducted in accordance with written procedures and checklists.

During the evaluation of the generator's waste management program, Corrective Action Requests (CARs) may be issued for quality-affecting problems. These CARs must be answered by a Corrective Action Plan (CAP) identifying the root cause, corrective actions, and actions to preclude re-occurrence. The generator is not approved until all CARs are closed.

Once the NNSA/NFO AMEM approves the generator, waste profiles are accepted for review. The NNSA/NFO AMEM can suspend approvals at any time, based on programmatic or waste stream deficiencies.

#### B.3.g.1 Generator Approval Process

Once a generator is approved for shipping waste to the NNSS, a waste stream approval process is initiated. This process includes submitting a notification and/or waste profile, reviewing the waste profile, and determining the physical screening type and frequency. The generator's program and waste profile are reevaluated at the specified frequency. If the waste analysis data are sufficient and the waste stream meets the NNSSWAC, the waste profile is approved. The approved waste is then scheduled for receipt at the NNSS.

The operating organization obtains detailed chemical and physical analysis of LLMW from generators requesting disposal at the MWDU. Before waste can be disposed, generators must perform a hazardous waste determination as required by their State regulations, **40 CFR 262.11**, and **40 CFR 268.7**. The characterization data are used to complete a waste profile for each waste stream.

A notification form (Exhibit 3) is submitted for waste that has not yet been treated. By requiring generators to submit the notification, coordination of remote sampling and offsite visual verification is more readily accomplished. A waste profile form is submitted for post-treatment final waste forms. For waste already treated, the generator submits the waste profile. The notification and/or waste profile is submitted to NNSA/NFO for review and approval.

In general, LLMW received from onsite generators is managed the same as waste received from offsite generators. Differences include, but are not limited to, physical and chemical screening and shipping documentation (Uniform Hazardous Waste Manifests for waste from offsite generators, and onsite waste manifest forms for waste from onsite generators).

Generators shall provide, as necessary, sampling and analysis data that are of a known precision and accuracy to identify the physical and chemical properties of the waste.

### B.3.g.2 Notification Review

If treatment is required but has yet to occur, the operating organization reviews the notification form, determines the physical screening frequency (Section B.3.g.4), and schedules offsite verification activities with the generator. Exhibit 3 includes an example notification review form.

### B.3.g.3 Waste Profile Review

The operating organization reviews the initial generator-supplied waste analysis for waste profile approval in accordance with **40 CFR 264.13(b)(4)**.

The operating organization reviews the waste profile information including general waste stream information, chemical and physical characterization, treatment, and packaging information to verify that waste streams are defined adequately. This demonstrates that the waste meets the NNSSWAC and complies with appropriate LDR treatment standards. If discrepancies are found or inadequate characterization data have been provided, the operating organization requests additional information from the generators. Resolutions could include providing processing or treatment procedures, drawings, process flow information, or supplemental analytical data. Results from the review are documented in the operating record (Exhibit 4 includes an example Waste Stream Recommendation Form).

The operating organization evaluates sampling and analysis documentation to ensure that: (1) samples are representative of the waste stream, (2) appropriate analytical procedures are used, and (3) sufficient quality controls are established to allow measurement and documentation of data quality. The initial physical screening frequency is determined.

Generators that submit a notification form include verification activity documentation with the waste profile. This information is reviewed for final approval of the waste profile. After approval, generators can schedule waste shipments.

### B.3.g.4 Analytical Frequency [40 CFR 264.13(b)(4)]

The screening frequency is determined by the operating organization with the following process:

1. The generator waste profile is reviewed to determine the relative potential for mischaracterization or inappropriate segregation based on all relevant information, including any previous experience with the generator. Based on this review, the operating organization identifies any concerns associated with the following criteria:
   a. Documented waste management program
   b. Waste stream characterization information
   c. Potential for inappropriate segregation
   d. Waste type and packaging
2. The physical screening frequency is established for the waste stream.
3. The physical screening minimum is 5 percent of the waste stream.

#### B.3.g.5 Screening Options

The following screening options are available:

1. Offsite (at generator or treatment facility) visual inspection
2. Offsite chemical screening
3. Offsite or onsite review of photographs, videos, real-time radiography (RTR) images, and/or RTR recordings of treatment
4. Onsite RTR
5. Onsite visual inspection of container exterior (100 percent)

### B.3.h Physical and Chemical Screening

Verification activities are performed as required by **40 CFR 264.13(c)**. The activities include container receipt inspection and could also include physical and/or chemical screening. Containers can be inspected visually, verified by RTR, or sampled for field or laboratory analysis to confirm that the waste matches the waste profile and container data information supplied by the generator. Discrepancies between the verification results and the waste profile must be resolved before acceptance at the MWDU.

Screening methods have sufficient performance levels to yield valid decisions when considering method variability (precision and accuracy). When screening is performed at a location not within the RWMC, TIDs may be applied to each container examined and, on receipt, verified as acceptable to ensure that no changes could have occurred to the packaging or waste content. Written procedures are maintained that detail the requirements for applying TIDs. Some waste packaging does not allow for the application of TIDs (e.g., welded boxes). The following elements are used to verify and provide sufficient data to ensure that waste received is correctly described in the shipping documentation.

#### B.3.h.1 Physical Screening

This section describes the methods, frequency, and exceptions for physical screening verification. Physical screening can be performed before the waste is shipped to the MWDU.

##### B.3.h.1.1 Physical Screening Frequency

The minimum physical screening frequency is 5 percent. The operating organization adjusts the visual and RTR inspection levels for generators based on objective performance criteria.

##### B.3.h.1.2 Physical Screening Exceptions

Waste that cannot be physically screened at the RWMC may be visually inspected at the generator location (e.g., classified LLMW, large components, remote-handled containers that cannot be opened or will not fit in RTR).

Waste that was treated prior to issuance of the Permit is considered previously treated waste. The operating organization will evaluate the generator’s approved Waste Certification Program, the waste profile including the LDR Certification Statement, treatment and packaging procedures, package inventories, acceptable knowledge information, and historical analytical data for acceptability.

#### B.3.h.1.3 Physical Screening Methods

The following physical screening methods comply with the requirement to verify waste (**40 CFR 264.13[c]**):

1. Visual inspection
2. RTR

#### B.3.h.1.4 Physical Screening Quality Control (QC)

Physical screening QC ensures that quality data are obtained when performing RTR. Visual inspection does not use instrumentation or chemical tests. The operating organization RTR procedures and training requirements identify necessary QC elements.

#### B.3.h.1.5 Physical Screening Parameters

The following methods are approved for use.

##### B.3.h.1.5.1 Visual Inspection

<u>Rationale</u>: Because the NNSS does not have a container-opening facility, a visual verification of the waste will be accomplished at the generator or treatment facility. This method meets the requirement to ensure consistency among the waste containers and the waste profile.

<u>Method</u>: The container is opened, and the contents are inspected by direct visual observation or review of the images of the treatment process and package. Homogenous loose solids are probed. If the waste is being treated, direct visual observation of the treatment and container-filling process is performed. Visual observations are compared with the applicable waste profile and container-specific information. Visual observations may include review of available RTR tapes, videotapes, photographs, and digital images of the treatment and packaging process to ensure compliance.

<u>Failure Criteria</u>: A container fails inspection for any of the following: (1) undocumented or improperly packaged waste, (2) discovery of prohibited articles or materials, (3) discovery of material not consistent with the applicable waste profile (i.e., waste form), or (4) void space greater than 10 percent.

##### B.3.h.1.5.2 Real-Time Radiography

<u>Rationale</u>: This method meets the requirement to ensure the absence of prohibited items and consistency among waste containers, the waste profile, and the shipment documentation. Containers that are not amenable to visual inspection because of physical or radiological content can be examined safely and economically.

<u>Method</u>: The container is scanned with an RTR system. Images are observed on a video monitor and/or captured on videotape. Personnel trained in the interpretation of RTR imagery record their observations. These observations are compared to the contents listed on the waste profile and accompanying shipment documentation.

<u>Failure Criteria</u>: A container fails inspection for any of the following: (1) undocumented or improperly packaged waste, (2) discovery of prohibited articles or materials, (3) image data

inconsistent with the waste profile or shipment documentation, or (4) void space greater than 10 percent.

### B.3.h.2 Chemical Screening

Chemical screening is performed before the waste is shipped to the RWMC. The operating organization determines which screening parameters are appropriate for the waste stream. Interpretation of the appropriate chemical screening method(s) are conducted and performed by trained personnel. Unless otherwise noted, chemical screening tests are qualitative, not quantitative. The objective of chemical screening is to obtain reasonable assurance that the waste received is consistent with the description of the waste on the waste profile and to ensure that the waste is safely managed.

#### B.3.h.2.1 Chemical Screening Frequency

At a minimum, 10 percent of the waste containers amenable to chemical screening and verified by visual inspection will be chemically screened.

#### B.3.h.2.2 Chemical Screening Exceptions

The following are cases in which chemical screening is not required:

1. Waste subject to a technology-based treatment standard
2. Chemical-containing equipment removed from service (e.g., ballasts, batteries)
3. Waste containing regulated asbestos
4. Waste containing beryllium
5. Waste, environmental media, and/or debris from the cleanup of spills or release of a single substance, commercial product, or otherwise known material (e.g., material for which a Safety Data Sheet [SDS] can be provided)
6. Confirmed noninfectious waste (e.g., xylene, acetone, ethyl alcohol, isopropyl alcohol) generated from laboratory tissue preparation, slide staining, or fixing processes
7. Hazardous debris
8. Package greater than 100 millirems (mrem) per hour at 30 cm

#### B.3.h.2.3 Chemical Screening Sampling

Chemical screening methods do not require sample preservation methods because the screening tests are performed at the time and location of sampling or as soon as possible thereafter. When a delay is required, the samples are stored in a manner that maintains chain-of-custody controls and protects the sample composition. The equipment requirements in Table 5 may apply to sampling for chemical screening.

Individual containers are selected based on a review of the contents described in the associated documentation. If the containers and their contents are similar, containers are selected randomly for screening. If there are substantial differences among the containers or their contents, the containers are selected by stratified sampling with the strata being the types of containers and or contents presented.

#### B.3.h.2.4 Chemical Screening QC

The following QC elements are used when performing chemical screening:

1. Containers and equipment of the appropriate size, given the analytical method, and that are chemically compatible with the waste and testing reagents
2. Chemicals and test kits that are labeled so that they are traceable
3. QC checks performed on each test kit and associated replacements at the frequency specified in operating procedures

#### B.3.h.2.5 Chemical Screening Parameters

The following methods are approved for use.

##### B.3.h.2.5.1 pH Screening

Rationale: This method identifies the pH and corrosive nature of waste and confirms consistency with the shipment documentation.

Method: Full-range pH paper is used for the initial screening. If the initial screening indicates a pH below 4 or above 10, a pH meter or a narrow-range pH paper can be used. Solids are mixed with an equal weight of water, and the liquid portion of the solution is tested.

Failure Criteria: If the pH of a matrix exceeds regulatory limits (less than or equal to 2.0 or greater than or equal to 12.5), the container fails verification.

##### B.3.h.2.5.2 Peroxide Screening

Rationale: This method determines the presence of organic peroxides in solvent waste, alerts personnel to potential hazards, and confirms consistency with the shipment documentation. The test is sensitive to low parts per million (ppm).

Method: Solids are tested by wetting the test strip with water and contacting a small sample of the waste. A color change indicates a positive reaction. The color change is compared with a chart on the packaging to determine an approximate organic peroxide concentration.

Failure Criteria: Peroxide concentrations greater than 20 ppm in liquid waste constituents that are known organic peroxide formers and are not documented as having been stabilized constitute failure.

##### B.3.h.2.5.3 Paint Filter Test

Rationale: This method verifies the presence or absence of free liquid in solid or semisolid material.

Method: Using a standard paint filter, 100 cubic centimeters or 100 grams of waste are added and allowed to settle for 5 minutes. Any liquid passing through the filter signifies failure of the test. EPA SW-846 requires Method 9095 for the paint filter test.

Failure Criteria: Failure of the test constitutes failure of the container. Small quantities of condensate trapped in inner plastic liner folds are acceptable.

#### B.3.h.2.5.4 Oxidizer Screening

Rationale: This method determines if a waste exhibits oxidizing properties and confirms consistency with the shipment documentation.

Method: Acidified potassium iodide test paper is used to measure the oxidizing properties of waste in accordance with written procedures or the manufacturer's suggested method.

Failure Criteria: A positive oxidizing indication in a waste that is not consistent with documented constituents fails verification.

#### B.3.h.2.5.5 Water Reactivity Screening

Rationale: This method determines if the waste has the potential to vigorously react with water or to form gases or other reaction products. This information is used to confirm consistency with the shipment documentation.

Method: Water reactivity screening is performed in accordance with written procedures or the manufacturer's suggested method.

Failure Criteria: A positive reactivity indication in a waste that is not consistent with documented properties fails verification.

#### B.3.h.2.5.6 Cyanide Screening

Rationale: This method indicates if waste releases hydrogen cyanide upon acidification near pH 2. This information is used to confirm consistency with the shipment documentation.

Method: A cyanide screening is performed in accordance with written procedures or the manufacturer's suggested method.

Failure Criteria: A positive cyanide indication in a waste that is not consistent with documented constituents fails verification.

#### B.3.h.2.5.7 Sulfide Screening

Rationale: This method indicates if the waste could release hydrogen sulfide upon acidification near pH 2. This information is used to confirm consistency with the shipment documentation.

Method: A sulfide screening is performed in accordance with written procedures or the manufacturer's suggested method.

Failure Criteria: A positive indication in a waste that is not consistent with documented constituents fails verification.

## B.3.i Pre-Shipment Authorization Process for Approved Wastes

For each shipment that is a candidate for disposal, the generator provides the following information:

1. Container identification number
2. Profile number
3. Waste description
4. Generator information (e.g., name, address, point of contact, telephone number)
5. Container information (e.g., type, size, weight)
6. EPA waste code(s)
7. Waste composition
8. Packaging materials and quantities
9. Applicable treatment standard/technology.

Where potential nonconformance issues exist in the information provided (i.e., waste characteristics do not match the waste profile information, waste does not meet the NNSSWAC, or additional constituents are expected to be present that do not appear in the documentation), the generator is contacted and the issue is addressed. Container data are compared to waste profile data to ensure that the waste to be shipped is as described on the profile. Screening provides a means to minimize the potential for acceptance of incorrectly identified waste.

### B.3.i.1 Paperwork Review

Every shipment is reviewed to ensure that the waste meets the NNSSWAC. If the shipment information is verified to be acceptable, the operating organization determines if any of the waste containers requires RTR verification.

### B.3.i.2 Visual Inspection and Chemical Screening Documentation Review

For waste streams that underwent verification at the generator site or offsite TSDF, the verification documentation is reviewed for completeness.

### B.3.i.3 RTR Container Selection

A list of waste packages with discrete identification numbers is required for a random selection of containers to undergo RTR verification. The operating organization follows procedures to select containers for RTR verification.

## B.3.j Waste Acceptance and Verification Procedures upon Arrival of Shipment

Waste containers undergo verification upon arrival at the NNSS. The following section provides a description of verification methods available at the NNSS. When a nonconformance issue exists, a determination is made regarding the acceptability of the container, and appropriate action is taken based on the severity of the issue.

#### B.3.j.1 RWMC Paperwork Review

Rationale: Each shipment's paperwork is reviewed for completeness.

Method: The shipment is documented on a shipping/receiver log upon arrival at the RWMC. Operations personnel perform a completeness review of the generator's required shipping paperwork which may include a bill of lading, uniform hazardous waste manifest or equivalent state-of-generation manifest, LDR form, original package storage and disposal request, and original waste certification statement. Paperwork review and inspection requirements are documented on a shipment checklist.

Failure Criteria: A shipment fails inspection if there is (1) missing paperwork, (2) a discrepancy in the number of containers in the shipment, and/or (3) incorrect paperwork.

#### B.3.j.2 RWMC Visual Examination

Rationale: Each container in the shipment is inspected in its entirety for damage, content leakage, complete marking and labeling, and intact TIDs as required. This is to ensure that the shipment (1) is received in good condition, (2) has the container(s) corresponding to the shipping papers, (3) has not been opened after physical screening is performed, and (4) is complete.

Method: When a container is off-loaded, markings, and labels are inspected and compared with associated manifests. Container inspections are individually recorded on a waste package checklist. These checklists, along with the shipment checklist, are recorded and filed with the shipping paperwork

Failure Criteria: A container fails inspection if (1) there is evidence of leaking or breaching of the container, (2) the container number is incorrect, (3) there is incorrect marking or labeling, (4) marking or labeling is missing, (5) the TID is broken or missing, and/or (6) there is a discrepancy in the TID number.

#### B.3.j.3 RWMC RTR Examination

See Section B.3.h.1.5.2 for the rationale, method, and failure criteria for RTR.

### B.3.k Manifest Tracking and Recordkeeping

The generator contacts the operating organization prior to shipment of waste to arrange for waste verification and shipment. The generator is responsible for the identification and tracking of the waste shipment. Upon receipt of waste, each shipment is screened according to the above sections. Once a shipment is accepted, the following actions are performed:

1. Each copy of the manifest is signed and dated to certify that the LLMW covered by the manifest was received.
2. Any significant discrepancies are noted on each copy of the manifest
3. One signed copy of the manifest is given to the transporter.
4. Within 30 days of delivery, a copy of the manifest is sent to the generator.
5. The manifest is retained at the facility for at least 3 years from date of delivery.

The following data are maintained in the RWMC operating record in accordance with the records inventory and disposition schedule:

1. Waste profile and supporting documentation
2. Shipping documentation
3. QA/QC data
4. Documentation from sampling events

Errors and omissions (e.g., transcription errors, typographical errors, errors in calculations) are corrected as information becomes available. These corrections are made in ink and initialed and dated by the person making the correction.

### B.3.l Sampling and Analysis

LLMW is sampled and analyzed by the test methods specified in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" (EPA SW-846) or approved equivalent methods. Analysis is performed by an accepted laboratory as discussed in Section B.3.l.4. The recommended sampling devices, EPA methods, parameters, and rationale for parameter selection for characterization and LDR requirements are identified in Tables 5 and 6.

For wastes with a treatment standard expressed as constituent concentrations, compliance with LDRs (**40 CFR 268.40**) can be shown by any appropriate method. If the treatment standard is expressed as constituent concentrations in waste extracts, TCLP analysis is required.

For parameters or methods not otherwise specified, the following are acceptable sources of testing methods (standard methods):

1. The most recently promulgated version of EPA SW-846
2. Other current EPA methods, as applicable to the matrix under evaluation
3. Standard Methods for the Examination of Water and Wastewater, American Public Health Association, American Water Works Association, and Water Environment Federation
4. Annual Book of American Society for Testing and Materials (ASTM) Standards
5. International Association of Official Analytical Chemists Methods of Analysis

Specific sampling procedures and techniques depend on both the nature of the waste and type of packaging. Waste samples are treated and preserved as necessary to protect the sample. Recommended treatment, preservation techniques, and holding times are stated in SW-846.

**Table 5. Sampling Devices**

| Material | Equipment |
|---|---|
| Liquid | Coliwasa, Dipper, or Weighted Bottle |
| Soil and Soil-like Material | Thief, Trier, Scoop, Shovel, Auger, or Veihmeyer Soil Sampler |

**Table 6. EPA Methods, Parameters, and Rationale for Parameter Selection**

| EPA Method[1] | Parameter | Rationale for Parameter Selection |
|---|---|---|
| 9040, 9041, or 9045 | pH | Assign hazardous waste number and identify prohibited waste |
| ASTM D 93-79, D 93-80, D 3278-78, or 1030 | Ignitability | Assign hazardous waste number and identify prohibited waste |
| 9014, 9034 | Reactivity | Assign hazardous waste number and identify prohibited waste |
| 9095 | Free liquids | Assign hazardous waste number and identify prohibited waste |
| 1311[2] | TCLP | Assign hazardous waste number and verify compliance with LDR treatment standards |
| 2540C | Total Suspended Solids | Determine whether LDR wastewater or non-wastewater treatment standards apply |
| 6010, 6020, or 7000 series | TCLP metals | Assign hazardous waste number and verify compliance with LDR treatment standards |
| 8000 series | Volatiles | Assign hazardous waste number and verify compliance with LDR treatment standards |
| 8000 series | Semivolatiles | Assign hazardous waste number and verify compliance with LDR treatment standards |
| 8000 series | Halogenated organic compounds (HOCs)[3] | Verify applicability of LDR requirements of soil |
| 8082 | PCBs | Identify prohibited items and meet *Toxic Substances Control Act* requirements |

[1] Referenced methods are from Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, SW-846 unless otherwise noted. More current SW-846 methods may be substituted for any method.

[2] An alternative to Method 1311 is to perform total contaminant concentration analysis and assume all contaminants to be leachable using the TCLP method. For purposes of this requirement, the total results based on a dry weight basis shall be divided by a conversion factor of 20 to determine whether a TCLP limit has the possibility of being exceeded.

[3] As specified in 40 CFR 268.2(a) and 40 CFR 268, Appendix III.

### B.3.I.1 Sampling Equipment and Preservation

Table 5 lists waste forms and sample equipment used to sample referenced waste. Sample preservation follows EPA SW-846 protocol.

### B.3.I.2 Sampling Methods

The appropriate personnel are responsible for arranging sampling and laboratory support. Samples are processed at laboratories qualified to perform analysis of waste samples (Section B.3.I.4). The operating organization determines proper sampling protocol (e.g., simple random, stratified simple random) for grab sample(s) based on the waste type and form. Table 6 lists the EPA methods, parameters, and the rationale for parameter selection.

Sampling typically includes the following:

1. Obtain a unique sample identification number and complete the sample tag before sampling.
2. Obtain a pre-cleaned sampling device and sample bottles.
3. For two-phase liquid waste, use a Coliwasa sampler or pipette; pour homogeneous liquids in small containers into a sample bottle.
4. For solid waste, use a scoop, trier, or hand auger to obtain a sample of the waste; for large containers of waste, composite several augers or scoops to ensure samples are representative.
5. Wipe the exterior surfaces of the sample bottles clean.
6. Attach sample label to sample bottles.
7. Complete the chain of custody forms.
8. Place samples in an appropriate receptacle for transfer to the laboratory; if appropriate, include equipment for temperature-sensitive samples to preserve the integrity of the sample as required by EPA methods.
9. Seal and mark the receptacle.
10. Transfer receptacle to the analytical laboratory to meet sample holding times.
11. Properly clean and decontaminate non-disposable sampling equipment or package for return to central sampling equipment decontamination area according to requirements.

### B.3.I.3 Establishing QA and QC Procedures for Sampling

The operating organization maintains compliance with DOE O 414.1C, “Quality Assurance.” Sampling personnel prepare a permanent log of sampling activities. A log of sampling activities is kept in accordance with EPA SW-846, Chapter 9. Log entries include, as appropriate, date of collection, time of collection, location, batch number, sample number, tank number, chain-of-custody information, sampling method, container description, waste matrix, description of generating process, number and volume of samples, field observations, field measurements (e.g., percent lower explosive limit), laboratory destination, and signature. Log entries are made while sampling is performed. Logs or copies of logs are maintained by appropriate personnel after completion of sampling activities. A chain of custody accompanies samples at all times.

Compliance with applicable industrial hygiene and safety standards is mandatory during sampling activities. Transportation of samples is performed in accordance with applicable DOT requirements.

The following QA/QC elements are used to ensure that sampling activities result in acceptable laboratory data:

1. Sampling methods as defined by EPA SW-846, Chapter 9
2. Appropriate sample containers and equipment for specific waste streams
3. Samples numbered and labeled
4. Traceable labeling system

5. Field QA/QC samples
6. Equipment calibration
7. Chain of custody

### B.3.I.4 Laboratories and Treatment Facilities

The U.S. Department of Energy Consolidated Accreditation Program (DOECAP) provides audits of commercial LLMW TSDFs and analytical laboratories. TSDFs and laboratories used by generators shall have a current DOECAP or equivalent audit.

DOECAP incorporates a national standard (statement of work/contracts) and reporting requirements consistent with user needs and regulatory requirements (International Standards Organization 17025 basis). Treatment facilities and laboratories providing support to DOE are required to be audited by DOECAP. DOECAP is a complex-wide consolidated audit program that uses a multi-checklist audit process. The checklists address the following areas:

1. Industrial and chemical safety
2. Environmental compliance/permitting
3. QA management systems
4. Radiological control
5. Transportation management
6. Sampling and analytical data quality
7. Waste operations

Each facility is audited annually to evaluate the effective implementation of the QA/QC program. QA and technical experts evaluate the facility through onsite observations and/or reviews of QA/QC documents, surveillances/inspections, audits, nonconformance issues, and corrective actions.

### B.3.I.5 Evaluation of Analytical Results

Acquired data need to be scientifically sound, of known quality, and thoroughly documented. The operating organization is responsible to ensure that data assessment or evaluation is completed. Data are assessed to determine compliance with the following:

<u>Precision</u> – Precision is the agreement between collected samples (duplicates) for the same parameters, at the same location, and subjected to the same preparative and analytical techniques. Analytical precision is the agreement between individual portions taken from the same sample, for the same parameters, and subjected to the same preparative and analytical techniques.

<u>Accuracy</u> – Accuracy of the measurement system is evaluated by use of various kinds of QA samples, including, but not limited to, certified standards, in-house standards, and performance evaluation samples.

Representativeness – Representativeness addresses the degree to which data accurately and precisely represent a real characterization of the waste stream, parameter variation at a sampling point, sampling conditions, and the environmental condition at the time of sampling.

Completeness – Completeness is the amount of usable data obtained from a measurement system compared to the total amount of data requested.

Comparability – Comparability is the confidence with which one data set can be compared to another. This usually is accomplished by using the same methods for each data set.

If the data are found to be insufficient, the operating organization may require re-analysis, data validation, and/or re-sampling.

### B.3.m Acceptable Knowledge

Acceptable knowledge is a characterization technique that relies on the generator's knowledge of the physical and chemical properties of the materials and the waste generation processes. It includes knowledge of the fate of those materials during and subsequent to the process and the associated administrative controls. When collecting documentation on a waste stream, the operating organization must determine if the information provided by the generator is acceptable knowledge. Acceptable knowledge requirements are met using any one or combination of the following types of information:

1. Mass balance from a controlled process that has a specified input and output
2. SDS of chemical products
3. Test data from a surrogate sample
4. Analytical data on the waste or a waste from a similar process

In addition, acceptable knowledge requirements can be met using a combination of analytical data or screening results and one or more of the following:

1. Interview information
2. Logbooks
3. Procurement records
4. Qualified analytical data
5. Radiation work packages
6. Procedures and/or methods
7. Process flow charts
8. Inventory sheets
9. Vendor information
10. Mass balance from an uncontrolled process (e.g., spill cleanup)
11. Mass balance from a process with variable inputs and outputs (e.g., washing/cleaning methods)

Acceptable knowledge may be used for determining:

1. Hazardous waste constituents
2. Wastes that are listed under **40 CFR 261.31**, **261.32**, and **261.33**
3. UHCs
4. Necessary confirmatory sampling
5. LDR compliance with technology-based standards

If the information is sufficient to quantify the constituents of regulatory concern and to determine waste characteristics as required by regulations and the NNSSWAC, the information is considered acceptable knowledge. If the information is not sufficient, sampling may be required. Waste must conform to requirements found in this WAP, the EPA codes found in Table 4, and the NNSSWAC.

### B.3.n Issue Resolution

Nonconformance issues identified during verification could result in a waste container that does not meet the NNSSWAC. If a possible nonconformance issue is identified, the following actions are taken to resolve the issue:

1. The operating organization compiles all information concerning the possible nonconformance issue(s).
2. The generator is notified and requested to supply additional information that could assist in the resolution of the concern(s). If the generator supplies information that resolves the concern(s), no further action is required.
3. The operating organization and the generator discuss the nonconformance issue(s) and identify the appropriate course of action to resolve the container/shipment in question.
4. The operating organization has the following options (more than one may be used): (1) suspend the waste stream, (2) suspend the generator's entire waste shipping program, (3) issue a CAR, (4) have the generator issue an internal nonconformance, (5) increase physical screening frequencies, (6) ensure issue is included during the next scheduled generator facility evaluation, (7) schedule a facility evaluation, and (8) return waste container and/or shipment to a generator-specified facility.
5. Upon issuance of a CAR, the operating organization requests the generator to provide a CAP that clearly states the reason for the failure and describes the actions to be completed to prevent reoccurrence.
6. The operating organization reviews the CAP for adequacy.
7. Issues and their corresponding resolutions are recorded and tracked by the operating organization.
8. On resolution of the initial nonconformance issue, the operating organization requests that the generator provide a CAP that clearly states the reason for the failure and describes the actions to be completed to prevent reoccurrence.
9. The generator may request a reduction in verification of unaffected waste streams. This request must be accompanied by a justification that identifies why the waste stream(s) would not exhibit the same nonconformance issue.

10. The operating organization reviews the CAP and waste stream justification for adequacy. If the waste stream justification is accepted, the operating organization adjusts the frequency.

### B.3.o Reducing the Physical Screening Frequency

Physical screening percentages may be reduced based on the waste stream compliance with the waste profile, shipping documentation, and verification results. At no time will the frequency be reduced below 5 percent.

### B.3.p Frequency of Analysis

#### B.3.p.1 Facility Evaluations

Generators are evaluated according to the NNSSWAC. CARs may be issued for quality-affecting problems. CARs must be answered by a CAP identifying the root causes, corrective actions, and actions to preclude reoccurrence. Dependent upon the severity of the problem(s), NNSA/NFO may:

1. Allow continued shipment of all approved waste streams.
2. Suspend one or more waste streams from shipments.
3. Suspend the entire waste shipment program.

#### B.3.p.2 Waste Profiles

Generators perform an initial characterization or identification analysis prior to submitting a waste profile. The following are examples of when an analysis may be repeated:

1. If requested by the operating organization due to insufficient data
2. After 1 year (365 days) from waste profile approval (see Exhibit 5)
3. If the generating process has changed
4. Upon submission of a waste profile revision regarding characterization changes (if revision is submitted within 1 year of previous evaluation)
5. If inspection or analysis indicates the waste received does not match the waste profile and/or shipment documentation

If the generator has informed the operating organization of a change in the waste generation process or if the waste may not conform to the waste profile, the waste must be re-profiled and re-reviewed.

When a waste profile is re-evaluated, the operating organization could request the generator to do one or more of the following:

1. Verify that the current waste profile is accurate
2. Supply a new waste profile
3. Submit a sample for analysis
4. Cancel the waste profile

# EXHIBIT 2. Approval Flow Diagrams

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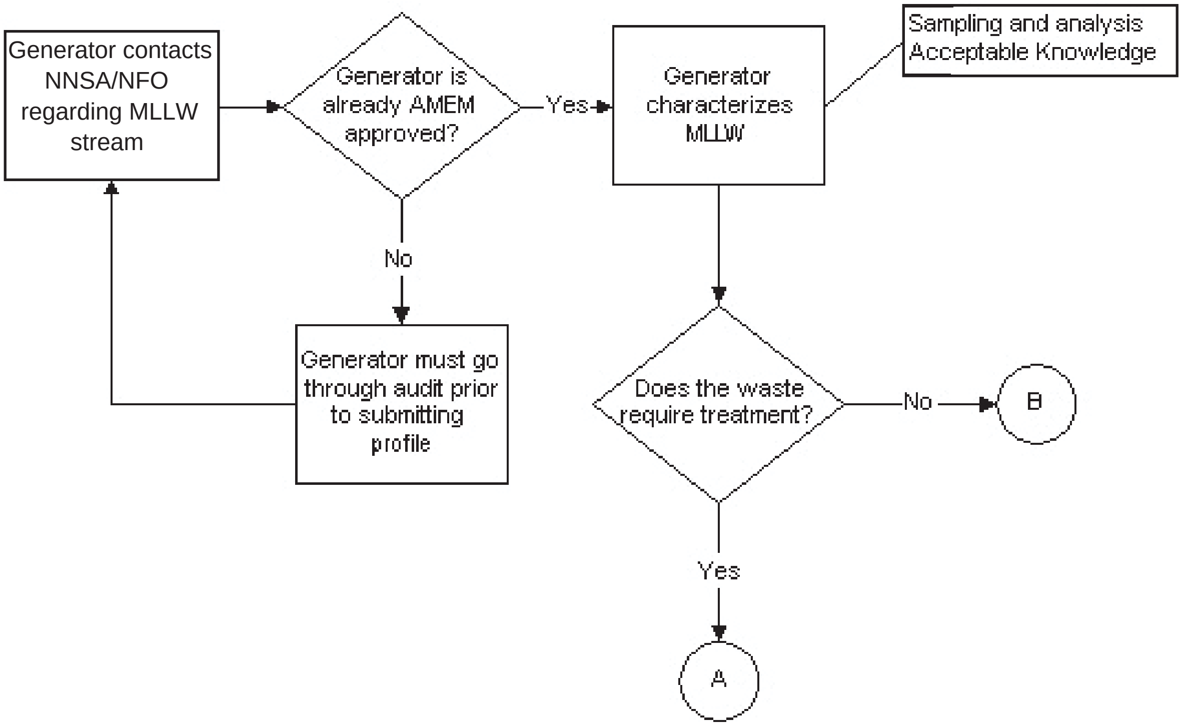
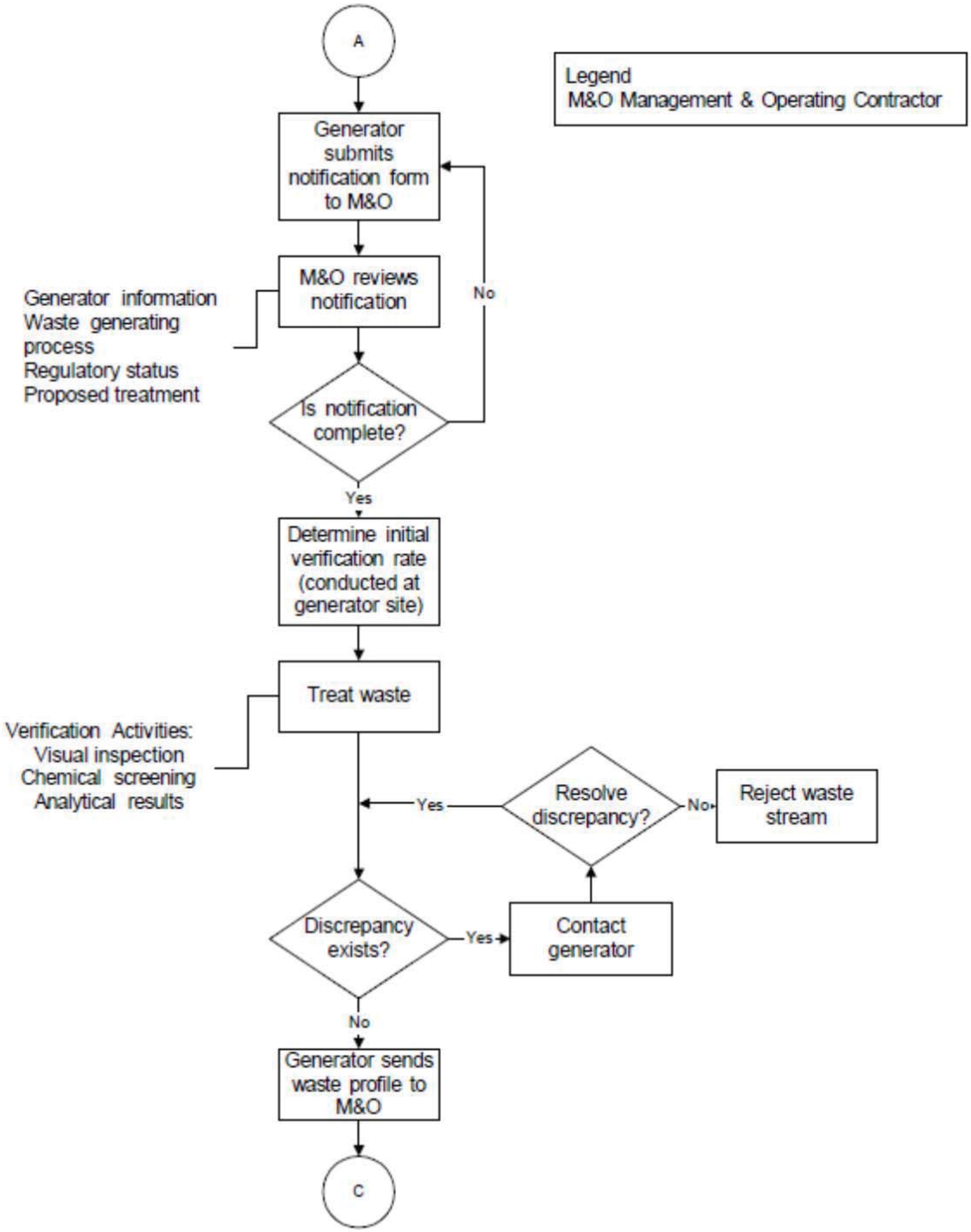
# WASTE GENERATOR APPROVAL

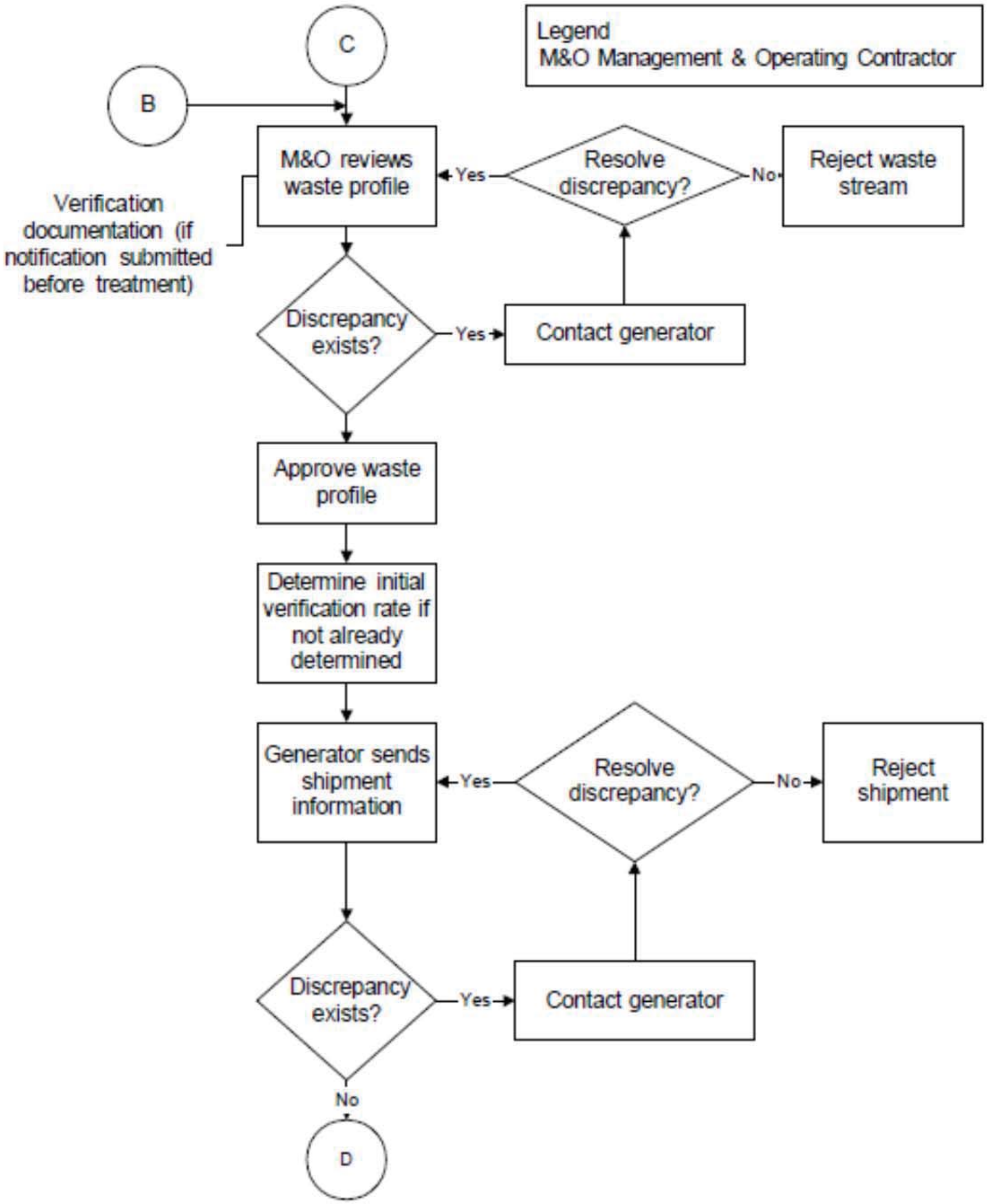
AMEM - Assistant Manager Environmental Management
NNSA/NFO - U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
MLLW - Mixed Low-Level Waste



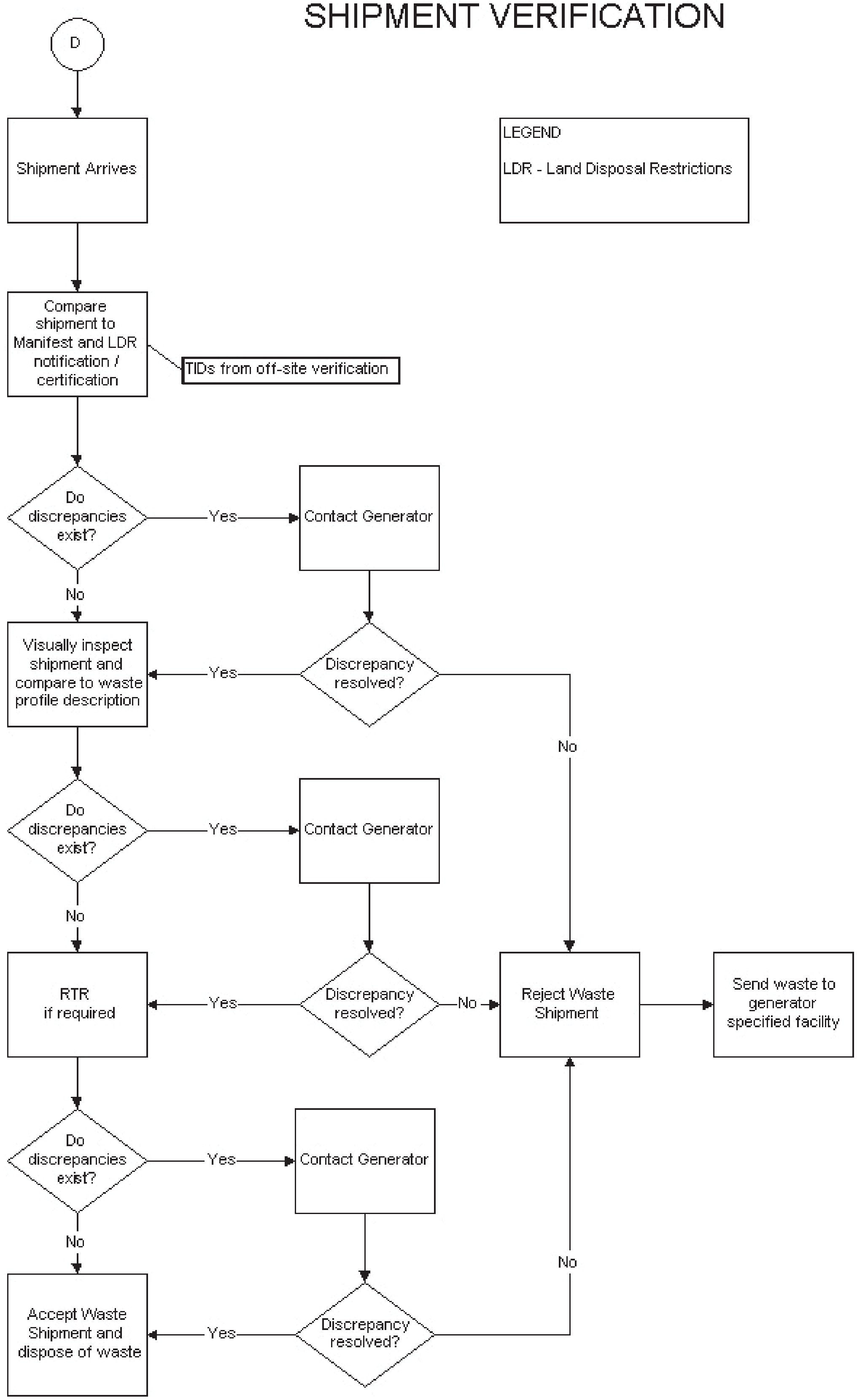
# PRE-TREATMENT NOTIFICATION



# POST-TREATMENT PROFILE



# SHIPMENT VERIFICATION



## EXHIBIT 3. NNSS Pre-Treatment Notification Form for Mixed Waste Example

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***A. Generator Information***

1. Company name:
2. Facility address:
3. Generator facility:
4. Primary technical contact: email: Phone: Fax:
5. Waste certification official: email: Phone: Fax:

***B. General Waste Stream Information***

1. Waste stream name:
2. Waste stream identification number:
3. Waste generating process description:
4. Estimated volume after treatment: ☐ Inventory attached
5.

| Container Size | Weight (lbs). | Dose rate (mR/hr @ 30 cm) |
|---|---|---|
| | | |
| | | |

6. Regulatory status. Check all boxes below that describe the regulatory status of the waste stream as generated:
   - ☐ Federally regulated (RCRA) hazardous waste (40 CFR 261). List all EPA hazardous waste numbers and applicable regulatory subcategories
   - ☐ State regulated hazardous waste codes:

1. Waste composition. Describe the gross composition/component of the waste stream and all hazardous constituents that contribute to any waste codes or LDR treatment standards.

| CAS Number | Chemical Constituent | Waste Component |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

8. Reportable radionuclides. List the radionuclides that could be reportable in the waste stream:

| Isotope | Activity ($Bq/m^3$) |
|---|---|
| | |
| | |
| | |

***C. Proposed Treatment Information***

1. Applicable LDR Treatment Standards:
2. Treatment standards: ☐ Concentration Based ☐ Technology Based
3. Proposed Treatment Facility:
   ☐ Onsite Generator procedures:
   ☐ Commercial Facility name:
   Address:
   EPA Identification number:
   Permit number:
4. DOECAP audit number and date completed of the treatment facility:
5. Treatment process(es) or technology(ies):
6. Proposed final waste form:
   ☐ Solidified/Stabilized ☐ Debris ☐ Macroencapsulated
   ☐ Incinerator Ash ☐ Soil ☐ Other; describe:
7. ☐ Waste will contain sorbent.
   What kind? *Sorbents used must meet 40 CFR 264.314(e)(1) or (2).*
8. Schedule for treatment:
9. Training or PPE necessary for visual inspection of treatment/waste:

Technical Contact Signature: _______________ Date:

WCO Signature: __________________ Date:

## EXHIBIT 4. Waste Stream Recommendation Example

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## EXHIBIT 5. Mixed Waste Profile Annual Certification Example

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## G.2 Mixed Low-Level Waste and Non-Radioactive Hazardous Classified Waste/Matter Profile Annual Certification Example

Waste Profile Number:
Waste Profile Revision No.: Expiration Date:
Facility: WCO:

The above profile is about to expire. The NNSSWAC requires generators to recertify MWPs and Non-Radioactive Hazardous Classified Waste/Matter profiles on an annual basis. No waste may be shipped under this profile after the expiration date unless it has been recertified or a new waste profile has been submitted and approved.

Please indicate your preference by checking the appropriate box below. If the waste stream has not changed significantly and the profile is still accurate, recertify by checking the third box below, providing the additional information requested, signing the certification statement, and returning this form to NNSA/NFO EMO. Upon approval, a letter will be sent which authorizes continued shipment of the waste stream for up to an additional year.

Check the appropriate box:

☐ This waste profile is no longer needed. Please cancel the waste profile.

☐ There have been significant changes to this waste stream. I understand that this waste stream cannot be shipped to the NNSS until a revised or new profile is approved. I will revise it or submit a new waste profile.

☐ I want to recertify the waste profile. I have reviewed the revision no. _______ and certify that it is current, complete, and accurate description of the waste stream and the methods employed to ensure that the waste meets the NNSSWAC.

If you checked the third box above, answer the following questions to confirm that the waste stream has not changed significantly. Significant changes will require a revision to the waste profile.

| | | | | |
|---|---|---|---|---|
| ☐ | No | ☐ | Yes | Has the generating process changed? |
| ☐ | No | ☐ | Yes | Have the methods used to perform radiological characterization changed? |
| ☐ | No | ☐ | Yes | Have the methods used to perform physical/chemical characterization changed? |
| ☐ | No | ☐ | Yes | Have any of the RCRA or state waste codes changed? |
| ☐ | No | ☐ | Yes | Has the LDR status (subcategories, treatment, etc.) changed? |
| ☐ | No | ☐ | Yes | Have there been any other changes to the waste stream that could affect management of the waste at NNSS? |
| ☐ | No | ☐ | Yes | Do you have any new waste analysis data that confirms or improves your waste characterization? |

Provide the volume remaining in the waste stream:

If you checked any "Yes" boxes, please explain below and attach additional sheets as necessary.
Certification: I certify that, to the best of my knowledge, the information provided on this form and any attached documentation is accurate and complete.

WCO Signature: ______________________________________________ Date: ____________

Print Name: ________________________________________

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## B.3.q Wastes to be Landfilled [40 CFR 270.14(b)(2)]

Wastes that are disposed at the MWDU contain both radioactive and hazardous material components as defined by the AEA, RCRA (**40 CFR 261.24** through **261.35**), NRS, and NAC (**NAC 444** and **459**).

Waste streams accepted for disposal at the MWDU may carry only the EPA hazardous waste numbers listed in Table 4 and must meet the NNSSWAC. Waste must also meet the LDR treatment standard requirements in **40 CFR 268.40** and **268.45**, including applicable standards for UHCs. Waste meeting the alternative LDR treatment standard for contaminated soil (**40 CFR 268.49**) or equivalent technologies (**40 CFR 268.42[b]**) approved by NDEP are also accepted.

Waste that contains metals, solvents, organics, and listed constituents, waste from specific processes regulated in **40 CFR 261**, and State-only designated hazardous waste may also be received at the NNSS as hazardous waste.

LLMW containing friable or non-friable asbestos is disposed at the MWDU. An asbestos cell will not be designated within the MWDU; instead, the location of disposed asbestos waste is documented as described in Section B.20.a.7.

Two types of LLW containing PCBs may be disposed at the MWDU:

- Bulk PCB remediation waste at concentrations greater than or equal to 50 parts per million (**40 CFR 761.61[a][5][I][b][2][iii]**)
- PCB bulk product waste at concentrations greater than or equal to 50 parts per million and that leaches PCBs at concentrations greater than or equal to 10 micrograms per L (**40 CFR 761.62[a][3]**)

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## B.4 Security [40 CFR 270.14(b)(4)]

The NNSS is bordered on three sides by 6,629 $km^2$ (2,560 $mi^2$) of federal land, which provides restricted and secure access for the NNSS. This restricted zone provides an additional buffer between the MWDU and other properties. Land administered by the BLM borders the fourth side of the NNSS.

In addition to the remote location of the NNSS, NNSA/NFO maintains a contractor security force of highly trained security personnel who are present at the NNSS 24 hours a day, 7 days a week, including holidays. These personnel monitor entry to and exit from the NNSS and provide security measures throughout the NNSS. The size and location of the NNSS with respect to public highways have made the construction of a facility boundary fence impractical. General security measures taken at the NNSS are maintained by a two-level system: (1) security stations at all authorized entrances to the NNSS, property line warning signs, and surveillance patrolling; and (2) specific security measures taken at individual locations such as fencing, warning signs, and building security.

### B.4.a NNSS Access

There are security stations at all authorized entrances to the NNSS. Only authorized and badged personnel are allowed access to the NNSS. Security personnel perform a visual and tactile inspection of each person’s badge before entry to and exit from the NNSS.

Signs stating **No Trespassing by Order of the United States Department of Energy** are located along the public highways that border the NNSS. The signs are legible from a distance of 7.6 m (25 ft) and are spaced at regular intervals. In areas where the visibility of the sign may be obstructed, signs appear at more frequent intervals.

Security personnel also perform random patrols of the NNSS boundaries and roads. Security personnel also check buildings, facilities, and vehicles on the NNSS on a 24-hour basis, including holidays.

### B.4.b RWMC Access

Security safeguards are provided by RWMC personnel and engineered structures. The active area of the RWMC is surrounded by a fence. **Danger – Unauthorized Personnel Keep Out** signs visible from 7.6 m (25 ft) are posted along the fence. Entry to and exit from the active area of the RWMC is via a controlled gate. All personnel entering the RWMC must log in at the main office building before access is granted.

Within the RWMC, the Cell 18 MWDU is surrounded by a fence, and the entrance is secured by a locked gate. The unit remains secured except during authorized operations such as vehicle off-loading, waste stacking, disposal operations, maintenance, and inspections. A sign warning unauthorized personnel to keep out is posted on the entrance gates. Fencing is inspected once a week for signs of intrusion, deterioration, or damage.

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## B.5 General Inspection Schedule [40 CFR 270.14(b)(5)]

The inspection schedule addresses requirements for environmental monitoring equipment, fire protection systems, safety and emergency equipment, security devices, and operating or structural equipment that are critical to prevent, detect, or respond to incidents that could adversely affect human health or the environment. Observations and descriptions of repairs or corrective actions are noted on the inspection forms. Completed inspection forms are filed at the RWMC as a record of inspection.

Weekly inspections include spill control materials, fences, gates, signage, exposed packages, run-on/runoff control, pits/trenches, the leachate storage tank and secondary containment, the leachate sump, and general housekeeping. Table 7 provides a detailed list of inspection items and frequencies for the MWDU. A sample weekly inspection checklist is provided as Figure 5.

If an inspection reveals deterioration or malfunctioning equipment, containers, or structures, the problem is documented on the inspection checklist. Corrective actions are scheduled to ensure that an incident does not occur that could adversely affect human health or the environment. When corrective actions are completed, they are noted on the next inspection checklist. When a hazard is imminent or already exists, corrective action is taken immediately.

**Table 7. MWDU Inspection Schedule**

| Inspection | Description | Frequency |
|---|---|---|
| Exposed Waste Packages | Ensure that damage, deterioration, leaks, or spills are not present. | Weekly |
| General Areas | Ensure that general areas are free of spills, leaks, releases, trash, and debris. | Weekly/During waste handling operations |
| Fencing/Gates | Ensure that fences and gates are intact with no corrosion, breaches, or deterioration. | Weekly |
| Signs | Ensure that signs are posted in proper locations, are visible, and adequately communicate entry requirements. | Weekly |
| Run-on/Runoff Control | Ensure the integrity of berms and dikes (no erosion or sloughing) and the adequacy of stacking. | Weekly/After storms |
| Spill Control | Ensure that adequate supplies are present. | Weekly |
| Fire Extinguishers[1] | Verify that hoses are in good condition and pressure gauges are in the appropriate range. | Monthly |
| Communication Equipment | Ensure that communication equipment is functioning properly. | Monthly/Before entering the MWDU |
| Leachate Storage Tank and Secondary Containment | Ensure that the tank's containment leak detection and overfill protection are operational, check tank liquid level, inspect valves for leaks and proper orientation, ensure that secondary containment is empty of liquid and debris, and check tank and containment for signs of leakage or deterioration. | Each operating day |
| Leachate Sump | Ensure that pumpable liquids are removed to minimize head on the liner and document liquid levels. | Weekly/After storms |

[1] Fire extinguishers are certified annually by trained personnel per National Fire Protection Association requirements.

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**Figure 5. Sample Inspection Checklist**

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**CHECKLIST D**
**Area 5 Weekly Permitted Cell Checklist**
**Page 1 of 1**

**NOTE:** The checklist entry blocks follow the tour route for performing this inspection

| **General Area Inspections** | **YES** | **NO** |
|---|---|---|
| Radcon "Ready Kit" inspected in the past month. | ☐ | ☐ |
| Respirators have current inspection stickers. | ☐ | ☐ |
| Berms and/or levees intact (no erosion, sloughing, etc.). | ☐ | ☐ |
| **MWDU [Mixed Waste Disposal Unit]** | **YES** | **NO** |
| Readable signs posted on the perimeter fence and entry gate. | ☐ | ☐ |
| Access gate locked when area is uninhabited and is fencing intact. | ☐ | ☐ |
| Spill kit available and complete. | ☐ | ☐ |
| Portable Fire Extinguishers readily accessible and nearby. | ☐ | ☐ |
| Cell walls free of erosion and instability. | ☐ | ☐ |
| Exposed packages free of damage or deterioration. | ☐ | ☐ |
| Exposed packages free of leaks or spills or indications thereof. | ☐ | ☐ |
| Exposed container labels legible. | ☐ | ☐ |
| Communication system available for facility personnel to signal an emergency. | ☐ | ☐ |
| Good housekeeping practices followed in the cell to allow for unobstructed access of personnel and fire protection /spill control/decontamination equipment. | ☐ | ☐ |
| Daily average secondary leachate flow (Data Sheet A) less than 755 gallons (Permitted Action Leakage Rate). | ☐ | ☐ |
| **Asbestos Disposal Cells** | **YES** | **NO** |
| Readable signs posted on the perimeter fence and entry gate. | ☐ | ☐ |
| Access gate locked when area is uninhabited or cell is not in use. | ☐ | ☐ |
| Perimeter fence in good condition. | ☐ | ☐ |
| Portable fire extinguishers readily accessible and nearby. | ☐ | ☐ |
| Run-on control structure free of erosion. | ☐ | ☐ |
| Covered material free of settling. | ☐ | ☐ |
| Good housekeeping practices followed in the cell. | ☐ | ☐ |

Remarks: (If "NO" is marked on any item, the noncompliance and corrective action taken are stated below.)

**LOW-LEVEL WASTE SPECIALIST**

| Name | Signature | Date/Time |
|---|---|---|

**LOW-LEVEL WASTE SUPERVISOR**

| Name | Signature | Date/Time |
|---|---|---|

**NUCLEAR FACILITY MANAGER**

| Name | Signature | Date/Time |
|---|---|---|

† = DSA/TSR Control

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## B.6 Preparedness and Prevention [40 CFR 270.14(b)(6)]

RWMC emergency response activities are performed by the DOE contractor and/or subcontractor. Contractor emergency services located on the NNSS include the NNSS Fire Department and NNSS Occupational Medicine, and the Nye County Sheriff's Office provides law enforcement services. Verbal and written notification requirements to the appropriate federal and state agencies are performed by an NNSA/NFO representative.

DOE maintains Memorandums of Understanding with Nye County, the Bureau of Land Management, Creech Air Force Base, and the U.S. DOE Office of Secure Transportation for emergency activities. Las Vegas area hospitals that are notified include University Medical Center, Mountain View Hospital, Sunrise Hospital, and Mercy Flight for Life air ambulance service. NNSA/NFO also maintains an Agreement-in-Principle with the State of Nevada.

Because of the complexity of operations at the NNSS, facilities are required to maintain individual emergency response procedures. Exhibit 6 provides a copy of the Emergency Plan Implementing Procedure (EPIP) for the Area 5 RWMC. As required by **40 CFR 264.51**, any imminent or actual emergency requiring implementation of the EPIP is recorded in the operating record, and a written report is submitted to NDEP by NNSA/NFO within 15 days of the incident. The written report includes the following information:

- Name, address, and telephone number of the owner or operator
- Name address, and telephone number of the facility
- Date, time, and type of incident
- Name and quantity of materials involved
- Extent of injuries (if any)
- An assessment of actual or potential hazards to human health or the environment (as applicable)
- Estimated quantity and disposition of recovered material that resulted from the incident

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## B.7 Contingency Plan [40 CFR 270.14(b)(7)]

Exhibit 6 is a copy of EPIP-RWMC.001, “Radioactive Waste Management Complex Emergency Response Actions.”

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## EXHIBIT 6. EPIP-RWMC.001, "Radioactive Waste Management Complex Emergency Response Actions"

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## B.8 MWDU Procedures to Prevent Hazards [40 CFR 270.14(b)(8)]

This section describes the procedures that are used at the MWDU to prevent hazards to human health, safety, and the environment. A description of the procedures, structures, and equipment used at the MWDU are summarized below.

### B.8.a Hazards in Off-Loading Operations

Specific precautions taken during off-loading operations include preventative measures and monitoring activities to safely manage waste. Generators provide advanced notification of shipments to the RWMC to ensure that shipments are authorized and scheduled with the facility.

Precautions taken during off-loading operations to prevent releases to the environment or MWDU personnel being exposed to waste include the following:

- Examination of required documents for each waste shipment to verify that all information is accurate and complete
- Surveys of waste transport vehicles using appropriate portable radiation detection instruments and/or standard swipe survey techniques and surveys of vehicles and trailers before being released from the RWMC
- Collection and analysis of swipe samples for radiological parameters from the exterior surfaces of selected containers
- Use of container-handling equipment, including drum dollies, mobile cranes, or forklifts with drum lift attachments or slings, to prevent ruptured containers; use of ramps if needed during off-loading and to conduct visual inspections of containers
- Limiting personnel access within the MWDU during container-handling operations

### B.8.b Waste Handling Areas Surface Water Run-On and Runoff

The design of the Cell 18 MWDU prevents runoff from the unit. Run-on is limited to the cell ramp and unloading areas. The RWMC facility is protected from run-on as described in B.1.b.2.

### B.8.c Contamination of Water Supplies

Contamination of water supplies by wastes disposed at the MWDU is highly unlikely due to the following conditions:

- There is no surface water near the MWDU.
- The average annual potential evapotranspiration rate is approximately 11 times the average annual precipitation rate at the NNSS; leading to a net water deficit in surrounding soils.
- The depth from the land surface to the ground water in the uppermost aquifer is approximately 255 m (835 ft).
- Wastes containing free liquids are prohibited.
- The nearest drinking water well (Well 5b) is located approximately 6.5 km (4.0 mi) from the RWMC.

- The RWMC inspection program is designed to quickly discover safety or environmental hazards. The EPIP facilitates rapid response and cleanup of releases.
- The leachate storage tank has a secondary containment vault, and underground piping is constructed of double-walled fiberglass/fiberglass-reinforced plastic.

### B.8.d Equipment Failure and Effects of Power Outages

Equipment failures and power outages will not affect MWDU operations, cause a release of waste, or present safety hazards for the following reasons:

- Waste containers are moved and placed in disposal configuration by equipment. Failed equipment is replaced, or activities are delayed until the equipment is repaired.
- RWMC emergency communication equipment is inspected monthly to ensure adequate inventory and proper operation. Hand-held radios are tested daily for proper functioning.
- The leachate collection system includes a backup system to remove leachate from the sumps.
- Normal operations are limited to daylight hours.

### B.8.e Undue Personnel Exposure to Typical Waste

Waste disposed at the MWDU is containerized or encapsulated, limiting the possibility of undue personnel exposure to waste. RWMC personnel are trained in the proper procedures for handling waste, performing site operations, and responding to emergency situations. Frequent inspections of the facility and equipment minimize undue exposure, accidents, and injuries. RWMC personnel working with waste are trained and aware of potential hazards. Health and safety plans and radiological work permits further reduce potential employee exposure.

### B.8.f Aisle Space

Aisle space is maintained by designated travel routes and an access ramp that allows the unobstructed movement of personnel and fire protection, spill control, and decontamination equipment to the MWDU during an emergency.

### B.8.g Spills or Releases from the Tank or Tank Components

Spills or releases from the leachate storage tank are contained in the tank's secondary containment structure. The tank and secondary containment are inspected as described in Table 7, and corrective actions are documented and tracked to completion.

### B.8.h Releases to the Atmosphere

Releases to the atmosphere are minimized through the use of DOT-compliant packaging. All waste is packaged, shipped, handled, and disposed in DOT-compliant containers. Broken containers are not accepted for disposal. Additionally, transporters are required to hold an EPA identification number for transporting hazardous waste.

## B.9 Prevention of Reaction of Ignitable, Reactive, and Incompatible Waste [40 CFR 270.14(b)(9)]

Ignitable, corrosive, reactive, and incompatible wastes are not accepted for disposal at the MWDU.

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## B.10 Traffic [40 CFR 270.14(b)(10)]

Offsite generators transport waste to the NNSS on U.S. Highway 95 to the Mercury Highway entrance to the NNSS. Major traffic flow into Area 5 is via the paved 5-01 Road. Direct access to the RWMC from the 5-01 Road is provided by a large paved parking lot and turnaround area.

Traffic volume on the 5-01 Road ranges from 40 to 60 vehicles per day, and the posted speed limit is 73 km per hour (45 mi per hour). Conventional stop and yield signs at major intersections are used to maintain traffic flow and control throughout the NNSS. Traffic regulations are enforced by the Nye County Sheriff.

The 5-01 Road consists of medium-sized gravel chips compacted into a solid mass (surfacing) that uses bituminous (asphaltic) oil as a binding agent. Oil and chip applications are applied as needed. Total thickness varies from 2.5 to 7.6 cm (1 to 3 in.) along the length of the road.

An engineered-base, load-bearing capacity cannot be definitively stated due to the 5-01 Road not conforming to pavement structural design standards. Laboratory testing of the 5-01 Road subgrade material (i.e., types of subgrade soils and basic engineering index properties) indicates that they provide relatively good support for pavements based on the American Association of State Highway and Transportation Officials classification system.

Subjective engineering evaluations of the 5-01 Road were performed in 1994 and 1999. These evaluations included visual observation of the entire road; pavement thickness measurements; evaluation of cracking, heaving, and other unconformities; and a review of the road's history and maintenance. Based on engineering judgment, these evaluations indicate that the existing capacity is adequate to support existing and future waste shipments in conjunction with regular inspections, continued maintenance, and reduced speed limits.

Within the RWMC, transport vehicles proceed through the gate adjacent to Building 5-31, the Controlled Area Access Building, to Building 5-6 for RTR if required. Upon conclusion of RTR, waste containers are transported to the Cell 18 MWDU. Shipments not requiring RTR proceed directly to the Cell 18 MWDU.

Containers that fail RTR are moved to the verification hold area for disposition. Figure 6 depicts the waste transportation routes through the RWMC access gate and to the Cell 18 MWDU.

Vehicles transporting waste to the RWMC include tractor/trailers and enclosed vans. Transporters are required to have an EPA identification number for transport of hazardous waste.

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**Figure 6. Travel Routes**

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# B.11 Facility Location [40 CFR 270.14(b)(11)]

## B.11.a Seismic Standard

The southwestern United States, including Nevada, is tectonically active compared with other parts of the country (**40 CFR 264, Appendix VI**). Natural seismic risk is moderate in the NNSS region. The structural development and present structure of the region have been summarized by Carr et al. (1974), Barnes et al. (1982), and Hudson (1992). The mountains surrounding Frenchman Flat have had a complex structural history. There are numerous surface expressions of faults in the area (Figure 7).

The RWMC lies between two northeast-trending Quaternary fault zones, the Cane Spring fault zone (6.5 km [4 mi] northwest of the RWMC) and the Rock Valley fault zone (9.0 km [5.5 mi] south of the RWMC). The University of Nevada-Reno Seismology Laboratory database (1852 to 2005) lists 67 earthquakes with Richter magnitudes greater than 4.0 occurring in the southern half of the NNSS. Of these, 33 were coincident with an underground test, and seven occurred within a few days after an underground test, which, with one exception, had a yield greater than 1 megaton; the exception had a yield between 20 and 200 kilotons (DOE, 1994). Of the 67 earthquakes, 13 had Richter magnitudes between 5 and 6; and 2 had Richter magnitudes greater than 6 (the largest had a magnitude of 6.2).

No surface-cutting or Holocene faults have been identified within 915 m (3,000 ft) of the RWMC (Raytheon Services Nevada, 1994). Activities to identify and evaluate potential surface-cutting faults included (1) geomorphic mapping of waste disposal trench walls and pits at the RWMC, (2) video logging of one of the Greater Confinement Disposal boreholes, (3) lineament map preparation and field investigations, (4) trench excavations and mapping, (5) evaluation of previously drilled boreholes, and (6) large-scale (1:6,000) air photo analysis and mapping of surficial deposits.

Soil trenches 1 and 4 were excavated to evaluate a previously mapped scarp (Rawlinson, 1991) and a possible fault in the surface alluvium identified by the U.S. Geological Survey (USGS) (Carr et al., 1967) at drill site U-5l (Figure 7). Mapping of approximately 200 m (650 ft) of exposed walls in these trenches to a depth of 3 m (10 ft) did not identify surface-cutting faults associated with either the scarp or apparent fault in the surface alluvium. Additionally, a basalt flow or sill was intersected beneath 290 m (950 ft) of alluvium in drill holes UE-5i and UE-5k, located 2 km (1.2 mi) north and northeast of the RWMC, respectively (Figure 7). The age of the basalt, presumably from a local center within or near Frenchman Flat, is 8.6 million years (Turrin, 1993). Occurrence of the basalt at a similar depth in drill holes, which are 2 km (1.2 mi) apart and separated by the scarp, provides further evidence that the lineament is either not related to faulting or, if so, is not active or has had minimal displacement during the past 8.6 million years. The only lineament confirmed to be related to faulting and associated with surficial deposits is 3.6 km (2.2 mi) northwest of the RWMC in the longitudinal valley of the Massachusetts Mountains (Figure 7). The faulting is believed to be late Tertiary to early Quaternary based on bed attitude and faulting of conglomeratic alluvium presumably of this age.

In summary, no known surface-cutting faults that have had displacement during Holocene time are present within 915 m (3,000 ft) of the RWMC (**40 CFR 264.18**). Trench excavations and mapping, large-scale (1:6,000) air-photo analysis, and surficial-deposit mapping were performed to evaluate a lineament located within 61 m (200 ft) of the RWMC. These investigations show that this lineament is not a surface-cutting fault or Holocene tectonic feature.

### B.11.b Flood Plain

The MWDU is located outside the 100-year floodplain and is in compliance with **40 CFR 264.18(b)** and **270.14(b)(11)(iii)**. The southwest corner of the RWMC falls within a 100-year floodplain as illustrated in Figure 8. The RWMC is not subject to frequent flooding. The washes that drain toward the RWMC are normally dry and flow only during intense rainfall.

According to **40 CFR 270.14 (b)**, Flood Insurance Rate Maps (FIRMs) produced by the Federal Emergency Management Agency (FEMA) should be used to determine if a unit is within a 100-year flood hazard area (100-year flow depth greater than 0.30 m [1 ft]). When a FIRM has not been developed for an area, which is the case for Area 5, a flood hazard map must be developed using FEMA methods. A flood study using FEMA methods was completed and submitted to the NDEP in February 1993 (Exhibit 7).

The overall watershed that could impact the RWMC is approximately 365 $km^2$ (140 $mi^2$) (Figure 2). This watershed was divided into 16 subbasins to best represent the hydrology of the study area. USGS topographic maps were used to divide the drainage area into subbasins ranging in size from 0.8 $km^2$ (0.3 $mi^2$) to 210 $km^2$ (81.3 $mi^2$). Barren Wash, Scarp Canyon, and Halfpint alluvial fans were delineated. These fans are characterized by incised channels in the upper parts of the fans decreasing to sheet flow in lower parts of the fans.

The 100-year flood hazard for the Barren Wash, Scarp Canyon, and Halfpint alluvial fans was analyzed using FAN, a computer program developed by FEMA (1990). This program was used to delineate the flood hazard zones on the alluvial fans according to FEMA methods. The results of the alluvial fan analyses are shown in Figure 8.

FEMA designates alluvial fan flooding, shallow concentrated flow, and sheet flow areas with 100-year flood depths between 0.30 m (1 ft) and 0.90 m (3 ft) as Zone AO. FEMA further designates an associated flow velocity for alluvial fan flood hazards. The flood hazard analysis of the alluvial fans determined that the southwest corner of the RWMC is within the 100-year flood hazard (Zone AO) of the Barren Wash alluvial fan. This part of the RWMC does not include RCRA units covered in the NNSS RCRA Part B permit application.

The HEC-2 model developed by the U.S. Army Corps of Engineers to determine water surface elevations in channels was used to assess the flood hazard of shallow concentrated flow in a channel impacting the southwest corner of the RWMC. This analysis determined that flows exceed a depth of 0.30 m (1 ft) along the southwest corner of the RWMC, also placing this part of the RWMC in the 100-year flood hazard (Zone AO).

For the remaining subbasins that could impact the RWMC, flood hazard determinations were conducted assuming sheet flow conditions. The analysis, using FEMA methods for sheet flow, concluded that these sheet flow regions should be designated as Zone X. FEMA defines Zone X as areas outside the 100-year flood hazard and/or areas of 100-year shallow flooding (sheet flow) where average depths are less than 0.30 m (1 ft). A Zone X delineation does not mean that floods will not occur in this zone; therefore, flood hazard zone protection must be addressed.

Flow from the watersheds above the RWMC is diverted by flood control structures located on three upstream sides of the RWMC. These structures have been engineered to maintain a run-on control system capable of preventing flow into the active portion of the RWMC during peak discharge from a 25-year, 24-hour storm.

**Figure 7. Map of Structural Pattern**

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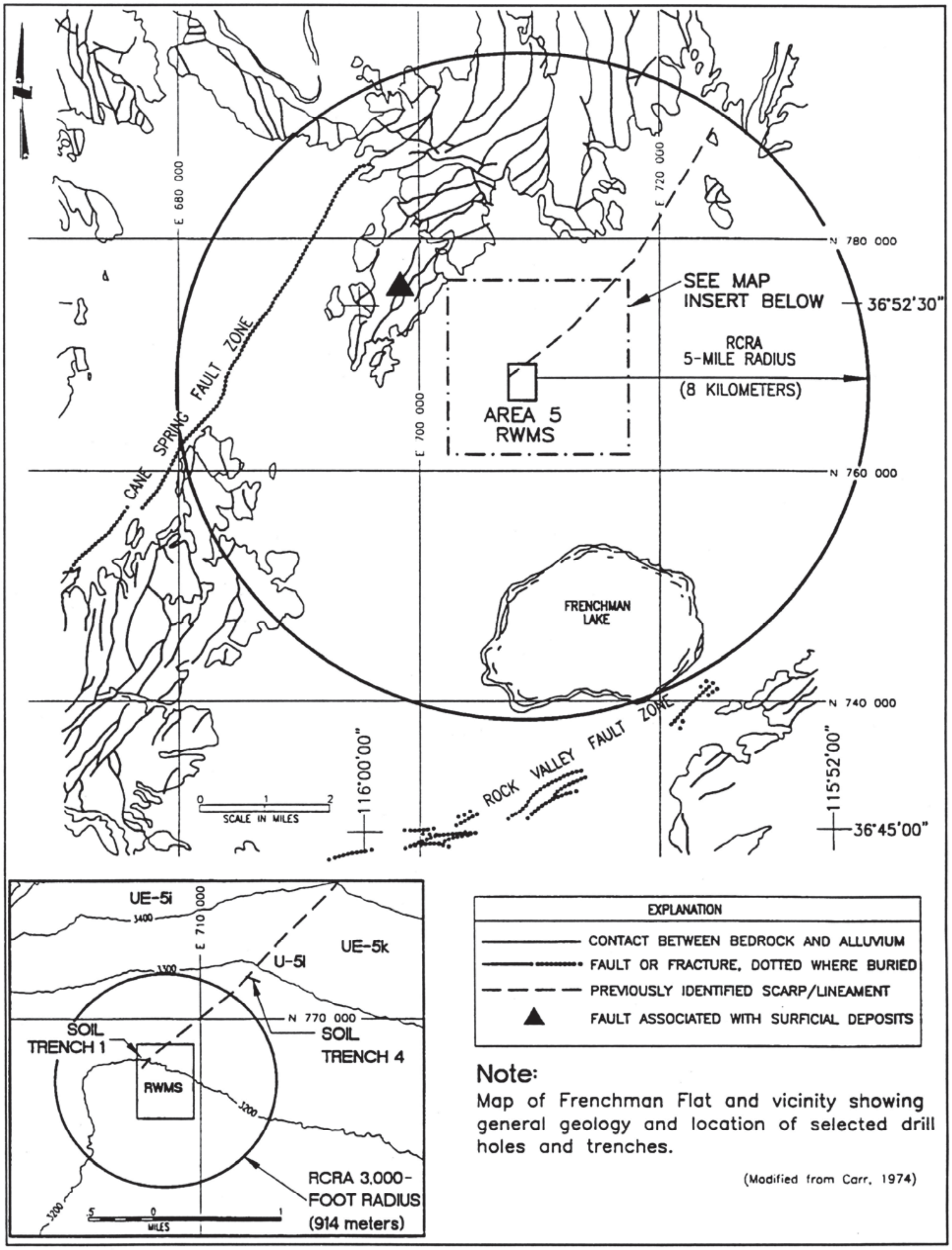


**Map of Structural Pattern**

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**Figure 8. 100-Year Flood Zone Delineation**

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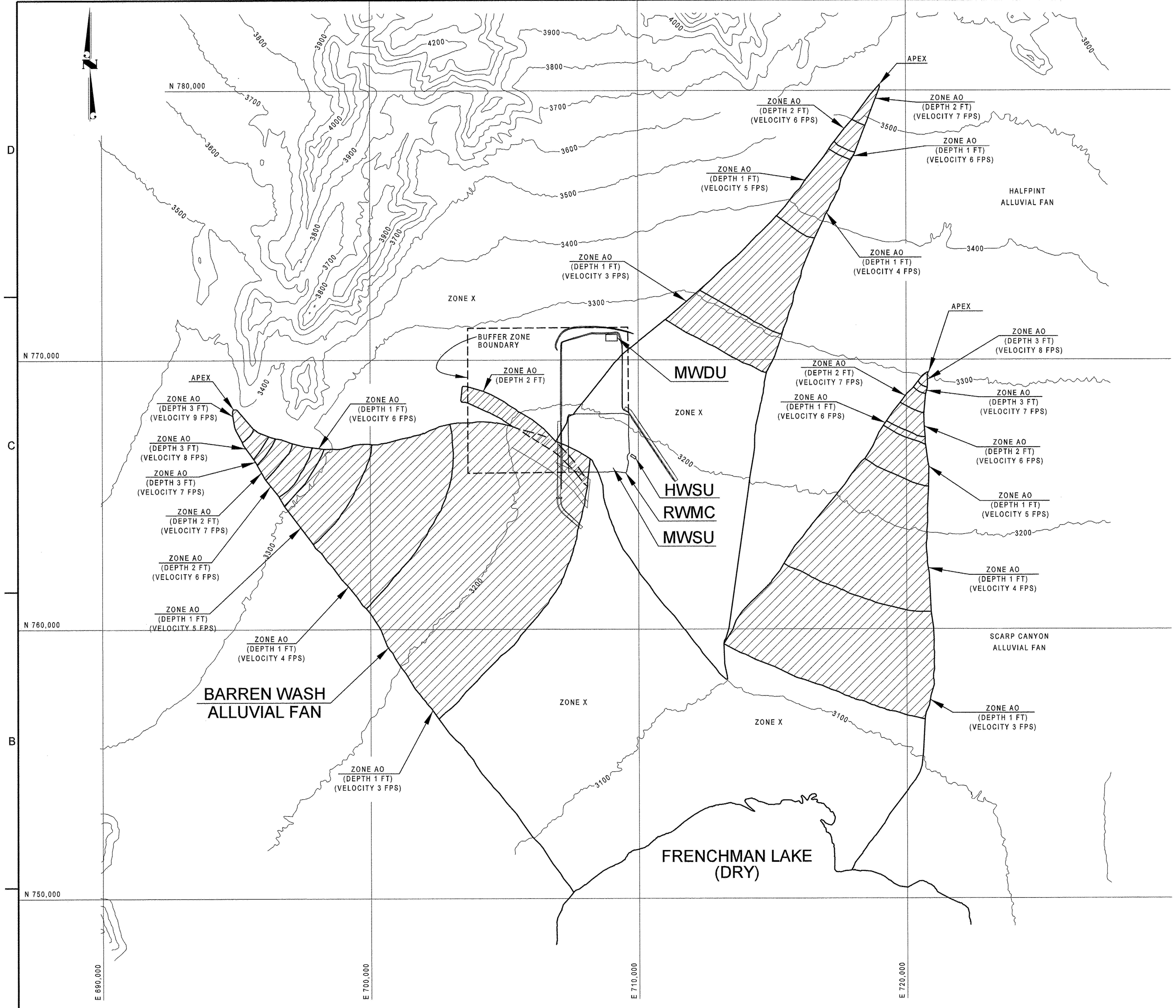


## LEGEND

| | |
|---|---|
| (solid line) | ALLUVIAL FAN BOUNDARY |
| (solid line) | BOUNDARY OF RADIOACTIVE WASTE MANAGEMENT COMPLEX (RWMC) |
| (dashed line) | BOUNDARY OF AREA PROPOSED FOR RWMC EXPANSION |
| (open box) | 100-YEAR FLOOD ZONE OF SHALLOW CONCENTRATED FLOW |
| (hatched box) | AREA OF ALLUVIAL FAN 100-YEAR FLOOD ZONE |
| ZONE AO (DEPTH 2 FT) | SHALLOW CONCENTRATED FLOW 100-YEAR FLOOD ZONE DESIGNATION: FEMA FLOOD ZONE THAT CORRESPONDS TO AREAS OF 100-YEAR SHALLOW FLOODING WHERE AVERAGE DEPTHS ARE BETWEEN 1 AND 3 FEET (0.30M AND 0.91M). |
| ZONE AO (DEPTH 2 FT) (VELOCITY 5 FPS) | ALLUVIAL FAN 100-YEAR FLOOD ZONE DESIGNATION: FEMA FLOOD ZONE THAT CORRESPONDS TO AREAS OF 100-YEAR SHALLOW FLOODING WHERE AVERAGE DEPTHS ARE BETWEEN 1 AND 3 FEET (0.30M AND 0.91M). ANYWHERE THROUGHOUT THE ZONE THERE IS AN EQUALLY LIKELY CHANCE THAT A CHANNEL CAN OCCUR OF THE DESIGNATED DEPTH WITH A FLOW OF THE DESIGNATED VELOCITY. |
| ZONE X | FEMA FLOOD ZONE THAT CORRESPONDS TO AREAS OUTSIDE THE 100-YEAR FLOOD HAZARD AND TO AREAS OF 100 YEAR SHEETFLOW FLOODING WHERE AVERAGE DEPTHS ARE LESS THAN 1 FOOT (0.30M). |

100-YEAR FLOOD ZONE DELINEATION

SCALE : 1" = 2000'

GRAPHIC SCALE

0 1000 2000 4000 6000 FEET

1" = 2000'

GS

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA FIELD OFFICE LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 05A
RWMC UTILITY INFRASTRUCTURE

# 100-YEAR FLOOD ZONE DELINEATION

| DRAWN | PREPARER | CHECKER | PROJECT ENGINEER | APPROVER / USER |
|---|---|---|---|---|
| S. [signature] 4-21-15 | [signature] 4/21/15 | N/A | [signature] 4/21/15 | N/A |

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ENGINEERING NO. 01327
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER: SK-01327-C-1004
REVISION 0

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# EXHIBIT 7. Flood Assessment at the Area 5 Radioactive Waste Management Site DOE/Nevada Test Site, Nye County, Nevada

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# FLOOD ASSESSMENT AT THE
# AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE
## DOE/Nevada Test Site, Nye County, Nevada

Prepared by Raytheon Services Nevada
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For the United States Department of Energy
Nevada Operations Office
Office of Assistant Manager for Environmental
Restoration and Waste Management
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Under Raytheon Services Nevada
Contract DE-AC08-91NV10833

## FLOOD ASSESSMENT

### EXECUTIVE SUMMARY

A flood assessment at the Radioactive Waste Management Site (RWMS) and the Hazardous Waste Storage Unit (HWSU) in Area 5 of the Nevada Test Site (NTS) was performed to determine the 100-year flood hazard at these facilities. No previous flood studies of these facilities delineated the 100-year flood hazard. This current study was conducted to determine whether the RWMS and HWSU are located within a 100-year flood hazard as defined by the Federal Emergency Management Agency (FEMA), and to provide discharges for the design of flood protection.

The overall watershed which could impact the RWMS and HWSU is approximately 140-square miles. This watershed was divided into 16 subbasins to best represent the hydrology of the study area. United States Geologic Survey (USGS) topographic maps were used to divide the drainage area into subbasins ranging in size from 0.3-square miles to 81.3-square miles. Barren Wash, Scarp Canyon, and Halfpint alluvial fans were delineated. These fans are characterized by incised channels in the upper parts of the fans decreasing to sheetflow in lower parts of the fan.

The 2-year, 10-year, and 100-year discharges were determined using methods and guidelines provided in the Clark County Regional Flood Control District (CCRFCD) *Hydrologic Criteria and Drainage Manual, 1990*. The methodology in the CCRFCD Manual was developed specifically for Southern Nevada by Clark County and the U.S. Army Corps of Engineers, Los Angeles District, and is the most current and region-specific approach to develop discharges. Flood studies conducted in Clark County following the methods provided in the CCRFCD Manual have been accepted by FEMA. The proximity of Area 5 to Clark County and their similar physical and climatic characteristics support the use of this region-specific method as the means of generating discharges for the study area.

As directed in CCRFCD Manual, the HEC-1 rainfall-runoff model developed by the U.S. Army Corps of Engineers was used to generate discharges for the RWMS and HWSU areas. Hydrologic models were developed for the 2-year, 10-year, and 100-year discharges. Point precipitation values used in this model were taken from NOAA Atlas 2, Volume VII. Field observations were made to determine the vegetation type and cover density, Manning roughness coefficient, slope, channel geometry, and concentration point locations. From this information, curve numbers (a method to quantify precipitation losses) and lag times for each of the subbasins were determined, routing parameters were applied, and discharges were calculated. Discharges developed in this hydrologic analysis were used in the subsequent analysis to define the 100-year flood hazard.

The 100-year flood hazard for the Barren Wash, Scarp Canyon, and Halfpint alluvial fans was analyzed using FAN, a computer program developed by FEMA. This program was used to delineate the flood hazard zones on these alluvial fans in accordance with FEMA methodology. The FAN model requires information regarding apex location, fan boundaries, potential flow obstructions and diversions, fan surface slopes, Manning roughness coefficients, single-channel versus multiple-channel regions, and the 2-year, 10-year, and 100-year discharges from the hydrologic analysis. This information was gathered from studies of available topographic and surficial geologic maps and intensive field investigations. The results of the alluvial fan analyses are shown on the maps included in this document.

Part of the RWMS is located within the 100-year flood hazard on the Barren Wash Alluvial Fan. The southwest corner of the RWMS is within the Zone AO of the Barren Wash Alluvial Fan. (This part of the RWMS does not include RCRA units covered in the NTS RCRA Part B Permit Application.) FEMA designates alluvial fan flooding, shallow concentrated flow, and sheetflow areas with 100-year flood depths between 1 and 3 feet as Zone AO. FEMA further designates an associated flow velocity for alluvial fan flood hazards.

The HEC-2 model developed by the U.S. Army Corps of Engineers to determine water surface elevations in channels was used to assess the flood hazard of shallow concentrated flow in a channel impacting the southwest corner of the RWMS. This analysis determined that flows exceed a depth of 1 foot along the southwest corner of the RWMS, which places this part of the RWMS in the AO zone.

For the remaining subbasins that could impact the RWMS and HWSU, flood hazard determinations were conducted assuming sheetflow conditions. This analysis, using FEMA methodology for sheetflow, concluded that depths of flow during the 100-year flow event were less than 1 foot. Thus, the RWMS and the HWSU are not in a 100-year flood hazard as defined by FEMA.

Although the RWMS and HWSU facilities that are included in the RCRA Part B Permit Application are not within a 100-year flood hazard per FEMA definition (100-year flood depth at or greater than 1 foot), flow from a 100-year event could impact the facilities. Flood protection requirements are being evaluated.

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# 1.0 INTRODUCTION

## 1.1 Location

A flood assessment was conducted at the Radioactive Waste Management Site (RWMS) and the Hazardous Waste Storage Unit (HWSU) in Area 5 of the Nevada Test Site (NTS) in Nye County, Nevada (Figure 1). In this report, the RWMS includes the Transuranic (TRU) Radioactive pad, Mixed-Waste Disposal Unit, and Pit 3 within the RWMS. The study area encompasses portions of the Massachusetts Mountains, the Halfpint Range, and the drainages of Barren Wash and Scarp Canyon.

## 1.2 Purpose

Flood assessment is one of the subtasks related to surficial geology studies at and near the RWMS. Surficial geology studies respond primarily to requirements and guidelines for site characterization found in federal regulations. The principal federal regulations and criteria pertaining to flooding with which the RWMS must comply are:

- Executive Order 11988 (*Floodplain Management*),
- 10 CFR 61.50 (*Technical Requirements for Land Disposal Facilities*),
- 40 CFR 264.18 (*Location Standards for Hazardous Waste Management Facility*),
- 40 CFR 270.14 (*General Requirements for a Hazardous Waste Facility*), and
- Department of Energy (DOE)/Nevada-341, *Environmental Compliance Handbook, September 1990.*

The RWMS must also comply with Nevada Administrative Code 444.8456 (*Restrictions on Locations of Stationary Facilities for Management of Hazardous Waste; Exceptions*). These regulations prohibit the placement of a hazardous waste facility in a 100-year floodplain. This subtask focuses on the potential 100-year flood hazard on the RWMS. Although the flood assessment subtask does not evaluate the erosion hazard over a geologic time scale (10,000 years), as required under 40 CFR 191.13 (*Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Waste; Final Rule*), other subtasks are being conducted to gather information regarding erosion on the RWMS. These subtasks include detailed trench and surface mapping, alluvial structure, and seismic fault definitions.

## 1.3 Objective

The objective of this flood assessment was to determine the 100-year flood hazard on and near the Area 5 RWMS using the most site-specific and applicable approaches for the hydrologic and hydraulic analyses. This flood assessment was conducted to provide hydrologic and hydraulic information for flood protection design and to follow the criteria for flood hazard determination required by the Federal Emergency Management Agency (FEMA), as specified in 40 CFR 270.14.

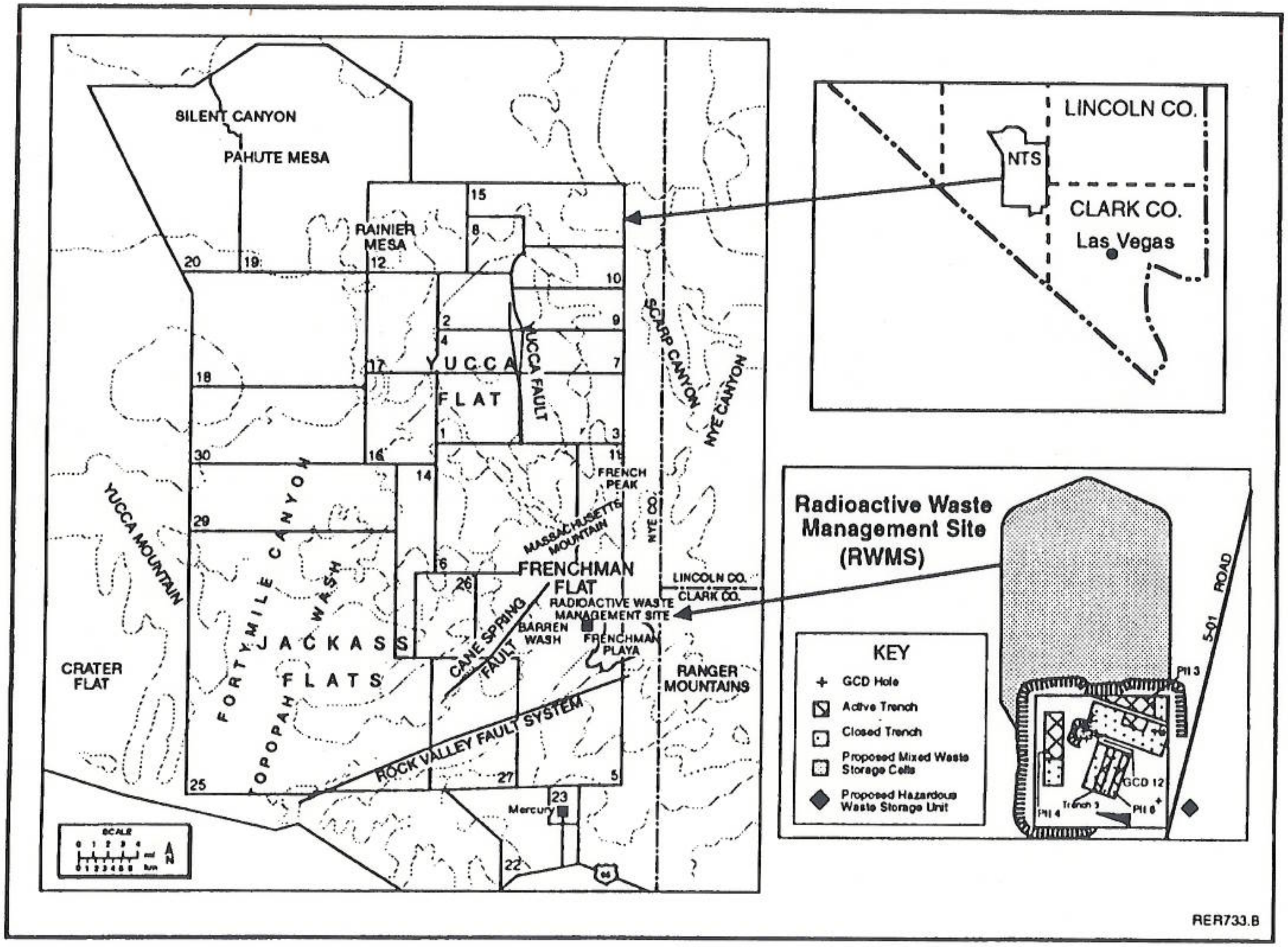



Figure 1. Location Map and Physiographic Features of the Nevada Test Site and the Area 5 Radioactive Waste Management Site

### 1.4 Previous Studies

Case *et al.*, (1984), French and Lombardo (1984), and Cox (1986) discussed the potential for flooding at the Area 5 RWMS. Raytheon Services Nevada (1991) reported results of a limited study on surface water at and near the RWMS using methods discussed in these previous studies. These studies used regional flow equations that were developed in the late 1970's and early 1980's. At the time of these studies, the Clark County Regional Flood Control District Manual (CCRFCD Manual) had not yet been completed and the regional equations were the best method available. Methodology in the CCRFCD Manual is now the accepted method in Clark County. The proximity of Area 5 to Clark County and their similar physical and climatic characteristics support the use of this region-specific method as the means of generating discharges for the study area. Also since these studies, FEMA has adopted a methodology to evaluate flood hazards on alluvial fans. For these reasons, a more detailed flood assessment was required using the most updated information and methods.

## 2.0 WATERSHED DESCRIPTION

### 2.1 Introduction

The 140-square-mile watershed that could impact the RWMS and HWSU was divided into 16 subbasins (Figures 2 and 3). (For more detailed watershed maps, see Sheets 1 and 2.) Concentration points for the flow from the 16 delineated subbasins were chosen to best represent the hydrology of the study area. The apexes of Barren Wash, Scarp Canyon, and Halfpint alluvial fans represent three of these concentration points. The other concentration points were difficult to define because they represented the confluence of large areas of shallow concentrated flow and/or sheetflow that could impact the RWMS. Concentration point locations were based on aerial photographs, topographic data, and field observations.

### 2.2 Apex Definitions

In this study, both a geologic definition and a FEMA definition for the apex of an alluvial fan are described. The geologic apex of an alluvial fan is the intersection of the mountain front and the piedmont plain (Figure 4). On many alluvial fans, a channel is entrenched into the upper, and possibly the middle part of the fan (Bull, 1964). Fans with entrenched channels have the active apex farther down the fan. FEMA defines the apex as the point below which the flowpath of the major stream that formed the fan becomes unpredictable and flooding of the fan can occur (FEMA, 1991). The FEMA definition was used in this study to determine the concentration points of flow at the active apex of the three alluvial fans within the study area: Barren Wash, Scarp Canyon, and Halfpint alluvial fans (see *Figure 3* and *Sheet* 2) for locations of these apexes).

### 2.3 Barren Wash Alluvial Fan

The Barren Wash watershed covers 81.3-square miles and is located northwest of the RWMS (*Figure 2* and *Sheet 1*). The wash drains to Frenchman Flat from an area that is bordered to the east by the Massachusetts Mountains, to the north by the CP Hogback, and to the west by the CP Hills. The watershed has been divided into two separate subbasins: Barren Wash 1 (BW1, 60.5-square miles) and Barren Wash 2 (BW2, 20.8-square miles).

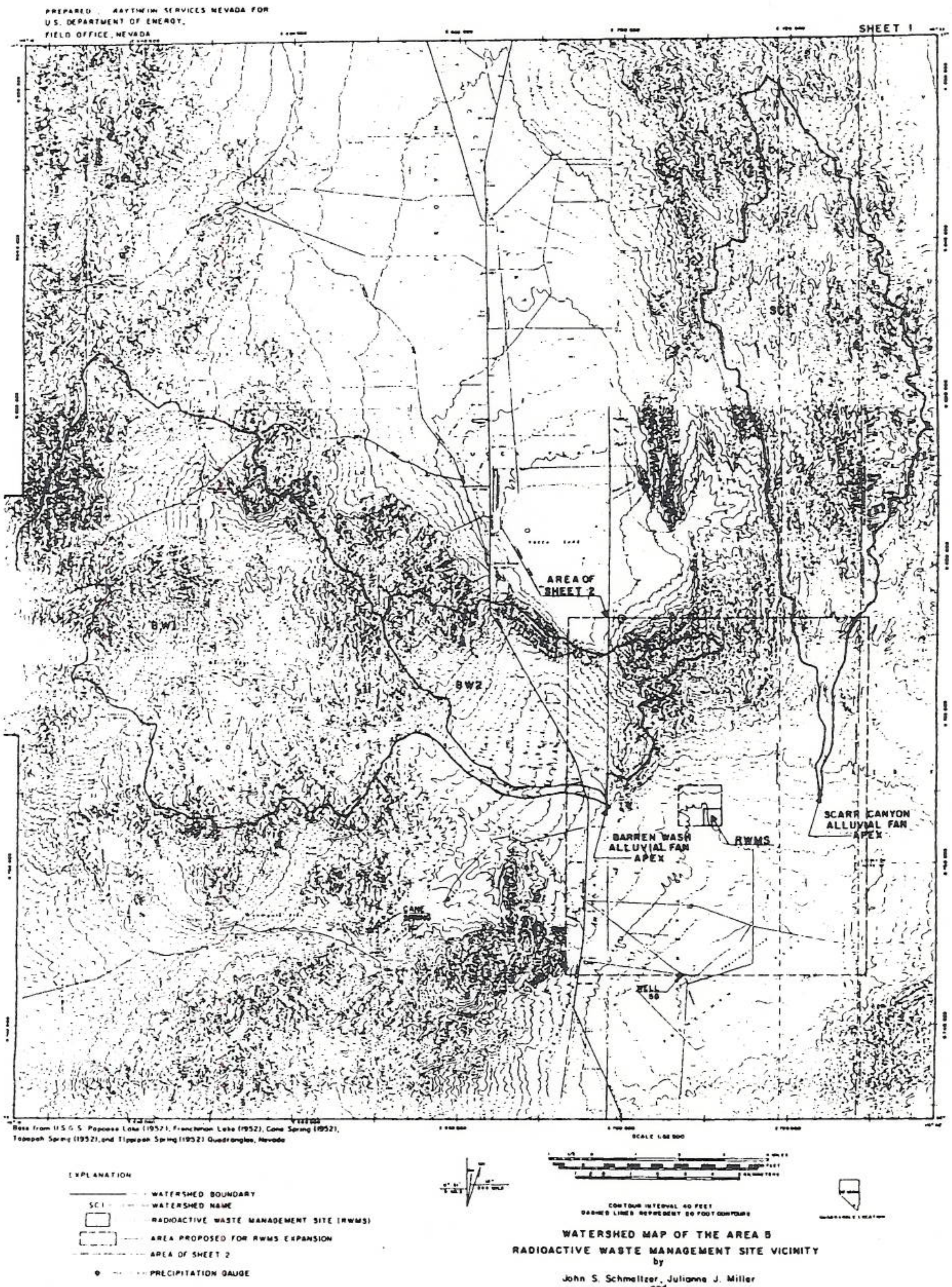



**Figure 2. Watershed Map of the Area 5 Radioactive Waste Management Site Vicinity (Sheet 1).** The overall watershed is divided into 16 subbasins; 13 are shown here, with the remainder shown on Figure 3 (Sheet 2).

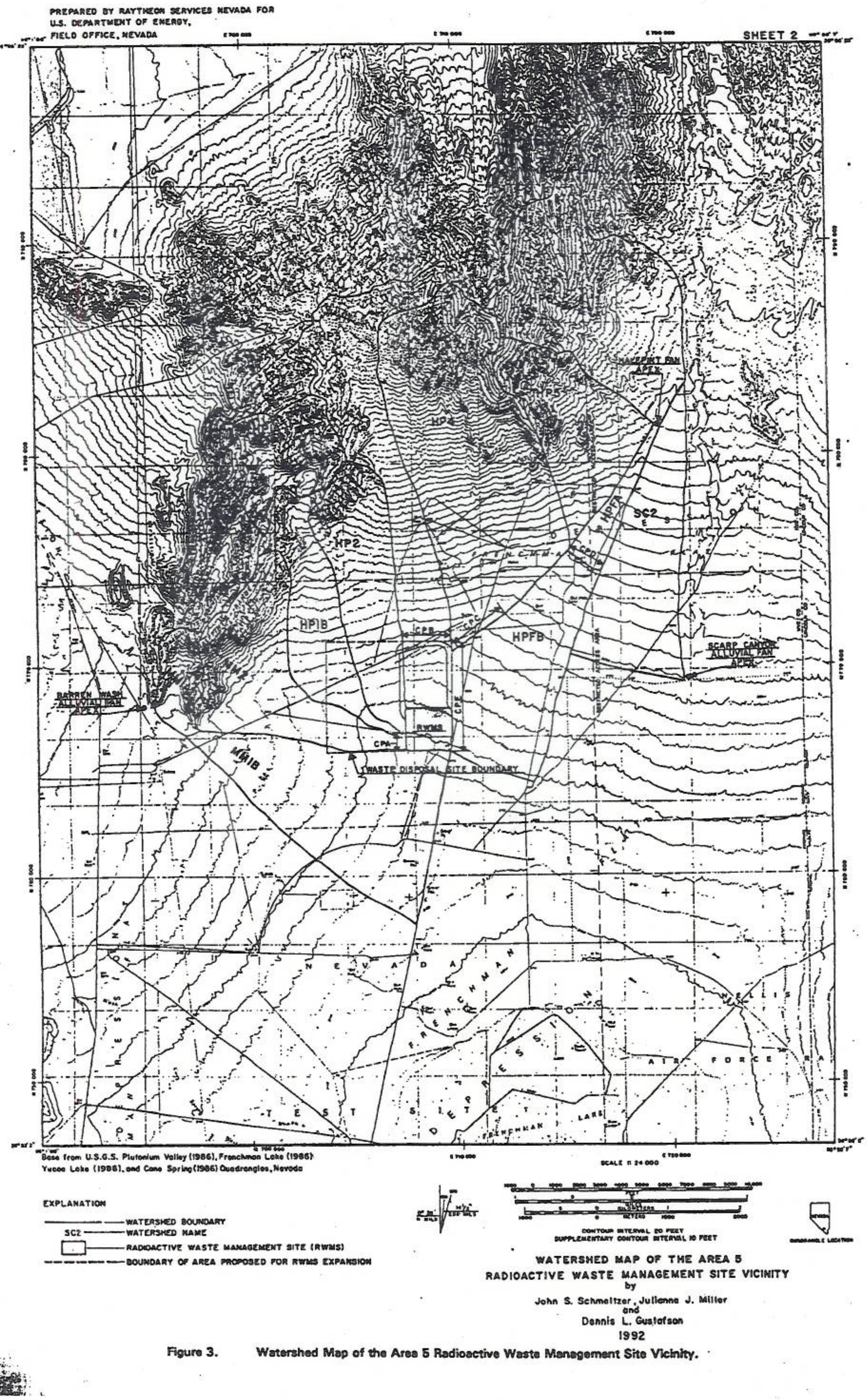



Figure 3. Watershed Map of the Area 5 Radioactive Waste Management Site Vicinity.

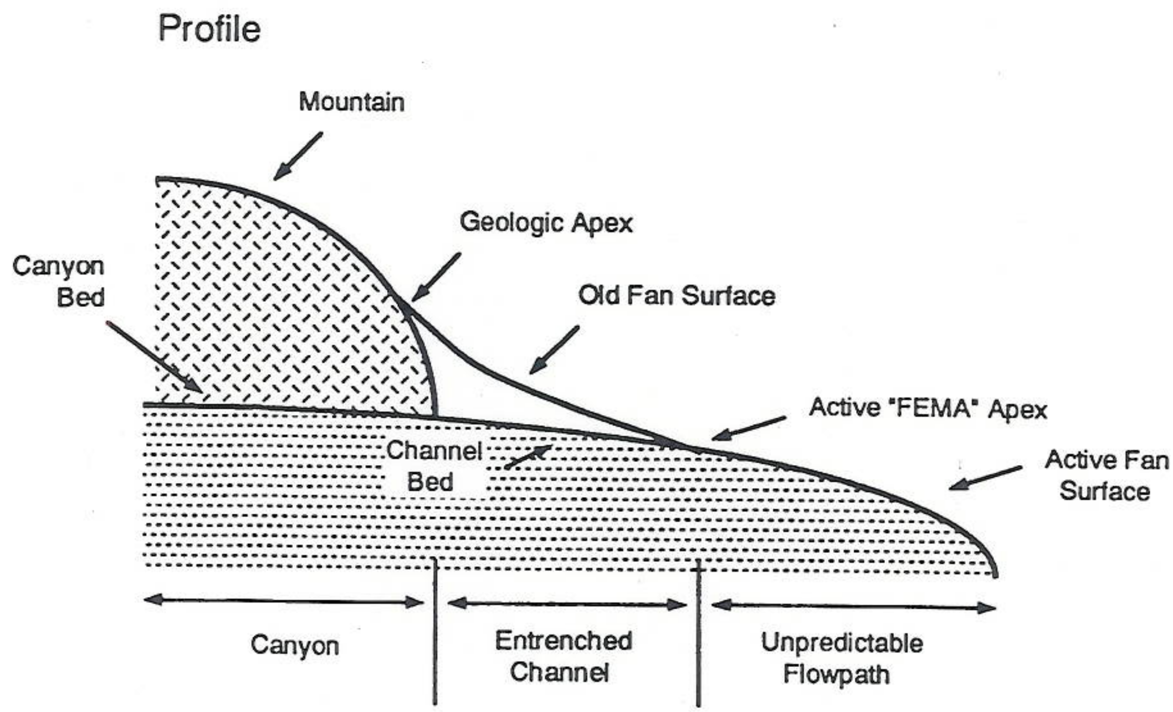



**Figure 4. Idealized Alluvial Fan Profile.** The geologic apex is the intersection of the mountain front and the piedmont plain. The active "FEMA" apex is the point below which the flow of the main channel becomes unpredictable.

The Barren Wash Alluvial Fan is the dominant landform in the watershed. The proximal part of the fan (the area on the alluvial fan near the apex) is deeply entrenched by a stream channel. Significant parts of the fan surface are covered by desert pavement with desert varnish, and vegetation covers 15 to 25 percent of the surface. Erosion is the primary geomorphological process occurring on the proximal part of the fan, as shown by scalloping of the fanhead trench.

Continued trench incision has shifted deposition to a distal part of the fan (the outermost area, or lower zone of the fan). The Barren Wash channel captures the channel draining from the Massachusetts Mountains 1A (MM1A) subbasin at the southwestern corner of the Massachusetts Mountains (*Figure 3* and *Sheet 2*). At this point a new, secondary fan is being formed which extends east toward the RWMS and south to Frenchman Flat. The RWMS is located on the lower-mid part of this secondary fan.

### 2.4 Scarp Canyon Alluvial Fan

The Scarp Canyon watershed, located northeast and east of the RWMS, covers about 40.9-square miles (*Figure 2* and *Sheet 1*). This watershed drains onto Scarp Canyon Alluvial Fan from an area that extends north to Carbonate Ridge (French and Lombardo, 1984), west to the Massachusetts Mountains, and east to Raysonde Butte. The watershed is divided into two subbasins: Scarp Canyon 1 (SC1, 39.4-square miles), the drainage area above the active apex; and Scarp Canyon 2 (SC2, 1.5-square miles), the area between the channel that drains SC1 and the eastern boundary of Halfpint Alluvial Fan (*Figure 3* and *Sheet 2*).

A large fanhead trench, ranging to a depth of 40 feet, cuts through a thin layer of alluvium and bedrock above the active apex. Below the active apex, the channel cuts through unconsolidated and calcrete-cemented alluvium. Parts of the fan surface are covered by desert pavement with desert varnish. Vegetation density is 15 to 25 percent over the fan surface.

The channel within the trench of Scarp Canyon is braided. Relatively flat interchannel bars and side terraces are approximately 1 to 5 feet above the streambeds, and covered by fine-grained sediment. High-water indicators are present on the bars and terraces several feet above the streambed. These indicators include large clasts and boulders, small logs and sticks, and uprooted Joshua trees found snagged in the vegetation. The vegetation also shows signs of being washed over by water. Concurrence of the high-water indicators with the fine-grained deposits suggests that these deposits are fluvial rather than eolian.

### 2.5 Halfpint Alluvial Fan

Halfpint Alluvial Fan, located northeast of the RWMS, develops from a channel that collects flow from the drainage area (HP6, 2.2-square miles) along the eastern front of the Halfpint Range (*Figure 3* and *Sheet 2*). The alluvial fan is divided into two separate subbasins: Halfpint Fan A (HPFA, 0.26-square miles) and Halfpint Fan B (HPFB, 1.61-square miles).

The channel located above the apex of the Halfpint Alluvial Fan is incised 2 to 3 feet in depth. The apex of the fan was located where the flowpath of the channel becomes unpredictable. Below the apex, a very braided channel system has developed. Relatively little desert pavement or desert varnish is found on this fan surface; vegetation cover density is approximately 20 percent. The RWMS is located in the lower-mid part of this fan.

### 2.6 Massachusetts Mountains/Halfpint Range Subbasins

The 13.6-square-mile watershed that drains from the Massachusetts Mountains/Halfpint Range toward the RWMS was divided into nine subbasins (*Figure 3* and *Sheet* 2). These subbasins include MM1A, MM1B, MM2, HP1A, HP1B, HP2, HP3, HP4, and HP5. The upper parts of these subbasins are located in bedrock consisting of several different tuffs. From a geomorphic viewpoint, the drainages in the lower regions extending into Frenchman Flat form coalescing alluvial fans along the mountain front. From a hydraulic engineering viewpoint, the flow system on these landforms are distributary-flow systems. Hjalmerson (1992) states that the ". . . major physiographic characteristics used to identify and categorize distributary-flow areas . . . include (1) vegetation density and soil color, (2) drainage texture, and (3) the random nature of channel links."

The proximal parts of these coalescing alluvial fans (geomorphic viewpoint) are characterized by channels incised 5 to 10 feet across the surface. Vegetation density on the fan surface is 20 to 35 percent. Undisturbed deposits covered by desert pavement with desert varnish are present.

Channel incisions, averaging 1 to 3 feet, decrease near the middle part of the fan. Debris flow deposits from the HP1A and HP1B subbasins in part compose the coalescing alluvial fans (geomorphic viewpoint). Channel depths decrease down gradient until sheetflow occurs.

Sheetflow, typical of areas of low relief and poorly established drainage systems, occurs on the distal parts of the coalescing alluvial fans (geomorphic viewpoint). The RWMS is located in the lower-mid parts of these coalescing alluvial fans where channel depths average less than 1 foot. Vegetation covers 20 to 30 percent of the fan surface. There are relatively few undisturbed areas of relic deposits covered by desert pavement with desert varnish.

## 3.0 HYDROLOGY

### 3.1 Methodology

Standard statistical methods to determine flood discharges for a specific return period are not applicable to a majority of the watersheds in the arid Southwest because most of the watersheds in this region are ungaged and do not have stream discharge information. Furthermore, arid watersheds that do have discharge data usually have a short period of record with many years of no flow. A study conducted by Hjalmarson and Thomas (1992) found that 20 years is the average recording period for stream gages located in Nevada, western Utah, western Arizona, and southeastern California.

In the arid Southwest, rainfall-runoff models are often used to estimate flood discharges. In this flood assessment, rainfall-runoff models were developed using the HEC-1 computer program developed by the U.S. Army Corps of Engineers (COE) (1990). The CCRFCD Manual lists the HEC-1 computer program as an acceptable tool to estimate discharges and to generate hydrographs for watersheds within Clark County. Methods in the CCRFCD Manual were used to produce the input parameters required for the HEC-1 computer program. Other jurisdictions in the arid Southwest, such as Maricopa County (central Arizona), Pima County (southern Arizona), and San Bernardino County (southern California), use similar approaches to estimate flood discharges.

The hydrologic approach described in the CCRFCD Manual was developed for Clark County from studies conducted by WRC Engineering and the COE. The methods described in the CCRFCD Manual were considered the best approach for estimating discharges for the flood assessment of the RWMS and vicinity for these reasons:

a. The physical setting and flood-producing storms for the RWMS and vicinity are similar to those of Clark County;

b. The eastern boundary of the study area is adjacent to the Clark County line;

c. Local and federal agencies (e.g., FEMA) accept the methods in the CCRFCD Manual; and,

d. Clark County is the nearest local jurisdiction with a hydrologic method based on region-specific information.

The Soil Conservation Service (SCS) unit hydrograph option in the HEC-1 computer program was used in the hydrologic models. The SCS unit hydrograph is widely used in rainfall-runoff models and is recommended as an option in the CCRFCD Manual. The input parameters required to run the HEC-1 computer model using the SCS unit hydrograph option are:

- precipitation parameters (depth of precipitation, storm duration and time distribution, and depth-area ratios);
- drainage area (total drainage area and subbasins);
- precipitation losses (curve numbers);
- lag time for each basin; and,
- channel routing parameters.

The procedure used to obtain these parameters generally followed the methods described in the CCRFCD Manual. The following sections provide an overview of how these parameters were determined and substantiate any deviations from the methods provided in the CCRFCD Manual. A detailed description of how these parameters are determined is in the CCRFCD Manual.

### 3.1.1 *Precipitation*

Rainfall events that cause flooding on the NTS and in southern Nevada are usually convectional storms. According to Christenson and Spahr (1980), the probable flood-generating storm in the NTS area would be from summer convectional storms. These flood-producing storms are normally characterized as short-duration (6 hours or less), high-intensity storms over a localized area. Methods regarding precipitation parameters in the CCRFCD Manual assume that summer convectional storms are the likely precipitation event to produce flooding in Clark County. In an analysis of precipitation records for southern Nevada, WRC Engineering and the COE determined that a 6-hour rainfall should be the design storm. A 6-hour mass curve (intensity of rainfall per 15-minute intervals over the 6-hour design storm) was developed and a relationship between precipitation depth and storm size (depth-area ratios) was determined. These parameters are discussed below in more detail.

### a. Point Precipitation Values

As specified in the CCRFCD Manual, the design depths of precipitation for the 6-hour storm were taken from NOAA Atlas 2, Volume VII (1973) and are listed in Table 1.

**Table 1. Six-Hour Storm Point Precipitation Values and Correction Factors (CCRFCD Manual, 1990).** Correction factors used to adjust precipitation values for design depths of precipitation for the six-hour storm.

| | NOAA Values (inches) | Correction Factor | Corrected Point Rainfall (inches) |
|---|---|---|---|
| 2-Year, 6-Hour | 0.70 | 1.00 | 0.70 |
| 10-Year, 6-Hour | 1.10 | 1.24 | 1.36 |
| 100-Year, 6-Hour | 1.60 | 1.43 | 2.43 |

The 100-year, 6-hour point precipitation value of 1.6-inches (NOAA Atlas 2, Volume VII, 1973) compares well with the 1.8-inch value generated from a figure developed by French (1983) for the Cane Springs precipitation gauge (Figure 5). A preliminary value of 2.6-inches for the 100-year, 24-hour storm taken from a statistical analysis of the rainfall data at Well 5b (*Figure 5*) by Reynolds Electrical & Engineering Co., Inc., (personal communication, Barker, 1992) compares well with the value listed in NOAA Atlas 2, Volume VII (1973). Locations of these gauges are shown on *Figure 3* and *Sheet 1*.

The CCRFCD Manual requires that the point precipitation values listed in NOAA Atlas 2, Volume VII (1973) be used to determine point precipitation; however, the CCRFCD Manual specifies that rainfall events above the 2-year storm be adjusted. *Table 1* shows the correction factors listed in the CCRFCD Manual. These correction factors were identified from studies conducted by WRC Engineering and COE for Clark County (CCRFCD Manual, 1990) based on available rainfall data, primarily from the Las Vegas Valley; these factors may not be applicable for the RWMS study area.

French (1983) hypothesized that the southern part of Nevada can be divided into three precipitation zones: an excess zone, a transition zone, and a deficient zone (Figure 6). French (1983) indicates that the Las Vegas Valley is located in the excess zone, and the NTS is located in the transition zone. He further hypothesizes that the excess zone is a result of storms tracking up the Colorado River Valley, and the influence of the river on precipitation values lessens with distance away from the Colorado River Valley. The precipitation analysis by French (1983) and Barker (1992) support this hypothesis and suggest that the noncorrected precipitation values for the RWMS study area are more applicable than using the precipitation correction factors specified in the CCRFCD Manual. Hydrologic models in this flood assessment used the nonadjusted values in NOAA Atlas 2, Volume VII (1973); however, a discharge model was developed using the adjustment factors specified in the CCRFCD Manual to compare with the hydrologic models developed without the adjustment factors. The results of this comparison are discussed in Section 3.4, *Hydrology Discussion*.

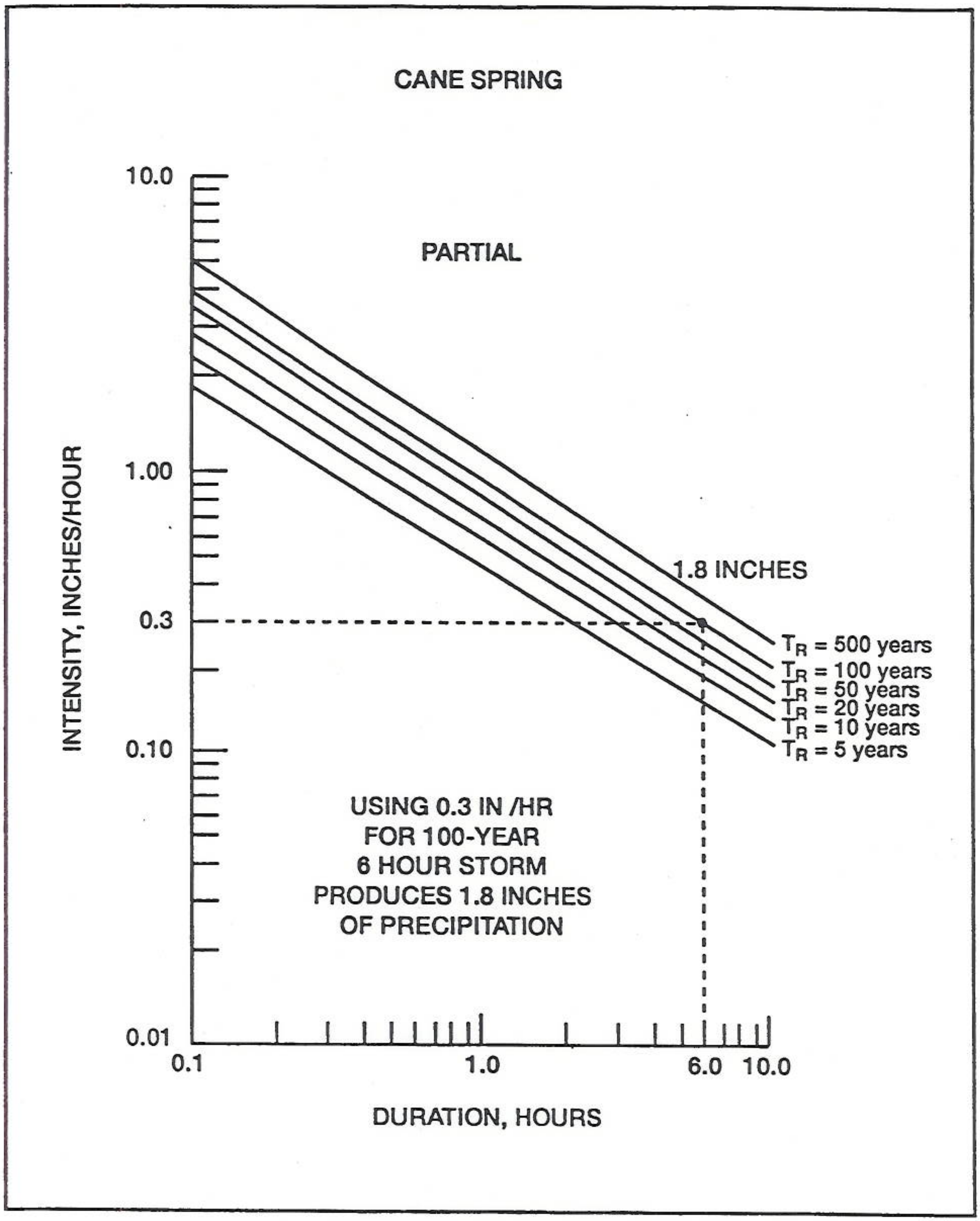



**Figure 5. Intensity Duration Relationships for Various Return Periods, Cane Springs, Nevada Test Site, Nevada (modified from French, 1983).** The 100-year, 6-hour point precipitation value of 1.6 inches compares well with the value from French, 1983.

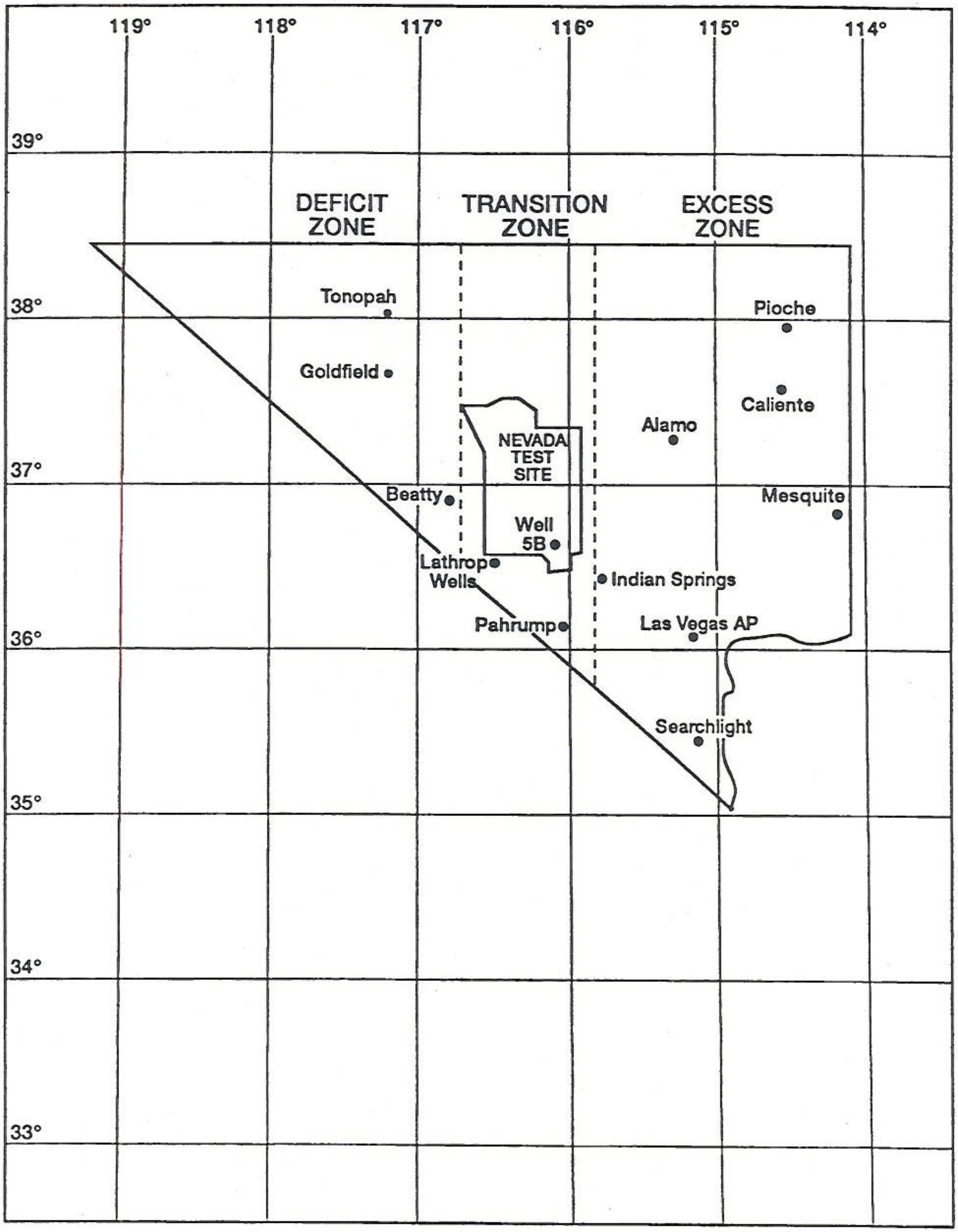



**Figure 6. Hypothesized Zones of Precipitation in Southern Nevada (modified from French, 1983).** The NTS is located in the transition zone of precipitation.

### b. Storm Duration and Time Distribution

Clark County has adopted two 6-hour storm distribution tables to be used to generate discharges (CCRFCD Manual, 1990). The two storm distributions defined in this manual are for areas less than or larger than 10 square miles. These storm distributions were used for the subbasins in the hydrologic models for the RWMS. A mass curve of the two storm distributions is shown in Figure 7.

### c. Depth-Area Ratios

During a flood-producing storm, usually a convectional storm in this region, point precipitation values probably would not apply to an entire drainage basin. Depth-area ratios have been developed for arid regions which reduce the point precipitation value for a watershed as a function of area. Clark County uses the depth-area ratios that were developed by the COE for Clark County and vicinity (Table 2). These depth-area ratios are a modification of ratios developed by Zehr (1984) on arid watersheds in Arizona and New Mexico. Ratios in the CCRFCD Manual were used in the hydrologic model for the RWMS.

### 3.1.2 *Drainage Areas*

The area of each drainage basin defined in the hydrologic model was delineated using 7.5- and 15-minute United States Geological Survey (USGS) topographic quadrangle maps of the area (*Figures* 2 and *3*; *Sheets 1* and 2), along with 1:6,000 orthophotos with a 10-foot contour interval that were developed for the area. Basin delineations were verified by field observations and study of color and infrared aerial photos. The area of each subbasin was determined using a planimeter. The drainage area, and the other watershed parameters for each subbasin used in the HEC-1 model, are listed in Table 3. The USGS topographic maps used to define the drainage area are:

15-minute Topographic Quadrangles (USGS):

- Papoose Lake (1952)
- Frenchman Lake (1952)
- Cane Spring (1952)
- Topopah Spring (1952)
- Tippipah Spring (1952)

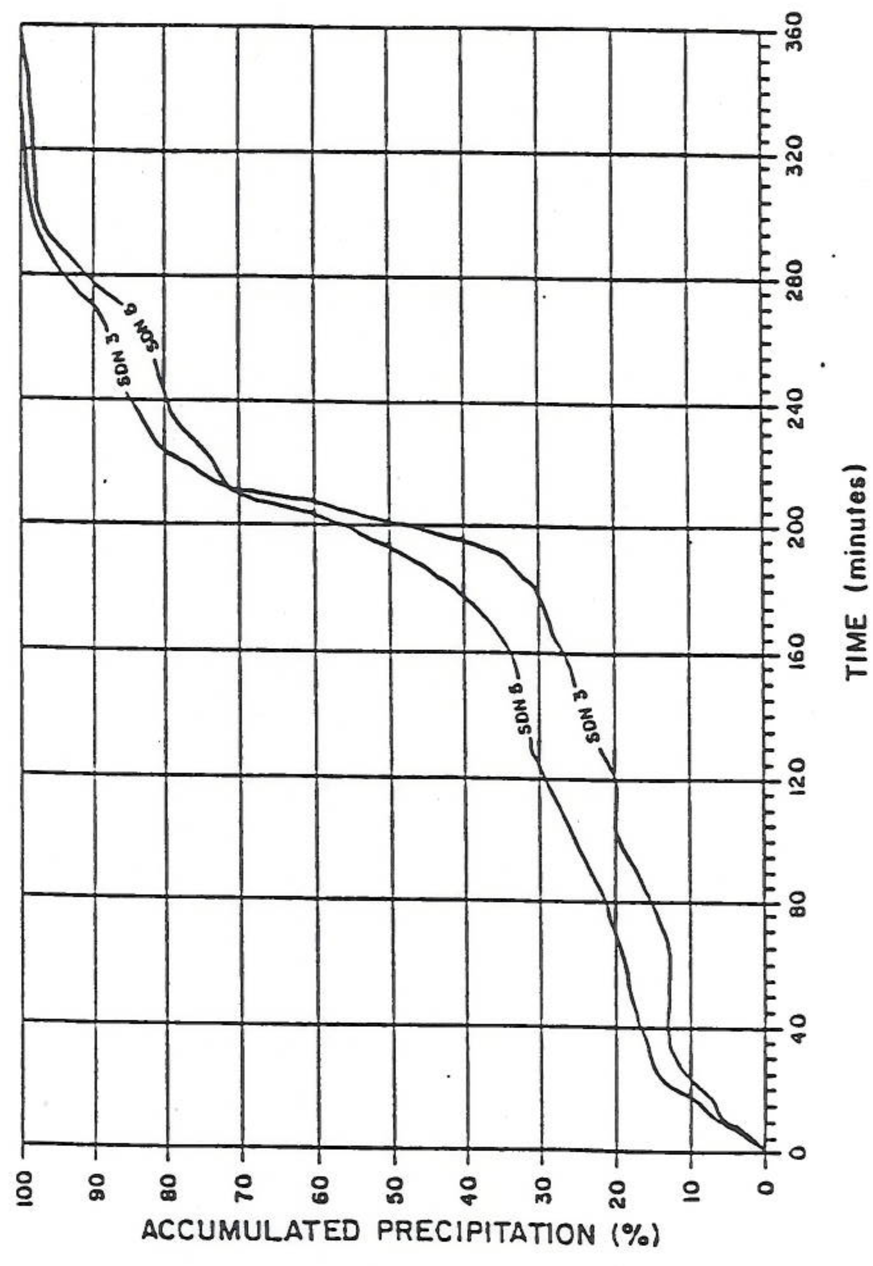
7.5-minute Topographic Quadrangles (USGS):

- Plutonium Valley (1986)
- Frenchman Lake (1986)
- Yucca Lake (1986)
- Cane Spring (1986)

### 3.1.3 *Precipitation Losses*

Precipitation losses were determined using the SCS curve number methodology and the applicable table (Table 4) found in the CCRFCD Manual. The following information is required to determine a curve number for a specific subbasin:

## SIX-HOUR DESIGN STORM DISTRIBUTIONS




Notes:

1. For drainage areas less than 10 square miles in size, use SDN 3.
2. For drainage areas equal to or greater than 10 square miles in size, use SDN 5.

**Figure 7. Storm Distributions (CCRFCD Manual, 1990 [reference USACE, Los Angeles District, 1988]).** Storm distribution curves are selected based on drainage basin size.

**Table 2.** **Six-Hour Precipitation Depth-Area Reduction Factors (CCRFCD Manual, 1990).** Depth-area ratios reduce the point precipitation value for a watershed as a function of area.

| Drainage Area ($mi^2$) | Reduction Factor | 100-Year (in.) | 10-Year (in.) | 2-Year (in.) |
|---|---|---|---|---|
| 0.01 | 1.00 | 2.43 | 1.36 | 0.70 |
| 1 | 0.97 | 2.36 | 1.32 | 0.68 |
| 10 | 0.86 | 2.09 | 1.17 | 0.60 |
| 20 | 0.79 | 1.92 | 1.07 | 0.55 |
| 30 | 0.74 | 1.80 | 1.01 | 0.52 |
| 50 | 0.68 | 1.65 | 0.92 | 0.48 |
| 100 | 0.60 | 1.46 | 0.82 | 0.42 |

**Table 3.** **Watershed Parameters.** Watershed parameters were delineated using topographic maps, aerial photos, and field investigations.

| Watershed Name | Basin Area ($mi^2$) | Curve Numbers: AMC I | Curve Numbers: AMC II | Curve Numbers: AMC III | Lag Time (hrs) |
|---|---|---|---|---|---|
| MM1A | 0.9 | 63 | 80 | 90 | 0.31 |
| BW1 | 60.5 | 67 | 83 | 93 | 2.10 |
| BW2 | 20.8 | 63 | 80 | 90 | 0.90 |
| MM1B | 2.1 | 59 | 77 | 87 | 0.48 |
| MM2 | 1.4 | 62 | 79 | 89 | 0.47 |
| HP1A | 0.8 | 70 | 85 | 95 | 0.48 |
| HP1B | 1.0 | 60 | 78 | 88 | 0.51 |
| HP2 | 1.2 | 60 | 78 | 88 | 0.51 |
| HP3 | 1.7 | 66 | 82 | 92 | 0.59 |
| HP4 | 3.3 | 62 | 79 | 89 | 0.52 |
| HP5 | 1.2 | 62 | 79 | 89 | 0.30 |
| HP6 | 2.2 | 63 | 80 | 90 | 0.55 |
| HPFA | 0.3 | 59 | 77 | 87 | 0.33 |
| HPFB | 1.6 | 59 | 77 | 87 | 0.44 |
| SC1 | 39.4 | 66 | 82 | 92 | 2.10 |
| SC2 | 1.5 | 59 | 77 | 87 | 0.48 |

**Table 4. Runoff Curve Numbers (Semiarid Rangelands[1]) [CCRFCD Drainage Manual, 1990 {reference SCS TR-55, USDA, June 1986}].** Hydrologic soil group, vegetation type, and percent of ground cover determine curve numbers.

| Cover Description | | Curve Numbers for Hydrologic Soil Group | | | |
|---|---|---|---|---|---|
| **Cover Type** | **Hydrologic Condition[2]** | **A[3]** | **B** | **C** | **D** |
| Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element | Poor | -- | 80 | 87 | 93 |
| | Fair | -- | 71 | 81 | 89 |
| | Good | -- | 62 | 74 | 85 |
| Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush | Poor | -- | 66 | 74 | 79 |
| | Fair | -- | 48 | 57 | 63 |
| | Good | -- | 30 | 41 | 48 |
| Pinyon-juniper—pinyon, juniper, or both; grass understory | Poor | -- | 75 | 85 | 89 |
| | Fair | -- | 58 | 73 | 80 |
| | Good | -- | 41 | 61 | 71 |
| Sagebrush with grass understory | Poor | -- | 67 | 80 | 85 |
| | Fair | -- | 51 | 63 | 70 |
| | Good | -- | 35 | 47 | 55 |
| Desert shrub—major plants include saltbush, greasewood, creosote bush, blackbrush, bursage, palo verde, mesquite, and cactus | Poor | 63 | 77 | 85 | 88 |
| | Fair | 55 | 72 | 81 | 86 |
| | Good | 49 | 68 | 79 | 84 |

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* < 30% ground cover (litter, grass, and brush overstory).
*Fair:* 30 to 70% ground cover.
*Good:* > 70% ground cover.

[3] Curve numbers for Group A have been developed only for desert shrub.

- hydrologic soil group;
- vegetation type; and
- percent vegetation cover.

The following procedures were used to obtain this information:

1. The percent of bedrock and alluvium was determined for each subbasin using aerial photos and geologic and topographic maps. Bedrock areas of the subbasins were assigned as hydrologic soil group D. This soil group has high runoff potential and applies to areas with shallow soils or exposed bedrock. The alluvium is mostly sand and was assigned as hydrologic

soil group B based on the preliminary surficial map by Rawlinson (1991), Romney (1973), and extensive field investigation conducted by the authors.

2. The cover type for the subbasins was determined to be desert shrub based on descriptions given in *Table 4*, field investigation, and study of aerial color and infrared photos.

3. The hydrologic condition was determined to be poor based on 30 ground surveys conducted on the alluvium (*Table 4*). Ground cover ranged between 5 and 30 percent. Results of these surveys were assumed to be representative of all subbasins. This assumption was verified by study of aerial photos and field investigations. Because of the very steep slopes and minimal or nonexistent soil, bedrock areas have less vegetation than alluvial areas; therefore, the hydrologic condition of the bedrock areas was also classified as poor.

According to the CCRFCD Manual, curve numbers for precipitation losses should be determined assuming an antecedent moisture condition of II (AMC-II). Antecedent moisture condition is dependent on the antecedent rainfall. The antecedent rainfall is the amount of rainfall between 5 and 30 days preceding a flood-producing storm. AMC-I assumes the soil is dry, and AMC-III assumes the soil is near or at saturation; AMC-II is halfway between AMC-I and AMC-III. The CCRFCD Manual designates AMC-II because data required to determine the antecedent moisture condition for an entire area are not quantifiable.

Assuming AMC-II, curve numbers for the alluvium and bedrock were 77 and 88, respectively. The curve number for each subbasin was determined by taking the weighted average between the percentage of alluvium and bedrock present in each subbasin. Curve numbers for each subbasin for AMC-I, AMC-II, and AMC-III are listed in *Table 3*. Hydrologic models in this study developed to estimate the 2-year and 10-year discharges assumed the antecedent moisture conditions were AMC-II. The 100-year hydrologic models developed for this study assumed conditions ranging between AMC-II and AMC-III. The results from all the models and the justification for varying the curve numbers per antecedent moisture conditions are addressed in Section 3.4, *Hydrology Discussion*.

#### 3.1.4 *Lag Time*

In the SCS unit hydrograph method, only 1 input parameter, the lag time, is required. The CCRFCD Manual uses the lag time equation from the U.S. Bureau of Reclamation (Cudworth, 1989) for subbasins greater than 1-square mile:

$$TLag = 20K_n\left(\frac{LL_c}{S^{1/2}}\right)^{1/3}$$

*where:*

TLag = the lag time (hours) between the center of mass of rainfall excess and the peak of the unit hydrograph.

$K_n$ = the Manning roughness factor (dimensionless) for the basin channels.

L = the length of the longest watercourse (miles) within the subbasin.

$L_c$ = the length along the longest watercourse (miles) measured upstream to a point opposite the centroid of the basin.

S = the average slope of the longest watercourse (feet per mile).

As indicated in the CCRFCD Manual, $K_n$ is subjective. Therefore, criteria listed in Table 604 in the CCRFCD Manual (Table 5) are recommended and were used for this study. Characteristics of the subbasins fell halfway between the "n" value description for 0.03 and 0.05. Parameters used to determine the lag time are listed in Table 6. The L and S values for each subbasin were determined using a map wheel on the watershed maps (*Sheets 1* and *2*). The $L_c$ value was determined using a planimeter to find the centroid of each subbasin. A point on the longest watercourse of each subbasin which was closest to the respective centroid was selected.

#### 3.1.5 *Channel Routing*

The Muskingum routing method was used for routing reaches. This routing method requires three parameters: x, K, and the integer step. The weighting factor (x) expresses the amount of attenuation of the flood wave within the reach (Dunne and Leopold, 1978), and was determined using criteria cited by Cudworth (1989). The Muskingum coefficient (K) accounts for the translation of the peak flow for the entire channel reach. This storage constant K is directly related to the length and the average velocity of the reach. The average channel velocity is determined using the Manning Equation. The Manning roughness coefficient was chosen based on field observations. Channel geometry was determined through field measurements. (The integer step and routing reach were determined so that the total travel time through the reach would be equal to K.) Only three reaches were routed in the models. Table 7 lists the routing parameters for these reaches.

Transmission losses for the routing reaches are ignored in the models. Variability of infiltration rates along a channel reach can be extensive; thus, these losses over an entire reach are difficult to quantify. Ignoring these losses adds another conservative assumption into the model.

### 3.2 Hydrologic Models

Seven hydrologic models were developed using the HEC-1 computer program to determine discharges for this flood assessment (Table 8). All the models have the same hydrologic parameters, with the exception of point precipitation values and curve numbers. The differences between the models are explained in each model description (*Table 8*). Output from the seven hydrologic models are located in Appendix A.

#### 3.2.1 *Model Layout*

The overall watershed that could impact the RWMS was divided into 16 subbasins to provide discharges at key concentration points. Figure 8 is a schematic showing how the subbasins were connected in the HEC-1 models. The model layout was the same for all models.

**Table 5. Lag Equation Roughness Factors (CCRFCD Manual, 1990 [reference USACE, Los Angeles District, 1982]).** Characteristics of the subbasins fell halfway between the 0.030 and 0.50 "n" values.

| Watershed Characteristics | Roughness Factor, $K_n$ |
|---|---|
| Urbanized Areas: Water courses in the drainage area consist of street, storm sewer, and improved channels. | 0.015 |
| Natural Areas: Water courses in the drainage area are well defined, unimproved channels or washes. Watershed has minimal vegetation. | 0.030 |
| Natural Areas: Water courses in the drainage area are not well defined, and consist of many small rills and braided wash areas. Runoff from area combines slowly into channels. Includes mountainous channels with large boulders and flow restrictions. | 0.050 |

**Table 6. Lag Time Parameters.** Parameters used to calculate lag times.

| Watershed Name | L (mi) | Lc (mi) | S (ft/mi) | Kn | Lag Time (hrs) |
|---|---|---|---|---|---|
| MM1A | 0.87 | 0.64 | 97.7 | 0.04 | 0.31 |
| BW1 | 18.60 | 11.50 | 143.0 | 0.04 | 2.07 |
| BW2 | 6.50 | 3.10 | 251.5 | 0.04 | 0.87 |
| MM1B | 2.46 | 0.72 | 71.9 | 0.04 | 0.48 |
| MM2 | 2.16 | 1.33 | 215.3 | 0.04 | 0.47 |
| HP1A | 1.33 | 0.83 | 503.8 | 0.04 | 0.30 |
| HP1B | 2.54 | 1.33 | 173.2 | 0.04 | 0.51 |
| HP2 | 2.58 | 1.55 | 242.2 | 0.04 | 0.51 |
| HP3 | 3.79 | 2.27 | 459.1 | 0.04 | 0.59 |
| HP4 | 3.18 | 1.70 | 415.1 | 0.04 | 0.52 |
| HP5 | 1.48 | 0.64 | 378.4 | 0.04 | 0.30 |
| HP6 | 3.37 | 1.74 | 332.3 | 0.04 | 0.55 |
| HPFA | 1.44 | 0.53 | 121.5 | 0.04 | 0.33 |
| HPFB | 2.08 | 0.80 | 103.4 | 0.04 | 0.44 |
| SC1 | 18.10 | 10.60 | 106.1 | 0.04 | 2.10 |
| SC2 | 2.69 | 0.85 | 119.0 | 0.04 | 0.48 |

NOTE:

$$TLag = 20K_n\left(\frac{LL_c}{S^{1/2}}\right)$$

*where:*

TLag = the lag time (hours) between the center of mass of rainfall excess and the peak of the unit hydrograph.

$K_n$ = the Manning roughness factor (dimensionless) for the basin channels.

L = the length of the longest watercourse (miles) within the subbasin.

$L_c$ = the length along the longest watercourse (miles) measured upstream to a point opposite the centroid of the basin.

S = the average slope of the longest watercourse (feet per mile).

**Table 7. Routing Parameters.** The Muskingum routing method was used for routing reaches.

| Reach name | Integer Step | Storage Constant (K) | Weighting Factor (X) |
|---|---|---|---|
| HP1A to CPA | 9 | 0.43 | 0.2 |
| HP6 to CPD | 5 | 0.27 | 0.2 |
| CPD to CPE | 8 | 0.39 | 0.2 |

NOTE:

**Integer Step:** The integer step is the number of subreaches for the Muskingum routing.

**Storage Constant (K):** The Muskingum "K" coefficient is the travel time (hours) through the reach.

**Weighting Factor (X):** The weighting factor expresses the amount of attentuation of the flood wave within the reach.

---

**Table 8. Hydrologic Models.** Hydrologic models were developed for the 2-year, 10-year, and 100-year flood events.

| | |
|---|---|
| **100-Year Hydrologic Model** | |
| RWMS.OUT | Point precipitation values were taken from NOAA Atlas 2, Volume VII. Curve numbers were developed assuming AMC-II. |
| RWMSCN.OUT | Point precipitation values were taken from NOAA Atlas 2, Volume VII. Curve numbers for all basins were increased by 5 to account for an AMC greater than II. |
| RWMSW.OUT | Point precipitation values were taken from NOAA Atlas 2, Volume VII. Curve numbers for all basins were increased by 10 to account for AMC-III. |
| RWMSC.OUT | Clark County correction factors were used in conjunction with the point precipitation values taken from NOAA Atlas 2, Volume VII. Curve numbers are the same as those used in RWMS.OUTassuming AMC-II. |
| **10-Year Hydrologic Model** | |
| RWMS10.OUT | Point precipitation values were taken from NOAA Atlas 2, Volume VII. Curve numbers are the same as those used in RWMS.OUTassuming AMC-II. |
| RWMS10C.OUT | Clark County correction factors were used in conjunction with the point precipitation values taken from NOAA Atlas 2, Volume VII. Curve numbers are the same as those used in RWMS.OUTassuming AMC-II. |
| **2-Year Hydrologic Model** | |
| RWMS2.OUT | Point precipitation values were taken from NOAA Atlas 2, Volume VII. Curve numbers are the same as those used in RWMS.OUTassuming AMC-II. No correction factor to the 2-year point precipitation values from the NOAA Atlas 2, Volume VII, is required by the CCRFCD Manual. |

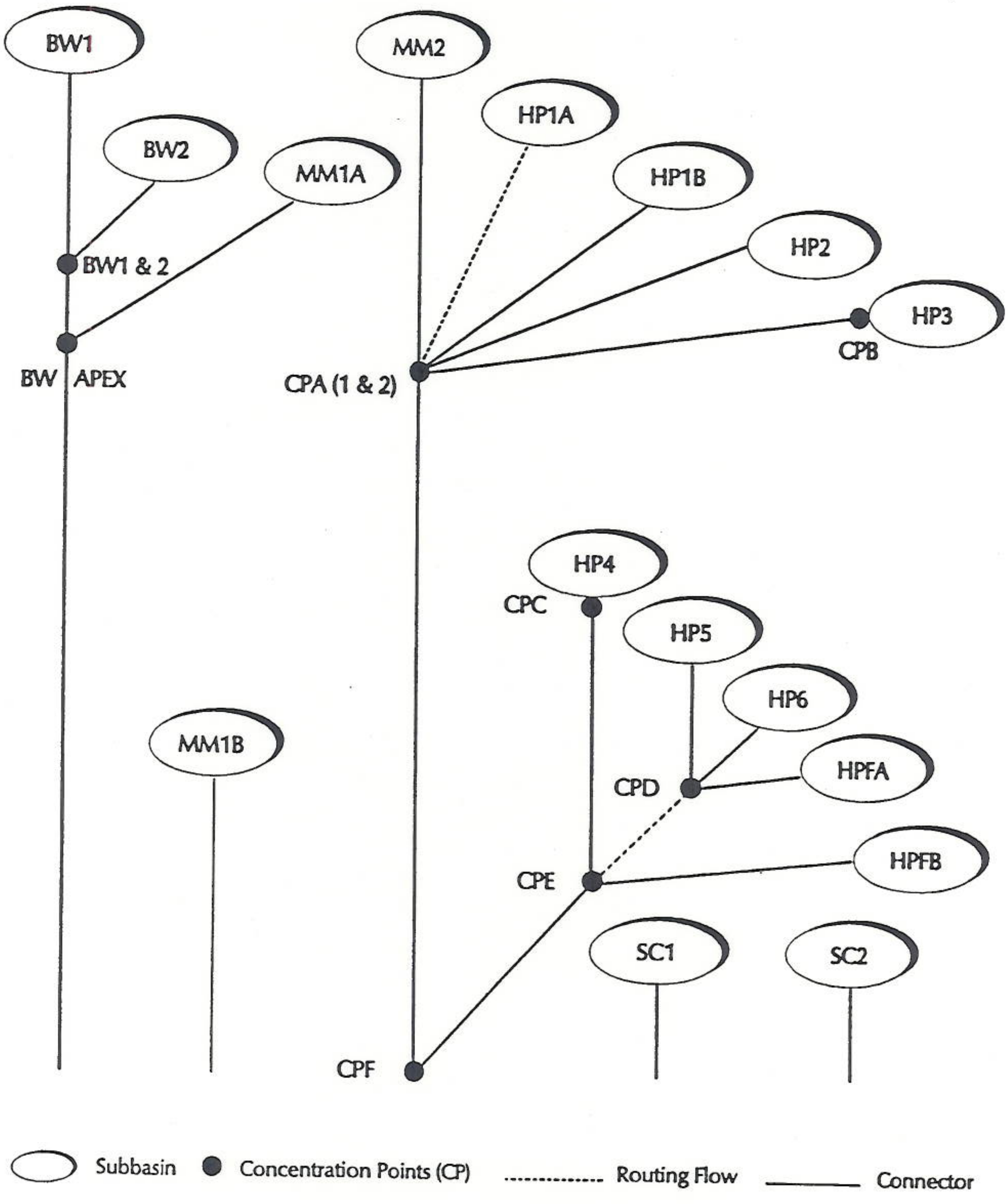



**Figure 8. Schematic Diagram of Stream Network.** This diagram shows how the 16 subbasins were combined in the HEC-1 models.

Conservative assumptions which simplified the model layout were made regarding routing and combining subbasins. For example, subbasins BW1, BW2, and MM1A within the HEC-1 models were considered to combine at the same point (*Figure 8*), but MM1A actually combines with the Barren Wash subbasins (BW1 and BW2) approximately 2,000 feet downstream. The HEC-1 models demonstrated little attenuation and translation of peak flows through this short reach; therefore, combining these basins without routing simplified the model and provided an additional conservative assumption to the model. Also, subbasins were combined along the perimeter of the RWMS without routing. First, flows from Concentration Point A (CPA1) were combined with flows from CPB; then flows from CPC and CPE were combined; and finally flows from CPA (1 and 2), CPC, and CPE were combined at CPF (*Figure 8*). CPF is located downstream from the RWMS. Again, the attenuation and translation of the peak flows as modeled using HEC-1 were minimal and, by combining the subbasins as shown on *Figure 8*, the models were simplified and conservative.

Another conservative assumption pertaining to subbasin HPFB was made in the model layout for a part of this subbasin that drains directly towards CPE. Difficulty in determining the percentage of discharge that could reach the RWMS from this subbasin led to the assumption that the entire subbasin would drain towards the RWMS.

*Figure 8* shows flow from BW Apex, MM1B, SC1, and SC2 not connected to the major concentration points. Flow from BW Apex was not connected because flow from this drainage does not currently impact the RWMS; however, channel avulsions can potentially occur during a flood, thus directing flow towards the RWMS. This potential is addressed in Section 4.2, *Results and Discussion of Flood Hazard Determination*. Subbasin MM1B encompasses the Barren Wash Alluvial Fan, and flow that falls directly onto the fan would not drain towards the RWMS.

Subbasin SC1 is the Scarp Canyon watershed. The concentration point for this watershed is the apex of the Scarp Canyon alluvial fan. Flow from this watershed does not impact the RWMS, as shown in the Section 4.2, *Results and Discussion of Flood Hazard Determination*. Subbasin SC2 is a portion of the nonactive fan surface composed of sediments deposited by the Scarp Canyon channel. Because the channel has become entrenched and has extended the active apex approximately 2.5 miles down the existing fan surface, runoff from this surface would be sheetflow and, as indicated by the topography (*Figure 3* and *Sheet 2*), drains away from the RWMS.

#### 3.2.2 *Concentration Points*

The concentration point locations were determined to provide discharges at the most appropriate location for the hydraulic analysis (*Figures 3* and *4* and *Sheets 1* and *2*). Concentration points were selected for sheetflow locations and at the active apexes of the alluvial fans. In the case of sheetflow, with the exception of CPC and CPD, the concentration points were spread across the area of potential flood impact with the RWMS. CPC was selected where all water from subbasin HP4 would be funneled southwest between subbasins HP4 and HPFB towards the RWMS. CPD was selected where water from subbasins HP5, HP6, and HPFA would be concentrated together before being routed to CPE.

### 3.3 Hydrology Results

Discharges of key concentration points from the seven models used in this analysis are listed in Table 9.

Table 9. Discharges From HEC-1 Models at Key Concentration Points

| | | 100-Year Discharges (cfs) | | | | 10-Year Discharges (cfs) | | 2-Year Discharges (cfs) |
|---|---|---|---|---|---|---|---|---|
| Concentration Point | DA ($mi^2$) | RWMS.OUT | RWMSCN.OUT | RWMSW.OUT | RWMSC.OUT | RWMS10.OUT | RWMS10C.OUT | RWMS2.OUT |
| BWAPX* | 82.20 | 1,848 | 3,513 | 6,018 | 5,498 | 510 | 1,083 | 22 |
| CPA1 | 4.40 | 459 | 786 | 1,229 | 1,297 | 130 | 278 | 15 |
| CPA2 | 6.10 | 659 | 1,126 | 1,757 | 1,827 | 187 | 399 | 23 |
| CPB | 1.70 | 263 | 420 | 624 | 661 | 87 | 170 | 14 |
| CPC | 3.30 | 360 | 626 | 984 | 1,060 | 88 | 210 | 8 |
| CPD | 3.70 | 333 | 570 | 884 | 945 | 90 | 199 | 10 |
| CPE | 8.60 | 603 | 1,180 | 1,819 | 1,898 | 168 | 335 | 9 |
| CPF | 14.70 | 878 | 1,462 | 2,396 | 2,462 | 301 | 576 | 25 |
| SC1APX** | 39.40 | 1,251 | 2,178 | 3,498 | 3,438 | 356 | 769 | 15 |

*Barren Wash Apex
**Scarp Canyon Apex

NOTE: Discharge outputs are from the HEC-1 model and do not incorporate significant figures.

Discharges from the models RWMS2.OUT, RWMS10.OUT, and RWMSW.OUT (2-year, 10-year, and 100-year discharges, respectively) were used in the analysis to determine the flood hazard zones for the Barren Wash, Scarp Canyon, and Halfpint alluvial fans. Discharges from RWMSW.OUT were used to evaluate the 100-year sheetflow and shallow concentrated flow that could impact the RWMS. Justification for choosing these models is discussed in the following section.

### 3.4 Hydrology Discussion

Although only three models were used in the flood assessment, a total of seven models were developed and evaluated in this study. A two-step approach was used to select the appropriate models for the 2-year, 10-year, and 100-year discharges. The following paragraphs provide a description of this approach.

The first step focused on the hydrologic model (HEC-1) for the 2-year flood. In arid regions, such as the RWMS location, it is common that no flow will occur in washes for several years; therefore, the 2-year model-generated discharges for the subbasins should be close to zero. The 2-year discharges from RWMS2.OUT (*Table 9*) were low, less than 25 cubic feet per second. These discharges from RWMS2.OUT appear reasonable so no other model was developed for the 2-year flood.

To verify the model-generated discharges for the 10-year and 100-year floods, another step was required. This step compared the skew coefficient developed from model-generated discharges and the regional skew coefficient (Water Resource Council [WRC] 17B, 1981). If the hydrologic models are producing reasonable discharges, then the skew coefficient from these models should be close to the regional skew coefficient.

A major assumption in using skew coefficients is that the relationship between discharge and return period must follow a Log-Pearson Type III (LPIII) probability distribution, as specified in WRC (1981). The FEMA FAN computer program (1990) contains a subroutine that calculates skew coefficients using a least-square fit and a LPIII probability distribution. This program calculated skew coefficients for specific concentration points using model-generated discharges. This program requires discharges for a minimum of three return periods to calculate the skew coefficient. (In this analysis the 2-year, 10-year, and 100-year model-generated discharges were entered into the FAN program.)

WRC (1981) contains a map which shows the regional skew coefficients for the country (Figure 9). According to the information on this map, the skew coefficient for washes on the NTS should be near zero. A zero skew coefficient means that if discharge versus probability were plotted on log-probability paper, then the flood frequency curve would plot as a log-normal distribution (a straight line). Preliminary results from a study by the USGS using stream gage data gathered after 1981 also support a zero skew for this region (Hjalmarson [personal communication], 1992).

The first three models that were evaluated using the skew comparison approach were RWMS2.OUT, RWMS10.OUT, and RWMS.OUT (Model Set 1). These models were developed using the noncorrected precipitation values from NOAA Atlas 2, Volume VII (1973) and followed the methods in CCRFCD Manual for the remaining input parameters. Discharges at the apexes of the Barren Wash, Halfpint, and Scarp Canyon alluvial fans were evaluated. Discharges at these apexes were entered into the FAN program to determine the skew coefficients. The skew coefficients, as shown in Table 10, were negative and were not close to zero. The discharges

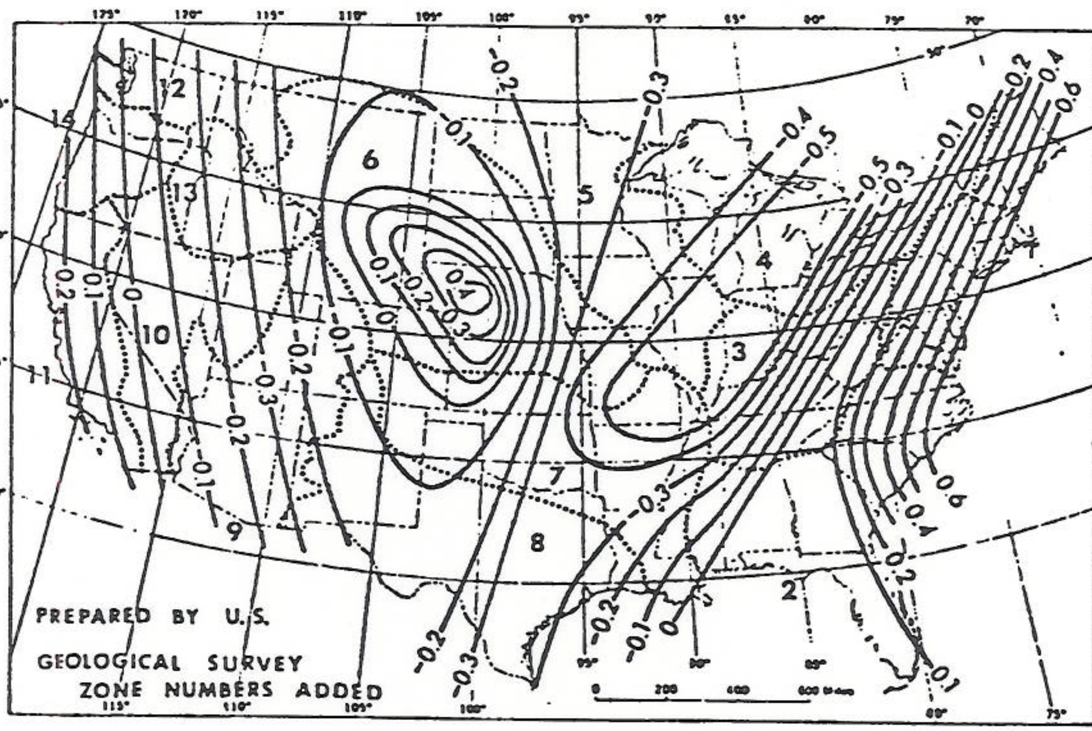



Figure 9. **Generalized U.S. Skew Coefficients (WRC [1981]).** The Nevada Test Site is located in an area with a zero skew coefficient value.

**Table 10. Skew Coeffieicnts From Different Model Sets.** Model Set 3 generated skew coefficients closest to zero for the three apexes.

| Apex Locations | Model Set 1 | Model Set 2 | Model Set 3 | Model Set 4 |
|---|---|---|---|---|
| Barren Wash | -1.2 | -0.6 | -0.1 | -1.2 |
| Scarp Canyon | -1.2 | -0.7 | -0.3 | -1.3 |
| Halfpint | -1.1 | -0.4 | 0.1 | -1.0 |

| Return Period | Model Set 1 | Model Set 2 | Model Set 3 | Model Set 4 |
|---|---|---|---|---|
| 2-Year Model | RWMS2.OUT | RWMS2.OUT | RWMS2.OUT | RWMS2.OUT |
| 10-Year Model | RWMS10.OUT | RWMS10.OUT | RWMS10.OUT | RWMS10C.OUT |
| 100-Year Model | RWMS.OUT | RWMSCN.OUT | RWMSW.OUT | RWMSC.OUT |

in this set must be adjusted to move the skew coefficients closer to zero. The 2-year model (RWMS.OUT2) was determined to generate reasonable results; therefore, adjustment must occur either to the 10-year, 100-year or both models.

The 10-year and 100-year hydrologic models could be modified by adjusting the curve numbers, depth of precipitation, or lag times. Of these three parameters, curve numbers have the widest variability because they are dependent on antecedent moisture conditions, as indicated in *Table 3.* Curve numbers for the subbasin in this study (*Table 3*) can range in the 50's and 60's under dry soil conditions (AMC-I) to the high 80's and low 90's (AMC-III) for saturated conditions. The CCRFCD Manual assumes AMC-II because antecedent moisture conditions for a drainage basin are impossible to quantify and a standard approach is required in Clark County to assure consistent analysis and design in drainage facilities and structures. The assumption of AMC-II may be reasonable for the 2-year flood event, as reflected in RWMS2.OUT, but may not be for the 10-year and 100-year flood events. For 10-year floods or greater, the antecedent moisture condition as well as rainfall may contribute to flooding.

Precipitation depth and lag times are not as variable. Variation from the precipitation depths in NOAA Atlas 2, Volume VII is not supportable because analysis of precipitation data in the study area (French, 1983; and Barker [personal communication], 1992) do not vary substantially from the values in NOAA Atlas 2, Volume VII, and any variation to precipitation data would be difficult to support. Variability in lag time is limited because three of the four parameters (L, $L_c$, and S) are measured from a topographic map, and significant variations in the $K_n$ are not defensible using the methods described in the CCRFCD Manual (*Table 5*). Therefore, the curve numbers in the models were considered the most reasonable parameter to modify.

Modification of curve numbers in the 100-year model were evaluated first. Two additional 100-year models were created from the original 100-year model (RWMS.OUT): RWMSCN.OUT and RWMSW.OUT. In RWMSCN. OUT, curve numbers were 5 greater than the original model, and in RWMSW.OUT, curve numbers were 10 greater than the original model. Increasing the curve numbers by 5 assumes an antecedent moisture condition between AMC-II and AMC-III; increasing the curve numbers by 10 assumes AMC-III.

Using these models, two additional model sets were developed with these two models: Model Set 2 (RWMS2.OUT, RWMS10.OUT, and RWMSCN.OUT) and Model Set 3 (RWMS2.OUT, RWMS10.OUT, and RWMSW.OUT). The 2-year, 10-year, and 100-year discharges for each model set were entered into the FAN program. The skew coefficients of the apexes of the three fans were closer to zero (*Table 10*). Model Set 3 generated skew coefficients closest to zero for the three apexes. These models from Model Set 3 were used to define the 100-year flood hazards in this flood assessment.

The 10-year model was not modified because an increase in the curve numbers would require a corresponding increase in the curve numbers for the 100-year model to maintain a zero skew. Assuming AMC-III (saturated conditions), the discharges generated from RWMSW.OUT are at their upper limit; therefore, an increase in curve numbers for the 10-year model would result in a negative skew.

Additional HEC-1 models were developed using the precipitation correction factors in the CCRFCD Manual required to the 10-year and 100-year precipitation depths (*Table 1).* Two additional models were necessary: RWMS10C.OUT and RWMSC.OUT. The skew coefficient using discharges from the models RWMS2.OUT, RWMS10C.OUT, and RWMSC.OUT (Model Set 4) were calculated and are listed in *Table 10.*

Adjusting the curve numbers for the 100-year event and not using precipitation correction factors varies from the methods given in the CCRFCD Manual, but the 100-year discharges generated using this approach (RWMSW.OUT) are comparable to 100-year discharges from the model (RWMSC.OUT). Plus, the skew coefficients calculated using RWMSW.OUT for the 100-year discharges (Model Set 3) are closer to zero than the model following CCRFCD Manual criteria (Model Set 4). For these reasons, Model Set 3 was used in this flood assessment instead of Model Set 4.

As a result of this two-step approach to determine the appropriate hydrologic models, seven models were developed but only three models (RWMS2.OUT, RWMS10.OUT, and RWMSW.OUT) were used in determining the flood hazard of the RWMS and HWSU facilities.

## 4.0 HYDRAULICS AND FLOOD HAZARD DETERMINATION

The RWMS and HWSU are located in an arid region where traditional approaches to define flood hazards (e.g., the hydraulic model HEC-2, which assumes a stable and fixed channel geometry) may not be appropriate for all types of flooding. Potential flooding of the RWMS and HWSU can occur as alluvial fan flooding, shallow concentrated flow, and sheetflow. FEMA has developed methodology to determine the 100-year flood hazards from these types of flooding. FEMA methodology was used to delineate the flood hazards impacting the RWMS and HWSU per 40 CFR 270.14. This section provides:

- a brief description of the FEMA methodology used to evaluate alluvial fan flooding, shallow concentrated flow, and sheetflow;
- the results and discussion of the flood hazard evaluation; and
- flood hazard maps.

## 4.1 Hydraulics and Flood Hazard Determination Methodology

### *4.1.1 FEMA Alluvial Fan Methodology*

Flooding from the Barren Wash, Scarp Canyon, and Halfpint alluvial fans could impact these facilities. Hydraulic processes on alluvial fans are different than in riverine channels. Alluvial fan flooding, as described by FEMA (1991), ". . . is characterized by high-velocity flows; active processes of erosion, sediment transport, and deposition; and unpredictable flowpaths." Channel geometry and direction on alluvial fans can change in direct response to a flood discharge. Field investigations and study of topographic maps and aerial photos of the Barren Wash, Scarp Canyon, and Halfpint alluvial fans support this description because flowpaths are unpredictable, soil development is weak, and evidence of recent erosion and deposition is present.

FEMA (1991) states that if flowpaths below the active apex cannot be predicted (which is the case for the Barren Wash, Scarp Canyon, and Halfpint alluvial fans), the FEMA Alluvial Fan Methodology must be applied to evaluate the 100-year flood hazard. This methodology, which is a modification of the method proposed by Dawdy (1979), relates probability of discharges at the apex to probability of channel depths and flow velocities that occur on the alluvial fan.

According to Dawdy (1979), flood flow from the apex of a typical alluvial fan does not spread evenly over the fan surface, but is instead confined to a surface or channel that carries the flood waters from the apex to the toe of the fan (Figure 10). The active apex is selected at the point where the flowpath becomes unpredictable, and flow is no more likely to follow an existing channel than create a new path. In the upper region of an alluvial fan, flow is confined to a single channel where the depth and width of the channel is a function of the flow itself. In general, flow occurs at critical depth and velocity as a result of steep slopes associated with this upper region. As slopes decrease towards the mid and distal parts of the fans, channel bifurcation can occur resulting in a multiple-channel region. Dawdy (1979) did not incorporate a multiple-channel region into his methodology. FEMA (1985, 1991) modified the Dawdy methodology to address multiple-channel regions of alluvial fans.

Key assumptions of the FEMA Alluvial Fan Methodology follow (French, 1989):

1. The location of the flood event channel on the fan surface is random. Furthermore, the probability of the channel passing through any given point on a contour is uniform.

2. Flow occurs in flow-formed channels. Well-defined channels result from the subsequent erosion from this process.

   a. Incised channels do not exist previous to the first flow event.

   b. Existing channel capacity is not adequate to convey the flow, and overbank flooding occurs.

3. The width and depth of the channel is a function of discharge.

4. Transmission losses are not considered.

5. On-fan precipitation is not considered.

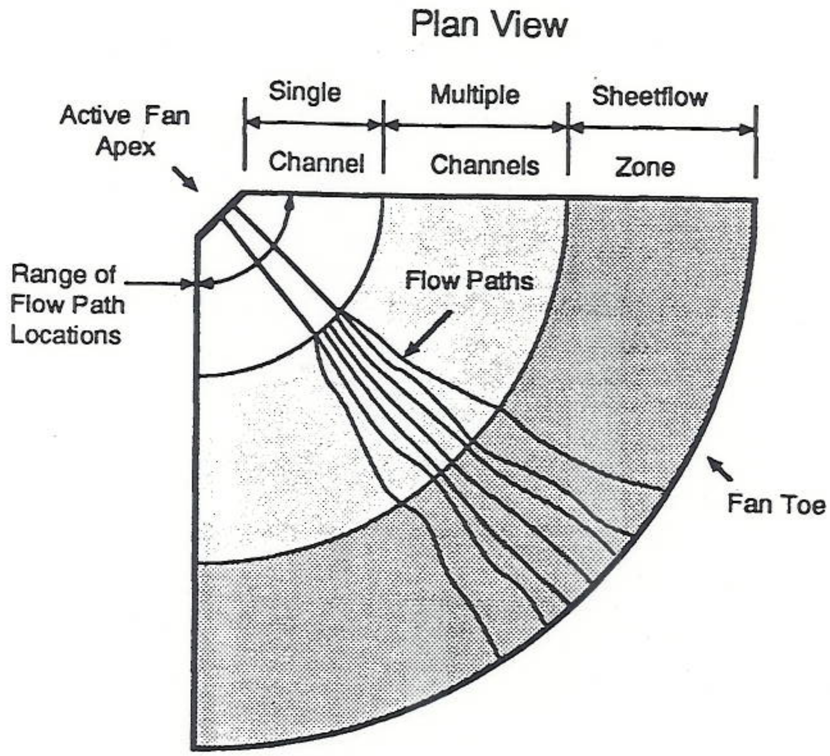



**Figure 10. Alluvial Fan Plan View (modified from French, 1989).** Plan view of an idealized alluvial fan showing the single channel, multiple channel, and sheetflow regions.

6. The alluvial fan is active; e.g., net deposition is occurring in both time and space and avulsions (the migration of channel from one location to another during a single event) are occurring.

7. Flood discharge frequency distribution must be available at the apex of the alluvial fan.

Field observations, a study of topographic and geologic maps, aerial photographs, and examination of historic records were made during the flood assessment of these alluvial fans. Sources of flooding were defined, an apex selected, active fan boundaries delineated, entrenched reaches of channels located and measured, and locations of barriers to flow determined.

The methodology used for defining flood hazards on alluvial fans incorporates FEMA's computer model, FAN (1990). Delineation of the 100-year flood hazard using the FEMA FAN Model requires the following parameters and assumptions:

- Discharge information
- Apex location
- Fan boundaries and dimensions
- Potential flow obstructions and/or diversions
- Multiple channel region parameters:
  - Manning roughness coefficient
  - Slope

The FAN model requires that at least three discharges of different return periods be used to define the flood hazard zones. The 2-year, 10-year, and 100-year flood discharges for the Barren Wash, Scarp Canyon, and Halfpint alluvial fans were taken from the HEC-1 models labeled RWMS2.OUT, RWMS10.OUT, and RWMSW.OUT, respectively (*Table 9*). Discharges calculated by the HEC-1 models for CPBWAPEX or CPBW1&BW2 (*Figure 8*), whichever were greater, were used as the discharges at the apex of the Barren Wash Alluvial Fan in the FAN model. Discharges used in the FAN model for Scarp Canyon were taken from the HEC-1 models at the active apex of Scarp Canyon (Subbasin SC2). Discharges for Halfpint Alluvial Fan were taken from CPE as calculated within the HEC-1 model, and were assumed to have originated from the fan apex. All approaches for selecting discharges at the apexes are considered to be conservative.

Apex locations and fan boundaries were determined from aerial photographs; available topographic, geologic, and surficial maps; and field investigations. Apexes were located using the FEMA definition for an active apex. Location of the apexes for Barren Wash, Scarp Canyon, and Halfpint alluvial fans are shown in Figure 11 and Sheet 3.

Potential flow obstructions and diversions such as roads, buildings and other structures which can prevent flooding in some areas and increase flooding in others must be designated. In this flood assessment, all barriers such as Mercury Highway, 5-01 road, all secondary roads, the nonengineered berms surrounding the RWMS perimeter, and all disturbed areas diverting flow away from the RWMS were ignored. Quantification of the diversion would be difficult. Assuming that all flow can reach the RWMS produces a more conservative flood analysis.

A Manning roughness coefficient of 0.030 was used for the multiple-channel regions of all three fans. The Manning roughness coefficient for the multiple-channel regions of the fan were

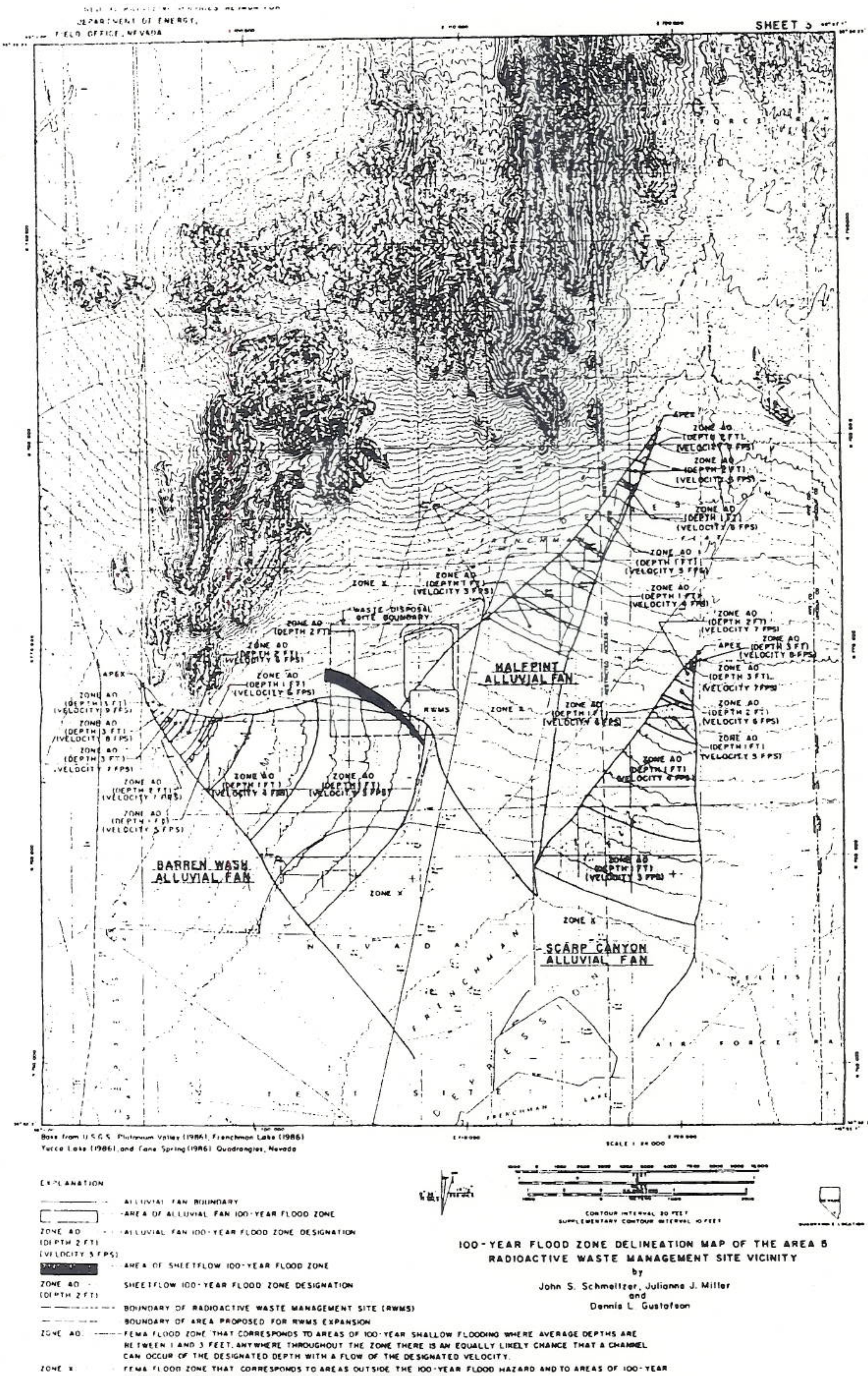



Figure 11. 100-Year Flood Zone Delineation Map of the Area 5 Radioactive Waste Management Site Vicinity (Sheet 3)

determined from field observations, and confirmed using the descriptions and values found in tables developed by Chow (1959). Slope of the fans for the multiple-channel region parameters were determined from the 1:6,000 orthophotos with a 10-foot contour interval.

#### *4.1.2 Shallow Concentrated Flow*

For subbasins MM2 and HP1B, a defined natural drainage exists that traverses the southwest corner of the RWMS. Field investigation of the geomorphology and a study of aerial photos suggest that shallow concentrated flow occurs through this reach and that standard hydraulic analysis may be appropriate. The 100-year flood hazard elevation of this drainage was estimated using the HEC-2 computer program (COE, 1990), a standard hydraulic method. HEC-2 is a hydraulic model developed by the COE and is used by FEMA to delineate flood hazards of channelized flow. The input requirements of the HEC-2 model include channel cross section information; distances between cross sections; and Manning roughness coefficient. Cross section information and distances were taken from a 1:4,800 topographic map with a 5-foot contour interval (Appendix C contains HEC-2 output, work map and cross sections) in conjunction with field observations and measurements. As in the alluvial fan analysis, Manning roughness coefficients were estimated from field observations, and confirmed using the descriptions and values found in tables developed by Chow (1959).

#### *4.1.3 Sheetflow*

According to FEMA (1991), sheetflow

> . . . is the broad, relatively unconfined downslope movement of water across sloping terrain that results from . . . a channel that crosses a drainage divide, . . . and overflow from a perched channel onto . . . plains of lower elevations . . . . [Sheetflow] is typical in areas of low topographic relief and poorly established drainage systems . . . . Shallow flooding is often characterized by poorly defined channels and highly unpredictable flow direction because of low relief or shifting channels and debris loads. Where such conditions exist, the entire area susceptible to this unpredictable flow should be delineated as an area of equal risk. Small-scale topographic relief that is not evident on existing topographic mapping and that might lead to "islands" of one flood hazard zone within larger areas of another should be ignored.

This definition of sheetflow describes the distributary-flow system (hydraulic engineering viewpoint) areas that drain from the Halfpint Range towards the RWMS. With current elevation information (10-foot contour interval) on available orthophotos, a detailed assessment of the flood hazard was not possible because of the inability to distinguish channels and nonchannel regions; therefore, per FEMA (1991) the 100-year flood hazard of this area was analyzed assuming that the entire area is prone to flooding and is delineated as an area of equal risk. Geomorphologic evidence gathered from analysis of color and infrared aerial photos and field observations supports this assumption because these areas have weak soil development and relatively few areas of relic deposits covered by desert pavement with desert varnish.

## 4.2 Results and Discussion of Flood Hazard Determination

Using the methods described in the previous section, the 100-year flood hazard areas were defined on the topographic maps (*Figure 11* and *Sheet 3*). Zone AO and Zone X were used to denote the flood hazards in the vicinity of the RWMS.

FEMA designates alluvial fan, shallow concentrated flow, and sheetflow areas with a 100-year flood depth of greater than 1 foot as a Zone AO. FEMA (1990) defines Zone AO as the area of 100-year shallow flooding where average depths are between 1 and 3 feet. For alluvial fans, anywhere throughout the zone there is a probability of 0.01 that a channel can occur at the designated depth with flow at the designated velocity. Zone X, shown on *Figure 11* and *Sheet 3* and Figure 12 and Sheet 4, represents areas outside the 100-year flood hazard and/or areas of the 100-year shallow flooding (sheetflow or shallow concentrated flow) where average depths are less than 1 foot. A Zone X delineation does not mean that floods will not occur within this zone. For this reason, flood hazard protection must be addressed.

### *4.2.1 Alluvial Fan Flooding*

The 100-year flood hazard zones for the Barren Wash, Scarp Canyon, and the Halfpint fans are shown on *Figure 11* and *Sheet 3*. The 100-year flood hazard for the RWMS and its immediate vicinity is also shown on an 1:6,000 orthophoto (*Figure 12* and *Sheet 4*).

Using the FEMA Fan Methodology, the southwest corner of the RWMS is within the 100-year flood hazard zone, designated as Zone AO; depth 1 foot; velocity 3 feet per second, of the Barren Wash Alluvial Fan. The part of the RWMS that is located within Zone AO of this alluvial fan is not included in the RCRA Part B Permit Application for the Area 5 RWMS because it is not used for storage or disposal of hazardous, mixed, or radioactive waste. This designation means that the southwest corner of the RWMS has a probability of 0.01 (a 100-year event) to be impacted by channelized flow averaging 1 foot of depth and having a velocity of 3 feet per second. The HWSU is not within the 100-year flood hazard of the Barren Wash Alluvial Fan.

Neither the RWMS nor the HWSU are located within the 100-year flood hazard of the Halfpint Alluvial Fan (100-year flow depths 1 foot or greater), but are located in the Zone X area of the Halfpint Alluvial Fan (100-year flow depths less than 1 foot). This study determined that 100-year flow from the Scarp Canyon Alluvial Fan does not impact the RWMS or HWSU. Appendix B contains the output of the FAN model results.

The review of field data; topographic, geologic, and surficial maps; and aerial photographs does not invalidate the assumptions of the FEMA Alluvial Fan Methodology. However, other methods for determining flood hazards in arid regions are currently being developed. At the time of the writing of this report, none of these other methods have been adopted by FEMA; therefore, the FEMA methods were the only methods used. For example, French (1992) argues that the FEMA assumption of an uniform probability of a channel being formed on any given contour may not be valid. As a result of analyzing channel orientation of over 90 alluvial fans in the United States, French found that fanhead channels tend to form along or near the centerline of alluvial fans (an imaginary line which bisects the alluvial fan from the apex to the toe of the alluvial fan). In his study, French modified the FEMA Alluvial Fan Methodology to incorporate this tendency. Using French's approach, the flood hazard potential from the Barren Wash Alluvial Fan is less than the potential determined from the FEMA methodology because the RWMS is located adjacent to the north boundary of the fan.

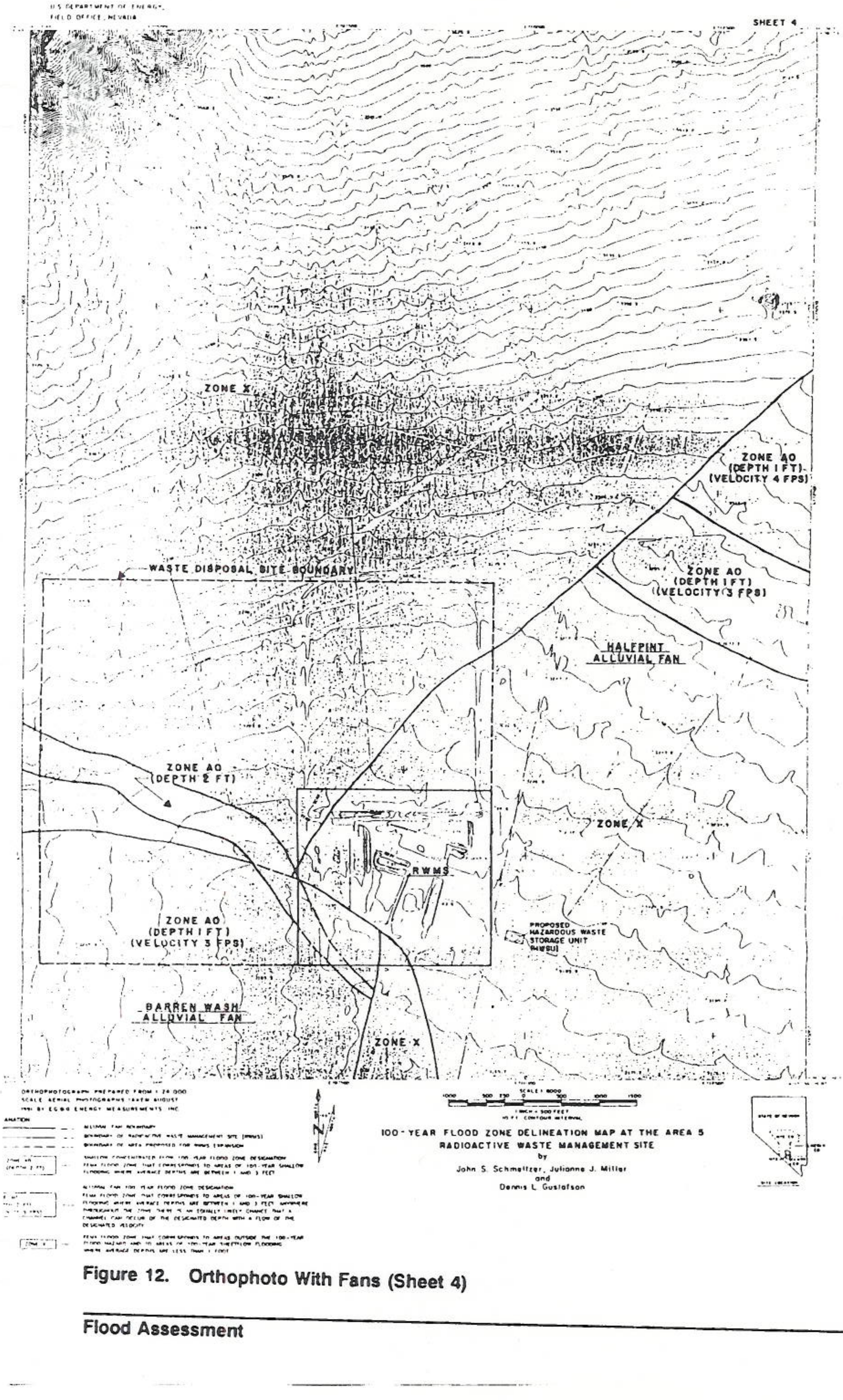



Figure 12. Orthophoto With Fans (Sheet 4)

### *4.2.2 Shallow Concentrated Flooding*

Results of the HEC-2 analysis for the watercourses draining subbasins MM2 and HP1A&B estimated the 100-year flow depths at 2 feet. The southwest corner of the site is also located within the 100-year flood hazard of this drainage, and is designated as Zone AO; depth 2 feet (*Figure 11* and *Sheet 3*). Again, this portion of the RWMS is not used for disposal of waste and is not included in the RCRA Part B Permit Application for the Area 5 RWMS. Appendix C contains the output of the HEC-2 model, the workmap, and cross sections used to analyze this drainage.

### *4.2.3 Sheetflow*

FEMA (1991) usually describes areas that experience sheetflow as Zone X (an area of flooding with depths less than 1 foot). Calculations to determine the average 100-year depths for sheetflow areas support this assertion. Calculated depths within the proposed RWMS boundary and the HWSU were all less than 1 foot. These facilities are not in a 100-year flood hazard from flow draining from the Massachusetts Mountains/Halfpint Range. Appendix D contains the calculations used to estimate the depth of flow in sheetflow regions.

Several measures were taken to assure that this flood assessment would be as conservative as reasonable. Discharges were calculated using a "state-of-the-art" approach for this region (i.e., CCRFCD Manual). All flow barriers such as roads, structures and existing nonengineered dikes were ignored to assume that all flow could reach the RWMS. The entire area was assumed to be prone to flooding and was delineated as an area of equal risk because of the inability to distinguish channels from the available topographic maps.

A Zone X designation is somewhat misleading. Although FEMA requires flood protection only for areas listed as Zone AO, a flood hazard must still be recognized within a Zone X. The sheetflow region to the north of the RWMS contains channels which range in depth up to 3 feet. FEMA (1991) states that discharge in sheetflow regions must be spread equally over the entire surface area. To the north of the RWMS, this results in average flow depths of less than 1 foot, and thus the designation of Zone X. Field observations of channels within this region indicate that flows greater than 1 foot could occur in these channels during a 100-year flood. Any type of flood protection design criteria must address the potential of channelized flow for this area.

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# HEC-1 MODEL OUTPUT

**FILENAME: RWMSCN.OUT**

**(100-YEAR MODEL)**

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*****************************************                    *****************************************
*                                       *                    *                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *  U.S. ARMY CORPS OF ENGINEERS         *
*            SEPTEMBER 1990             *                    *  HYDROLOGIC ENGINEERING CENTER        *
*             VERSION 4.0               *                    *        609 SECOND STREET              *
*                                       *                    *     DAVIS, CALIFORNIA 95616           *
*  RUN DATE  01/29/1993  TIME  21:56:35 *                    *        (916) 756-1104                 *
*                                       *                    *                                       *
*****************************************                    *****************************************
```

```
X       X  XXXXXXX   XXXXX          X
X       X  X        X     X        XX
X       X  X        X               X
XXXXXXX    XXXX     X        XXXXX  X
X       X  X        X               X
X       X  X        X     X         X
X       X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
 1    ID   FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMS.DAT
 2    ID   100-YEAR 6-HOUR STORM 1.6 INCHES
 3    ID   POINT RAINFALL VALUES FORM NOAA ATLAS 2 VOL VII
 4    ID   DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
 5    ID   CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCRFCD, 1990)
 6    ID   CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
 7    ID   LAG TIMES DETERMINED USING METHOD IN SECTION 606.3 IN CCRFCD, 1990
 8    ID   DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
 9    ID   THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
      *DIAGRAM
10    IT       3       0       0     300
11    IO       5
12    IN       5
13    JD     1.6     .01
      * RAINFALL DISTRIBUTION FROM CLARK COUNTY MANUAL LESS THAN 10 SQ. MILES
14    PC       0       2     5.7     7.0     8.7    10.8    12.4    13.0    13.0    13.0
15    PC    13.0    13.0    13.0    13.3    14.0    14.2    14.8    15.8    17.2    18.1
16    PC    19.0    19.7    19.9    20.0    20.1    20.4    21.4    22.9    24.1    24.9
17    PC    25.1    25.6    27.0    27.8    28.1    28.3    29.5    32.2    35.2    40.9
18    PC    49.9    59.0    71.0    74.4    78.1    81.2    81.9    83.5    85.1    85.6
19    PC    86.0    86.8    87.6    88.8    91.0    92.6    93.7    95.0    97.0    97.6
20    PC    98.2    98.5    98.7    98.9    99.0    99.3    99.3    99.4    99.5    99.8
21    PC    99.8    99.9   100.0
22    JD    1.55       1
23    JD    1.38    9.99
      * CHANGED RAINFALL DISTRIBUTION ABOVE 10 SQ. MILES PER CLARK COUNTY MANUAL
24    JD    1.38   10.01
25    PC       0     2.0     5.9     8.0    11.0    14.4    15.0    16.0    16.8    17.1
26    PC    18.0    18.2    18.7    19.0    19.7    20.2    21.0    22.0    23.0    24.1
27    PC    25.0    25.9    26.5    28.0    29.0    30.0    30.5    30.9    31.0    31.7
28    PC    32.1    32.7    33.3    34.6    36.1    38.1    40.8    43.0    47.7    51.4
29    PC    56.1    63.0    71.0    72.0    73.1    75.2    77.9    79.0    79.5    80.4
30    PC    81.0    82.0    82.6    84.0    85.9    88.9    91.0    93.8    96.6    97.0
31    PC    97.4    97.9    98.1    98.3    98.5    98.9    99.0    99.2    99.3    99.6
32    PC    99.7    99.9   100.0
33    JD    1.26      20
34    JD    1.18      30
35    JD    1.09      50
36    JD     .96     100

37    KK    MM1A
38    KM   Basin runoff calculation for Mass. Mountains 1A
39    BA      .9
40    LS              80
41    UD     .31

42    KK     BW1
43    KM     Basin runoff calculation for Barren Wash 1
44    BA    60.5
45    LS              83
46    UD     2.1
```

```
KK     BW2
KM     Basin runoff calculation for Barren Wash 2
BA    20.8
LS                 80
UD      .9

KK   BW1&2
KM   Combined BW1 and BW2
HC       2

KK BW APX
KM   Combine BW1,BW2, and MM1A (assume dischcarge of Barren Wash "active apex")
HC       2

KK     MM1B
KM     Basin runoff calulation for Mass. Mountains 1B
*    Flow was not combined with BW APX because flow from this watershed
*    will not directly impact RWMS wereas a channel migration at the apex
*    could impact the RWMS
BA     2.1
LS                 77
UD     .48

KK     MM2
KM     Basin runoff calculation for Mass. Mountains 2
BA     1.4
LS                 79
UD     .47

KK     HP1A
KM     Basin runoff calculation for Half Pint Range 1A
BA      .8
LS                 85
UD     .48

KK   RTCPA
KM   Route Flow from HP1A to CPA
RM       9      .43       .2

KK     HP1B
KM     Basin runoff calculation for Half Pint Range 1B
BA     1.0
LS                 78
UD     .51

KK     HP2
KM     Basin runoff calculation for Half Pint Range 2
BA     1.2
LS                 78
UD     .51

KK     CPA1
KM     Combine MM2, routed HP1A, HP1B, HP2
HC       4

KK     HP3
KM     (CPB) Basin runoff calculation for Half Pint Range 3
BA     1.7
LS                 82
UD     .59

KK     CPA2
KM     Combine HP3 with flow from CPA1
HC       2

KK     HP4
KM     (CPC) Basin runoff calculation for Half Pint Range 4
BA     3.3
LS                 79
UD     .52

KK     HP5
KM     Basin runoff calculation for Half Pint Range 5
BA     1.2
LS                 79
UD      .3

KK     HP6
KM     Basin runoff calculation for Half Pint Range 6
BA     2.2
LS                 80
UD     .55

KK   RTCPD
KM     Route HP6 to CPD
RM       5      .27       .2
```

```
KK    HPFA
KM     Basin runoff calculation for Half Pint Range FA
BA      .3
LS               77
UD     .33

KK     CPD
KM     Combine HP5, routed HP6, and HPFA
HC      3

KK   RTCPE
KM     Route flow from CPD to CPE
RM      8     .39      .2

KK    HPFB
KM     Basin runoff calculation for Half Pint Range FB
BA     1.6
LS               77
UD     .44

KK     CPE
KM    Combine HP4 (CPC) with routed flow from CPD, and HPFB
HC      3

KK     CPF
KM    Combine all flow at Concentration just below RWMS (Flow from CPA & CPE)
HC      2

KK     SC1
KM     Basin runoff calculation for Scarp Canyon 1
* Concentration Pt of this watershed is the active apex of the Scarp Canyon Fan
BA    39.4
LS              82
UD     2.1

KK     SC2
KM     Basin runoff calculation for Scarp Canyon 2
BA     1.5
LS              77
UD     .48
ZZ
```

```
                SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE     (V) ROUTING            (--->) DIVERSION OR PUMP FLOW

  NO.     (.) CONNECTOR          (<---) RETURN OF DIVERTED OR PUMPED FLOW

  37      MM1A
             .
  42         .       BW1
             .         .
  47         .         .       BW2
             .         .         .
  52         .     BW1&2..........
             .         .
  55    BW APX..........
             .
  58         .      MM1B
             .         .
  63         .         .       MM2
             .         .         .
  68         .         .         .      HP1A
             .         .         .         V
  73         .         .         .         V
             .         .         .     RTCPA
             .         .         .         .
  76         .         .         .         .      HP1B
             .         .         .         .         .
  81         .         .         .         .         .       HP2
             .         .         .         .         .         .
  86         .         .      CPA1..............................
             .         .         .
  89         .         .         .       HP3
             .         .         .         .
  94         .         .      CPA2..........
             .         .         .
  97         .         .         .       HP4
             .         .         .         .
 102         .         .         .         .       HP5
             .         .         .         .         .
 107         .         .         .         .         .      HP6
             .         .         .         .         .         V
 112         .         .         .         .         .         V
             .         .         .         .         .     RTCPD
             .         .         .         .         .         .
 115         .         .         .         .         .         .      HPFA
             .         .         .         .         .         .         .
 120         .         .         .         .       CPD....................
             .         .         .         .         V
 123         .         .         .         .         V
             .         .         .         .     RTCPE
             .         .         .         .         .
 126         .         .         .         .         .      HPFB
             .         .         .         .         .         .
 131         .         .         .       CPE....................
             .         .         .         .
 134         .         .       CPF..........
             .         .         .
 137         .         .         .       SC1
             .         .         .         .
 142         .         .         .         .       SC2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
****************************************
*                                      *
* FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*         SEPTEMBER 1990               *
*          VERSION 4.0                 *
*                                      *
* RUN DATE  01/29/1993  TIME  21:56:35 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER      *
*        609 SECOND STREET             *
*      DAVIS, CALIFORNIA 95616         *
*         (916) 756-1104               *
*                                      *
****************************************
```

```
FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMS.DAT
100-YEAR 6-HOUR STORM 1.6 INCHES
POINT RAINFALL VALUES FORM NOAA ATLAS 2 VOL VII
DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCRFCD, 1990)
CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
LAG TIMES DETERMINED USING METHOD IN SECTION 606.3 IN CCRFCD, 1990
DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS

11 IO          OUTPUT CONTROL VARIABLES
                    IPRNT          5  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT           HYDROGRAPH TIME DATA
                     NMIN          3  MINUTES IN COMPUTATION INTERVAL
                    IDATE     1    0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ        300  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE     1    0  ENDING DATE
                   NDTIME       1457  ENDING TIME
                    ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL     .05 HOURS
                     TOTAL TIME BASE   14.95 HOURS

          ENGLISH UNITS
               DRAINAGE AREA          SQUARE MILES
               PRECIPITATION DEPTH    INCHES
               LENGTH, ELEVATION      FEET
               FLOW                   CUBIC FEET PER SECOND
               STORAGE VOLUME         ACRE-FEET
               SURFACE AREA           ACRES
               TEMPERATURE            DEGREES FAHRENHEIT

13 JD          INDEX STORM NO. 1
                     STRM       1.60  PRECIPITATION DEPTH
                     TRDA        .01  TRANSPOSITION DRAINAGE AREA

14 PI           PRECIPITATION PATTERN
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

```
22 JD          INDEX STORM NO. 2
                     STRM       1.55  PRECIPITATION DEPTH
                     TRDA       1.00  TRANSPOSITION DRAINAGE AREA

 0 PI           PRECIPITATION PATTERN
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

23 JD INDEX STORM NO. 3

STRM 1.38 PRECIPITATION DEPTH

TRDA 9.99 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

24 JD INDEX STORM NO. 4

STRM 1.38 PRECIPITATION DEPTH

TRDA 10.01 TRANSPOSITION DRAINAGE AREA

25 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

33 JD INDEX STORM NO. 5

STRM 1.26 PRECIPITATION DEPTH

TRDA 20.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

34 JD INDEX STORM NO. 6

STRM 1.18 PRECIPITATION DEPTH

TRDA 30.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

35 JD INDEX STORM NO. 7

STRM 1.09 PRECIPITATION DEPTH

TRDA 50.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

36 JD INDEX STORM NO. 8

STRM .96 PRECIPITATION DEPTH

TRDA 100.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

| | OPERATION | STATION | PEAK FLOW | TIME OF PEAK | AVERAGE FLOW FOR MAXIMUM PERIOD | | | BASIN AREA | MAXIMUM STAGE | TIME OF MAX STAGE |
|---|---|---|---|---|---|---|---|---|---|---|
| + | | | | | 6-HOUR | 24-HOUR | 72-HOUR | | | |
| + | HYDROGRAPH AT | MM1A | 174. | 3.80 | 30. | 12. | 12. | .90 | | |
| + | HYDROGRAPH AT | BW1 | 1786. | 6.35 | 961. | 405. | 405. | 60.50 | | |
| + | HYDROGRAPH AT | BW2 | 1016. | 5.40 | 389. | 156. | 156. | 20.80 | | |
| + | 2 COMBINED AT | BW1&2 | 1848. | 5.95 | 1003. | 421. | 421. | 81.30 | | |
| + | 2 COMBINED AT | BW APX | 1841. | 5.95 | 1004. | 421. | 421. | 82.20 | | |
| + | HYDROGRAPH AT | MM1B | 200. | 4.05 | 47. | 19. | 19. | 2.10 | | |
| + | HYDROGRAPH AT | MM2 | 184. | 4.00 | 41. | 16. | 16. | 1.40 | | |
| + | HYDROGRAPH AT | HP1A | 200. | 3.95 | 42. | 17. | 17. | .80 | | |
| + | ROUTED TO | RTCPA | 190. | 4.40 | 42. | 17. | 17. | .80 | | |
| + | HYDROGRAPH AT | HP1B | 116. | 4.05 | 27. | 11. | 11. | 1.00 | | |
| + | HYDROGRAPH AT | HP2 | 136. | 4.05 | 32. | 13. | 13. | 1.20 | | |
| + | 4 COMBINED AT | CPA1 | 459. | 4.15 | 120. | 48. | 48. | 4.40 | | |
| + | HYDROGRAPH AT | HP3 | 263. | 4.10 | 64. | 26. | 26. | 1.70 | | |
| + | 2 COMBINED AT | CPA2 | 659. | 4.15 | 170. | 68. | 68. | 6.10 | | |
| + | HYDROGRAPH AT | HP4 | 360. | 4.05 | 86. | 35. | 35. | 3.30 | | |
| + | HYDROGRAPH AT | HP5 | 206. | 3.80 | 36. | 14. | 14. | 1.20 | | |
| + | HYDROGRAPH AT | HP6 | 277. | 4.10 | 67. | 27. | 27. | 2.20 | | |
| + | ROUTED TO | RTCPD | 268. | 4.35 | 67. | 27. | 27. | 2.20 | | |
| + | HYDROGRAPH AT | HPFA | 41. | 3.85 | 8. | 3. | 3. | .30 | | |
| + | 3 COMBINED AT | CPD | 333. | 4.25 | 99. | 40. | 40. | 3.70 | | |
| + | ROUTED TO | RTCPE | 326. | 4.65 | 99. | 40. | 40. | 3.70 | | |
| + | HYDROGRAPH AT | HPFB | 167. | 4.00 | 37. | 15. | 15. | 1.60 | | |
| + | 3 COMBINED AT | CPE | 603. | 4.20 | 191. | 77. | 77. | 8.60 | | |
| + | 2 COMBINED AT | CPF | 878. | 5.15 | 301. | 121. | 121. | 14.70 | | |
| + | HYDROGRAPH AT | SC1 | 1251. | 6.35 | 673. | 283. | 283. | 39.40 | | |
| + | HYDROGRAPH AT | SC2 | 151. | 4.05 | 35. | 14. | 14. | 1.50 | | |

*** NORMAL END OF HEC-1 ***

# HEC-1 MODEL OUTPUT

**FILENAME: RWMS.OUT**

**(100-YEAR MODEL)**

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             SEPTEMBER 1990            *
*              VERSION 4.0              *
*                                       *
* RUN DATE  01/29/1993  TIME  21:59:18  *
*                                       *
*****************************************
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*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*         609 SECOND STREET             *
*      DAVIS, CALIFORNIA 95616          *
*          (916) 756-1104               *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X               X
XXXXXXX  XXXX     X       XXXXX   X
X     X  X        X               X
X     X  X        X     X         X
X     X  XXXXXXX   XXXXX         XXX
```

```
THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM
```

```
  1        ID   FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMSCN.DAT
  2        ID   100-YEAR 6-HOUR STORM 1.6 INCHES
  3        ID   POINT RAINFALL VALUES FROM NOAA ATLAS 2 VOL VII
  4        ID   DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
  5        ID   CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MODEL (CCRFCD, 1990)
  6        ID   CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
  7        ID   LAG TIMES DETERMINED USING METHOD IN SECTION 606.3 IN CCRFCD, 1990
  8        ID   DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
  9        ID   THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
 10        ID   ADJUSTED CURVE NUMBERS BY 5 TO ACCOUNT FOR MOISTER SOILS DURING THE 100-YR EV
           *DIAGRAM
 11        IT       3       0       0     300
 12        IO       5
 13        IN       5
 14        JD     1.6     .01
           * RAINFALL DISTRIBUTION FROM CLARK COUNTY MANUAL LESS THAN 10 SQ. MILES
 15        PC       0       2     5.7     7.0     8.7    10.8    12.4    13.0    13.0    13.0
 16        PC    13.0    13.0    13.0    13.3    14.0    14.2    14.8    15.8    17.2    18.1
 17        PC    19.0    19.7    19.9    20.0    20.1    20.4    21.4    22.9    24.1    24.9
 18        PC    25.1    25.6    27.0    27.8    28.1    28.3    29.5    32.2    35.2    40.9
 19        PC    49.9    59.0    71.0    74.4    78.1    81.2    81.9    83.5    85.1    85.6
 20        PC    86.0    86.8    87.6    88.8    91.0    92.6    93.7    95.0    97.0    97.6
 21        PC    98.2    98.5    98.7    98.9    99.0    99.3    99.3    99.4    99.5    99.8
 22        PC    99.8    99.9   100.0
 23        JD    1.55       1
 24        JD    1.38    9.99
           * CHANGED RAINFALL DISTRIBUTION ABOVE 10 SQ. MILES PER CLARK COUNTY MANUAL
 25        JD    1.38   10.01
 26        PC       0     2.0     5.9     8.0    11.0    14.4    15.0    16.0    16.8    17.1
 27        PC    18.0    18.2    18.7    19.0    19.7    20.2    21.0    22.0    23.0    24.1
 28        PC    25.0    25.9    26.5    28.0    29.0    30.0    30.5    30.9    31.0    31.7
 29        PC    32.1    32.7    33.3    34.6    36.1    38.1    40.8    43.0    47.7    51.4
 30        PC    56.1    63.0    71.0    72.0    73.1    75.2    77.9    79.0    79.5    80.4
 31        PC    81.0    82.0    82.6    84.0    85.9    88.9    91.0    93.8    96.6    97.0
 32        PC    97.4    97.9    98.1    98.3    98.5    98.9    99.0    99.2    99.3    99.6
 33        PC    99.7    99.9   100.0
 34        JD    1.26      20
 35        JD    1.18      30
 36        JD    1.09      50
 37        JD     .96     100

 38        KK    MM1A
 39        KM   Basin runoff calculation for Mass. Mountains 1A
 40        BA      .9
 41        LS              85
 42        UD     .31

 43        KK     BW1
 44        KM     Basin runoff calculation for Barren Wash 1
 45        BA    60.5
 46        LS              88
 47        UD     2.1
```

```
48   KK    BW2
49   KM     Basin runoff calculation for Barren Wash 2
50   BA    20.8
51   LS              85
52   UD      .9

53   KK   BW1&2
54   KM   Combined BW1 and BW2
55   HC      2

56   KK  BW APX
57   KM   Combine BW1,BW2, and MM1A (assume dischcarge of Barren Wash "active apex")
58   HC      2

59   KK    MM1B
60   KM    Basin runoff calulation for Mass. Mountains 1B
     *   Flow was not combined with BW APX because flow from this watershed
     *   will not directly impact RWMS wereas a channel migration at the apex
     *   could impact the RWMS
61   BA     2.1
62   LS              82
63   UD     .48

64   KK    MM2
65   KM    Basin runoff calculation for Mass. Mountains 2
66   BA     1.4
67   LS              84
68   UD     .47

69   KK    HP1A
70   KM    Basin runoff calculation for Half Pint Range 1A
71   BA     .8
72   LS              90
73   UD     .48

74   KK   RTCPA
75   KM   Route Flow from HP1A to CPA
76   RM      9      .43      .2

77   KK    HP1B
78   KM    Basin runoff calculation for Half Pint Range 1B
79   BA     1.0
80   LS              83
81   UD     .51

82   KK     HP2
83   KM    Basin runoff calculation for Half Pint Range 2
84   BA    1.2
85   LS              83
86   UD     .51

87   KK    CPA1
88   KM    Combine MM2, routed HP1A, HP1B, HP2
89   HC      4

90   KK     HP3
91   KM     (CPB) Basin runoff calculation for Half Pint Range 3
92   BA     1.7
93   LS              87
94   UD     .59

95   KK    CPA2
96   KM    Combine HP3 with flow from CPA1
97   HC      2

98   KK     HP4
99   KM     (CPC) Basin runoff calculation for Half Pint Range 4
100  BA     3.3
101  LS              84
102  UD     .52

103  KK     HP5
104  KM     Basin runoff calculation for Half Pint Range 5
105  BA     1.2
106  LS              84
107  UD      .3

108  KK     HP6
109  KM     Basin runoff calculation for Half Pint Range 6
110  BA     2.2
111  LS              85
112  UD     .55

113  KK   RTCPD
114  KM    Route HP6 to CPD
115  RM      5      .27      .2
```

```
KK    HPFA
KM     Basin runoff calculation for Half Pint Range FA
BA      .3
LS              82
UD     .33

KK     CPD
KM     Combine HP5, routed HP6, and HPFA
HC       3

KK   RTCPE
KM     Route flow from CPD to CPE
RM       8     .39       .2

KK    HPFB
KM     Basin runoff calculation for Half Pint Range FB
BA     1.6
LS              82
UD     .44

KK     CPE
KM    Combine HP4 (CPC) with routed flow from CPD, and HPFB
HC       3

KK     CPF
KM    Combine all flow at Concentration just below RWMS (Flow from CPA & CPE)
HC       2

KK     SC1
KM     Basin runoff calculation for Scarp Canyon 1
* Concentration Pt of this watershed is the active apex of the Scarp Canyon Fan
BA    39.4
LS              87
UD     2.1

KK     SC2
KM     Basin runoff calculation for Scarp Canyon 2
BA     1.5
LS              82
UD     .48
ZZ
```

```
                SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
LINE       (V) ROUTING           (--->) DIVERSION OR PUMP FLOW

 NO.       (.) CONNECTOR         (<---) RETURN OF DIVERTED OR PUMPED FLOW

  38         MM1A
                 .
                 .
  43             .         BW1
                 .           .
                 .           .
  48             .           .         BW2
                 .           .           .
                 .           .           .
  53             .       BW1&2............
                 .           .
                 .           .
  56        BW APX............
                 .
                 .
  59             .        MM1B
                 .           .
                 .           .
  64             .           .         MM2
                 .           .           .
                 .           .           .
  69             .           .           .        HP1A
                 .           .           .           V
                 .           .           .           V
  74             .           .           .       RTCPA
                 .           .           .           .
                 .           .           .           .
  77             .           .           .           .       HP1B
                 .           .           .           .          .
                 .           .           .           .          .
  82             .           .           .           .          .         HP2
                 .           .           .           .          .           .
                 .           .           .           .          .           .
  87             .           .        CPA1...................................
                 .           .           .
                 .           .           .
  90             .           .           .         HP3
                 .           .           .           .
                 .           .           .           .
  95             .           .        CPA2............
                 .           .           .
                 .           .           .
  98             .           .           .         HP4
                 .           .           .           .
                 .           .           .           .
 103             .           .           .           .        HP5
                 .           .           .           .          .
                 .           .           .           .          .
 108             .           .           .           .          .         HP6
                 .           .           .           .          .           V
                 .           .           .           .          .           V
 113             .           .           .           .          .       RTCPD
                 .           .           .           .          .           .
                 .           .           .           .          .           .
 116             .           .           .           .          .           .        HPFA
                 .           .           .           .          .           .           .
                 .           .           .           .          .           .           .
 121             .           .           .           .        CPD........................
                 .           .           .           .          V
                 .           .           .           .          V
 124             .           .           .           .      RTCPE
                 .           .           .           .          .
                 .           .           .           .          .
 127             .           .           .           .          .        HPFB
                 .           .           .           .          .           .
                 .           .           .           .          .           .
 132             .           .           .         CPE.......................
                 .           .           .           .
                 .           .           .           .
 135             .           .         CPF............
                 .           .           .
                 .           .           .
 138             .           .           .         SC1
                 .           .           .           .
                 .           .           .           .
 143             .           .           .           .        SC2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             SEPTEMBER 1990            *
*               VERSION 4.0             *
*                                       *
* RUN DATE  01/29/1993  TIME  21:59:18  *
*                                       *
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*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER       *
*        609 SECOND STREET              *
*     DAVIS, CALIFORNIA 95616           *
*         (916) 756-1104                *
*                                       *
*****************************************
```

```
FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMSCN.DAT
100-YEAR 6-HOUR STORM 1.6 INCHES
POINT RAINFALL VALUES FROM NOAA ATLAS 2 VOL VII
DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MODEL (CCRFCD, 1990)
CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
LAG TIMES DETERMINED USING METHOD IN SECTION 606.3 IN CCRFCD, 1990
DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
ADJUSTED CURVE NUMBERS BY 5 TO ACCOUNT FOR MOISTER SOILS DURING THE 100-YR EV

12 IO       OUTPUT CONTROL VARIABLES
                  IPRNT          5  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT       HYDROGRAPH TIME DATA
                  NMIN           3  MINUTES IN COMPUTATION INTERVAL
                  IDATE      1   0  STARTING DATE
                  ITIME       0000  STARTING TIME
                  NQ           300  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     1   0  ENDING DATE
                  NDTIME      1457  ENDING TIME
                  ICENT         19  CENTURY MARK

             COMPUTATION INTERVAL     .05 HOURS
                  TOTAL TIME BASE   14.95 HOURS

        ENGLISH UNITS
             DRAINAGE AREA           SQUARE MILES
             PRECIPITATION DEPTH     INCHES
             LENGTH, ELEVATION       FEET
             FLOW                    CUBIC FEET PER SECOND
             STORAGE VOLUME          ACRE-FEET
             SURFACE AREA            ACRES
             TEMPERATURE             DEGREES FAHRENHEIT

14 JD       INDEX STORM NO. 1
                  STRM        1.60  PRECIPITATION DEPTH
                  TRDA         .01  TRANSPOSITION DRAINAGE AREA

15 PI       PRECIPITATION PATTERN
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

```
23 JD       INDEX STORM NO. 2
                  STRM        1.55  PRECIPITATION DEPTH
                  TRDA        1.00  TRANSPOSITION DRAINAGE AREA

 0 PI       PRECIPITATION PATTERN
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

24 JD INDEX STORM NO. 3

STRM 1.38 PRECIPITATION DEPTH

TRDA 9.99 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

25 JD INDEX STORM NO. 4

STRM 1.38 PRECIPITATION DEPTH

TRDA 10.01 TRANSPOSITION DRAINAGE AREA

26 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

34 JD INDEX STORM NO. 5

STRM 1.26 PRECIPITATION DEPTH

TRDA 20.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

35 JD INDEX STORM NO. 6

STRM 1.18 PRECIPITATION DEPTH

TRDA 30.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

36 JD INDEX STORM NO. 7

STRM 1.09 PRECIPITATION DEPTH

TRDA 50.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

37 JD INDEX STORM NO. 8

STRM .96 PRECIPITATION DEPTH

TRDA 100.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

| | OPERATION | STATION | PEAK FLOW | TIME OF PEAK | AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR | 24-HOUR | 72-HOUR | BASIN AREA | MAXIMUM STAGE | TIME OF MAX STAGE |
|---|---|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | MM1A | 284. | 3.75 | 47. | 19. | 19. | .90 | | |
| + | HYDROGRAPH AT | BW1 | 3190. | 6.15 | 1762. | 745. | 745. | 60.50 | | |
| + | HYDROGRAPH AT | BW2 | 1645. | 4.40 | 678. | 273. | 273. | 20.80 | | |
| + | 2 COMBINED AT | BW1&2 | 3513. | 5.75 | 1943. | 817. | 817. | 81.30 | | |
| + | 2 COMBINED AT | BW APX | 3506. | 5.75 | 1948. | 819. | 819. | 82.20 | | |
| + | HYDROGRAPH AT | MM1B | 361. | 4.00 | 78. | 31. | 31. | 2.10 | | |
| + | HYDROGRAPH AT | MM2 | 311. | 3.95 | 65. | 26. | 26. | 1.40 | | |
| + | HYDROGRAPH AT | HP1A | 300. | 3.95 | 62. | 25. | 25. | .80 | | |
| + | ROUTED TO | RTCPA | 284. | 4.35 | 62. | 25. | 25. | .80 | | |
| + | HYDROGRAPH AT | HP1B | 200. | 4.00 | 44. | 18. | 18. | 1.00 | | |
| + | HYDROGRAPH AT | HP2 | 235. | 4.00 | 52. | 21. | 21. | 1.20 | | |
| + | 4 COMBINED AT | CPA1 | 786. | 4.10 | 194. | 78. | 78. | 4.40 | | |
| + | HYDROGRAPH AT | HP3 | 420. | 4.10 | 99. | 40. | 40. | 1.70 | | |
| + | 2 COMBINED AT | CPA2 | 1126. | 4.10 | 274. | 110. | 110. | 6.10 | | |
| + | HYDROGRAPH AT | HP4 | 626. | 4.00 | 139. | 56. | 56. | 3.30 | | |
| + | HYDROGRAPH AT | HP5 | 345. | 3.75 | 56. | 23. | 23. | 1.20 | | |
| + | HYDROGRAPH AT | HP6 | 465. | 4.05 | 106. | 42. | 42. | 2.20 | | |
| + | ROUTED TO | RTCPD | 449. | 4.30 | 106. | 42. | 42. | 2.20 | | |
| + | HYDROGRAPH AT | HPFA | 71. | 3.80 | 12. | 5. | 5. | .30 | | |
| + | 3 COMBINED AT | CPD | 570. | 4.20 | 161. | 64. | 64. | 3.70 | | |
| + | ROUTED TO | RTCPE | 558. | 4.55 | 161. | 64. | 64. | 3.70 | | |
| + | HYDROGRAPH AT | HPFB | 299. | 3.95 | 61. | 25. | 25. | 1.60 | | |
| + | 3 COMBINED AT | CPE | 1108. | 4.15 | 319. | 128. | 128. | 8.60 | | |
| + | 2 COMBINED AT | CPF | 1462. | 4.10 | 513. | 206. | 206. | 14.70 | | |
| + | HYDROGRAPH AT | SC1 | 2178. | 6.15 | 1201. | 508. | 508. | 39.40 | | |
| + | HYDROGRAPH AT | SC2 | 269. | 4.00 | 58. | 23. | 23. | 1.50 | | |

*** NORMAL END OF HEC-1 ***

# HEC-1 MODEL OUTPUT

**FILENAME: RWMSW.OUT**

**(100-YEAR MODEL)**

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*            SEPTEMBER 1990             *
*              VERSION 4.0              *
*                                       *
* RUN DATE  01/29/1993  TIME  22:01:21  *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*     U.S. ARMY CORPS OF ENGINEERS      *
*     HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616          *
*          (916) 756-1104               *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX           X
X     X  X        X     X         XX
X     X  X        X                X
XXXXXXX  XXXX     X         XXXXX  X
X     X  X        X                X
X     X  X        X     X          X
X     X  XXXXXXX   XXXXX          XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1
     1     ID   FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMSW.DAT
     2     ID   100-YEAR 6-HOUR STORM 1.6 INCHES
     3     ID   POINT RAINFALL VALUES FROM NOAA ATLAS 2 VOL VII
     4     ID   DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
     5     ID   CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MAUAL (CCRFCD, 1990)
     6     ID   CURVE NUMBER DETERMINED USING TABLE 602 IN CCRFCD, 1990
     7     ID   LAG TIMES DETERMINED USING METHOD IN SECTION 606.3 IN CCRFCD, 1990
     8     ID   DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
     9     ID   THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
    10     ID   ADJUSTED CURVE NUMBERS BY 10 TO ACCOUNT FOR MOISTER SOILS DURING THE 100-YR E
           *DIAGRAM
    11     IT       3       0       0     300
    12     IO       5
    13     IN       5
    14     JD     1.6     .01
           * RAINFALL DISTRIBUTION FROM CLARK COUNTY MANUAL LESS THAN 10 SQ. MILES
    15     PC       0       2     5.7     7.0     8.7    10.8    12.4    13.0    13.0    13.0
    16     PC    13.0    13.0    13.0    13.3    14.0    14.2    14.8    15.8    17.2    18.1
    17     PC    19.0    19.7    19.9    20.0    20.1    20.4    21.4    22.9    24.1    24.9
    18     PC    25.1    25.6    27.0    27.8    28.1    28.3    29.5    32.2    35.2    40.9
    19     PC    49.9    59.0    71.0    74.4    78.1    81.2    81.9    83.5    85.1    85.6
    20     PC    86.0    86.8    87.6    88.8    91.0    92.6    93.7    95.0    97.0    97.6
    21     PC    98.2    98.5    98.7    98.9    99.0    99.3    99.3    99.4    99.5    99.8
    22     PC    99.8    99.9   100.0
    23     JD    1.55       1
    24     JD    1.38    9.99
           * CHANGED RAINFALL DISTRIBUTION ABOVE 10 SQ. MILES PER CLARK COUNTY MANUAL
    25     JD    1.38   10.01
    26     PC       0     2.0     5.9     8.0    11.0    14.4    15.0    16.0    16.8    17.1
    27     PC    18.0    18.2    18.7    19.0    19.7    20.2    21.0    22.0    23.0    24.1
    28     PC    25.0    25.9    26.5    28.0    29.0    30.0    30.5    30.9    31.0    31.7
    29     PC    32.1    32.7    33.3    34.6    36.1    38.1    40.8    43.0    47.7    51.4
    30     PC    56.1    63.0    71.0    72.0    73.1    75.2    77.9    79.0    79.5    80.4
    31     PC    81.0    82.0    82.6    84.0    85.9    88.9    91.0    93.8    96.6    97.0
    32     PC    97.4    97.9    98.1    98.3    98.5    98.9    99.0    99.2    99.3    99.6
    33     PC    99.7    99.9   100.0
    34     JD    1.26      20
    35     JD    1.18      30
    36     JD    1.09      50
    37     JD     .96     100

    38     KK    MM1A
    39     KM   Basin runoff calculation for Mass. Mountains 1A
    40     BA      .9
    41     LS              90
    42     UD     .31

    43     KK     BW1
    44     KM     Basin runoff calculation for Barren Wash 1
    45     BA    60.5
    46     LS              93
    47     UD     2.1
```

```
 48    KK     BW2
 49    KM     Basin runoff calculation for Barren Wash 2
 50    BA    20.8
 51    LS              90
 52    UD      .9

 53    KK    BW1&2
 54    KM    Combined BW1 and BW2
 55    HC       2

 56    KK   BW APX
 57    KM    Combine BW1,BW2, and MM1A (assume dischcarge of Barren Wash "active apex")
 58    HC       2

 59    KK     MM1B
 60    KM      Basin runoff calulation for Mass. Mountains 1B
       *    Flow was not combined with BW APX because flow from this watershed
       *    will not directly impact RWMS wereas a channel migration at the apex
       *    could impact the RWMS
 61    BA      2.1
 62    LS              87
 63    UD      .48

 64    KK      MM2
 65    KM     Basin runoff calculation for Mass. Mountains 2
 66    BA      1.4
 67    LS              89
 68    UD      .47

 69    KK     HP1A
 70    KM     Basin runoff calculation for Half Pint Range 1A
 71    BA      .8
 72    LS              95
 73    UD      .48

 74    KK     RTCPA
 75    KM     Route Flow from HP1A to CPA
 76    RM       9     .43      .2

 77    KK      HP1B
 78    KM     Basin runoff calculation for Half Pint Range 1B
 79    BA      1.0
 80    LS              88
 81    UD      .51

 82    KK      HP2
 83    KM     Basin runoff calculation for Half Pint Range 2
 84    BA     1.2
 85    LS              88
 86    UD      .51

 87    KK     CPA1
 88    KM     Combine MM2, routed HP1A, HP1B, HP2
 89    HC       4

 90    KK      HP3
 91    KM      (CPB) Basin runoff calculation for Half Pint Range 3
 92    BA      1.7
 93    LS              92
 94    UD      .59

 95    KK     CPA2
 96    KM     Combine HP3 with flow from CPA1
 97    HC       2

 98    KK      HP4
 99    KM      (CPC) Basin runoff calculation for Half Pint Range 4
100    BA      3.3
101    LS              89
102    UD      .52

103    KK      HP5
104    KM      Basin runoff calculation for Half Pint Range 5
105    BA      1.2
106    LS              89
107    UD       .3

108    KK      HP6
109    KM      Basin runoff calculation for Half Pint Range 6
110    BA      2.2
111    LS              90
112    UD      .55

113    KK    RTCPD
114    KM     Route HP6 to CPD
115    RM       5     .27      .2
```

```
KK    HPFA
KM     Basin runoff calculation for Half Pint Range FA
BA      .3
LS              87
UD     .33

KK     CPD
KM     Combine HP5, routed HP6, and HPFA
HC       3

KK   RTCPE
KM     Route flow from CPD to CPE
RM       8      .39      .2

KK    HPFB
KM     Basin runoff calculation for Half Pint Range FB
BA     1.6
LS              87
UD     .44

KK     CPE
KM    Combine HP4 (CPC) with routed flow from CPD, and HPFB
HC       3

KK     CPF
KM    Combine all flow at Concentration just below RWMS (Flow from CPA & CPE)
HC       2

KK     SC1
KM     Basin runoff calculation for Scarp Canyon 1
* Concentration Pt of this watershed is the active apex of the Scarp Canyon Fan
BA    39.4
LS              92
UD     2.1

KK     SC2
KM     Basin runoff calculation for Scarp Canyon 2
BA     1.5
LS              87
UD     .48
ZZ
```

```
                SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE      (V) ROUTING           (--->) DIVERSION OR PUMP FLOW

  NO.      (.) CONNECTOR         (<---) RETURN OF DIVERTED OR PUMPED FLOW

   38        MM1A
               .
   43          .          BW1
               .           .
   48          .           .          BW2
               .           .           .
   53          .        BW1&2...........
               .           .
   56       BW APX..........
               .
   59          .         MM1B
               .           .
   64          .           .          MM2
               .           .           .
   69          .           .           .         HP1A
               .           .           .           V
   74          .           .           .           V
               .           .           .         RTCPA
   77          .           .           .           .
               .           .           .           .         HP1B
   82          .           .           .           .           .
               .           .           .           .           .         HP2
   87          .           .           .           .           .           .
               .           .         CPA1.............................
   90          .           .           .
               .           .           .          HP3
   95          .           .           .           .
               .           .         CPA2...........
   98          .           .           .
               .           .           .          HP4
  103          .           .           .           .
               .           .           .           .          HP5
  108          .           .           .           .           .
               .           .           .           .           .         HP6
  113          .           .           .           .           .           V
               .           .           .           .           .           V
               .           .           .           .           .         RTCPD
  116          .           .           .           .           .           .
               .           .           .           .           .           .          HPFA
  121          .           .           .           .           .           .           .
               .           .           .           .          CPD........................
  124          .           .           .           .           V
               .           .           .           .           V
               .           .           .           .         RTCPE
  127          .           .           .           .           .
               .           .           .           .           .         HPFB
  132          .           .           .           .           .           .
               .           .           .          CPE.......................
  135          .           .           .           .
               .           .          CPF............
  138          .           .           .
               .           .           .          SC1
  143          .           .           .           .
               .           .           .           .          SC2
(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE   (HEC-1)   *
*          SEPTEMBER 1990               *
*            VERSION 4.0                *
*                                       *
* RUN DATE  01/29/1993  TIME  22:01:21  *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*          (916) 756-1104               *
*                                       *
*****************************************
```

```
                    FLOOD ASSESSMENT FOR RWMS JOB #:51056        FILE: RWMSW.DAT
                    100-YEAR 6-HOUR STORM 1.6 INCHES
                    POINT RAINFALL VALUES FROM NOAA ATLAS 2 VOL VII
                    DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
                    CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MAUAL (CCRFCD, 1990)
                    CURVE NUMBER DETERMINED USING TABLE 602 IN CCRFCD, 1990
                    LAG TIMES DETERMINED USING METHOD IN SECTION 606.3 IN CCRFCD, 1990
                    DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
                    THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
                    ADJUSTED CURVE NUMBERS BY 10 TO ACCOUNT FOR MOISTER SOILS DURING THE 100-YR E

  12 IO          OUTPUT CONTROL VARIABLES
                      IPRNT           5  PRINT CONTROL
                      IPLOT           0  PLOT CONTROL
                      QSCAL          0.  HYDROGRAPH PLOT SCALE

   IT            HYDROGRAPH TIME DATA
                      NMIN            3  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      1    0  ENDING DATE
                     NDTIME        1457  ENDING TIME
                      ICENT          19  CENTURY MARK

                  COMPUTATION INTERVAL    .05 HOURS
                      TOTAL TIME BASE   14.95 HOURS

            ENGLISH UNITS
                DRAINAGE AREA          SQUARE MILES
                PRECIPITATION DEPTH    INCHES
                LENGTH, ELEVATION      FEET
                FLOW                   CUBIC FEET PER SECOND
                STORAGE VOLUME         ACRE-FEET
                SURFACE AREA           ACRES
                TEMPERATURE            DEGREES FAHRENHEIT

  14 JD          INDEX STORM NO. 1
                       STRM        1.60  PRECIPITATION DEPTH
                       TRDA         .01  TRANSPOSITION DRAINAGE AREA

  15 PI           PRECIPITATION PATTERN
                   1.20     1.54     2.22     1.26      .78     1.02     1.10     1.26     1.06      .96
                    .36      .24      .00      .00      .00      .00      .00      .00      .00      .00
                    .18      .26      .42      .22      .12      .36      .44      .60      .76      .84
                    .54      .54      .54      .46      .42      .12      .10      .06      .06      .06
                    .18      .32      .60      .80      .90      .72      .64      .48      .24      .12
                    .30      .48      .84      .60      .48      .18      .16      .12      .52      .72
                   1.62     1.68     1.80     2.88     3.42     5.40     5.42     5.46     6.62     7.20
                   2.04     2.10     2.22     1.98     1.86      .42      .60      .96      .96      .96
                    .30      .28      .24      .40      .48      .48      .56      .72     1.12     1.32
                    .96      .86      .66      .74      .78     1.20      .92      .36      .36      .36
                    .18      .16      .12      .12      .12      .06      .10      .18      .06      .00
                    .06      .06      .06      .14      .18      .00      .02      .06      .06      .06

  23 JD          INDEX STORM NO. 2
                       STRM        1.55  PRECIPITATION DEPTH
                       TRDA        1.00  TRANSPOSITION DRAINAGE AREA

   0 PI           PRECIPITATION PATTERN
                   1.20     1.54     2.22     1.26      .78     1.02     1.10     1.26     1.06      .96
                    .36      .24      .00      .00      .00      .00      .00      .00      .00      .00
                    .18      .26      .42      .22      .12      .36      .44      .60      .76      .84
                    .54      .54      .54      .46      .42      .12      .10      .06      .06      .06
                    .18      .32      .60      .80      .90      .72      .64      .48      .24      .12
                    .30      .48      .84      .60      .48      .18      .16      .12      .52      .72
                   1.62     1.68     1.80     2.88     3.42     5.40     5.42     5.46     6.62     7.20
                   2.04     2.10     2.22     1.98     1.86      .42      .60      .96      .96      .96
                    .30      .28      .24      .40      .48      .48      .56      .72     1.12     1.32
                    .96      .86      .66      .74      .78     1.20      .92      .36      .36      .36
                    .18      .16      .12      .12      .12      .06      .10      .18      .06      .00
                    .06      .06      .06      .14      .18      .00      .02      .06      .06      .06
```

24 JD INDEX STORM NO. 3

| | | |
|---|---|---|
| STRM | 1.38 | PRECIPITATION DEPTH |
| TRDA | 9.99 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

25 JD INDEX STORM NO. 4

| | | |
|---|---|---|
| STRM | 1.38 | PRECIPITATION DEPTH |
| TRDA | 10.01 | TRANSPOSITION DRAINAGE AREA |

26 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

34 JD INDEX STORM NO. 5

| | | |
|---|---|---|
| STRM | 1.26 | PRECIPITATION DEPTH |
| TRDA | 20.00 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

35 JD INDEX STORM NO. 6

| | | |
|---|---|---|
| STRM | 1.18 | PRECIPITATION DEPTH |
| TRDA | 30.00 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

36 JD INDEX STORM NO. 7

| | | |
|---|---|---|
| STRM | 1.09 | PRECIPITATION DEPTH |
| TRDA | 50.00 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

37 JD INDEX STORM NO. 8

| | | |
|---|---|---|
| STRM | .96 | PRECIPITATION DEPTH |
| TRDA | 100.00 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

| | OPERATION | STATION | PEAK FLOW | TIME OF PEAK | AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR | 24-HOUR | 72-HOUR | BASIN AREA | MAXIMUM STAGE | TIME OF MAX STAGE |
|---|---|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | MM1A | 426. | 3.75 | 70. | 28. | 28. | .90 | | |
| + | HYDROGRAPH AT | BW1 | 5241. | 6.00 | 2989. | 1289. | 1289. | 60.50 | | |
| + | HYDROGRAPH AT | BW2 | 2759. | 4.35 | 1102. | 445. | 445. | 20.80 | | |
| + | 2 COMBINED AT | BW1&2 | 6018. | 5.65 | 3425. | 1462. | 1462. | 81.30 | | |
| + | 2 COMBINED AT | BW APX | 6014. | 5.65 | 3441. | 1469. | 1469. | 82.20 | | |
| + | HYDROGRAPH AT | MM1B | 580. | 3.95 | 120. | 48. | 48. | 2.10 | | |
| + | HYDROGRAPH AT | MM2 | 477. | 3.95 | 98. | 39. | 39. | 1.40 | | |
| + | HYDROGRAPH AT | HP1A | 423. | 3.90 | 91. | 37. | 37. | .80 | | |
| + | ROUTED TO | RTCPA | 401. | 4.35 | 91. | 37. | 37. | .80 | | |
| + | HYDROGRAPH AT | HP1B | 309. | 4.00 | 66. | 27. | 27. | 1.00 | | |
| + | HYDROGRAPH AT | HP2 | 365. | 4.00 | 78. | 32. | 32. | 1.20 | | |
| + | 4 COMBINED AT | CPA1 | 1229. | 4.05 | 298. | 120. | 120. | 4.40 | | |
| + | HYDROGRAPH AT | HP3 | 624. | 4.05 | 148. | 59. | 59. | 1.70 | | |
| + | 2 COMBINED AT | CPA2 | 1757. | 4.05 | 423. | 170. | 170. | 6.10 | | |
| + | HYDROGRAPH AT | HP4 | 984. | 4.00 | 214. | 86. | 86. | 3.30 | | |
| + | HYDROGRAPH AT | HP5 | 526. | 3.75 | 85. | 34. | 34. | 1.20 | | |
| + | HYDROGRAPH AT | HP6 | 711. | 4.00 | 160. | 64. | 64. | 2.20 | | |
| + | ROUTED TO | RTCPD | 689. | 4.30 | 160. | 64. | 64. | 2.20 | | |
| + | HYDROGRAPH AT | HPFA | 110. | 3.80 | 19. | 8. | 8. | .30 | | |
| + | 3 COMBINED AT | CPD | 884. | 4.15 | 246. | 99. | 99. | 3.70 | | |
| + | ROUTED TO | RTCPE | 868. | 4.50 | 246. | 99. | 99. | 3.70 | | |
| + | HYDROGRAPH AT | HPFB | 476. | 3.90 | 94. | 38. | 38. | 1.60 | | |
| + | 3 COMBINED AT | CPE | 1819. | 4.10 | 502. | 202. | 202. | 8.60 | | |
| + | 2 COMBINED AT | CPF | 2396. | 4.05 | 820. | 330. | 330. | 14.70 | | |
| + | HYDROGRAPH AT | SC1 | 3498. | 6.00 | 1988. | 855. | 855. | 39.40 | | |
| + | HYDROGRAPH AT | SC2 | 427. | 3.95 | 89. | 36. | 36. | 1.50 | | |

*** NORMAL END OF HEC-1 ***

# HEC-1 MODEL OUTPUT

**FILENAME: RWMSC.OUT**

**(100-YEAR MODEL)**

```
*****************************************          *****************************************
*                                       *          *                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *          *   U.S. ARMY CORPS OF ENGINEERS        *
*            SEPTEMBER 1990             *          *   HYDROLOGIC ENGINEERING CENTER       *
*             VERSION 4.0               *          *         609 SECOND STREET             *
*                                       *          *      DAVIS, CALIFORNIA 95616          *
*  RUN DATE  01/29/1993  TIME  22:03:06 *          *          (916) 756-1104               *
*                                       *          *                                       *
*****************************************          *****************************************
```

```
X       X  XXXXXXX   XXXXX           X
X       X  X        X     X         XX
X       X  X        X                X
XXXXXXX    XXXX     X       XXXXX    X
X       X  X        X                X
X       X  X        X     X          X
X       X  XXXXXXX   XXXXX          XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL    LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
  1   ID   FLOOD ASSESSMENT FOR RWMS JOB #:51056           FILE: RWMSC.DAT
  2   ID   100-YEAR 6-HOUR STORM 2.43 INCHES
  3   ID   POINT RAINFALL VALUES FROM NOAA ATLAS 2 VOL VII
  4   ID   ADJUSTED RAINFALL PER CORRECTION FACTOR IN TABLE 501 OF
  5   ID   CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCRFCD, 1990)
  6   ID   DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN CCRFCD, 1990
  7   ID   CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
  8   ID   LAG TIMES DETERMINED USING METHOD IN SECITON 606.3 IN CCRFCD, 1990
  9   ID   DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
 10   ID   THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
      *DIAGRAM
 11   IT       3        0        0      300
 12   IO       5
 13   IN       5
 14   JD    2.43      .01
      * RAINFALL DISTRIBUTION FROM CLARK COUNTY MANUAL LESS THAN 10 SQ. MILES
 15   PC       0        2      5.7      7.0      8.7     10.8     12.4     13.0     13.0     13.0
 16   PC    13.0     13.0     13.0     13.3     14.0     14.2     14.8     15.8     17.2     18.1
 17   PC    19.0     19.7     19.9     20.0     20.1     20.4     21.4     22.9     24.1     24.9
 18   PC    25.1     25.6     27.0     27.8     28.1     28.3     29.5     32.2     35.2     40.9
 19   PC    49.9     59.0     71.0     74.4     78.1     81.2     81.9     83.5     85.1     85.6
 20   PC    86.0     86.8     87.6     88.8     91.0     92.6     93.7     95.0     97.0     97.6
 21   PC    98.2     98.5     98.7     98.9     99.0     99.3     99.3     99.4     99.5     99.8
 22   PC    99.8     99.9    100.0
 23   JD    2.36        1
 24   JD    2.09     9.99
      * CHANGED RAINFALL DISTRIBUTION ABOVE 10 SQ. MILES PER CLARK COUNTY MANUAL
 25   JD    2.09    10.01
 26   PC       0      2.0      5.9      8.0     11.0     14.4     15.0     16.0     16.8     17.1
 27   PC    18.0     18.2     18.7     19.0     19.7     20.2     21.0     22.0     23.0     24.1
 28   PC    25.0     25.9     26.5     28.0     29.0     30.0     30.5     30.9     31.0     31.7
 29   PC    32.1     32.7     33.3     34.6     36.1     38.1     40.8     43.0     47.7     51.4
 30   PC    56.1     63.0     71.0     72.0     73.1     75.2     77.9     79.0     79.5     80.4
 31   PC    81.0     82.0     82.6     84.0     85.9     88.9     91.0     93.8     96.6     97.0
 32   PC    97.4     97.9     98.1     98.3     98.5     98.9     99.0     99.2     99.3     99.6
 33   PC    99.7     99.9    100.0
 34   JD    1.92       20
 35   JD    1.80       30
 36   JD    1.65       50
 37   JD    1.46      100

 38   KK    MM1A
 39   KM   Basin runoff calculation for Mass. Mountains 1A
 40   BA      .9
 41   LS               80
 42   UD     .31

 43   KK     BW1
 44   KM     Basin runoff calculation for Barren Wash 1
 45   BA    60.5
 46   LS               83
 47   UD     2.1
```

```
KK    BW2
KM     Basin runoff calculation for Barren Wash 2
BA    20.8
LS              80
UD      .9

KK   BW1&2
KM   Combined BW1 and BW2
HC       2

KK  BW APX
KM   Combine BW1,BW2, and MM1A (assume dischcarge of Barren Wash "active apex")
HC       2

KK     MM1B
KM     Basin runoff calulation for Mass. Mountains 1B
*    Flow was not combined with BW APX because flow from this watershed
*    will not directly impact RWMS wereas a channel migration at the apex
*    could impact the RWMS
BA      2.1
LS              77
UD      .48

KK     MM2
KM     Basin runoff calculation for Mass. Mountains 2
BA      1.4
LS              79
UD      .47

KK     HP1A
KM     Basin runoff calculation for Half Pint Range 1A
BA       .8
LS              85
UD      .48

KK    RTCPA
KM    Route Flow from HP1A to CPA
RM       9      .43       .2

KK     HP1B
KM     Basin runoff calculation for Half Pint Range 1B
BA      1.0
LS              78
UD      .51

KK     HP2
KM     Basin runoff calculation for Half Pint Range 2
BA     1.2
LS              78
UD      .51

KK     CPA1
KM     Combine MM2, routed HP1A, HP1B, HP2
HC       4

KK      HP3
KM      (CPB) Basin runoff calculation for Half Pint Range 3
BA      1.7
LS              82
UD      .59

KK     CPA2
KM     Combine HP3 with flow from CPA1
HC       2

KK      HP4
KM      (CPC) Basin runoff calculation for Half Pint Range 4
BA      3.3
LS              79
UD      .52

KK      HP5
KM      Basin runoff calculation for Half Pint Range 5
BA      1.2
LS              79
UD       .3

KK      HP6
KM      Basin runoff calculation for Half Pint Range 6
BA      2.2
LS              80
UD      .55

KK     RTCPD
KM     Route HP6 to CPD
RM       5      .27       .2
```

```
KK    HPFA
KM     Basin runoff calculation for Half Pint Range FA
BA      .3
LS              77
UD     .33

KK     CPD
KM     Combine HP5, routed HP6, and HPFA
HC      3

KK   RTCPE
KM     Route flow from CPD to CPE
RM      8     .39      .2

KK     HPFB
KM     Basin runoff calculation for Half Pint Range FB
BA     1.6
LS              77
UD     .44

KK     CPE
KM    Combine HP4 (CPC) with routed flow from CPD, and HPFB
HC      3

KK     CPF
KM    Combine all flow at Concentration just below RWMS (Flow from CPA & CPE)
HC      2

KK     SC1
KM     Basin runoff calculation for Scarp Canyon 1
* Concentration Pt of this watershed is the active apex of the Scarp Canyon Fan
BA    39.4
LS              82
UD     2.1

KK     SC2
KM     Basin runoff calculation for Scarp Canyon 2
BA     1.5
LS              77
UD     .48
ZZ
```

```
             SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE     (V) ROUTING           (--->) DIVERSION OR PUMP FLOW

  NO.     (.) CONNECTOR         (<---) RETURN OF DIVERTED OR PUMPED FLOW

   38        MM1A
                .
                .
   43           .        BW1
                .           .
                .           .
   48           .           .         BW2
                .           .           .
                .           .           .
   53           .      BW1&2............
                .           .
                .           .
   56      BW APX............
                .
                .
   59           .        MM1B
                .           .
                .           .
   64           .           .         MM2
                .           .           .
                .           .           .
   69           .           .           .        HP1A
                .           .           .           V
                .           .           .           V
   74           .           .           .       RTCPA
                .           .           .           .
                .           .           .           .
   77           .           .           .           .        HP1B
                .           .           .           .           .
                .           .           .           .           .
   82           .           .           .           .           .         HP2
                .           .           .           .           .           .
                .           .           .           .           .           .
   87           .           .        CPA1....................................
                .           .           .
                .           .           .
   90           .           .           .         HP3
                .           .           .           .
                .           .           .           .
   95           .           .        CPA2............
                .           .           .
                .           .           .
   98           .           .           .         HP4
                .           .           .           .
                .           .           .           .
  103           .           .           .           .         HP5
                .           .           .           .           .
                .           .           .           .           .
  108           .           .           .           .           .         HP6
                .           .           .           .           .           V
                .           .           .           .           .           V
  113           .           .           .           .           .       RTCPD
                .           .           .           .           .           .
                .           .           .           .           .           .
  116           .           .           .           .           .           .        HPFA
                .           .           .           .           .           .           .
                .           .           .           .           .           .           .
  121           .           .           .           .         CPD........................
                .           .           .           .           V
                .           .           .           .           V
  124           .           .           .           .       RTCPE
                .           .           .           .           .
                .           .           .           .           .
  127           .           .           .           .           .        HPFB
                .           .           .           .           .           .
                .           .           .           .           .           .
  132           .           .           .         CPE........................
                .           .           .           .
                .           .           .           .
  135           .           .         CPF............
                .           .           .
                .           .           .
  138           .           .           .         SC1
                .           .           .           .
                .           .           .           .
  143           .           .           .           .         SC2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
*****************************************                    *****************************************
*                                       *                    *                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *                    *  U.S. ARMY CORPS OF ENGINEERS         *
*            SEPTEMBER 1990             *                    *  HYDROLOGIC ENGINEERING CENTER        *
*              VERSION 4.0              *                    *        609 SECOND STREET              *
*                                       *                    *     DAVIS, CALIFORNIA 95616           *
* RUN DATE  01/29/1993  TIME  22:03:06  *                    *        (916) 756-1104                 *
*                                       *                    *                                       *
*****************************************                    *****************************************


                    FLOOD ASSESSMENT FOR RWMS JOB #:51056        FILE: RWMSC.DAT
                    100-YEAR 6-HOUR STORM 2.43 INCHES
                    POINT RAINFALL VALUES FROM NOAA ATLAS 2 VOL VII
                    ADJUSTED RAINFALL PER CORRECTION FACTOR IN TABLE 501 OF
                    CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCRFCD, 1990)
                    DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN CCRFCD, 1990
                    CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
                    LAG TIMES DETERMINED USING METHOD IN SECITON 606.3 IN CCRFCD, 1990
                    DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
                    THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS

12 IO          OUTPUT CONTROL VARIABLES
                    IPRNT          5  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT           HYDROGRAPH TIME DATA
                     NMIN          3  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1   0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ        300  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      1   0  ENDING DATE
                   NDTIME       1457  ENDING TIME
                    ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL    .05 HOURS
                     TOTAL TIME BASE  14.95 HOURS

          ENGLISH UNITS
               DRAINAGE AREA          SQUARE MILES
               PRECIPITATION DEPTH    INCHES
               LENGTH, ELEVATION      FEET
               FLOW                   CUBIC FEET PER SECOND
               STORAGE VOLUME         ACRE-FEET
               SURFACE AREA           ACRES
               TEMPERATURE            DEGREES FAHRENHEIT

14 JD           INDEX STORM NO. 1
                     STRM       2.43  PRECIPITATION DEPTH
                     TRDA        .01  TRANSPOSITION DRAINAGE AREA

15 PI           PRECIPITATION PATTERN
                     1.20     1.54     2.22     1.26      .78     1.02     1.10     1.26     1.06      .96
                      .36      .24      .00      .00      .00      .00      .00      .00      .00      .00
                      .18      .26      .42      .22      .12      .36      .44      .60      .76      .84
                      .54      .54      .54      .46      .42      .12      .10      .06      .06      .06
                      .18      .32      .60      .80      .90      .72      .64      .48      .24      .12
                      .30      .48      .84      .60      .48      .18      .16      .12      .52      .72
                     1.62     1.68     1.80     2.88     3.42     5.40     5.42     5.46     6.62     7.20
                     2.04     2.10     2.22     1.98     1.86      .42      .60      .96      .96      .96
                      .30      .28      .24      .40      .48      .48      .56      .72     1.12     1.32
                      .96      .86      .66      .74      .78     1.20      .92      .36      .36      .36
                      .18      .16      .12      .12      .12      .06      .10      .18      .06      .00
                      .06      .06      .06      .14      .18      .00      .02      .06      .06      .06

23 JD           INDEX STORM NO. 2
                     STRM       2.36  PRECIPITATION DEPTH
                     TRDA       1.00  TRANSPOSITION DRAINAGE AREA

 0 PI           PRECIPITATION PATTERN
                     1.20     1.54     2.22     1.26      .78     1.02     1.10     1.26     1.06      .96
                      .36      .24      .00      .00      .00      .00      .00      .00      .00      .00
                      .18      .26      .42      .22      .12      .36      .44      .60      .76      .84
                      .54      .54      .54      .46      .42      .12      .10      .06      .06      .06
                      .18      .32      .60      .80      .90      .72      .64      .48      .24      .12
                      .30      .48      .84      .60      .48      .18      .16      .12      .52      .72
                     1.62     1.68     1.80     2.88     3.42     5.40     5.42     5.46     6.62     7.20
                     2.04     2.10     2.22     1.98     1.86      .42      .60      .96      .96      .96
                      .30      .28      .24      .40      .48      .48      .56      .72     1.12     1.32
                      .96      .86      .66      .74      .78     1.20      .92      .36      .36      .36
                      .18      .16      .12      .12      .12      .06      .10      .18      .06      .00
                      .06      .06      .06      .14      .18      .00      .02      .06      .06      .06
```

24 JD INDEX STORM NO. 3

STRM 2.09 PRECIPITATION DEPTH

TRDA 9.99 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

25 JD INDEX STORM NO. 4

STRM 2.09 PRECIPITATION DEPTH

TRDA 10.01 TRANSPOSITION DRAINAGE AREA

26 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

34 JD INDEX STORM NO. 5

STRM 1.92 PRECIPITATION DEPTH

TRDA 20.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

35 JD INDEX STORM NO. 6

STRM 1.80 PRECIPITATION DEPTH

TRDA 30.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

36 JD INDEX STORM NO. 7

STRM 1.65 PRECIPITATION DEPTH

TRDA 50.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

37 JD INDEX STORM NO. 8

STRM 1.46 PRECIPITATION DEPTH

TRDA 100.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

| | OPERATION | STATION | PEAK FLOW | TIME OF PEAK | AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR | 24-HOUR | 72-HOUR | BASIN AREA | MAXIMUM STAGE | TIME OF MAX STAGE |
|---|---|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | MM1A | 467. | 3.75 | 77. | 31. | 31. | .90 | | |
| + | HYDROGRAPH AT | BW1 | 4883. | 6.15 | 2699. | 1141. | 1141. | 60.50 | | |
| + | HYDROGRAPH AT | BW2 | 2778. | 4.40 | 1133. | 456. | 456. | 20.80 | | |
| + | 2 COMBINED AT | BW1&2 | 5498. | 5.75 | 3049. | 1282. | 1282. | 81.30 | | |
| + | 2 COMBINED AT | BW APX | 5488. | 5.75 | 3060. | 1287. | 1287. | 82.20 | | |
| + | HYDROGRAPH AT | MM1B | 644. | 4.00 | 136. | 55. | 55. | 2.10 | | |
| + | HYDROGRAPH AT | MM2 | 526. | 3.95 | 108. | 44. | 44. | 1.40 | | |
| + | HYDROGRAPH AT | HP1A | 444. | 3.95 | 92. | 37. | 37. | .80 | | |
| + | ROUTED TO | RTCPA | 420. | 4.40 | 92. | 37. | 37. | .80 | | |
| + | HYDROGRAPH AT | HP1B | 346. | 4.00 | 75. | 30. | 30. | 1.00 | | |
| + | HYDROGRAPH AT | HP2 | 407. | 4.00 | 89. | 36. | 36. | 1.20 | | |
| + | 4 COMBINED AT | CPA1 | 1297. | 4.05 | 317. | 127. | 127. | 4.40 | | |
| + | HYDROGRAPH AT | HP3 | 661. | 4.05 | 156. | 63. | 63. | 1.70 | | |
| + | 2 COMBINED AT | CPA2 | 1827. | 4.10 | 442. | 177. | 177. | 6.10 | | |
| + | HYDROGRAPH AT | HP4 | 1060. | 4.00 | 233. | 94. | 94. | 3.30 | | |
| + | HYDROGRAPH AT | HP5 | 582. | 3.75 | 94. | 38. | 38. | 1.20 | | |
| + | HYDROGRAPH AT | HP6 | 766. | 4.05 | 174. | 70. | 70. | 2.20 | | |
| + | ROUTED TO | RTCPD | 741. | 4.30 | 174. | 70. | 70. | 2.20 | | |
| + | HYDROGRAPH AT | HPFA | 125. | 3.80 | 21. | 9. | 9. | .30 | | |
| + | 3 COMBINED AT | CPD | 945. | 4.15 | 266. | 107. | 107. | 3.70 | | |
| + | ROUTED TO | RTCPE | 927. | 4.55 | 266. | 107. | 107. | 3.70 | | |
| + | HYDROGRAPH AT | HPFB | 533. | 3.95 | 107. | 43. | 43. | 1.60 | | |
| + | 3 COMBINED AT | CPE | 1898. | 4.10 | 537. | 215. | 215. | 8.60 | | |
| + | 2 COMBINED AT | CPF | 2462. | 4.05 | 854. | 343. | 343. | 14.70 | | |
| + | HYDROGRAPH AT | SC1 | 3438. | 6.15 | 1900. | 804. | 804. | 39.40 | | |
| + | HYDROGRAPH AT | SC2 | 478. | 4.00 | 101. | 41. | 41. | 1.50 | | |

*** NORMAL END OF HEC-1 ***

# HEC-1 MODEL OUTPUT

**FILENAME: RWMS10.OUT**

**(10-YEAR MODEL)**

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*            SEPTEMBER 1990             *
*             VERSION 4.0               *
*                                       *
* RUN DATE  01/29/1993  TIME  22:05:10  *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*   U.S. ARMY CORPS OF ENGINEERS        *
*   HYDROLOGIC ENGINEERING CENTER       *
*        609 SECOND STREET              *
*     DAVIS, CALIFORNIA 95616           *
*         (916) 756-1104                *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX           X
X     X  X        X     X         XX
X     X  X        X                X
XXXXXXX  XXXX     X         XXXXX  X
X     X  X        X                X
X     X  X        X     X          X
X     X  XXXXXXX   XXXXX          XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
 1      ID   FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMS10.DAT
 2      ID   10-YEAR 6-HOUR STORM 1.1 INCHES
 3      ID   POINT RAINFALL VALUE FROM NOAA ATLASS 2 VOL VII
 4      ID   DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
 5      ID   CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCRFCD, 1990)
 6      ID   CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
 7      ID   LAG TIMES DETEMINED USING METHOD IN SECTION 606.3 IN CCRFCD, 1990
 8      ID   DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
 9      ID   THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
        *DIAGRAM
10      IT       3        0        0      300
11      IO       5
12      IN       5
13      JD     1.1      .01
        * RAINFALL DISTRIBUTION FROM CLARK COUNTY MANUAL LESS THAN 10 SQ. MILES
14      PC       0        2      5.7      7.0      8.7     10.8     12.4     13.0     13.0     13.0
15      PC    13.0     13.0     13.0     13.3     14.0     14.2     14.8     15.8     17.2     18.1
16      PC    19.0     19.7     19.9     20.0     20.1     20.4     21.4     22.9     24.1     24.9
17      PC    25.1     25.6     27.0     27.8     28.1     28.3     29.5     32.2     35.2     40.9
18      PC    49.9     59.0     71.0     74.4     78.1     81.2     81.9     83.5     85.1     85.6
19      PC    86.0     86.8     87.6     88.8     91.0     92.6     93.7     95.0     97.0     97.6
20      PC    98.2     98.5     98.7     98.9     99.0     99.3     99.3     99.4     99.5     99.8
21      PC    99.8     99.9    100.0
22      JD    1.07        1
23      JD     .95     9.99
        * CHANGED RAINFALL DISTRIBUTION ABOVE 10 SQ. MILES PER CLARK COUNTY MANUAL
24      JD     .95    10.01
25      PC       0      2.0      5.9      8.0     11.0     14.4     15.0     16.0     16.8     17.1
26      PC    18.0     18.2     18.7     19.0     19.7     20.2     21.0     22.0     23.0     24.1
27      PC    25.0     25.9     26.5     28.0     29.0     30.0     30.5     30.9     31.0     31.7
28      PC    32.1     32.7     33.3     34.6     36.1     38.1     40.8     43.0     47.7     51.4
29      PC    56.1     63.0     71.0     72.0     73.1     75.2     77.9     79.0     79.5     80.4
30      PC    81.0     82.0     82.6     84.0     85.9     88.9     91.0     93.8     96.6     97.0
31      PC    97.4     97.9     98.1     98.3     98.5     98.9     99.0     99.2     99.3     99.6
32      PC    99.7     99.9    100.0
33      JD     .87       20
34      JD     .81       30
35      JD     .75       50
36      JD     .66      100

37      KK    MM1A
38      KM   Basin runoff calculation for Mass. Mountains 1A
39      BA      .9
40      LS                80
41      UD     .31

42      KK     BW1
43      KM     Basin runoff calculation for Barren Wash 1
44      BA    60.5
45      LS                83
46      UD     2.1
```

```
 47    KK    BW2
 48    KM     Basin runoff calculation for Barren Wash 2
 49    BA    20.8
 50    LS              80
 51    UD      .9

 52    KK   BW1&2
 53    KM   Combined BW1 and BW2
 54    HC      2

 55    KK  BW APX
 56    KM   Combine BW1,BW2, and MM1A (assume dischcarge of Barren Wash "active apex")
 57    HC      2

 58    KK     MM1B
 59    KM     Basin runoff calulation for Mass. Mountains 1B
       *   Flow was not combined with BW APX because flow from this watershed
       *   will not directly impact RWMS wereas a channel migration at the apex
       *   could impact the RWMS
 60    BA     2.1
 61    LS              77
 62    UD     .48

 63    KK     MM2
 64    KM    Basin runoff calculation for Mass. Mountains 2
 65    BA     1.4
 66    LS              79
 67    UD     .47

 68    KK    HP1A
 69    KM    Basin runoff calculation for Half Pint Range 1A
 70    BA      .8
 71    LS              85
 72    UD     .48

 73    KK   RTCPA
 74    KM   Route Flow from HP1A to CPA
 75    RM      9     .43      .2

 76    KK    HP1B
 77    KM    Basin runoff calculation for Half Pint Range 1B
 78    BA     1.0
 79    LS              78
 80    UD     .51

 81    KK    HP2
 82    KM    Basin runoff calculation for Half Pint Range 2
 83    BA    1.2
 84    LS              78
 85    UD     .51

 86    KK    CPA1
 87    KM    Combine MM2, routed HP1A, HP1B, HP2
 88    HC      4

 89    KK     HP3
 90    KM     (CPB) Basin runoff calculation for Half Pint Range 3
 91    BA     1.7
 92    LS              82
 93    UD     .59

 94    KK    CPA2
 95    KM    Combine HP3 with flow from CPA1
 96    HC      2

 97    KK     HP4
 98    KM     (CPC) Basin runoff calculation for Half Pint Range 4
 99    BA     3.3
100    LS              79
101    UD     .52

102    KK     HP5
103    KM     Basin runoff calculation for Half Pint Range 5
104    BA     1.2
105    LS              79
106    UD      .3

107    KK     HP6
108    KM     Basin runoff calculation for Half Pint Range 6
109    BA     2.2
110    LS              80
111    UD     .55

112    KK   RTCPD
113    KM    Route HP6 to CPD
114    RM      5     .27      .2
```

```
KK     HPFA
KM      Basin runoff calculation for Half Pint Range FA
BA       .3
LS                 77
UD       .33

KK      CPD
KM      Combine HP5, routed HP6, and HPFA
HC        3

KK    RTCPE
KM      Route flow from CPD to CPE
RM        8      .39       .2

KK     HPFB
KM      Basin runoff calculation for Half Pint Range FB
BA      1.6
LS                 77
UD       .44

KK      CPE
KM     Combine HP4 (CPC) with routed flow from CPD, and HPFB
HC        3

KK      CPF
KM     Combine all flow at Concentration just below RWMS (Flow from CPA & CPE)
HC        2

KK      SC1
KM      Basin runoff calculation for Scarp Canyon 1
* Concentration Pt of this watershed is the active apex of the Scarp Canyon Fan
BA     39.4
LS                82
UD      2.1

KK      SC2
KM      Basin runoff calculation for Scarp Canyon 2
BA      1.5
LS                77
UD      .48
ZZ
```

```
                    SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE        (V) ROUTING            (--->) DIVERSION OR PUMP FLOW

  NO.        (.) CONNECTOR          (<---) RETURN OF DIVERTED OR PUMPED FLOW

    37        MM1A
                 .
    42           .         BW1
                 .           .
    47           .           .         BW2
                 .           .           .
    52           .       BW1&2............
                 .           .
    55      BW APX............
                 .
    58           .        MM1B
                 .           .
    63           .           .         MM2
                 .           .           .
    68           .           .           .        HP1A
                 .           .           .           V
                 .           .           .           V
    73           .           .           .       RTCPA
                 .           .           .           .
    76           .           .           .           .        HP1B
                 .           .           .           .           .
    81           .           .           .           .           .         HP2
                 .           .           .           .           .           .
    86           .           .        CPA1....................................
                 .           .           .
    89           .           .           .         HP3
                 .           .           .           .
    94           .           .        CPA2............
                 .           .           .
    97           .           .           .         HP4
                 .           .           .           .
   102           .           .           .           .         HP5
                 .           .           .           .           .
   107           .           .           .           .           .         HP6
                 .           .           .           .           .           V
                 .           .           .           .           .           V
   112           .           .           .           .           .       RTCPD
                 .           .           .           .           .           .
   115           .           .           .           .           .           .        HPFA
                 .           .           .           .           .           .           .
   120           .           .           .           .         CPD........................
                 .           .           .           .           V
                 .           .           .           .           V
   123           .           .           .           .       RTCPE
                 .           .           .           .           .
   126           .           .           .           .           .        HPFB
                 .           .           .           .           .           .
   131           .           .           .         CPE........................
                 .           .           .           .
   134           .           .         CPF............
                 .           .           .
   137           .           .           .         SC1
                 .           .           .           .
   142           .           .           .           .         SC2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*           SEPTEMBER 1990              *
*             VERSION 4.0               *
*                                       *
*  RUN DATE  01/29/1993  TIME  22:05:10 *
*                                       *
*****************************************

*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
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                    FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMS10.DAT
                    10-YEAR 6-HOUR STORM 1.1 INCHES
                    POINT RAINFALL VALUE FROM NOAA ATLASS 2 VOL VII
                    DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
                    CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCRFCD, 1990)
                    CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
                    LAG TIMES DETEMINED USING METHOD IN SECTION 606.3 IN CCRFCD, 1990
                    DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
                    THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS

 11 IO          OUTPUT CONTROL VARIABLES
                      IPRNT          5  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT           HYDROGRAPH TIME DATA
                       NMIN          3  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1   0  STARTING DATE
                      ITIME       0000  STARTING TIME
                         NQ        300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      1   0  ENDING DATE
                     NDTIME       1457  ENDING TIME
                      ICENT         19  CENTURY MARK

                 COMPUTATION INTERVAL     .05 HOURS
                      TOTAL TIME BASE   14.95 HOURS

       ENGLISH UNITS
            DRAINAGE AREA           SQUARE MILES
            PRECIPITATION DEPTH     INCHES
            LENGTH, ELEVATION       FEET
            FLOW                    CUBIC FEET PER SECOND
            STORAGE VOLUME          ACRE-FEET
            SURFACE AREA            ACRES
            TEMPERATURE             DEGREES FAHRENHEIT

 13 JD           INDEX STORM NO. 1
                       STRM       1.10  PRECIPITATION DEPTH
                       TRDA        .01  TRANSPOSITION DRAINAGE AREA

 14 PI           PRECIPITATION PATTERN
                   1.20     1.54     2.22     1.26      .78     1.02     1.10     1.26     1.06      .96
                    .36      .24      .00      .00      .00      .00      .00      .00      .00      .00
                    .18      .26      .42      .22      .12      .36      .44      .60      .76      .84
                    .54      .54      .54      .46      .42      .12      .10      .06      .06      .06
                    .18      .32      .60      .80      .90      .72      .64      .48      .24      .12
                    .30      .48      .84      .60      .48      .18      .16      .12      .52      .72
                   1.62     1.68     1.80     2.88     3.42     5.40     5.42     5.46     6.62     7.20
                   2.04     2.10     2.22     1.98     1.86      .42      .60      .96      .96      .96
                    .30      .28      .24      .40      .48      .48      .56      .72     1.12     1.32
                    .96      .86      .66      .74      .78     1.20      .92      .36      .36      .36
                    .18      .16      .12      .12      .12      .06      .10      .18      .06      .00
                    .06      .06      .06      .14      .18      .00      .02      .06      .06      .06

 22 JD           INDEX STORM NO. 2
                       STRM       1.07  PRECIPITATION DEPTH
                       TRDA       1.00  TRANSPOSITION DRAINAGE AREA

  0 PI           PRECIPITATION PATTERN
                   1.20     1.54     2.22     1.26      .78     1.02     1.10     1.26     1.06      .96
                    .36      .24      .00      .00      .00      .00      .00      .00      .00      .00
                    .18      .26      .42      .22      .12      .36      .44      .60      .76      .84
                    .54      .54      .54      .46      .42      .12      .10      .06      .06      .06
                    .18      .32      .60      .80      .90      .72      .64      .48      .24      .12
                    .30      .48      .84      .60      .48      .18      .16      .12      .52      .72
                   1.62     1.68     1.80     2.88     3.42     5.40     5.42     5.46     6.62     7.20
                   2.04     2.10     2.22     1.98     1.86      .42      .60      .96      .96      .96
                    .30      .28      .24      .40      .48      .48      .56      .72     1.12     1.32
                    .96      .86      .66      .74      .78     1.20      .92      .36      .36      .36
                    .18      .16      .12      .12      .12      .06      .10      .18      .06      .00
                    .06      .06      .06      .14      .18      .00      .02      .06      .06      .06
```

23 JD INDEX STORM NO. 3
STRM .95 PRECIPITATION DEPTH
TRDA 9.99 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

24 JD INDEX STORM NO. 4
STRM .95 PRECIPITATION DEPTH
TRDA 10.01 TRANSPOSITION DRAINAGE AREA

25 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

33 JD INDEX STORM NO. 5
STRM .87 PRECIPITATION DEPTH
TRDA 20.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

34 JD INDEX STORM NO. 6
STRM .81 PRECIPITATION DEPTH
TRDA 30.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

35 JD INDEX STORM NO. 7
STRM .75 PRECIPITATION DEPTH
TRDA 50.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

36 JD INDEX STORM NO. 8

| | | |
|---|---|---|
| STRM | .66 | PRECIPITATION DEPTH |
| TRDA | 100.00 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

| | OPERATION | STATION | PEAK FLOW | TIME OF PEAK | AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR | 24-HOUR | 72-HOUR | BASIN AREA | MAXIMUM STAGE | TIME OF MAX STAGE |
|---|---|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | MM1A | 50. | 3.90 | 10. | 4. | 4. | .90 | | |
| + | HYDROGRAPH AT | BW1 | 511. | 6.55 | 265. | 111. | 111. | 60.50 | | |
| + | HYDROGRAPH AT | BW2 | 328. | 5.50 | 104. | 42. | 42. | 20.80 | | |
| + | 2 COMBINED AT | BW1&2 | 510. | 6.35 | 268. | 112. | 112. | 81.30 | | |
| + | 2 COMBINED AT | BW APX | 452. | 6.40 | 237. | 99. | 99. | 82.20 | | |
| + | HYDROGRAPH AT | MM1B | 43. | 5.10 | 13. | 5. | 5. | 2.10 | | |
| + | HYDROGRAPH AT | MM2 | 48. | 4.10 | 13. | 5. | 5. | 1.40 | | |
| + | HYDROGRAPH AT | HP1A | 81. | 4.00 | 18. | 7. | 7. | .80 | | |
| + | ROUTED TO | RTCPA | 77. | 4.45 | 18. | 7. | 7. | .80 | | |
| + | HYDROGRAPH AT | HP1B | 28. | 4.20 | 8. | 3. | 3. | 1.00 | | |
| + | HYDROGRAPH AT | HP2 | 33. | 4.20 | 10. | 4. | 4. | 1.20 | | |
| + | 4 COMBINED AT | CPA1 | 130. | 4.35 | 39. | 16. | 16. | 4.40 | | |
| + | HYDROGRAPH AT | HP3 | 87. | 4.20 | 24. | 10. | 10. | 1.70 | | |
| + | 2 COMBINED AT | CPA2 | 187. | 4.30 | 56. | 22. | 22. | 6.10 | | |
| + | HYDROGRAPH AT | HP4 | 88. | 4.20 | 26. | 10. | 10. | 3.30 | | |
| + | HYDROGRAPH AT | HP5 | 54. | 3.90 | 11. | 5. | 5. | 1.20 | | |
| + | HYDROGRAPH AT | HP6 | 77. | 4.20 | 22. | 9. | 9. | 2.20 | | |
| + | ROUTED TO | RTCPD | 75. | 4.45 | 22. | 9. | 9. | 2.20 | | |
| + | HYDROGRAPH AT | HPFA | 9. | 3.95 | 2. | 1. | 1. | .30 | | |
| + | 3 COMBINED AT | CPD | 90. | 4.70 | 31. | 12. | 12. | 3.70 | | |
| + | ROUTED TO | RTCPE | 90. | 5.05 | 31. | 12. | 12. | 3.70 | | |
| + | HYDROGRAPH AT | HPFB | 35. | 5.05 | 10. | 4. | 4. | 1.60 | | |
| + | 3 COMBINED AT | CPE | 168. | 5.10 | 53. | 21. | 21. | 8.60 | | |
| + | 2 COMBINED AT | CPF | 301. | 5.20 | 84. | 34. | 34. | 14.70 | | |
| + | HYDROGRAPH AT | SC1 | 356. | 6.55 | 184. | 78. | 78. | 39.40 | | |
| + | HYDROGRAPH AT | SC2 | 32. | 5.10 | 10. | 4. | 4. | 1.50 | | |

*** NORMAL END OF HEC-1 ***

# HEC-1 MODEL OUTPUT

**FILENAME: RWMS10C.OUT**

**(10-YEAR MODEL)**

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*            SEPTEMBER 1990             *
*             VERSION 4.0               *
*                                       *
* RUN DATE  01/29/1993  TIME  22:06:45  *
*                                       *
*****************************************
```

```
***************************************
*                                     *
*   U.S. ARMY CORPS OF ENGINEERS      *
*   HYDROLOGIC ENGINEERING CENTER     *
*        609 SECOND STREET            *
*     DAVIS, CALIFORNIA 95616         *
*         (916) 756-1104              *
*                                     *
***************************************
```

```
X     X  XXXXXXX   XXXXX         X
X     X  X        X     X       XX
X     X  X        X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL    LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
ID    FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMS10C.DAT
ID    10-YEAR 6-HOUR STORM 1.1 INCHES
ID    POINT RAINFALL VALUES FROM NOAA ATLAS 2 VOL VII
ID    ADJUSTED RAINFALL PER CORRECTION FACTOR IN CLARK COUNTY MANUAL TABLE 501
ID    DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
ID    CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCRFCD, 1990)
ID    CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
ID    LAG TIMES DETEMINED USING METHOD IN SECITON 606.3 IN CCRFCD, 1990
ID    DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
ID    THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
*DIAGRAM
IT        3         0         0       300
IO        5
IN        5
JD     1.36       .01
* RAINFALL DISTRIBUTION FROM CLARK COUNTY MANUAL LESS THAN 10 SQ. MILES
PC        0         2       5.7       7.0       8.7      10.8      12.4      13.0      13.0      13.0
PC     13.0      13.0      13.0      13.3      14.0      14.2      14.8      15.8      17.2      18.1
PC     19.0      19.7      19.9      20.0      20.1      20.4      21.4      22.9      24.1      24.9
PC     25.1      25.6      27.0      27.8      28.1      28.3      29.5      32.2      35.2      40.9
PC     49.9      59.0      71.0      74.4      78.1      81.2      81.9      83.5      85.1      85.6
PC     86.0      86.8      87.6      88.8      91.0      92.6      93.7      95.0      97.0      97.6
PC     98.2      98.5      98.7      98.9      99.0      99.3      99.3      99.4      99.5      99.8
PC     99.8      99.9     100.0
JD     1.32         1
JD     1.17      9.99
* CHANGED RAINFALL DISTRIBUTION ABOVE 10 SQ. MILES PER CLARK COUNTY MANUAL
JD     1.17     10.01
PC        0       2.0       5.9       8.0      11.0      14.4      15.0      16.0      16.8      17.1
PC     18.0      18.2      18.7      19.0      19.7      20.2      21.0      22.0      23.0      24.1
PC     25.0      25.9      26.5      28.0      29.0      30.0      30.5      30.9      31.0      31.7
PC     32.1      32.7      33.3      34.6      36.1      38.1      40.8      43.0      47.7      51.4
PC     56.1      63.0      71.0      72.0      73.1      75.2      77.9      79.0      79.5      80.4
PC     81.0      82.0      82.6      84.0      85.9      88.9      91.0      93.8      96.6      97.0
PC     97.4      97.9      98.1      98.3      98.5      98.9      99.0      99.2      99.3      99.6
PC     99.7      99.9     100.0
JD     1.07        20
JD     1.01        30
JD      .92        50
JD      .82       100

KK     MM1A
KM    Basin runoff calculation for Mass. Mountains 1A
BA       .9
LS                 80
UD      .31

KK      BW1
KM      Basin runoff calculation for Barren Wash 1
BA     60.5
LS                 83
UD      2.1
```

```
48    KK   BW2
49    KM    Basin runoff calculation for Barren Wash 2
50    BA   20.8
51    LS             80
52    UD     .9

53    KK   BW1&2
54    KM   Combined BW1 and BW2
55    HC      2

56    KK  BW APX
57    KM   Combine BW1,BW2, and MM1A (assume dischcarge of Barren Wash "active apex")
58    HC      2

59    KK    MM1B
60    KM    Basin runoff calulation for Mass. Mountains 1B
      *   Flow was not combined with BW APX because flow from this watershed
      *   will not directly impact RWMS wereas a channel migration at the apex
      *   could impact the RWMS
61    BA     2.1
62    LS             77
63    UD     .48

64    KK    MM2
65    KM    Basin runoff calculation for Mass. Mountains 2
66    BA     1.4
67    LS             79
68    UD     .47

69    KK    HP1A
70    KM    Basin runoff calculation for Half Pint Range 1A
71    BA     .8
72    LS             85
73    UD     .48

74    KK   RTCPA
75    KM   Route Flow from HP1A to CPA
76    RM      9      .43      .2

77    KK    HP1B
78    KM    Basin runoff calculation for Half Pint Range 1B
79    BA     1.0
80    LS             78
81    UD     .51

82    KK     HP2
83    KM    Basin runoff calculation for Half Pint Range 2
84    BA    1.2
85    LS             78
86    UD     .51

87    KK    CPA1
88    KM    Combine MM2, routed HP1A, HP1B, HP2
89    HC      4

90    KK     HP3
91    KM     (CPB) Basin runoff calculation for Half Pint Range 3
92    BA     1.7
93    LS             82
94    UD     .59

95    KK    CPA2
96    KM    Combine HP3 with flow from CPA1
97    HC      2

98    KK     HP4
99    KM     (CPC) Basin runoff calculation for Half Pint Range 4
100   BA     3.3
101   LS             79
102   UD     .52

103   KK     HP5
104   KM     Basin runoff calculation for Half Pint Range 5
105   BA     1.2
106   LS             79
107   UD      .3

108   KK     HP6
109   KM     Basin runoff calculation for Half Pint Range 6
110   BA     2.2
111   LS             80
112   UD     .55

113   KK   RTCPD
114   KM    Route HP6 to CPD
115   RM      5      .27      .2
```

```
KK    HPFA
KM     Basin runoff calculation for Half Pint Range FA
BA      .3
LS             77
UD     .33

KK     CPD
KM     Combine HP5, routed HP6, and HPFA
HC       3

KK    RTCPE
KM     Route flow from CPD to CPE
RM       8       .39        .2

KK     HPFB
KM     Basin runoff calculation for Half Pint Range FB
BA     1.6
LS             77
UD     .44

KK     CPE
KM    Combine HP4 (CPC) with routed flow from CPD, and HPFB
HC       3

KK     CPF
KM    Combine all flow at Concentration just below RWMS (Flow from CPA & CPE)
HC       2

KK     SC1
KM     Basin runoff calculation for Scarp Canyon 1
* Concentration Pt of this watershed is the active apex of the Scarp Canyon Fan
BA    39.4
LS             82
UD     2.1

KK     SC2
KM     Basin runoff calculation for Scarp Canyon 2
BA     1.5
LS             77
UD     .48
ZZ
```

FLOOD HYDROGRAPH PACKAGE (HEC-1)
SEPTEMBER 1990
VERSION 4.0

RUN DATE 01/29/1993 TIME 22:06:45

U.S. ARMY CORPS OF ENGINEERS
HYDROLOGIC ENGINEERING CENTER
609 SECOND STREET
DAVIS, CALIFORNIA 95616
(916) 756-1104

FLOOD ASSESSMENT FOR RWMS JOB #:51056 FILE: RWMS10C.DAT
10-YEAR 6-HOUR STORM 1.1 INCHES
POINT RAINFALL VALUES FROM NOAA ATLAS 2 VOL VII
ADJUSTED RAINFALL PER CORRECTION FACTOR IN CLARK COUNTY MANUAL TABLE 501
DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCRFCD, 1990)
CURVE NUMBERS DETERMINED USING TABLE 602 IN CCRFCD, 1990
LAG TIMES DETEMINED USING METHOD IN SECITON 606.3 IN CCRFCD, 1990
DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS

12 IO OUTPUT CONTROL VARIABLES
IPRNT 5 PRINT CONTROL
IPLOT 0 PLOT CONTROL
QSCAL 0. HYDROGRAPH PLOT SCALE

IT HYDROGRAPH TIME DATA
NMIN 3 MINUTES IN COMPUTATION INTERVAL
IDATE 1 0 STARTING DATE
ITIME 0000 STARTING TIME
NQ 300 NUMBER OF HYDROGRAPH ORDINATES
NDDATE 1 0 ENDING DATE
NDTIME 1457 ENDING TIME
ICENT 19 CENTURY MARK

COMPUTATION INTERVAL .05 HOURS
TOTAL TIME BASE 14.95 HOURS

ENGLISH UNITS
DRAINAGE AREA SQUARE MILES
PRECIPITATION DEPTH INCHES
LENGTH, ELEVATION FEET
FLOW CUBIC FEET PER SECOND
STORAGE VOLUME ACRE-FEET
SURFACE AREA ACRES
TEMPERATURE DEGREES FAHRENHEIT

14 JD INDEX STORM NO. 1
STRM 1.36 PRECIPITATION DEPTH
TRDA .01 TRANSPOSITION DRAINAGE AREA

15 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

23 JD INDEX STORM NO. 2
STRM 1.32 PRECIPITATION DEPTH
TRDA 1.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

24 JD INDEX STORM NO. 3

STRM 1.17 PRECIPITATION DEPTH

TRDA 9.99 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

25 JD INDEX STORM NO. 4

STRM 1.17 PRECIPITATION DEPTH

TRDA 10.01 TRANSPOSITION DRAINAGE AREA

26 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

34 JD INDEX STORM NO. 5

STRM 1.07 PRECIPITATION DEPTH

TRDA 20.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

35 JD INDEX STORM NO. 6

STRM 1.01 PRECIPITATION DEPTH

TRDA 30.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

36 JD INDEX STORM NO. 7

STRM .92 PRECIPITATION DEPTH

TRDA 50.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

37 JD INDEX STORM NO. 8

STRM .82 PRECIPITATION DEPTH

TRDA 100.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

```
                         SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE      (V) ROUTING            (--->) DIVERSION OR PUMP FLOW

 NO.       (.) CONNECTOR          (<---) RETURN OF DIVERTED OR PUMPED FLOW

  38         MM1A
                .
                .
  43            .         BW1
                .           .
                .           .
  48            .           .         BW2
                .           .           .
                .           .           .
  53            .       BW1&2............
                .           .
                .           .
  56       BW APX............
                .
                .
  59            .        MM1B
                .           .
                .           .
  64            .           .         MM2
                .           .           .
                .           .           .
  69            .           .           .        HP1A
                .           .           .           V
                .           .           .           V
  74            .           .           .       RTCPA
                .           .           .           .
                .           .           .           .
  77            .           .           .           .        HP1B
                .           .           .           .           .
                .           .           .           .           .
  82            .           .           .           .           .         HP2
                .           .           .           .           .           .
                .           .           .           .           .           .
  87            .           .        CPA1....................................
                .           .           .
                .           .           .
  90            .           .           .         HP3
                .           .           .           .
                .           .           .           .
  95            .           .        CPA2............
                .           .           .
                .           .           .
  98            .           .           .         HP4
                .           .           .           .
                .           .           .           .
 103            .           .           .           .         HP5
                .           .           .           .           .
                .           .           .           .           .
 108            .           .           .           .           .         HP6
                .           .           .           .           .           V
                .           .           .           .           .           V
 113            .           .           .           .           .       RTCPD
                .           .           .           .           .           .
                .           .           .           .           .           .
 116            .           .           .           .           .           .        HPFA
                .           .           .           .           .           .           .
                .           .           .           .           .           .           .
 121            .           .           .           .         CPD........................
                .           .           .           .           V
                .           .           .           .           V
 124            .           .           .           .       RTCPE
                .           .           .           .           .
                .           .           .           .           .
 127            .           .           .           .           .        HPFB
                .           .           .           .           .           .
                .           .           .           .           .           .
 132            .           .           .         CPE........................
                .           .           .           .
                .           .           .           .
 135            .           .         CPF............
                .           .           .
                .           .           .
 138            .           .           .         SC1
                .           .           .           .
                .           .           .           .
 143            .           .           .           .         SC2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

| | OPERATION | STATION | PEAK FLOW | TIME OF PEAK | AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR | 24-HOUR | 72-HOUR | BASIN AREA | MAXIMUM STAGE | TIME OF MAX STAGE |
|---|---|---|---|---|---|---|---|---|---|---|
| + | HYDROGRAPH AT | MM1A | 108. | 3.85 | 20. | 8. | 8. | .90 | | |
| + | HYDROGRAPH AT | BW1 | 1083. | 6.40 | 574. | 242. | 242. | 60.50 | | |
| + | HYDROGRAPH AT | BW2 | 653. | 5.45 | 232. | 93. | 93. | 20.80 | | |
| + | 2 COMBINED AT | BW1&2 | 1083. | 6.10 | 581. | 244. | 244. | 81.30 | | |
| + | 2 COMBINED AT | BW APX | 1078. | 6.10 | 581. | 244. | 244. | 82.20 | | |
| + | HYDROGRAPH AT | MM1B | 110. | 4.10 | 28. | 11. | 11. | 2.10 | | |
| + | HYDROGRAPH AT | MM2 | 110. | 4.05 | 26. | 10. | 10. | 1.40 | | |
| + | HYDROGRAPH AT | HP1A | 139. | 4.00 | 30. | 12. | 12. | .80 | | |
| + | ROUTED TO | RTCPA | 132. | 4.40 | 30. | 12. | 12. | .80 | | |
| + | HYDROGRAPH AT | HP1B | 68. | 4.10 | 17. | 7. | 7. | 1.00 | | |
| + | HYDROGRAPH AT | HP2 | 79. | 4.10 | 20. | 8. | 8. | 1.20 | | |
| + | 4 COMBINED AT | CPA1 | 278. | 4.25 | 76. | 31. | 31. | 4.40 | | |
| + | HYDROGRAPH AT | HP3 | 170. | 4.15 | 43. | 17. | 17. | 1.70 | | |
| + | 2 COMBINED AT | CPA2 | 399. | 4.20 | 108. | 43. | 43. | 6.10 | | |
| + | HYDROGRAPH AT | HP4 | 210. | 4.10 | 54. | 21. | 21. | 3.30 | | |
| + | HYDROGRAPH AT | HP5 | 123. | 3.85 | 23. | 9. | 9. | 1.20 | | |
| + | HYDROGRAPH AT | HP6 | 168. | 4.10 | 43. | 17. | 17. | 2.20 | | |
| + | ROUTED TO | RTCPD | 164. | 4.40 | 43. | 17. | 17. | 2.20 | | |
| + | HYDROGRAPH AT | HPFA | 23. | 3.90 | 5. | 2. | 2. | .30 | | |
| + | 3 COMBINED AT | CPD | 199. | 4.30 | 62. | 25. | 25. | 3.70 | | |
| + | ROUTED TO | RTCPE | 196. | 4.70 | 62. | 25. | 25. | 3.70 | | |
| + | HYDROGRAPH AT | HPFB | 93. | 4.05 | 23. | 9. | 9. | 1.60 | | |
| + | 3 COMBINED AT | CPE | 335. | 4.25 | 116. | 46. | 46. | 8.60 | | |
| + | 2 COMBINED AT | CPF | 576. | 5.20 | 182. | 73. | 73. | 14.70 | | |
| + | HYDROGRAPH AT | SC1 | 769. | 6.40 | 408. | 172. | 172. | 39.40 | | |
| + | HYDROGRAPH AT | SC2 | 84. | 4.10 | 21. | 9. | 9. | 1.50 | | |

*** NORMAL END OF HEC-1 ***

# HEC-1 MODEL OUTPUT

**FILENAME: RWMS2.OUT**

**(2-YEAR MODEL)**

```
*****************************************                    ***************************************
*                                       *                    *                                     *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *  U.S. ARMY CORPS OF ENGINEERS       *
*            SEPTEMBER 1990             *                    *  HYDROLOGIC ENGINEERING CENTER      *
*             VERSION 4.0               *                    *        609 SECOND STREET            *
*                                       *                    *     DAVIS, CALIFORNIA 95616         *
*  RUN DATE  01/29/1993  TIME  22:08:57 *                    *        (916) 756-1104               *
*                                       *                    *                                     *
*****************************************                    ***************************************


                  X     X  XXXXXXX   XXXXX          X
                  X     X  X        X     X        XX
                  X     X  X        X               X
                  XXXXXXX  XXXX     X       XXXXX   X
                  X     X  X        X               X
                  X     X  X        X     X         X
                  X     X  XXXXXXX   XXXXX         XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


   1      ID   FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMS2.DAT
   2      ID    2-YEAR 6-HOUR STORM 0.7 INCHES
   3      ID   POINT RAINFALL FROM NOAA ATLAS 2 VOL VII (NO ADJUSTMENT NECESSARY)
   4      ID   DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
   5      ID   CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCFRCD, 1990)
   6      ID   CURVE NUMBERS DETERMINED USING TABLE 602 IN CCFRCD, 1990
   7      ID   LAG TIMES DETERMINED USING METHOD IN SECTION 606.3 IN CCFRCD, 1990
   8      ID   DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
   9      ID   THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS
          *DIAGRAM
  10      IT       3       0       0     300
  11      IO       5
  12      IN       5
  13      JD     0.7     .01
          * RAINFALL DISTRIBUTION FROM CLARK COUNTY MANUAL LESS THAN 10 SQ. MILES
  14      PC       0       2     5.7     7.0     8.7    10.8    12.4    13.0    13.0    13.0
  15      PC    13.0    13.0    13.0    13.3    14.0    14.2    14.8    15.8    17.2    18.1
  16      PC    19.0    19.7    19.9    20.0    20.1    20.4    21.4    22.9    24.1    24.9
  17      PC    25.1    25.6    27.0    27.8    28.1    28.3    29.5    32.2    35.2    40.9
  18      PC    49.9    59.0    71.0    74.4    78.1    81.2    81.9    83.5    85.1    85.6
  19      PC    86.0    86.8    87.6    88.8    91.0    92.6    93.7    95.0    97.0    97.6
  20      PC    98.2    98.5    98.7    98.9    99.0    99.3    99.3    99.4    99.5    99.8
  21      PC    99.8    99.9   100.0
  22      JD     .68       1
  23      JD     .60    9.99
          * CHANGED RAINFALL DISTRIBUTION ABOVE 10 SQ. MILES PER CLARK COUNTY MANUAL
  24      JD     .60   10.01
  25      PC       0     2.0     5.9     8.0    11.0    14.4    15.0    16.0    16.8    17.1
  26      PC    18.0    18.2    18.7    19.0    19.7    20.2    21.0    22.0    23.0    24.1
  27      PC    25.0    25.9    26.5    28.0    29.0    30.0    30.5    30.9    31.0    31.7
  28      PC    32.1    32.7    33.3    34.6    36.1    38.1    40.8    43.0    47.7    51.4
  29      PC    56.1    63.0    71.0    72.0    73.1    75.2    77.9    79.0    79.5    80.4
  30      PC    81.0    82.0    82.6    84.0    85.9    88.9    91.0    93.8    96.6    97.0
  31      PC    97.4    97.9    98.1    98.3    98.5    98.9    99.0    99.2    99.3    99.6
  32      PC    99.7    99.9   100.0
  33      JD     .55      20
  34      JD     .52      30
  35      JD     .48      50
  36      JD     .42     100

  37      KK    MM1A
  38      KM   Basin runoff calculation for Mass. Mountains 1A
  39      BA      .9
  40      LS              80
  41      UD     .31

  42      KK     BW1
  43      KM    Basin runoff calculation for Barren Wash 1
  44      BA    60.5
  45      LS              83
  46      UD     2.1
```

```
47    KK     BW2
48    KM     Basin runoff calculation for Barren Wash 2
49    BA     20.8
50    LS              80
51    UD      .9

52    KK    BW1&2
53    KM    Combined BW1 and BW2
54    HC      2

55    KK   BW APX
56    KM    Combine BW1,BW2, and MM1A (assume dischcarge of Barren Wash "active apex")
57    HC      2

58    KK     MM1B
59    KM     Basin runoff calulation for Mass. Mountains 1B
      *    Flow was not combined with BW APX because flow from this watershed
      *    will not directly impact RWMS wereas a channel migration at the apex
      *    could impact the RWMS
60    BA      2.1
61    LS              77
62    UD      .48

63    KK      MM2
64    KM     Basin runoff calculation for Mass. Mountains 2
65    BA      1.4
66    LS              79
67    UD      .47

68    KK     HP1A
69    KM     Basin runoff calculation for Half Pint Range 1A
70    BA       .8
71    LS              85
72    UD      .48

73    KK     RTCPA
74    KM     Route Flow from HP1A to CPA
75    RM       9       .43       .2

76    KK     HP1B
77    KM     Basin runoff calculation for Half Pint Range 1B
78    BA      1.0
79    LS              78
80    UD      .51

81    KK      HP2
82    KM     Basin runoff calculation for Half Pint Range 2
83    BA     1.2
84    LS              78
85    UD      .51

86    KK     CPA1
87    KM     Combine MM2, routed HP1A, HP1B, HP2
88    HC       4

89    KK      HP3
90    KM      (CPB) Basin runoff calculation for Half Pint Range 3
91    BA      1.7
92    LS              82
93    UD      .59

94    KK     CPA2
95    KM     Combine HP3 with flow from CPA1
96    HC       2

97    KK      HP4
98    KM      (CPC) Basin runoff calculation for Half Pint Range 4
99    BA      3.3
100   LS              79
101   UD      .52

102   KK      HP5
103   KM      Basin runoff calculation for Half Pint Range 5
104   BA      1.2
105   LS              79
106   UD       .3

107   KK      HP6
108   KM      Basin runoff calculation for Half Pint Range 6
109   BA      2.2
110   LS              80
111   UD      .55

112   KK    RTCPD
113   KM     Route HP6 to CPD
114   RM       5      .27       .2
```

```
115         KK    HPFA
116         KM     Basin runoff calculation for Half Pint Range FA
117         BA      .3
118         LS              77
119         UD     .33

120         KK     CPD
121         KM     Combine HP5, routed HP6, and HPFA
122         HC       3

123         KK    RTCPE
124         KM     Route flow from CPD to CPE
125         RM       8      .39      .2

126         KK    HPFB
127         KM     Basin runoff calculation for Half Pint Range FB
128         BA     1.6
129         LS              77
130         UD     .44

131         KK     CPE
132         KM    Combine HP4 (CPC) with routed flow from CPD, and HPFB
133         HC       3

134         KK     CPF
135         KM    Combine all flow at Concentration just below RWMS (Flow from CPA & CPE)
136         HC       2

137         KK     SC1
138         KM     Basin runoff calculation for Scarp Canyon 1
            * Concentration Pt of this watershed is the active apex of the Scarp Canyon Fan
139         BA    39.4
140         LS              82
141         UD     2.1

142         KK     SC2
143         KM     Basin runoff calculation for Scarp Canyon 2
144         BA     1.5
145         LS              77
146         UD     .48
147         ZZ
```

```
                      SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE       (V) ROUTING           (--->) DIVERSION OR PUMP FLOW

  NO.       (.) CONNECTOR         (<---) RETURN OF DIVERTED OR PUMPED FLOW

  37        MM1A
             .
  42         .        BW1
             .         .
  47         .         .       BW2
             .         .        .
  52         .      BW1&2.........
             .         .
  55        BW APX.........
             .
  58         .        MM1B
             .         .
  63         .         .       MM2
             .         .        .
  68         .         .        .      HP1A
             .         .        .       V
             .         .        .       V
             .         .        .      RTCPA
  73         .         .        .       .
             .         .        .       .     HP1B
  76         .         .        .       .      .
             .         .        .       .      .     HP2
  81         .         .        .       .      .      .
             .         .        .       .      .      .
  86         .         .       CPA1...........................
             .         .        .
  89         .         .        .      HP3
             .         .        .       .
  94         .         .       CPA2.......
             .         .        .
  97         .         .        .      HP4
             .         .        .       .
 102         .         .        .       .     HP5
             .         .        .       .      .
 107         .         .        .       .      .     HP6
             .         .        .       .      .      V
             .         .        .       .      .      V
             .         .        .       .      .     RTCPD
 112         .         .        .       .      .      .
             .         .        .       .      .      .      HPFA
 115         .         .        .       .      .      .       .
             .         .        .       .     CPD.................
 120         .         .        .       .      V
             .         .        .       .      V
             .         .        .       .     RTCPE
 123         .         .        .       .      .
             .         .        .       .      .     HPFB
 126         .         .        .       .      .      .
             .         .        .      CPE................
 131         .         .        .       .
             .         .       CPF.........
 134         .         .        .
             .         .        .      SC1
 137         .         .        .       .
             .         .        .       .     SC2
 142         .         .        .

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              SEPTEMBER 1990           *
*                VERSION 4.0            *
*                                       *
* RUN DATE  01/29/1993  TIME  22:08:57  *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*   U.S. ARMY CORPS OF ENGINEERS        *
*   HYDROLOGIC ENGINEERING CENTER       *
*        609 SECOND STREET              *
*     DAVIS, CALIFORNIA 95616           *
*         (916) 756-1104                *
*                                       *
*****************************************
```

```
                    FLOOD ASSESSMENT FOR RWMS JOB #:51056          FILE: RWMS2.DAT
                     2-YEAR 6-HOUR STORM 0.7 INCHES
                    POINT RAINFALL FROM NOAA ATLAS 2 VOL VII (NO ADJUSTMENT NECESSARY)
                    DEPTH-AREA REDUCTION FACTORS FROM TABLE 502 IN
                    CLARK COUNTY HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL (CCFRCD, 1990)
                    CURVE NUMBERS DETERMINED USING TABLE 602 IN CCFRCD, 1990
                    LAG TIMES DETERMINED USING METHOD IN SECTION 606.3 IN CCFRCD, 1990
                    DRAINAGE AREAS FROM 7.5 MINUTE AND 15 MINUTE QUADS
                    THIS MODEL ADDRESSES DRAINAGES THAT COULD IMPACT THE RWMS

 11 IO         OUTPUT CONTROL VARIABLES
                    IPRNT          5  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT          HYDROGRAPH TIME DATA
                     NMIN          3  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1   0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ        300  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      1   0  ENDING DATE
                   NDTIME       1457  ENDING TIME
                    ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL     .05 HOURS
                     TOTAL TIME BASE   14.95 HOURS

         ENGLISH UNITS
              DRAINAGE AREA           SQUARE MILES
              PRECIPITATION DEPTH     INCHES
              LENGTH, ELEVATION       FEET
              FLOW                    CUBIC FEET PER SECOND
              STORAGE VOLUME          ACRE-FEET
              SURFACE AREA            ACRES
              TEMPERATURE             DEGREES FAHRENHEIT

 13 JD          INDEX STORM NO. 1
                     STRM         .70  PRECIPITATION DEPTH
                     TRDA         .01  TRANSPOSITION DRAINAGE AREA
```

14 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

```
 22 JD          INDEX STORM NO. 2
                     STRM         .68  PRECIPITATION DEPTH
                     TRDA        1.00  TRANSPOSITION DRAINAGE AREA
```

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

23 JD INDEX STORM NO. 3

| | | |
|---|---|---|
| STRM | .60 | PRECIPITATION DEPTH |
| TRDA | 9.99 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.54 | 2.22 | 1.26 | .78 | 1.02 | 1.10 | 1.26 | 1.06 | .96 |
| .36 | .24 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| .18 | .26 | .42 | .22 | .12 | .36 | .44 | .60 | .76 | .84 |
| .54 | .54 | .54 | .46 | .42 | .12 | .10 | .06 | .06 | .06 |
| .18 | .32 | .60 | .80 | .90 | .72 | .64 | .48 | .24 | .12 |
| .30 | .48 | .84 | .60 | .48 | .18 | .16 | .12 | .52 | .72 |
| 1.62 | 1.68 | 1.80 | 2.88 | 3.42 | 5.40 | 5.42 | 5.46 | 6.62 | 7.20 |
| 2.04 | 2.10 | 2.22 | 1.98 | 1.86 | .42 | .60 | .96 | .96 | .96 |
| .30 | .28 | .24 | .40 | .48 | .48 | .56 | .72 | 1.12 | 1.32 |
| .96 | .86 | .66 | .74 | .78 | 1.20 | .92 | .36 | .36 | .36 |
| .18 | .16 | .12 | .12 | .12 | .06 | .10 | .18 | .06 | .00 |
| .06 | .06 | .06 | .14 | .18 | .00 | .02 | .06 | .06 | .06 |

24 JD INDEX STORM NO. 4

| | | |
|---|---|---|
| STRM | .60 | PRECIPITATION DEPTH |
| TRDA | 10.01 | TRANSPOSITION DRAINAGE AREA |

25 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

33 JD INDEX STORM NO. 5

| | | |
|---|---|---|
| STRM | .55 | PRECIPITATION DEPTH |
| TRDA | 20.00 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

34 JD INDEX STORM NO. 6

| | | |
|---|---|---|
| STRM | .52 | PRECIPITATION DEPTH |
| TRDA | 30.00 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

35 JD INDEX STORM NO. 7

| | | |
|---|---|---|
| STRM | .48 | PRECIPITATION DEPTH |
| TRDA | 50.00 | TRANSPOSITION DRAINAGE AREA |

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

36 JD INDEX STORM NO. 8

STRM .42 PRECIPITATION DEPTH

TRDA 100.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.20 | 1.58 | 2.34 | 1.62 | 1.26 | 1.80 | 1.88 | 2.04 | .92 | .36 |
| .60 | .56 | .48 | .28 | .18 | .54 | .40 | .12 | .24 | .30 |
| .18 | .26 | .42 | .34 | .30 | .48 | .52 | .60 | .60 | .60 |
| .66 | .62 | .54 | .54 | .54 | .36 | .54 | .90 | .70 | .60 |
| .60 | .50 | .30 | .26 | .24 | .06 | .18 | .42 | .30 | .24 |
| .36 | .36 | .36 | .64 | .78 | .90 | 1.00 | 1.20 | 1.48 | 1.62 |
| 1.32 | 1.82 | 2.82 | 2.42 | 2.22 | 2.82 | 3.26 | 4.14 | 4.58 | 4.80 |
| .60 | .62 | .66 | 1.06 | 1.26 | 1.62 | 1.30 | .66 | .42 | .30 |
| .54 | .48 | .36 | .52 | .60 | .36 | .52 | .84 | 1.04 | 1.14 |
| 1.80 | 1.62 | 1.26 | 1.54 | 1.68 | 1.68 | 1.20 | .24 | .24 | .24 |
| .30 | .24 | .12 | .12 | .12 | .12 | .16 | .24 | .12 | .06 |
| .12 | .10 | .06 | .14 | .18 | .06 | .08 | .12 | .08 | .06 |

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

| OPERATION | STATION | PEAK FLOW | TIME OF PEAK | AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR | 24-HOUR | 72-HOUR | BASIN AREA | MAXIMUM STAGE | TIME OF MAX STAGE |
|---|---|---|---|---|---|---|---|---|---|
| + HYDROGRAPH AT | MM1A | 6. | 5.00 | 1. | 0. | 0. | .90 | | |
| + HYDROGRAPH AT | BW1 | 22. | 7.10 | 11. | 4. | 4. | 60.50 | | |
| + HYDROGRAPH AT | BW2 | 7. | 6.00 | 2. | 1. | 1. | 20.80 | | |
| + 2 COMBINED AT | BW1&2 | 22. | 7.10 | 11. | 4. | 4. | 81.30 | | |
| + 2 COMBINED AT | BW APX | 9. | 7.10 | 4. | 2. | 2. | 82.20 | | |
| + HYDROGRAPH AT | MM1B | 2. | 5.30 | 0. | 0. | 0. | 2.10 | | |
| + HYDROGRAPH AT | MM2 | 5. | 5.15 | 1. | 0. | 0. | 1.40 | | |
| + HYDROGRAPH AT | HP1A | 16. | 4.15 | 4. | 2. | 2. | .80 | | |
| + ROUTED TO | RTCPA | 15. | 4.55 | 4. | 2. | 2. | .80 | | |
| + HYDROGRAPH AT | HP1B | 3. | 5.25 | 0. | 0. | 0. | 1.00 | | |
| + HYDROGRAPH AT | HP2 | 3. | 5.25 | 1. | 0. | 0. | 1.20 | | |
| + 4 COMBINED AT | CPA1 | 15. | 5.40 | 4. | 2. | 2. | 4.40 | | |
| + HYDROGRAPH AT | HP3 | 14. | 5.20 | 4. | 2. | 2. | 1.70 | | |
| + 2 COMBINED AT | CPA2 | 23. | 5.30 | 6. | 3. | 3. | 6.10 | | |
| + HYDROGRAPH AT | HP4 | 8. | 5.25 | 2. | 1. | 1. | 3.30 | | |
| + HYDROGRAPH AT | HP5 | 6. | 5.00 | 1. | 0. | 0. | 1.20 | | |
| + HYDROGRAPH AT | HP6 | 10. | 5.25 | 2. | 1. | 1. | 2.20 | | |
| + ROUTED TO | RTCPD | 10. | 5.50 | 2. | 1. | 1. | 2.20 | | |
| + HYDROGRAPH AT | HPFA | 1. | 5.10 | 0. | 0. | 0. | .30 | | |
| + 3 COMBINED AT | CPD | 10. | 5.40 | 2. | 1. | 1. | 3.70 | | |
| + ROUTED TO | RTCPE | 9. | 5.75 | 2. | 1. | 1. | 3.70 | | |
| + HYDROGRAPH AT | HPFB | 2. | 5.25 | 0. | 0. | 0. | 1.60 | | |
| + 3 COMBINED AT | CPE | 9. | 5.55 | 2. | 1. | 1. | 8.60 | | |
| + 2 COMBINED AT | CPF | 25. | 5.50 | 6. | 3. | 3. | 14.70 | | |
| + HYDROGRAPH AT | SC1 | 15. | 7.10 | 7. | 3. | 3. | 39.40 | | |
| + HYDROGRAPH AT | SC2 | 2. | 5.30 | 0. | 0. | 0. | 1.50 | | |

*** NORMAL END OF HEC-1 ***

# FEMA FAN MODEL OUTPUT

**BARREN WASH ALLUVIAL FAN**

**(Model Sets 1, 2, 3 & 4)**

Barren Wash Alluvial Fan: Model Set 1

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 22 | 22 |
| 10 | 510 | 511 |
| 100 | 1848 | 1845 |

MEAN = 1.042752
STANDARD DEVIATION = 1.533850
SKEW = -1.2

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 511
50-YEAR DISCHARGE = 1440
100-YEAR DISCHARGE = 1845
500-YEAR DISCHARGE = 2633

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.6502+0.5415 LOG(Q)

MEAN OF Z = 2.214841
STANDARD DEVIATION = 0.830596
SKEW = -1.200000
TRANSFORMATION CONSTANT = 4.989660

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: $Q$ | $44.6869\ Q^{0.5415}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.39939 | 0.77515 | 5458 |
| 1.5 | 1.0 | 756 | 0.06472 | 0.22080 | 1555 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: $Q$ | $44.6869\ Q^{0.5415}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.35475 | 0.72986 | 5139 |
| 4.5 | 0.6 | 238 | 0.18938 | 0.50031 | 3523 |
| 5.5 | 0.9 | 649 | 0.07853 | 0.25818 | 1818 |
| 6.5 | 1.3 | 1496 | 0.01847 | 0.07781 | 548 |

MULTIPLE-CHANNEL REGION

SLOPE = 0.0120000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $44.6869\ Q^{0.5415}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.4 | 429 | 0.12044 | 0.35977 | 9627 |

| ..OCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $44.6869\ Q^{0.5415}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.5 | 1046 | 0.03859 | 0.14838 | 3970 |

Barren Wash Alluvial Fan: Model Set 2

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 22 | 22 |
| 10 | 510 | 508 |
| 100 | 3513 | 3523 |

MEAN = 1.220155
STANDARD DEVIATION = 1.237478
SKEW = -0.6

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 508
50-YEAR DISCHARGE = 2234
100-YEAR DISCHARGE = 3523
500-YEAR DISCHARGE = 8018

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.3608+0.7454 LOG(Q)

MEAN OF Z = 2.270321
STANDARD DEVIATION = 0.922428
SKEW = -0.600000
TRANSFORMATION CONSTANT = 5.221557

## SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $22.9512\ Q^{0.7454}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.38603 | 0.75342 | 5552 |
| 1.5 | 1.0 | 756 | 0.07282 | 0.27335 | 2014 |
| 2.5 | 1.7 | 2712 | 0.01575 | 0.08826 | 650 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $22.9512\ Q^{0.7454}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.33839 | 0.70932 | 5227 |
| 4.5 | 0.6 | 238 | 0.17753 | 0.49364 | 3637 |
| 5.5 | 0.9 | 649 | 0.08326 | 0.30011 | 2211 |
| 6.5 | 1.3 | 1496 | 0.03427 | 0.16404 | 1209 |
| 7.5 | 1.7 | 3059 | 0.01310 | 0.07724 | 566 |

MULTIPLE-CHANNEL REGION

SLOPE = 0.0120000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $22.9512\ Q^{0.7454}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.4 | 429 | 0.11715 | 0.37930 | 10621 |

| OCITY FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $22.9512\ Q^{0.7454}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.5 | 1046 | 0.05069 | 0.21668 | 6067 |
| 4.5 | 0.8 | 2981 | 0.01367 | 0.07961 | 2218 |

Barren Wash Alluvial Fan: Model Set 3

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 22 | 22 |
| 10 | 510 | 511 |
| 100 | 6018 | 6011 |

MEAN = 1.323916
STANDARD DEVIATION = 1.089877
SKEW = -0.1

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 511
50-YEAR DISCHARGE = 3187
100-YEAR DISCHARGE = 6011
500-YEAR DISCHARGE = 21319

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.1038+0.9523 LOG(Q)

MEAN OF Z = 2.364550
STANDARD DEVIATION = 1.037845
SKEW = -0.100000
TRANSFORMATION CONSTANT = 5.498632

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $12.7010\ Q^{0.9523}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.37636 | 0.74376 | 5771 |
| 1.5 | 1.0 | 756 | 0.07741 | 0.31531 | 2447 |
| 2.5 | 1.7 | 2712 | 0.02368 | 0.15673 | 1203 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $12.7010\ Q^{0.9523}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.32668 | 0.70074 | 5438 |
| 4.5 | 0.6 | 238 | 0.17183 | 0.50209 | 3896 |
| 5.5 | 0.9 | 649 | 0.08625 | 0.33928 | 2633 |
| 6.5 | 1.3 | 1496 | 0.04176 | 0.22110 | 1712 |
| 7.5 | 1.7 | 3059 | 0.02093 | 0.14484 | 1104 |
| 8.5 | 2.2 | 5719 | 0.01078 | 0.08963 | 639 |

MULTIPLE-CHANNEL REGION

SLOPE = 0.0120000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $12.7010\ Q^{0.9523}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.4 | 429 | 0.11639 | 0.40412 | 11916 |

| __OCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $12.7010\ Q^{0.9523}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.5 | 1046 | 0.05870 | 0.26939 | 7936 |
| 4.5 | 0.8 | 2981 | 0.02152 | 0.14740 | 4278 |

Barren Wash Alluvial Fan: Model Set 4

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 22 | 22 |
| 10 | 1083 | 1100 |
| 100 | 5498 | 5436 |

MEAN = 0.967763
STANDARD DEVIATION = 1.909410
SKEW = -1.2

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 1100
50-YEAR DISCHARGE = 3994
100-YEAR DISCHARGE = 5436
500-YEAR DISCHARGE = 8466

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=2.1296+0.4869 LOG(Q)

MEAN OF Z = 2.600766
STANDARD DEVIATION = 0.929608
SKEW = -1.200000
TRANSFORMATION CONSTANT = 6.163823

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $134.7735\ Q^{0.4869}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.41930 | 0.84140 | 7319 |
| 1.5 | 1.0 | 756 | 0.13521 | 0.45395 | 3949 |
| 2.5 | 1.7 | 2712 | 0.03806 | 0.17863 | 1554 |

| LOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $134.7735\ Q^{0.4869}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.38395 | 0.81578 | 7096 |
| 4.5 | 0.6 | 238 | 0.24947 | 0.66394 | 5775 |
| 5.5 | 0.9 | 649 | 0.14958 | 0.48573 | 4225 |
| 6.5 | 1.3 | 1496 | 0.07778 | 0.30563 | 2659 |
| 7.5 | 1.7 | 3059 | 0.03212 | 0.15540 | 1352 |

## MULTIPLE-CHANNEL REGION

SLOPE = 0.0120000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $134.7735\ Q^{0.4869}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.4 | 429 | 0.18835 | 0.56624 | 18717 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $134.7735\ Q^{0.4869}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.5 | 1046 | 0.10475 | 0.38461 | 12713 |
| 4.5 | 0.8 | 2981 | 0.03340 | 0.16040 | 5302 |

# FEMA FAN MODEL OUTPUT

## SCARP CANYON ALLUVIAL FAN

**(Model Sets 1, 2, 3 & 4)**

Scarp Canyon Alluvial Fan: Model Set 1

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 15 | 15 |
| 10 | 356 | 351 |
| 100 | 1251 | 1265 |

MEAN = 0.878659
STANDARD DEVIATION = 1.533991
SKEW = -1.2

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 351
50-YEAR DISCHARGE = 987
100-YEAR DISCHARGE = 1265
500-YEAR DISCHARGE = 1805

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.5751+0.5415 LOG(Q)

MEAN OF Z = 2.050915
STANDARD DEVIATION = 0.830638
SKEW = -1.200000
TRANSFORMATION CONSTANT = 4.290921

## SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $37.5951\ Q^{0.5415}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.34883 | 0.72387 | 4383 |
| 1.5 | 1.0 | 756 | 0.03535 | 0.13698 | 829 |

| VELOCITY T/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $37.5951\ Q^{0.5415}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.30420 | 0.67202 | 4069 |
| 4.5 | 0.6 | 238 | 0.14528 | 0.41207 | 2495 |
| 5.5 | 0.9 | 649 | 0.04559 | 0.17003 | 1030 |

## MULTIPLE-CHANNEL REGION

SLOPE = 0.0148000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: | | WIDTH (FT) |
|---|---|---|---|---|---|
| | | | Q | $37.5951\ Q^{0.5415}$ | |
| 0.5 | 0.4 | 443 | 0.07886 | 0.25909 | 5962 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: | | WIDTH (FT) |
|---|---|---|---|---|---|
| | | | Q | $37.5951\ Q^{0.5415}$ | |
| 3.5 | 0.4 | 805 | 0.03152 | 0.12353 | 2842 |

Scarp Canyon Alluvial Fan: Model Set 2

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 15 | 15 |
| 10 | 356 | 351 |
| 100 | 2178 | 2198 |

MEAN = 1.030262
STANDARD DEVIATION = 1.279943
SKEW = -0.7

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 351
50-YEAR DISCHARGE = 1443
100-YEAR DISCHARGE = 2198
500-YEAR DISCHARGE = 4604

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.3680+0.7081 LOG(Q)

MEAN OF Z = 2.097573
STANDARD DEVIATION = 0.906384
SKEW = -0.700000
TRANSFORMATION CONSTANT = 4.459600

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 0.7081 23.3345 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.33492 | 0.70714 | 4450 |
| 1.5 | 1.0 | 756 | 0.04683 | 0.19857 | 1250 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 0.7081 23.3345 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.28883 | 0.65373 | 4114 |
| 4.5 | 0.6 | 238 | 0.14038 | 0.42021 | 2645 |
| 5.5 | 0.9 | 649 | 0.05653 | 0.22635 | 1425 |
| 6.5 | 1.3 | 1496 | 0.01914 | 0.09895 | 623 |

## MULTIPLE-CHANNEL REGION

SLOPE = 0.0148000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $23.3345\ Q^{0.7081}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.4 | 443 | 0.08348 | 0.29635 | 7087 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $23.3345\ Q^{0.7081}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 805 | 0.04358 | 0.18942 | 4530 |

Scarp Canyon Alluvial Fan: Model Set 3

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 15 | 15 |
| 10 | 356 | 357 |
| 100 | 3498 | 3491 |

MEAN = 1.117872
STANDARD DEVIATION = 1.152607
SKEW = -0.3

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 357
50-YEAR DISCHARGE = 1976
100-YEAR DISCHARGE = 3491
500-YEAR DISCHARGE = 10458

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.2079+0.8628 LOG(Q)

MEAN OF Z = 2.172367
STANDARD DEVIATION = 0.994433
SKEW = -0.300000
TRANSFORMATION CONSTANT = 4.652288

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $16.1400\ Q^{0.8628}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.32531 | 0.70098 | 4602 |
| 1.5 | 1.0 | 756 | 0.05446 | 0.24845 | 1631 |
| 2.5 | 1.7 | 2712 | 0.01444 | 0.09633 | 625 |

| LOCITY (T/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $16.1400\ Q^{0.8628}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.27964 | 0.64926 | 4263 |
| 4.5 | 0.6 | 238 | 0.13909 | 0.43758 | 2873 |
| 5.5 | 0.9 | 649 | 0.06377 | 0.27117 | 1780 |
| 6.5 | 1.3 | 1496 | 0.02760 | 0.16044 | 1051 |
| 7.5 | 1.7 | 3059 | 0.01232 | 0.08785 | 565 |

MULTIPLE-CHANNEL REGION

SLOPE = 0.0148000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $16.1400\ Q^{0.8628}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.4 | 443 | 0.08692 | 0.33143 | 8269 |

| ELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $16.1400\ Q^{0.8628}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 805 | 0.05067 | 0.23920 | 5968 |
| 4.5 | 0.6 | 2293 | 0.01738 | 0.11285 | 2774 |

Scarp Canyon Alluvial Fan: Model Set 4

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 15 | 15 |
| 10 | 769 | 779 |
| 100 | 3438 | 3406 |

MEAN = 0.751408
STANDARD DEVIATION = 2.011177
SKEW = -1.3

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 779
50-YEAR DISCHARGE = 2597
100-YEAR DISCHARGE = 3406
500-YEAR DISCHARGE = 4925

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=2.0997+0.4540 LOG(Q)

MEAN OF Z = 2.440823
STANDARD DEVIATION = 0.913058
SKEW = -1.300000
TRANSFORMATION CONSTANT = 5.305945

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 0.4540 125.8027 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.38263 | 0.81739 | 6120 |
| 1.5 | 1.0 | 756 | 0.10286 | 0.37538 | 2811 |
| 2.5 | 1.7 | 2712 | 0.01841 | 0.09197 | 689 |

| LOCITY rT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 0.4540 125.8027 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.34751 | 0.78692 | 5892 |
| 4.5 | 0.6 | 238 | 0.21491 | 0.61188 | 4582 |
| 5.5 | 0.9 | 649 | 0.11751 | 0.41056 | 3074 |
| 6.5 | 1.3 | 1496 | 0.05029 | 0.21689 | 1624 |
| 7.5 | 1.7 | 3059 | 0.01396 | 0.07173 | 537 |

MULTIPLE-CHANNEL REGION

SLOPE = 0.0148000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 0.4540 125.8027 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.4 | 443 | 0.15397 | 0.49326 | 14035 |

| :LOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 0.4540 125.8027 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 805 | 0.09752 | 0.36091 | 10269 |
| 4.5 | 0.6 | 2293 | 0.02578 | 0.12522 | 3563 |

# FEMA FAN MODEL OUTPUT

**HALFPINT ALLUVIAL FAN**

**(Model Sets 1, 2, 3 & 4)**

Halfpint Alluvial Fan: Model Set 1

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 10 | 10 |
| 10 | 168 | 170 |
| 100 | 603 | 598 |

MEAN = 0.759609
STANDARD DEVIATION = 1.328618
SKEW = -1.1

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 170
50-YEAR DISCHARGE = 464
100-YEAR DISCHARGE = 598
500-YEAR DISCHARGE = 876

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.2765+0.5980 LOG(Q)

MEAN OF Z = 1.730742
STANDARD DEVIATION = 0.794495
SKEW = -1.100000
TRANSFORMATION CONSTANT = 3.392134

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $18.9020 Q^{0.5980}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.26742 | 0.59475 | 2847 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $18.9020 Q^{0.5980}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.21876 | 0.52204 | 2499 |
| 4.5 | 0.6 | 238 | 0.06832 | 0.21587 | 1033 |

MULTIPLE-CHANNEL REGION

SLOPE = 0.0196000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $18.9020\ Q^{0.5980}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 449 | 0.02168 | 0.08480 | 1543 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $18.9020\ Q^{0.5980}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 566 | 0.01212 | 0.04847 | 882 |

Halfpint Alluvial Fan: Model Set 2

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 10 | 10 |
| 10 | 168 | 169 |
| 100 | 1180 | 1176 |

MEAN = 0.928731
STANDARD DEVIATION = 1.055311
SKEW = -0.4

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 169
50-YEAR DISCHARGE = 731
100-YEAR DISCHARGE = 1176
500-YEAR DISCHARGE = 2890

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.0090+0.8374 LOG(Q)

MEAN OF Z = 1.786716
STANDARD DEVIATION = 0.883714
SKEW = -0.400000
TRANSFORMATION CONSTANT = 3.569505

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 0.8374 10.2094 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.24808 | 0.57142 | 2878 |
| 1.5 | 1.0 | 756 | 0.01928 | 0.09924 | 500 |

| VELOCITY T/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 0.8374 10.2094 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.20017 | 0.50667 | 2552 |
| 4.5 | 0.6 | 238 | 0.07596 | 0.26560 | 1338 |
| 5.5 | 0.9 | 649 | 0.02353 | 0.11884 | 599 |

## MULTIPLE-CHANNEL REGION

SLOPE = 0.0196000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $10.2094\ Q^{0.8374}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 449 | 0.03741 | 0.16695 | 3196 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $10.2094\ Q^{0.8374}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 566 | 0.02835 | 0.13656 | 2614 |

## Halfpint Alluvial Fan: Model Set 3

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 10 | 10 |
| 10 | 168 | 168 |
| 100 | 1819 | 1821 |

MEAN = 1.016033
STANDARD DEVIATION = 0.935309
SKEW = 0.1

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 168
50-YEAR DISCHARGE = 970
100-YEAR DISCHARGE = 1821
500-YEAR DISCHARGE = 6634

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=0.7953+1.0450 LOG(Q)

MEAN OF Z = 1.857036
STANDARD DEVIATION = 0.977359
SKEW = 0.100000
TRANSFORMATION CONSTANT = 3.728261

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $6.2420\ Q^{1.0450}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.23709 | 0.56316 | 2963 |
| 1.5 | 1.0 | 756 | 0.02605 | 0.15414 | 802 |

| VELOCITY T/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $6.2420\ Q^{1.0450}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.19242 | 0.50416 | 2653 |
| 4.5 | 0.6 | 238 | 0.07866 | 0.29407 | 1546 |
| 5.5 | 0.9 | 649 | 0.03085 | 0.16909 | 883 |
| 6.5 | 1.3 | 1496 | 0.01313 | 0.09258 | 462 |

MULTIPLE-CHANNEL REGION

SLOPE = 0.0196000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 1.0450 6.2420 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 449 | 0.04315 | 0.20703 | 4126 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | 1.0450 6.2420 Q | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 566 | 0.03509 | 0.18232 | 3625 |
| 4.5 | 0.5 | 1614 | 0.01192 | 0.08813 | 1651 |

Halfpint Alluvial Fan: Model Set 4

AVULSION FACTOR = 1.5000

FLOOD FREQUENCY CURVE DEFINED BY LEAST-SQUARES FIT OF DATA

| RETURN INTERVAL (YEARS) | INPUT DISCHARGE (CFS) | BEST FIT DISCHARGE (CFS) |
|---|---|---|
| 2 | 10 | 10 |
| 10 | 335 | 343 |
| 100 | 1898 | 1867 |

MEAN = 0.734788
STANDARD DEVIATION = 1.596884
SKEW = -1.0

SUMMARY OF DISCHARGES:

10-YEAR DISCHARGE = 343
50-YEAR DISCHARGE = 1310
100-YEAR DISCHARGE = 1867
500-YEAR DISCHARGE = 3269

STATISTICS AFTER TRANSFORMATION OF Y=LOG(Q) TO Z=1.6637+0.5765 LOG(Q)

MEAN OF Z = 2.087308
STANDARD DEVIATION = 0.920624
SKEW = -1.000000
TRANSFORMATION CONSTANT = 4.101043

SINGLE-CHANNEL REGION

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $46.0992\ Q^{0.5765}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 0.5 | 0.3 | 49 | 0.31010 | 0.71462 | 4136 |
| 1.5 | 1.0 | 756 | 0.04476 | 0.19714 | 1141 |

| VELOCITY T/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: Q | $46.0992\ Q^{0.5765}$ | WIDTH (FT) |
|---|---|---|---|---|---|
| 3.5 | 0.4 | 68 | 0.27085 | 0.66516 | 3850 |
| 4.5 | 0.6 | 238 | 0.13611 | 0.43540 | 2520 |
| 5.5 | 0.9 | 649 | 0.05423 | 0.22757 | 1317 |
| 6.5 | 1.3 | 1496 | 0.01626 | 0.08582 | 497 |

MULTIPLE-CHANNEL REGION

SLOPE = 0.0196000
N-VALUE = 0.0300000

| ENERGY (FT) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: | | WIDTH (FT) |
| --- | --- | --- | --- | --- | --- |
| | | | Q | $46.0992\ Q^{0.5765}$ | |
| 0.5 | 0.3 | 449 | 0.08068 | 0.30203 | 6642 |

| VELOCITY (FT/SEC) | DEPTH (FT) | DISCHARGE (CFS) | PROBABILITY OF DISCHARGE BEING EXCEEDED AT THE APEX BY: | | WIDTH (FT) |
| --- | --- | --- | --- | --- | --- |
| | | | Q | $46.0992\ Q^{0.5765}$ | |
| 3.5 | 0.4 | 566 | 0.06397 | 0.25496 | 5607 |
| 4.5 | 0.5 | 1614 | 0.01411 | 0.07631 | 1678 |

```
**********************************************
*  HEC-2 WATER SURFACE PROFILES              *
*                                            *
*  Version   4.6.2;  May 1991                *
*                                            *
*  RUN DATE    29JAN93    TIME    15:20:50   *
**********************************************
```

```
**************************************
*  U.S. ARMY CORPS OF ENGINEERS      *
*  HYDROLOGIC ENGINEERING CENTER     *
*  609 SECOND STREET, SUITE D        *
*  DAVIS, CALIFORNIA 95616-4687      *
*        (916) 756-1104              *
**************************************
```

```
X     X  XXXXXXX   XXXXX            XXXXX
X     X  X        X     X          X     X
X     X  X        X                      X
XXXXXXX  XXXX     X         XXXXX   XXXXX
X     X  X        X                X
X     X  X        X     X          X
X     X  XXXXXXX   XXXXX           XXXXXXX
```

T1 HEC-2 RUN TO DETERMINE 100-YEAR FLOOD HAZARD LIMITS AND DEPTHS
T2 SOUTHWEST CORNER OF RWMS ASSUMING NO BERM
T3 FLOW CONDITION OF "NATURAL CONDITIONS" FILE: SWCRWMS.DAT
SUBCRITICAL FLOW
CROSS SECTIONS DEVELOPED FROM 1"=400', 5' C.I. TOPOGRAPHIC MAP OF THE RWMS.
THE 100-YEAR DISCHARGE AT CROSS SECTION 1 FROM HEC-1 MODEL RWMSW.OUT (CPF)
IS 2396 CFS. THE REMAINING CROSS SECTIONS (2-7) USED THE 100-YEAR DISCHARGE
OF 1230 CFS FROM HEC-1 MODEL RWMSW.OUT (CPA1).

| J1 | ICHECK | INQ | NINV | IDIR | STRT | METRIC | HVINS | Q | WSEL | FQ |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 0 | 0 | -1 | 0 | 0 | 0 | 3166 | 0 |

| J2 | NPROF | IPLOT | PRFVS | XSECV | XSECH | FN | ALLDC | IBW | CHNIM | ITRACE |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 0 | -1 | 0 | 0 | -1 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NC | 0.040 | 0.040 | .035 | .1 | .3 | 0 | 0 | 0 | | |
| QT | 1 | 2396 | | | | | | | | |
| X1 | 1.0 | 6 | 0 | 670 | 0 | 0 | 0 | | | |
| GR | 3175 | 0 | 3165 | 300 | 3167 | 340 | 3165 | 360 | 3170 | 390 |
| GR | 3175 | 670 | | | | | | | | |
| QT | 1 | 1229 | | | | | | | | |
| X1 | 2.0 | 19 | 445 | 661 | 1240 | 1240 | 1240 | | | |
| GR | 3180 | 0 | 3177.5 | 420 | 3177.5 | 445 | 3177 | 446 | 3176.5 | 460 |
| GR | 3176 | 461 | 3176 | 470 | 3175.5 | 471 | 3175.5 | 490 | 3176 | 491 |
| GR | 3176 | 555 | 3175 | 556 | 3175 | 590 | 3176.5 | 591 | 3176.5 | 610 |
| GR | 3176 | 611 | 3176 | 660 | 3178 | 661 | 3180 | 930 | | |
| X1 | 3.0 | 9 | 765 | 821 | 560 | 560 | 560 | | | |
| GR | 3185 | 0 | 3181 | 740 | 3181 | 765 | 3180 | 766 | 3180 | 775 |
| GR | 3181 | 776 | 3181 | 820 | 3182 | 821 | 3185 | 1100 | | |
| X1 | 4.0 | 3 | 0 | 1060 | 800 | 800 | 800 | | | |
| GR | 3190 | 0 | 3185 | 660 | 3190 | 1060 | | | | |
| X1 | 5.0 | 3 | 0 | 1440 | 1840 | 1840 | 1840 | | | |
| GR | 3215 | 0 | 3210 | 770 | 3215 | 1440 | | | | |
| X1 | 6.0 | 3 | 0 | 1130 | 820 | 820 | 820 | | | |
| GR | 3220 | 0 | 3215 | 440 | 3220 | 1130 | | | | |
| X1 | 7 | 3 | 0 | 1150 | 780 | 780 | 780 | | | |
| GR | 3230 | 0 | 3225 | 590 | 3230 | 1150 | | | | |

```
     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST

 *PROF 1
0

 CCHV=     .100 CEHV=      .300
 *SECNO 1.000
 3720 CRITICAL DEPTH ASSUMED
     1.000      3.18   3168.18    3168.18    3166.00    3169.09       .91        .00        .00    3175.00
    2396.0        .0    2396.0         .0         .0      312.8        .0         .0         .0    3175.00
       .00       .00      7.66        .00       .000       .035      .000       .000    3165.00     204.61
   .015002        0.        0.         0.          0         22         0        .00     174.47     379.08

 *SECNO 2.000

 3301 HV CHANGED MORE THAN HVINS

     2.000      2.68   3177.68        .00        .00    3177.84       .16       8.67        .08    3177.50
    1229.0       3.6    1225.4         .0        7.0      383.9        .0       10.0        6.3    3178.00
       .11       .52      3.19        .00       .040       .035      .000       .000    3175.00     390.55
   .002669      1240.     1240.      1240.         6          0         0        .00     270.29     660.84

 *SECNO 3.000
 3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     3.000      2.30   3182.30    3182.30        .00    3182.70       .40       2.92        .07    3181.00
    1229.0     691.4     532.6        5.1      187.7       82.1       4.1       14.3       10.3    3182.00
       .14      3.68      6.49       1.25       .040       .035      .040       .000    3180.00     500.26
   .014448       560.      560.       560.        20         12         0        .00     348.26     848.52

 *SECNO 4.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.19

     4.000      2.17   3187.17        .00        .00    3187.26       .09       4.54        .03    3190.00
    1229.0        .0    1229.0         .0         .0      499.9        .0       21.4       17.7    3190.00
       .23       .00      2.46        .00       .000       .035      .000       .000    3185.00     373.34
   .003005       800.      800.       800.         5          0         0        .00     460.39     833.73

 *SECNO 5.000
 3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     5.000      1.34   3211.34    3211.34        .00    3211.69       .35      11.64        .08    3215.00
    1229.0        .0    1229.0         .0         .0      260.3        .0       37.4       35.6    3215.00
       .34       .00      4.72        .00       .000       .035      .000       .000    3210.00     562.95
   .021001      1840.     1840.      1840.        20         14         0        .00     387.21     950.16

 *SECNO 6.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.55

     6.000      2.09   3217.09        .00        .00    3217.18       .10       5.47        .03    3220.00
    1229.0        .0    1229.0         .0         .0      494.3        .0       44.6       43.7    3220.00
       .43       .00      2.49        .00       .000       .035      .000       .000    3215.00     255.94
   .003231       820.      820.       820.         8          0         0        .00     472.69     728.63

 *SECNO 7.000
 3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     7.000      1.47   3226.47    3226.47        .00    3226.85       .38       5.16        .09    3230.00
    1229.0        .0    1229.0         .0         .0      248.4        .0       51.2       51.0    3230.00
       .47       .00      4.95        .00       .000       .035      .000       .000    3225.00     416.57
   .020478       780.      780.       780.        20         19         0        .00     338.04     754.61


 NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST
```

CONDITION OF "NATURAL C

SUMMARY PRINTOUT TABLE 150

| | SECNO | XLCH | ELTRD | ELLC | ELMIN | Q | CWSEL | CRIWS | EG | 10*KS | VCH | AREA | .01K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | 1.000 | .00 | .00 | .00 | 3165.00 | 2396.00 | 3168.18 | 3168.18 | 3169.09 | 150.02 | 7.66 | 312.77 | 195.62 |
| | 2.000 | 1240.00 | .00 | .00 | 3175.00 | 1229.00 | 3177.68 | .00 | 3177.84 | 26.69 | 3.19 | 390.85 | 237.88 |
| * | 3.000 | 560.00 | .00 | .00 | 3180.00 | 1229.00 | 3182.30 | 3182.30 | 3182.70 | 144.48 | 6.49 | 273.88 | 102.25 |
| * | 4.000 | 800.00 | .00 | .00 | 3185.00 | 1229.00 | 3187.17 | .00 | 3187.26 | 30.05 | 2.46 | 499.89 | 224.21 |
| * | 5.000 | 1840.00 | .00 | .00 | 3210.00 | 1229.00 | 3211.34 | 3211.34 | 3211.69 | 210.01 | 4.72 | 260.30 | 84.81 |
| * | 6.000 | 820.00 | .00 | .00 | 3215.00 | 1229.00 | 3217.09 | .00 | 3217.18 | 32.31 | 2.49 | 494.33 | 216.23 |
| * | 7.000 | 780.00 | .00 | .00 | 3225.00 | 1229.00 | 3226.47 | 3226.47 | 3226.85 | 204.78 | 4.95 | 248.41 | 85.88 |
| * | 1.000 | 2396.00 | 3168.18 | .00 | .00 | 2.18 | 174.47 | .00 | | | | | |
| | 2.000 | 1229.00 | 3177.68 | .00 | 9.50 | .00 | 270.29 | 1240.00 | | | | | |
| * | 3.000 | 1229.00 | 3182.30 | .00 | 4.62 | .00 | 348.26 | 560.00 | | | | | |
| * | 4.000 | 1229.00 | 3187.17 | .00 | 4.87 | .00 | 460.39 | 800.00 | | | | | |
| * | 5.000 | 1229.00 | 3211.34 | .00 | 24.17 | .00 | 387.21 | 1840.00 | | | | | |
| * | 6.000 | 1229.00 | 3217.09 | .00 | 5.74 | .00 | 472.69 | 820.00 | | | | | |
| * | 7.000 | 1229.00 | 3226.47 | .00 | 9.38 | .00 | 338.04 | 780.00 | | | | | |

SUMMARY OF ERRORS AND SPECIAL NOTES

```
CAUTION SECNO=     1.000  PROFILE=  1  CRITICAL DEPTH ASSUMED

    ION SECNO=     3.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     3.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     3.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO=     4.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=     5.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     5.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     5.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

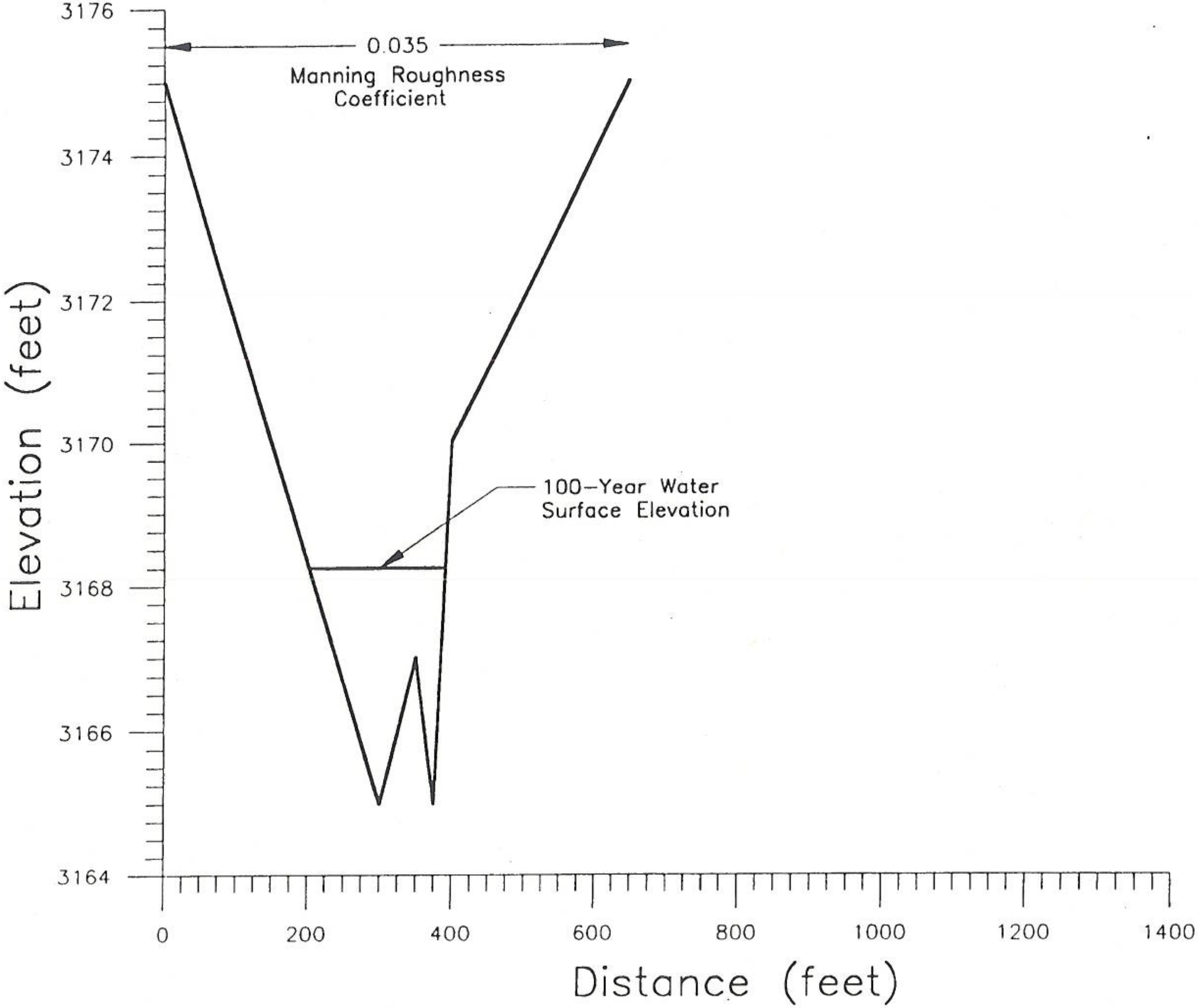
WARNING SECNO=     6.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=     7.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     7.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     7.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL
```

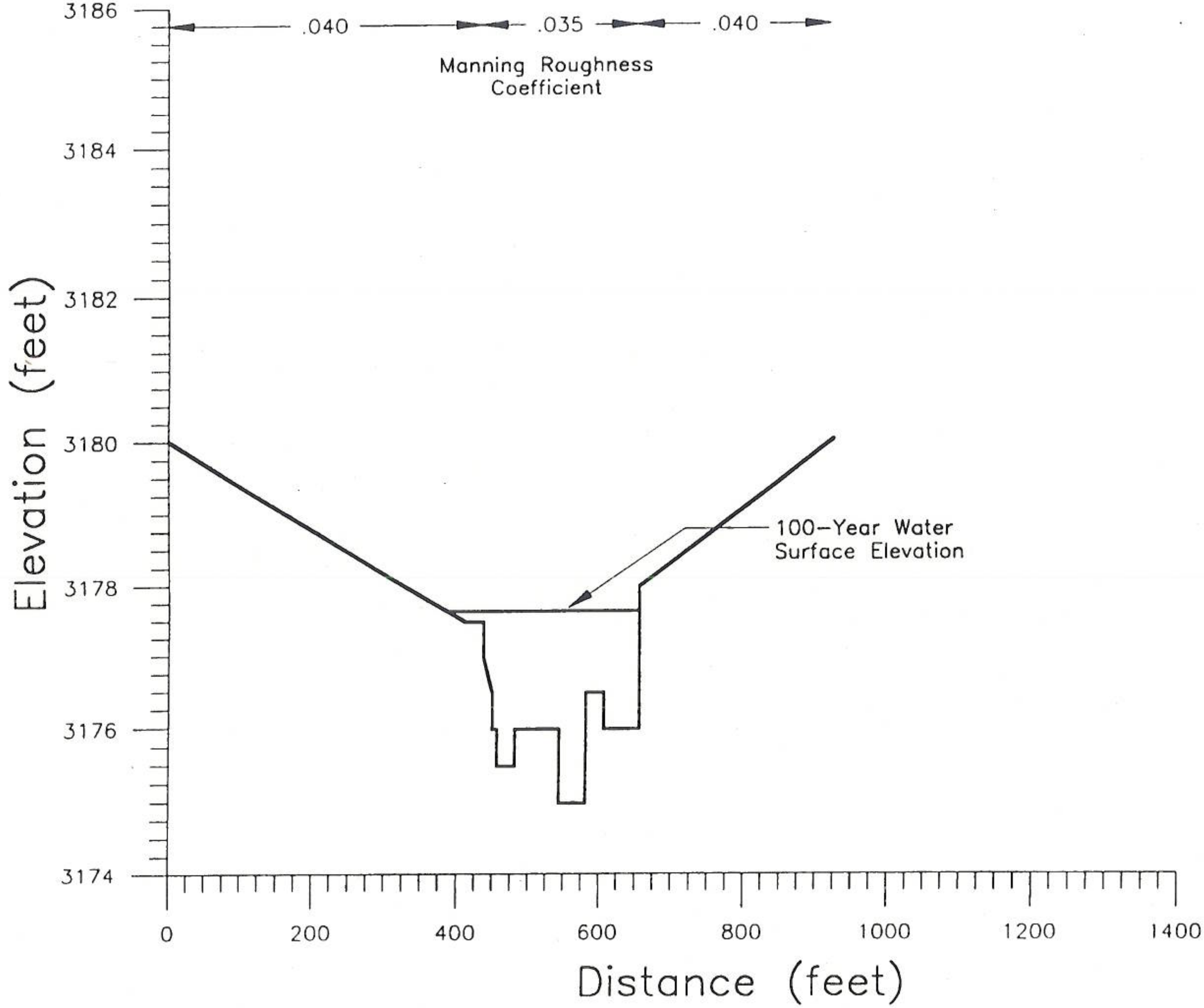
# HEC-2 MODEL OUTPUT

## CROSS SECTIONS

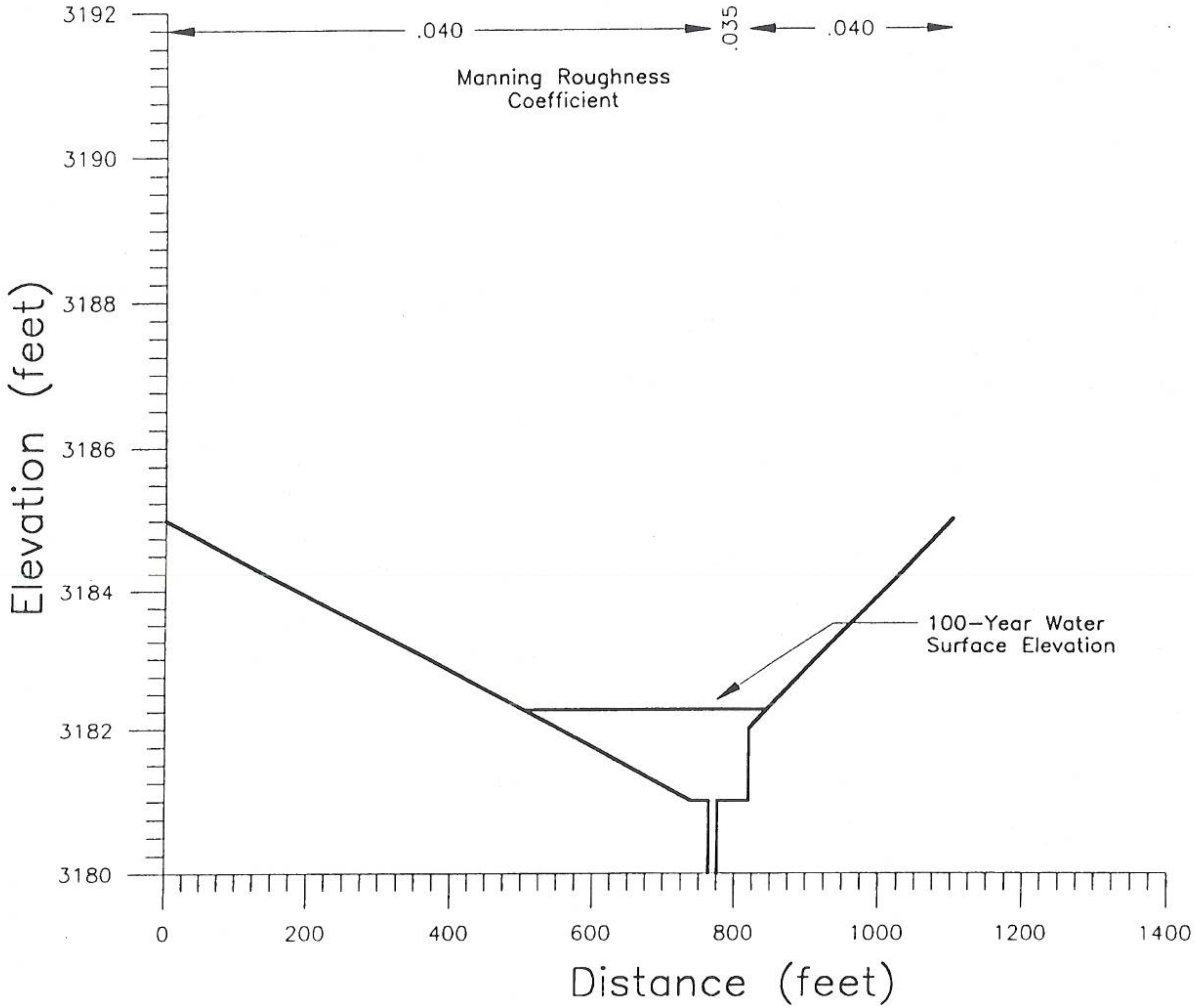
# Cross-Section 1.000



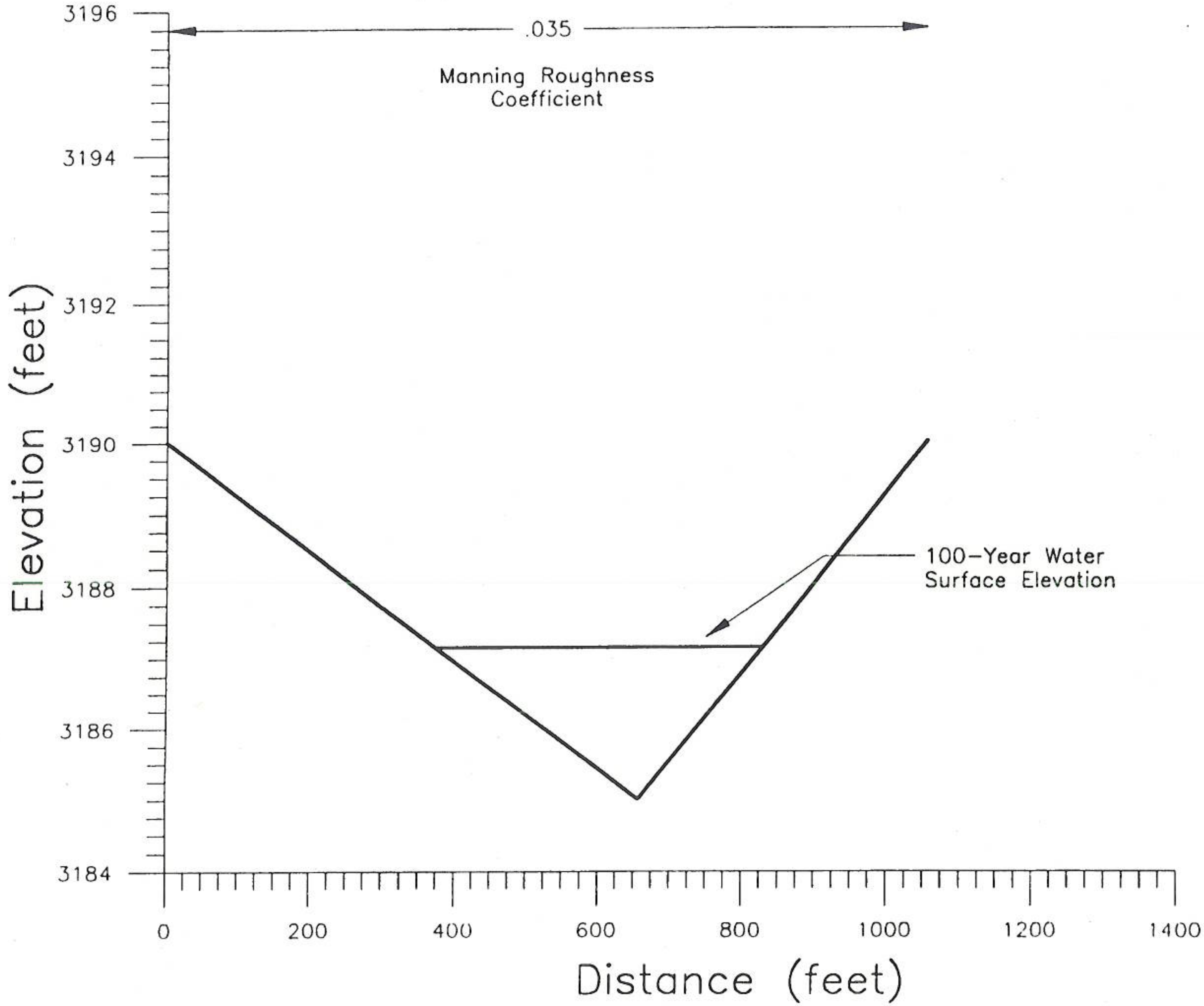
# Cross-Section 2.000



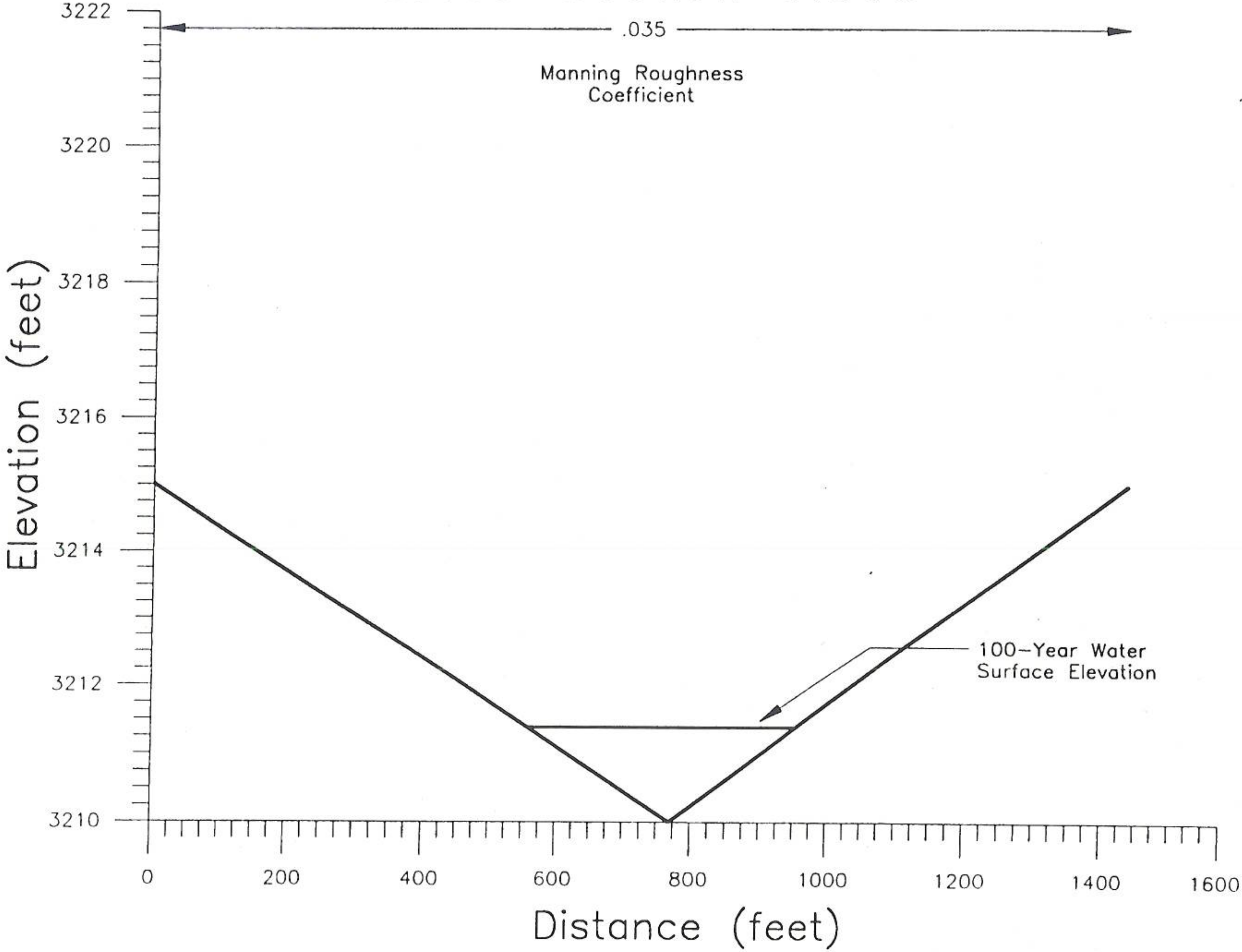
# Cross–Section 3.000

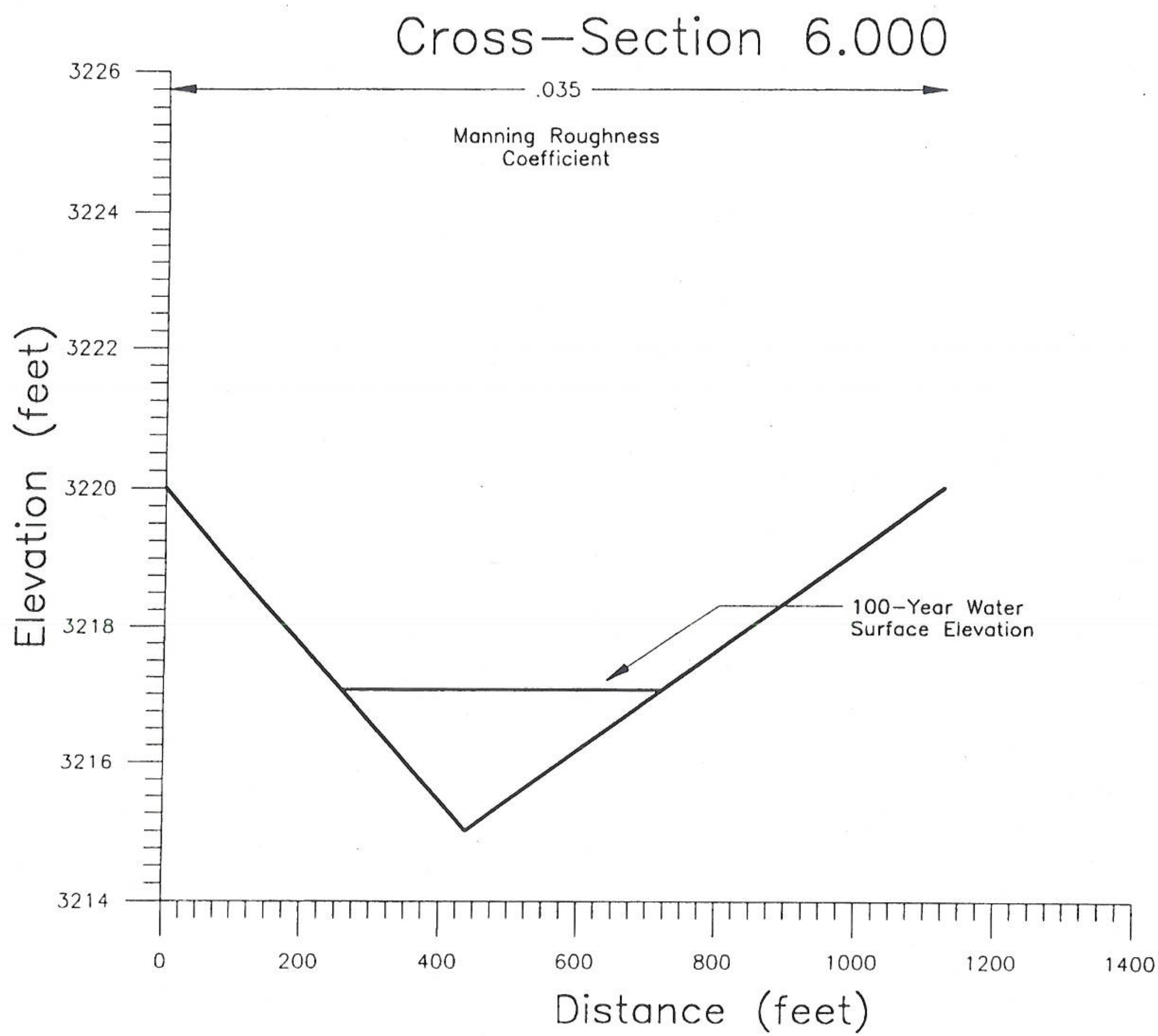


# Cross-Section 4.000

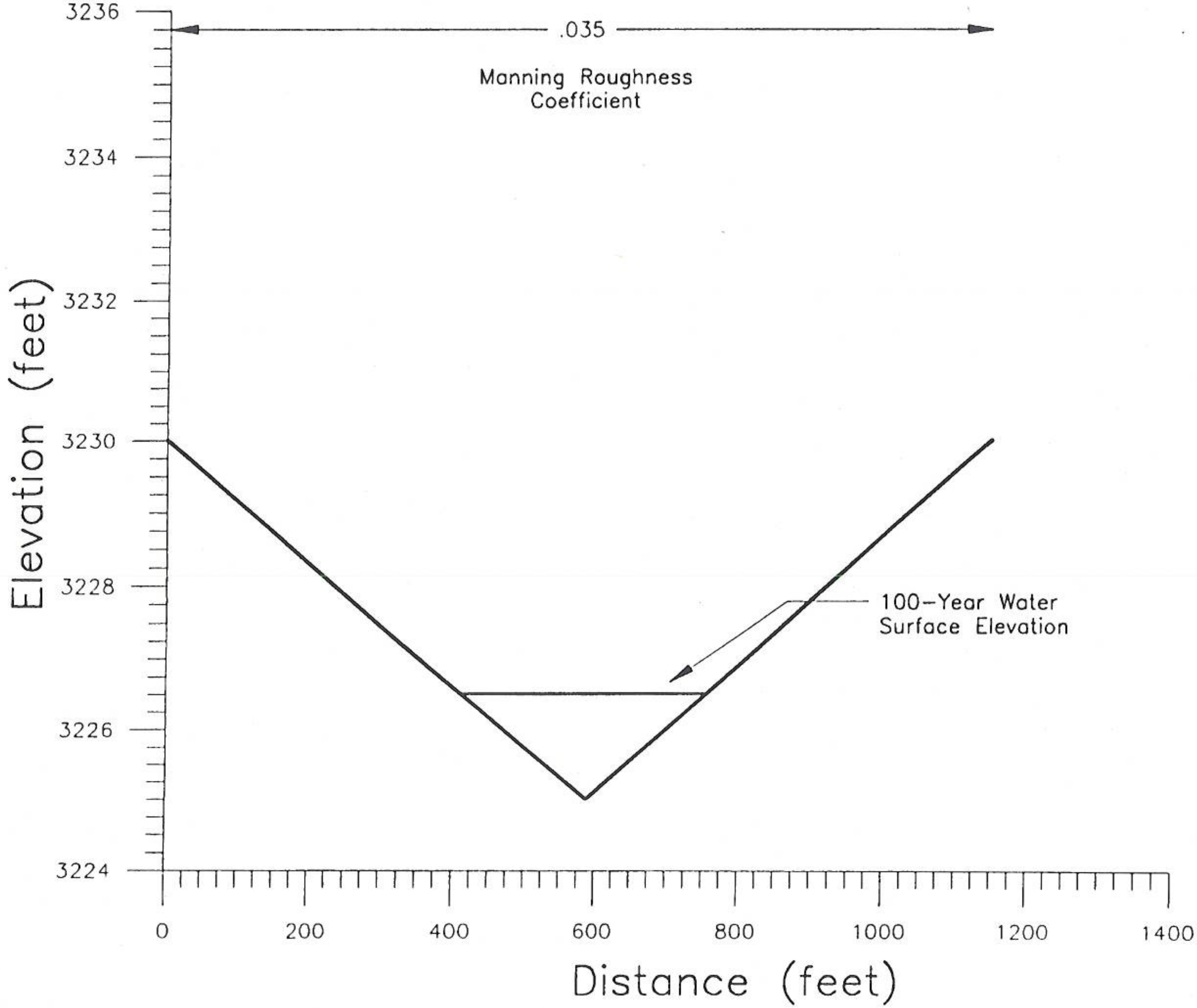


# Cross–Section 5.000




Cross-Section 6.000
.035
Manning Roughness
Coefficient
100-Year Water
Surface Elevation
3226
3224
3222
3220
3218
3216
3214
Elevation (feet)
0
200
400
600
800
1000
1200
1400
Distance (feet)

# Cross-Section 7.000



## SHEETFLOW CALCULATIONS FOR THE NORTH SIDE OF THE AREA 5 RWMS

| CHANGE IN ELEVATION (ft) | REACH LENGTH (ft) | MANNING COEFFICIENT | SLOPE (ft/ft) | WIDTH (ft) | DISCHARGE ($ft^3$/sec) |
|---|---|---|---|---|---|
| 90 | 3500 | 0.035 | 0.026 | 2500 | 624 |

Q=DISCHARGE ($ft^3$/sec)
V=VELOCITY (ft/sec)
A=AREA ($ft^2$) (For a rectangular channel, area = depth * width)
R=HYDRAULIC RADIUS (ft) (For a shallow channel, assume R=depth)
S=SLOPE (ft/ft)
n=MANNING COEFFICIENT
W=WIDTH (ft)
d=DEPTH (ft)

EQUATIONS:

$$Q=VA$$

$$V=\frac{1.49}{n}R^{2/3}S^{1/2}$$

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

CALCULATIONS:

$$Q=\frac{1.49}{n}d^{2/3}S^{1/2}dW$$

$$Q=\frac{1.49}{n}d^{5/3}S^{1/2}W$$

$$d=\frac{Qn}{(1.49S^{1/2}W)^{3/5}}$$

DEPTH CALCULATION:

FLOW DEPTH = 0.11 ft

## SHEETFLOW CALCULATIONS FOR THE EAST SIDE OF THE AREA 5 RWMS

| CHANGE IN ELEVATION (ft) | REACH LENGTH (ft) | MANNING COEFFICIENT | SLOPE (ft/ft) | WIDTH (ft) | DISCHARGE ($ft^3$/sec) |
|---|---|---|---|---|---|
| 75 | 4250 | 0.035 | 0.018 | 2460 | 1100 |

Q=DISCHARGE ($ft^3$/sec)
V=VELOCITY (ft/sec)
A=AREA ($ft^2$) (For a rectangular channel, area = depth * width)
R=HYDRAULIC RADIUS (ft) (For a shallow channel, assume R=depth)
S=SLOPE (ft/ft)
n=MANNING COEFFICIENT
W=WIDTH (ft)
d=DEPTH (ft)

EQUATIONS:

$$Q=VA$$

$$V=\frac{1.49}{n}R^{2/3}S^{1/2}$$

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

CALCULATIONS:

$$Q=\frac{1.49}{n}d^{2/3}S^{1/2}dW$$

$$Q=\frac{1.49}{n}d^{5/3}S^{1/2}W$$

$$d=\frac{Qn}{(1.49S^{1/2}W)^{3/5}}$$

DEPTH CALCULATION:

FLOW DEPTH = 0.22 ft

SHEETFLOW CALCULATIONS FOR THE WEST SIDE OF THE AREA 5 RWMS

| CHANGE IN ELEVATION (ft) | REACH LENGTH (ft) | MANNING COEFFICIENT | SLOPE (ft/ft) | WIDTH (ft) | DISCHARGE ($ft^3$/sec) |
|---|---|---|---|---|---|
| 100 | 3500 | 0.035 | 0.029 | 2780 | 450 |

Q=DISCHARGE ($ft^3$/sec)
V=VELOCITY (ft/sec)
A=AREA ($ft^2$) (For a rectangular channel, area = depth * width)
R=HYDRAULIC RADIUS (ft) (For a shallow channel, assume R=depth)
S=SLOPE (ft/ft)
n=MANNING COEFFICIENT
W=WIDTH (ft)
d=DEPTH (ft)

EQUATIONS:

$$Q=VA$$

$$V=\frac{1.49}{n}R^{2/3}S^{1/2}$$

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

CALCULATIONS:

$$Q=\frac{1.49}{n}d^{2/3}S^{1/2}dW$$

$$Q=\frac{1.49}{n}d^{5/3}S^{1/2}W$$

$$d=\frac{Qn}{(1.49S^{1/2}W)^{3/5}}$$

DEPTH CALCULATION:

FLOW DEPTH = 0.10 ft

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## B.12 Training [40 CFR 270.14(b)(12)]

This section identifies the training requirements applicable to personnel assigned to perform duties at the MWDU.

### B.12.a Radioactive Waste Management Program Training

Training requirements are established by the contractor's Training Program Manual, which uses a systematic approach to ensure personnel assigned to waste handling operations are trained and qualified to safely and effectively perform their assigned work. Qualified training personnel work with the Operations Manager and subject matter experts, who are knowledgeable of hazardous and radioactive waste management and emergency procedures, to develop job descriptions for each functional title. Based on job descriptions, qualification programs are developed for each position to identify critical task assignments, entry-level qualifications, and additional training needs. Qualification cards are prepared for all RWMC personnel to document completion of the assigned training program for their functional title. Annual reviews of training programs and qualification statuses for RWMC personnel are performed to ensure personnel training qualifications are current. Personnel qualification cards are maintained by the contractor's Training Division. Personnel training records are accessible at the RWMC via the contractor's training database. The Operations Manager also maintains a List of Qualified Individuals at the RWMC to ensure personnel training and qualifications are current.

### B.12.b RWMC Personnel [40 CFR 264.16(d)]

Table 8 includes functional titles and required training for personnel assigned to perform work at the MWDU. Current functional titles and job descriptions are maintained in the Radioactive Waste Operations Training Records.

### B.12.c Visitors

Visitors are not permitted within the boundaries of the RWMC without an escort. Training requirements for visitors are reviewed on a case-by-case basis by the RWMC Facility Manager. The training required for a visitor depends upon the task the visitor is performing, the operations occurring at the RWMC, and whether exposure to wastes of hazardous constituents could occur. Visitors include inspectors, auditors, vendors, consultants, subcontractors, and TSDF contractors. Other visitors can include personnel not assigned to perform normal day-to-day operations at the RWMC. Visitors receive a facility indoctrination briefing that, at a minimum, includes the following:

- Elements of the contingency plan and emergency procedures (e.g., alarms, evacuation routes, emergency equipment)
- Hazard communication
- Hazard awareness and PPE requirements

Personnel not assigned to the RWMC who are performing work within the RWMC boundaries must receive approval from the RWMC Facility Manager or designee, present credentials certifying that they have successfully completed Hazardous Waste General Site Worker Training, and receive a detailed briefing specific to the task to be performed including additional hazard communication when required. Visitors must sign in and out each day they are visiting.

**Table 8. MWDU Training Matrix**

| Functional Title | Outline of Required Training |
|---|---|
| Operations Manager (Qualification OQ00202) | Hazard Communication<br>Hazardous Waste Site General Worker<br>Basic RCRA and Hazardous Waste Manifest<br>Hazardous Waste Site General Worker Refresher<br>RCRA Refresher<br>Radiation Worker II<br>Radioactive Waste Operations (RWO) Annual Refresher<br>RWO General Employee Training<br>Employee Emergency Action Training for RWO<br>Hazardous Materials Handling and Spill Response |
| RWMC LLW Supervisor (Qualification OQ00151) | Hazard Communication<br>Hazardous Waste Site General Worker Supervisor<br>Basic RCRA and Hazardous Waste Manifest<br>Hazardous Waste Site General Worker Refresher<br>RCRA Refresher<br>Radiation Worker II<br>RWO Annual Refresher<br>RWO General Employee Training<br>Employee Emergency Action Training for RWO<br>Hazardous Materials Handling and Spill Response |
| RWO Waste Specialist (Qualification OQ00152) | Hazard Communication<br>Hazardous Waste Site General Worker<br>Basic RCRA and Hazardous Waste Manifest<br>Hazardous Waste Site General Worker Refresher<br>RCRA Refresher<br>Respirator Fit Test<br>Radiation Worker II<br>RWO Annual Refresher<br>RWO General Employee Training<br>Employee Emergency Action Training for RWO<br>Hazardous Materials Handling and Spill Response |
| Radiological Control Technician (Qualification OQ00123) | Hazard Communication<br>Hazardous Waste Site General Worker<br>Basic RCRA and Hazardous Waste Manifest<br>Hazardous Waste Site General Worker Refresher<br>RCRA Refresher<br>Respirator Fit Test<br>Radiation Control Technician Training<br>RWO Annual Refresher<br>RWO General Employee Training<br>Employee Emergency Action Training for RWO<br>Hazardous Materials Handling and Spill Response |

| Functional Title | Outline of Required Training |
|---|---|
| Laborer<br>(Qualification OQ00154) | Hazard Communication<br>Hazardous Waste Site General Worker<br>Hazardous Waste Site General Worker Refresher<br>Respirator Fit Test<br>RCRA for Crafts<br>Radiation Worker II<br>RWO Annual Refresher<br>RWO General Employee Training<br>Employee Emergency Action Training for RWO<br>Hazardous Materials Handling and Spill Response |
| RWO RTR Operator<br>(Qualification OQ00124) | Hazard Communication<br>Hazardous Waste Site General Worker<br>Hazardous Waste Site General Worker Refresher<br>RCRA Refresher<br>Radiation Worker II<br>RWO Annual Refresher<br>RWO General Employee Training<br>Employee Emergency Action Training for RWO<br>Hazardous Materials Handling and Spill Response |

## B.12.d Implementation and Documentation of the Training Program

New employees must meet the training requirements within 6 months of employment and before working at the MWDU. The contractor's Training Division and the Operations Manager will perform the following activities:

- Maintain, update, and revise the training program as necessary
- Review regulations and operations/safety procedures to determine the adequate amount of training for each employee
- Ensure that personnel conducting or administering training have proper credentials and certifications
- Verify that the training program is documented and maintained in the MWDU personnel training records
- Verify that former employee records are maintained for a minimum of 3 years from the date the employee is reassigned or terminated
- Verify that employees are notified when specific training is required or due and that the training is received and successfully completed
- Verify that employees have successfully completed the required training before working in an unsupervised capacity

### B.12.e Course Descriptions

- Hazard Communication (**29 CFR 1910.1200**) – This course provides awareness of the hazard communication standard and its basic requirements. Course elements include hazards in the workplace, employee right-to-know, methods and observations, and safe work practices. (Frequency – one time)
- Hazardous Waste Site General Worker/Annual Refresher (**29 CFR 1910.120** and **40 CFR 264.16**) – Workers at a hazardous waste or LLMW TSDF are required to have a minimum of 40 hours of training with an 8-hour annual refresher. The training includes regulations, PPE, toxicology, basic chemistry, decontamination techniques, monitoring instruments, risk assessment/hazard evaluation, sampling methods and techniques, and emergency management. (Frequency – one-time 40-hour training and annual 8-hour refresher)
- Hazardous Waste Site Supervisor (**29 CFR 1910.120**) – This course provides a review of the supervisor's responsibilities concerning the health and safety program, associated employee training programs, the PPE Program, the spill containment program, health hazard monitoring procedure and techniques, and the legal aspects of supervising when conducting hazardous waste operations. (Frequency – one time)
- Basic RCRA and Hazardous Waste Manifest/Annual Refresher (**40 CFR 260–268**) – This course discusses RCRA regulations, how they apply to LLMW handling and disposal, types of waste, how to identify hazardous waste, emergency response, and the LDRs for hazardous waste. Hazardous waste manifest requirements are also covered. (Frequency – annual refresher)
- Radiological Worker II (**10 CFR 835.901**) – This course provides knowledge necessary to work safely in areas controlled for radiological purposes. The course covers identification of controlled areas, proper work practices, contamination control, practical factors demonstration, and handling radioactive material. (Frequency – refresher every 2 years)
- RWO Annual Refresher (**40 CFR 264.16**) – This course provides RCRA information for waste management activities, identification of hazardous waste and LLMW, LDRs, uniform hazardous waste manifest, and emergency response actions. (Frequency – annual)
- RWO General Employee Training (**29 CFR 1910.120** and **40 CFR 264.16**) – This course provides information on RWO facilities related to waste characterization, handling classified waste, transuranic waste activities, LLMW disposal, general work hazards, and response to emergency/off-normal events. (Frequency – one time)
- Radiological Control Technician (RCT) Qualification Program (**10 CFR 835.103**) – This qualification program requires RCTs to complete both national and site-specific written and oral examinations of radiological control procedures, work practices, and instrumentation. Job performance is also tested using field situations. Continuing education to maintain qualification is provided through in-house training on specific and general radiation control topics at regular intervals. (Frequency – continuing)
- Employee Emergency Action Training for RWO (**40 CFR 264.16, 29 CFR 1910.38,** and **29 CFR 1910.120**) – This course provides employees assigned to the facility with emergency response training. The course provides information on alarm recognition and

proper response, making notifications, sheltering, evacuation route maps, identification of location of fire alarms, first aid kits, and spill response kits.

- Hazardous Materials Handling and Spill Response (**49 CFR 172.704**) – This course provides measures to protect employees from the hazards associated with hazardous materials to which they may be exposed in the work place, including specific measures the hazmat employer has implemented to protect employees from exposure and methods and procedures for avoiding accidents, such as the proper procedures for handling packages containing hazardous materials. (Frequency – every 3 years)

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# B.13 Closure and Post-Closure Care Plan [40 CFR 270.14(b)(13)]

This information represents the Closure and Post-Closure Care Plan for the MWDU. A description of the waste managed at this unit is found in Section B.2 and the facility operating record. Closure activities are subject to the requirements of **40 CFR 264.112**. This document presents an interim closure and post-closure care plan for the MWDU. New information, technologies, or changes in performance monitoring may warrant an amendment to this plan. A copy of this plan is maintained in the MWDU Operating Record.

## B.13.a Description of Closure [40 CFR 264.112(b)(4)]

### B.13.a.1 MWDU (Landfill)

The MWDU (landfill) will be closed in place with a native soil cover. The cover will be of adequate thickness to preclude the movement of moisture through the cover and into the waste zone. The final cover design and construction will meet the following performance standards:

- Provide long-term minimization or migration of liquid through the closed landfill
- Function with minimum maintenance
- Promote drainage and minimize erosion of the cover
- Accommodate settling and subsidence
- Have a permeability less than or equal to the permeability of the bottom liner system and natural sub-soils

After final closure, the cover will be maintained as necessary to correct the effects of settling, subsidence, or erosion. The leachate collection and removal system will be operated until leachate is no longer detected. The leak detection system will be maintained and monitored as required in **40 CFR 264.301(3)(iv)** and **(4)** and **264.303(c)**. Benchmarks will be surveyed, marked, and maintained to meet the requirements of **40 CFR 264.309**.

### B.13.a.2 Leachate Collection Tank

The leachate collection tank will be clean-closed. The tank and tank components will be dismantled and disposed in compliance with the regulations in effect at the time of closure. Any residues from the decontamination of equipment, structures, and soil will be collected, containerized, characterized, and disposed in compliance with the regulations in effect at the time of closure.

## B.13.b Performance Standards for the Final Closure Cover

### B.13.b.1 Long-Term Minimization of Migration of Liquids [40 CFR 264.310(a)(1)]

The 24-year performance of non-vegetated and vegetated monolayer evapotranspiration closure covers has been conservatively modeled by simulating flow of water through the covers. The model used data collected from an existing non-vegetated operational cover on an LLMW interim status unit at the RWMC, interpreted data from two weighing lysimeters near the RWMC, and laboratory analyses of samples collected at the RWMC. Modeled drainage depths through a 2.4-m (8-ft) non-vegetated cover and vegetated cover were 1.02 cm per year and zero, respectively.

The final closure cover for the MWDU will be vegetated and nominally 2.4 m (8 ft) thick, thereby eliminating the possibility of migration of liquids through the cover to the waste zone. The cover may require additional soil to allow for surface grading, drainage, and placement of vegetation.

#### B.13.b.2 Function with Minimum Maintenance [40 CFR 264.310(a)(2)]

The closure cover will be a monolayer of native soil. The composition of the native soil and absence of layering will minimize maintenance (**40 CFR 264.111[a]**) and the need for repairs. Subsidence of the waste zone is expected after placement of the final closure cover. Subsidence will likely manifest as depressions, shear fractures, or holes in the cover. Disruptions of the cover surface will be repaired by adding native soil, grading, and re-vegetating as necessary. During the post-closure period, monitoring of the cover will continue, and repairs will be noted in inspection documentation.

#### B.13.b.3 Promote Drainage and Minimize Erosion of the Cover [40 CFR 264.310(a)(3)]

The closure cover will have a 1- to 2-percent slope to direct precipitation sheet flow to an adjacent drainage channel. The channel will be designed to move water away from the unit. The low slope will allow the closure cover to drain while minimizing erosion and surface scour. Erosion will be repaired by adding soil, grading, and re-vegetating as necessary.

#### B.13.b.4 Accommodate Settling and Subsidence [40 CFR 264.310(a)(4)]

During the post-closure care period, subsidence of the cover will be repaired. Following the post-closure care period, the cover will likely have differential subsidence and develop an uneven topography. The absence of layering in the cover will eliminate concerns with shearing of soils. Over time, low areas will fill in naturally, and the uneven topography will become increasingly subdued.

Potential settling was investigated within the RWMC and is discussed in the structural stability section of the Performance Assessment. The investigation considered factors such as the types of waste containers, the density of containerized wastes, and the configuration of stacking. Maximum subsidence is conservatively estimated for a typical trench in the RWMC to be 1.5 to 4 m (5 to 13 ft) and is expected to occur sometime after the 100-year post-closure care period of the RWMC in 2028. Much of the waste disposed is solidified and in steel containers. Stacking containers results in smaller spacing between containers, reducing gaps and subsidence.

Subsidence observed at other operational covers at the RWMC has been either small fissures or shallow depressions, both of which were easily repaired by infilling with soil.

#### B.13.b.5 Have a Permeability Less Than or Equal to the Permeability of Any Bottom Liner System or Natural Sub-Soils Present [40 CFR 264.310(a)(5)]

The monolayer evapotranspiration cover proposed for the final closure cover will meet this requirement with an alternative design. The native soil cover will have a greater permeability than the liner system on the floor of the disposal cell. Layered closure covers have a layer of natural or synthetic, low-permeability material to prohibit infiltration of moisture. The MWDU monolayer evapotranspiration cover will allow moisture to infiltrate into the cover, be stored in the open pore spaces within the soil, and then be removed by evaporation and/or transpiration. The closure cover will achieve the same results as a standard layered closure cover design, and no moisture migration will occur through the closure cover to the waste zone.

Modeling of liquid migration through the closure cover has demonstrated equivalency to a standard closure cover. The cover inhibits infiltration of liquid beyond a given depth based on site data. This equivalency was accepted by NDEP for closure of Corrective Action Unit (CAU) 110 at the Area 3 RWMS.

#### B.13.b.6 Coordination with Other Regulatory Standards

Disposal of LLW waste (including the LLW component of LLMW) at the RWMC is subject to requirements and performance objectives of DOE O 435.1, "Radioactive Waste Management," and the associated manual (DOE M 435.1-1) and guidance (DOE G 435.1-1). DOE O 435.1 requires that a Disposal Authorization Statement be obtained for new or existing disposal facilities. A Disposal Authorization Statement for the RWMC was issued by DOE Headquarters in December 2000 and specifies that the disposal program shall be conducted according to the site Performance Assessment.

### B.13.c Financial Requirements [40 CFR 264.140(c)]

Federal and state governments are exempt from the requirements of **40 CFR 264, Subpart H**.

### B.13.d Operational Activities and Schedule [40 CFR 264.112(b)(2)]

At the NNSS, final closure of disposal units regulated under RCRA follows a sequence of closure activities that takes approximately 2 years. The closure activity schedule is shown in Table 9.

1. **Preliminary Assessment.** Data are compiled and summarized in a report regarding the unit and surrounding area. Data are typically derived through onsite inspections, interviews, literature reviews, databases, historical records, manifests, waste profiles, maps, engineering drawings, photographs, and other media.
2. **Initial Planning.** A conceptual model is developed, data requirements are identified, and the approaches to acquiring and using needed data are identified based on the preliminary assessment. NDEP is involved in the planning process and approves the results from this planning stage.
3. **Characterization Plan.** A plan for acquiring data identified in initial planning is developed. The characterization plan should include a field plan, a sampling and analysis plan, a health and safety plan, and any other sub-plans necessary to acquire data. NDEP reviews and approves the characterization plan.
4. **Characterization.** Activities identified in the characterization plan are conducted.
5. **Characterization Report.** Results of site characterization activities are presented. NDEP reviews and approves the characterization report.
6. **Closure Plan.** A plan for closing the disposal unit is developed based on the results of the characterization report. The closure plan provides a summary of the disposal unit, physical setting, regulatory basis, relationship of closure activities to other programs, assumptions, and technical approach to closure. NDEP reviews and approves the closure plan.
7. **Closure Cover Construction.** The final closure cover is constructed based on the closure plan.

8. **Closure Report.** A report is developed after construction of the final closure cover that discusses the process of construction and the as-built conditions of the closure cover. NDEP reviews and approves the closure report; approval of the report acknowledges final closure of the disposal unit.
9. **Post-Closure Monitoring and Maintenance.** Post-closure monitoring and maintenance is conducted after completion of final closure. NDEP is involved in the determination of the post-closure schedule and frequency for monitoring and reporting.

### B.13.e Facility Location and Description at Closure [40 CFR 264.112(b)(1)]

The MWDU is located in the northeast corner of the RWMC in a remote area of the southern NNSS. Figures and text describing the unit are found in Section B.1 of this permit application. The physical surface area of the MWDU will not be changed after closure. During closure, unused portions of the landfill will be filled with native soil or LLW (with NDEP approval). The final closure cover is discussed in Section B.13.b.

The leachate tank and associated equipment will be decontaminated, dismantled, and disposed as required.

### B.13.f Final Waste Acceptance Date, Hazardous Waste Inventory [40 CFR 264.112(b)(3)]

The final waste acceptance date is unknown at this time. The closure process will begin within 30 days after the date that the MWDU receives the final volume of waste. An estimate of the final inventory of hazardous wastes managed over the active life of the facility will be provided.

### B.13.g Closure Schedule [40 CFR 264.112(b)(6)]

Table 9 depicts a closure activity schedule for the unit.

**Table 9. MWDU Closure Activity Schedule**

| Closure Activity | Duration |
|---|---|
| Notify NDEP of closure | Within 45 days before commencement of closure activities and within 30 days of receipt of the last shipment of LLMW |
| Conduct closure of the unit | Initiated 45 days after notification of closure and completed within 180 days of receiving the final volume of LLMW |
| Submit certification of closure to NDEP | Within 60 days after completion of closure activities |

### B.13.h Amendment to Closure Plan [40 CFR 264.112(c)]

Any amendments to the closure plan will be submitted to NDEP for approval as a permit modification at least 60 days before a proposed change in facility design or operation or no later than 60 days after an unexpected event that affects the closure plan has occurred. However, if an unexpected event occurs during the partial or final closure period, NNSA/NFO will request a permit modification no later than 30 days after the unexpected event. The approved closure plan will become a condition of the permit. If contamination is detected, this closure plan will be amended to provide specific decontamination and removal procedures applicable to the type and extent of contamination.

## B.13.i Post-Closure Care [40 CFR 264.310(b)]

### B.13.i.1 Post-Closure Care for MWDU Landfill

The final closure cover will be maintained and repaired as necessary to correct the effects of settling, subsidence, or erosion. The leachate collection and removal system will be operated until leachate is no longer detected. The leak detection system will be maintained and monitored. Pumpable liquids will be removed to minimize the head on the bottom liner. Groundwater monitoring will be conducted at permit-established intervals and reported as described in Section C. Run-on and runoff control structures will be maintained to prevent erosion or damage to the final closure cover. Surveyed benchmarks will be maintained to ensure that the landfill location can be identified and facilitate the location of wastes disposed at the MWDU. A survey plat will be provided to NDEP with the locations and dimensions of the MWDU.

### B.13.i.2 Post-Closure Care for Leachate Collection Tank [40 CFR 264.197]

The leachate collection tank will be clean-closed; therefore, post-closure care is not required. Impacted soils (if present) will be managed and disposed according to regulations in effect at the time of closure.

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## B.14 Post-Closure Notices [40 CFR 270.14(b)(14)]

Closed hazardous waste disposal units on the NNSS are noted in NDEP Permit NEV HW0101, Section 9.

Closure of legacy hazardous waste management sites on the NNSS is carried out through the *Federal Facility Agreement and Consent Order* (FFACO). The FFACO is an agreement between the State of Nevada, DoD, DOE Legacy Management, and NNSA/NFO. The process requires that use restrictions (URs) be instituted at sites where contamination above regulatory limits is being closed in place. Two types of URs are established in the FFACO, administrative and standard. Administrative URs differ from standard URs in that they do not require onsite postings or other physical barriers. Administrative URs apply to remote locations and occasional-use areas where future land use scenarios are used to calculate final action levels.

Each UR site is identified and documented on a UR form with an enclosed map. The completed form and map are the official records documenting the sites where contamination remains in place after closure. The DOE and DoD will maintain UR records as long as the land is under their jurisdiction. The information on the form and the maps are filed in the FFACO database, the DOE Corrective Action Unit/Corrective Action Site files, and in the U.S. Air Force Geographical Information System.

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## B.15 Closure Cost Estimate [40 CFR 270.14(b)(15)]

The federal government is exempt from the financial requirements according to **40 CFR 264.140(c)**.

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## B.16 Post-Closure Cost Estimate [40 CFR 270.14(b)(16)]

The federal government is exempt from the financial requirements according to **40 CFR 264.140(c)**.

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## B.17 Liability Requirements [40 CFR 270.14(b)(17)]

The federal government is exempt from the financial requirements according to **40 CFR 264.140(c)**.

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# B.19 Topographic Map [40 CFR 270.14(b)(19)]

## B.19.a MWDU Topographic Maps and Facility Location

The Site Location Map in Exhibit 1 (Drawing Number 09062-C-1001), with 1.5-m (5-ft) contour intervals and a scale of 2.5 cm (1 in.) equal to 91 m (300 ft), illustrates the MWDU boundaries. This figure shows access roads, gates, existing facilities, wells, drainage, and flood control structures. Figure 9 illustrates the existing LLW disposal units in the Expansion Area and the location of the Cell 18 MWDU.

The center of the RWMC is located at N 768,650.25 ft and E 706,476.40 ft. The center of the Cell 18 MWDU is located at approximately N 770,840 ft and E 708,820 ft (based on Nevada State Plane Grid – Central Zone, North American Datum, 1983).

## B.19.b Land Use

Several Public Land Orders (PLOs) withdrew land from the public domain to establish the NNSS. PLO 805, issued in 1952, withdrew the land where the MWDU is located. Since then, NNSS land has been used for national defense, energy-related testing and research, and waste management activities. The NNSS is not open to public entry for any purpose (e.g., agriculture, mining, homestead, or recreation). Due to the nature of land use at the NNSS since 1952, there are no plans to return the area to public use. Certain areas in and adjacent to Area 5 were used for atmospheric and underground nuclear weapons testing. Current land uses in Area 5 include waste disposal; transuranic waste characterization, repackaging, and storage; controlled hazardous materials spill testing; and hazardous waste storage. An NNSS land use map is provided as Figure 3.

## B.19.c Wind Rose

Wind speed and direction are provided in Figure 10. Winds in this area are generally from the southwest, with wind velocities varying from 0 to 20 (0 to 66 ft) m per second. However, there is diurnal reversal effect such that winds are predominantly southerly during the day and northerly at night. In a similar manner, there is a seasonal reversal such that winds are predominantly southerly during the summer and northerly during the winter.

## B.19.d Well Locations

The Site Location Map in Exhibit 1 (Drawing Number 09062-C-1001) is a topographic map with 1.5-m (5-ft) contour intervals showing the MWDU location and the surrounding area, including nearby well locations. The well locations are also shown in Figure 9.

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**Figure 9. Overall Location Map**

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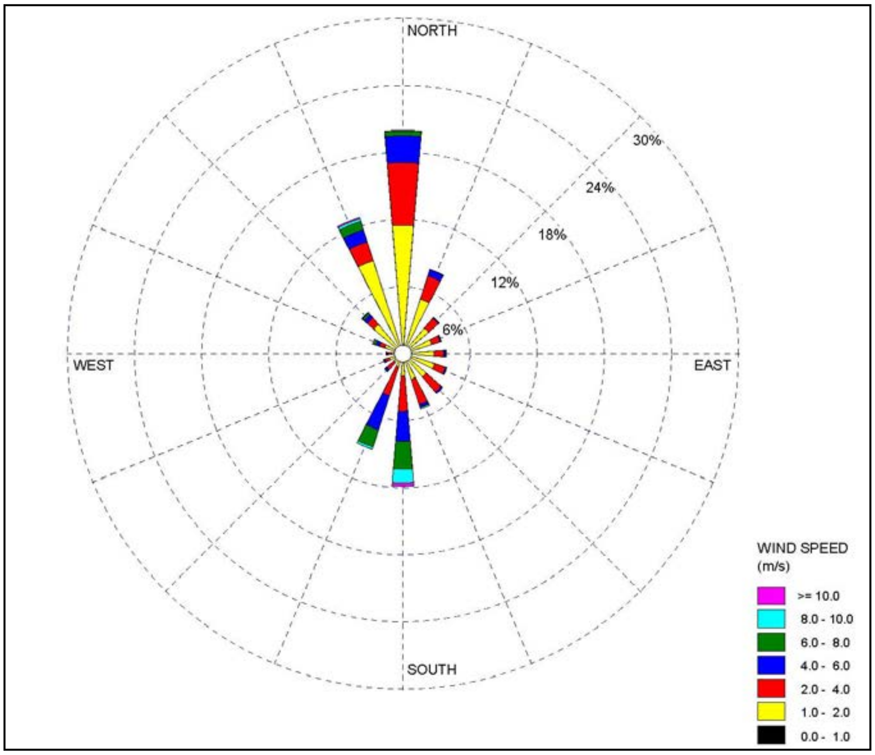


**Figure 10. Wind Rose Diagram for the RWMC Meteorology Station**

## B.19.e Utility Characteristics

Utilities at the RWMC are shown in Figures 11 through 13.

### (1) Potable Water, Wastewater, and Fire Protection

The potable and fire protection water system for the RWMC is served by Public Water System Permit NY-0360-12NTNC. Domestic wastewater from RWMC office buildings is discharged to a permitted septic system (NY-1083) located south of the RWMC.

RWMC fire alarm pull boxes are located in Buildings 5-6, 5-7, and 5-31. Personnel working at the MWDU have access to hand-held and vehicle radio and cell phone communications. Emergency response is discussed in Section B.7.

### (2) Power System

Offsite electrical power is supplied to the NNSS and transmitted through a loop. The voltage is transformed down to a distribution voltage and then to a working voltage. The Frenchman Flat Substation provides power to the RWMC through an overhead power line. A diesel generator provides emergency power to the RWMC buildings.

### (3) Storm Water Drainage

The storm drainage system designed to protect the RWMC from run-on and runoff is depicted in the Site Location Map in Exhibit 1 (Drawing Number 09062-C-1001).

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**Figure 11. Water and Sewer Plan**

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**Figure 12. Electrical and Communications Plan – South**

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**Figure 13. Electrical and Communications Plan – North**

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# B.20 Additional Information [40 CFR 270.14(b)(20)]

## B.20.a Operations

### B.20.a.1 Operating Record [40 CFR 264.73]

NNSA/NFO maintains a written operating record. Because the MWDU is located in a remote area, portions of the operating record are maintained at the RWMC, Mercury, or North Las Vegas Facility for convenience. NDEP inspections of the current operating record acknowledge this separation as functional and compliant with regulatory requirements. The operating record includes the following information:

- Description and quantity of each hazardous waste received/disposed and the date of disposal
- Location and quantity of each hazardous waste within the disposal cell (Section B.20.a.7), cross-referenced to specific manifest document numbers
- Records and results of waste analyses and waste determinations
- Summary reports and details of incidents that require implementation of the contingency plan
- Records and results of inspections for the last 3 years
- Monitoring, testing, analytical data, and corrective actions resulting from a release from the MWDU
- Record of written notice from NNSA/NFO to generators indicating that NNSA/NFO has the necessary permits for and will accept the waste the generator is shipping

### B.20.a.2 Generator Process

The following outlines the procedure for shipping waste to the NNSS:

- Waste generators and the waste profile are approved according to the current revision of the NNSSWAC and the WAP (Section B.3) before waste is shipped. An initial waste verification rate per waste stream is developed and approved by NNSA/NFO.
- An EPA Uniform Hazardous Waste Manifest (**40 CFR 264.71**), appropriate LDR certification or notification (**40 CFR 268.7**), and "Package Storage and Disposal Request" form are required for each waste shipment. Waste is transported according to federal, DOE, and State requirements. Applicable State requirements include those of the State in which the shipment originates, State(s) the waste is transported through, and the State of Nevada. The package number and waste stream number are entered on the "Package Shipment and Disposal Request" form.
- The NNSS receives and verifies waste containers Monday through Thursday, unless otherwise coordinated in advance.
- Transporters provide paperwork for initial review at Gate 100, the entrance to the NNSS. If the transporter does not have an NNSS badge, a temporary badge is issued after checking the driver's identification. A map to the RWMC is also available at the gate.
- The transporter delivers the waste shipment to the RWMC for off-loading.

### B.20.a.3 Waste Receipt, Survey, and Shipping Records

When a shipment arrives at the RWMC, the driver parks and signs in at Building 5-7, completes a route survey, and submits applicable shipping documents. RWMC personnel perform a completeness review of the generator's shipping documents, which may include the following:

- Uniform Hazardous Waste Manifest
- LDR documents
- Original Package Storage and Disposal Request

For flatbed trailers, the vehicle and load are surveyed for radiological contamination and transport integrity before entering the controlled area. For closed transport vehicles (vans), the vehicle is surveyed for radiological contamination and van integrity.

Upon approval from RWMC personnel, the transporter is escorted into the controlled area by proceeding through the gate adjacent to Building 5-31, the Controlled Area Access Building. For containers requiring RTR, the transporter is escorted to the RTR in Building 5-6. Figure 6 depicts waste transportation routes within the RWMC.

RWMC personnel perform pre-entry radiation surveys of the exterior of the waste transport vehicle and a radiation survey as the closed transport vehicle door is opened. Radiation surveys are conducted on all packages off-loaded at the MWDU.

At Building 5-6, containers are unloaded for RTR verification, if required. The RTR system can process three 55-gallon drums or one typical waste box at a time. Only the specified quantity of waste requiring RTR is removed from the transport vehicle. After RTR is completed, accepted containers are reloaded on the transport vehicle and the transporter is escorted to the MWDU.

Containers, markings, and labels are inspected and compared with associated manifests. Paperwork review and inspection requirements are documented on a shipment checklist. Waste manifests, LDR documents, and certifications are inspected by qualified personnel. Specific details on containers are recorded on a container checklist that is filed with the associated shipping paperwork. When unloading is complete and all containers have been accepted, RWMC personnel commence placing the waste containers in the disposal configuration. Radiological surveys of the truck bed and tires are performed before releasing the waste transport vehicles from the RWMC.

### B.20.a.4 Discrepancies

If a discrepancy is detected at any time during the paperwork or inspection process, the discrepancy is categorized dependent upon the level of severity of the condition. Waste containers remain on the transporter vehicle until the noncompliant condition is resolved.

If one container in an original sample set fails RTR, a second sample set of equal quantity is selected from the shipment. A second failure in either the first or the second sample set constitutes failure of the shipment. If the second sample set passes inspection, the single failed container is considered an anomaly, and the remainder of the shipment passes verification. Failed containers and shipments are dispositioned via the Radioactive Waste Acceptance Program.

If a discrepancy requires several days to resolve, the containers are placed in the verification hold area. Wastes in this area must meet the requirements in **40 CFR 264.170** through **178**, inclusive.

If the discrepancy cannot be resolved, all waste packages associated with the noncompliant shipment are returned to a generator-specified facility, and required discrepancy notifications are made. Manifesting of partial or full loads that are rejected by NNSA/NFO is carried out as required in **40 CFR 264.72**.

#### B.20.a.5 Waste Segregation within the MWDU [40 CFR 264.312 and 264.313]

Meeting LDR requirements and adherence to the WAP eliminate the acceptance of incompatible, corrosive, reactive, or ignitable wastes. Therefore, segregation of wastes at the MWDU is not necessary.

#### B.20.a.6 Prohibited Waste [40 CFR 264.314 and 264.317]

Wastes containing free liquids or with EPA waste codes F020, F021, F022, F023, F026, and F027 are not accepted for disposal at the MWDU. Other prohibited waste codes include D001, D002, and D003.

#### B.20.a.7 Waste Placement, Surveying, and Recordkeeping [40 CFR 264.309]

Waste placement is documented using the NNSS container-stacking coordinate system. Based on the availability and configuration of packages, waste is stacked in stair-step configuration in an attempt to maintain a face angle of 1:1. Tiered stacking may be used as necessary to accommodate irregular containers. Waste containers disposed at the MWDU are at least 90 percent full as required in **40 CFR 264.315**.

The following sequence for waste placement is followed at the MWDU:

1. Stack waste containers
2. Record the location coordinates of each container
3. Place and maintain operational cover over the filled portion of the cell, excluding the active face
4. Maintain access road surfaces, shoulders, berms, and drainage
5. File hard copy records and enter waste coordinates into the database

#### B.20.a.8 Wind Dispersal

All wastes are containerized, thereby eliminating the possibility of wind dispersal of wastes. In addition, an operational cover is maintained as the cell is filled, with only the active face left uncovered.

#### B.20.a.9 Leachate Collection and Management

The Cell 18 MWDU leachate collection system consists of two leachate collection layers, one located above the primary liner and one between the primary and secondary liner. Liquids are collected in sumps and pumped via riser to the surface.

On an annual basis and/or when the leachate collection tank is at capacity and must be emptied, the fluid in the leachate collection tank is sampled and analyzed for contaminants as described in Table 1 of **40 CFR 261.24**.

If sample results from leachate collected in the storage tank exceed regulatory levels for any contaminant identified in Table 1 of **40 CFR 261.24**, NNSA/NFO will notify NDEP within 10 days of discovering the exceedance. The notification will include copies of the laboratory report containing the analytical results from the sample that showed the exceedance.

Collected leachate, including leachate that exceeds regulatory levels for any contaminant identified in Table 1 of **40 CFR 261.24**, may be used for dust suppression within the Cell 18 MWDU, provided the collected leachate is not used for any other purpose. If the leachate is not used for dust control within Cell 18, it is managed as hazardous waste. The hazardous waste leachate is managed in accordance with applicable regulations, whether or not sample results from leachate exceed regulatory levels for any contaminant identified in Table 1 of **40 CFR 261.24** and will carry the EPA hazardous waste number F039, multi-source leachate (wastewaters).

Design features for the leachate collection system are discussed in Section B.1.b.1.

### B.20.b Other Federal Laws [40 CFR 270.3]

Other federal laws that apply to operations and discharges from the MWDU include the following:

- *National Historic Preservation Act* – Within the boundaries of the RWMC, waste disposal activities do not create adverse effects to properties listed or eligible for listing on the National Register of Historic Places.
- *Endangered Species Act* – Waste disposal activities at the RWMC are not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect critical habitats.
- *Clean Air Act* – Fugitive dust emissions from activities at the RWMC are regulated by air quality permit AP9711-2557 (NNSS Class II Air Quality Operating Permit) issued by the State of Nevada.
- *Clean Air Act* (National Emissions Standards for Hazardous Air Pollutants) – Air monitoring for radionuclide emissions is conducted from two monitoring stations at the RWMC. Results confirm that emissions are below reporting limits for radionuclide emissions.

### B.20.c Exposure Information Report [40 CFR 270.10(j)]

This exposure information report has been prepared using the Permit Applicants' Guidance Manual for Exposure Information under RCRA 3019. Other sections of this permit application address measures used to limit employees and the general public from being exposed to waste (Section B.1 Section B.4, Section B.5, Section B.7, Section B.8, Section B.10, Section B.11, Section B.12, Section B.13, Section B.14, Section C.1, and Section F.1).

### B.20.c.1 General Information

Prevention of the general public and employees from being exposed to releases of hazardous waste and hazardous constituents during normal operations is accomplished as follows:

- Wastes are transported to and from the MWDU using qualified, DOT-certified transporters who have EPA identification numbers identifying them as shippers of hazardous waste. In addition, waste packages meet DOT packaging requirements.
- Public access to the NNSS is strictly controlled. Members of the public who visit the RWMC and non-RWMC personnel who perform work at the RWMC must meet access and training requirements. Members of the public who visit the RWMC and non-RWMC personnel who perform work at the RWMC are not typically present during waste-related activities. Non-assigned personnel and visitors are escorted at all times. An armed security force patrols the NNSS 24 hours a day, 7 days a week.
- Unauthorized Entry Prohibited signs are posted along the RWMC perimeter and at the gate to the MWDU. Traffic enters the RWMC through a single controlled access gate.
- PPE commonly used at the MWDU includes safety shoes, safety glasses, and hard hats.
- Qualifications for workers at the RWMC include site-specific training for RCRA compliance and specialized training for radiation workers/technicians.
- Emergency procedures detail actions to be taken in emergencies. The NNSS onsite response organizations include the NNSS Fire Department, NNSS Occupational Medicince, and the Nye County Sheriff's Department. Emergency equipment is located at the RWMC and at the MWDU to respond to spills and releases.
- A 1.2-m (4-ft) thick operational cover is maintained at the MWDU during normal operations. The operational cover limits exposure of the waste to wind, precipitation, and human contact.

**(1) Existing Risk Assessment Reports and Information**

The contingency plan and emergency procedure detail emergency response procedures and personnel protective procedures to prevent exposure and environmental hazards. Section B.8 includes detailed information relative to the protection of human health, safety, and the environment. The NNSS is a federal facility that is exempt from financial or insurance requirements.

**(2) Land Use and Zoning**

The MWDU is located in the southern portion of the NNSS and is surrounded by a radius of more than 6.5 km (4 mi) of federally owned land. Access to the NNSS is monitored and restricted. The NNSS is patrolled by armed security and the Nye County Sheriff's Department.

This land is not anticipated to be returned to the private sector in the future. The PLO that withdrew land for the NNSS does not allow cattle grazing or mineral mining near the RWMC. No economic or demographic pressures are expected to affect the use of the RWMC. A land use map of the NNSS is provided in Figure 3.

**(3) Aerial Photograph**

Figure 4 provides an aerial photograph of the RWMC.

**(4) Waste Analysis Data**

Wastes that are accepted at the MWDU for disposal are identified in Section B.2. The hazardous constituents in the waste streams are characterized, to the extent possible, as described in Section B.2.

**(5) Annual Waste Volume and Treatment Process**

Treatment of waste is not performed at the MWDU. For hazardous and/or mixed wastes generated at the NNSS, the following treatment options are available:

- Treatment at the RCRA-permitted EODU
- Transport to an offsite, permitted treatment facility
- Treatment onsite in a 90-day accumulation area in an accumulation tank or container
- Treatment onsite under a treatability study
- Treatment onsite under a RCRA CAP
- Treatment under a generator treatment plan

LLMW received at the MWDU from offsite generators meets the applicable LDR treatment standards in **40 CFR 268** and is containerized according to applicable requirements set forth in the NNSSWAC (Section B.3).

**(6) Federal, State, or Local Environmental and Health Inspection of Compliance Records**

The MWDU is subject to annual inspections performed by NDEP.

### B.20.d Groundwater Pathway

**(1) Groundwater Uses within 4.9 km (3 mi) of the MWDU**

There are three groundwater monitoring wells (active), one withdrawal well (active), and three other wells (inactive) within 4.9 km (3 mi) of the RWMC (Figure 9). None of these wells supply potable water and there is no use of local groundwater for domestic, commercial, or agricultural purposes. The closest well supplying potable water is approximately 6.5 km (4 mi) south of the MWDU. The aquifers used by the wells are separated by volcanic confining units from the underlying regional carbonate aquifer considered to be part of the Ash Meadows groundwater system.

Monitoring wells RNM-1, RMN-2, and RMN-2S, completed in the valley-fill alluvial aquifer, were used for radionuclide migration studies. Well 5c, completed in the tuff aquitard underlying the valley-fill aquifer, supplies non-potable water for construction activities. In addition, three other wells were used to characterize the RWMC.

**(2) Regional Map of Groundwater Recharge and Discharge**

A regional map showing directions of groundwater flow and discharge areas is provided in Figure 14. This is also discussed in Section C.1.

**Figure 14. Regional Groundwater Flow Directions**

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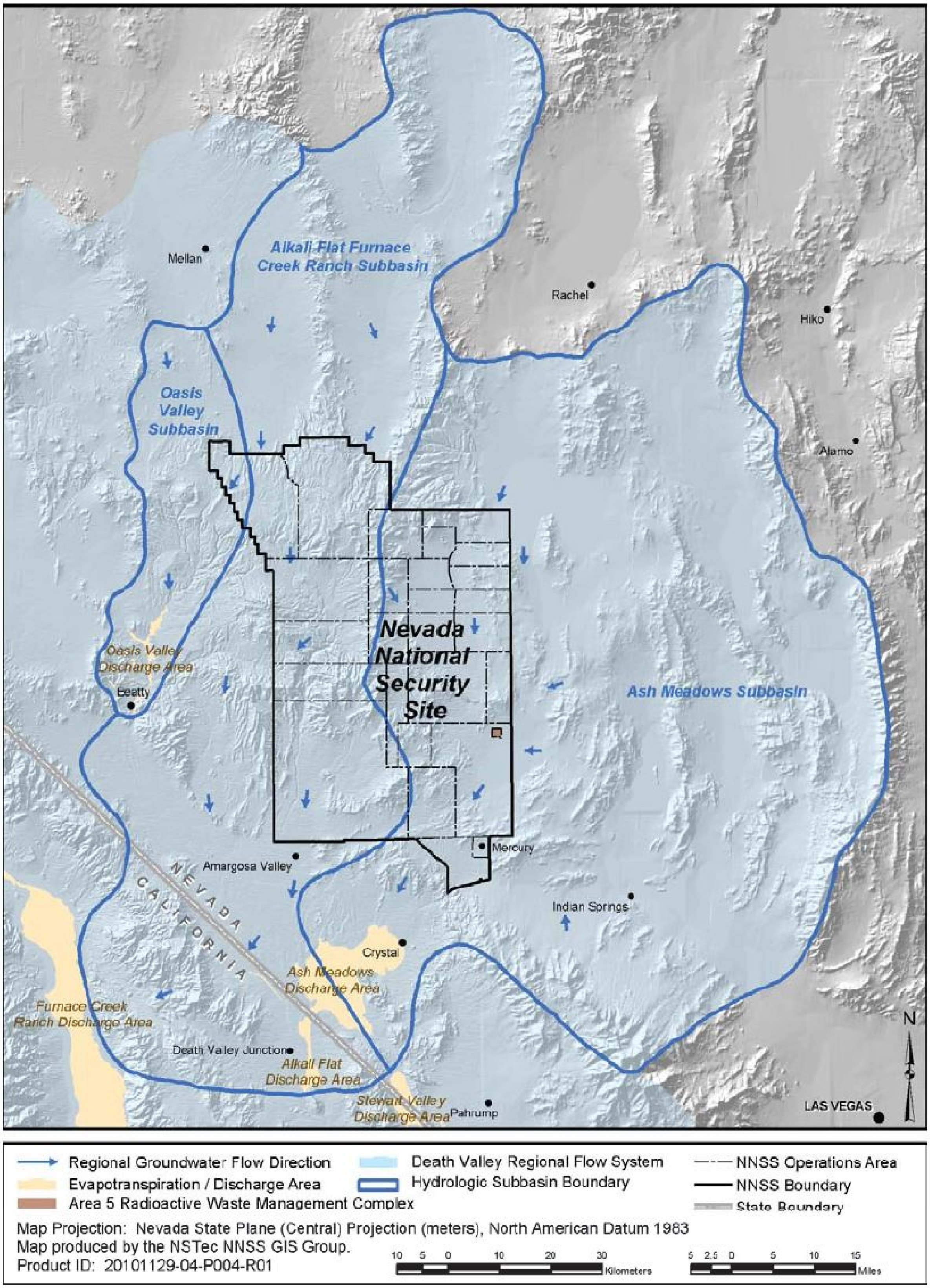


**Regional Groundwater Flow Directions**

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#### (4) Well Data Indicating a Release of Pollutants

Water from supply wells and other monitoring wells near the RWMC is sampled to evaluate the possibility of movement of radioactive contaminants. Results of sampling to date indicate no contaminant migration has occurred. An interim status RCRA groundwater monitoring program has indicated that contamination has not occurred as a result of waste disposal, which has been ongoing since 1987 at the RWMC.

#### (5) Food Chain Contamination

There is no known pathway of contamination within the food chain that would result from a release at the MWDU. There is no commercially produced food on or near the NNSS.

### B.20.e Surface Water Pathway

#### (1) Surface Water Uses within 4.9 km (3 mi) of the MWDU

There are no perennial sources of surface water in the vicinity of the RWMC. The only natural surface water within 4.9 km (3 mi) of the RWMC is Frenchman Lake, a playa at the bottom of the closed hydrographic basin. Ephemeral streams convey runoff to the playa, where it may stand for a few days or weeks as a lake before evaporating. The playa is dry throughout most of the year.

#### (2) Velocities of Streams and Rivers

There are no perennial streams or rivers within the Frenchmen Flat Basin. The RWMC is located on coalescing alluvial fans, where flow events are ephemeral. A flood assessment for the RWMC (Figure 8) shows flow velocities on the alluvial fans to be 1 m per second or less during a flood event.

#### (3) Surface Water Quality and Monitoring

Due to the absence of perennial surface waters, no surface water monitoring is performed within the Frenchman Flat Basin.

### B.20.f Air Pathway

#### (1) Air Monitoring Data and Current Monitoring System

Monitoring of atmospheric moisture for tritium and of air particulates for plutonium, americium, gross alpha, gross beta, and gamma radioactivity is conducted around the RWMC to meet National Emissions Standards for Hazardous Air Pollutants requirements and to demonstrate compliance with the 25-mrem limit specified by DOE O 435.1. No sampling is performed for RCRA hazardous constituents. Atmospheric radioactivity has never been greater than 3 percent of the value that would result in a 25-mrem dose to a person if he or she were to reside at the RWMC.

#### (2) Population

There are no residents living within 6.5 km (4 mi) of the RWMC. The nearest population centers are Amargosa Valley (approximately 45 km [28 mi] from the RWMC) and Indian Springs (approximately 39 km [24 mi] from the RWMC).

## B.20.g Subsurface Gas Pathway

### (1) Disposal of Municipal Waste

Municipal waste has never been accepted for disposal at the RWMC. No methane gas is expected to be generated from the waste disposed at the MWDU.

### (2) Location of Underground Conduits

Figures 11 through 13 illustrate underground conduits for electrical, water, and sewer in the vicinity of the MWDU and the RWMC.

### (3) Monitoring and/or Control Mechanisms for Subsurface Gas Releases

There is no system planned to continually monitor for non-radiological subsurface gas releases. Due to the absence of municipal waste, no methane gas is expected to be generated from within the waste disposed at the MWDU.

### (4) Description of Known Releases

There is no evidence that past disposal of waste at existing RWMC disposal cells has ever released hazardous subsurface gases.

## B.20.h Contaminated Soil Pathway

### (1) Areas of Soil Contamination

A soil sampling project began at the RWMC in 1979 to determine the effects of waste operations on levels of tritium, cesium-137, and plutonium-239 in surface soils. Sampling was not performed to determine the presence or concentrations of RCRA pollutants. The 1979 soil sampling results have been used as reference points for comparison with data obtained in subsequent years. All soil sampling conducted to date indicates that there have been no statistically significant increases in radioactive contaminant levels.

### (2) Releases that Resulted in Soil Contamination

There have been no known releases at the MWDU that have resulted in soil contamination from radioactive or hazardous constituents.

## B.20.i Transportation Information

Transportation information is provided in Section B.10. Transporters handling either incoming or exiting shipments are DOT-certified and have assigned EPA identification numbers. NNSS maintains onsite first responder personnel through the NNSS Fire Department.

## B.20.j Management Practices Information

There have been no occupational illnesses or claims of injury from ongoing waste disposal activities at the RWMC.

### B.20.k Exposure Potential of the MWDU

The following sections summarize the exposure potential to hazardous constituents from the MWDU.

**(1) Groundwater Pathway**

The MWDU is approximately 255 m (835 ft) above the uppermost aquifer. Contaminants must migrate through the unsaturated zone before contacting groundwater. Based on RWMC characterization studies, the exposure potential for humans via the groundwater is very low.

The climate at the RWMC is characterized by low precipitation and high evapotranspiration. A water balance study was performed at the RWMC to characterize the movement of water within the near surface and to quantify water available for deep drainage, which could interact with buried waste and recharge the uppermost aquifer. Data from this study provide direct evidence of the effectiveness of evaporation processes within the operational cover to remove infiltrated water from the near-surface alluvium. The data indicate that recharge is zero due to high evapotranspiration in the near surface. Under existing conditions, the near-surface alluvium is effectively disconnected from the uppermost aquifer because water movement is directed toward the land surface. Evidence of this upward flow is provided by water potential and environmental tracer data obtained from the RWMC characterization projects. Environmental tracer studies have confirmed that there has been no movement of surface water to the alluvial aquifer for thousands of years. Because water is not moving through the alluvium to the water table, liquid-phase contaminant migration to the groundwater is highly unlikely.

If natural processes at the ground surface and near-surface vadose zone did not prevent downward liquid migration, the thickness and dryness of the unsaturated alluvium results in excessive liquid phase travel times to the uppermost aquifer. Monte Carlo simulations of travel time, based on data from characterization studies, indicate that there is a 95-percent probability that the unretarded travel time is between 32,000 and 102,000 years.

Groundwater elevation measurements beneath the RWMC indicate that the water table is essentially horizontal. These data show that the horizontal potential gradient is too weak to produce groundwater movement of any significance under current conditions.

The alluvial aquifer is weakly connected to the carbonate aquifer. The groundwater flow pathway is downward through the alluvial aquifer to the underlying volcanic aquifer and confining unit. It then travels into the regional carbonate aquifer, then south and southwest laterally to wells or springs located offsite. Because the volcanic confining unit is very resistant to flow, it is the dominant barrier to contaminant migration.

Based on these factors and because there are no domestic, commercial, or agricultural uses of the groundwater in the vicinity of the RWMC, there is minimal potential for human exposure to contaminants from groundwater.

**(2) Surface Water Pathway**

The only surface water body within 4.9 km (3 mi) of the RWMC is a playa lake (Frenchman Lake), which is dry except during rain events. There are no domestic, commercial, or agricultural uses of this water and thus no possibility for human exposure, other than occupational exposures, in the unlikely event of surface water contamination.

**(3) Air Pathway**

Waste is encapsulated and/or containerized. The waste acceptance container requirements minimize the possibility of an airborne release of waste. The operational cover is a minimum of 1.2 m (4 ft). The RWMC is located in an unpopulated remote area and, if a release were to occur, the only possible exposure would be to workers at the site.

**(4) Subsurface Gas Release**

There are no significant methanogenic waste forms present at the MWDU. Data have been presented from LLW landfills that show the microbial degradation of cellulose materials (paper, wood packaging, and laboratory trash associated with LLW) results in negligible gas production of methane and carbon dioxide. The RWMC is located in an unpopulated remote area and, if a release were to occur, the only possible exposure would be to workers at the site.

**(5) Soil Release**

There is no evidence to indicate that soil contamination has occurred related to the MWDU. Spills of waste are unlikely to contaminate soil because only non-liquid containerized wastes are accepted for disposal. In the event of a spill of waste, affected soil will be placed in containers and managed as waste. The potential for human exposure resulting from the dispersal of contaminated soil is low due to the sparse population in the vicinity. Because no crops are grown in the area, food chain contamination is extremely unlikely.

**(6) Transportation Related Releases**

The only method of transporting waste to the RWMC is by vehicle. All shipments are made according to applicable DOT, EPA, and NNSA/NFO requirements. Drivers are encouraged to refrain from unnecessary stops until the waste shipment is delivered to the NNSS. The contingency plan and emergency procedures (Exhibit 6) include emergency response procedures that are implemented in the event of an accidental spill of waste onsite.
For transportation-related accidents in the Las Vegas area, the City of Las Vegas and Clark County or Nye County emergency response organizations respond.

**(7) Potential for Human Exposure from Worker Management Practices**

There have been no recorded injuries, accidents, or illnesses resulting in exposures related to operating the Cell 18 MWDU or closed cell P03 at the MWDU. The contingency plan and emergency procedures (Exhibit 6) describe emergency response activities. The plan calls for immediate action whenever necessary and provides for investigation of releases and initiation of corrective actions. Procedures to prevent hazards are described in Section B.8. In addition, all employees at the RWMC are required to complete the training program described in Section B.12.

Based on existing NNSA/NFO and contractor operating procedures and quality assurance programs, the potential for offsite migration and public exposure resulting from releases from the MWDU is extremely low.

## B.22 Summary of Pre-Application Meeting [40 CFR 124.31 and 270.14(b)]

A pre-application meeting is not required per **40 CFR 124.31** since this application is seeking renewal of an existing permit and contains no significant (Class III permit modification) changes.

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# C.1 MWDU Groundwater Protection [40 CFR 270.14(c)]

## C.1.a Groundwater Monitoring Data

Groundwater monitoring is currently conducted for the MWDU at the RWMC. The groundwater monitoring program includes three wells located in the uppermost aquifer (alluvial aquifer). These three wells have been sampled since 1993, and results have formally been reported to NDEP since 1997. To date, no hazardous waste constituents have been detected, the monitoring parameters set by NDEP have not been exceeded, and background values have been established for groundwater in the uppermost aquifer.

## C.1.b Groundwater Monitoring Program

Exhibit 8 is a copy of the 2014 groundwater monitoring data report for the RWMC. The report includes a data summary of monitored parameters since program inception.

Groundwater monitoring is conducted at three wells as a RCRA requirement. Water levels in each well are measured every 3 months, and water samples are collected every 6 months. Water samples are analyzed for indicators of contamination (pH, specific conductance, total organic carbon, total organic halides, PCBs, and tritium) and general water chemistry parameters (calcium, magnesium, potassium, sodium, iron, manganese, bicarbonate, sulfate, chloride, and fluoride). Semi-annual monitoring data collected and reported for the three current monitoring wells have established the following:

- There has been no measurable impact on the quality of the uppermost aquifer as a result of disposal activities at the RWMC.
- There has been no statistically significant change in the background concentrations of monitoring limits (**40 CFR 264.90[3]**).
- Based on groundwater elevations, the aquifer under the RWMC is essentially flat.
- Groundwater in the uppermost aquifer generally flows from north to south.
- The approximate flow velocity in the uppermost aquifer is 0.1 m (0.3 ft) per year.
- The flat groundwater table elevations make local groundwater flow mapping difficult. The measured groundwater table elevations are relatively flat. The water table elevation difference between PW3 and Well 5b is approximately 1 m (3.3 ft). This condition makes determination of local flow direction difficult to model.

## C.1.c Detection Monitoring Program

Exhibit 8 includes the following information required by **40 CFR 264.98**:

- A list of indicator parameters (pH, specific conductance, total organic carbon, total organic halides, PCBs, and tritium) and general water chemistry parameters (calcium, magnesium, potassium, sodium, iron, manganese, bicarbonate, sulfate, chloride, and fluoride), which provide a reliable indication of the presence of hazardous constituents in groundwater
- The groundwater monitoring system
- Investigation levels for indicator parameters

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# EXHIBIT 8. Nevada National Security Site 2014 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site

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DOE/NV/25946--2336

# NEVADA NATIONAL SECURITY SITE

# 2014 DATA REPORT: GROUNDWATER MONITORING PROGRAM AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

February 2015

Prepared for:

U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office

Prepared by:

National Security Technologies, LLC
Las Vegas, Nevada

DOE/NV/25946--2336

# NEVADA NATIONAL SECURITY SITE

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Las Vegas, Nevada

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# LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

| | |
|---|---|
| ac | acre |
| AMSL | above mean sea level |
| BN | Bechtel Nevada |
| °C | degrees Celsius |
| Ca | calcium |
| CFR | Code of Federal Regulations |
| Cl | chloride |
| cm | centimeter |
| DOE | U.S. Department of Energy |
| E | easting |
| °F | degrees Fahrenheit |
| F | fluoride |
| Fe | iron |
| ft | foot |
| GW | groundwater |
| ha | hectare |
| $HCO_3$ | bicarbonate |
| HDPE | high density polyethylene |
| IL | investigation level |
| in. | inch |
| K | potassium |
| LCA | lower carbonate aquifer |
| m | meter |
| m/m | meter change in water level elevation per meter change in gradient direction |
| $m^3/m^3$ | void space volume (cubic meter) per total aquifer volume (cubic meter) |
| MDC | minimum detectable concentration |
| MDL | method detection limit |
| Mg | magnesium |
| mg/L | milligram per liter |
| mmhos/cm | millimhos per centimeter |
| Mn | manganese |
| N | northing |
| Na | sodium |
| NDEP | Nevada Division of Environmental Protection |
| NNSS | Nevada National Security Site |
| NSTec | National Security Technologies, LLC |
| PCB | polychlorinated biphenyl |
| pCi/L | picocurie per liter |
| QL | quantification limit |
| RCRA | Resource Conservation and Recovery Act |
| REECo | Reynolds Electrical and Engineering Company, Inc. |
| RWMS | Radioactive Waste Management Site |
| SC | specific conductance |
| $SiO_2$ | silicate |
| $SO_4$ | sulfate |
| TOC | total organic carbon |
| TOX | total organic halides |
| µg/L | microgram per liter |

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# EXECUTIVE SUMMARY

This report is a compilation of the groundwater sampling results from the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada National Security Site, Nye County, Nevada. Groundwater samples from the aquifer immediately below the Area 5 RWMS have been collected and analyzed and static water levels have been measured in this aquifer since 1993. This report updates these data to include the 2014 results. Analysis results for leachate contaminants collected from the mixed-waste cell at the Area 5 RWMS (Cell 18) are also included.

During 2014, groundwater samples were collected and static water levels were measured at three wells surrounding the Area 5 RWMS. Groundwater samples were collected at wells UE5PW-1, UE5PW-2, and UE5PW-3 on March 11 and August 12, 2014, and static water levels were measured at each of these wells on March 10, June 2, August 11, and October 14, 2014. Groundwater samples were analyzed for the following indicators of contamination: pH, specific conductance, total organic carbon, total organic halides, and tritium. General water chemistry (cations and anions) was also measured. Results from samples collected in 2014 are within the limits established by agreement with the Nevada Division of Environmental Protection for each analyte. The data from the shallow aquifer indicate that there has been no measurable impact to the uppermost aquifer from the Area 5 RWMS, and there were no significant changes in measured groundwater parameters compared to previous years.

Leachate from above the primary liner of Cell 18 drains into a sump and is collected in a tank at the ground surface. Cell 18 began receiving waste in January 2011. Samples were collected from the tank when the leachate volume approached the 3,000-gallon tank capacity. Leachate samples have been collected 16 times since January 2011. During 2014, samples were collected on February 25, March 5, May 20, August 12, September 16, November 11, and December 16. Each leachate sample was analyzed for toxicity characteristic contaminants and polychlorinated biphenyls (PCB). Beginning with the sample from July 31, 2013, pH and specific conductance were also measured. Leachate analysis results are below the reporting limits identified in Resource Conservation and Recovery Act Permit NEV HW0101. Results for toxicity characteristic contaminants are all below regulatory levels and analysis quantification limits. No quantifiable PCB levels were detected in any sample. Results for pH and specific conductance are also within expected ranges. After analysis, leachate was pumped from the collection tank and used in Cell 18 for dust control.

The report contains an updated cumulative chronology for the Area 5 RWMS Groundwater Monitoring Program and a brief description of the site hydrogeology.

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# *1.0 INTRODUCTION*

## 1.1 PURPOSE AND SCOPE

This report is a compilation of groundwater and leachate sampling results collected from the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada National Security Site (NNSS) in Nye County, Nevada. Groundwater samples were collected from three monitoring wells surrounding the Area 5 RWMS, and leachate samples were collected from the lined mixed-waste disposal cell inside the Area 5 RWMS. Data collected during calendar year 2014 are included along with previous data.

The NNSS is an approximately 3,536 square kilometer (1,360 square mile) restricted-access federal facility located approximately 105 kilometers (65 miles) northwest of Las Vegas, Nevada (Figure 1-1). The three Pilot Wells, UE5PW-1, UE5PW-2, and UE5PW-3, are located just outside the Area 5 RWMS. These wells are used to monitor groundwater in the upper aquifer below the Area 5 RWMS. The mixed-waste disposal cell (Cell 18) and leachate collection tank are located in the northeast corner of the Area 5 RWMS (Figure 1-2). In addition to groundwater and leachate monitoring results, this report includes information regarding site hydrogeology, well construction, sample collection, and meteorological data measured at the Area 5 RWMS.

The disposal of low-level radioactive waste and mixed low-level radioactive waste at the Area 5 RWMS is regulated by U.S. Department of Energy (DOE) Order DOE O 435.1, "Radioactive Waste Management" (DOE 2001). The disposal of mixed low-level radioactive waste is also regulated by the State of Nevada under the Resource Conservation and Recovery Act (RCRA) regulation Title 40 Code of Federal Regulations (CFR) Part 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" (CFR 1999). The format of this report was requested by the Nevada Division of Environmental Protection (NDEP) in a letter dated August 12, 1997. The appearance and arrangement of this document have been modified slightly since that date to provide additional information, to facilitate the readability of the document, and to include the leachate monitoring results. The objective of this report is to satisfy any Area 5 RWMS groundwater monitoring reporting agreements between DOE and NDEP.

## 1.2 SITE HYDROGEOLOGY

The Area 5 RWMS is located in northern Frenchman Flat in the southeast portion of the NNSS. Frenchman Flat is a topographically closed basin. Erosion of surrounding mountains has resulted in accumulation of thick, unsaturated, alluvial deposits above volcanic rocks within the basin (Bright et al. 2001). Alluvial and volcanic aquifers are present beneath the Area 5 RWMS and are believed to extend throughout much of the Frenchman Flat basin (Bechtel Nevada [BN] 2005). In this south-central portion of the NNSS, a moderately thick volcanic confining unit, consisting of altered volcanic rocks, separates the shallow alluvial and volcanic aquifers from the underlying regional lower carbonate aquifer (LCA) (BN 2005; Laczniak et al. 1996).

The groundwater type from the three monitoring wells (UE5PW-1, UE5PW-2, and UE5PW-3) is sodium-bicarbonate. This type of groundwater is common in the upper aquifers in Frenchman Flat. UE5PW-1 and UE5PW-2 are completed in an alluvial aquifer, and UE5PW-3 is completed in a volcanic aquifer. Similar groundwater chemistry and water table elevations in UE5PW-1, UE5PW-2, and UE5PW-3 indicate that the alluvial and volcanic aquifers are locally connected near the Area 5 RWMS.

Some vertical groundwater flow occurs between the uppermost aquifers in Frenchman Flat and the underlying regional LCA (Navarro Nevada Environmental Services 2010). Based on measured groundwater elevations above mean sea level (AMSL) (Figure 1-3), the lateral hydraulic gradient in the upper Frenchman Flat aquifer is very small. Lateral groundwater movement beneath Frenchman Flat primarily occurs within the deep carbonate aquifer and is generally from the northeast to southwest. It eventually discharges in Amargosa Valley and Ash Meadows in southwest Nevada and Death Valley in California (Figure 1-4) (Laczniak et al. 1996).

For more detailed descriptions of Area 5 RWMS site characteristics, refer to the report *Revised Area 5 Radioactive Waste Management Site, Outline of a Comprehensive Groundwater Monitoring Program* (BN 1998).

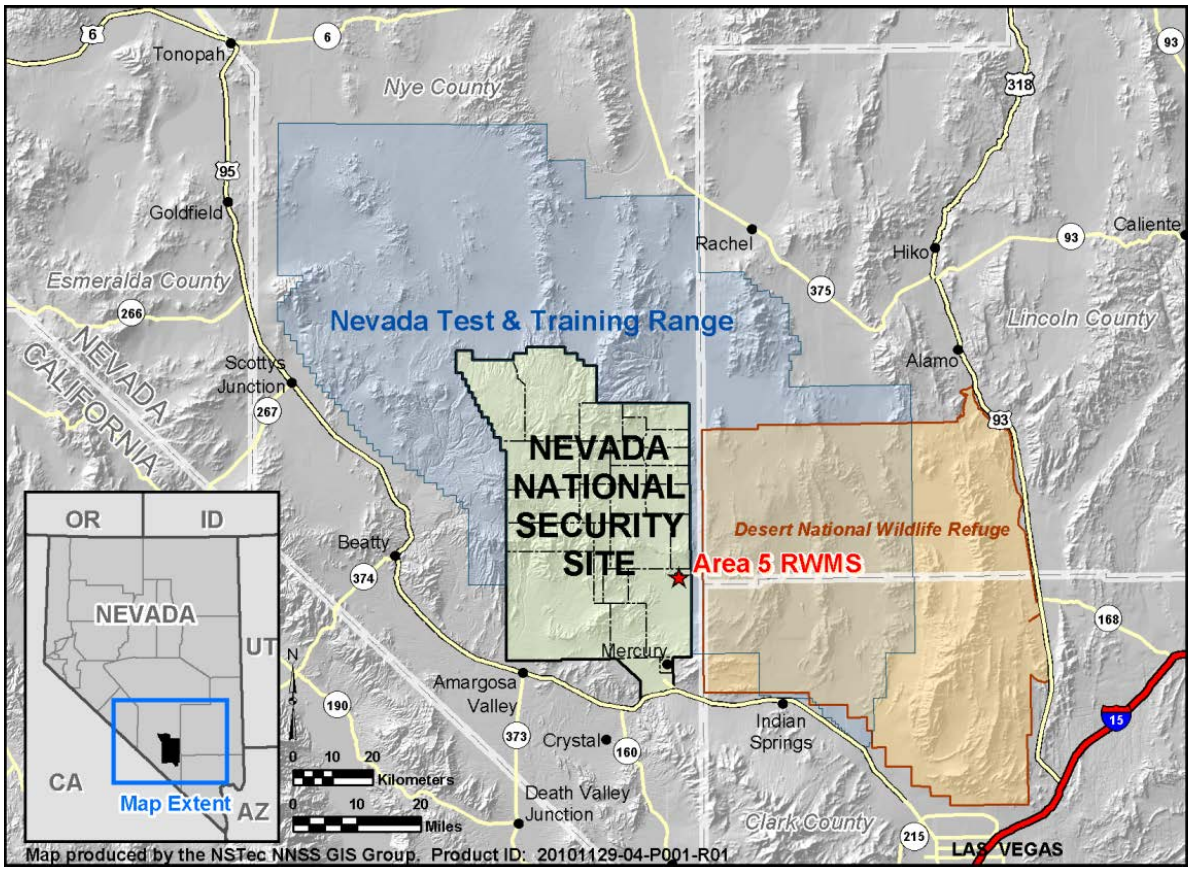


**Figure 1-1. Location of Area 5 RWMS and Nevada National Security Site within Nevada**

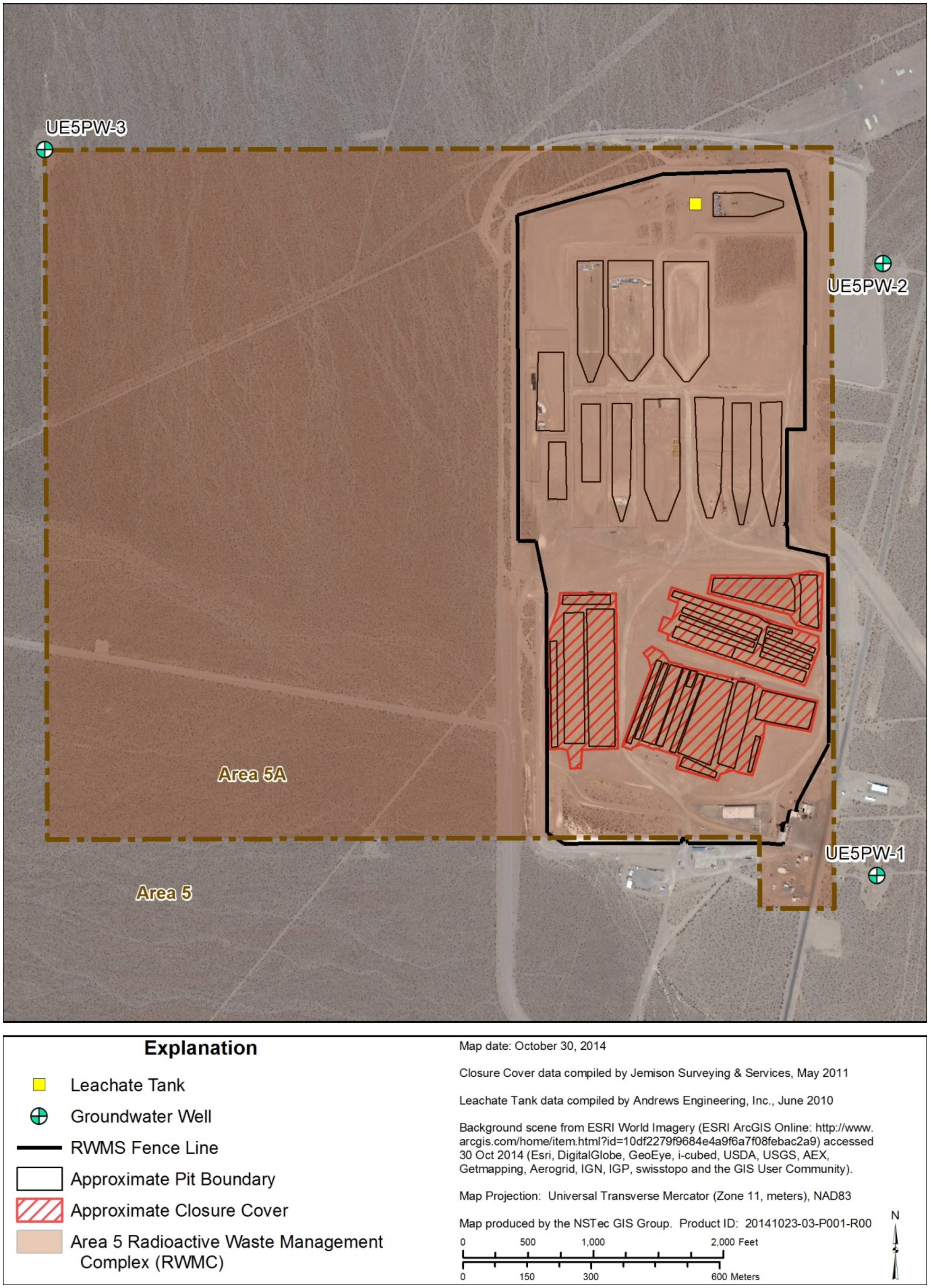


**Figure 1-2. Location of Pilot Wells and Leachate Collection Tank at Area 5 RWMS**

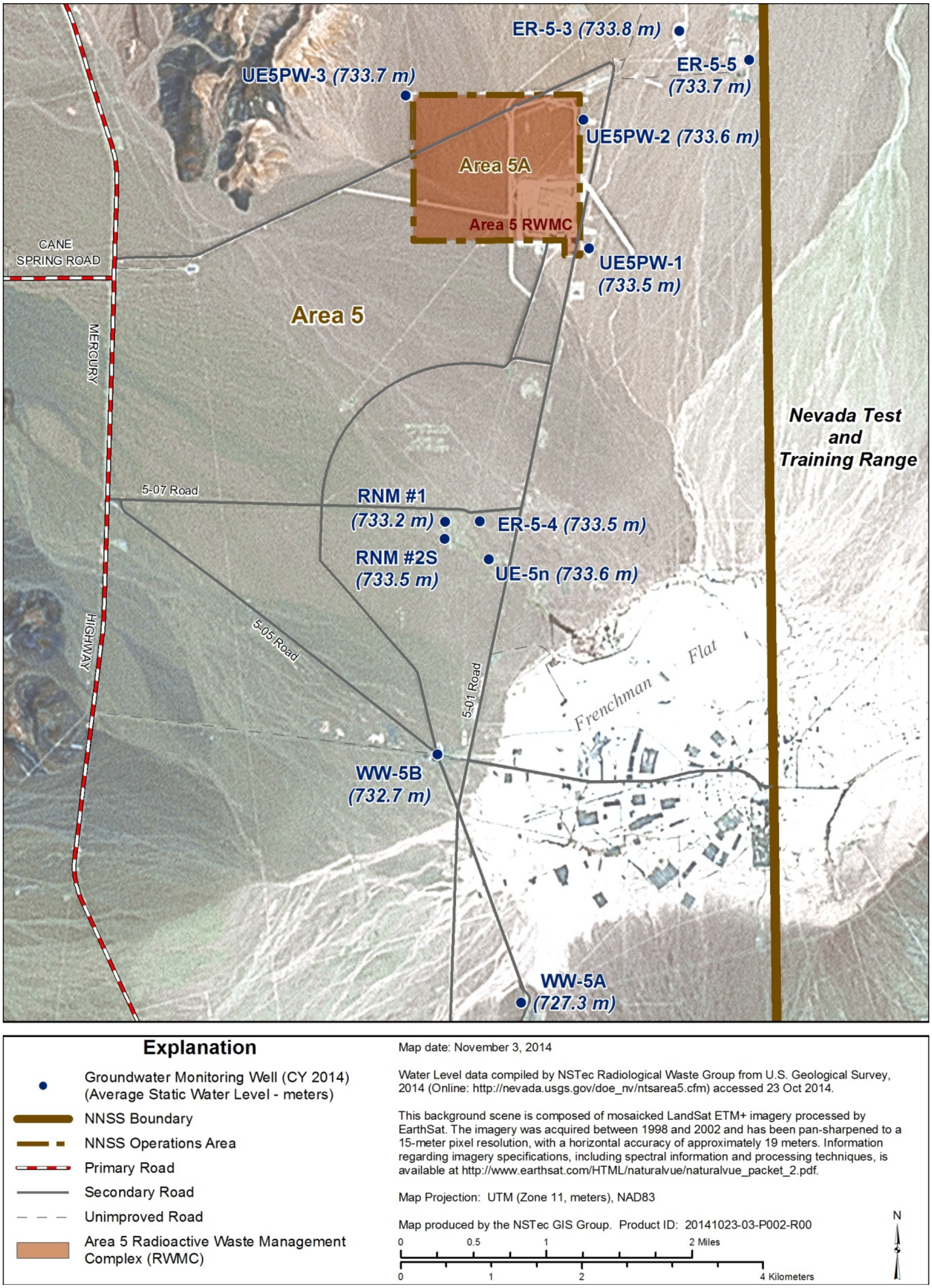


**Figure 1-3. Average Water Level Elevation at Groundwater Monitoring Wells in the Vicinity of the Area 5 RWMS (U.S. Geological Survey [USGS] 2014)**

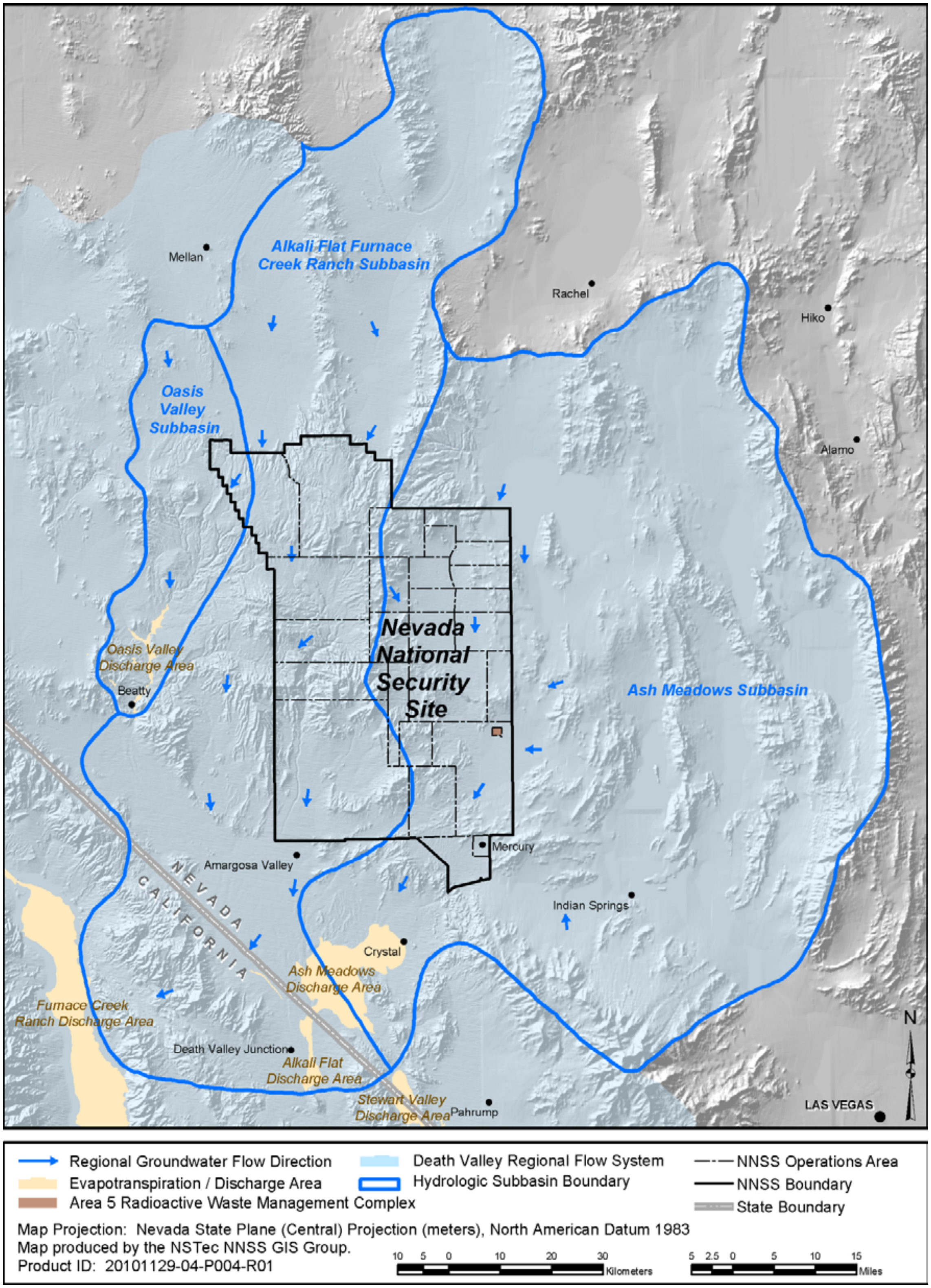


**Figure 1-4. Groundwater Sub-basins and Flow in the Vicinity of the Area 5 RWMS**

## 1.3 MONITORING WELL DESCRIPTIONS

Pilot Wells UE5PW-1, UE5PW-2, and UE5PW-3 were drilled between March and November 1992, and the groundwater has been monitored since 1993. Each well is completed with a centralized 6.35-centimeter (cm) (2.50-inch [in.]) diameter stainless steel casing with an 18.3-meter (m) (60-foot [ft]) dual-screen filter pack attached to the bottom of the casing. The borehole annulus below and around the screen is filled with 6/12 coarse mesh sand (Reynolds Electrical and Engineering Company, Inc. [REECo] 1994). Well locations around the Area 5 RWMS are shown in Figure 1-2. Previously this report used survey location coordinates and elevations for the Pilot Wells provided in REECo (1994). This report uses location coordinates and elevations for the Pilot Wells from more recent surveys provided by the U.S. Geological Survey (USGS 2014). UE5PW-1 and UE5PW-3 were surveyed by National Security Technologies, LLC (NSTec), during September 2013, and UE5PW-2 was surveyed by BN during March and April 2001. These new locations and elevation are summarized in Table 1-1.

**Table 1-1. Pilot Well Locations**

| | UE5PW-1 (m [ft]) | UE5PW-2 (m [ft]) | UE5PW-3 (m [ft]) |
|---|---|---|---|
| Northing[1] | 233,386.53 (765,702.32) | 234,817.22 (770,396.15) | 235,089.98 (771,291.03) |
| Easting[1] | 216,357.39 (709,832.53) | 216,376.16 (709,894.12 | 214,415.13 (703,460.32) |
| Top of Casing Elevation[2] | 969.38 (3,180.37) | 990.09 (3,248.34) | 1,005.29 (3,298.20) |
| Northing Change[3] | 0.05 ( 0.13) | 0.09 (0.25) | 0.05 (0.11) |
| Easting Change[3] | 0.31 (0.96) | 0.16 (0.49) | 0.09 (0.25) |
| Top of Casing Change[3] | 0.01 (0.02) | -0.03 (-0.08) | 0.07 (0.23) |
| Well Deviation at Water Table | 0.08 (0.27) | 0.21 (0.68) | 0.02 (0.06) |

[1] Nevada State Plan Central Zone 1927 North American Datum
[2] 1929 National Geodetic Vertical Datum
[3] Change calculated as New Coordinate minus Previous Coordinate.

UE5PW-1 is 255.7 m (839 ft) deep from the top of the casing and is screened from 232.3 m (762 ft) to 250.5 m (822 ft). UE5PW-1 is completed in alluvium. During 2014, the average water table depth below the top of the well casing was 235.86 m (773.82 ft), and the average water table elevation was 733.52 m (2,406.56 ft) AMSL.

UE5PW-2 is 280.3 m (920 ft) deep from the top of the casing and is screened from 253.0 m (830 ft) to 271.3 m (890 ft). UE5PW-2 is completed in alluvium. During 2014, the average water table depth below the top of the well casing was 256.47 m (841.44 ft), and the average water table elevation was 733.62 m (2,406.89 ft) AMSL.

UE5PW-3 is 291.1 m (955 ft) deep from the top of the casing and is screened from 267.6 m (878 ft) to 282.9 m (928 ft). UE5PW-3 is completed in volcanic rock. The alluvium/volcanic rock contact is 188 m (617 ft) deep at UE5PW-3 (REECo 1994). During 2014, the average water table depth below the top of the well casing was 271.57 m (890.98 ft), and the average water table elevation was 733.72 m (2,407.21 ft) AMSL.

Groundwater samples are collected from each well twice per year. A dedicated, removable pump is used for each well. The pumps are stainless steel, air-powered, submersible piston pumps. Flexible polypropylene tubing for air supply, air exhaust, and water discharge are bundled together and mounted on electric-powered reels. Pumping rates from the wells range from 0.15 to 0.50 gallons per minute. Static water levels at each well are measured using an electronic polyethylene tape four times per year. Water levels are measured with the sample pumps removed from the wells.

## 1.4 LEACHATE COLLECTION DESCRIPTION

Cell 18 is a lined, mixed-waste disposal cell located in the northeastern corner of the Area 5 RWMS (Figure 1-2). Cell 18 was constructed during 2010 and began receiving waste in January 2011. The Cell 18 liner is a RCRA-compliant double liner with a leachate collection and leak detection system placed over a geosynthetic clay liner. The double liner is covered by approximately 61 cm (24 in.) of compacted soil on the cell side slopes and by approximately 76 cm (30 in.) of compacted soil on the cell floor. The primary liner is 80 mil. textured high density polyethylene (HDPE) and the secondary liner is 60 mil. textured HDPE. The primary liner is directly below a 160-mil. double-sided geocomposite drainage layer, and a second 160-mil. double-sided geocomposite drainage layer separates the primary liner from the secondary liner.

Any precipitation or other water applied to the 1.35 hectare (ha) area (3.33 acres [ac]) covered by the liner that is not removed by evapotranspiration eventually infiltrates into the soil above the liner, percolates through the soil to the primary liner, and eventually drains into the primary sump in the floor of Cell 18. Any water leaking through the primary liner would percolate to the secondary liner and eventually drain into the secondary sump in the floor of Cell 18. Water collected in the primary sump is pumped from the sump to a 3,000-gallon tank on the surface above the cell. When the tank approaches its capacity, leachate samples are collected from the tank and analyzed for toxicity characteristic contaminants, polychlorinated biphenyls (PCBs), specific conductance, and pH. Through 2014, no regulatory limits for toxicity characteristic contaminants have been exceeded, and no PCBs have been detected in the leachate samples. After leachate analysis results are evaluated, the leachate is pumped from the collection tank and used for dust control in Cell 18.

## 1.5 SITE METEOROLOGY

Meteorological data are also measured at the Area 5 RWMS. These data include temperature, relative humidity, barometric pressure, wind speed and direction, solar radiation, and precipitation. During 2014 the average daily temperature at 3 m height was 17.4 degrees Celsius (°C) (63.3 degrees Fahrenheit [°F]). The maximum observed temperature at 3 m height was 44.3°C (111.7°F) on July 13, 2014, and the minimum observed temperature at 3 m was −11.0°C (12.2°F) on December 29, 2014. The maximum observed wind gust at 3 m was 19.7 meters per second (44.1 miles per hour) on May 10, 2014. The average annual precipitation measured at the Area 5 RWMS from 1994 through 2014 is 12.1 cm per year (4.76 in. per year). The Area 5 RWMS had 9.3 cm (3.66 in.) of precipitation during 2014. During the 21-year measurement period, 2014 is the fourteenth wettest year. There were 26 days of measurable precipitation in 2014 at the Area 5 RWMS. The wettest month in 2014 was August, which had approximately 40 percent of the 2014 precipitation. Monthly precipitation at the Area 5 RWMS from January 1994 through December 2014 is provided in Figure 1-5.

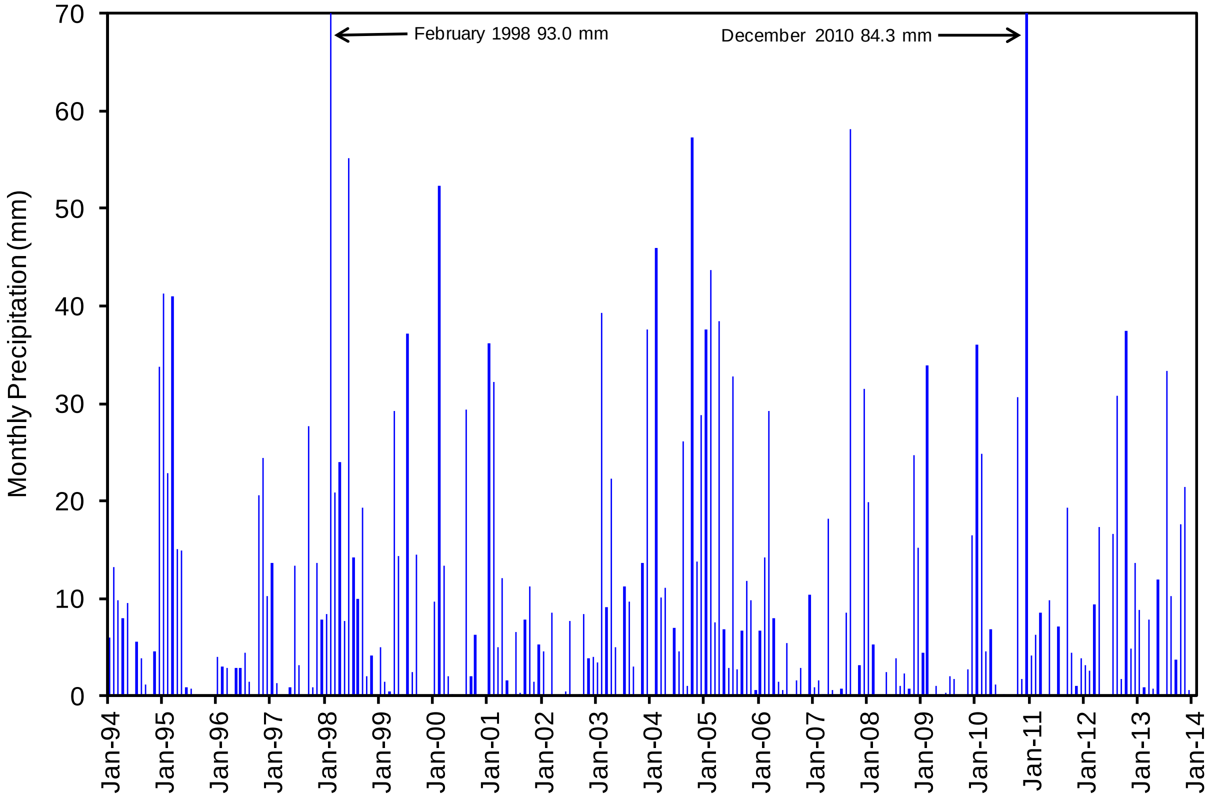


**Figure 1-5. Area 5 RWMS Monthly Precipitation from 1994 through 2014**

# *2.0 GROUNDWATER MONITORING METHODS AND RESULTS*

The groundwater at the Area 5 RWMS pilot wells has been monitored since 1993 (see Appendix A). The Groundwater Monitoring Program has transitioned from monitoring all parameters required by 40 CFR 265 to a program that monitors parameters applicable to the Area 5 RWMS. The current monitoring program is modeled after the 40 CFR 265 Detection Monitoring Program.

## 2.1 METHODS

Samples are tested semiannually for the analytes listed below, which are divided into groups representing indicators of contamination and general water chemistry parameters.

Indicators of contamination:

- pH
- Specific conductance (SC)
- Total organic carbon (TOC)
- Total organic halides (TOX)
- Tritium

General water chemistry parameters:

- Cations: calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), potassium (K), sodium (Na)
- Anions: bicarbonate ($HCO_3$), sulfate ($SO_4$), chloride (Cl), fluoride (F)
- Silicate ($SiO_2$)

Investigation levels (ILs) for each analyte identified as an indicator of contamination were established by DOE and NDEP in 1998 (Table 2-1). Further groundwater analyses are required if the IL is exceeded (BN 1998; Liebendorfer 2000). The ILs for pH and SC are based on the distributions of data collected from 1993 through 1996. Historic analyses for TOC, TOX, and tritium typically have concentration levels less than the method detection limit (MDL) or the minimum detectable concentration (MDC); so, the ILs for TOC and TOX are set slightly above their MDLs or MDCs, and the tritium IL is set at 2,000 picocuries per liter (pCi/L), which is 10 percent of the National Primary Drinking Water Standard of 20,000 pCi/L.

**Table 2-1. Investigation Levels of Indicator Parameters**

| Parameter | Investigation Level (IL) |
|---|---|
| pH | <7.6 or >9.2 |
| SC | 0.440 mmhos/cm[a] |
| TOC | 1 mg/L[b] |
| TOX | 50 µg/L[c] |
| Tritium | 2,000 pCi/L |

[a] mmhos/cm = millimhos per centimeter
[b] mg/L = milligrams per liter
[c] µg/L = micrograms per liter

During 2014, groundwater samples were collected at UE5PW-1, UE5PW-2, and UE5PW-3 on March 11 and August 12, 2014. The current groundwater sampling procedure (NSTec 2010a; 2014a) was followed. During 2014, most tritium samples were enriched prior to shipment to a contract laboratory for analysis, but single samples from each well were not enriched so results for enriched and non-enriched samples could be compared. Prior to 2014 all tritium samples were enriched, during 2014 some tritium samples were enriched and some were not enriched, and after 2014 no tritium samples will be enriched. Tritium analyses were conducted by Test America Laboratories and GEL Laboratories. All other analyses were conducted by GEL Laboratories.

For TOC and TOX analysis, three replicate water samples are collected consecutively from each well for each analyte. Replicate samples provide additional data in case any sample result is above the analyte's IL. Well re-sampling is required if all three replicate water samples are above the analyte's IL. False detections of these analytes above their ILs and subsequent re-sampling of the wells have occurred in the past. No resampling was done in 2014.

## 2.2 RESULTS

This section lists the results for each of the five indicators of contamination, the general water chemistry parameters, and the groundwater elevation.

### 2.2.1 pH

The measured pH at each well remained within the ILs of 7.6 and 9.2 during 2014 (Table 2-2). The 2014 pH values ranged from 8.22 to 8.36 and represent the stable pH reading obtained from each well just prior to sampling for other analytes. Measured pH has remained relatively stable throughout the entire monitoring period (Figure 2-1). No groundwater contamination is indicated by the pH monitoring results.

**Table 2-2. Pilot Wells pH Values**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| **Date** | **pH** | **Date** | **pH** | **Date** | **pH** |
| 03/31/1993 | 8.17 | 03/24/1993 | 7.99 | 04/14/1993 | 8.24 |
| 07/06/1993 | 8.30 | 06/22/1993 | 8.24 | 06/02/1993 | 8.68 |
| 09/01/1993 | 8.25 | 11/15/1993 | 8.40 | 10/12/1993 | 8.69 |
| 12/07/1993 | 7.91 | 01/19/1994 | 8.79 | 12/20/1993 | 8.60 |
| 06/15/1994 | 8.45 | No sample | | 05/24/1994 | 8.87 |
| 08/01/1994 | 8.28 | 06/07/1994 | 8.81 | 08/08/1994 | 8.77 |
| No sample | | 11/29/1994 | 8.79 | 01/18/1995 | 8.58 |
| 04/04/1995 | 8.25 | 04/04/1995 | 8.58 | 04/05/1995 | 8.28 |
| 11/09/1995 | 8.35 | 11/09/1995 | 8.08 | 11/09/1995 | 8.43 |
| 01/18/1996 | 8.41 | 01/25/1996 | 8.63 | 01/18/1996 | 8.55 |
| 04/16/1996 | 8.22 | 04/23/1996 | 8.21 | 04/23/1996 | 8.23 |
| No sample | | 04/30/1996 | 8.15 | 04/30/1996 | 8.15 |
| 10/02/1996 | 8.18 | 10/02/1996 | 8.28 | 10/02/1996 | 8.18 |
| 11/20/1996 | 8.25 | 11/20/1996 | 8.16 | 11/20/1996 | 8.13 |
| 04/16/1997 | 8.33 | 04/16/1997 | 8.40 | 04/16/1997 | 8.25 |

**Table 2-2. Pilot Wells pH Values (continued)**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| **Date** | **pH** | **Date** | **pH** | **Date** | **pH** |
| 11/05/1997 | 8.30 | 11/05/1997 | 8.17 | 11/05/1997 | 8.22 |
| 05/13/1998 | 8.31 | 05/13/1998 | 8.37 | 05/13/1998 | 8.34 |
| 07/29/1998 | 8.63 | No sample | | No sample | |
| 10/28/1998 | 8.34 | 10/28/1998 | 8.32 | 10/28/1998 | 8.14 |
| 05/19/1999 | 8.50 | 05/19/1999 | 8.49 | 05/19/1999 | 8.47 |
| 10/27/1999 | 8.49 | 10/27/1999 | 8.52 | 10/27/1999 | 8.34 |
| 04/26/2000 | 8.50 | 04/26/2000 | 8.39 | 04/26/2000 | 8.24 |
| 08/09/2000 | 8.26 | 08/09/2000 | 8.14 | 08/09/2000 | 8.23 |
| 05/29/2001 | 8.46 | 05/29/2001 | 8.25 | 05/29/2001 | 8.27 |
| 10/03/2001 | 8.39 | 10/03/2001 | 8.22 | 10/03/2001 | 8.13 |
| 05/15/2002 | 8.46 | 05/15/2002 | 8.30 | 05/15/2002 | 8.32 |
| 10/22/2002 | 8.43 | 10/22/2002 | 8.23 | 10/22/2002 | 8.24 |
| 04/15/2003 | 8.54 | 04/15/2003 | 8.38 | 04/15/2003 | 8.42 |
| 10/22/2003 | 8.37 | 10/22/2003 | 8.24 | 10/21/2003 | 8.16 |
| 05/04/2004 | 8.50 | 05/04/2004 | 8.25 | 05/04/2004 | 8.26 |
| 10/19/2004 | 8.30 | 10/19/2004 | 8.32 | 10/20/2004 | 8.24 |
| 04/19/2005 | 8.48 | 04/19/2005 | 8.30 | 04/19/2005 | 8.33 |
| 10/11/2005 | 8.47 | 10/11/2005 | 8.27 | 10/11/2005 | 8.31 |
| 04/26/2006 | 8.34 | 04/26/2006 | 8.12 | 04/26/2006 | 8.17 |
| 10/10/2006 | 8.11 | 10/10/2006 | 8.03 | 10/10/2006 | 8.07 |
| 03/19/2007 | 8.37 | 03/19/2007 | 8.13 | 03/19/2007 | 8.44 |
| 08/29/2007 | 8.29 | 08/29/2007 | 8.09 | 09/05/2007 | 8.10 |
| 09/10/2008 | 8.17 | 09/10/2008 | 8.08 | 09/10/2008 | 8.14 |
| 03/10/2009 | 8.40 | 03/10/2009 | 8.17 | 03/10/2009 | 8.22 |
| 08/18/2009 | 8.45 | 08/18/2009 | 8.25 | 08/18/2009 | 8.22 |
| 03/10/2010 | 8.37 | 03/10/2010 | 8.17 | 03/31/2010 | 8.13 |
| 08/10/2010 | 8.39 | 08/10/2010 | 8.27 | 08/10/2010 | 8.22 |
| 03/08/2011 | 8.35 | 03/08/2011 | 8.27 | 03/08/2011 | 8.22 |
| 08/02/2011 | 8.39 | 08/02/2011 | 8.32 | 08/02/2011 | 8.30 |
| 03/21/2012 | 8.39 | 03/21/2012 | 8.24 | 03/21/2012 | 8.27 |
| 08/07/2012 | 8.35 | 08/07/2012 | 8.29 | 08/07/2012 | 8.29 |
| 03/05/2013 | 7.98 | 03/05/2013 | 8.30 | 03/05/2013 | 7.80 |
| 08/13/2013 | 8.08 | 08/13/2013 | 7.90 | 08/13/2013 | 8.13 |
| 03/11/2014 | 8.36 | 03/11/2014 | 8.35 | 03/11/2014 | 8.22 |
| 08/12/2014 | 8.27 | 08/12/2014 | 8.32 | 08/12/2014 | 8.30 |

NOTE: Values before 05/19/1999 are means of multiple measurements, and values from 05/19/1999 to present are the stable pH value measured just prior to sampling.

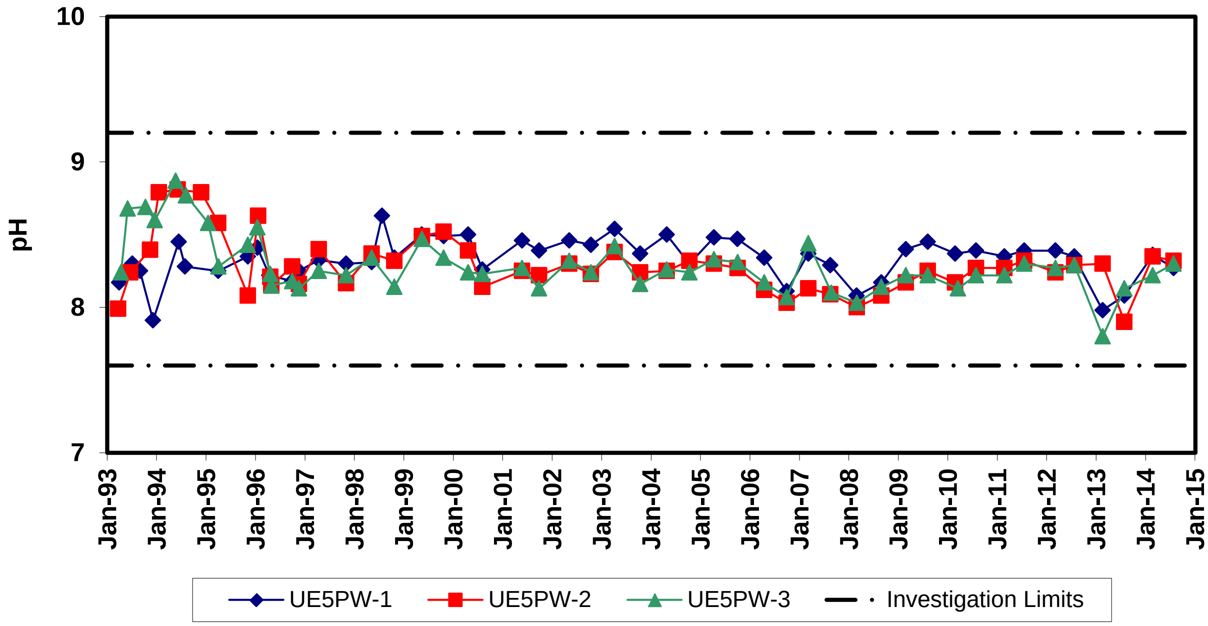


**Figure 2-1. Time Series Plot of Pilot Well pH**

### 2.2.2 Specific Conductance

The 2014 measured SC of water samples from each well remained below the IL of 0.440 millimhos per centimeter (mmhos/cm) and ranged from 0.331 to 0.381 mmhos/cm (Table 2-3). SC values from each well have remained relatively stable throughout the entire monitoring period (Figure 2-2). No groundwater contamination is indicated by the SC monitoring results.

**Table 2-3. Pilot Wells SC Values in mmhos/cm**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| Date | SC | Date | SC | Date | SC |
| 03/31/1993 | 0.401 | 03/24/1993 | 0.371 | 04/14/1993 | 0.383 |
| 06/06/1993 | 0.391 | 06/22/1993 | 0.411 | 06/02/1993 | 0.382 |
| 09/01/1993 | 0.391 | 11/15/1993 | 0.384 | 10/12/1993 | 0.376 |
| 12/07/1993 | 0.383 | 01/19/1994 | 0.371 | 12/20/1993 | 0.359 |
| 06/15/1994 | 0.383 | 06/07/1994 | 0.363 | 05/24/1994 | 0.363 |
| 08/01/1994 | 0.380 | No Sample | | 08/08/1994 | 0.367 |
| No Sample | | 11/29/1994 | 0.325 | 01/18/1995 | 0.338 |
| 04/04/1995 | 0.320 | 04/04/1995 | 0.336 | 04/05/1995 | 0.347 |
| 11/09/1995 | 0.366 | 11/09/1995 | 0.348 | 11/09/1995 | 0.352 |
| 01/18/1996 | 0.360 | 01/25/1996 | 0.343 | 01/18/1996 | 0.355 |
| 04/16/1996 | 0.363 | 04/23/1996 | 0.355 | 04/23/1996 | 0.363 |
| No Sample | | 04/30/1996 | 0.356 | 04/30/1996 | 0.379 |
| 10/02/1996 | 0.383 | 10/02/1996 | 0.363 | 10/02/1996 | 0.376 |
| 11/20/1996 | 0.374 | 11/20/1996 | 0.365 | 11/20/1996 | 0.378 |
| 04/16/1997 | 0.385 | 04/16/1997 | 0.364 | 04/16/1997 | 0.376 |

**Table 2-3. Pilot Wells SC Values in mmhos/cm (continued)**

| UE5PW-1 | | UE5PW-2 | | UE5PW-2 | |
|---|---|---|---|---|---|
| **Date** | **SC** | **Date** | **SC** | **Date** | **SC** |
| 11/05/1997 | 0.377 | 11/05/1997 | 0.358 | 11/05/1997 | 0.361 |
| 05/13/1998 | 0.377 | 05/13/1998 | 0.356 | 05/13/1998 | 0.370 |
| 07/29/1998 | 0.373 | No Sample | | No Sample | |
| 10/28/1998 | 0.380 | 10/28/1998 | 0.358 | 10/28/1998 | 0.370 |
| 05/19/1999 | 0.379 | 05/19/1999 | 0.351 | 05/19/1999 | 0.369 |
| 10/27/1999 | 0.370 | 10/27/1999 | 0.355 | 10/27/1999 | 0.370 |
| 04/26/2000 | 0.378 | 04/26/2000 | 0.355 | 04/26/2000 | 0.369 |
| 08/09/2000 | 0.378 | 08/09/2000 | 0.357 | 08/09/2000 | 0.370 |
| 05/29/2001 | 0.377 | 05/29/2001 | 0.358 | 05/29/2001 | 0.371 |
| 10/03/2001 | 0.376 | 10/03/2001 | 0.358 | 10/03/2001 | 0.371 |
| 05/15/2002 | 0.386 | 05/15/2002 | 0.374 | 05/15/2002 | 0.384 |
| 10/22/2002 | 0.374 | 10/22/2002 | 0.368 | 10/22/2002 | 0.368 |
| 04/15/2003 | 0.372 | 04/15/2003 | 0.355 | 04/15/2003 | 0.369 |
| 10/22/2003 | 0.376 | 10/22/2003 | 0.357 | 10/21/2003 | 0.373 |
| 05/04/2004 | 0.378 | 05/04/2004 | 0.361 | 05/04/2004 | 0.353 |
| 10/19/2004 | 0.372 | 10/19/2004 | 0.352 | 10/20/2004 | 0.365 |
| 04/19/2005 | 0.377 | 04/19/2005 | 0.359 | 04/19/2005 | 0.369 |
| 10/11/2005 | 0.368 | 10/11/2005 | 0.352 | 10/11/2005 | 0.364 |
| 04/26/2006 | 0.361 | 04/26/2006 | 0.341 | 04/26/2006 | 0.357 |
| 10/10/2006 | 0.384 | 10/10/2006 | 0.363 | 10/10/2006 | 0.376 |
| 03/19/2007 | 0.390 | 03/19/2007 | 0.330 | 03/19/2007 | 0.332 |
| 08/29/2007 | 0.385 | 08/29/2007 | 0.359 | 09/05/2007 | 0.378 |
| 03/11/2008 | 0.386 | 03/11/2008 | 0.371 | 03/11/2008 | 0.386 |
| 09/10/2008 | 0.378 | 09/10/2008 | 0.360 | 09/10/2008 | 0.375 |
| 03/10/2009 | 0.376 | 03/10/2009 | 0.363 | 03/10/2009 | 0.386 |
| 08/18/2009 | 0.377 | 08/18/2009 | 0.363 | 08/18/2009 | 0.376 |
| 03/10/2010 | 0.379 | 03/10/2009 | 0.358 | No Sample | |
| 08/10/2010 | 0.363 | 08/10/2010 | 0.345 | 08/10/2010 | 0.359 |
| 03/08/2011 | 0.381 | 03/08/2011 | 0.360 | 03/08/2011 | 0.374 |
| 08/02/2011 | 0.376 | 08/02/2011 | 0.358 | 08/02/2011 | 0.374 |
| 03/21/2012 | 0.374 | 03/21/2012 | 0.362 | 03/21/2012 | 0.374 |
| 08/07/2012 | 0.383 | 08/07/2012 | 0.370 | 08/07/2012 | 0.381 |
| 03/05/2013 | 0.374 | 03/05/2013 | 0.366 | 03/05/2013 | 0.370 |
| 08/13/2013 | 0.372 | 08/13/2013 | 0.352 | 08/13/2013 | 0.364 |
| 03/11/2014 | 0.381 | 03/11/2014 | 0.366 | 03/11/2014 | 0.374 |
| 08/12/2014 | 0.379 | 08/12/2014 | 0.331 | 08/12/2014 | 0.374 |

NOTE: Values before 05/19/1999 are means of multiple measurements, and values from 05/19/1999 to present are the stable SC value measured just prior to sampling.

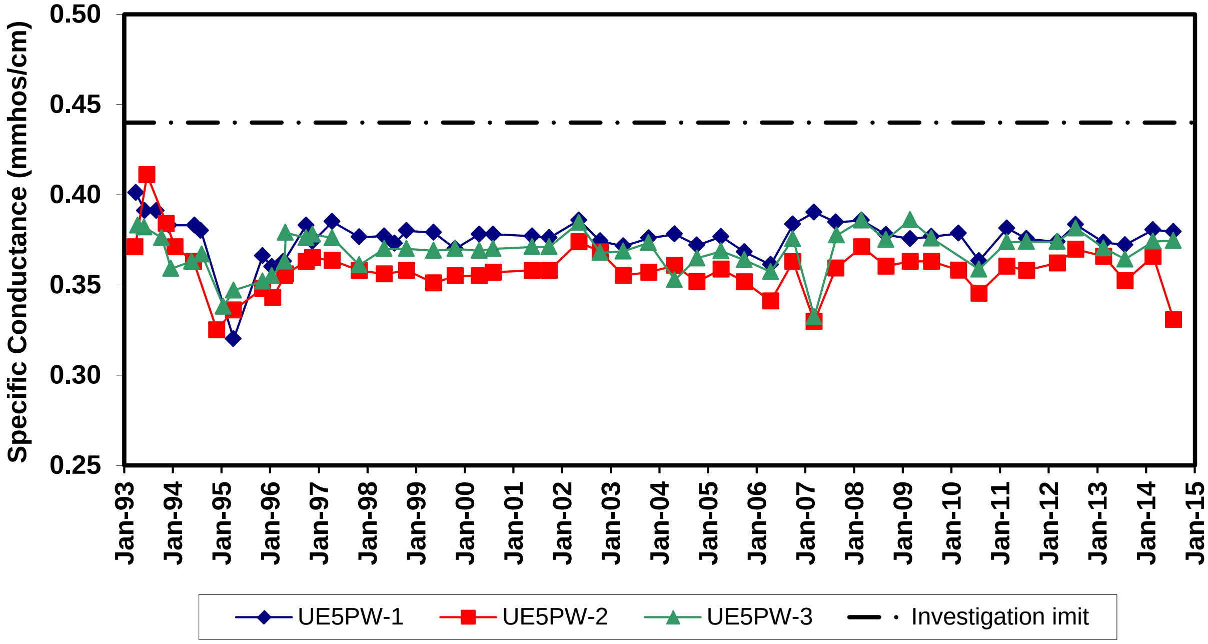


**Figure 2-2. Time Series Plot of Pilot Wells SC**

### 2.2.3 Total Organic Carbon

Three samples were collected consecutively from each well on each sampling date for TOC analysis. The averages of the three sample measurements are reported in Table 2-4. When sample TOC values fell below the sample's MDL, the MDL value was used to calculate the reported average. Values preceded by a less than symbol (<) in Table 2-4 indicate that all three sample results were less than the MDL. TOC results for 2014 ranged from <0.33 to 0.35 mg/L.

TOC values have remained relatively low and stable throughout the monitoring period (Figure 2-3). Most variation in TOC values is the result of variation in the MDL. No groundwater contamination is indicated by the TOC monitoring results.

**Table 2-4. Pilot Wells TOC Values in mg/L**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| **Date** | **TOC** | **Date** | **TOC** | **Date** | **TOC** |
| 03/31/1993 | <1.0 | 03/24/1993 | <1.0 | 04/14/1993 | <1.0 |
| 07/06/1993 | <1.0 | 06/22/1993 | <1.0 | 06/02/1993 | <1.0 |
| 09/01/1993 | <1.0 | 11/15/1993 | <1.0 | 10/12/1993 | <1.0 |
| 12/07/1993 | <1.0 | 01/19/1994 | <1.0 | 12/20/1993 | <1.0 |
| No Sample | | 06/07/1994 | <1.0 | No Sample | |
| 08/01/1994 | 1.7[a] | 11/29/1994 | <1.0 | 08/08/1994 | <1.0 |
| 04/04/1995 | <1.0 | 04/04/1995 | <1.0 | 04/05/1995 | <1.0 |
| 10/02/1996 | <0.3 | 10/02/1996 | <0.3 | 10/02/1996 | <0.3 |
| 11/20/1996 | <0.3 | 11/20/1996 | <0.3 | 11/20/1996 | <0.3 |
| 11/05/1997 | <0.3 | 11/05/1997 | <0.3 | 11/05/1997 | <0.3 |
| 05/13/1998 | <1.0 | 05/13/1998 | <1.0 | 05/13/1998 | <1.0 |

**Table 2-4. Pilot Wells TOC Values in mg/L (continued)**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| Date | TOC | Date | TOC | Date | TOC |
| 10/28/1998 | <1.0 | 10/28/1998 | <1.0 | 10/28/1998 | <1.0 |
| 05/19/1999 | <1.0 | 05/19/1999 | <1.0 | 05/19/1999 | <1.0 |
| 10/27/1999 | <1.0 | 10/27/1999 | 1.3 | 10/27/1999 | <1.0 |
| No Sample | | 12/13/1999 | <0.5 | No Sample | |
| 04/26/2000 | 0.98[a] | 04/26/2000 | 0.60[a] | 04/26/2000 | 1.3[a] |
| 08/09/2000 | <0.5[b] | 08/09/2000 | <0.5[b] | 04/26/2000 | <0.5[b] |
| 05/29/2001 | 0.51[b] | 05/29/2001 | <0.5[b] | 05/29/2001 | 0.53[b] |
| 10/03/2001 | <0.5 | 10/03/2001 | <0.5 | 10/03/2001 | <0.5 |
| 05/15/2002 | <0.5 | 05/15/2002 | <0.5 | 05/15/2002 | <0.5 |
| 10/22/2002 | <0.5 | 10/22/2002 | 0.55 | 10/22/2002 | 0.58 |
| 04/15/2003 | 0.51 | 04/15/2003 | 0.58 | 04/15/2003 | 0.52 |
| 10/22/2003 | 0.64 | 10/22/2003 | 0.68 | 10/21/2003 | 0.62 |
| 05/04/2004 | 0.55 | 05/04/2004 | <0.5 | 05/04/2004 | 0.58 |
| 10/19/2004 | 0.58 | 10/19/2004 | 0.90 | 10/20/2004 | 0.83 |
| 04/19/2005 | 0.65 | 04/19/2005 | 0.62 | 04/19/2005 | 0.50 |
| 10/11/2005 | 0.60 | 10/11/2005 | 0.53 | 10/11/2005 | <0.5 |
| 04/26/2006 | <0.5 | 04/26/2006 | 0.97 | 04/26/2006 | 0.51 |
| 10/10/2006 | 0.80 | 10/10/2006 | 1.12 | 10/10/2006 | 0.52 |
| 03/19/2007 | 0.62 | 03/19/2007 | 0.54 | 03/19/2007 | <0.5 |
| 08/29/2007 | <0.5 | 08/29/2007 | <0.5 | 09/05/2007 | <0.5 |
| 03/11/2008 | <0.5 | 03/11/2008 | <0.5 | 03/11/2008 | <0.5 |
| 09/10/2008 | 0.54 | 09/10/2008 | 0.56 | 09/10/2008 | <0.5 |
| 03/10/2009 | 0.52 | 03/10/2009 | 0.55 | 03/10/2009 | <0.5 |
| 08/18/2009 | 0.55 | 08/18/2009 | 0.56 | 08/18/2009 | 0.52 |
| 03/10/2009 | 0.52 | 03/10/2009 | 0.55 | 03/10/2009 | <0.5 |
| 08/18/2009 | 0.55 | 08/18/2009 | 0.56 | 08/18/2009 | 0.52 |
| 03/10/2010 | 0.54 | 03/10/2010 | 0.76 | 03/31/2010 | 0.60 |
| 08/10/2010 | 0.56 | 08/25/2010 | <0.5 | 08/25/2010 | 0.56 |
| 03/08/2011 | <0.5 | 03/08/2011 | 0.59 | 03/08/2011 | 0.52 |
| 10/19/2011 | 0.52 | 10/19/2011 | 0.53 | 10/19/2011 | 0.53 |
| 03/21/2012 | 0.35 | 03/21/2012 | 0.20 | 03/21/2012 | <0.20 |
| 08/21/2012 | 0.21 | 08/21/2012 | <0.20 | 08/21/2012 | 0.28 |
| 03/05/2013 | 0.44 | 03/05/2013 | 0.45 | 03/05/2013 | 0.41 |
| 08/13/2013 | 0.49 | 08/13/2013 | 0.47 | 08/13/2013 | 0.57 |
| 03/11/2014 | <0.33 | 03/11/2014 | <0.33 | 03/11/2014 | 0.35 |
| 08/12/2014 | <0.33 | 08/12/2014 | <0.33 | 08/12/2014 | 0.33 |

[a] Determined to be a false positive through resampling

[b] Multiple laboratories used; this value is the average of Lionville Laboratory only

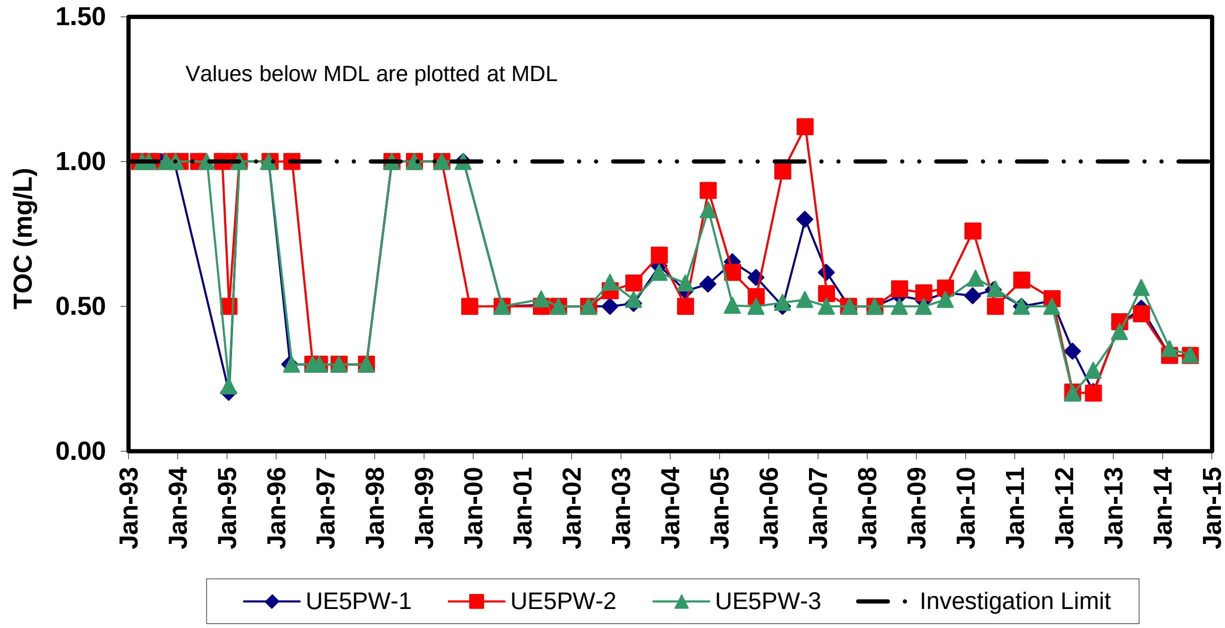


**Figure 2-3. Time Series Plot of Pilot Wells TOC**

## 2.2.4 Total Organic Halides

Three groundwater samples were collected consecutively from each well on each sampling date for TOX analysis. The averages of the three sample results are reported in Table 2-5. When sample TOX values fell below the sample's MDL, the MDL is used to calculate the reported average. Values in Table 2-5 preceded by a less than symbol (<) indicate that all three samples are less than the MDL.

TOX values have remained relatively stable and below the IL throughout the monitoring period (Figure 2-4). Most variation in TOX values is the result of variation in the MDL. No groundwater contamination is indicated by the TOX results.

**Table 2-5. Pilot Wells TOX Values in µg/L**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| **Date** | **TOX** | **Date** | **TOX** | **Date** | **TOX** |
| 03/31/1993 | 17 | 03/24/1993 | 23 | 04/14/1993 | <10 |
| 07/06/1993 | <10 | 06/22/1993 | <10 | 06/02/1993 | 13 |
| 09/01/1993 | 13 | 11/15/1993 | <10 | 10/12/1993 | <10 |
| 12/07/1993 | <10 | 01/19/1994 | <10 | 12/20/1993 | <10 |
| 06/15/1994 | <10 | 06/07/1994 | <10 | No Sample | |
| 08/01/1994 | 11 | 11/29/1994 | 13 | 08/08/1994 | <10 |
| 01/18/1995 | <10 | 01/18/1995 | <10 | 01/18/1995 | <10 |
| 04/04/1995 | <10 | 04/04/1995 | <10 | 04/05/1995 | <10 |
| 11/09/1995 | <40 | 11/09/1995 | <40 | 11/09/1995 | <40 |
| 04/16/1996 | <40 | 04/30/1996 | <40 | 04/30/1996 | <40 |
| No Sample | | 10/02/1996 | <20 | 10/02/1996 | <20 |

**Table 2-5. Pilot Wells TOX Values in µg/ (continued)**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| **Date** | **TOX** | **Date** | **TOX** | **Date** | **TOX** |
| 11/20/1996 | <20 | 11/20/1996 | <20 | 11/20/1996 | <20 |
| 04/16/1997 | <20 | 04/16/1997 | <20 | 04/16/1997 | <20 |
| 11/05/1997 | <20 | 11/05/1997 | <20 | 11/05/1997 | <20 |
| 05/13/1998 | 391[a] | 05/13/1998 | 843[a] | 05/13/1998 | 1000[a] |
| 07/29/1998 | <5 | No Sample | | No Sample | |
| 10/28/1998 | <5 | 10/29/1998 | <5 | 10/29/1998 | <5 |
| 05/19/1999 | <5 | 05/19/1999 | <5 | 05/19/1999 | <5 |
| 10/27/1999 | <5 | 10/27/1999 | <5 | 10/27/1999 | 7 |
| 04/26/2000 | 72[a] | 04/26/2000 | 59[a] | 04/26/2000 | 57[a] |
| 08/09/2000 | 92[a,b] | 08/09/2000 | 73[a,b] | 08/09/2000 | 83[a,b] |
| 05/29/2001 | <12.7[b] | 05/29/2001 | <12[b] | 05/29/2001 | <12[b] |
| 10/03/2001 | <6.1 | 10/03/2001 | <5.8 | 10/03/2001 | <5.2 |
| 05/15/2002 | <5.2 | 05/15/2002 | 5.4 | 05/15/2002 | <5.2 |
| 10/22/2002 | <5.2 | 10/22/2002 | <5.2 | 10/22/2002 | <5.2 |
| 04/15/2003 | <5.2 | 04/15/2003 | <5.2 | 04/15/2003 | <5.2 |
| 10/22/2003 | <5.2 | 10/22/2003 | 5.5 | 10/21/2003 | <5.2 |
| 05/04/2004 | <5.2 | 05/04/2004 | <5.2 | 05/04/2004 | <5.2 |
| 10/19/2004 | <5.2 | 10/19/2004 | <5.2 | 10/20/2004 | <5.2 |
| 04/19/2005 | <5 | 04/19/2005 | <5 | 04/19/2005 | <5 |
| 10/11/2005 | 5.2 | 10/11/2005 | 6.5 | 10/11/2005 | <5 |
| 04/26/2006 | 7.3 | 04/26/2006 | 5.8 | 04/26/2006 | 7.4 |
| 10/10/2006 | <5.1 | 10/10/2006 | <5 | 10/10/2006 | <5 |
| 03/19/2007 | <5.2 | 03/19/2007 | <5.2 | 03/19/2007 | <5.2 |
| 08/29/2007 | <5.2 | 08/29/2007 | <5.2 | 09/05/2007 | <5.2 |
| 03/11/2008 | <5.2 | 03/11/2008 | <5.2 | 03/11/2008 | <5.2 |
| 09/10/2008 | <5.2 | 09/10/2008 | 5.9 | 09/10/2008 | 8.9 |
| 03/10/2009 | <5 | 03/10/2009 | <5 | 03/10/2009 | <5 |
| 08/18/2009 | <7.7 | 08/18/2009 | <7.7 | 08/18/2009 | <7.7 |
| 03/10/2010 | <5 | 03/10/2010 | <5 | 03/31/2010 | <5 |
| 08/10/2010 | 5.5 | 08/25/2010 | 5.9 | 08/25/2010 | <5 |
| 03/08/2011 | 13.3 | 03/08/2011 | 9.1 | 03/08/2011 | 6.7 |
| 08/24/2011 | <5 | 8/23/2011 | 5.2 | 08/23/2011 | <5 |
| 03/21/2012 | 9.2 | 03/21/2012 | 8.2 | 03/21/2012 | 11.0 |
| 09/11/2012 | <20 | 09/11/2012 | <20 | 09/11/2012 | <20 |
| 03/05/2013 | <3.3 | 03/05/2013 | 7.6 | 03/05/2013 | <3.3 |
| 08/13/2013 | <3.3 | 08/13/2013 | <3.3 | 08/13/2013 | <3.3 |
| 03/11/2014 | <3.3 | 03/11/2014 | 3.7 | 03/11/2014 | 3.4 |
| 08/12/2014 | <3.3 | 08/12/2014 | <3.3 | 08/12/2014 | <3.3 |

[a] Determined to be a false positive through resampling
[b] Multiple laboratories used; this value is the average of Lionville Laboratory only

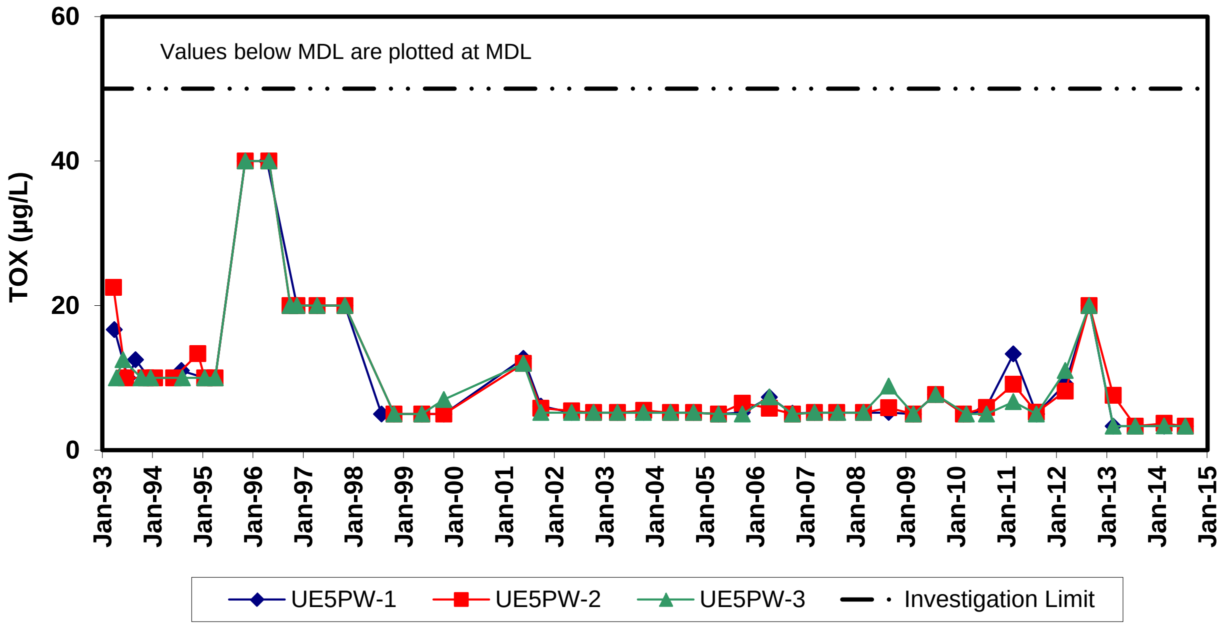


**Figure 2-4. Time Series Plot of Pilot Wells TOX**

## 2.2.5 Tritium

All tritium results from 2014 groundwater samples were below the IL of 2,000 pCi/L and the laboratory MDC (Table 2-6). In 2014, duplicate samples were collected from each well on each sampling date and these samples were enriched before analysis. Also, one more sample was collected from each well that was not enriched before analysis. Table 2-6 reports the average of the two results from the enriched samples. All Table 2-6 results are from enriched samples. Negative tritium results indicate the measured activity is less than the measured laboratory background activity.

Tritium values have remained relatively stable and below the IL and MDC throughout the monitoring period (Figure 2-5). No groundwater contamination is indicated by the tritium results.

**Table 2-6. Pilot Wells Tritium Values in pCi/L**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| **Date** | **Tritium** | **Date** | **Tritium** | **Date** | **Tritium** |
| 03/31/1993 | 0.442 | 03/24/1993 | −4.28 | 04/14/1993 | 1.96 |
| 12/07/1993 | −1.58 | 11/15/1993 | 32.2 | 06/02/1993 | −2.74 |
| No Sample | | 01/19/1994 | 3.69 | 12/20/1993 | −0.459 |
| 06/15/1994 | −2.04 | 06/07/1994 | 1.29 | 05/24/1994 | 1.13 |
| 08/01/1994 | 1.86 | 11/29/1994 | 0.015 | 08/08/1994 | 1.04 |
| 04/04/1995 | 2.80 | 04/04/1995 | −0.920 | 04/05/1995 | 1.50 |
| 04/16/1996 | −1.72 | 04/30/1996 | −1.91 | 04/30/1996 | −2.29 |
| 04/16/1997 | 3.15 | 04/16/1997 | 0.189 | 04/16/1997 | 3.69 |

**Table 2-6. Pilot Wells Tritium Values in pCi/L (continued)**

| UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|
| **Date** | **Tritium** | **Date** | **Tritium** | **Date** | **Tritium** |
| 10/28/1998 | −1.09 | 10/28/1998 | −1.85 | 10/28/1998 | −8.25 |
| 05/19/1999 | 5.17 | 05/19/1999 | 4.24 | 05/19/1999 | 4.60 |
| 10/27/1999 | −1.36 | 10/27/1999 | −3.37 | 10/27/1999 | 1.08 |
| 04/26/2000 | −2.56 | 04/26/2000 | 1.17 | 04/26/2000 | −0.080 |
| 08/09/2000 | −1.48 | 08/09/2000 | 6.97 | 08/09/2000 | 4.35 |
| 05/29/2001 | −1.90 | 05/29/2001 | −11.5 | 05/29/2001 | −12.4 |
| 10/03/2001 | −2.93 | 10/03/2001 | −2.82 | 10/03/2001 | 2.46 |
| 05/15/2002 | −2.82 | 05/15/2002 | 0.150 | 05/15/2002 | −3.26 |
| 10/22/2002 | −4.15 | 10/22/2002 | 0.113 | 10/22/2002 | −1.17 |
| 04/15/2003 | −1.13 | 04/15/2003 | −5.22 | 04/15/2003 | 1.62 |
| 10/22/2003 | 0.952 | 10/22/2003 | 11.4 | 10/21/2003 | 0.405 |
| 05/04/2004 | −2.69 | 05/04/2004 | −6.17 | 05/04/2004 | −6.04 |
| 10/19/2004 | −1.50 | 10/19/2004 | −10.0 | 10/20/2004 | −6.39 |
| 04/19/2005 | 3.67 | 04/19/2005 | 3.76 | 04/19/2005 | 3.56 |
| 10/11/2005 | 8.83 | 10/11/2005 | 5.24 | 10/11/2005 | −4.78 |
| 04/26/2006 | 0.480 | 04/26/2006 | −2.70 | 04/26/2006 | −6.71 |
| 10/10/2006 | 7.42 | 10/10/2006 | 9.35 | 10/10/2006 | 13.8 |
| 09/10/2008 | 4.53 | 09/10/2008 | −2.03 | 09/10/2008 | −4.98 |
| 03/19/2007 | −10.3 | 03/19/2007 | −7.96 | 03/19/2007 | −4.15 |
| 08/29/2007 | −7.25 | 08/29/2007 | −5.61 | 09/05/2007 | −5.60 |
| 03/11/2008 | 5.33 | 03/11/2008 | 7.63 | 03/11/2008 | −1.41 |
| 03/10/2009 | 5.36 | 03/10/2009 | 11.80 | 03/10/2009 | −3.77 |
| 08/18/2009 | 3.38 | 08/18/2009 | 1.62 | 08/18/2009 | 11.9 |
| 03/10/2010 | −6.55 | 03/10/2010 | −25.15 | 03/31/2010 | −22.6 |
| 08/10/2010 | −4.25 | 08/10/2010 | 0.08 | 08/10/2010 | 2.08 |
| 03/08/2011 | 2.97 | 03/08/2011 | 1.30 | 03/08/2011 | 2.76 |
| 08/02/2011 | −1.32 | 08/02/2011 | 1.66 | 08/02/2011 | −3.17 |
| 03/21/2012 | 1.57 | 03/21/2012 | 6.01 | 03/21/2012 | 2.31 |
| 08/07/2012 | 4.37 | 08/07/2012 | 6.84 | 08/07/2012 | 4.69 |
| 03/05/2013 | −22.95 | 03/05/2013 | −21.45 | 03/05/2013 | −13.75 |
| 08/13/2013 | −7.54 | 08/13/2013 | −12.40 | 08/13/2013 | −11.03 |
| 03/11/2014 | −5.09 | 03/11/2014 | −1.45 | 03/11/2014 | 3.51 |
| 08/12/2014 | 6.08 | 08/12/2014 | 16.71 | 08/12/2014 | 2.16 |

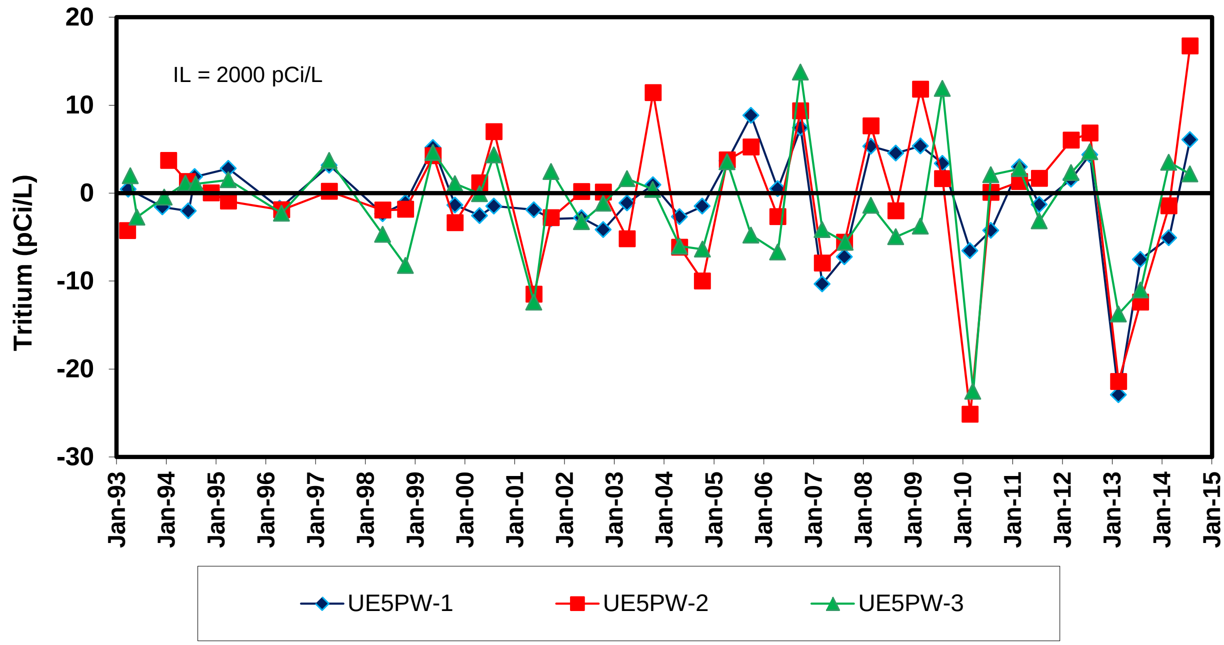


**Figure 2-5. Time Series Plot of Pilot Wells Tritium**

Average 2014 Pilot Well tritium results for all enriched samples is 3.7 pCi/L with an average quantification limit (QL) of 29 pCi/L and an average detection limit of 14 pCi/L. Average 2014 Pilot Well tritium results for all samples that were not enriched is 35 pCi/L with an average QL of 197 pCi/L and an average detection limit of 88 pCi/L. All of these average results are below the detection limit for the analysis method used and well below the tritium IL of 2000 pCi/L. Beginning in 2015, tritium enrichment of pilot well samples will be discontinued.

## 2.2.6 General Water Chemistry Parameters

General water chemistry analyses during 2014 for cations (Ca, Mg, Na, K, Fe), anions (Cl, F, $SO_4$, $HCO_3$), and $SiO_2$ indicate similar groundwater in all three wells and no changes in groundwater chemistry (Table 2-7, Table 2-8, and Table 2-9). Stiff plots for 2014 also indicate similar groundwater chemistry for all three wells (Figure 2-6). A piper diagram for the same water chemistry data from 2011 through 2014 indicates that the groundwater is a sodium-bicarbonate type (Figure 2-7).

Groundwater temperatures measured in March 2014 ranged from 18.6°C to 19.2°C (65.5°F to 66.6°F) and in August 2014 ranged from 22.3°C to 23.1°C (72.1°F to 73.6°F). Temperature measurements are collected at the ground surface and are influenced by the ambient air temperature.

**Table 2-7. UE5PW-1 General Water Chemistry Values in mg/L**

| Date | Ca | Mg | K | Na | Mn | Fe | $SiO_2$ | $SO_4$ | $HCO_3$ | Cl | Fl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 03/31/93 | NA | NA | NA | 48 | <0.006 | 0.013 | NA | 32 | 167 | 9.2 | 1.2 |
| 06/06/93 | NA | NA | NA | 58 | <0.001 | 0.059 | NA | 37 | 161 | 9.7 | 1.4 |
| 09/01/93 | NA | NA | NA | 56 | 0.0066 | 0.027 | NA | NA | 158 | 8.4 | 5.7 |
| 12/07/93 | NA | NA | NA | 57 | <0.0012 | 0.012 | NA | 36 | 150 | 9.9 | 1.5 |
| 06/15/94 | NA | NA | NA | 61 | <0.004 | 0.01 | NA | NA | NA | NA | NA |
| 08/01/94 | NA | NA | NA | 53 | <0.0012 | 0.021 | NA | 36 | NA | 10.0 | NA |
| 04/04/95 | NA | NA | NA | 58 | <0.01 | <0.05 | NA | 34 | NA | 9.9 | NA |
| 04/16/96 | NA | NA | NA | 61 | <0.001 | 0.02 | NA | 34 | NA | 9.9 | NA |
| 04/16/97 | 15.1 | 5.3 | 5.9 | 54.5 | <0.001 | 0.012 | NA | 32.2 | 156 | 9.3 | 1.3 |
| 11/05/97 | 15.5 | 5.6 | 6.4 | 57.8 | NA | 0.012 | NA | 35.2 | 151 | 10.2 | 1.2 |
| 05/13/98 | 14.0 | 5.4 | 5.2 | 55.8 | 0.0015 | 0.034 | 54.2 | 34.6 | 151 | 9.6 | 1.1 |
| 10/28/98 | 14.9 | 5.6 | 6.9 | 57.6 | 0.0015 | 0.024 | 60.5 | 34 | 160 | 9.7 | 1.1 |
| 05/19/99 | 12.5 | 5.3 | 6.9 | 61.0 | <0.0025 | <0.05 | 68.5 | 34 | 146 | 10.0 | 1.0 |
| 10/27/99 | 14.5 | 6.0 | 6.6 | 63.5 | <0.005 | <0.1 | 62.0 | 35 | 159 | 8.8 | 1.1 |
| 04/26/00 | 12.8 | 4.8 | 6.7 | 53.7 | 0.001 | 0.033 | 58.4 | 35.7 | 165 | 10.0 | 1.0 |
| 08/09/00 | 15.0 | 4.9 | 6.6 | 52.0 | 0.00045 | <0.0164 | 59.9 | 37.1 | 146 | 10.4 | 1.1 |
| 05/29/01 | 14.4 | 4.9 | 6.0 | 59.0 | <0.025 | 0.0122 | 61.7 | 0.0 | 143 | NA | NA |
| 10/03/01 | 13.7 | 4.8 | 6.7 | 51.0 | 0.0002 | <0.0156 | 58.3 | 36.0 | 151 | 10.2 | 1.0 |
| 05/15/02 | 14.3 | 5.1 | 7.0 | 54.5 | 0.00053 | 0.0285 | 60.9 | 35.9 | 155 | 10.7 | 1.0 |
| 10/22/02 | 14.6 | 5.2 | 6.4 | 50.0 | 0.0002 | 0.0181 | 60.7 | 35.6 | 143 | 10.1 | 1.0 |
| 04/15/03 | 13.7 | 5.0 | 6.2 | 58.0 | <0.005 | 0.0110 | 59.2 | 32.9 | 150 | 12.3 | 1.0 |
| 10/22/03 | 14.0 | 5.0 | 6.0 | 58.1 | <0.0016 | 0.0141 | 61.2 | 36.6 | 0 | 9.5 | 1.1 |
| 05/04/04 | 12.9 | 4.6 | 6.4 | 55.3 | 0.0027 | 0.0374 | 54.4 | 34.4 | 154 | 9.8 | 1.1 |
| 10/19/04 | 13.1 | 5.2 | 6.0 | 56.2 | <0.0003 | 0.0279 | 59.9 | 37.3 | 168 | 10.1 | 1.0 |
| 04/19/05 | 13.8 | 4.8 | 6.6 | 55.1 | <0.0006 | 0.007 | 58.6 | 39.6 | 149 | 10.5 | 1.0 |
| 10/11/05 | 13.4 | 5.0 | 6.1 | 50.5 | <0.0002 | <0.026 | 61.2 | 35.7 | 156 | 9.7 | 1.0 |
| 04/26/06 | 14.6 | 5.3 | 6.3 | 60.4 | <0.0032 | <0.0054 | 63.3 | 35.4 | 149 | 10.7 | 1.2 |
| 10/10/06 | 14.0 | 5.2 | 5.9 | 58.8 | 0.0007 | <0.0048 | 61.4 | 33.8 | 148 | 9.9 | 0.9 |
| 03/19/07 | 15.7 | 5.4 | 6.0 | 57.4 | <0.0036 | 0.0124 | 64.0 | 37.7 | 151 | 10.5 | 1.0 |
| 08/29/07 | 15.4 | 5.4 | 6.2 | 59.0 | 0.00046 | 0.0058 | 64.6 | 35.9 | 148 | 10.0 | 1.2 |
| 03/11/08 | 14.0 | 5.4 | 6.3 | 60.4 | <0.00045 | 0.0066 | 63.1 | 37.4 | 149 | 11.1 | 1.2 |
| 09/10/08 | 14.3 | 5.5 | 6.4 | 59.1 | <0.0009 | <0.045 | 62.5 | 34.7 | 155 | 11.0 | 1.2 |
| 03/10/09 | 13.4 | 5.3 | 6.1 | 58.1 | <0.005 | <0.100 | 58.6 | 35.7 | 174 | 10.1 | 1.1 |
| 08/18/09 | 13.4 | 5.3 | 6.0 | 58.3 | 0.00113 | 0.0168 | 61.8 | 37.1 | 160 | 11.0 | 1.0 |
| 03/10/10 | 13.3 | 5.3 | 6.0 | 59.6 | <0.005 | <0.100 | 65.2 | 38.5 | 151 | 10.7 | 1.0 |
| 08/10/10 | 12.8 | 5.2 | 5.9 | 57.6 | 0.00054 | <0.050 | 44.1 | 35.7 | 162 | 11.0 | 1.0 |
| 03/09/11 | 13.6 | 5.6 | 6.1 | 59.6 | <0.002 | <0.050 | 60.1 | 42.4 | 173 | 10.5 | 1.0 |
| 08/02/11 | 14.2 | 5.6 | 6.1 | 59.2 | <0.002 | <0.050 | 64.4 | 36.2 | 162 | 9.1 | 1.2 |
| 03/21/12 | 13.2 | 5.2 | 5.9 | 56.8 | <0.002 | <0.050 | 62.5 | 38.0 | 155 | 9.7 | 1.4 |
| 08/08/12 | 14.5 | 5.6 | 6.0 | 58.3 | <0.002 | 0.0112 | 64.4 | 36.2 | 162 | 10.0 | 1.3 |
| 03/05/13 | 14.2 | 5.9 | 6.4 | 63.0 | <0.002 | <0.03 | 65.7 | 35.4 | 151 | 9.0 | 1.1 |
| 08/13/13 | 14.6 | 5.8 | 6.3 | 58.3 | <0.002 | <0.03 | 63.8 | 36.8 | 159 | 9.5 | 1.2 |
| 03/11/14 | 14.7 | 5.9 | 5.7 | 64.4 | <0.002 | 0.123 | 64.5 | 34.2 | 120 | 9.9 | 1.2 |
| 08/12/14 | 14.4 | 5.8 | 6.1 | 55.8 | <0.002 | <0.03 | 61.4 | 36.5 | 138 | 10.2 | 1.2 |

Data source: Data before 10/27/1999 from BN, 2001.
NA is no analysis.

**Table 2-8. UE5PW-2 General Water Chemistry Values in mg/L**

| Date | Ca | Mg | K | Na | Mn | Fe | $SiO_2$ | $SO_4$ | $HCO_3$ | Cl | Fl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 03/24/93 | NA | NA | NA | 46 | 0.11 | 0.062 | NA | 28 | 159 | 8.4 | 1.0 |
| 06/22/93 | NA | NA | NA | 54 | 0.032 | 0.25 | NA | 30 | 183 | 9.7 | 1.1 |
| 11/15/93 | NA | NA | NA | 51 | <0.004 | 0.180 | NA | 31 | 171 | 9.4 | 1.3 |
| 01/19/94 | NA | NA | NA | 45 | <0.0012 | 0.074 | NA | 29 | 159 | NA | 1.2 |
| 06/07/94 | NA | NA | NA | 55 | <0.004 | 0.14 | NA | NA | NA | NA | NA |
| 11/29/94 | NA | NA | NA | NA | NA | NA | NA | 28 | NA | 8.0 | NA |
| 04/04/95 | NA | NA | NA | 50 | <0.01 | <0.05 | NA | 28 | NA | 8.5 | NA |
| 04/30/96 | NA | NA | NA | 51 | <0.001 | 0.013 | NA | 29 | NA | 8.3 | NA |
| 04/16/97 | 15.9 | 6.0 | 5.0 | 47.6 | <0.001 | 0.012 | NA | 26.4 | 149 | 7.9 | 1.2 |
| 11/05/97 | 17.4 | 6.8 | 4.9 | 50.6 | NA | 0.018 | NA | 28.9 | 140 | 8.6 | 0.9 |
| 05/13/98 | 14.8 | 5.7 | 3.8 | 45.2 | <0.0011 | 0.066 | 50.8 | 28.2 | 151 | 8.2 | 1.0 |
| 10/28/98 | 15.8 | 6.2 | 5.6 | 47.4 | 0.0009 | 0.015 | 55.9 | 28.4 | 157 | 8.3 | 1.0 |
| 05/19/99 | 15.0 | 6.3 | 6.2 | 52.0 | <0.0025 | <0.05 | 62.0 | 27.5 | 134 | 8.7 | 0.9 |
| 10/27/99 | 16.0 | 6.7 | 5.7 | 52.0 | <0.005 | <0.1 | 55.6 | 28.0 | 152 | 7.4 | 1.0 |
| 04/26/00 | 15.3 | 6.5 | 5.6 | 45.6 | 0.0007 | 0.029 | 55.8 | 29.1 | 177 | 8.6 | 0.8 |
| 08/09/00 | 17.0 | 6.6 | 5.3 | 44.5 | <0.0002 | <0.0164 | 59.2 | 28.8 | 155 | 9.3 | 0.9 |
| 05/29/01 | 16.6 | 6.6 | 4.8 | 48.8 | <0.0088 | <0.0107 | 60.4 | NA | 152 | NA | NA |
| 10/03/01 | 16.0 | 6.7 | 5.5 | 44.7 | 0.00017 | 0.0214 | 58.8 | 28.4 | 152 | 8.7 | 1.0 |
| 05/15/02 | 16.5 | 6.8 | 5.6 | 46.1 | 0.00059 | 0.0603 | 60.1 | 28.7 | 155 | 9.3 | 0.9 |
| 10/22/02 | 17.6 | 7.1 | 5.3 | 44.4 | 0.0031 | <0.0181 | 63.0 | 28.7 | 149 | 8.7 | 0.8 |
| 04/15/03 | 16.3 | 6.6 | 5.3 | 50.8 | <0.0005 | <0.0101 | 60.3 | 26.7 | 157 | 9.8 | 0.8 |
| 10/22/03 | 16.1 | 6.6 | 5.2 | 49.6 | <0.0016 | 0.0618 | 60.5 | 29.5 | 141 | 8.8 | 0.9 |
| 05/04/04 | 16.0 | 6.3 | 5.4 | 47.2 | <0.0007 | 0.0397 | 58.2 | 28.1 | 159 | 8.2 | 0.9 |
| 10/19/04 | 15.7 | 6.7 | 5.1 | 48.6 | <0.0003 | <0.0279 | 59.7 | 29.6 | 169 | 8.9 | 0.9 |
| 04/19/05 | 16.3 | 6.3 | 5.2 | 44.9 | <0.0006 | 0.0115 | 58.6 | 31.3 | 133 | 8.4 | 0.9 |
| 10/11/05 | 16.0 | 6.8 | 5.0 | 44.0 | <0.0002 | 0.0270 | 62.2 | 29.0 | 167 | 8.1 | 0.9 |
| 04/26/06 | 16.6 | 6.7 | 5.4 | 51.2 | <0.0032 | 0.0612 | 62.5 | 28.1 | 152 | 8.8 | 1.1 |
| 10/10/06 | 16.5 | 6.5 | 5.2 | 48.0 | <0.0007 | 0.0170 | 61.2 | 27.2 | 156 | 8.6 | 1.1 |
| 03/19/07 | 16.8 | 6.6 | 5.4 | 49.8 | <0.0036 | 0.0387 | 62.9 | 42.2 | 149 | 11.3 | 0.9 |
| 08/29/07 | 16.9 | 6.7 | 5.2 | 50.5 | <0.00045 | 0.0098 | 63.7 | 27.9 | 151 | 9.0 | 1.1 |
| 03/11/08 | 16.7 | 6.7 | 5.2 | 50.5 | <0.00045 | 0.0159 | 60.3 | 30.7 | 149 | 10.0 | 1.0 |
| 09/10/08 | 16.8 | 7.0 | 5.7 | 52.7 | 0.0020 | <0.045 | 60.3 | 28.7 | 152 | 9.2 | 1.0 |
| 03/10/09 | 15.9 | 6.7 | 5.0 | 50.0 | <0.005 | <0.100 | 61.6 | 28.9 | 165 | 8.4 | 1.0 |
| 08/18/09 | 15.5 | 6.8 | 5.1 | 50.9 | 0.00066 | 0.0123 | 61.2 | 29.1 | 155 | 8.8 | 0.9 |
| 03/10/10 | 15.6 | 6.6 | 5.0 | 51.2 | 0.00052 | 0.0199 | 62.2 | 30.9 | 156 | 8.9 | 0.9 |
| 08/10/10 | 15.2 | 6.5 | 4.9 | 49.9 | 0.00074 | 0.0158 | 47.5 | 29.8 | 167 | 8.8 | 0.9 |
| 03/08/11 | 15.6 | 6.7 | 4.9 | 49.2 | <0.002 | <0.050 | 55.6 | 32.4 | 172 | 8.8 | 0.8 |
| 08/02/11 | 16.6 | 7.1 | 5.2 | 51.0 | <0.002 | 0.0118 | 62.9 | 29.0 | 162 | 8.8 | 1.1 |
| 03/22/12 | 15.1 | 6.2 | 5.0 | 49.4 | <0.002 | <0.050 | 60.7 | 30.6 | 166 | 9.1 | 1.3 |
| 08/08/12 | 15.8 | 6.7 | 4.9 | 49.3 | <0.002 | <0.050 | 60.1 | 29.1 | 169 | 8.8 | 1.2 |
| 03/06/13 | 17.1 | 7.5 | 5.6 | 55.3 | <0.002 | <0.03 | 66.4 | 33.7 | 150 | 7.9 | 1.0 |
| 08/13/13 | 16.5 | 7.2 | 5.4 | 51.1 | <0.002 | <0.03 | 61.8 | 31.9 | 163 | 8.4 | 1.1 |
| 03/11/14 | 16.4 | 7.4 | 4.9 | 55.7 | <0.002 | 0.071 | 62.9 | 28.7 | 150 | 8.2 | 1.0 |
| 08/12/14 | 16.4 | 7.3 | 5.2 | 49.3 | <0.002 | <0.03 | 60.5 | 29.4 | 138 | 8.6 | 1.1 |

Data source: Data before 10/27/1999 from BN, 2001.
NA is no analysis.

**Table 2-9. UE5PW-3 General Water Chemistry Values in mg/L**

| Date | Ca | Mg | K | Na | Mn | Fe | $SiO_2$ | $SO_4$ | $HCO_3$ | Cl | Fl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 04/14/93 | NA | NA | NA | 46 | 0.042 | 0.024 | NA | 31 | 157 | 8.5 | 1.3 |
| 06/02/93 | NA | NA | NA | 53 | 0.009 | 0.014 | NA | 31 | 162 | 9.1 | 1.2 |
| 10/12/93 | NA | NA | NA | 57 | <0.006 | 0.11 | NA | 30 | 156 | 7.9 | 1.2 |
| 12/20/93 | NA | NA | NA | 48 | <0.0012 | 0.1 | NA | 33 | 156 | 8.7 | 1.3 |
| 05/24/94 | NA | NA | NA | 56 | <0.0012 | 0.02 | NA | NA | NA | NA | NA |
| 08/08/94 | NA | NA | NA | 51 | <0.0012 | <0.009 | NA | 33 | NA | 8.9 | NA |
| 04/05/95 | NA | NA | NA | 55 | <0.01 | <0.05 | NA | 31 | NA | 8.8 | NA |
| 04/30/96 | NA | NA | NA | 57 | <0.001 | 0.0088 | NA | 32 | NA | 8.7 | NA |
| 04/16/97 | 15.8 | 5.7 | 4.0 | 54.2 | <0.001 | <0.006 | NA | 29 | 155 | 8.4 | 1.3 |
| 11/05/97 | 16.8 | 6.1 | 4.3 | 55.5 | NA | 0.0133 | NA | 32.1 | 140 | 9.2 | 1.1 |
| 05/13/98 | 15.8 | 5.8 | 3.3 | 53.8 | <0.0011 | 0.035 | 56.6 | 30.9 | 151 | 8.6 | 1.0 |
| 10/28/98 | 15.6 | 5.7 | 4.2 | 53.7 | 0.0009 | 0.009 | 57.1 | 31.4 | 156 | 8.7 | 1.0 |
| 05/19/99 | 15.0 | 5.8 | 4.8 | 56.0 | <0.0025 | <0.05 | 66.3 | 30.5 | 146 | 9.2 | 0.9 |
| 10/27/99 | 16.0 | 6.4 | 3.8 | 58.5 | <0.005 | <0.1 | 59.9 | 31.0 | 159 | 7.7 | 0.9 |
| 04/26/00 | 15.3 | 5.9 | 4.5 | 49.8 | 0.0003 | 0.0178 | 58.5 | 32.0 | 169 | 9.1 | 0.9 |
| 08/09/00 | 16.0 | 5.8 | 4.3 | 48.3 | <0.0002 | <0.0164 | 57.8 | 32.6 | 162 | 9.9 | 1.0 |
| 05/29/01 | 16.4 | 5.9 | 4.0 | 54.8 | 0.0018 | <0.0107 | 60.5 | NA | 151 | NA | NA |
| 10/03/01 | 15.6 | 6.0 | 4.5 | 48.4 | 0.00022 | 0.0237 | 57.9 | 31.5 | 154 | 8.9 | 1.0 |
| 05/15/02 | 15.7 | 6.0 | 4.5 | 49.3 | 0.00027 | 0.0249 | 57.9 | 33.0 | 151 | 9.8 | 0.9 |
| 10/22/02 | 17.2 | 6.2 | 4.3 | 47.6 | <0.0002 | <0.0181 | 60.5 | 32.2 | 143 | 9.3 | 0.9 |
| 04/15/03 | 16.0 | 5.9 | 4.5 | 54.7 | 0.00083 | 0.0195 | 58.4 | 29.3 | 144 | 11.8 | 0.8 |
| 10/21/03 | 16.3 | 5.8 | 4.1 | 54.4 | <0.0016 | 0.0212 | 59.5 | 32.5 | 160 | 9.2 | 1.0 |
| 05/04/04 | 16.1 | 5.6 | 4.7 | 52.2 | 0.0019 | 0.0453 | 58.2 | 31.1 | 155 | 8.7 | 1.0 |
| 10/20/04 | 15.6 | 5.9 | 4.0 | 52.3 | <0.0003 | <0.0279 | 58.4 | 32.0 | 166 | 9.4 | 0.8 |
| 04/19/05 | 16.2 | 5.6 | 4.5 | 50.9 | <0.0006 | 0.0319 | 57.8 | 34.4 | 148 | 8.8 | 0.9 |
| 10/11/05 | 16.1 | 6.1 | 4.3 | 48.5 | <0.0002 | <0.026 | 61.4 | 32.5 | 156 | 8.5 | 0.9 |
| 04/26/06 | 16.6 | 6.1 | 4.2 | 58.1 | <0.0032 | 0.0057 | 61.6 | 31.6 | 159 | 9.4 | 1.2 |
| 10/10/06 | 15.9 | 5.5 | 4.0 | 49.7 | 0.0007 | 0.0114 | 57.3 | 30.1 | 152 | 9.0 | 1.0 |
| 03/19/07 | 16.8 | 6.1 | 4.0 | 55.5 | <0.0036 | 0.0921 | 61.2 | 19.9 | 149 | 9.3 | 0.8 |
| 09/05/07 | 16.5 | 5.9 | 4.3 | 54.7 | 0.0012 | 0.0041 | 60.1 | 32.5 | 149 | 9.8 | 1.1 |
| 03/11/08 | 16.7 | 6.1 | 4.2 | 57.2 | <0.00045 | 0.0045 | 58.8 | 32.1 | 144 | 9.9 | 1.0 |
| 09/10/08 | 16.4 | 6.1 | 4.5 | 56.4 | <0.0009 | <0.045 | 58.8 | 35.9 | 165 | 9.5 | 1.0 |
| 03/10/09 | 15.9 | 6.0 | 4.2 | 55.6 | <0.005 | 0.100 | 59.0 | 31.7 | 155 | 9.0 | 0.9 |
| 08/18/09 | 15.4 | 5.9 | 4.0 | 54.7 | 0.00062 | 0.0112 | 58.4 | 32.5 | 152 | 9.4 | 0.9 |
| 03/31/10 | 15.5 | 6.1 | 4.1 | 55.9 | 0.00111 | 0.0276 | 56.9 | 38.3 | 144 | 11.0 | 1.3 |
| 08/10/10 | 14.9 | 5.6 | 4.0 | 54.6 | <0.002 | 0.0154 | 49.4 | 31.5 | 162 | 9.5 | 0.9 |
| 03/08/11 | 15.5 | 6.0 | 4.0 | 54.2 | 0.001 | <0.05 | 55.6 | 37.3 | 172 | 9.4 | 0.9 |
| 08/02/11 | 15.8 | 6.2 | 4.2 | 55.7 | <0.002 | 0.023 | 61.0 | 32.5 | 156 | 9.5 | 1.1 |
| 03/21/12 | 15.0 | 5.7 | 4.1 | 54.6 | <0.002 | <0.05 | 59.0 | 33.2 | 157 | 9.7 | 1.3 |
| 08/08/12 | 15.7 | 6.0 | 4.1 | 54.5 | <0.002 | <0.05 | 59.0 | 32.1 | 167 | 9.2 | 1.2 |
| 03/06/13 | 16.3 | 6.6 | 4.4 | 59.5 | <0.002 | 0.0674 | 62.8 | 35.2 | 150 | 8.1 | 1.0 |
| 08/13/13 | 16.9 | 6.5 | 4.6 | 58.2 | <0.002 | <0.05 | 62.2 | 33.0 | 161 | 9.3 | 1.1 |
| 03/11/14 | 16.5 | 6.4 | 3.9 | 60.9 | <0.002 | 0.122 | 61.1 | 31.0 | 154 | 8.7 | 1.0 |
| 08/12/14 | 15.9 | 6.2 | 4.1 | 52.0 | <0.002 | 0.037 | 57.7 | 32.3 | 139 | 9.2 | 1.0 |

Data source: Data before 10/27/1999 from BN, 2001.

NA is no analysis.

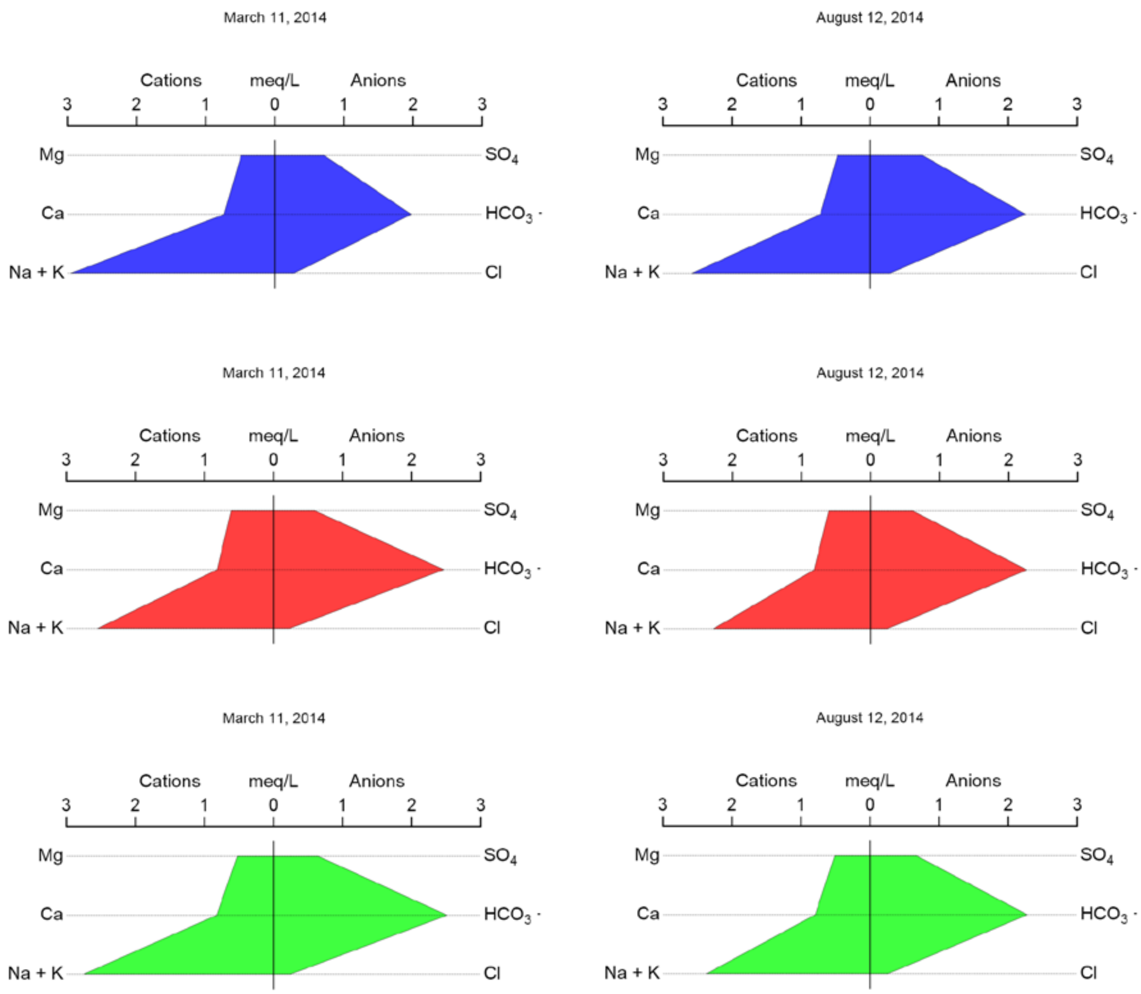


**Figure 2-6. Stiff Diagrams for Pilot Well Samples Collected in 2014**

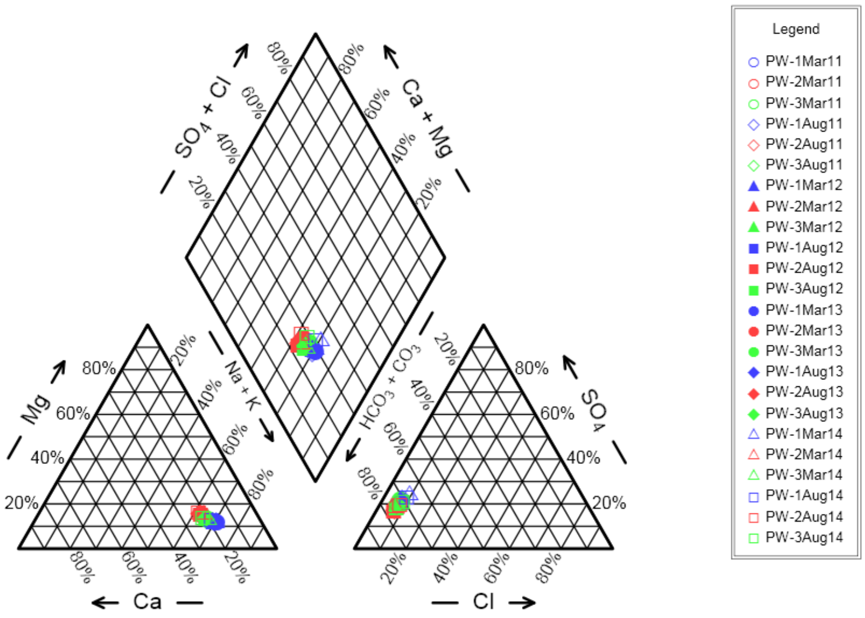


**Figure 2-7. Piper Diagram for Pilot Wells from 2011 through 2014**

### 2.2.7 Groundwater Elevation

Groundwater elevations in UE5PW-1, UE5PW-2, and UE5PW-3 are measured quarterly using an electronic water-level tape (Table 2-10). The 2014 average depths to water from the top of casing are 235.86 m (773.82 ft), 256.47 m (841.44 ft), and 271.57 m (890.98 ft) for UE5PW-1, UE5PW-2, and UE5PW-3, respectively. These measurements are corrected for borehole deviation (REECo 1994).

The 2014 average groundwater elevations are 733.52 m (2,406.56 ft) AMSL, 733.62 m (2,406.89 ft) AMSL, and 733.72 m (2,407.22 ft) AMSL for UE5PW-1, UE5PW-2, and UE5PW-3, respectively. These measurements are corrected for borehole deviation (REECo 1994).

Based on the similar groundwater elevations, the groundwater table is essentially flat with little or no flow. Groundwater gradient, velocity, and flow direction are calculated from the groundwater elevations, borehole locations, and aquifer hydraulic properties (Table 2-11; Appendix B). The average calculated flow velocity during 2014 was 0.08 meters per year and the flow direction was southeast. The very low calculated flow velocities and the fluctuating flow directions indicate little or no groundwater movement. Changes in calculated flow directions and velocity are due to new surveys of well elevations (USGS 2014).

**Table 2-10. Pilot Wells Groundwater Elevation Data**

| Well Characteristics[1] | UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|---|
| Northing[2] (m) | 233,386.53 | | 234,817.22 | | 235,089.98 | |
| Easting[2] (m) | 216,357.39 | | 216,376.16 | | 214,415.13 | |
| Well Casing Elevation[3] (m) | 969.38 | | 990.09 | | 1,005.29 | |
| Casing stickup height[4] (m) | 0.60 | | 0.68 | | 0.78 | |
| Land Surface Elevation (m) | 968.77 | | 989.41 | | 1,004.51 | |
| Borehole Deviation Correction (m) | 0.08 | | 0.21 | | 0.02 | |
| Date | Depth to Water (m below Top of Casing) | Water Table Elevation (m) | Depth to Water (m below Top of Casing) | Water Table Elevation (m) | Depth to Water (m below Top of Casing) | Water Table Elevation (m) |
| 03/22/1993 | 235.55 | 733.83 | 256.38 | 733.71 | 271.69 | 733.60 |
| 03/23/1993 | 235.53 | 733.85 | 256.48 | 733.61 | 271.68 | 733.61 |
| 03/24/1993 | 235.53 | 733.85 | 256.36 | 733.73 | 271.69 | 733.60 |
| 03/25/1993 | 235.53 | 733.85 | 256.35 | 733.74 | 271.69 | 733.60 |
| 03/29/1993 | 235.59 | 733.79 | 256.38 | 733.71 | 271.73 | 733.56 |
| 03/30/1993 | 235.62 | 733.76 | 256.43 | 733.66 | 271.75 | 733.54 |
| 03/31/1993 | 235.62 | 733.76 | 256.44 | 733.65 | 271.74 | 733.55 |
| 04/01/1993 | 235.54 | 733.84 | 256.37 | 733.72 | 271.69 | 733.60 |
| 04/05/1993 | 235.51 | 733.87 | 256.35 | 733.74 | 271.67 | 733.62 |
| 04/06/1993 | 235.59 | 733.79 | 256.40 | 733.69 | 271.75 | 733.54 |
| 05/10/1993 | 235.64 | 733.74 | 256.46 | 733.63 | 271.76 | 733.53 |
| 05/11/1993 | 235.56 | 733.82 | 256.42 | 733.67 | 271.70 | 733.59 |
| 05/12/1993 | 235.54 | 733.84 | 256.40 | 733.69 | 271.72 | 733.57 |
| 05/13/1993 | 235.61 | 733.77 | 256.45 | 733.64 | 271.75 | 733.54 |
| 05/17/1993 | 235.61 | 733.77 | 256.45 | 733.64 | 271.74 | 733.55 |
| 05/18/1993 | 235.59 | 733.79 | 256.45 | 733.64 | 271.74 | 733.55 |
| 05/19/1993 | 235.59 | 733.79 | 256.44 | 733.65 | 271.73 | 733.56 |
| 05/20/1993 | 235.54 | 733.84 | 256.39 | 733.70 | 271.70 | 733.59 |
| 05/24/1993 | 235.60 | 733.78 | 256.43 | 733.66 | 271.74 | 733.55 |
| 05/25/1993 | 235.61 | 733.77 | 256.45 | 733.64 | 271.74 | 733.55 |
| 06/01/1993 | 235.58 | 733.80 | 256.43 | 733.66 | 271.73 | 733.56 |
| 06/07/1993 | 235.64 | 733.74 | 256.46 | 733.63 | 271.76 | 733.53 |
| 06/14/1993 | 235.61 | 733.77 | 256.46 | 733.63 | 271.74 | 733.55 |
| 06/21/1993 | 235.58 | 733.80 | 256.43 | 733.66 | 271.73 | 733.56 |
| 07/26/1993 | 235.59 | 733.79 | 256.45 | 733.64 | 271.74 | 733.55 |
| 08/03/1993 | 235.54 | 733.84 | 256.42 | 733.67 | 271.70 | 733.59 |
| 08/09/1993 | 235.62 | 733.76 | 256.46 | 733.63 | 271.75 | 733.54 |
| 08/16/1993 | 235.59 | 733.79 | 256.42 | 733.67 | 271.73 | 733.56 |
| 08/30/1993 | 235.58 | 733.80 | 256.43 | 733.66 | 271.72 | 733.57 |
| 12/28/1993 | 235.59 | 733.79 | 256.47 | 733.62 | 271.74 | 733.55 |
| 01/03/1994 | 235.57 | 733.81 | 256.44 | 733.65 | 271.70 | 733.59 |
| 02/02/1994 | 235.53 | 733.85 | 256.44 | 733.65 | 271.66 | 733.63 |
| 02/22/1994 | 235.60 | 733.78 | 256.43 | 733.66 | 271.71 | 733.58 |

**Table 2-10. Pilot Wells Groundwater Elevation Data (continued)**

| Date | UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|---|
| | Depth to Water (m below Top of Casing) | Water Table Elevation (m) | Depth to Water (m below Top of Casing) | Water Table Elevation (m) | Depth to Water (m below Top of Casing) | Water Table Elevation (m) |
| 02/28/1994 | 235.60 | 733.78 | 256.45 | 733.64 | 271.70 | 733.59 |
| 03/07/1994 | 235.54 | 733.84 | 256.38 | 733.71 | 271.66 | 733.63 |
| 03/14/1994 | 235.55 | 733.83 | 256.45 | 733.64 | 271.67 | 733.62 |
| 03/21/1994 | 235.56 | 733.82 | 256.38 | 733.71 | 271.68 | 733.61 |
| 03/28/1994 | 235.63 | 733.75 | 256.47 | 733.62 | 271.70 | 733.59 |
| 04/04/1994 | 235.53 | 733.85 | 256.40 | 733.69 | 271.66 | 733.63 |
| 04/13/1994 | 235.55 | 733.83 | 256.43 | 733.66 | 271.65 | 733.64 |
| 04/20/1994 | 235.51 | 733.87 | 256.38 | 733.71 | 271.64 | 733.65 |
| 04/26/1994 | 235.55 | 733.83 | 256.35 | 733.74 | 271.65 | 733.64 |
| 01/18/1995 | 235.63 | 733.75 | 256.45 | 733.64 | 271.62 | 733.67 |
| 04/03/1995 | 235.57 | 733.81 | 256.39 | 733.70 | 271.61 | 733.68 |
| 01/16/1996 | 235.36 | 734.02 | 256.13 | 733.96 | 271.35 | 733.94 |
| 04/15/1996 | 235.56 | 733.82 | 256.30 | 733.79 | 271.43 | 733.86 |
| 10/01/1996 | 235.54 | 733.84 | 256.32 | 733.77 | 271.51 | 733.78 |
| 11/19/1996 | 235.59 | 733.79 | 256.33 | 733.76 | 271.52 | 733.77 |
| 03/03/1997 | 235.54 | 733.84 | 256.30 | 733.79 | 271.41 | 733.88 |
| 04/15/1997 | 235.63 | 733.75 | 256.40 | 733.69 | 271.54 | 733.75 |
| 06/18/1997 | 235.61 | 733.77 | 256.40 | 733.69 | 271.52 | 733.77 |
| 07/28/1997 | 235.60 | 733.78 | 256.37 | 733.72 | 271.51 | 733.78 |
| 08/20/1997 | 235.52 | 733.86 | 256.29 | 733.80 | 271.44 | 733.85 |
| 09/25/1997 | 235.59 | 733.79 | 256.35 | 733.74 | 271.49 | 733.80 |
| 10/27/1997 | 235.57 | 733.81 | 256.34 | 733.75 | 271.48 | 733.81 |
| 11/03/1997 | 235.65 | 733.73 | 256.40 | 733.69 | 271.55 | 733.74 |
| 11/06/1997 | 235.57 | 733.81 | 256.36 | 733.73 | 271.48 | 733.81 |
| 11/12/1997 | 235.66 | 733.72 | 256.45 | 733.64 | 271.54 | 733.75 |
| 11/13/1997 | 235.60 | 733.78 | 256.29 | 733.80 | 271.49 | 733.80 |
| 11/19/1997 | 235.63 | 733.75 | 256.42 | 733.67 | 271.55 | 733.74 |
| 11/20/1997 | 235.65 | 733.73 | 256.43 | 733.66 | 271.57 | 733.72 |
| 11/25/1997 | 235.64 | 733.74 | 256.39 | 733.70 | 271.54 | 733.75 |
| 11/26/1997 | 235.50 | 733.88 | 256.27 | 733.82 | 271.45 | 733.84 |
| 12/03/1997 | 235.71 | 733.67 | 256.43 | 733.66 | 271.60 | 733.69 |
| 01/26/1998 | 235.72 | 733.66 | 256.47 | 733.62 | 271.60 | 733.69 |
| 05/12/1998 | 235.60 | 733.78 | 256.32 | 733.77 | 271.52 | 733.77 |
| 10/27/1998 | 235.52 | 733.86 | 256.21 | 733.88 | 271.36 | 733.93 |
| 12/22/1998 | 235.54 | 733.84 | 256.20 | 733.89 | 271.35 | 733.94 |
| 02/02/1999 | 235.61 | 733.77 | 256.34 | 733.75 | 271.42 | 733.87 |
| 05/18/1999 | 235.56 | 733.82 | 256.26 | 733.83 | 271.35 | 733.94 |
| 08/25/1999 | 235.56 | 733.82 | 256.26 | 733.83 | 271.38 | 733.91 |
| 10/26/1999 | 235.57 | 733.81 | 256.26 | 733.83 | 271.34 | 733.95 |
| 04/24/2000 | 235.64 | 733.74 | 256.34 | 733.75 | 271.52 | 733.77 |
| 08/07/2000 | 235.59 | 733.79 | 256.30 | 733.79 | 271.47 | 733.82 |
| 11/13/2000 | 235.66 | 733.72 | 256.34 | 733.75 | 271.45 | 733.84 |
| 02/22/2001 | 235.57 | 733.81 | 256.26 | 733.83 | 271.38 | 733.91 |
| 05/21/2001 | 235.67 | 733.71 | 256.35 | 733.74 | 271.49 | 733.80 |
| 08/01/2001 | 235.66 | 733.72 | 256.36 | 733.73 | 271.48 | 733.81 |
| 10/01/2001 | 235.66 | 733.72 | 256.35 | 733.74 | 271.45 | 733.84 |
| 02/26/2002 | 235.76 | 733.62 | 256.43 | 733.66 | 271.52 | 733.77 |

**Table 2-10. Pilot Wells Groundwater Elevation Data (continued)**

| | UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|---|
| Date | Depth to Water (m below Top of Casing) | Water Table Elevation (m) | Depth to Water (m below Top of Casing) | Water Table Elevation (m) | Depth to Water (m below Top of Casing) | Water Table Elevation (m) |
| 08/19/2002 | 235.61 | 733.77 | 256.28 | 733.81 | 271.42 | 733.87 |
| 10/21/2002 | 235.61 | 733.77 | 256.31 | 733.78 | 271.44 | 733.85 |
| 02/26/2003 | 235.65 | 733.73 | 256.28 | 733.81 | 271.43 | 733.86 |
| 04/10/2003 | 235.61 | 733.77 | 256.30 | 733.79 | 271.41 | 733.88 |
| 09/10/2003 | 235.74 | 733.64 | 256.35 | 733.74 | 271.50 | 733.79 |
| 10/20/2003 | 235.73 | 733.65 | 256.42 | 733.67 | 271.53 | 733.76 |
| 02/25/2004 | 235.78 | 733.60 | 256.36 | 733.73 | 271.52 | 733.77 |
| 04/27/2004 | 235.72 | 733.66 | 256.43 | 733.66 | 271.52 | 733.77 |
| 08/18/2004 | 235.72 | 733.66 | 256.38 | 733.71 | 271.48 | 733.81 |
| 10/18/2004 | 235.71 | 733.67 | 256.29 | 733.80 | 271.47 | 733.82 |
| 01/26/2005 | 235.67 | 733.71 | 256.45 | 733.64 | 271.46 | 733.83 |
| 04/18/2005 | 235.66 | 733.72 | 256.33 | 733.76 | 271.44 | 733.85 |
| 07/27/2005 | 235.75 | 733.63 | 256.42 | 733.67 | 271.51 | 733.78 |
| 10/10/2005 | 235.77 | 733.61 | 256.44 | 733.65 | 271.54 | 733.75 |
| 03/08/2006 | 235.74 | 733.64 | 256.39 | 733.70 | 271.50 | 733.79 |
| 05/03/2006 | 235.69 | 733.69 | 256.41 | 733.68 | 271.62 | 733.67 |
| 08/23/2006 | 235.76 | 733.62 | 256.43 | 733.66 | 271.50 | 733.79 |
| 10/09/2006 | 235.69 | 733.69 | 256.38 | 733.71 | 271.44 | 733.85 |
| 02/28/2007 | 235.74 | 733.64 | 256.29 | 733.80 | 271.49 | 733.80 |
| 07/11/2007 | 235.77 | 733.61 | 256.41 | 733.68 | 271.50 | 733.79 |
| 08/28/2007 | 235.78 | 733.60 | 256.42 | 733.67 | 271.47 | 733.82 |
| 10/15/2007 | 235.76 | 733.62 | 256.40 | 733.69 | 271.49 | 733.80 |
| 01/22/2008 | 235.79 | 733.59 | 256.39 | 733.70 | 271.53 | 733.76 |
| 03/03/2008 | 235.80 | 733.58 | 256.38 | 733.71 | 271.53 | 733.76 |
| 06/16/2008 | 235.74 | 733.64 | 256.32 | 733.77 | 271.48 | 733.81 |
| 09/09/2008 | 235.73 | 733.65 | 256.39 | 733.70 | 271.47 | 733.82 |
| 02/17/2009 | 235.78 | 733.60 | 256.40 | 733.69 | 271.52 | 733.77 |
| 05/06/2009 | 235.80 | 733.58 | 256.41 | 733.68 | 271.52 | 733.77 |
| 08/17/2009 | 235.76 | 733.62 | 256.39 | 733.70 | 271.51 | 733.78 |
| 11/10/2009 | 235.81 | 733.57 | 256.46 | 733.63 | 271.55 | 733.74 |
| 03/01/2010 | 235.85 | 733.53 | 256.47 | 733.62 | 271.57 | 733.72 |
| 04/26/2010 | 235.78 | 733.60 | 256.44 | 733.65 | 271.52 | 733.77 |
| 08/09/2010 | 235.82 | 733.56 | 256.41 | 733.68 | 271.51 | 733.78 |
| 11/09/2010 | 235.82 | 733.56 | 256.40 | 733.69 | 271.54 | 733.75 |
| 03/01/2011 | 235.88 | 733.50 | 256.50 | 733.59 | 271.56 | 733.73 |
| 06/07/2011 | 235.82 | 733.56 | 256.45 | 733.64 | 271.52 | 733.77 |
| 08/01/2011 | 235.85 | 733.53 | 256.49 | 733.60 | 271.56 | 733.73 |
| 10/17/2011 | 235.86 | 733.52 | 256.49 | 733.60 | 271.59 | 733.70 |
| 03/19/2012 | 235.85 | 733.53 | 256.39 | 733.70 | 271.57 | 733.72 |
| 06/06/2012 | 235.88 | 733.50 | 256.47 | 733.62 | 271.57 | 733.72 |
| 08/02/2012 | 235.81 | 733.57 | 256.46 | 733.63 | 271.52 | 733.77 |
| 10/15/2012 | 235.86 | 733.52 | 256.50 | 733.59 | 271.56 | 733.73 |
| 03/04/2013 | 235.80 | 733.58 | 256.43 | 733.66 | 271.55 | 733.74 |
| 06/06/2013 | 235.86 | 733.52 | 256.46 | 733.63 | 271.56 | 733.73 |
| 08/12/2013 | 235.87 | 733.51 | 256.45 | 733.64 | 271.56 | 733.73 |
| 10/15/2013 | 235.91 | 733.47 | 256.51 | 733.58 | 271.58 | 733.71 |

**Table 2-10. Pilot Wells Groundwater Elevation Data (continued)**

| Date | UE5PW-1 | | UE5PW-2 | | UE5PW-3 | |
|---|---|---|---|---|---|---|
| | Depth to Water (m below Top of Casing) | Water Table Elevation (m) | Depth to Water (m below Top of Casing) | Water Table Elevation (m) | Depth to Water (m below Top of Casing) | Water Table Elevation (m) |
| 03/10/2014 | 235.83 | 733.55 | 256.47 | 733.62 | 271.55 | 733.74 |
| 06/12/2014 | 235.87 | 733.51 | 256.45 | 733.64 | 271.56 | 733.73 |
| 08/11/2014 | 235.89 | 733.49 | 256.49 | 733.60 | 271.59 | 733.70 |
| 10/14/2014 | 235.84 | 733.54 | 256.48 | 733.61 | 271.57 | 733.72 |

[1] Source for northings, eastings, and well casing elevations: USGS, 2014
[2] Coordinates-Nevada State Plan Central Zone Coordinates (1927) Zone 2702, 1927 National Geodetic Datum
[3] Measured from top of well casing
[4] Measured from top of well casing to land surface
[5] Source: REECo (1994)

Note: All elevations are m above mean sea level

**Table 2-11. 2014 Area 5 RWMS Groundwater Flow Calculations**

| Hydraulic Conductivity = 1.12E-03 cm/second (3.67E-05ft/second)[a] Effective Porosity = 0.38[a] | | | |
|---|---|---|---|
| **Date** | **Hydraulic Gradient (m/m)** | **Velocity (m/yr)** | **Flow direction (degrees East of North)** |
| 3/10/14 | 7.36E-05 | 0.068 | 132 |
| 6/2/14 | 9.71E-05 | 0.090 | 160 |
| 8/11/14 | 8.72E-05 | 0.081 | 153 |
| 10/14/14 | 6.98E-05 | 0.065 | 135 |

[a] Source: REECo (1994)

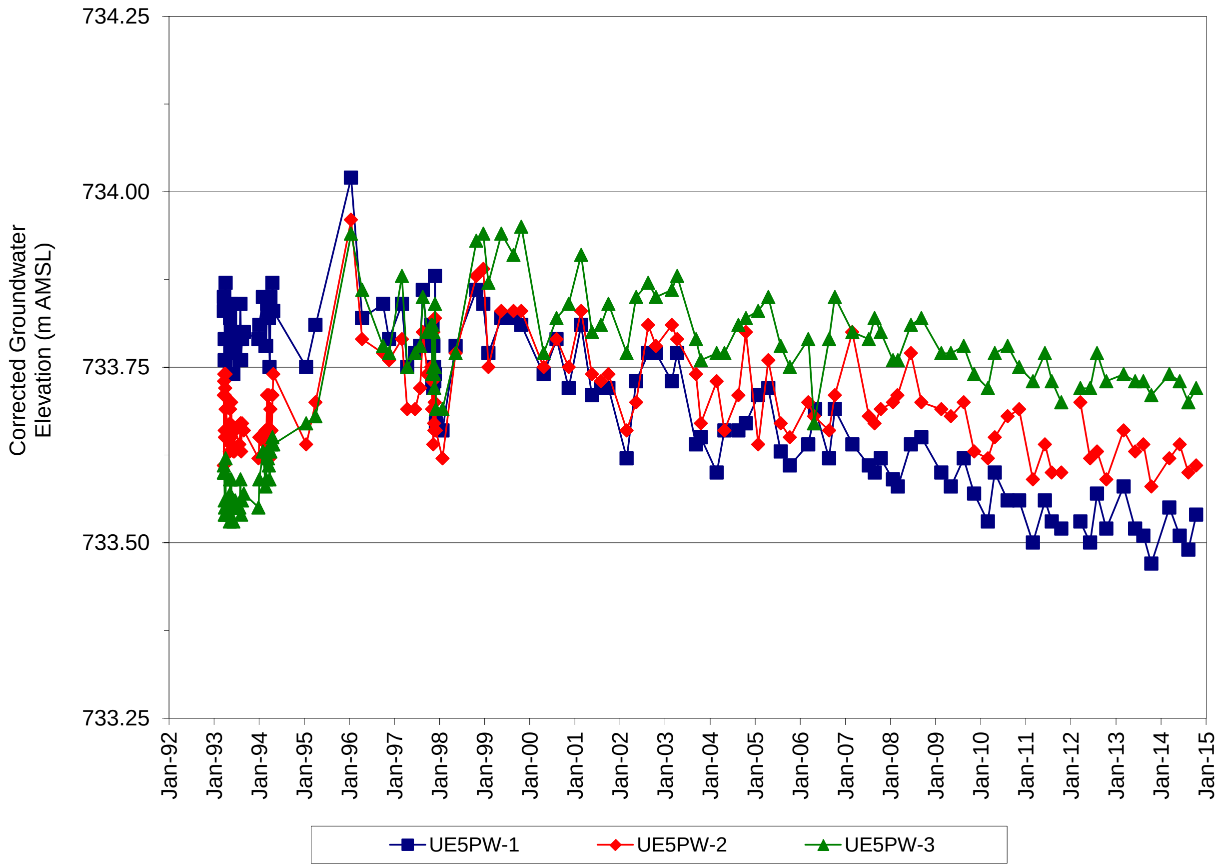


**Figure 2-8. Time Series Plot of Pilot Wells Groundwater Elevations**

# *3.0 LEACHATE MONITORING METHODS AND RESULTS*

The leachate from Cell 18 has been monitored since the cell opened and began receiving waste in January 2011.

## 3.1 METHODS

Leachate samples were collected and analyzed when the leachate collection tank approached its 3,000-gallon capacity. The current leachate tank sampling procedure (NSTec 2010b; 2014b) was followed. The RCRA permit for Cell 18 (NDEP 2011) requires groundwater monitoring at the Pilot Wells. These results are reported in Section 2.0 of this report. In addition to groundwater monitoring, the leachate samples are analyzed for the toxicity characteristic contaminants listed in Table 1 of 40 CFR 261.24 (CFR 2003), PCBs, pH, and SC. These results for the leachate are reported in this section of the report.

Indicators of contamination monitored for leachate:

- Toxicity characteristic contaminants
  - Metals – arsenic, barium, cadmium, chromium, lead, selenium, silver
  - Mercury
  - Semi-volatiles – o-cresol, m-cresol, p-cresol, 1,4-dichlorobenzene, 2,4-dinitrotoluene, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, nitrobenzene, pentachlorophenol, pyridine, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol
  - Volatiles – benzene, carbon tetrachloride, chlorobenzene, chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, methyl ethyl ketone, tetrachloroethylene, trichloroethylene, vinyl chloride
  - Organochlorine pesticides – chlordane, endrin, heptachlor (and its epoxide), lindane, methoxychlor, toxaphene
  - Chlorinated herbicides – 2,4-D, 2,4,5-TP (Silvex)
- PCBs
- pH
- SC

Leachate volume is measured with a totalizing flow meter when the contents of the primary sump at Cell P18 are pumped into the leachate collection tank. The flow meter measurement is recorded at an interval of approximately one week. Leachate drains into the primary sump from above the primary liner. No leachate has ever been pumped from the secondary sump, which collects leachate from between the primary and secondary liner.

The total volume pumped from the primary sump into the leachate collection tank from January 2011 through December 2014 is 143,142 liters (37,814 gallons). From January 2011 through December 2014, there has been 41.28 cm (16.25 in.) of precipitation at the Area 5 RWMS. The equivalent depth of the collected leachate distributed over the 1.35 ha (3.33 ac) covered by the Cell 18 liner is 1.06 cm (0.42 in.). Neglecting additional water applied to Cell 18 for dust control, leachate is approximately 2.6 percent of the precipitation.

The total volume pumped from the primary sump into the leachate collection tank in 2014 is 56,350 liters (14,886 gallons). In 2014 there has been 9.29 cm (3.66 in.) of precipitation at the Area 5 RWMS. The equivalent depth of the yearly collected leachate distributed over the 1.35 ha (3.33 ac) covered by the Cell 18 liner is 0.42 cm (0.16 in.). Neglecting additional water applied to Cell 18 for dust control, leachate is approximately 4.5 percent of the 2014 precipitation.

## 3.2 RESULTS

This section provides analysis results for leachate samples.

### 3.2.1 Toxicity Characteristic Contaminants

All leachate analysis results for toxicity characteristic contaminants and the regulatory limits for each contaminant are provided in Table 3-1 through Table 3-4. Results preceded by a less than symbol (<) are below the specific analysis QL and are reported as less than the QL. No contaminants were above the regulatory limit or the specific analysis QL. There is no evidence for leachate contamination indicated by analysis for the toxicity characteristic contaminants.

**Table 3-1. Cell 18 Results for Toxicity Characteristic Contaminants (Metals)**

| | Arsenic | Barium | Cadmium | Chromium | Lead | Selenium | Silver | Mercury |
|---|---|---|---|---|---|---|---|---|
| Regulatory Level (mg/L) | 5.0 | 100.0 | 1.0 | 5.0 | 5.0 | 1.0 | 5.0 | 0.2 |
| 3/9/2011 | < 0.075 | 0.0794 | < 0.015 | < 0.025 | < 0.05 | < 0.1 | < 0.03 | < 0.0002 |
| 9/28/2011 | < 0.075 | 0.09 | < 0.015 | < 0.025 | < 0.05 | < 0.1 | < 0.03 | < 0.0002 |
| 8/23/2012 | < 0.075 | 0.0565 | < 0.015 | < 0.025 | < 0.05 | < 0.1 | < 0.03 | < 0.0002 |
| 9/19/2012 | < 0.075 | 0.0388 | < 0.015 | < 0.025 | < 0.05 | < 0.1 | < 0.03 | < 0.0002 |
| 11/27/2012 | < 0.075 | 0.0277 | < 0.015 | < 0.025 | < 0.05 | < 0.1 | < 0.03 | < 0.0002 |
| 3/27/2013 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 7/31/2013 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 10/3/2013 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | 0.077 | < 0.1 | < 0.002 |
| 11/6/2013 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 12/18/2013 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 3/5/2014 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 5/20/2014 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 8/12/2014 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 9/16/2014 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 11/4/2014 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |
| 12/16/2014 | < 0.1 | < 1 | < 0.05 | < 0.1 | < 0.03 | < 0.05 | < 0.1 | < 0.002 |

Results are in mg/L

## Table 3-2. Cell 18 Results for Toxicity Characteristic Contaminants (Semi-volatiles)

| | o-Cresol | m-Cresol | 1,4-Dichloro benzene | 2,4-Dinitro toluene | Hexachloro benzene | Hexachloro butadiene | Hexachloro ethane | Nitro benzene | Pentachlor o phenol | Pyridine | 2,4,5-Trichloro phenol | 2,4,6-Trichloro phenol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Regulatory Level (mg/L) | 200.0 | 200.0 | 7.5 | 0.1 | 0.1 | 0.5 | 3.0 | 2.0 | 100.0 | 5.0 | 400.0 | 2.0 |
| 3/9/2011 | < 0.05 | < 0.05 | < 0.00005 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.125 | < 0.05 | < 0.05 | < 0.05 |
| 9/28/2011 | < 0.05 | < 0.05 | < 0.00005 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.125 | < 0.05 | < 0.05 | < 0.05 |
| 8/23/2012 | < 0.05 | < 0.05 | < 0.00005 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.125 | < 0.05 | < 0.05 | < 0.05 |
| 9/19/2012 | < 0.05 | < 0.05 | < 0.00005 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.125 | < 0.05 | < 0.05 | < 0.05 |
| 11/27/2012 | < 0.05 | < 0.05 | < 0.00005 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.125 | < 0.05 | < 0.05 | < 0.05 |
| 3/27/2013 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 7/31/2013 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 10/3/2013 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 11/6/2013 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 12/18/2013 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 3/5/2014 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 5/20/2014 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 8/12/2014 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 9/16/2014 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 11/4/2014 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |
| 12/16/2014 | < 0.1 | < 0.1 | < 0.0001 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.2 | < 0.1 | < 0.1 | < 0.1 |

Results are in mg/L

## Table 3-3. Cell 18 Results for Toxicity Characteristic Contaminants (Volatiles)

| | Benzene | Carbontetra chloride | Chloro benzene | Chloroform | 1,2-Dichloro ethane | 1,1-Dichloro ethylene | Methylethyl ketone | Tetrachloro ethylene | Trichloro ethylene | Vinyl chloride |
|---|---|---|---|---|---|---|---|---|---|---|
| Regulatory Level (mg/L) | 0.5 | 0.5 | 100.0 | 6.0 | 0.5 | 0.7 | 200.0 | 0.7 | 0.5 | 0.2 |
| 3/9/2011 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.05 | < 0.02 | < 0.02 | < 0.05 |
| 9/28/2011 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.05 | < 0.02 | < 0.02 | < 0.05 |
| 8/23/2012 | < 0.005 | < 0.005 | < 0.005 | < 0.005 | < 0.005 | < 0.005 | < 0.01 | < 0.005 | < 0.005 | < 0.01 |
| 9/19/2012 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.05 | < 0.02 | < 0.02 | < 0.05 |
| 11/27/2012 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.05 | < 0.02 | < 0.02 | < 0.05 |
| 3/27/2013 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.01 | < 0.001 | < 0.001 | < 0.001 |
| 7/31/2013 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.1 | < 0.01 | < 0.01 | < 0.01 |
| 10/3/2013 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.01 | < 0.001 | < 0.001 | < 0.001 |
| 11/6/2013 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.01 | < 0.001 | 0.0014 | < 0.001 |
| 12/18/2013 | < 0.001 | < 0.001 | < 0.001 | 0.0012 | < 0.001 | < 0.001 | < 0.01 | < 0.001 | 0.002 | < 0.001 |
| 3/5/2014 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.01 | < 0.001 | 0.0014 | < 0.001 |
| 5/20/2014 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.01 | < 0.001 | < 0.001 | < 0.001 |
| 8/12/2014 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.01 | < 0.001 | 0.0013 | < 0.001 |
| 9/16/2014 | < 0.001 | < 0.001 | < 0.001 | 0.0014 | < 0.001 | < 0.001 | < 0.01 | 0.0012 | 0.0026 | < 0.001 |
| 11/4/2014 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.01 | < 0.001 | 0.0013 | < 0.001 |
| 12/16/2014 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.01 | 0.0011 | 0.0022 | < 0.001 |

Results are in mg/L

**Table 3-4. Cell 18 Results for Toxicity Characteristic Contaminants (Pesticides)**

| | Chlordane | Endrin | Heptachlor | Lindane | Meth oxychlor | Toxaphene | 2,4,5-TP (Silvex) | 2,4-D |
|---|---|---|---|---|---|---|---|---|
| Regulatory Level (mg/L) | 0.0 | 0.0 | 0.0 | 0.4 | 10.0 | 0.5 | 1.0 | 10.0 |
| 3/9/2011 | < 0.001 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.005 | < 0.005 | < 0.005 |
| 9/28/2011 | < 0.001 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.005 | < 0.005 | < 0.005 |
| 8/23/2012 | < 0.001 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.005 | < 0.005 | < 0.005 |
| 9/19/2012 | < 0.001 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.005 | < 0.005 | < 0.005 |
| 11/27/2012 | < 0.001 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.005 | < 0.005 | < 0.005 |
| 3/27/2013 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 7/31/2013 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 10/3/2013 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 11/6/2013 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 12/18/2013 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 3/5/2014 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 5/20/2014 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 8/12/2014 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 9/16/2014 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 11/4/2014 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |
| 12/16/2014 | < 0.01 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0025 | < 0.025 | < 0.0005 | < 0.005 |

Results are in mg/L

### 3.2.2 Polychlorinated Biphenyls

All leachate analysis results for PCBs are provided in Table 3-5. None of the PCB analysis results are above the analysis method QL. Results preceded by a less than symbol (<) are below the specific analysis QL and are reported as less than the QL. There is no evidence for leachate contamination indicated by analysis for PCBs.

**Table 3-5. PCB Results for Cell 18 Leachate**

| | AROCLOR 1016 | AROCLOR 1221 | AROCLOR 1232 | AROCLOR 1242 | AROCLOR 1248 | AROCLOR 1254 | AROCLOR 1260 | AROCLOR 1262 | AROCLOR 1268 |
|---|---|---|---|---|---|---|---|---|---|
| 3/9/2011 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 |
| 9/28/2011 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | no analysis | no analysis |
| 8/23/2012 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | no analysis | no analysis |
| 9/19/2012 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 |
| 11/27/2012 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 | < 0.40 |
| 3/27/2013 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | no analysis | no analysis |
| 7/31/2013 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | no analysis | no analysis |
| 10/3/2013 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | < 0.47 | no analysis | no analysis |
| 11/6/2013 | < 0.48 | < 0.48 | < 0.48 | < 0.48 | < 0.48 | < 0.48 | < 0.48 | no analysis | no analysis |
| 12/18/2013 | < 0.49 | < 0.49 | < 0.49 | < 0.49 | < 0.49 | < 0.49 | < 0.49 | no analysis | no analysis |
| 3/5/2014 | < 0.53 | < 0.53 | < 0.53 | < 0.53 | < 0.53 | < 0.53 | < 0.53 | no analysis | no analysis |
| 5/20/2014 | < 0.55 | < 0.55 | < 0.55 | < 0.55 | < 0.55 | < 0.55 | < 0.55 | no analysis | no analysis |
| 8/12/2014 | < 0.52 | < 0.52 | < 0.52 | < 0.52 | < 0.52 | < 0.52 | < 0.52 | no analysis | no analysis |
| 9/16/2014 | < 0.50 | < 0.50 | < 0.50 | < 0.50 | < 0.50 | < 0.50 | < 0.50 | no analysis | no analysis |
| 11/4/2014 | < 0.50 | < 0.50 | < 0.50 | < 0.50 | < 0.50 | < 0.50 | < 0.50 | no analysis | no analysis |
| 12/16/2014 | < 0.51 | < 0.51 | < 0.51 | < 0.51 | < 0.51 | < 0.51 | < 0.51 | no analysis | no analysis |

Results are in µg/L

### 3.2.3 Specific Conductance and pH

Field measurements of SC and pH were taken for leachate samples collected since October 3, 2013. The results are provided in Table 3-6. The measurements are within expected ranges. SC values are above the ILs for groundwater but this is expected due to evaporation. The pH results are within the IL for groundwater of between 7.6 and 9.2. No leachate contamination is indicated by the SC and pH monitoring results.

**Table 3-6. SC and pH Results for Cell 18 Leachate**

| | Conductance (mmhos/cm) | pH |
|---|---|---|
| 3/9/2011 | no analysis | no analysis |
| 9/28/2011 | no analysis | no analysis |
| 8/23/2012 | no analysis | no analysis |
| 9/19/2012 | no analysis | no analysis |
| 11/27/2012 | no analysis | no analysis |
| 3/27/2013 | no analysis | no analysis |
| 7/31/2013 | no analysis | no analysis |
| 10/3/2013 | 2.48 | 7.95 |
| 11/6/2013 | 2.70 | 7.59 |
| 12/18/2013 | 2.81 | 7.72 |
| 3/5/2014 | 2.83 | 7.87 |
| 5/20/2014 | 2.87 | 8.07 |
| 8/12/2014 | 2.91 | 7.68 |
| 9/16/2014 | 2.43 | 7.56 |
| 11/4/2014 | 2.54 | 7.51 |
| 12/16/2014 | 3.00 | 7.34 |

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# *4.0 SUMMARY*

The hydrologic conditions in the uppermost aquifer beneath the Area 5 RWMS remain stable and are not affected by the Area 5 RWMS. Groundwater flow in this uppermost aquifer is negligible. No significant changes were detected in the water chemistry, and all indicator parameters remain within the established ILs.

Cell 18 leachate analysis results are all below the reporting limits identified in the RCRA permit for Cell 18 (NDEP 2011).

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# *5.0 CONCLUSION*

There is no measurable impact to the uppermost aquifer from the Area 5 RWMS. Cell 18 leachate analysis results are below the reporting limits identified in the RCRA permit for Cell 18 (NDEP 2011), so the leachate is suitable to use for dust control on Cell 18.

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# Appendix A – Cumulative Chronology for the Area 5 Radioactive Waste Management Site Groundwater Monitoring Program

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| **Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program** | | | | | |
|---|---|---|---|---|---|
| **Date** | **UE5PW-1** | **Date** | **UE5PW-2** | **Date** | **UE5PW-3** |
| 03/20/1990 | DOE letter requesting installation of monitoring wells near the Area 5 RWMS | | | | |
| 03/13/1992 | Drilling begins | 06/18/1992 | Drilling begins | 09/16/1992 | Drilling begins |
| 06/16/1992 | Drilling ends | 09/04/1992 | Drilling ends | 11/09/1992 | Drilling ends |
| 09/11/1992 | Well developed | 03/30/1993 | Well developed | 04/04/1993 | Well developed |
| 03/31/1993 | GW Sampling | 03/24/1993 | GW Sampling | 04/14/1993 | GW Sampling |
| 06/06/1993 | GW Sampling | 06/22/1993 | GW Sampling | 06/02/1993 | GW Sampling |
| 09/01/1993 | GW Sampling | | | 10/12/1993 | GW Sampling |
| 12/07/1993 | GW Sampling | 11/15/1993 | GW Sampling | 12/20/1993 | GW Sampling |
| 12/17/1993 | DOE letter to Nevada Division of Environmental Protection (NDEP) requesting to establish pilot wells located near the Area 5 RWMS as Resource Conservation and Recovery Act (RCRA) GW monitoring wells | | | | |
| 02/24/1994 | NDEP letter stating that the pilot wells appear to meet the applicable design, construction, and development criteria for RCRA GW monitoring wells | | | | |
| 06/15/1994 | GW Sampling | 06/07/1994 | GW Sampling | 05/24/1994 | GW Sampling |
| 08/01/1994 | GW Sampling | 11/29/1994 | GW Sampling | 08/08/1994 | GW Sampling |
| 09/30/1994 | DOE submits 1993 GW monitoring results from quarterly sampling effort | | | | |
| 01/18/1995 | UE5PW-3 GW resampling for 08/01/1994 total organic carbon (TOC) hit | | | | |
| 02/23/1995 | DOE transmits to NDEP GW Monitoring Program Outline | | | | |
| 03/01/1995 | 1994 GW Monitoring Report submitted to NDEP | | | | |
| 04/04/1995 | GW Sampling | | | | |
| 11/09/1995 | GW Sampling | | | | |
| 11/09/1995 | UE5PW-1 pump snagged in hole, resulting in a bent shaft on the reel | | | | |
| 01/18/1996 | GW Sampling | 01/25/1996 | GW Sampling | 01/18/1996 | GW Sampling |
| 01/22/1996 | Bennett pump seals replaced at all three wells | | | | |
| 03/01/1996 | DOE submits to NDEP the 1995 GW Monitoring Report | | | | |
| 04/16/1996 | GW Sampling | 04/23/1996 | GW Sampling | | |
| | | 04/30/1996 | GW Sampling | | |
| 10/02/1996 | GW Sampling | | | | |
| 10/25/1996 | NDEP requests clarifications/changes in the GW Monitoring Report | | | | |
| 11/20/1996 | GW Sampling | | | | |
| 03/01/1997 | DOE submits 1996 GW Monitoring Report and revised GW Monitoring Program Outline | | | | |

| **Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program** | | | | | |
|---|---|---|---|---|---|
| **Date** | **UE5PW-1** | **Date** | **UE5PW-2** | **Date** | **UE5PW-3** |
| 04/16/1997 | GW Sampling | | | | |
| 08/12/1997 | NDEP comments on 1996 GW Monitoring Report/Proposed Outline | | | | |
| 10/22/1997 | Pump and water-level meter lodge in UE5PW-1 during simultaneous operation; retrieved 10/23/1997 | | | | |
| 10/22/1997 | Larger diameter air lines installed at all three wells | | | | |
| 11/05/1997 | GW Sampling | | | | |
| 03/01/1998 | DOE submits to NDEP the 1997 GW Monitoring Report and new outline | | | | |
| 03/31/1998 | NDEP letter stating that they concur on the indicator parameters and investigation levels submitted in the GW Monitoring Outline | | | | |
| 05/13/1998 | GW Sampling | | | | |
| 06/22/1998 | Total organic halides (TOX) detected in the 05/13/1998 samples and blanks from all three wells | | | | |
| 07/10/1998 | DOE and NDEP agree to resample UE5PW-1 to confirm no TOX | | | | |
| 07/29/1998 | GW resampling at UE5PW-1 for 05/13/1998 TOX hits | | | | |
| 09/10/1998 | Results from 07/29/1998 resampling are non-detect for TOX. TOX results from the 05/13/1998 sampling event are determined to be false positives. | | | | |
| 09/10/1998 | Bennett pumps from three wells and spare pumps are sent to manufacturer for refurbishing | | | | |
| 09/12/1998 | Reels from three wells are returned to manufacturer for new tubing bundles | | | | |
| 10/28/1998 | GW Sampling | | | | |
| 09/12/1998 | UE5PW-1 reel returned to manufacturer for repair of exhaust tube. Spare pump returned to manufacturer for the repair of a leaky seal. | | | | |
| 03/01/1999 | DOE submits to NDEP 1998 GW Monitoring Report | | | | |
| 03/31/1999 | NDEP requests statistical analysis of data and states that values determined to be false positives through resampling do not need to be presented graphically | | | | |
| 05/19/1999 | GW Sampling | | | | |
| 10/27/1999 | GW Sampling | | | | |
| 12/13/1999 | Resample UE5PW-2 after TOC hit from 10/27/1999 | | | | |
| 12/27/1999 | Results from the resampling of UE5PW-2 are non-detect for TOC. TOC result from 10/27/1999 is determined to be a false positive. | | | | |
| 02/25/2000 | DOE submits to NDEP 1999 GW Monitoring Report | | | | |
| 04/17/2000 | NDEP states that future reports do not need to include statistical analyses | | | | |
| 04/26/2000 | GW Sampling | | | | |

**Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program**

| Date | UE5PW-1 | Date | UE5PW-2 | Date | UE5PW-3 |
|---|---|---|---|---|---|
| 06/28/2000 | DOE contacts State to report TOX/TOC hits from 04/26/2000. DOE and NDEP agree that the wells will be resampled in August, which would also constitute the Fall sampling event. | | | | |
| 08/09/2000 | GW Sampling | | | | |
| 09/20/2000 | DOE contacts NDEP to report TOX hits from 08/09/2000 sampling | | | | |
| 11/07/2000 | Letter from NDEP stating that DOE does not have a valid data set for TOX and possibly TOC and requests a plan to address contamination concerns prior to next sampling event | | | | |
| 11/20/2000 | Video log well | | | 11/27/2000 | Video log well |
| 12/20/2000 | DOE transmits to NDEP a proposed plan to address contamination issues | | | | |
| 01/31/2001 | Letter from NDEP generally concurring that the plan submitted to determine the cause of TOX and TOC hits is sound | | | | |
| 02/21/2001 | DOE submits to NDEP 2000 GW Monitoring Report | | | | |
| 03/14/2001 | Letter from NDEP stating that the 2000 GW Monitoring Report was received in a timely manner and contains all the data required by Title 40 Code of Federal Regulations Part 265.94. Letter also requests information regarding data in Appendix A of the 2000 GW Monitoring Report (BN 2001). | | | | |
| 04/19/2001 | Letter from DOE responding to NDEP's 3/14/2001 request for information regarding presentation of TOX/TOC data in the 2000 report | | | | |
| 04/30/2001 | Letter from NDEP concurring with the approach to data presentation as outlined by DOE in the 4/19/2001 correspondence | | | | |
| 05/29/2001 | GW Sampling | | | | |
| 10/03/2001 | GW Sampling | | | | |
| 03/01/2002 | DOE submits to NDEP 2001 GW Monitoring Report | | | | |
| 05/15/2002 | GW Sampling | | | | |
| 10/22/2002 | GW Sampling | | | | |
| 03/01/2003 | DOE submits to NDEP 2002 GW Monitoring Report | | | | |
| 04/15/2003 | GW Sampling | | | | |
| 10/22/2003 | GW Sampling | | | 10/21/2003 | GW Sampling |
| 02/27/2004 | DOE submits to NDEP 2003 GW Monitoring Report | | | | |
| 05/04/2004 | GW Sampling | | | | |
| 10/19/2004 | GW Sampling | | | 10/20/2003 | GW Sampling |
| 02/25/2005 | DOE submits to NDEP 2004 GW Monitoring Report | | | | |
| 04/19/2005 | GW Sampling | | | | |
| 10/11/2005 | GW Sampling | | | | |

| **Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program** | | | | | |
|---|---|---|---|---|---|
| **Date** | **UE5PW-1** | **Date** | **UE5PW-2** | **Date** | **UE5PW-3** |
| 02/28/2006 | DOE submits to NDEP 2005 GW Monitoring Report | | | | |
| 04/26/2006 | GW Sampling | | | | |
| 10/10/2006 | GW Sampling | | | | |
| 03/01/2007 | DOE submits to NDEP 2006 GW Monitoring Report | | | | |
| 03/19/2007 | GW Sampling | | | | |
| 08/29/2007 | GW Sampling | | | 09/05/2007 | GW Sampling |
| 03/01/2008 | DOE submits to NDEP 2007 GW Monitoring Report | | | | |
| 03/11/2008 | GW Sampling | | | | |
| 09/10/2008 | GW Sampling | | | | |
| 04/22/2009 | DOE submits to NDEP 2008 GW Monitoring Report | | | | |
| 03/10/2009 | GW Sampling | | | | |
| 08/18/2009 | GW Sampling | | | | |
| 03/01/2010 | DOE submits to NDEP 2009 GW Monitoring Report | | | | |
| 03/10/2010 | GW Sampling | | | 03/31/2010 | GW Sampling |
| 08/10/2010 | GW Sampling | | | | |
| 03/01/2011 | DOE submits to NDEP 2010 GW Monitoring Report | | | | |
| 03/08/2011 | GW Sampling | | | | |
| 03/19/2011 | Leachate Tank Sampling | | | | |
| 08/02/2011 | GW Sampling | | | | |
| 08/24/2011 | GW Sampling | | | | |
| 09/28/2011 | Leachate Tank Sampling | | | | |
| 10/18/2011 | Sample Pumps and Tubing Disinfected | | | | |
| 10/19/2011 | GW Sampling | | | | |
| 03/01/2012 | DOE submits to NDEP 2011 GW Monitoring Report | | | | |
| 03/21/2012 | GW Sampling | | | | |
| 08/08/2012 | GW Sampling | | | | |
| 08/21/2012 | GW Sampling | | | | |
| 08/23/2012 | Leachate Tank Sampling | | | | |
| 09/11/2012 | GW Sampling | | | | |
| 09/19/2012 | Leachate Tank Sampling | | | | |

| Cumulative Chronology for the Area 5 Radioactive Waste Management Site (RWMS) Groundwater (GW) Monitoring Program | | | | | |
|---|---|---|---|---|---|
| **Date** | **UE5PW-1** | **Date** | **UE5PW-2** | **Date** | **UE5PW-3** |
| 11/27/2012 | Leachate Tank Sampling | | | | |
| 03/01/2013 | DOE submits to NDEP 2012 GW Monitoring Report | | | | |
| 03/05/2013 | GW Sampling | | | | |
| 03/27/2013 | Leachate Tank Sampling | | | | |
| 07/31/2013 | Leachate Tank Sampling | | | | |
| 08/13/2013 | GW sampling | | | | |
| 10/03/2013 | Leachate Tank Sampling | | | | |
| 11/06/2013 | Leachate Tank Sampling | | | | |
| 12/18/2013 | Leachate Tank Sampling | | | | |
| 03/01/2014 | DOE submits to NDEP 2013 GW Monitoring Report | | | | |
| 03/05/2014 | Leachate Tank Sampling | | | | |
| 03/11/2014 | GW Sampling | | | | |
| 05/20/2014 | Leachate Tank Sampling | | | | |
| 08/12/2014 | Leachate Tank Sampling | | | | |
| 8/12/2014 | GW Sampling | | | | |
| 09/06/2014 | Leachate Tank Sampling | | | | |
| 11/04/2014 | Leachate Tank Sampling | | | | |
| 12/16/2014 | Leachate Tank Sampling | | | | |

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# Appendix B – Gradient/Velocity Calculations

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# Calculation of Magnitude and Direction of Area 5 Alluvial Aquifer Gradient

Water level elevations measured at three wells near the Area 5 Radioactive Waste Management Site (UE5PW-1, UE5PW-2, and UE5PW-3) are used to calculate the magnitude and direction of the aquifer hydraulic gradient.

The locations of the three wells are given in Nevada State Central Zone coordinates in meters as northing (N) and easting (E) values. The coordinates of each of the three water elevation points define a plane that contains the water level points. The coordinates of the water elevation points are ($E_i$, $N_i$, $e_i$), where:

$E_i$ is the East Coordinate of the $i^{th}$ well (m)
$N_i$ is the North Coordinate of the $i^{th}$ well (m)
$e_i$ is the water level elevation of the $i^{th}$ well (m)

Assuming i=1 for UE5PW-1, i=2 for UE5PW-2, and i=3 for UE5PW-3, the vector **a** connecting the water level at UE5PW-1 to the water level at UE5PW-2 and the vector **b** connecting the water level at UE5PW-1 to the water level at UE5PW-3 are defined by:

$\mathbf{a} = (E_2-E_1)\mathbf{i} + (N_2-N_1)\mathbf{j} + (e_2-e_1)\mathbf{k}$
$\mathbf{b} = (E_3-E_1)\mathbf{i} + (N_3-N_1)\mathbf{j} + (e_3-e_1)\mathbf{k}$

The aquifer hydraulic gradient is the cross product **a** x **b.**

$$\mathbf{a}\times\mathbf{b} = \mathbf{DET}\begin{bmatrix} i & j & k \\ E_2-E_1 & N_2-N_1 & e_2-e_1 \\ E_3-E_1 & N_3-N_1 & e_3-e_1 \end{bmatrix}$$

$$\begin{aligned} = \quad & [(N_2-N_1)(e_3-e_1) - (e_2-e_1)(N_3-N_1)]\mathbf{i} + \\ & [(e_2-e_1)(E_3-E_1) - (E_2-E_1)(e_3-e_1)]\mathbf{j} + \\ & [(E_2-E_1)(N_3-N_1) - (N_2-N_1)(E_3-E_1)]\mathbf{k} \\ = \quad & A\mathbf{i} + B\mathbf{j} + C\mathbf{k} \end{aligned}$$

Where: $A = (N_2-N_1)(e_3-e_1) - (e_2-e_1)(N_3-N_1)$
$B = (e_2-e_1)(E_3-E_1) - (E_2-E_1)(e_3-e_1)$
$C = (E_2-E_1)(N_3-N_1) - (N_2-N_1)(E_3-E_1)$

Dividing hydraulic gradient by C gives the magnitude of the gradient in Easting (**i**) and Northing (**j**) for a unit change in elevation (**k**)

$$(\mathbf{a}\times\mathbf{b})/C = A/C\,\mathbf{i} + B/C\,\mathbf{j} + \mathbf{k}$$

The magnitude of the gradient is:

$$\sqrt{{A/C}^{2} + {B/C}^{2}}$$

The direction of the gradient from north (θ) is calculated using the magnitudes of easting (E) and northing (N).

If B > 0, then θ = arctan (a/b)
If B < 0, then θ = 180° + arctan (a/b)
If B = 0 and A > 0, then θ = 90°
If B = 0 and A < 0, then θ = 270°
If B = 0 and A = 0, then the flow is straight down.

## *Calculation of Mean Groundwater Velocity*

Groundwater flux is calculated from Darcy's Law:

$$J = -K\left(\frac{\Delta e}{C}\right)$$

Where: J is groundwater flux (m/s)
K is saturated hydraulic conductivity (m/s)
$\Delta e / C$ is the hydraulic gradient (m/m)

The mean groundwater velocity is calculated from the flux:

$$V = J/\phi$$

Where: V is mean groundwater velocity (m/s)
J is the groundwater flux (m/s)
Φ is porosity ($m^3/m^3$)

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## C.2 Hydrologic Conditions at the RWMC

Extensive site characterization, environmental monitoring, and flow and transport modeling have been performed for the RWMC over the past several decades to assess facility performance. These are discussed in detail in the Performance Assessment Report (Shott, et al., 1998) and summarized in the draft data quality objective document for CAU 111. The Performance Assessment implements the conceptual site model, which indicates that release pathways are upward to the land surface with negligible infiltration below the root zone. Important transport processes are the rapid release of volatile compounds to the cover and the atmosphere and slow accumulation of particulates in the cover by the coupled processes of liquid phase advection/diffusion in deep cover layers and animal burrowing/plant uptake in the near surface.

The hydrologic conditions at the RWMC, as measured and predicted, include the following:

- Groundwater depth is approximately 255 m (835 ft) (Well UE5PW-1 at 236 m [775 ft], Well UE5PW-2 at 256 m [840 ft], and Well UE5PW-3 at 272 m [890 ft]).
- The water table is extremely flat (gradient of approximately 1 x $10^{-4}$ m per m [3 x $10^{-4}$ ft per ft]) with flow velocities of approximately 0.1 m (0.3 ft) per year.
- The travel time for infiltrated water from the top of the downward flow region to the water table far exceeds the required isolation periods for hazardous waste and LLW. Estimated travel time exceeds tens of thousands of years.
- Below the rooting zone, moisture flux (liquid and vapor) is upward from approximately 3 m to 40 m (9.8 ft to 131 ft), no flux from 40 m to 90 m (131 ft to 295 ft), and downward to water table below 90 m (295 ft).

Supporting evidence for negligible infiltration below the root zone includes the following:

- A thick (240 m [790 ft]) and dry (approximately 8 percent volumetric water content) vadose zone indicates very low hydraulic conductivity and very long travel times to the saturated zone.
- Estimated age of soil-pore water, based on chlorine-36 and stable isotope profiles, far exceeds measured age of groundwater.
- The water potential profile above 40 m (130 ft) indicates upward movement of water.
- Stable isotope ratios (oxygen-18 to oxygen-16 and deuterium to hydrogen) indicate deep profile soil-pore water entered the system under a cooler, wetter climate.
- Weighing lysimeter data collected for 14 years show no discharge below 2 m (6.6 ft).
- Reference evapotranspiration calculated from meteorological data is approximately 11.6 times precipitation.

### C.2.e Continuation of Existing Groundwater Monitoring

NNSA/NFO will continue to monitor the three existing wells for current parameters associated with the groundwater monitoring program. Annual reporting will follow format and content established between DOE and NDEP in a letter dated August 12, 1997.

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## D.1 Characterize Solid Waste Management Units [40 CFR 270.14(d)]

Closed solid waste management units on the NNSS are noted in NDEP Permit NEV HW0101, Section 9. Post-closure requirements are described in the Permit Application for Permit NEV HW0101. Closure Reports for each unit are maintained in NNSA/NFO contractor files; copies are provided to NDEP. Reports contain characterization parameters, location maps, and a description of each facility, time of operation, wastes managed, and the sampling and analysis results of characterization.

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## F.1 Information Requirements for Tank Systems [40 CFR 270.16]

An aboveground tank is used to contain leachate that is applied for dust control within the fenced area of the Cell 18 MWDU. A description of the leachate tank is included in Section B.1.b.1.

As-built drawings are provided in Exhibit 1.

The following **40 CFR 270.16** requirements were addressed based on the final configuration:

- A written assessment reviewed by a registered engineer as to the structural integrity and suitability for handling hazardous waste
- Dimensions and capacity of the tank
- Descriptions of feed systems, safety cutoff, bypass systems, and pressure controls
- A diagram of piping, instrumentation, and process flow
- Description of materials and equipment used to provide external corrosion protection (**40 CFR 264.192[a][3][ii]**)
- Detailed description of how the tank was installed (**40 CFR 264.192[b]** through **[e]**)
- Detailed plan and description of how the secondary containment system is designed constructed, and operated (**40 CFR 264.193[a]** through **[f]**)
- Description of controls and practices to prevent spills and overflows (**40 CFR 264.194[b]**)

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