





NEVADA TEST AND TRAINING RANGE (NTTR)

Land Withdrawal Application Packages/
Case File and Legislative EIS

WETLANDS, FLOODPLAINS, AND SEEPS AND SPRINGS OF THE NEVADA TEST AND TRAINING RANGE AND PROPOSED EXPANSION ALTERNATIVES

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Appendices

Appendix A: Reference Material for Floodplain Analysis

Appendix B: Floodplain Analysis Figures

Appendix C: Hydrologic Calculations

Appendix D: Hydraulic Calculations

Abbreviations

99 CES/CEIEA	99th Civil Engineering Squadron/Installation Management Environmental Assessments Section
ACC	Air Combat Command
AFI	Air Force Instruction
BLM	Bureau of Land Management
CAFB	Creech Air Force Base
CCRFCD	Clark County Regional Flood Control District
CN	Curve Number
CWA	Clean Water Act
DEM	Digital Elevation Model
DNWR	Desert National Wildlife Refuge
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
GPS	Global Positioning System
HC&DDM	Hydrologic Criteria & Drainage Design Manual
HSG	Hydrologic Soils Group
LEIS	Legislative Environmental Impact Statement
INRMP	Integrated Natural Resources Management Plan
MCL	Maximum Contaminant Limit
MSL	Mean Sea Level
NAFB	Nellis Air Force Base
NDCNR	Nevada Department of Conservation and Natural Resources
NDF	Nevada Division of Forestry
NDOW	Nevada Department of Wildlife
NDWR	Nevada Division of Water Resources
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NNRP	Nellis Natural Resources Program
NNSS	Nevada National Security Site
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NTTR	Nevada Test and Training Range. Also the new name for 98th Range Wing

NWAP	Nevada's Wildlife Action Plan
NWHR	Nevada Wild Horse Range
NWI	National Wetland Inventory
OHWM	Ordinary High Water Mark
SAR	Small Arms Range
SBCC	S & B Christ Consulting, LLC
STATSGO2	U.S. General Soil Map
TDS	Technical Drainage Study
TR-55	Technical Release No. 55
USACE	U.S. Army Corps of Engineers
USAF	United States Air Force
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

Report Introduction

The U.S. Air Force (USAF) is in the process of renewing the withdrawal of land for military operations and training on the Nevada Test and Training Range. Included in the withdrawal package are several potential expansion alternatives, which are discussed below in the "Study Area Description". The current withdrawal will expire in November 6, 2021, unless Congress enacts legislation to extend it. In accordance with Section 3016 of the Military Land Withdrawal Act (MLWA), the Department of the Air Force, in coordination with DOD, has notified Congress of a continuing military need for the NTTR withdrawal. Furthermore, the Air Force plans to submit a Legislative Environmental Impact Statement (LEIS) that supports a legislative proposal through the Department of the Interior (DOI) to extend the withdrawal. The National Environmental Policy Act of 1969, United States Code [USC] Sections 18 4321-4370h (NEPA) requires agencies to include an environmental impact statement (EIS) with any proposal for legislation that may significantly affect the quality of the human environment. The land withdrawal renewal includes actions that present potential impacts to floodplains, wetlands, and waters of the U.S.

This report also provides all documentation to support the wetlands/floodplains statement required for compliance with the Military Lands Withdrawal Act of 1999 (MLWA), Public Law 106-65. The report is divided into three major sections. The first section addresses potential jurisdictional waters found on the study area. This includes wetlands, streams, washes, and other natural features that meet the criteria for waters of the U.S. as described in the Clean Water Act and may be determined to be jurisdictional by the U.S. Army Corps of Engineers (USACE). The second section of the report discusses 100-year and 500-year floodplains that are found on the study area. These floodplains were determined by analysis of 10-meter digital elevation maps using standard hydrologic modeling. The third section of the report identifies and describes all the known seeps and springs found on the study area. These are being discussed because most of these water features do not fall under the jurisdiction of the Clean Water Act due to the lack of a connection to navigable waters. However, because they are in a desert environment, they are extremely important as water and food sources for wildlife.

Description of the Study Area

The study area for this report includes NTTR and potential expansion areas designated as Alternatives 3A, 3B, and 3C. NTTR consists of 2,949,603 acres, in rural portions of Nye, Lincoln, and Clark Counties, Nevada (Figure 1). The potential expansion areas are shown in Figure 1 and consist of about 302,000 acres. Alternative 3A is 18,000 acres lying along the southwest boundary of the North Range of NTTR. Alternative 3B is 57,000 acres located immediately south of the South Range of NTTR. Alternative 3C is 227,000 acres immediately east of the South Range of NTTR in the Desert National Wildlife Refuge (DNWR). Geology varies from limestone/dolomite in the south to volcanic fields in the north. The South Range Study Area lies in the eastern Mojave Desert, and the North Range Study Area lies in the southern Great Basin (Figure 2).

Natural sources of water are scarce across most of the study area. Annual precipitation ranges from 3 to 5 inches, in the basins, to 16 inches in upper elevations of mountains. Vegetation composition is strongly influenced by the levels of precipitation. Most of the active springs are found in the North Range Study Area, especially in the Kawich, Belted, and Cactus Mountain Ranges and Stonewall Mountain. Only five springs are found in the South Range Study Area. Most water sources for wildlife in the South Range Study Area are provided by wildlife water developments, which collect water from storm events and store it in water tanks.

The South Range Study Area is typical of the Mojave Desert. Except for the higher elevations, most of the mountains are covered by scattered populations of various desert brush and cactus species. Typical physiography of the area consists of mountain ranges which drain into bajadas (collections of alluvial fans) and which eventually drain into playas. Most of these areas are considered basins which are self-contained and do not drain into any of the major rivers in the area. Playas tend to have little or no vegetation while bajadas are often dominated by creosote bush (*Larrea tridentata*) and bursage (*Ambrosia dumosa*) in the lower bajadas and blackbrush (*Coleogyne ramosissima*) and Joshua tree (*Yucca brevifolia*) in the upper bajadas. Mountain ranges support scattered populations of bitterbrush (*Purshia spp.*), matchweed (*Gutierrezia spp.)*, and shadscale (*Atriplex confertifolia*). At higher elevations, plant communities may be dominated by Utah juniper (*Juniperus osteosperma*) and pinyon pine (*Pinus monophylla*).

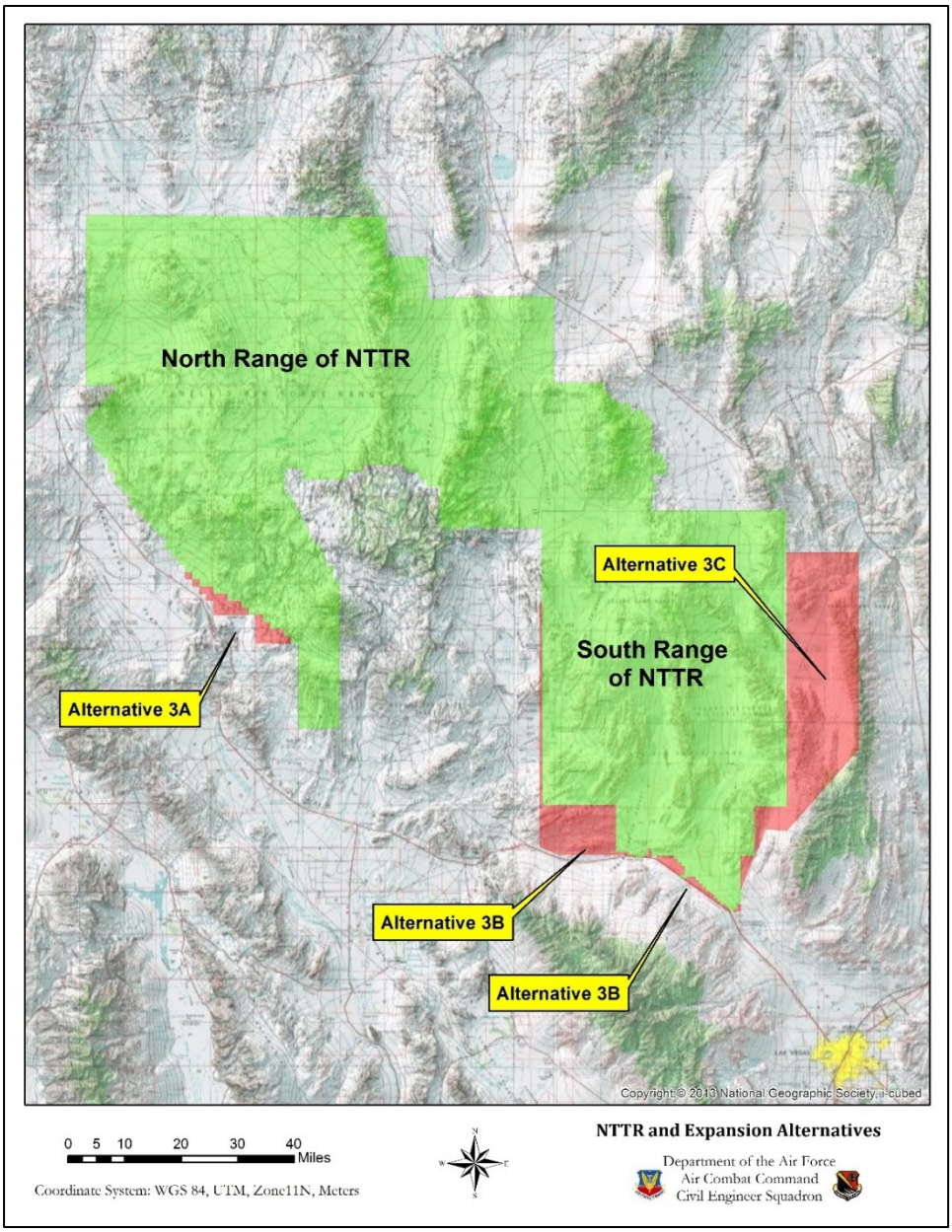


Figure 1. Location of the North and South Ranges of NTTR as well as Alternatives 3A, 3B, and 3C.

The North Range Study Area is typical of the southern portions of the Great Basin Desert. Again, the physiography of the area is comprised of mountains and closed basins similar to the South Range Study Area. However, rainfall is slightly higher in the North Range Study Area resulting in denser plant communities. Like the South Range Study Area, playas in the North Range Study Area contain little or no vegetation. From the boundaries of the playas to the base of mountains, plant communities are typically dominated by greasewood (*Sarcobatus spp.*) and shadscale (*Atriplex spp.*) in lower elevations and sagebrush (*Artemisia spp.*) in higher elevations. The upper elevations in the mountains are dominated by Utah juniper (*Juniperus osteosperma*) and pinyon pine (*Pinus monophylla*).

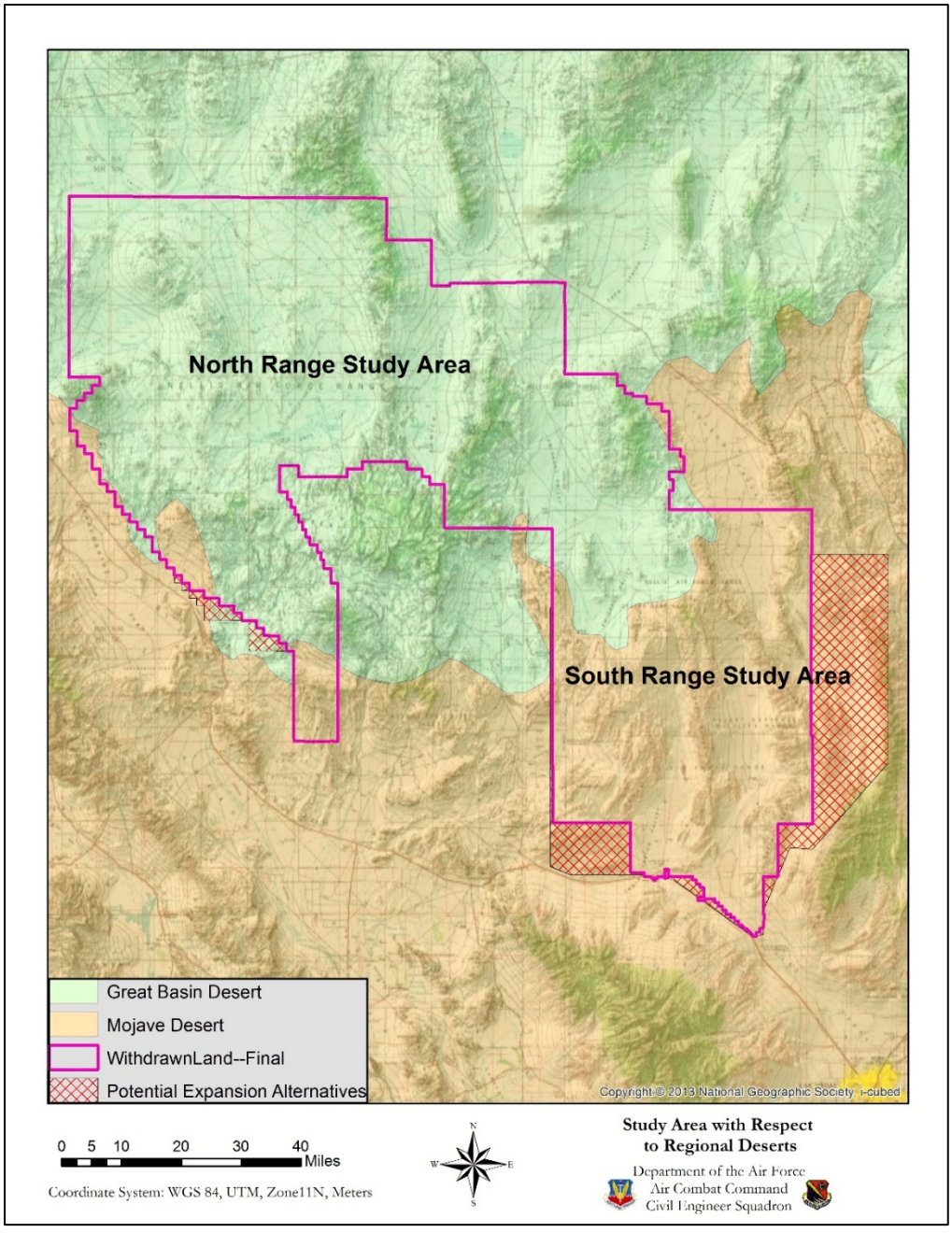


Figure 2. Location of the study area with respect to the Great Basin Desert and the Mojave Desert.

Potential Jurisdictional Waters

Regulatory Background

Activities that permanently adversely affect waters of the U.S. by filling, flooding, excavation, or drainage are regulated under Section 404 of the Clean Water Act (CWA). This includes activities that change an aquatic area to dry land, increase the bottom elevation of a surface water, or change the use of a surface water. The U.S. Army Corp of Engineers (USACE) is the regulatory agency responsible for enforcing Section 404 of the CWA, and activities conducted in waters of the U.S. may be subject to permits from the USACE.



Breen Creek in the North Range Study Area

The federal government defines waters of the U.S. as any surface water body that displays the following characteristics:

- Waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; all interstate waters including interstate wetlands;
- All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds; the use, degradation, or destruction of which could affect interstate or foreign commerce including any such waters;
- Relatively permanent tributaries of waters identified above; and wetlands adjacent to waters identified above (Environmental Protection Agency and the Department of the Army, 2008).

All of the waters described above, except wetlands which are delineated based on their own set of guidance, are delineated to the extent of the ordinary high water mark (OHWM) (Brostoff, Lichvar, & Sprecher, 2001). For a tributary to be considered relatively permanent, evidence of flow must be present. These physical indicators of flow include an ordinary high water mark, shelving, wracking, water staining, sediment sorting, and scour (Environmental Protection Agency and the Department of the Army, 2008). Essentially, there must be sufficient physical indicators to demonstrate significant flow volume, frequency, and duration within the tributary (Environmental Protection Agency, 2015). For an ephemeral tributary to be considered jurisdictional, it must display an ordinary high water mark, a bed and bank, and have a "significant nexus" to navigable waters of the U.S. (Environmental Protection Agency, 2015).



Wet meadow on NTTR (George's Water)

Supreme Court rulings (*Solid Waste Agency of Northern Cook County v. US Army Corps of Engineers, Rapanos v. United States, and Carabell v. United States*) that further clarify the types of waters which can be considered jurisdictional, dictate that the waters must be connected to a traditionally navigable water or exhibit a significant nexus to a traditionally navigable water to be considered under the jurisdiction of the USACE. A water is considered to have a significant nexus when it is found to have "more than a speculative or insubstantial effect on the chemical, physical, and biological integrity of a traditional navigable water" (Environmental Protection Agency and the Department of the Army, 2008). To determine if a tributary has more than a speculative impact on the downstream traditionally navigable water; multiple components are analyzed including volume, duration, and frequency of flow; proximity to the traditionally navigable water; size of the watershed; and the potential of the tributary to carry pollutants and flood waters to traditionally navigable waters (U.S. Army Corps of Engineers, Norfolk District, 2007).

Determining jurisdictional status within the arid southwest of the United States poses some unique challenges. The primary challenge is identifying the OHWM within intermittent and ephemeral streams that are exposed to infrequent but heavy rainfalls. While there is no flow within many southwest watersheds most of the time, these heavy rainfall events have the potential to reshape the geomorphology of the stream with every event, making consistent delineation over time a challenge (Lichvar & Wakeley, 2004). Recent reports suggest using a combination of hydrology, vegetation, and geomorphology to determine OHWM and jurisdictional status. This, in turn, will provide a more accurate representation of stream conditions (Lichvar & Wakeley, 2004). These indicators have more long-term consistency than traditional OHWM markers such as shelving, wracking, water staining, or destruction of terrestrial vegetation.

Additionally, the arid southwest has unique landforms that are not easily defined using an OHWM, such as playas, braided channels, and alluvial fans. Playas are broadly defined as flat, lower portions of arid basins with internal drainage and are subject to periodic flooding and sediment accumulation (Brostoff, Lichvar, & Sprecher, 2001). They are sometimes called alkali flats or arid dry lakes. While there is some variability in how USACE districts delineate playas, the majority rely on the presence of water as a primary indicator (Brostoff, Lichvar, & Sprecher, 2001). Other evidence used to delineate playas; such as drift lines, aerial photographs, and USGS maps, are secondarily incorporated using the best professional judgement possible (Brostoff, Lichvar, & Sprecher, 2001). Compound or braided channels, unlike traditional intermittent and ephemeral streams, have additional challenges in determining the OHWM because there are multiple, transitory pathways for discharge that may or may not be active with every rain event. Determining the OHWM for braided channels is challenging because these channels are susceptible to widening and channel relocation after significant storm events (Lichvar & McColley, 2008). Larger, meandering channels are formed within the compound channels after long sequences of low to moderate rain events (Lichvar & McColley, 2008). Because of this, OHWM indicators can be seemingly randomly distributed within a braided channel and are more apparent in specific portions of the channel directly after rain events (Lichvar, Finnegan, Ericsson, & Ochs, 2006). Instead of relying on OHWM indicators, using the active floodplain as identified in the field has been suggested as a preferred method to more consistently

and accurately delineate a braided channel (Lichvar, Finnegan, Ericsson, & Ochs, 2006). Alluvial fans are widespread in the southwestern United States where they are generally cone or fan-shaped and are commonly at the foot of mountains (Lichvar & McColley, 2008). Alluvial fans are delineated similarly to braided channels in that identifying the active floodplain provides a more reliable delineation than relying on OHWM indicators (Lichvar & McColley, 2008). While alluvial fans are subjected to different hydrologic and geologic forces than braided channels, they both similarly have transitory channels that are prone to widening after large rain events, which makes delineating with OHWM indicators challenging (Lichvar & McColley, 2008).



Saddle Guzzler on Alternative 3C

While delineating waters in the arid southwest have their own challenges, they are still subject to the same guidelines under Section 404 of the Clean Water Act. For a stream or channel to be considered a water of the U.S., it must possess an OHWM and for tributaries, a significant nexus to a traditionally navigable water. Determining a significant nexus can be done from an office based on current and historic USGS topographic maps. An OHWM can be preliminarily determined based on aerial photographs but should be verified in the field.

METHODOLOGY

The methods to create shapefiles for the stream channel delineation, drainage basin delineation, and potential jurisdictional determination of watersheds are described below. All three processes used a 10-m digital elevation model (DEM) from USGS and ArcMap 10.3.1 with the Spatial Analyst extension.

Stream Channel Delineation

The final channel delineation shapefile for the study area was created by combining a modeling output for the more mountainous regions and the USFWS wetlands and streams data (U.S. Fish and Wildlife Service, 2016) for the playas. Modeling channel flow based on a 10-m DEM within the mountainous regions of the study site proved to be accurate and effective. However, as terrain became less rugged and steep, the model lost reliability. To counter this effect; playas, bajadas, and areas where the modeling output was inaccurate were clipped. These clipped areas were later filled with wetland and streams data from the USFWS (U.S. Fish and Wildlife Service, 2016) to provide a total picture of channels within the study site and to connect those channels to determine if they were connected to navigable waters.

Mountainous areas were modeled using a 10-m DEM from USGS and the Arc Hydro toolbar within ArcMap 10.3.1. The DEM was preprocessed using the "Fill Sinks" tool within the Arc Hydro toolbar. Next, flow direction was determined using the "Flow Direction" tool under the "Terrain Preprocessing" tab. The

"Fill" raster created in the previous step was used as the "Hydro DEM" input within the tool dialog box. Based on the flow direction grid created, the flow accumulation was determined using the "Flow Accumulation" tool. Finally, the minimum threshold needed to initiate a stream was specified using the "Stream Definition" tool. A minimum area of 0.03 sq.mi. (1,000 cells) was set as the requirement to initiate a stream. The raster file output was converted to a polyline shapefile using the "Raster to Polyline" tool. The polyline shapefile was finally clipped to remove previously identified playas, bajadas, and similar terrain that were not modeled accurately. The polygon output was then manually edited, based on a USGS topographic map and satellite imagery, to better reflect actual conditions and to remove modeling created artifacts.

Streams and channels within the playas, bajadas, and other areas removed from the modeling output, were identified using stream and wetland data from the USFWS web portal. Stream and wetland data was provided as a polygon shapefile. To allow merging between the polyline modeling output and this data, the polygon shapefile was converted to a polyline using the "Create Centerline" tool within the GeoWizards toolbar (Tchoukanski, 2002). Within the tool dialog box, the option to create smooth derived centerlines was selected. These polylines were then manually reviewed to ensure accuracy and a smooth connection to the edges of the modeling output.

Finally, the edited USFWS data and modeling output were merged to create a complete picture of channels and streams within the study area.

Basin/Watershed Delineation

Watersheds for the streams within the study area were determined using a 10-m DEM from USGS and the Arc Hydro Toolset within ArcGIS 10.3.1. Initial watersheds were created based on streams rendered from the 10-m DEM, but were ultimately combined or separated based on the channel shapefile created in the stream channel delineation component of this report.

The DEM was prepared for analysis by first filling sinks. The "Fill Sinks" tool modifies the elevation of the DEM to allow more accurate modeling of stream flow by eliminating sink cells where water can accumulate. "Fill All" was selected as the Fill Method within the tool dialog box.

Next, a flow direction grid was computed for the filled DEM. The cells within the flow direction grid show the direction of the steepest descent from that cell. From this, flow direction can be inferred. The "Flow Direction" tool within the "Terrain Preprocessing" tab was used for this step. The "Outer Wall Polygon" was set to "Null" within the tool dialog box.

Flow accumulation was then calculated. The "Flow Accumulation" tool uses the flow direction grid produced in the previous step to create a grid of the accumulated number of cells upstream of each cell. This step can be used to separate larger streams from their smaller tributaries.

Next, the minimum threshold to initiate a stream is specified. Using the "Stream Definition" tool and the flow accumulation grid created in the previous step as an input, an area of nine (9) square kilometers was defined as the minimum threshold. The output is a raster with a value of "1" for all cells from the flow accumulation grid that have a value higher than the designated threshold value.

The stream raster is then segmented to give each segment a unique identification and to identify head segments. Using the previously created flow direction grid and stream grid as inputs to the "Stream Segmentation" tool, a "Stream Link Grid" is created. Inputs for "Sink Watershed Grid" and "Sink Link Grid" were marked as "Null" in the dialog box for the tool.

Next, the catchment grid was determined. The "Catchment Grid Delineation" tool uses the flow direction grid and stream link grid to create a raster file where each cell has a value corresponding to which catchment the cell belongs. The value for the catchment grid delineation corresponds to a value within the stream segment that drains into that area. The catchment grid is converted to a polygon feature class for easier processing using the "Catchment Polygon Processing" tool within the "Terrain Preprocessing" tab of the Arc Hydro toolbar.

The stream link grid created in a previous step is now converted into a "DrainageLine" feature class using the "DrainageLine Processing" tool. The drainage line feature class will be used in future steps to determine watersheds and drainage points.

Next, the Adjoint Catchment is created by aggregating upstream catchments from the catchment polygon feature class. The Adjoint Catchments represent an entire upstream watershed, draining into a single inlet point. Within the "Adjoint Catchment Processing" tool, "DrainageLine" and "Catchment" are added as inputs within the tool dialog box.

Drainage points are then added and serve as references for manual batch watershed delineation in the next set. Each drainage point corresponds to the point where water leaves the catchment. The "Drainage Point Processing" tool is used to create the drainage points. Within the "Drainage Point Processing" tool dialog box; the flow accumulation grid, catchment grid, and "Catchment" are added as inputs.

Finally, watersheds are delineated using the "Batch Watershed Delineation" tool. First, batch points need to be manually generated using the "Batch Point Generation" tool symbolized as a yellow "X" on the Arc Hydro toolbar. Using the "Batch Point Generation" tool, an outlet to a watershed is selected. The drainage points created in the previous step are helpful in identifying catchment outputs. Batch points for the entire study area should be identified as additional points cannot easily be added later. From the batch points identified, the "Batch Watershed Delineation" tool within the "Watershed Processing" tab of the Arc Hydro toolbar is used to create appropriate watersheds.

Because watersheds were identified based on a DEM derived stream file and to reflect a stream environment (not one where some tributaries flow into playas and basins with no outlet), the output watersheds were manually merged or separated. Thus, the output better reflected both the actual environment and the channel shapefile created in the stream channel delineation component of this report.

Potential Jurisdictional Determination

As a rule, determining jurisdictional status can only be accomplished by conducting a detailed field study of the stream and reviewing relevant documents such as historical aerial photographs, National Wetland Inventory maps, and USGS topographic maps. On a large scale, such as this study, identifying streams and drainage basins with a significant nexus to a named, potentially navigable water provides an indicator that jurisdictional waters may be present, which can be used for future planning efforts. In the future, any site-specific ground disturbing activities proposed within withdrawn lands supporting potential jurisdictional waters would require a site-specific jurisdictional waters determination, delineation, and potential impact assessment.

Each watershed was inspected to determine if it flowed into a basin with no outlets or eventually connected to traditionally navigable waters of the U.S. the only navigable waters potentially connected to watersheds and streams on the study area were the Amargosa River and the Las Vegas Wash (eventually flowing into the Colorado River. Watersheds that served as a source of surface water to either of these rivers were determined to be potentially jurisdictional.

Field Surveys

In 2013, NNRP conducted a study to identify potential seeps and springs by using false color (near infrared) imagery and the reflectance characteristics of the vegetation found at known water features on the North Range of NTTR. The reflectance property of a plant is strongly correlated with the concentration of chlorophyll present in the leaf and the photosynthetic performance of the plant (Slaton, 2000). In dry areas such as NTTR, plants with higher concentrations of chlorophyll tend to be found in areas of high soil moisture and would be expected to exhibit a higher reflectance of infrared waves compared to plants on uplands in dryer soils (Rasmussen, 2010). As a result, the plant communities with high reflective values display bright red signatures on infrared images, making these signatures an excellent indicator of water sources in a desert ecosystem like the NTTR. Figure 3 shows natural color and false color imagery of a spring located on the North Range Study Area (Breen Creek). The bright red signature is obvious for the plants found in the wet areas around the spring of the creek versus those plants located on the drier upland areas adjacent to the creek. Using this fact, the red (and sometimes pink) infrared signatures of plant communities associated with seeps and springs were manually identified on high resolution satellite imagery and categorized as potential seeps and springs. This same methodology was used for identification of wetlands, seeps, and springs on the potential expansion alternatives.

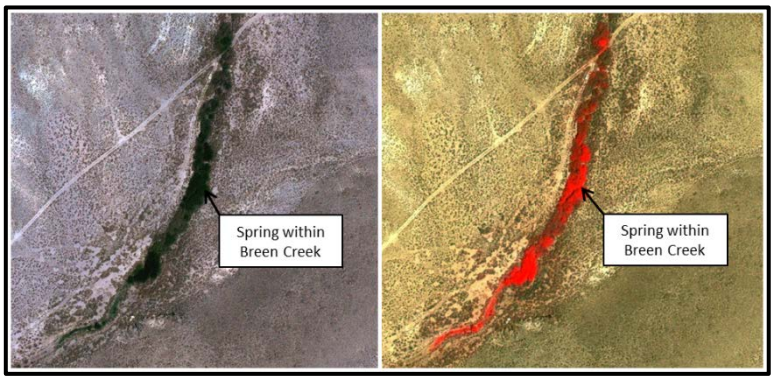


Figure 3. Natural color (Left) and false color (Right) high resolution satellite imagery showing the red signature typical of healthy plants found in spring plant communities.

For the potential expansion alternatives, 50 points were identified that showed infrared signatures typical of vegetation found in springs and wet areas (Figures 5-7). The imagery used for this survey was taken on April 2-3, 2016, which was during a relatively wet spring. A helicopter survey was conducted on August 21, 2016, to visit each of the 50 points and determine if any of the signatures were wetlands, springs, or seeps. At each point, the site was inspected while in flight in the helicopter to determine if vegetation, saturated soils, or standing water indicated the presence or potential presence of a water feature. If that observation indicated the presence or potential presence of a water feature, the helicopter was landed and the potential water feature surveyed for indicators of hydrology (wetland vegetation, saturated soils, hydric soils, standing water, shallow water table, etc.). If sufficient water was available, analytical equipment was used to determine conductivity, oxygen content, pH, salinity, turbidity, and temperature of the water. Dominant and subdominant plants were also identified, and the area was surveyed for rare plants.

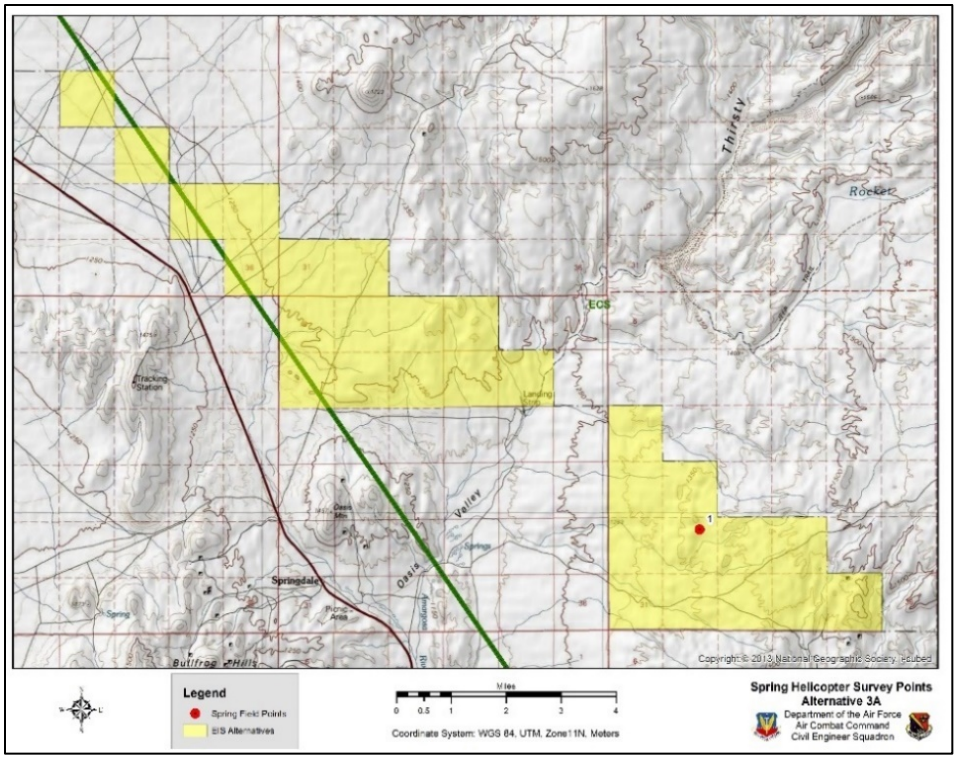


Figure 4. Locations where potential locations of seeps or springs were surveyed on Alternative 3A on August 21, 2016.

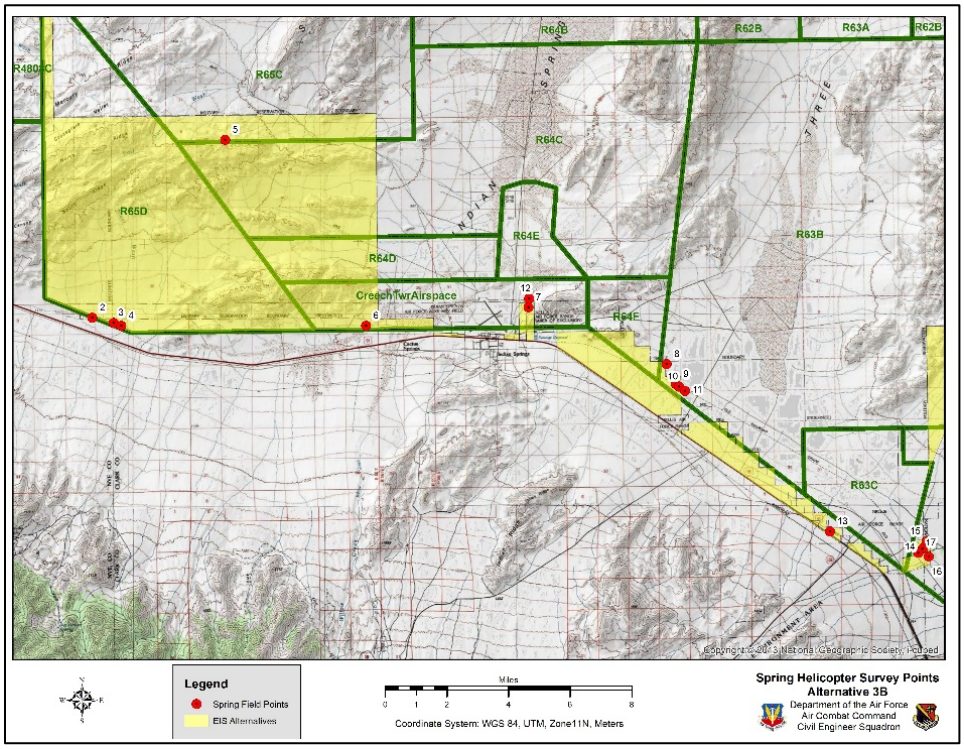


Figure 5. Locations where potential locations of seeps or springs were surveyed on Alternative 3B on August 21, 2016.

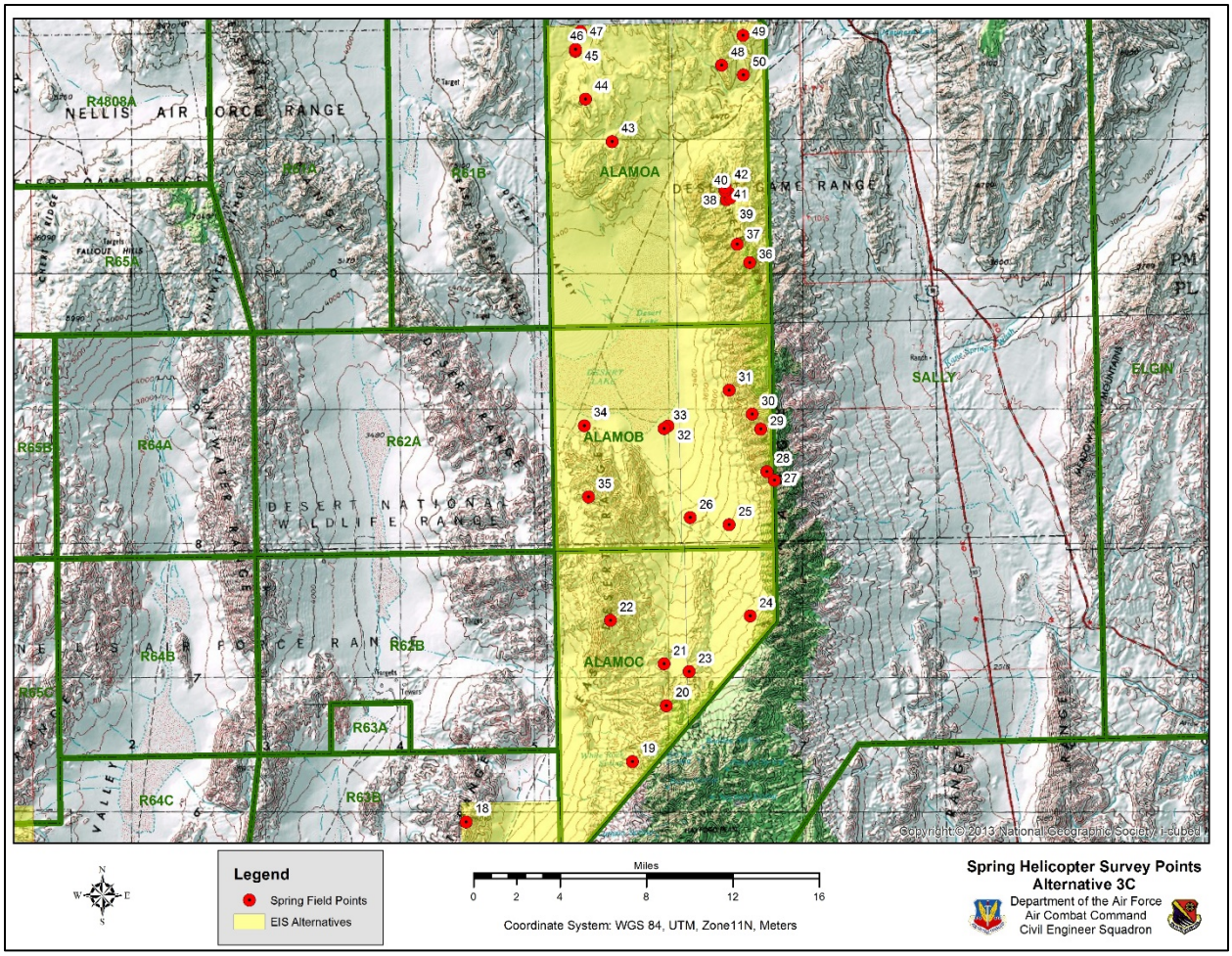


Figure 6. Locations where potential locations of seeps or springs were surveyed on Alternative 3A on August 21, 2016.

RESULTS

Stream Channel Delineation

Using the process described in the "Methodology" section of this report, Figures 7-11 depicting the channels and washes within the study area were created. The channels include all potential channels and washes where water will accumulate and flow during and after storm events. Note that all channels are washes that accumulate water for very short periods of time, thus serving as ephemeral streams. Although some of the streams on the study area are shown as "blue line features" on USGS maps, none of them meet the criteria of being "intermittent" or "perennial". This is not to diminish the fact that many of these ephemeral channels are large and potentially contain high volumes of water during significant storm events. The accumulated water either flows into navigable waters or playas. Some water may remain in the stream channels for short periods of time before it either evaporates or filters its way into groundwater.

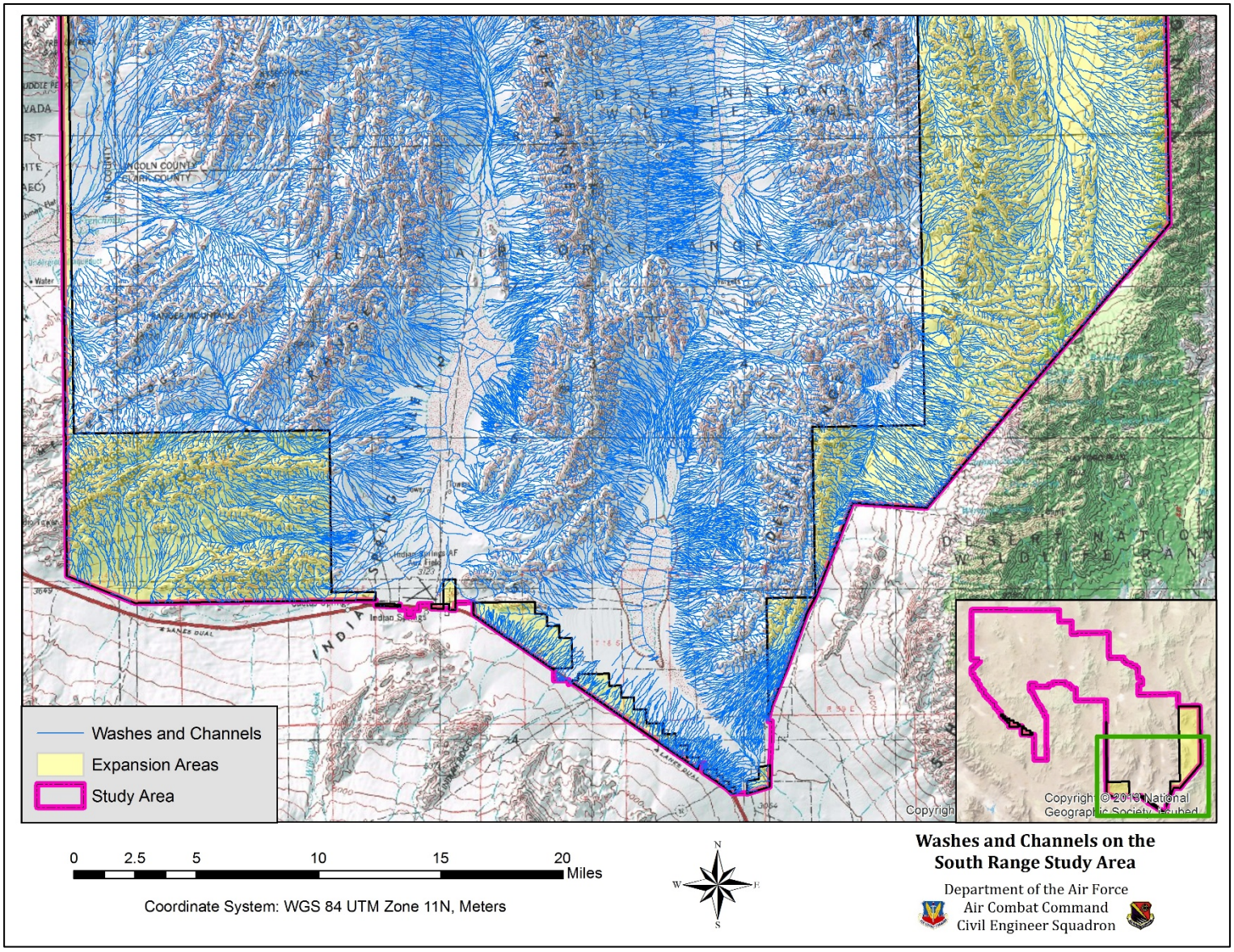


Figure 7. All channels and washes on the southern portion of the South Range Study Area.

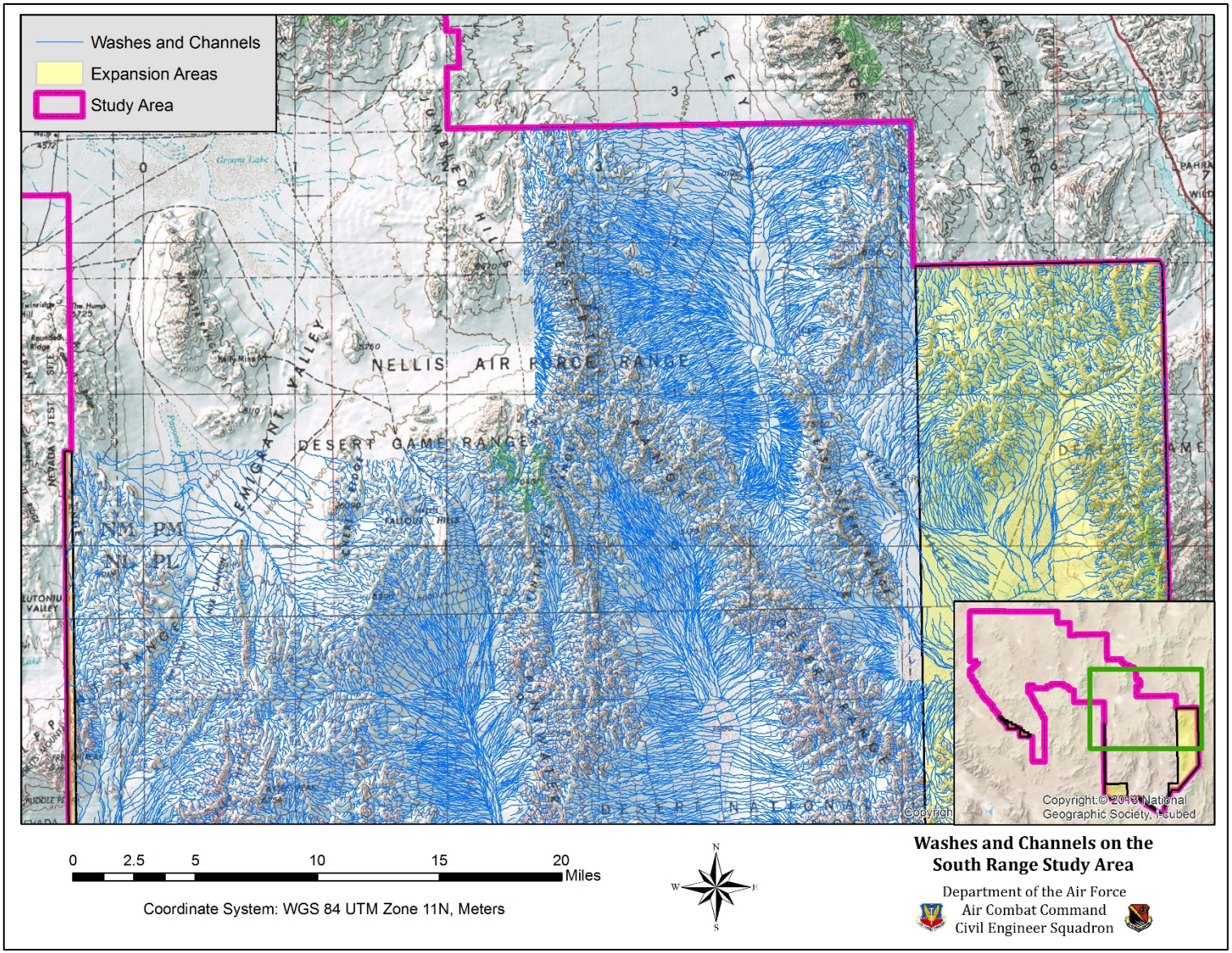


Figure 8. All channels and washes on the northern portion of the South Range Study Area.

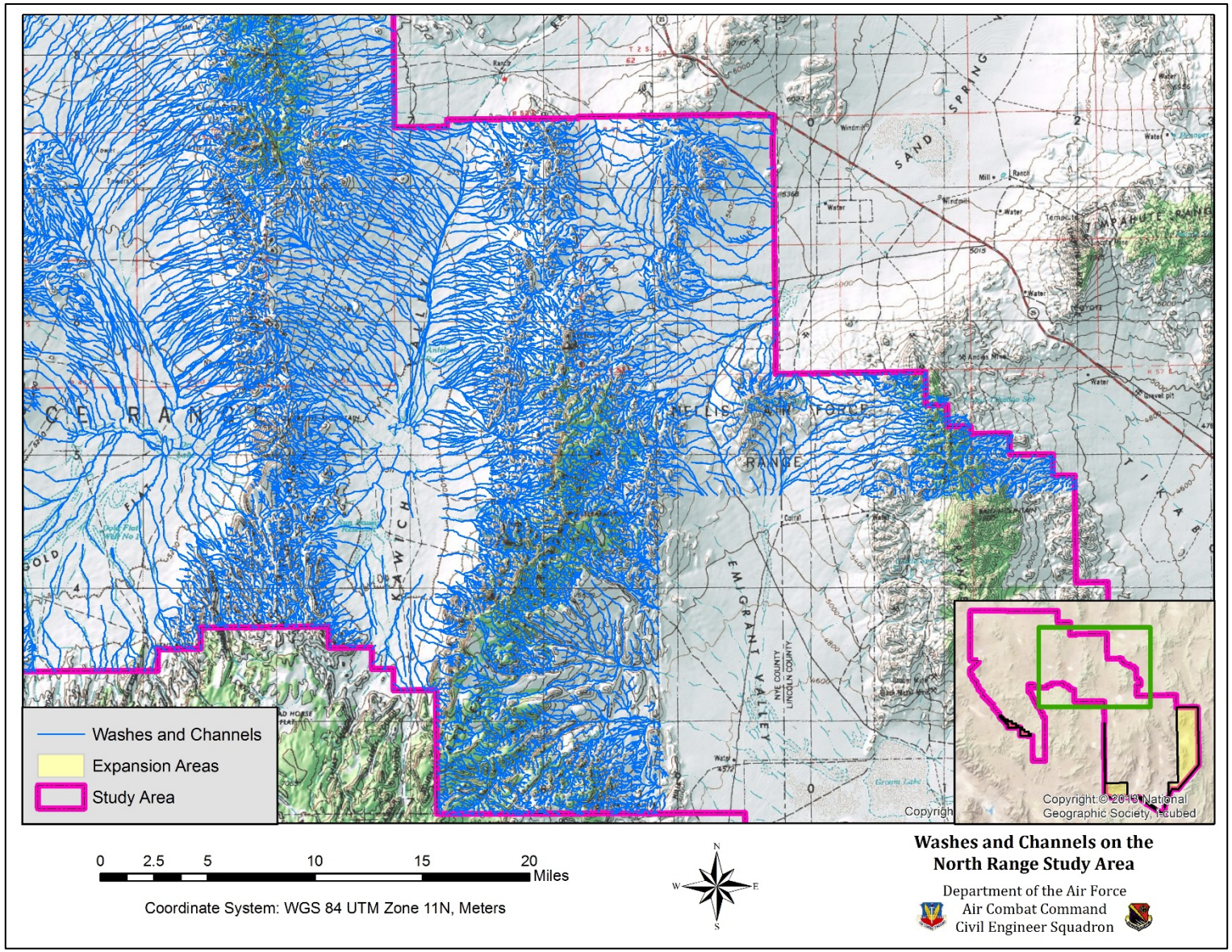


Figure 9. All channels and washes present on the central portion of the North Range Study Area.

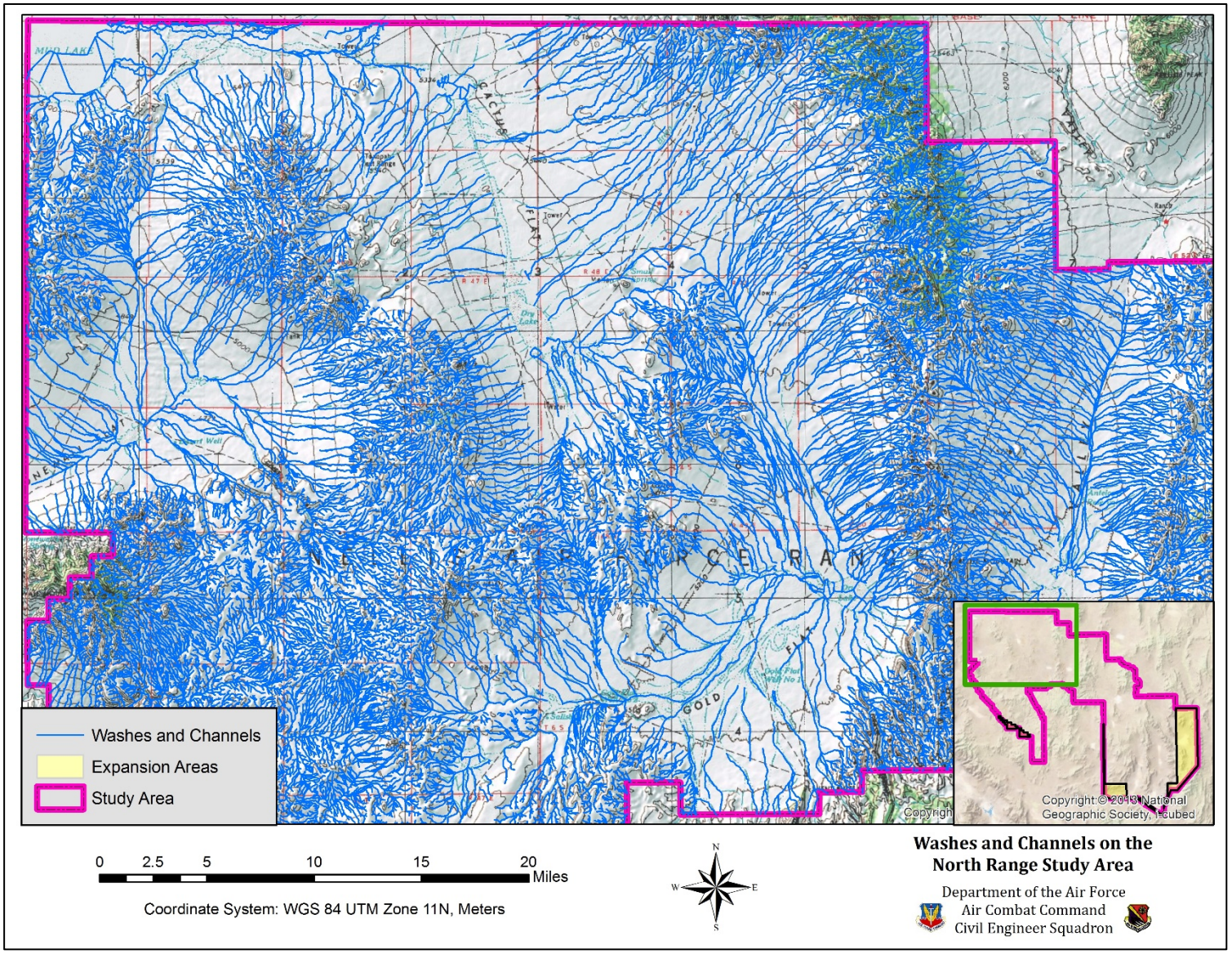


Figure 10. All channels and washes on the northwestern portion of the North Range Study Area.

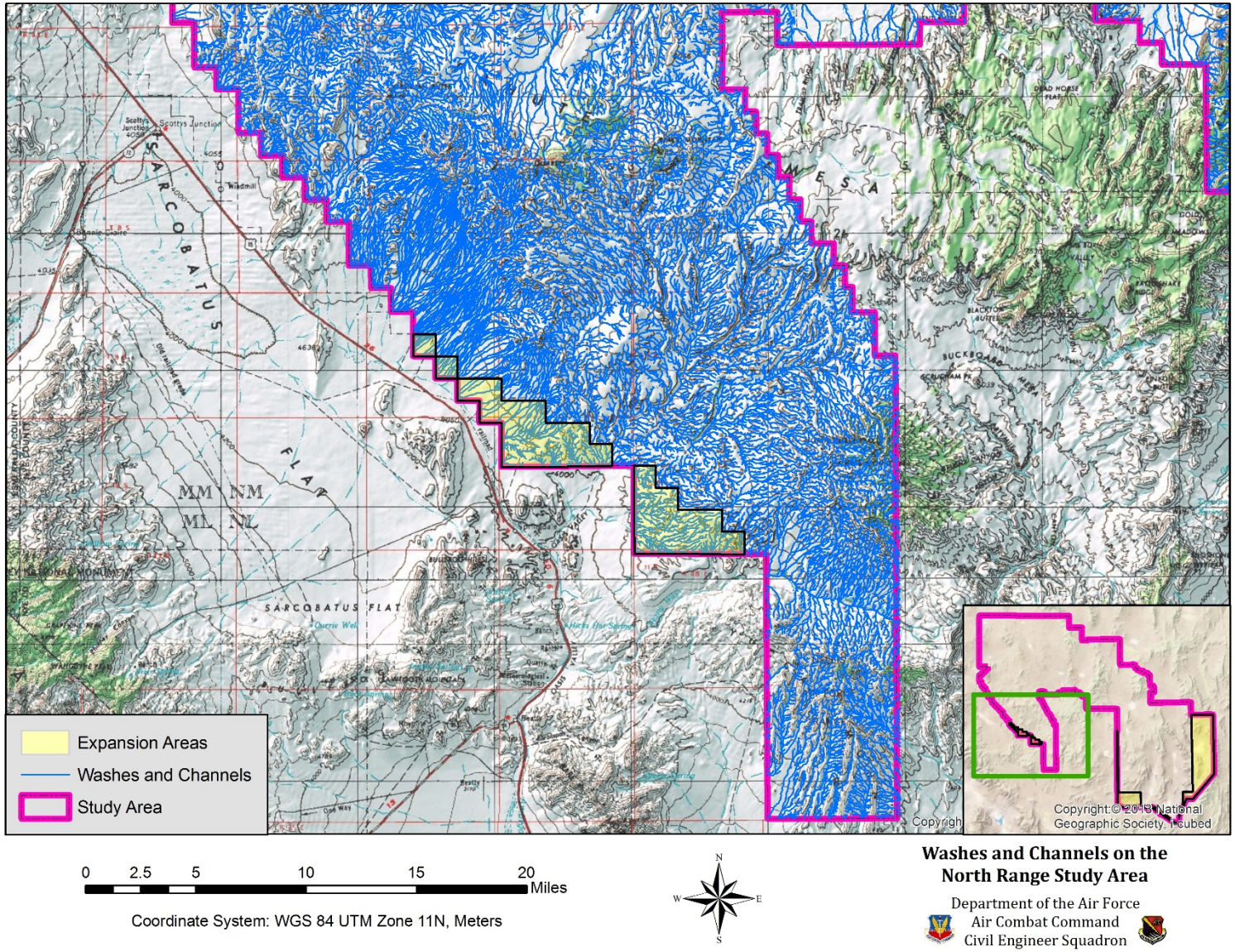


Figure 11. Channels and washes found on the southern portion of the North Range Study Area.

Watershed Basins

Potential jurisdictional watersheds were identified as watershed basins that drain into channels that are eventually connected with navigable waters. Within the study area, the only navigable waters potentially connected to drainage basins would be the Amargosa River and the Las Vegas Wash which is connected to the Colorado River. Thus, any surface waters and washes found within these watersheds have a potential significant nexus to a traditionally navigable water, making them potentially jurisdictional. The majority of the watersheds found on the study area drain into closed basins which are not connected to navigable waters. Surface waters and washes found in these watersheds would not be considered jurisdictional based on the current regulatory definitions. Therefore; impacts to wetlands, springs, washes, and streams found in those watersheds would not be subject to permitting under the regulations of Section 404. Impacts to wetlands, springs, washes, and streams found in watersheds that are considered potentially jurisdictional based on their connection with navigable waters would be subject to the jurisdiction of the USACE and those actions would require permitting under Section 404 regulations.

Figure 12 provides a map showing all watersheds found on the study area. Figures 13-15 show the location of potentially jurisdictional watersheds that are connected to navigable waters and probably contain waters of the U.S. that are subject to Section 404 permitting.

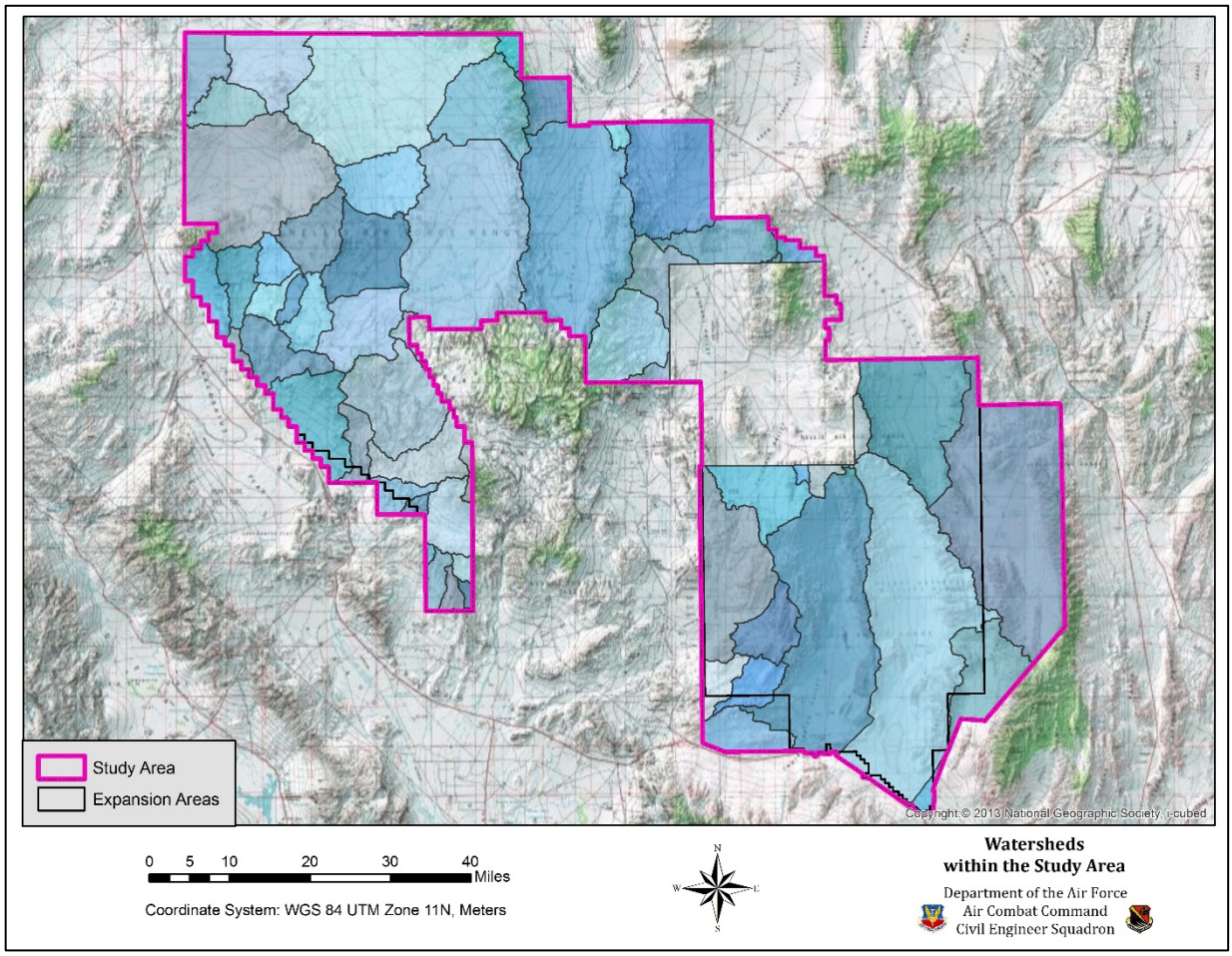


Figure 12. All drainage basins or watersheds found within the study area.

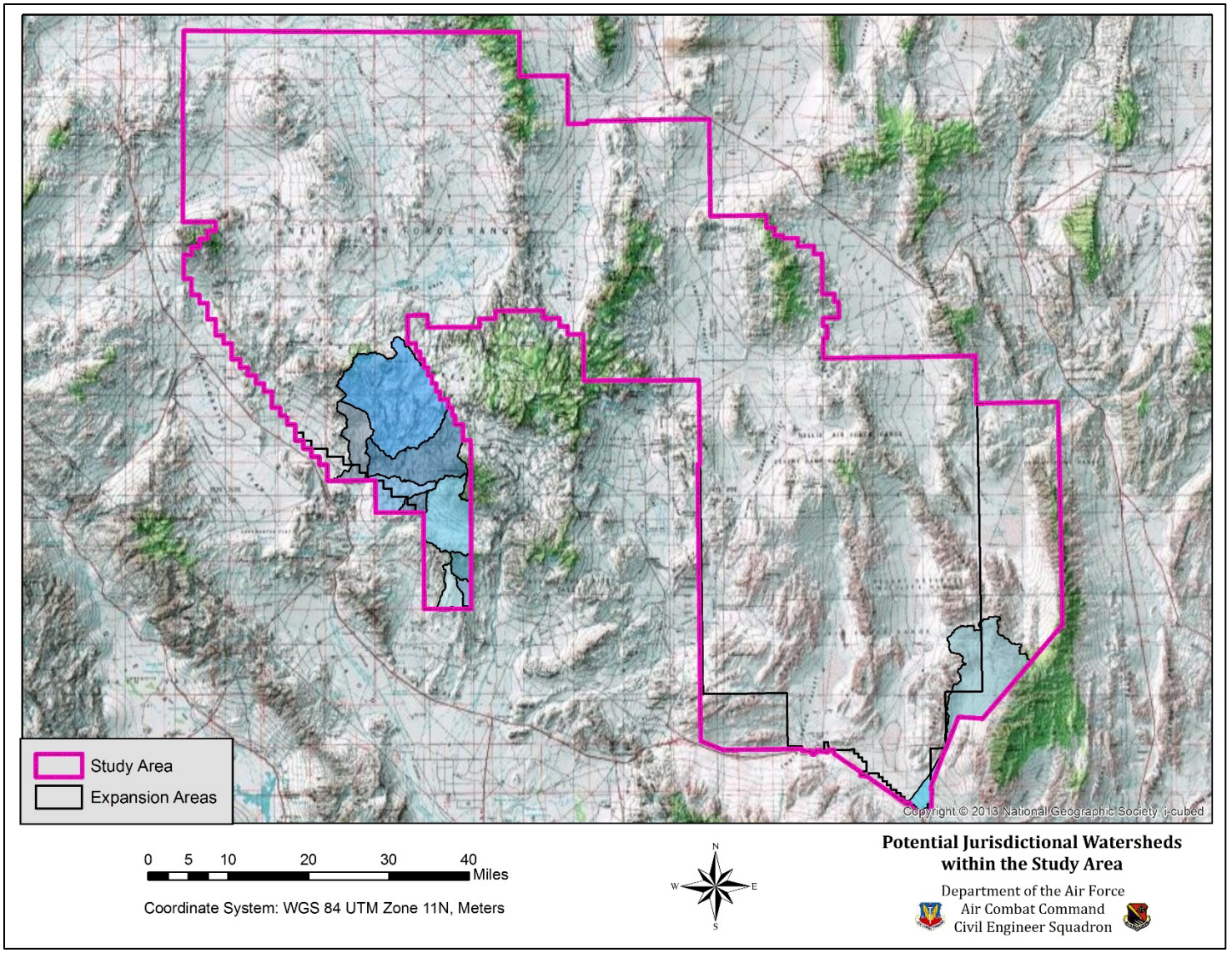


Figure 13. Watersheds in the study area that are potentially jurisdictional based on their connections with navigable waters of the U.S.

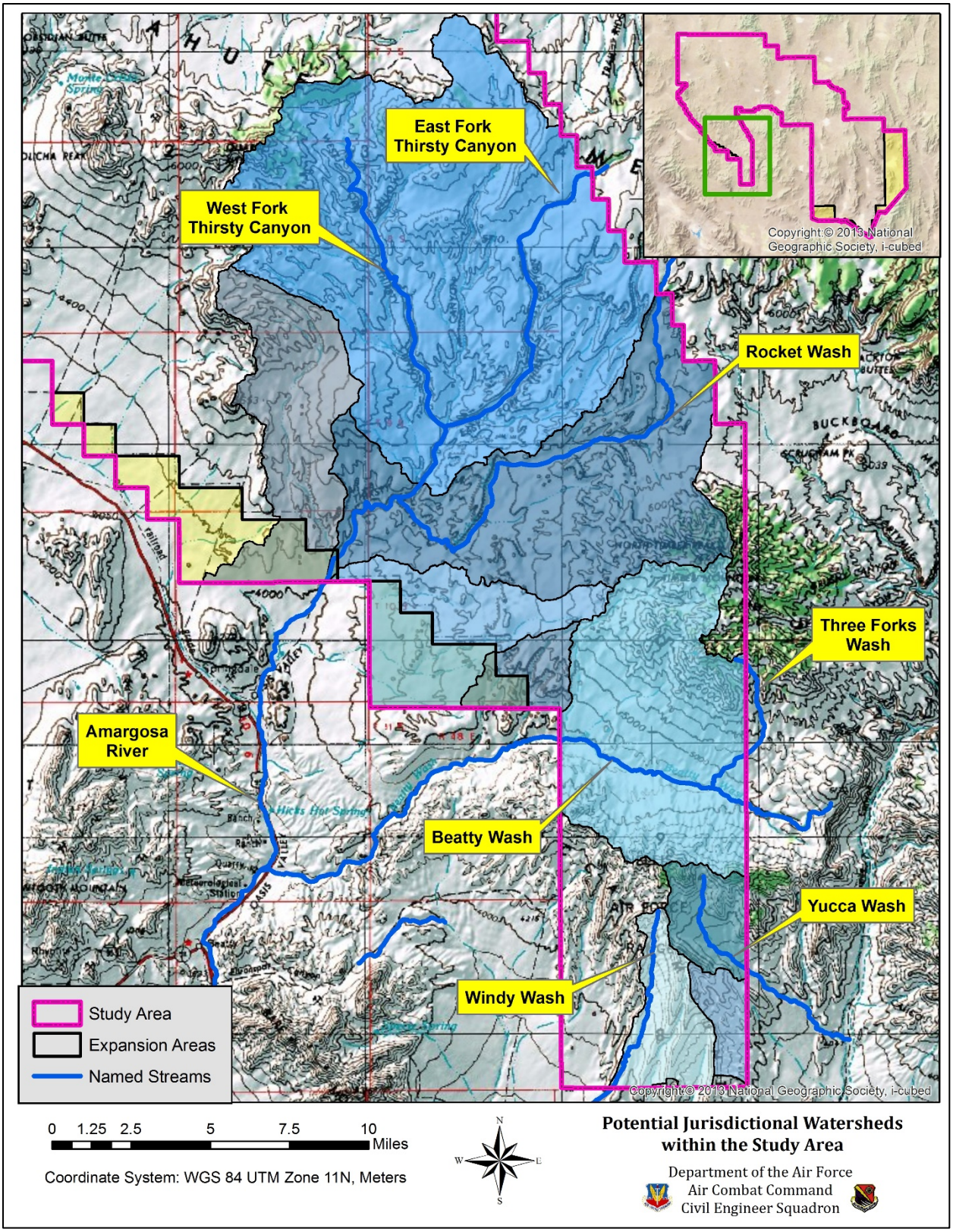


Figure 14. Potentially jurisdictional watersheds on the southern portion of the North Range Study Area.

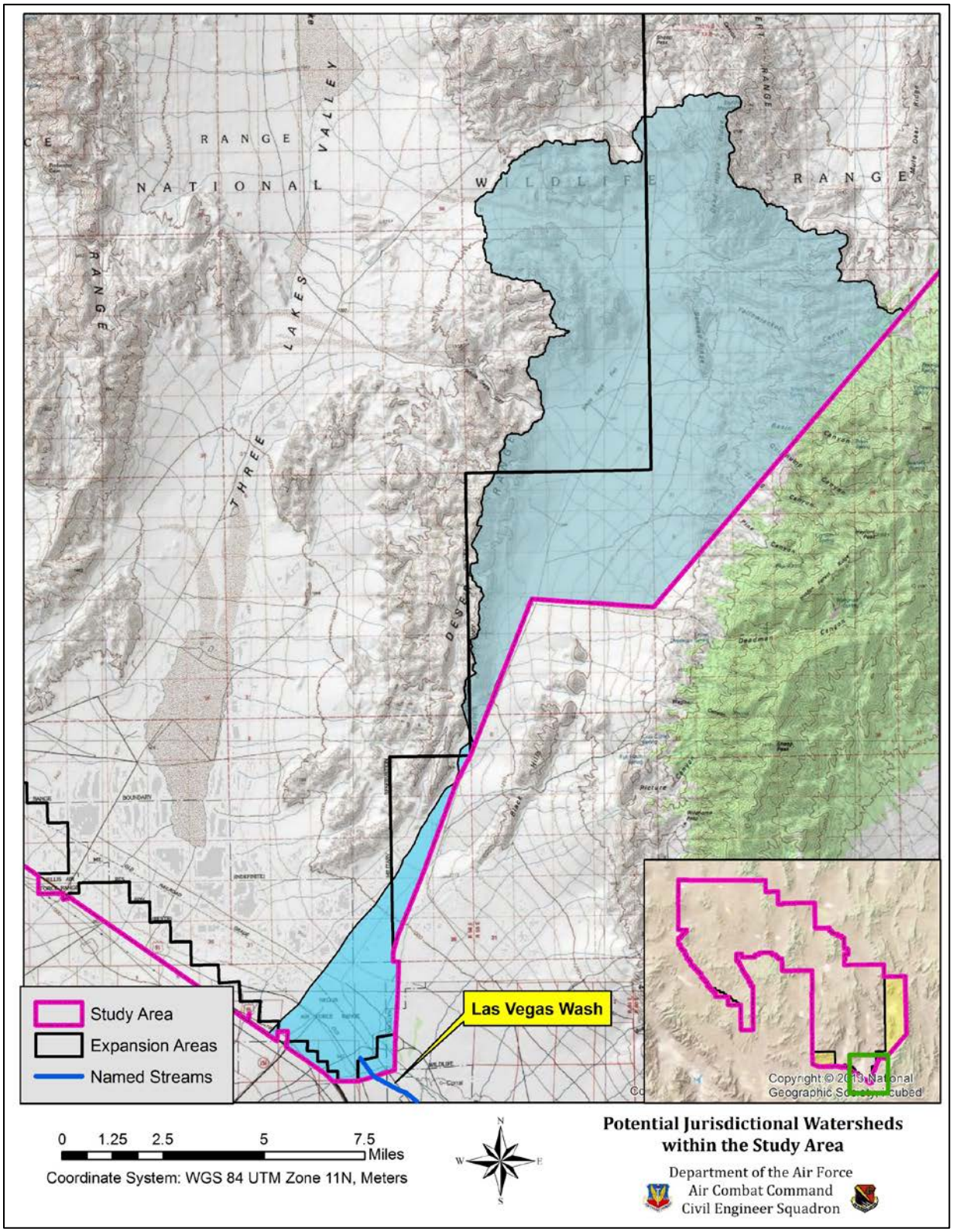


Figure 15. Potentially jurisdictional watersheds on the west South Range Study Area.

National Wetland Inventory Map

National Wetland Inventory (NWI) maps are prepared by the USFW primarily using stereoscopic analysis of high-altitude photographs. During map creation, NWI features were identified based on vegetation, visible hydrology, and geography in accordance with *Classification of Wetlands and Deepwater Habitats of the United States* (1979). Although these maps provide a good screening method for identifying potential features, a detailed on-the-ground and historical analysis of a site is required. NWI maps also do not define the jurisdictional limits of potential waters of the U.S. More recently, NWI maps have been upgraded using high resolution satellite imagery and other GIS mapping tools. This has resulted in excellent delineation of wetland features, washes, and channels in the southwest U.S.

Water features shown on NWI maps are not always present under field verification. Likewise, wetland or stream systems not depicted on NWI maps may be present on project areas. Not all wetlands identified on NWI maps are considered jurisdictional by the USACE because the USFWS uses a more liberal classification for wetlands. However, these maps are excellent tools for determining if an area may contain jurisdictional waters. Figures 16-20 show NWI maps for the study area.

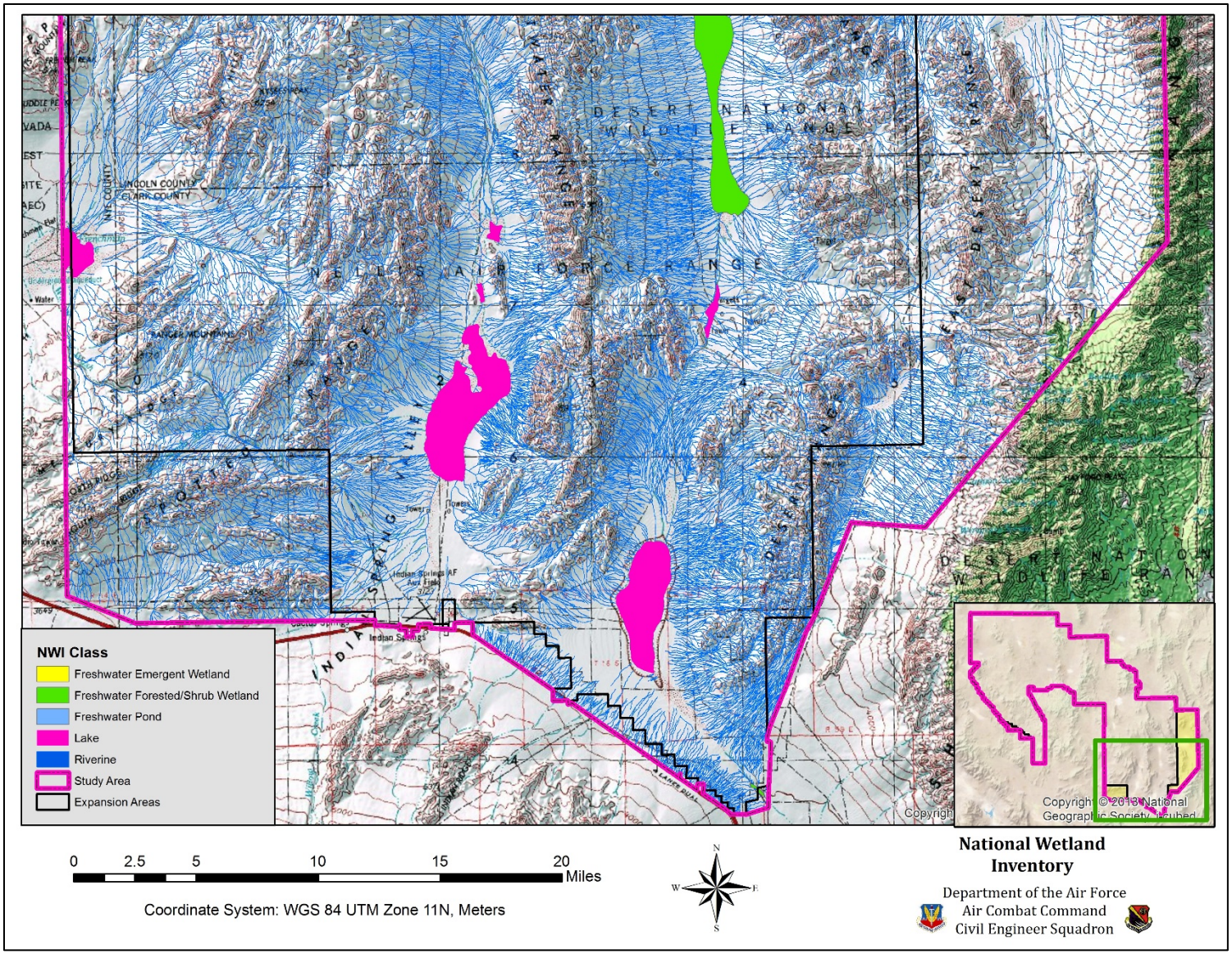


Figure 16. Water features identified on the southern portion of the South Range Study Area on the National Wetland Inventory conducted by USFWS.

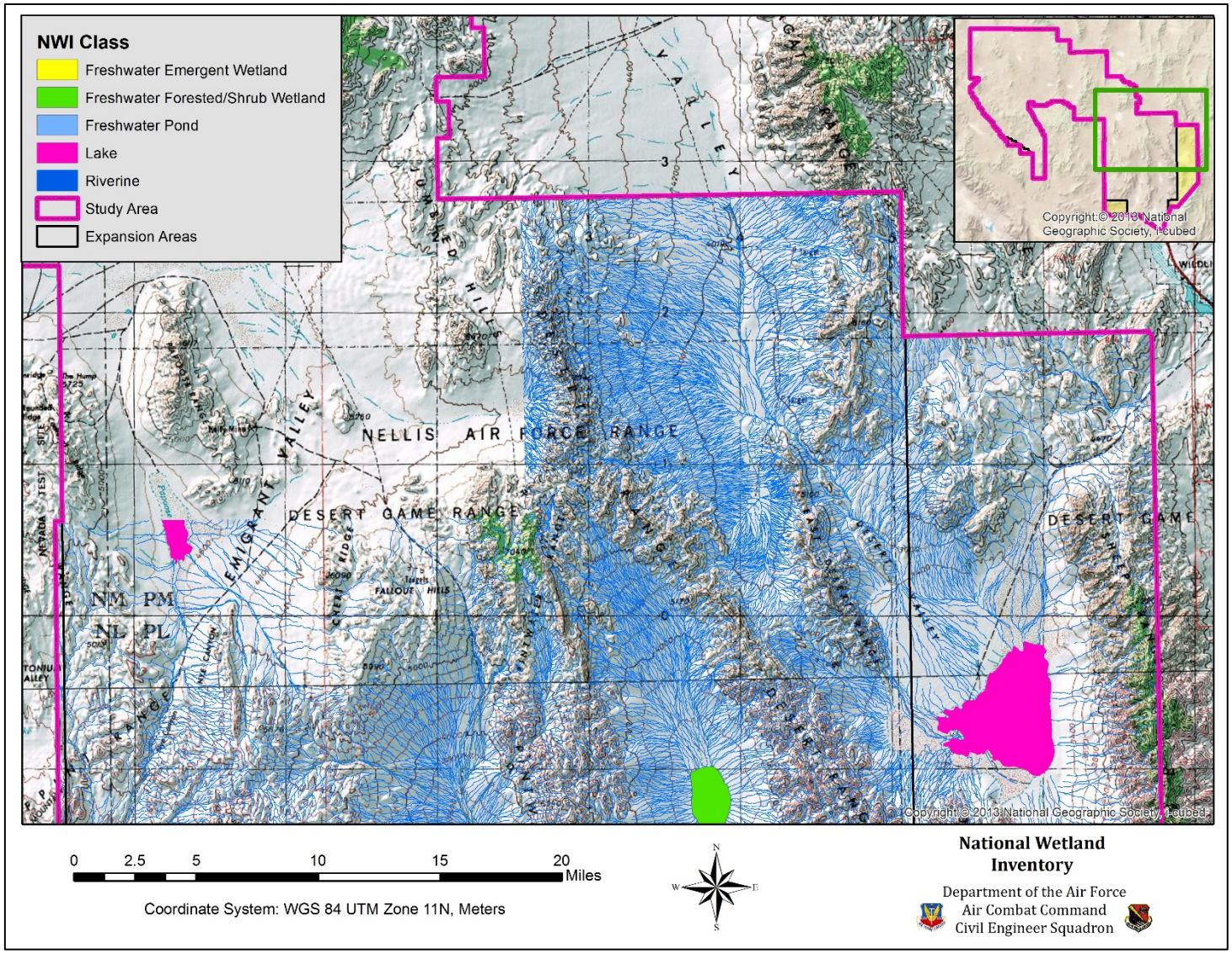


Figure 17. Water features identified on the northern portion of the South Range Study Area from the National Wetland Inventory conducted by the USFWS.

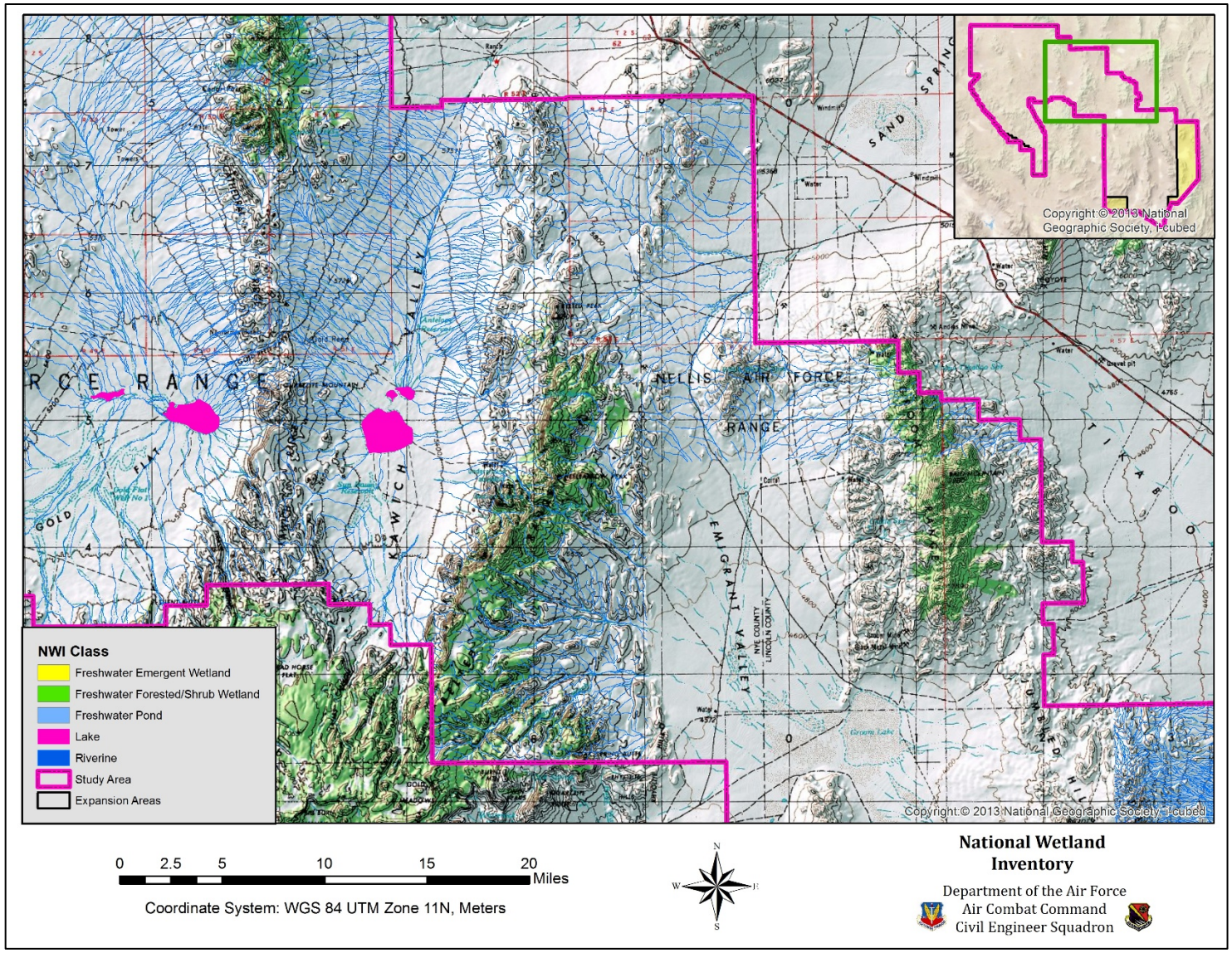


Figure 18. Surface waters identified on the central portion of the North Range Study Area by the National Wetland Inventory conducted by the USFWS.

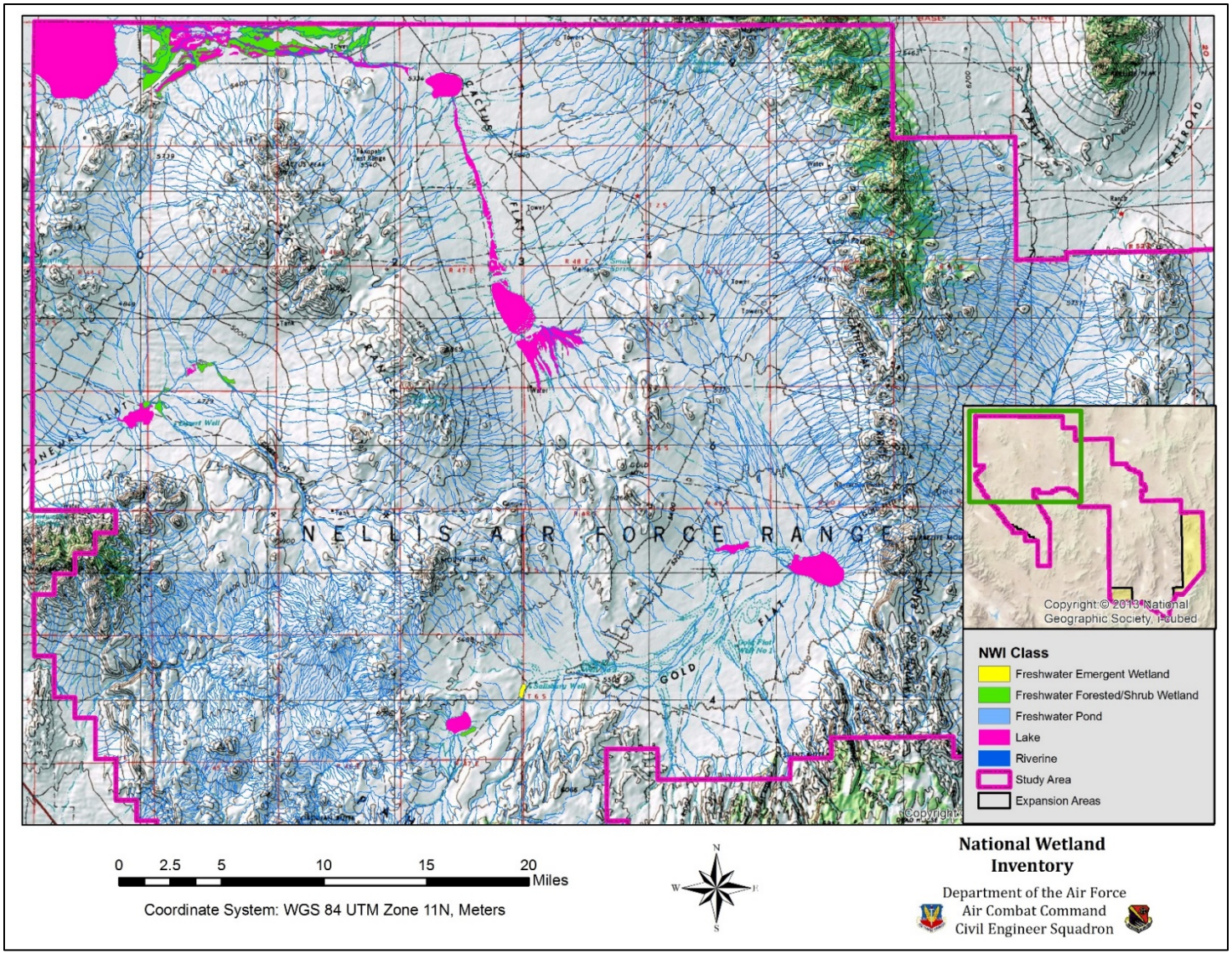


Figure 19. Surface waters identified on the northwestern corner of North Range Study Area by the National Wetland Inventory by the USFWS.

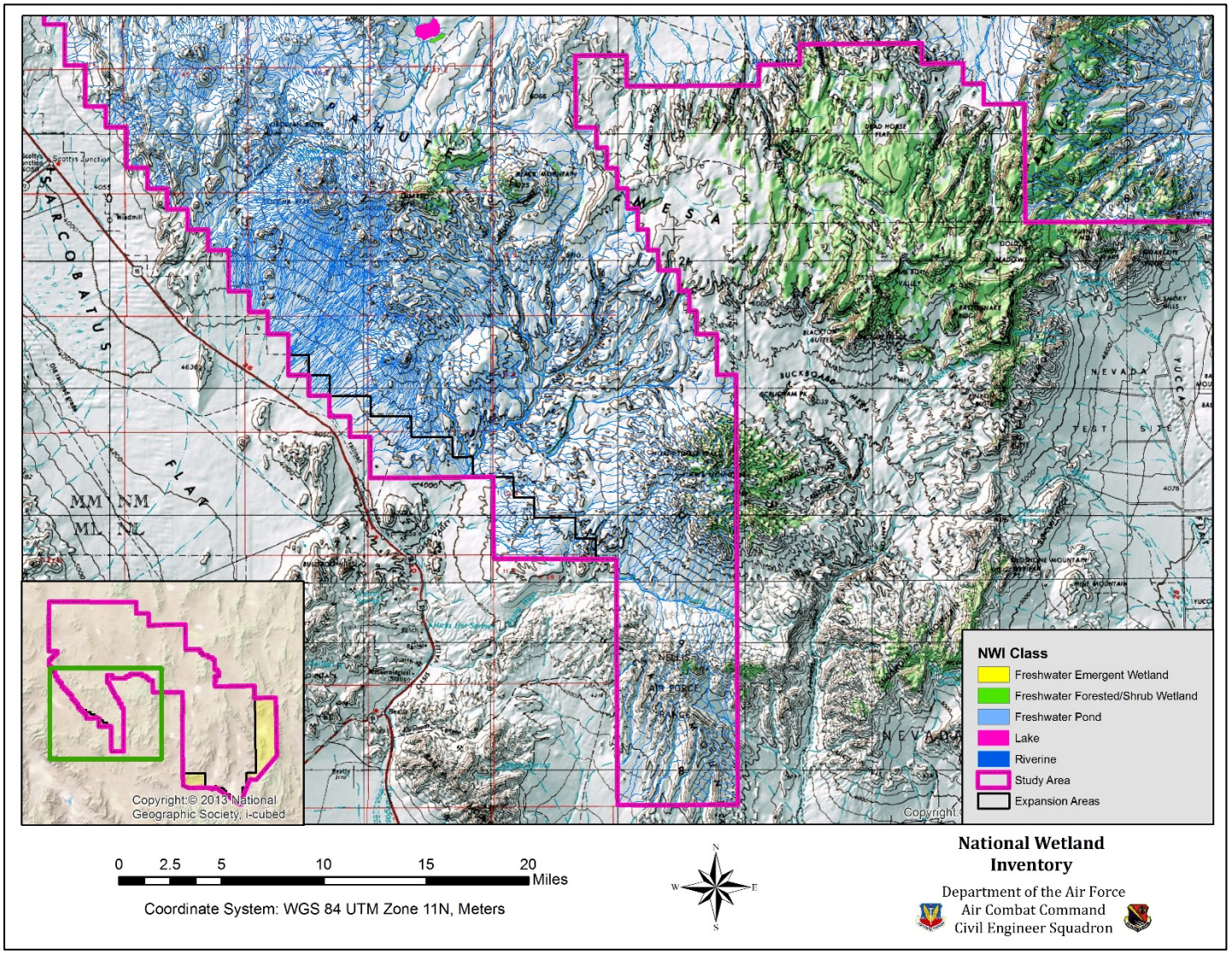


Figure 20. Surface waters identified on the southern portion of the North Range Study Area by the National Wetland Inventory conducted by the USFWS.

Field Surveys

Out of the 50 points identified as possible seeps or springs, only two springs and four wildlife water developments were positively identified as water sources based on the infrared imagery. No seeps, springs, or wetlands were found on Alternatives 3A and 3B. The six identified water features were all located in Alternative 3C. The two springs were Sheep Spring and White Rock Spring. Both of these springs were located on the west side of the Sheep Range. They were found to be perennial water sources that have been improved as wildlife water developments by the addition of artificial collection troughs. The four wildlife water developments are Enclosure Ridge Guzzler, Woody Guzzler, Saddle Mountain Guzzler, and Rug Mountain Guzzler. These developments do not have a groundwater source, but derive their water from stormwater collectors. No other wetlands, seeps, or springs were identified during the helicopter survey. Detailed information on these water features as well as other surface water features may be found in the Seeps and Springs Section of this report.

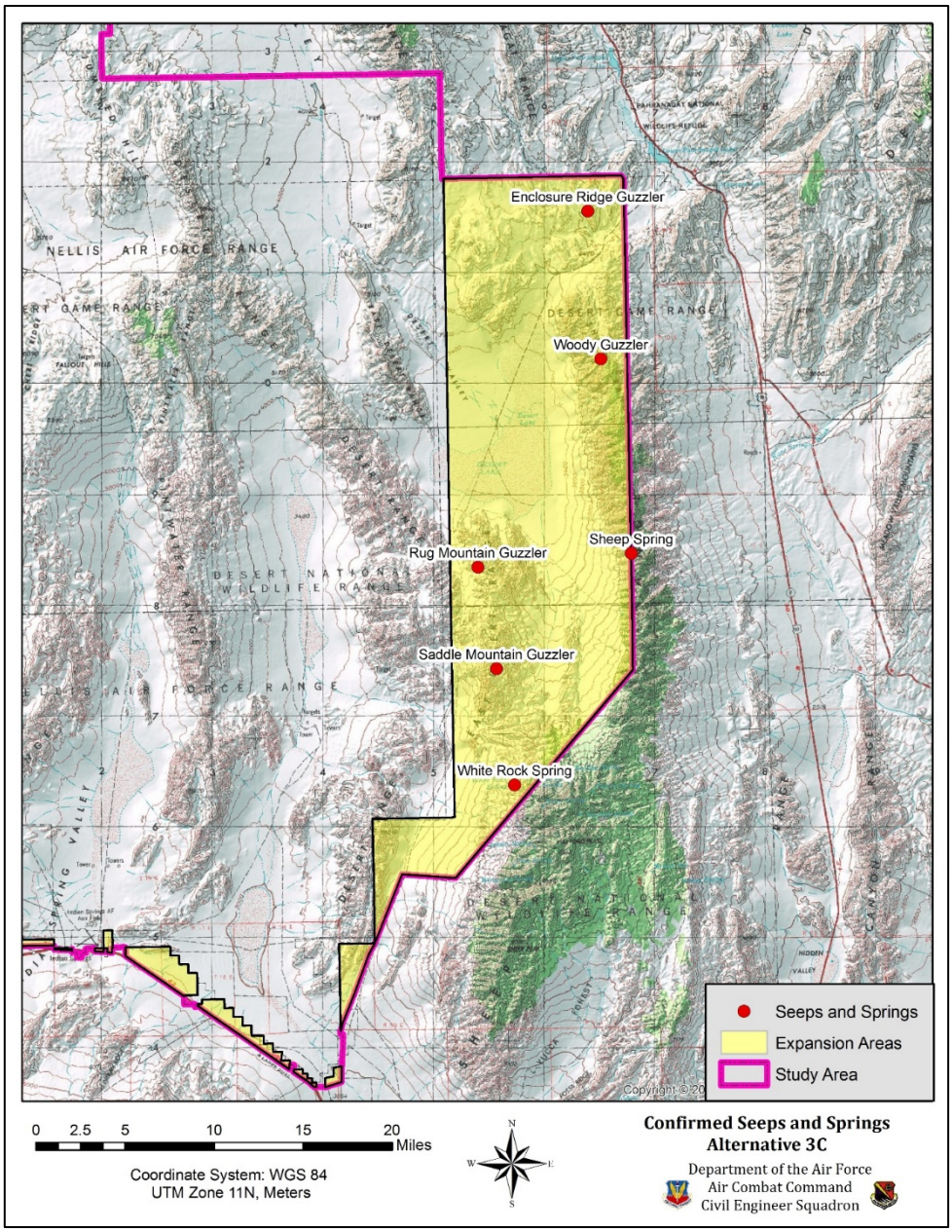


Figure 21. Seeps, Springs, and Wildlife Water Developments on Alternative Area 3C that were confirmed during helicopter surveys for wetlands conducted on August 21, 2016.

Floodplains

INTRODUCTION

This hydrology report was developed for the USAF by S&B Christ Consulting (SBCC) under contract with Adams Ecology (project no. 524-16-001). This report estimates the hydrologic conditions present on the NTTR and updates the previously prepared June 1997 NTTR Floodplain Inventory Report by Baker Environmental Inc. (Baker Environmental, Inc., 1997). The primary objective of this report is to complete hydrologic modeling to identify 100-year (1% chance of flood in any given year) and 500-year (0.2% chance of flood in any given year) storm event floodplains. The findings may be used as a general planning tool for the suitability of present and potential future use of the property in support of the Land Withdrawal Case File and Legislative Environmental Impact Statement (LEIS) addressing options for the NTTR Land Withdrawal.

HYDROLOGIC OVERVIEW

Climate

The climate of Nevada is characterized as semiarid to arid. Mean annual precipitation in the state varies depending upon elevation and can range from 4 inches on the valley floors to over 40 inches on mountain summits (USAF, Dept. of the Navy, DOI, 1991). Precipitation data from the USAF Climate Center and Western Region Climate Center managed by Desert Research Institute (DRI) is summarized in the table below (DRI, 2016):

Table 1. Precipitation data for the study area.

Weather Station	Mean Annual Precipitation (in.)	Period of Record	Source
Creech AFB/Indian Springs	2.8	2000-2007, 2009-2015	USAF Climate Center
Desert Rock	5.6	1978/05/15 to 2015/01/20	
Tonopah	5.0	2006/01/01 to 2015/12/31	
Alamo	6.3	1921 to 1962	Western Region Climate Center
Caliente	6.9	1997 to 2002	
Desert National Wildlife Refuge	4.4	1940/04/01 to 2015/01/20	

Water introduced to this area through precipitation evaporates rapidly for most of the year due to the arid conditions. Some of the water will percolate into the ground and will subsequently recharge the groundwater table. The remaining water may flow to channels or playas (dry lakes). Both perennial and intermittent seeps and springs are present throughout the proposed NTTR expansion area (USAF, 99 CES/CEIEA, 2016).

Designated Basins

Nevada divides the state's groundwater into discrete units interchangeably known as hydrographic basins, hydrographic regions, drainage basins, or watersheds. These regions are defined by a geographic area drained by a single major stream or an area consisting of a drainage system comprised of streams and natural or man-made lakes.

Groundwater and surface water basin delineations are typically defined by the mountain and valley range systems. The water basins are commonly named after these geologic features. Some major terrain features in the North Range Study Area include Stonewall Mountain, Stonewall Flat, Cactus Range, Cactus Flat, Pahute Mesa, Yucca Mountain, Gold Flat, Cathedral Ridge, Kawich Valley, Belted Range, Sand Spring Valley, Groom Range, and Emigrant Valley. Some major terrain features present in the South Range Study Area include the Emigrant Valley, Halfpint Range, Spotted Range, Indian Spring Valley, Pintwater Range, Three Lakes Valley, Desert Range, East Desert Range, Pahranagat Range, and Sheep Range. Figures for these geographic regions are included in Appendix B.

The United States Geological Survey (USGS) and the Nevada Division of Water Resources (NDWR) assigned 232 hydrographic basins (256 basins and sub-basins, combined) for the State of Nevada located within 14 major hydrographic regions for water planning and management purposes. This report utilizes USGS Geographic Information Systems (GIS) topographic data to generate custom-built hydrologic basins for this analysis as discussed in the hydrologic analysis section.

Surface Water

The semi-arid climate on the study area within this region limits the presence of surface water. Sources of surface water on the study area include perennial and ephemeral seeps, springs, and streams (USAF, 99 CES/CEIEA, 2016). One intermittent stream, Breen Creek, is present within Cactus Flats on the NTTR near Silverbow Corral. The only major river that is within the vicinity of the study area is the Amargosa River. The river is an approximately 200-mile regional drainage channel connecting the northern highlands of the Nevada National Security Site (NNSS) to the floor of Death Valley in Inyo County, California. Sections of this river are often dry, except following a storm event. Other portions of the river are fed by perennial springs and shallow water tables.

Surface water does not usually flow between basins due to the climate and topography of the area. Playas are dry or ephemeral lakebeds that form in semi-arid to arid regions in closed basins can be found within internally drained basins. Otherwise, no natural lakes or open bodies of water occur within the NTTR.

Infrequent severe thunderstorms and rain events can produce significant precipitation that will saturate the soils faster than it can be absorbed. The excess precipitation flows downgradient and is known as runoff. Large volumes of runoff lead to streamflow, flash flooding, and ponding in valleys and other low-lying regions such as the playas. A portion of water that is absorbed into the ground may recharge the aquifer system(s). However, precipitation events are not a significant source of perennial surface water accumulations due to the high loss from evaporation and to the infrequency of storm events.

The sparse sources of perennial surface water have come from springs that have formed where ground water intersects the surface. The springs flow for only short distances on the ground surface. Small, man-made impoundments are also present on the study area and serve as sources of surface water.

Hydrologic Analysis Approach

This report estimates the surface hydrologic and hydraulic conditions present on the current NTTR withdrawn land and proposed expansion areas. The June 1997 NTTR Floodplain Inventory Report by Baker Environmental Inc. (Baker Environmental, Inc., 1997) serves as the basis for this analysis. The primary objective of this report is to complete hydrologic modeling to identify 100-year (1% chance of flood in any given year) and 500-year (0.2% chance of flood in any given year) storm event floodplains. The findings may be used to assess the suitability of present and potential future use of the property and to support the 43 Code of Federal Regulations Part 2300, Land Withdrawal requirements.

The scope of work for this report required the use of publicly available topography of limited accuracy and detail. The models described in this report do not have the detail necessary for designing and constructing infrastructure. Additional modeling and drainage analysis, such as a Technical Drainage Study (TDS), should be considered prior to construction of fixed structures. The preparation of a TDS is beyond the scope of this report.

The drainage analysis undertaken entails the delineation of water basins and, subsequently, the identification of floodplains through use of hand calculations and hydrology programs. The basins are characterized as either internally drained (the water flow is maintained within the basin) or externally drained (the water flow may exit the basin). Runoff volume calculations have been performed for internally drained basins to determine water surface elevations in playas (dry lake beds) that collect runoff from storm events. Flow rate calculations were performed for externally drained basins to calculate the peak flow rate at a basin outlet point. Flow rate calculations were also conducted for internally drained basins located within proposed expansion areas. Overland flow calculations were conducted for cross sections of the proposed expansion areas using information from the flow rate calculations to determine the depth and velocity. An overview of the methodology is included in the table below:

Table 2. Hydrology Methodology Overview

Analysis Type and Method	Location(s)	Basin Type(s)	Primary Purpose
Stream and Basin Delineation ESRI GIS Program, Spatial Analyst Extension	NTTR and Proposed Expansion Areas	N/A	Determine stream networks and watersheds for report analysis
Runoff Volume Calculations TR-55 Interpolation Calculations	NTTR and Proposed Expansion Areas	Internally Drained	Determine water surface elevations discharged to playas (dry lake beds)
Flow Rate Calculations HEC-1 Program	NTTR and Proposed Expansion Areas	Externally Drained	Determine peak flow rate discharged to basin outlet point
	Proposed Expansion Areas	Internally Drained	Determine peak flow rate discharged to a specific point within the basin – *Used to set up overland flow calculations*
Overland Flow Calculations AutoCAD Program, Hydraflow Express Extension	Proposed Expansion Areas	Internally and Externally Drained	Determine depth and velocity within a cross section

The US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) methods from the Technical Release No. 55 (TR-55) was used as guidance throughout the analysis for each GIS generated basin. TR-55 presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs (USDA, Soil Conservation Service,

1986). Other guidelines have been referenced, but these sources tend to include information and methods originating from the NRCS publications.

The Federal Emergency Management Agency (FEMA) flood zone data was also utilized in this analysis. However, the study area is located outside of the FEMA study area (FEMA, 2016). FEMA flood zones are present near the NTTR boundary and coincide with the results from the previous Floodplain Inventory Report by Baker Environmental Inc. (see figures in Appendix B). The FEMA maps that are adjacent to the boundary were used to validate the model results for this study as well.

FEMA maps available for the area near the NTTR boundary include the proposed expansion areas. The FEMA maps of the proposed expansion areas were also used to validate the model results for this study.

Hydrologic computer programs and extensions were used in addition to the TR-55 hand calculations. An overview of the data, methodology, and programs used for the various steps of the analysis are further discussed within the following sections.

Stream and Basin Delineation

Methods

Water basins are discrete units of geographic areas that consist of a single drainage system. A drainage system is comprised of a network of streams that drain offsite to a single location or onsite to a playa. The basins are characterized as either internally drained (the storm water runoff is maintained within the basin) or externally drained (the storm water runoff exits the basin).

The data utilized for delineation of streams and basin limits were USGS National Elevation Dataset 1/3 arc-second (10 meter) Digital Elevation Model (DEM) files. The DEM files were received as multiple, individual files that were consolidated into a single file for processing through the spatial analyst extension of ArcGIS software (ArcMap version 10.4.1). Valley collectors that consist of major conveyance pathways for water drainage within a basin were identified through this processing. Stream networks, also referred to as concentrated flow paths in this report, are representative of valley collectors. Many ephemeral streams were not revealed by GIS due to limits of the topographic data and it is beyond the scope of this report to show such detail on the expansive 2.9 million acres of site.

Prior to mapping the stream network, the DEM files were refined to elevate minor low spots and isolated depressions. This prevents water from accumulating in such spots that would result in processing errors. These modifications allow surface runoff to drain to well-defined preferential pathways and ultimately towards a single drainage outlet or single playa for the basin.

Custom-built GIS generated drainage basins were delineated for the current NTTR and proposed expansion areas from the processed DEM file. This delineation produced mostly large basins (<3,000 square miles). Secondary delineation was performed to subdivide the large basins to create one basin per major playa. This was completed by adding additional outlet or pour points on the stream network to create the sub-basins. The locations of these additional pour points were selected based on best engineering judgment. The GIS generated basins were checked against available aerial imagery and the USGS GIS topographic base map layer to validate that basin boundaries followed mountain ridges that may contain a drainage system, as characteristic of a water basin. The process of subdividing basins was repeated until it produced boundaries that were consistent with the engineer's interpretation of the topographic maps and aerial imagery.

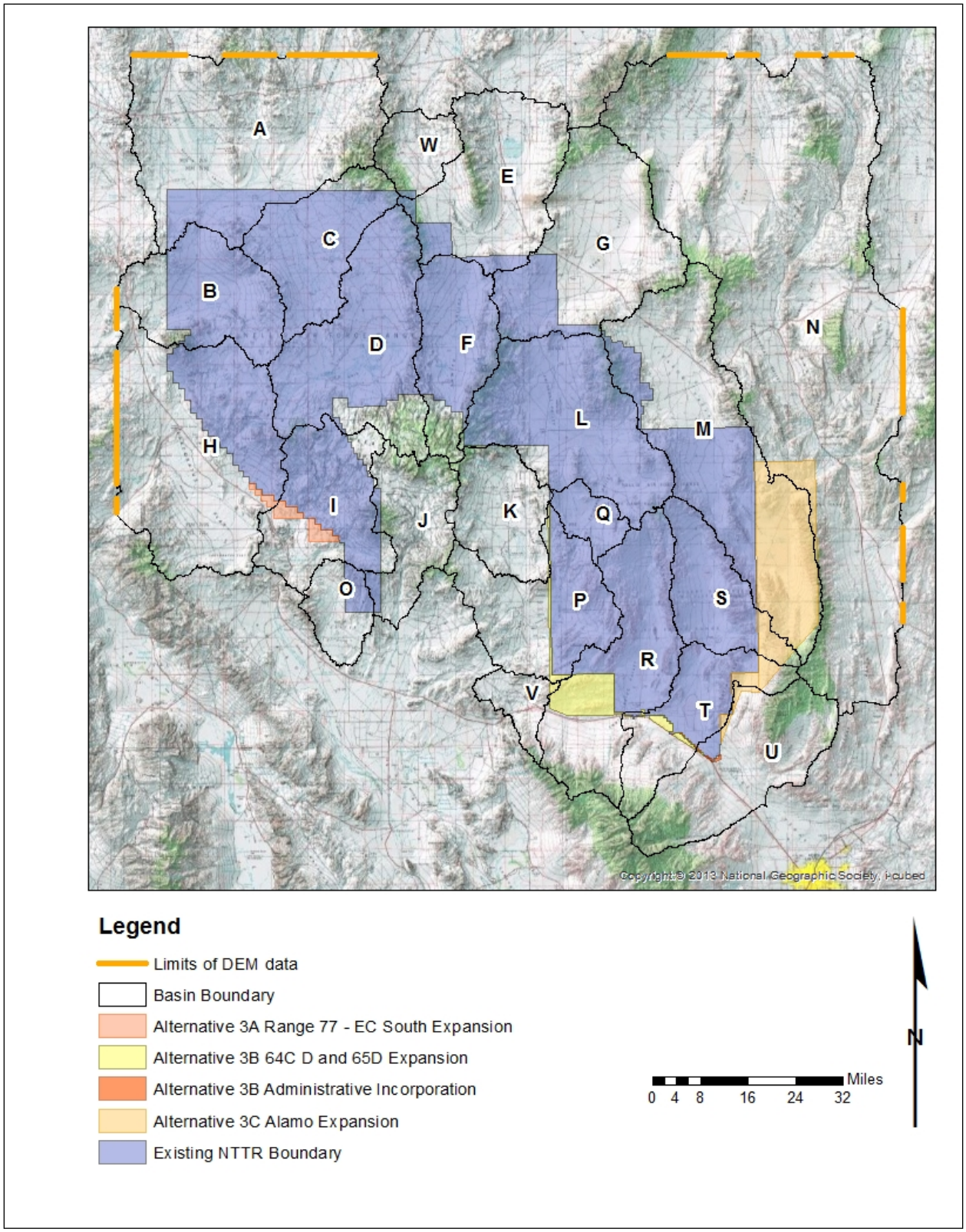


Figure 22. Hydrologic Basins

Results

A total of 23 drainage basins located within the NTTR and proposed expansion areas were ascertained using the methods described above. A summary of the basins generated and analyzed for NTTR and the expansion areas is included in Figure 22 and Tables 3 and 4.

Table 3. Areas of Hydrologic Basins within NTTR

Geographic Location	Basin Name	Total Basin Area (sq. mi.)	Basin Area Inside NTTR (sq. mi.)	Percent of NTTR
Ralston Valley/Stonecabin Valley	A	1,082	139	2.97
Stonewall Flat	B	430	333	7.12
Cactus Flat	C	386	349	7.46
Gold Flat	D	675	571	12.21
Reveille Valley/Railroad Valley	E	574	130	2.78
Kawich Valley	F	361	304	6.50
Sand Spring Valley	G	700	144	3.08
Sarcobatus Flat	H	981	298	6.37
Thirsty Canyon	I	448	267	5.71
Fortymile Canyon	J	306	21	0.45
Yucca Flat	K	298	1	0.02
Emigrant Valley	L	669	640	13.68
Tikaboo Valley/Desert Valley	M	991	330	7.05
Pahranagat Valley	N	2,919	1	0.02
Crater Flat	O	154	31	0.66
Frenchman Flat	P	458	209	4.47
Papoose Lake	Q	99	99	2.12
Indian Spring Valley	R	610	358	7.65
Three Lakes Valley (Northern)	S	304	268	5.73
Three Lakes Valley (Southern)	T	347	168	3.59
Yucca Forest	U	514	13	0.28
Mercury Valley	V	104	0	0
Reveille Valley	W	157	4	0.09
TOTAL	**23**	**13,567**	**4,678**	**100%**

Table 4. Areas of Hydrologic Basins within the Proposed Expansion Areas

Expansion Area	Basin Name	Basin Name	Total Basin Area (sq. mi.)	Basin Area Inside the Alternative (sq. mi.)	Percent of the Alternative
Alternative 3A	Sarcobatus Flat	H	981	7	1.4
	Thirsty Canyon	I	448	21	4.3
	Alternative 3A TOTAL	**2**	--	**28**	**5.8**
Alternative 3B—64 C/D & 65D	Frenchman Flat	P	458	11	2.3
	Indian Spring Valley	R	610	71	14.7
	Three Lakes Valley	T	347	8	1.7
	Mercury Valley	V	104	3	0.6
	64C/D &65D TOTAL	**4**	--	**93**	**19.2**
Alternative 3B—Administrative Incorporation	Three Lakes Valley	T	347	0.55	0.1
	Yucca Forest	U	514	1	0.2
	ADMIN INCORP TOTAL	**2**	--	**1.55**	**0.3**
Alternative 3C	Tikaboo Valley/Desert Valley	M	991	257	53.0
	Pahranagat Valley	N	2,919	39	8.0
	Three Lakes Valley (Northern)	S	304	28	5.8
	Three Lakes Valley (Southern)	T	347	30	6.2
	Yucca Forest	U	514	8	1.7
	Alternative 3C TOTAL	**5**	--	**362**	**74.7**

Some of the basins include areas where storm runoff either enters or leaves the NTTR. Offsite drainage enters NTTR property within Basins A, B, C, D, F, L, M, R, S, and T. Onsite drainage exits NTTR property within Basins A, E, G, H, I, J, K, M, N, O, P, U, and W. Basins A, I, and M have runoff entering at some locations and exiting at other locations. Refer to Figure 23 to view the basin delineations and general drainage patterns.

Portions of DEM data for Basins A, H, and N were not available, but were determined to not have a direct impact on the subject areas and were subsequently omitted from the hydrologic model. The locations of the omitted areas are labeled as “Limits of DEM Data” on Figure 2.0 located in Appendix B. Basin A extends approximately 28 miles north from the available DEM data limit. The runoff from this “off-site” area generally drains from north to south and concentrates in a playa, which is partly inside the NTTR land and partly outside. However, the remaining area of Basin A within the NTTR drains northwest off the range.

Runoff from the off-site portion of Basin H was found to drain towards a playa located outside the NTTR based on the review of USGS topographic maps. Off-site areas west of Basin H, located at the southwest corner of the NTTR, extend approximately 18 miles to the west. The runoff generally slopes from west to east and drains to an alkali flat (playa) at the center of the basin, which is approximately 8 miles southwest of the NTTR boundary.

Runoff from the off-site portion of Basin N drains away from the NTTR. Off-site areas north and east of Basin N, located at the eastern boundary of the NTTR, extend approximately 86 miles to the north and 6 miles to the east. Runoff generally drains southward and passes just east of the Alternative 3C proposed expansion area, eventually entering Pahranagat Wash on the way to Lake Mead.

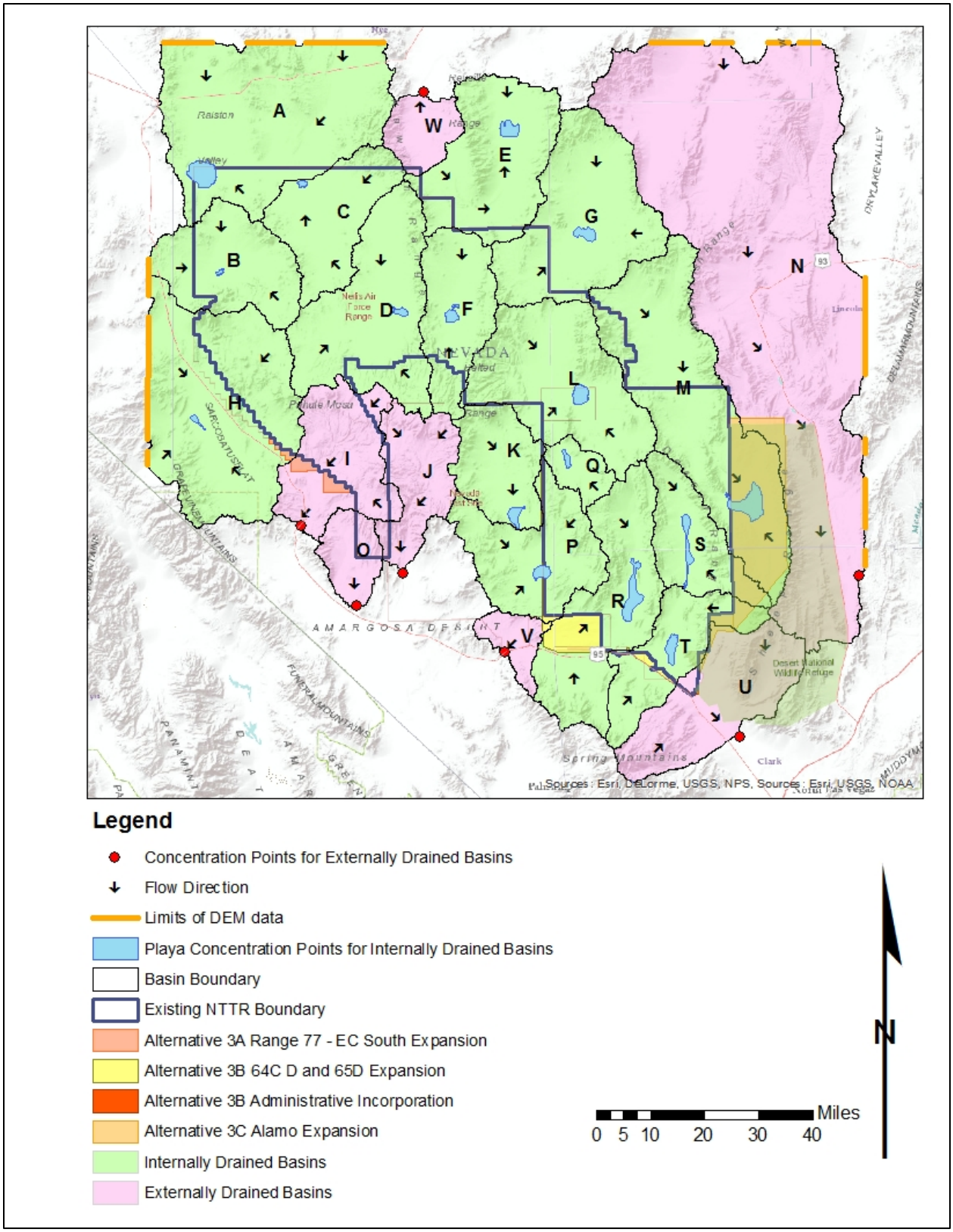


Figure 23. Internally and Externally Drained Basins

Tables 5-6 display the geographic location, drainage description, and storm water runoff pattern relative to the NTTR for internally and externally drained basins. Refer to Figures 5.1 – 5.23 located in Appendix B for individual basin overview maps with geographic features.

Table 5. Internally Drained Basins

Geographic/Basin Name	Basin Name	Drainage Description	Storm Runoff Relative to NTTR
Ralston Valley/Stonecabin Valley	A	Basin A is within Ralston and Stonecabin Valley and drains to the southwest to Mud Lake.	Both – Enters and Exits
Stonewall Flat	B	Basin B is within Stonewall Flat and drains to the center of the basin to a mud depression.	Enters
Cactus Flat	C	Basin C is within Cactus Flat and drains to the north to a mud depression.	Enters
Gold Flat	D	Basin D is within Gold Flat and drains to the east to a depression.	Enters
Reveille Valley/Railroad Valley	E	Basin E is within Reveille Valley and Railroad Valley and drains to the north to a mud depression.	Exits
Kawich Valley	F	Basin F is within Kawich Valley and drains to the center of the basin to a mud depression.	Enters
Sand Spring Valley	G	Basin G is within Sand Spring Valley and drains to the center of the basin to a playa.	Exits
Sarcobatus Flat	H	Basin H is within Sarcobatus Flat and drains to the center of the basin to the Alkali Flat.	Exits
Yucca Flat	K	Basin K is within Yucca Flat and drains to the south to Yucca Lake.	Exits
Emigrant Valley	L	Basin L is within Emigrant Valley and drains to the center of the basin to Groom Lake.	Enters
Tikaboo Valley/Desert Valley	M	Basin M is within Tikaboo Valley and Desert Valley and drains southeast to Desert Lake.	Both – Enters and Exits
Frenchman Flat	P	Basin P is within Frenchman Flat and drains to Frenchman Lake.	Exit
Emigrant Valley/ Papoose Lake	Q	Basin Q is within Emigrant Valley and drains to Papoose Lake.	N/A*
Indian Spring Valley	R	Basin R is within Indian Spring Valley and drains to the center of the basin to a playa.	Enters
Three Lakes Valley (Northern)	S	Basin S is within Three Lakes Valley and drains to Dog Bone Lake.	Enters
Three Lakes Valley (Southern)	T	Basin T is within Three Lakes Valley and drains to the center of the basin.	Enters
* Basin Q is an internally drained basin entirely within the NTTR and therefore runoff neither enters nor exits the NTTR.			

Table 6 describes the geographic location and drainage description for the externally drained basins.

Table 6. Externally Drained Basins

Geographic/Basin Name	Basin Name	Drainage Description	Storm Runoff Relative to NTTR
Thirsty Canyon	I	Basin I is within Thirsty Canyon and drains to the southwest to Beatty off the NTTR lands.	Both – Enters and Exits
Fortymile Canyon	J	Basin J is within Fortymile Canyon and drains to the south.	Exits
Pahranagat Valley	N	Basin N is within Pahranagat Valley and drains to the south.	Exits
Crater Flat	O	Basin O is within Crater Flat and drains towards the south	Exits
Yucca Forest	U	Basin U is within Yucca Forest and drains to the southeast towards Las Vegas	Exits
Mercury Valley	V	Basin V is within Mercury Valley and drains to the southwest.	N/A*
Reveille Valley	W	Basin W is within Reveille Valley and drains to the north.	Exits
* Basin V only impacts the proposed expansion area and therefore runoff would neither enter nor exit the NTTR.			

Runoff Volume Calculations

Methods

Runoff volumes were calculated by multiplying the basin areas by the runoff depth. Average runoff depths were interpolated from NRCS Table 2-1 based on average curve number (CN) values from the previous Flood Plain Inventory Report and National Oceanic and Atmospheric Administration (NOAA) rainfall data. The parameters required for these calculations are described below:

Basin Area: The area measurement of the GIS generated basin.

Curve Number (CN): The CN is based on various factors including the hydrologic soil group (HSG), cover type, hydrologic condition, and antecedent runoff condition (relative wetness or dryness of a watershed). A low CN corresponds to a lower runoff potential (e.g. sage brush) and a high CN corresponds to a higher runoff potential (e.g. bare rock). Antecedent runoff condition accounts for moisture content of soils from previous storm events, but was not incorporated due to the dry climate and higher CNs for the project area.

The USDA hydrology national engineering handbook chapter on hydrologic soil groups (HSG) defines four (4) HSG's as excerpted in the following descriptions:

- **Group A:** Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam, or silt loam textures, may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- **Group B:** Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

- **Group C:** Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through these soils is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- **Group D:** Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential. All soils with a depth to a water impermeable layer less than 50 centimeters [20 inches] and all soils with a water table within 60 centimeters [24 inches] of the surface are in this group, although some may have a dual classification, as described in the next section, if they can be adequately drained.

The NTTR land is primarily composed of undeveloped areas, native vegetation, limited roadways, and installations for base operations. The playas are fine-grained soils with low permeability, described as C or D hydrologic soil groups and classified as poor hydrologic condition. The valley collectors and overland areas present have higher permeability due to coarser material and are described as B or C type soils in poor condition. The mountainous areas are predominantly bare rock, which results in a higher CN due to the rock type generally being impermeable.

The HSG is often determined through the review of the Soil Survey Geographic Database (SSURGO); however, database information does not exist for the NTTR. SBCC reviewed and accepted the HSG data and CN of 85 from the previous Floodplain Inventory Report as representative for the regions under study. Refer to Appendix A for copies of the CN referenced material.

Precipitation Data: Precipitation estimates were found from the NOAA Atlas 14 Volume 1 in GIS data format. The data is 24-hour cumulative precipitation values with average recurrence intervals of 100 years and 500 years. Points from the center of the basin (centroid points) were determined and utilized to extract point precipitation values from the NOAA data for each basin. The centroid point data extraction method is used per Section 503 of the Clark County Regional Flood Control District (CCRFCD) Hydrologic Criteria & Drainage Design Manual (HC&DDM) (Clark County, 1999). These calculations involve liberal estimates due to the assumption that rainfall is evenly distributed over the entirety of the basin. Note that the centroid method was not used in the previous analysis.

Runoff Depth Table: Table 2-1 of the TR-55 labeled "runoff depth for selected CN's and rainfall amounts" is used to determine runoff depths for given CN's and rainfall amounts (depths) (See Appendix A). This table is the basis of the hand calculations performed for internally drained basins. Playa water surface elevations (depths) for the 100-year and 500-year storm events were determined for each internally drained basin. The storm water runoff volumes for the 100-year, 24-hour, and 500-year, 24-hour, storm events were first identified by multiplying the basin area by the interpolated runoff depth value obtained from Table 2-1 of the TR-55. Average lake bed bottom elevation and assumed top elevation were determined from the GIS topographic base map, then areas at each elevation were calculated. Total volume capacity for each lake bed was subsequently calculated using the average end area method. The average end area method is the average of the playa bottom area and assumed top area times the depth. Those runoff volumes were then interpolated to determine an estimated water surface elevation for the 100-year, 24-hour, and 500-year, 24-hour, storm events for each lake bed.

Results

Flood Zones are shown in Figures 6.1 through 6.23 and 7.1 through 7.23 in Appendix B. These figures include the following designations:

- GIS generated concentrated flow paths
- Predicted 100-year and 500-year playa water surfaces
- Alluvial fan and floodplain areas – The concentrated flow path locations and flow rates can vary between storms due to the characteristics of these areas (relatively flat cross sections and soil that easily erodes)
- Omitted GIS generated concentrated flow paths – GIS generated concentrated flow paths did not accurately reflect actual conditions in these areas because available topographic data had limited detail and accuracy

The following table summarizes estimated storm water runoff volumes and playa water surface elevations:

Table 7. Playa Volumes and Water Surface Elevations in Internally Drained Basins

Basin Name	Geographic Location	Basin Area (sq mi.)	100-year 24hr Runoff Volume (ac-ft)	500-year 24hr Runoff Volume (ac-ft)	100-year 24hr Water Surface Elevation (ft)	500-year 24hr Water Surface Elevation (ft)	100-year 24hr depth (ft)	500-year 24hr depth (ft)
A	Ralston Valley / Stonecabin Valley	1,082	58,284	85,983	5,190.7	5,192.5	3.7	5.5
B	Stonewall Flat	430	23,621	35,776	4,634.8	4,638.3	6.8	10.3
C	Cactus Flat	386	22,645	33,350	5,342.1	5,347.4	11.1	16.4
D	Gold Flat	675	48,960	74,160	5,066.4	5,069.7	6.4	9.7
E	Reveille Valley / Railroad Valley	574	38,267	56,635	4,854.0	4,856.9	6	8.9
F	Kawich Valley	361	32,153	47,556	5,324.0	5,326.9	6	8.9
G	Sand Spring Valley	700	57,867	84,000	4,740.6	4,744.9	9.6	13.9
H	Sarcobatus Flat	981	75,341	115,627	3,950.7	3,954.4	6.7	10.4
K	Yucca Flat	298	29,721	44,025	3,924.9	3,927.8	5.9	8.8
L	Emigrant Valley	669	63,867	92,768	4,447.1	4,450.8	8.1	11.8
M	Tikaboo Valley / Desert Valley	991	84,037	120,506	3,211.0	3,213.1	5	7.1
P	Frenchman Flat	458	34,197	51,052	3,085.3	3,088.5	6.3	9.5
Q	Emigrant Valley / Papoose Lake	99	11,141	16,210	4,572.2	4,573.3	2.2	3.3
R	Indian Spring Valley	610	38,715	60,837	3,021.2	3,023.0	3.2	5
S	Three Lakes Valley (Northern)	304	24,644	34,534	3,422.1	3,423.4	3.1	4.4
T	Three Lakes Valley (Southern)	347	22,023	34,422	3,033.5	3,035.5	3.5	5.5

Estimated playa water surface elevations for the 100-year and 500-year 24-hour storm events were also delineated on Figures 6.1 – 6.23 and 7.1 – 7.23 of Appendix B. Runoff depth interpolation calculations for both 100-year and 500-year storm events are provided in Appendix C. Also refer to Appendix C for the water surface elevation interpolation calculations, including Table C-1 for the runoff volume calculations summary.

Flow Rate Calculations

Methods

The US Army Corps of Engineer (USACE) HEC-1 program was used to determine peak flow rate for the 100-year (Q_{100}) and 500-year (Q_{500}) storm events at the outlet point of externally drained basins. Flow rate calculations were also conducted for internally drained basins located within proposed expansion areas. The Hydrologic Engineering Center (HEC) is an organization within the Institute for Water Resources of the USACE. HEC provides technical methods and guidance including software for watershed analysis. The parameters required for these calculations are described below:

Basin Area: The area measurement of the GIS generated basin.

Curve Number (CN): See discussion on CNs included in the previous section.

Precipitation Data:

- Precipitation Depth: Basin Centroid NOAA point precipitation data as previously detailed.
- Precipitation Ratio: Ratios between the 100-year and 500-year event centroid NOAA precipitation numbers. This enables the model to compute both storm events in the HEC-1 program.
- Precipitation Distribution: Figure B-2 of the TR-55 labeled “approximate geographic boundaries for NRCS rainfall distributions” describes the study area as being within a Type II rainfall distribution area. Standard 24-hour NRCS Type II rainfall distribution data at six minute intervals were applied.

These calculations assume rainfall is evenly distributed over the entirety of the basin.

Lag Time Values: Lag time equations are used to determine the lag (in hours) between the center of mass of rainfall excess and the peak of the unit hydrograph. The unit hydrograph is a model of the storm water runoff generated within the HEC-1 program utilizing the NRCS rainfall distribution. Lag time is related to the time of concentration, which is a measure of the time it takes for the water within the basin to flow from the furthest upstream concentration point to the basin outlet. The lag time equation is referenced from Section 606.3 in the CCRFCD HC&DDM, which also includes references to NRCS. Variables for the lag time equation are:

- Manning’s roughness factor for the basin channels. A Manning’s Roughness Factor (K_n) of 0.030 was chosen per Table 604 of the CCRFCD HC&DDM. This is defined as natural areas with water courses in the drainage area that are well defined, unimproved channels or washes and a watershed that has minimal vegetation.
- Length of longest watercourse (the furthest point in the stream network from the outlet point). Measurements were determined along the GIS generated stream network from the basin outlet to the furthest upstream point of concentration.
- Length along longest watercourse measured upstream to a point opposite the centroid of the basin. Measurements were determined using the GIS generated stream network.
- Representative (average) slope of the longest watercourse. Slopes were determined using contour information from the USGS GIS topographic base map.

These variables were input into the HEC-1 program and a report was produced for select basins for peak flow rates at the outlet point. Refer to Appendix C for the HEC-1 reports for the select basins.

The HEC-1 results were utilized to quantify flow rates of the proposed expansion areas. This was completed through calculating a runoff factor, which is the ratio of the HEC-1 total flow rate for the basin and the basin area. This basin runoff factor was then multiplied by the area of the basin within that expansion area.

Results

The following table summarizes the peak flow rates of storm water runoff at the outlet point of externally drained basins for the 100-year (Q_{100}) and 500-year (Q_{500}) storm events. Note that internally drained basins were included in the HEC-1 analysis if they contained any portions of the proposed expansion areas.

Table 8. HEC-1 Results for Externally and Internally Drained Basins

Basin Name	Geographic Location	Basin Area (sq mi.)	Q_{100} (cfs)	Q_{500} (cfs)
H	Sarcobatus Flat	981	116,077	179,899
I	Thirsty Canyon	448	92,187	140,504
J	Fortymile Canyon	306	80,249	119,606
M	Tikaboo Valley / Desert Valley	991	118,460	171,617
N	Pahranagat Valley	2,919	276,024	397,313
O	Crater Flat	154	35,508	56,446
P	Frenchman Flat	458	67,770	103,483
R	Indian Spring Valley	610	92,367	146,223
S	Three Lakes Valley	304	65,119	93,070
T	Three Lakes Valley	347	65,623	104,018
U	Yucca Forest	514	109,479	172,035
V	Mercury Valley	104	42,484	63,896
W	Reveille Valley	157	37,089	55,627

The flow results from utilizing HEC-1 results for the proposed expansion areas are summarized below:

Table 9. Proposed Expansion Areas Flow Rates

Alternative Name	Alternative Area (sq. mi.)	Q_{100} (cfs)	Q_{500} (cfs)
Alternative 3A	28	5,150	7,870
Alternative 3B 64 C/D & 65D Expansion	93	15,117	23,746
Alternative 3B Administrative Incorporation	1.55	317	500
Alternative 3C	362	47,784	70,057

Overland Flow Calculations

Methods

Overland flow calculations were conducted for cross sections chosen in 100-year FEMA flood zones within the proposed expansion areas using results from the flow rate calculations to determine the depth and velocity. Flow depths and velocities were determined at three critical sections (Sections I, R1 and R2) to analyze major collectors impacting the proposed expansion areas. Each section label corresponds to the drainage basin where it is located. This analysis was conducted utilizing the Hydraflow Express extension for AutoCAD Civil 3D, which produced flow velocities and depth of flow. The parameters required for these calculations are described below:

Cross Sectional Geometry: Cross sectional geometry and slopes were derived from the USGS GIS topographic base map at 1:24,000 scale. A cross-section is the profile cut perpendicular to the stream or probable flood zone flow path. The cross-section "cut" line functions as the x-axis and the elevation functions as the y-axis. Contour lines that demonstrate the elevation (y-value) on the topographic base map that intersect with the cross-section line were noted. The horizontal distance of the stream at the cross-section at one to two contour lines from each side of the flow line was measured with the GIS measuring tool (x-value). The flow line, or streambed, is defined as the lowest elevation of the cross-section. Those points were then input into the Hydraflow program in X and Y data format.

Average Slope: The average slope is determined by dividing the elevation difference by the distance between the contours immediately upstream and downstream of the cross-section.

Flow Rate Calculation Findings: Flow rate values from the HEC-1 program results were input into the Hydraflow program to determine estimated flow depths and velocities at each section.

Manning's Roughness Coefficient: Manning's roughness coefficient (n) of 0.035 was used, per Table 702 of the CCRFCD HC&DDM for natural channels with earth or sand bottom with sides of trees and shrubs.

Note that the flow rates utilized in the hydraulic calculations were based upon the amount of rainfall over the entire basin during the 100-year, 24 hour, and 500-year, 24 hour, storm event. However, the entire basin does not necessarily discharge through the delineated cross-sections. For example, the entire runoff flow generated by Basin R was analyzed through Section R1/R2, even though a portion of Basin R drains towards a playa at the center of the basin. Therefore, this calculation produces liberal estimates for this study and a site-specific study for proposed future projects should be undertaken if a more accurate estimate of the impacts is needed. Refer to the following Hydraulic Results figure, summary table, and the hydraulic calculations located in Appendix D.

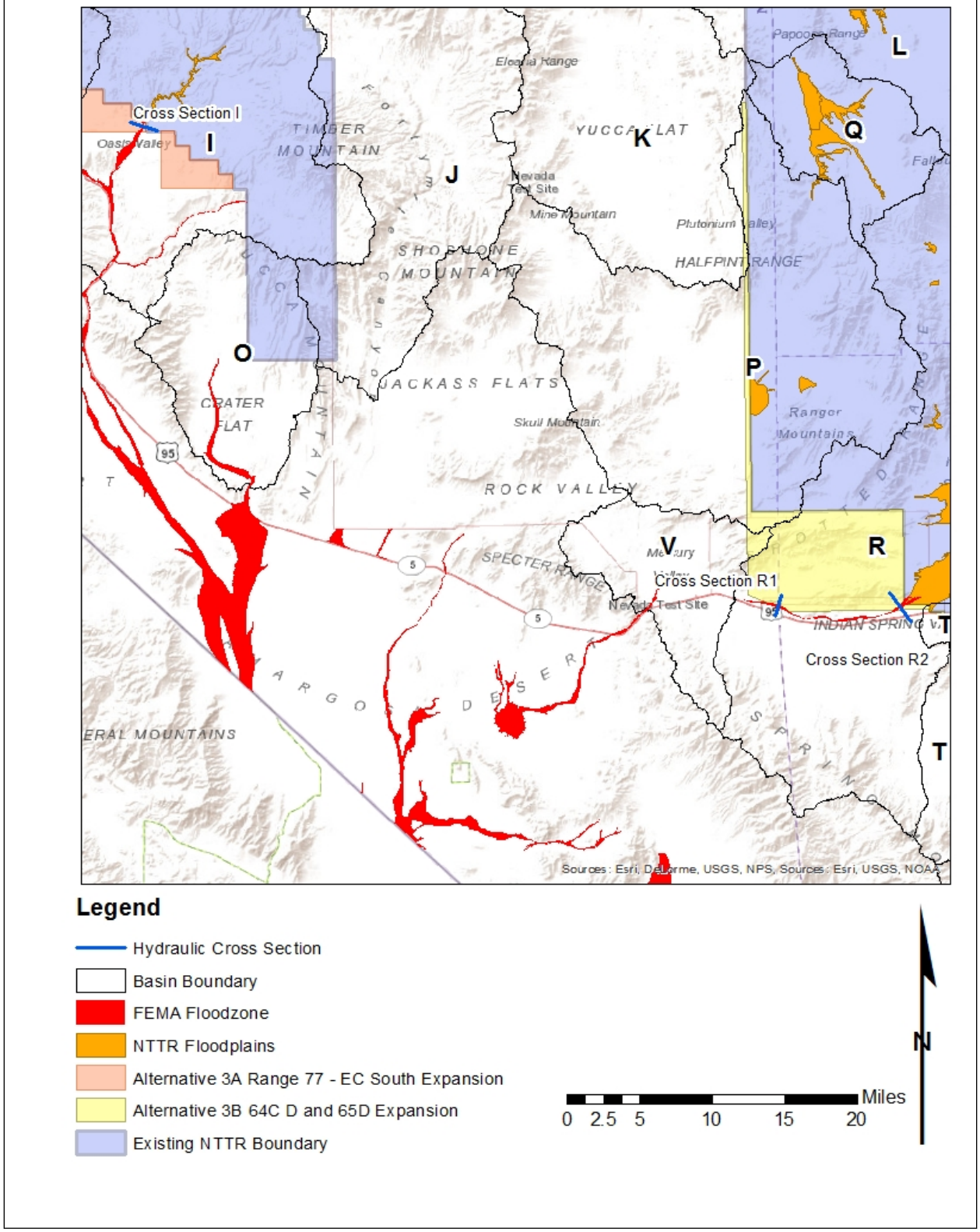


Figure 24. Hydraulic Cross Section Locations

Results

The following table summarizes the storm water flow velocities and depths of the three (3) cross-sections that directly impact the proposed expansion areas:

Table 10. Hydraulic Results

Cross-Section	100-year, 24-hour			500-year, 24-hour		
	Q_{100} (cfs)	Velocity (ft/s)	Depth (ft)	Q_{500} (cfs)	Velocity (ft/s)	Depth (ft)
Cross-Section I (Thirsty Canyon)	92,187	14.88	11.55	140,504	16.70	13.92
Cross-Section R1 (Indian Springs Valley)	92,367	9.23	7.24	146,223	10.52	9.19
Cross-Section R2 (Indian Springs Valley)	92,367	10.25	5.57	146,223	11.77	7.15

The water surface elevations determined at the critical hydraulic cross sections are consistent with the existing FEMA designated flood zone elevations for the 100-year storm event. Refer to Figures 4.0 - 4.3 in Appendix B for the cross-section delineations and the Hydraflow calculation reports located in Appendix D.

Summary

The data reviewed and produced through this analysis is represented through spatial data provided in the Appendix. A description of this data is included In Figures 25-27.

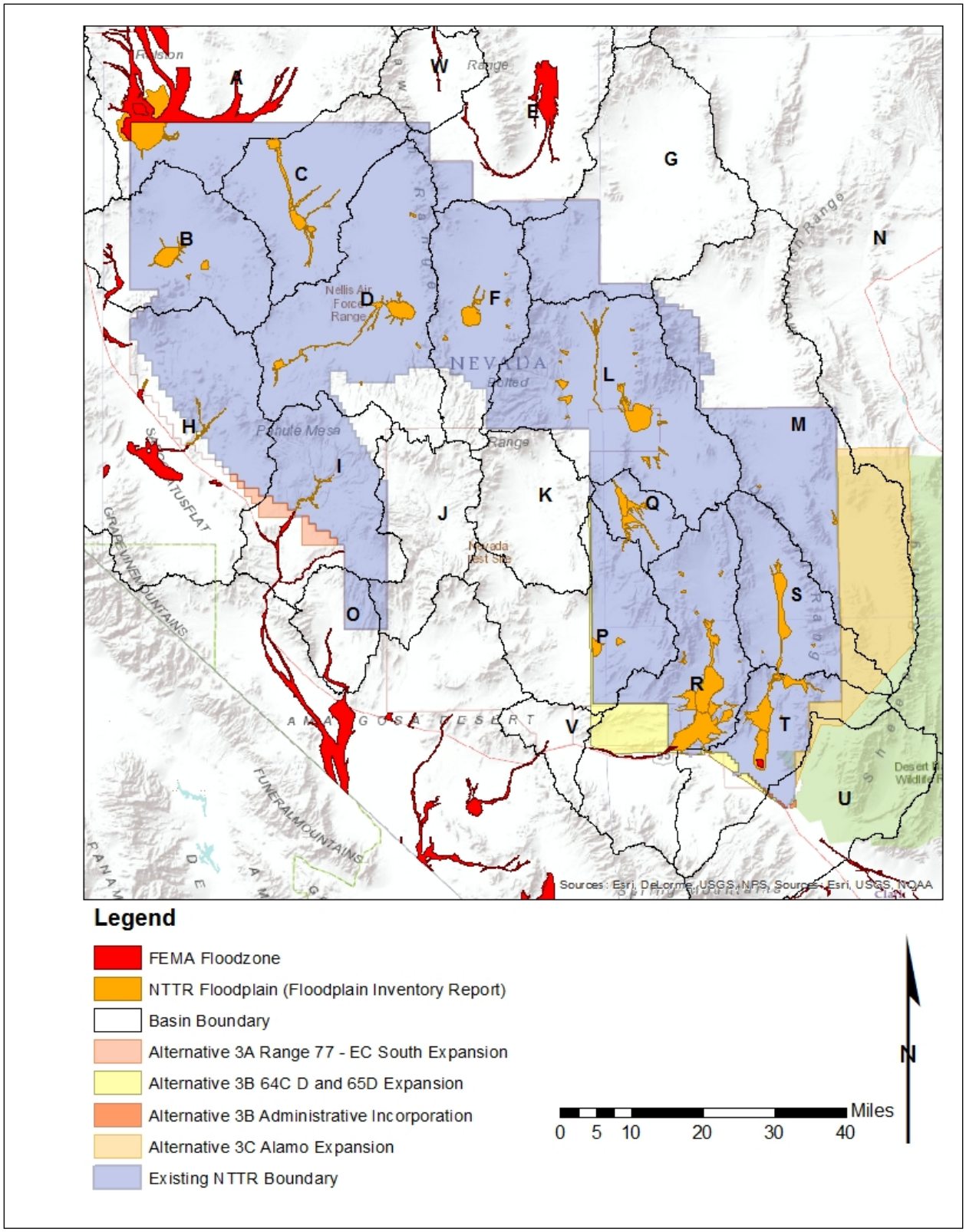


Figure 25. Existing FEMA Flood Zones & NTTR Floodplains

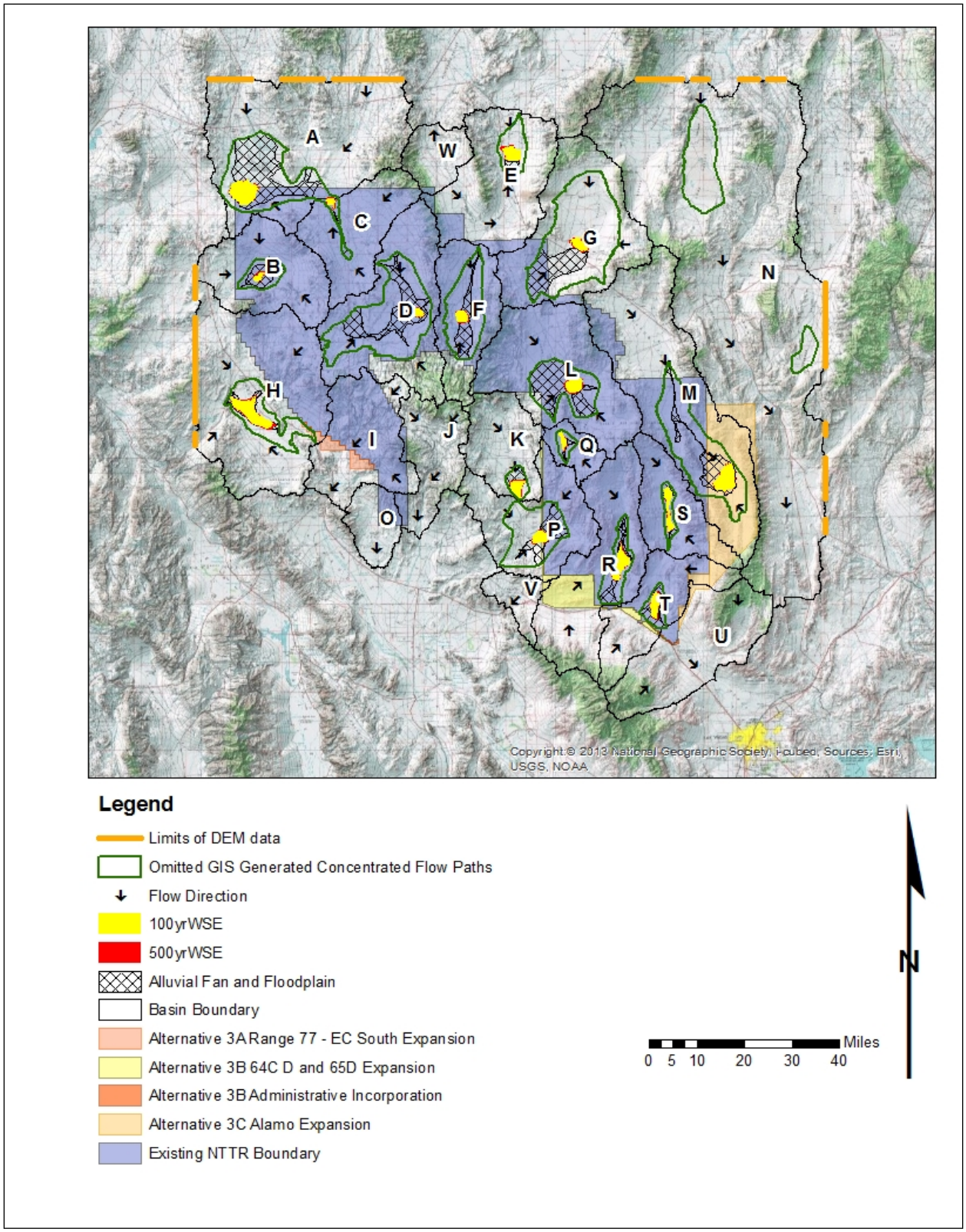


Figure 26. Proposed Flood Zones for NTTR with Topographic Base Map

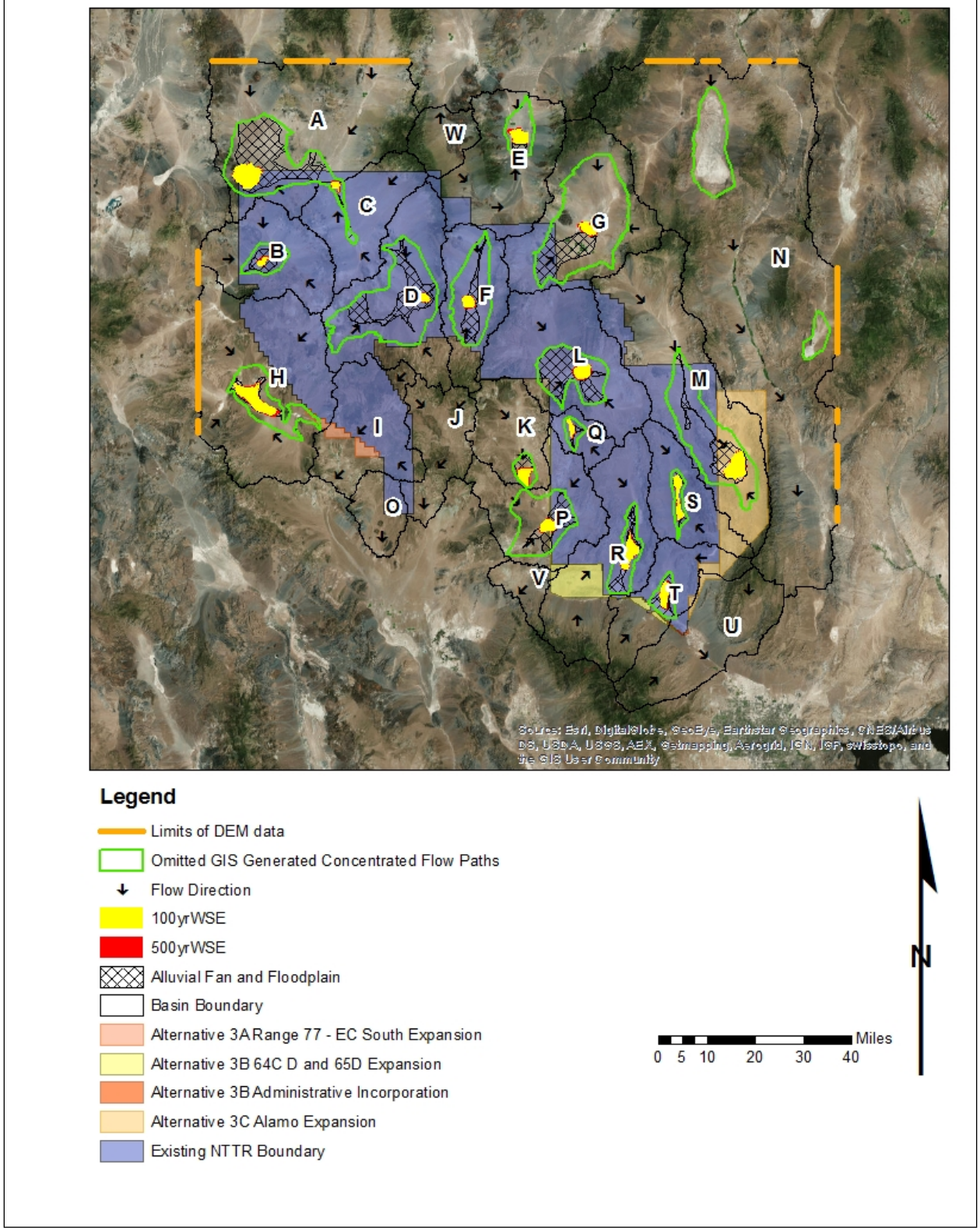


Figure 27. Proposed Flood Zones for NTTR with Aerial Image

Table 11. GIS Spatial Data Summary

Shapefile	Source(s)
100-year Floodplains	Previous Floodplain Inventory Report by Baker Inc.
100-year Flood Zones	FEMA
100-year Playa Water Surface Elevation (Flood Zones)	Runoff calculations from this analysis
500-year Playa Water Surface Elevation (Flood Zones)	Runoff calculations from this analysis
Concentrated Flow Paths	GIS processing from this analysis
Alluvial Fans and Floodplains	Manual editing from this analysis

NTTR Floodplain GIS data was included from the previous Floodplain Inventory Report for the existing NTTR boundary and FEMA flood zone GIS data for the proposed expansion areas. FEMA GIS data was not available for the NTTR; however, data was available around the boundary of the NTTR that incorporate the proposed expansion areas. Furthermore, only the 100-year, 24 hour, storm event GIS data was available from FEMA. The delineated floodplains developed from the analysis within this report are included as 100-year, 24 hour, and 500-year, 24 hour, storm events.

The spatial data described above are represented through multiple figure series as outlined in the following table:

Table 12. Figure Series Overview

Figure Series	Series Description	Base Map Layer Source
1	Mountain Ranges and Valleys of the NTTR	National Geographic by National Geographic, ESRI and various others
2	Overview maps of the GIS generated basins	World Terrain with Labels by ESRI, USGS, NOAA, DeLorme, NPS
3	Flood zone reference materials: GIS data from FEMA and the previous Floodplain Inventory Report.	World Terrain with Labels by ESRI, USGS, NOAA, DeLorme, NPS
4	Overall hydraulic cross sections	World Terrain with Labels by ESRI, USGS, NOAA, DeLorme, NPS
	Detailed hydraulic cross sections I, R1 West and R2 East	Topographic by National Geographic Society
	NOAA Rainfall data	None
5	Individual maps of the GIS generated basins	Topographic by National Geographic Society
6	Flood zone maps of Playa Water Surface Elevation (Flood Zones) derived from this analysis – Topography	Topographic by National Geographic Society
7	Flood zone maps of Playa Water Surface Elevation (Flood Zones) derived from this analysis – Aerial Imagery	Imagery by ESRI and various GIS contributors
8	Flood zone maps of Playa Water Surface Elevation (Flood Zones) derived from this analysis – Focused on Expansion Areas – Aerial Imagery	Imagery by ESRI and various GIS contributors

The GIS generated stream networks include channelized streams within alluvial fans and playas, which is not generally characteristic of these features. The streams within these areas were omitted from the figures for this report. A combination of reviewing the stream networks with aerial imagery was used to identify such areas.

The remaining GIS generated stream network delineates concentrated flow paths discharging to a sheet flow area (alluvial fan or playa) or conveyed to a basin outlet via a stream. Flood zone exhibits displaying the GIS generated stream network are provided for each basin as within Figure Series 6, 7, and 8 located in Appendix B. A summary of areas on the NTTR and proposed expansion areas potentially affected by flood zones is included below:

Table 13. NTTR and Proposed Expansion Areas Basins Potentially Affected by Flood Zones

Geographic Location	Basin Name	Reference Materials (Figure Series 3)		Analysis Findings (Figure Series 6 and 7)	
		FEMA, 100-year Flood Zones Present?	Previous Report, 100-year Flood Zones present?	This Report, 100-year Flood Zones present?	This Report, 500-year Flood Zones present?
Ralston Valley / Stonecabin Valley	A	N/A	Yes	Yes	Yes
Stonewall Flat	B	N/A	Yes	Yes	Yes
Cactus Flat	C	N/A	Yes	Yes	Yes
Gold Flat	D	N/A	Yes	Yes	Yes
Reveille Valley / Railroad Valley	E	N/A	No	No	No
Kawich Valley	F	N/A	Yes	Yes	Yes
Sand Spring Valley	G	N/A	No	No	No
Sarcobatus Flat*	H	No	Yes	No	No
Thirsty Canyon*	I	Yes	Yes	No	No
Fortymile Canyon	J	N/A	No	No	No
Yucca Flat	K	N/A	No	No	No
Emigrant Valley	L	N/A	Yes	Yes	Yes
Tikaboo Valley/Desert Valley*	M	No	Yes	Yes	Yes
Pahranagat Valley*	N	No	No	No	No
Crater Flat	O	N/A	No	No	No
Frenchman Flat*	P	No	Yes	Yes	Yes
Papoose Lake	Q	N/A	Yes	Yes	Yes
Indian Spring Valley*	R	Yes	Yes	Yes	Yes
Three Lakes Valley (Northern)*	S	No	Yes	Yes	Yes
Three Lakes Valley (Southern)*	T	Yes	Yes	Yes	Yes
Yucca Forest*	U	Yes	No	No	No
Mercury Valley*	V	No	No	No	No
Reveille Valley	W	N/A	No	No	No

N/A: Not available
*Within Proposed Expansion Area(s)

Existing improvements identified in Basin L through aerial imagery is located within the 100-year and 500-year flood. Further investigation is needed to determine the extent these facilities located on the NTTR would be impacted. Other facilities that are found to be located within or surrounding 100-year and 500-year flood zones should undergo additional analysis.

It should be noted that strong winds may alter localized water surface elevations and will correspondingly extend the shoreline. Therefore, development in the flat areas in the immediate vicinity of a predicted playa shoreline is discouraged.

HYDROLOGIC IMPACTS

There is minimal impact from storm water runoff on current NTTR Improvements. Storm runoff primarily follows natural drainage patterns since there is minimal development within the area and the effects are localized. Some of the existing structures may redirect runoff around them, but the runoff returns to the natural course within a relatively short distance. Ultimately, the runoff will concentrate within the playas or continue toward natural runoff discharge points with negligible differences in volumes and flow rates when compared to natural conditions. Development of the NTTR has not significantly altered drainage patterns throughout the range.

Some existing improvements located within Basin L adjacent to the playa may be affected by 100-year or 500-year floods. However, this analysis was conducted with topographic information lacking sufficient detail to confirm if the facilities are adequately protected from flooding. The scope of work for this report did not include visits to observe conditions around existing developments. Further investigation under the direction of a qualified engineer should be performed if the effects of erosion or flooding are apparent.

Overall drainage patterns and storm water runoff volumes are not anticipated to change significantly in the future within the NTTR unless future development is significantly larger than any of the current developments. Future development sites should be designed in accordance with Nevada Drainage Law to assess and mitigate hydrologic impacts.

Potential storm runoff flow paths and playas should be avoided. Figures 6.1 to 6.23 in Appendix B show flow paths and playas on a USGS topographic map background. Figures 7.1 to 7.23 in Appendix B show the same features, but on an aerial photograph background. This study was not intended to clear sites for construction due to the size of the NTTR and lack of accuracy in the topographic information. It is intended as a planning tool to identify smaller expanses of land within the 3.2 million acres that may warrant further investigation. Further investigations may include the reconnaissance of washes or other natural features.

Erosion resulting from development and potential migration of contamination are the two primary concerns with building in flood zones. Sediment is conveyed down the mountain within the runoff and is deposited at the alluvial fans as the runoff spreads out and loses velocity. Sediments within the flow continue to wash through streams toward the playas. Development within flood prone areas will likely increase the potential for erosion which in turn potentially spreads deposits over relatively large flat areas. The natural soil forms a crust over time that helps prevent erosion, and vegetation holds the soil in place. When disturbed, both natural conditions are removed and erosion becomes more prominent. Additionally, when contamination occurs within flood zones, the water can carry the contamination resulting in expansion of the contaminated area thus concentrating contamination in playas, or carrying contamination onto or off the NTTR.

CONCLUSION

The purpose of this hydrology report is to delineate and analyze drainage basins to identify areas that are subject to flooding. The report was prepared in support of the LEIS for currently withdrawn NTTR land and proposed expansion areas.

Areas of potential flooding include:

- Areas within the flood zones identified from the previous Floodplain Inventory Report.
- FEMA designated flood zones.
- Areas crossing or adjacent to concentrated flow paths generated by GIS.
- Areas determined to be within the 100-year and 500-year flood zone or playa water surface elevation through this report's calculations.

The hatched areas delineated in the appendix figures as alluvial fan and floodplain are areas anticipated to be impacted by concentrated runoff. The remaining unhatched areas within the omitted GIS generated flow paths area are described as sheet flow zones and do not have defined concentrated flow paths. Both of those areas would require further analysis to determine flow depths and susceptibility to erosion. These potential flood zones are shown on Figures 6.1 - 6.23 and Figures 7.1 - 7.23 located in Appendix B. Development within a flood zone is not encouraged; however, if such development is necessary, significant drainage improvements should be anticipated to mitigate the flood and erosion potential.

The information in this report should be used as a general planning tool only. Additional studies should also be conducted to help evaluate site suitability for development. It is recommended to conduct additional assessment of impacts of proposed development through completion of the following site-specific studies prior to construction:

- Completion of accurate survey of the area.
- Preparation of a preliminary site plan.
- Preparation of a preliminary grading plan.
- Preparation of a TDS.

Seeps and Springs

INTRODUCTION



Log Spring in the Northeast North Range

Seeps and springs are unique natural resources found throughout the Nevada Test and Training Range (NTTR) and proposed expansion alternatives associated with the renewal of the withdrawn land for the U.S. Air Force (USAF). In a desert ecosystem, these features are uncommon and are a vital source of water and forage for various species of plants and wildlife. Wildlife habitat ranges are often limited by proximity to seeps and springs, especially during the summer when temperatures are high and conditions are dry. A sustainable military training environment at NTTR must include judicious conservation and management of these critical natural resources. This report discusses the seeps and springs found on NTTR and the proposed expansion alternatives. Wetlands and other jurisdictional waters will be discussed in a separate report.

This report documents all the information gathered for seeps and springs located in NTTR and the proposed expansion alternatives (Figure 1). Numbers in parentheses refer to the number of a reference as listed in the "Works Cited" section at the end of the report. Each water feature listed in this report includes a short description of the feature, site specific data, photographs (if available), topographic map of the area, and historical information (if available). Historical information and documents were obtained from the Nevada Division of Water Resources (NDWR) database (Nevada Division of Water Resources, 2016). The site-specific data was collected from the following sources:

- **Coordinates**: Collected during formal seeps and springs surveys conducted from 2009-2016 (Nellis Natural Resources Program, 2016A; Nellis Natural Resources Program, 2014; Nellis Natural Resources Program, 2016B; Nellis Natural Resources Program, 2016C; Nellis Natural Resources Program, 2016D; Nellis Natural Resources Program, 2016E).
- **Elevation**: USGS Digital Elevation map, provided in feet above Mean Sea Level (MSL) or data collected in the field during surveys.
- **Vegetation**: List of the dominant plants identified on site and any rare, protected, or sensitive plants observed in the area. In most cases, the list of vegetation was derived from field surveys unless the seep or spring was inaccessible. In those cases, plant species were determined by observation from a helicopter.

When seeps and springs were surveyed, their status as a water feature was determined. In most cases, these determinations were made after springs were observed at least two times in two different years between 2005 and 2015, with one observation preferably occurring during the dry season (July – September). The classification of these springs is developed to accommodate natural resources management. Therefore, the most important characteristic of the feature is the source and permanence of the water. Basically, perennial or permanent springs flow throughout the year while intermittent or temporary springs flow only during or after rain when the water table is temporarily high. The flow of intermittent

springs is not always related to the fluctuations in rainfall (Kirk, 1919). For the purposes of this report, water features are designated as follows:

- ***Perennial Spring:*** Maintains flowing water for most of the year. Source of water is usually an artesian ground water point source. In many cases, this determination is drawn from historic designation and may not be applicable for the present time. However, it will be listed as perennial if it was considered perennial in the past. As more surveys are conducted, the perennial nature of the springs can be ascertained.
- ***Intermittent Spring:*** Flows periodically during the year, but may be completely dry at times. Source of water is usually an intermittent artesian groundwater point source.



Water in a tank being sampled and analyzed at Corral Spring.

- ***Perennial Seep:*** Vegetation is green and composition is dominated by facultative, facultative wet, and obligate wetland plants. Soils are moist or saturated year-round. Origin of water is an exposed shallow water table.
- ***Intermittent Seep:*** Vegetation is green and soils are moist or saturated at times, but at other times, vegetation may be desiccated and soils dry. Facultative upland and facultative plants tend to dominate this type of seep. Origin of water is a sporadically exposed shallow water table.
- ***Surface Water Accumulation:*** All water originates from melting snows or precipitation flowing on the surface of the land and accumulating in areas permanently or intermittently.
- ***Construction Pond:*** Man-made pond used to accumulate water for construction uses. The water usually is pumped from a well.
- ***Wildlife Water Development:*** A man-made structure generally constructed to accumulate, store and distribute rain water for use by wildlife. Wildlife water developments may also be used to supplement a spring water source or provide better access or storage of water.
- ***Mesic Plant Community:*** An area that accumulates sufficient surface moisture to support plants adapted to a more mesic or moist environment. These areas typically do not have standing water or saturated soils. Plants tend to be adapted to moist conditions, but can survive dry periods. These areas are easy to identify because they appear to be greener than the surrounding environment.

NTTR and the proposed expansion alternatives include 135 known water features (Nellis Air Force Base, 2016; U.S. Fish and Wildlife Service, 2016A; U.S. Fish and Wildlife Service, 2016B). This includes 46 perennial springs, 20 intermittent springs, seven perennial seeps and 36 intermittent seeps. It also includes one surface water accumulation, four construction ponds and 22 wildlife water developments.

This report is a living document which will be updated, as necessary, when new seeps and springs are discovered, or if existing springs or seeps become dry and are no longer active and useful to wildlife or no longer support mesic vegetation. Protecting and conserving these precious resources are critical in sustaining the military training environment on NTTR for use by future generations.

This report is a compilation of past reports and historic documents as well as current surveys conducted to identify and describe seeps and springs of NTTR and the proposed expansion alternatives. Beginning in 2004 and continuing through 2016, the Nellis Air Force Base Natural Resources Program (NNRP) initiated surveys to characterize and locate all seeps and springs on NTTR. This effort included a thorough review of historic documents concerning ownership of the springs on NTTR. Several reports were prepared documenting this information (Nellis Natural Resources Program, 2014; Nellis Natural Resources Program, 2016A; Nellis Natural Resources Program, 2016B; Nellis Natural Resources Program, 2016C; Nellis Natural Resources Program, 2016D; Nellis Natural Resources Program, 2016E). These reports were specifically written to provide baseline information for NTTR natural resources management and for the preparation of the LEIS. Much of the information contained in this report was copied directly from those documents since they had been approved by the USAF. In 2016, additional surveys were conducted to characterize and identify seeps and springs on the proposed expansion areas. Results of these surveys are included in this document in separate sections for Proposed Expansion Alternatives 3A, 3B, and 3C found on pages 173-181.

In this report, seeps and springs are designated as "Developed" or "Fenced". "Developed" indicates that the spring has been altered or enhanced by human activities in the past or present time. "Fenced" indicates that the spring has been enclosed by a fence to protect the spring from wild horses. If the seep or spring has no designation, it has not been altered and is in its natural setting.

NTTR Studies

A survey conducted in 1996 by Dames and Moore (Dames and Moore, 1996) delineated the boundaries and determined the jurisdictional status of 63 known springs on NTTR with respect to Section 404 of the Clean Water Act (33 U.S.C. 1344). Jurisdictional status of the seeps and springs identified in this report will be discussed in the jurisdictional waters report to be submitted at a later date. A survey of appropriated waters on NTTR was conducted to identify holders of Certificates of Appropriation for springs and other surface waters on NTTR (TRC Mariah Associates, 1996). This information, in combination with other data on seeps and springs, was used as a baseline to initiate the 2004 survey. For the 2004 seeps and springs survey, transects were flown via helicopter across the North Range of NTTR to confirm the location of known springs and to identify and describe seeps and springs that had not been previously found. The distance between helicopter transects varied according to vegetation and terrain. For example, in mountainous areas such as the Kawich Range, which is dominated by a relatively dense pinyon-juniper community, transects were generally flown along all canyons and drainages. In other areas dominated by sparse desert vegetation, transects were flown higher and covered several washes at one time. Desert basins and playas were inspected for the presence of reservoirs and dugouts, but not seeps and springs unless they had been previously identified, or showed obvious evidence of a water feature, such as the presence of lush, green vegetation or visible surface water that persisted for long periods of time.



Cedar Spring

Data collected during these surveys were general and mostly entailed pinpointing coordinates for the seep or spring and providing a general description of the spring status, such as “standing water”, “wetland vegetation”, or “mesic vegetation”. The intent was to locate the springs and gather detailed information to characterize the springs on a subsequent survey.

In early 2009, a draft report was written to document all seeps and springs discovered by the 2004 to 2009 surveys, including any historic springs that had not yet been visually confirmed. Each of the seeps and springs observed was located by GPS and photographed when optics were allowed. General information, such as vegetation and terrain, was collected by field observations and publicly available GIS databases. In 2010 and 2011, all the seeps and springs identified in the 2004 to 2009 surveys were revisited and their status as a water feature was determined. All unnamed seeps and springs were given a name, usually based on their location with respect to geographic features.

If possible, ground surveys were conducted to gather information on the seeps and springs when they were identified during helicopter surveys. If the helicopter could not be landed, vegetation was characterized while the helicopter hovered over the water feature. In these cases, dominant vegetation was identified and evidence of perennial presence of water was determined. Perennial presence was best determined by the presence of obligate wetland vegetation and observation of saturated soils or standing/flowing water. These characteristics were recorded and, if observed each time the spring was surveyed, the spring was considered potentially perennial. Current classification for seeps and springs are preliminary and subject to change based on the findings of continued monitoring of the water features.

If ground surveys were possible, vegetation at the spring and adjacent to the spring was visually characterized by dominant and subdominant species and the area was surveyed for rare species. Interestingly, no rare species were found at any of the water features subjected to ground surveys.

The water feature and the surrounding area were photographed during each survey. At times, the springs could not be photographed due to optic restrictions imposed by the USAF. If a photo of a spring is missing in this report, the spring could not be photographed due to such restrictions.

From 2013 to 2015, the water produced by perennial and intermittent springs and wildlife water developments was sampled and analyzed in the field. Additionally, water samples were collected in the field using containers provided by an analytical laboratory. Water was extracted using a clean open container or carefully aspirated with a plastic turkey baster that was thoroughly rinsed with distilled water between samples. Samples were labelled, placed in ice in an insulated cooler and transported to a laboratory within two days of sampling. During these surveys, water flow was estimated, if possible, and water was analyzed in the field using a YSI Model 556 Water Quality Meter for pH, temperature, conductivity, salinity, and dissolved oxygen. Water samples transported to the laboratory were analyzed for chloride, fluoride, nitrate/nitrite, sulfate, aluminum, arsenic, calcium, chromium, copper, iron, lead, magnesium, manganese, sodium, zinc, and



Sumner Spring

hardness. Results of the field and laboratory analysis for the active springs are provided in this report. Because maximum contaminant limits (MCL) have not been established for wildlife, drinking water standards for humans were used to determine if constituents in water sources exceeded acceptable concentrations.

Five reports were prepared in 2015 by the NNRP to summarize the data collected on seeps and springs of NTTR. Data was formalized, checked, and entered into the NNRP Geodatabase. Two different datasets were designed for the seeps and springs. One dataset contained general information about each of the seeps and springs, and the second dataset contained water quality information for springs and wildlife water developments. Reports prepared in 2015 included the following:

- Seeps and Springs of the Northeast North Range of the Nevada Test and Training Range (Nellis Natural Resources Program, 2016A)
- Seeps and Springs of the Northwest North Range of the Nevada Test and Training Range (Nellis Natural Resources Program, 2016B)
- Seeps and Springs of the Southeast North Range of the Nevada Test and Training Range (Nellis Natural Resources Program, 2016D)
- Seeps and Springs of the Southwest North Range of the Nevada Test and Training Range (Nellis Natural Resources Program, 2016E)
- Seeps, Springs and Wildlife Water Developments of the South Range of the Nevada Test and Training Range (Nellis Natural Resources Program, 2014)

As previously discussed in the jurisdictional waters section of this report, NNRP conducted a study in 2013 to identify potential seeps and springs by using false color (near infrared) imagery and the reflectance characteristics of the vegetation found at known water features on the North Range of NTTR. Ninety-one locations on the North Range Study Area showing red reflectance signatures were inspected on Labor Day weekend 2013 to determine if a surface water feature was present (Figure 31). The areas were accessed by helicopter and ground observations were made when possible. If the helicopter could not land, photographs were taken and the helicopter was flown sufficiently close to the location to identify plant species present. At each site, dominant vegetation species were recorded, and each feature was classified into a water feature, upland feature, or other. An effort was made to determine the type of water source at each feature. However, detailed hydrologic analysis was not always possible because the helicopter could not always land near the site. Details on this methodology and results of the surveys are documented in a 2014 report for Nellis AFB (Nellis Natural Resources Program, 2014).

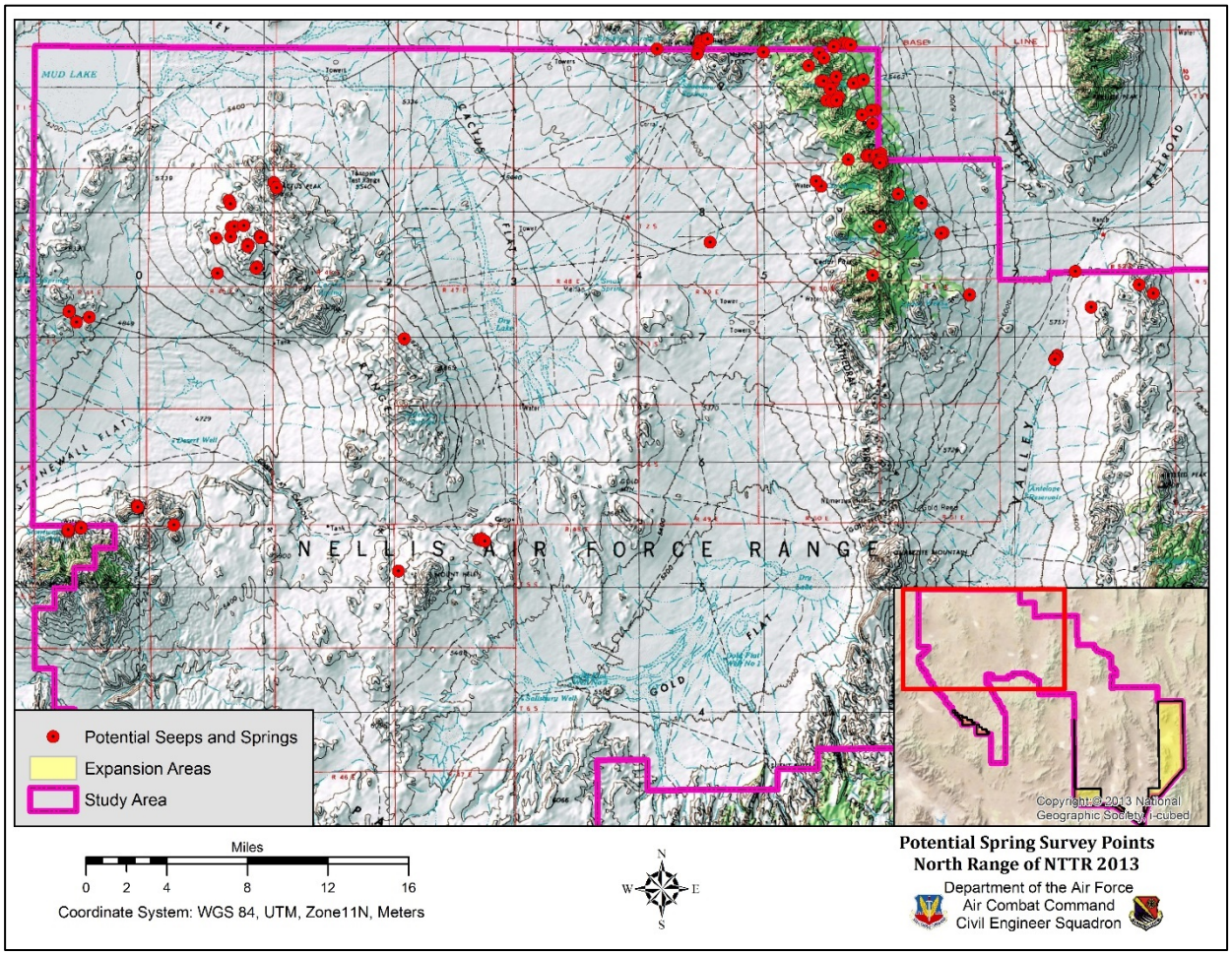


Figure 28. Points showing locations of potential new seeps and springs on the North Range of NTTR. These points were all inspected by helicopter surveys on August 31 – September 2, 2013.

GENERAL DISCUSSION

NTTR and the proposed expansion alternatives include 135 known water features. This includes 46 perennial springs, 20 intermittent springs, seven perennial seeps, and 36 intermittent seeps. It also includes one surface water accumulation, four construction ponds, and 21 wildlife water developments. As previously discussed, most of the perennial seeps and springs are found in the mountains and foothills of various mountain ranges in the study area. These springs are usually low flow (less than 2 gpm) and inundate very small areas (10 to 1000 sq. ft.). A majority of the perennial seeps and springs found on the North Range of NTTR are allowed to flow naturally over the landscape. This results in development of wetland plant communities where soils remain inundated throughout the year. The wetland plant community is often surrounded by a mesic plant community comprised of mostly facultative plants capable of growing in wet and dry areas. This area is very important to ungulates because it often supports healthy populations of grasses and forbs.

Most of the perennial springs on the South Range Study Area as well as a few of the perennial springs on the North Range Study Area are captured in troughs to allow water to accumulate for use by bighorn sheep, pronghorn, mule deer, and other wildlife. In many cases, these springs do not support wetland

vegetation unless the troughs overflow in small areas. Vegetation found in these areas is dominated by facultative and upland species of plants. No perennial seeps have been observed on the South Range Study Area.

Intermittent seeps and springs typically flow only in the early spring when water tables are higher. At that time, the seeps and springs support relatively lush vegetation which can be utilized by wildlife in the area. By summer, most of the vegetation becomes desiccated and may be replaced by more xeric species. Intermittent seeps are sometimes very difficult to differentiate from areas where water accumulates after significant precipitation. This is especially true for areas where winter snows melt and accumulate in the mountains. These areas of saturated soils could either be the result of accumulated surface water or a temporarily exposed water table. Regardless of the origin of the water, these areas provide excellent forage for wildlife, especially in the spring. These areas should be protected from soil disturbances and impacts whenever possible.

The 2016 helicopter surveys that were used to characterize potential seeps and springs on Alternatives 3A, 3B, and 3C did not discover any new seeps or springs. Most of the red signatures used to locate ground truth points were somewhat marginal in color, but still inspected during the surveys. The helicopter surveys confirmed that the only springs present on the alternative areas were wildlife water developments or perennial springs that had previously been identified. Two springs (Sheep Spring and White Rock Spring) were inspected on the alternative areas during this survey and were located on the west side of the Sheep Range in Alternative 3C. Four additional springs were identified by NDOW and USFWS as being active. These springs were not inspected in 2016. One spring was unnamed and located in Alternative 3A. The three other springs (Deadman Spring, Dry Lake Spring, and Lower Lake Spring) were located on the east side of alternative 3C.

In the figures that follow, locations of seeps and springs found on NTTR and the proposed expansion alternatives are shown. Descriptions of each seep and spring is provided. These descriptions include a photograph and map of the feature, short description, and analytical laboratory results for seeps or springs that provide sufficient water for sampling. References to the habitat in which springs are found are based on the key habitat in the surrounding area as mapped by NDOW in the Wildlife Action Plan (Wildlife Action Plan Team, 2006). By default, the seeps and springs should be Springs and Springbrooks, Mesquite Bosques and Desert Washes, or Wet Meadow key habitat, but this report documents the surrounding habitat to define the "setting" of the seep or spring in the immediate area. New springs found by the 2013 NTTR survey are discussed in a separate section because they have not been officially named and their status confirmed.

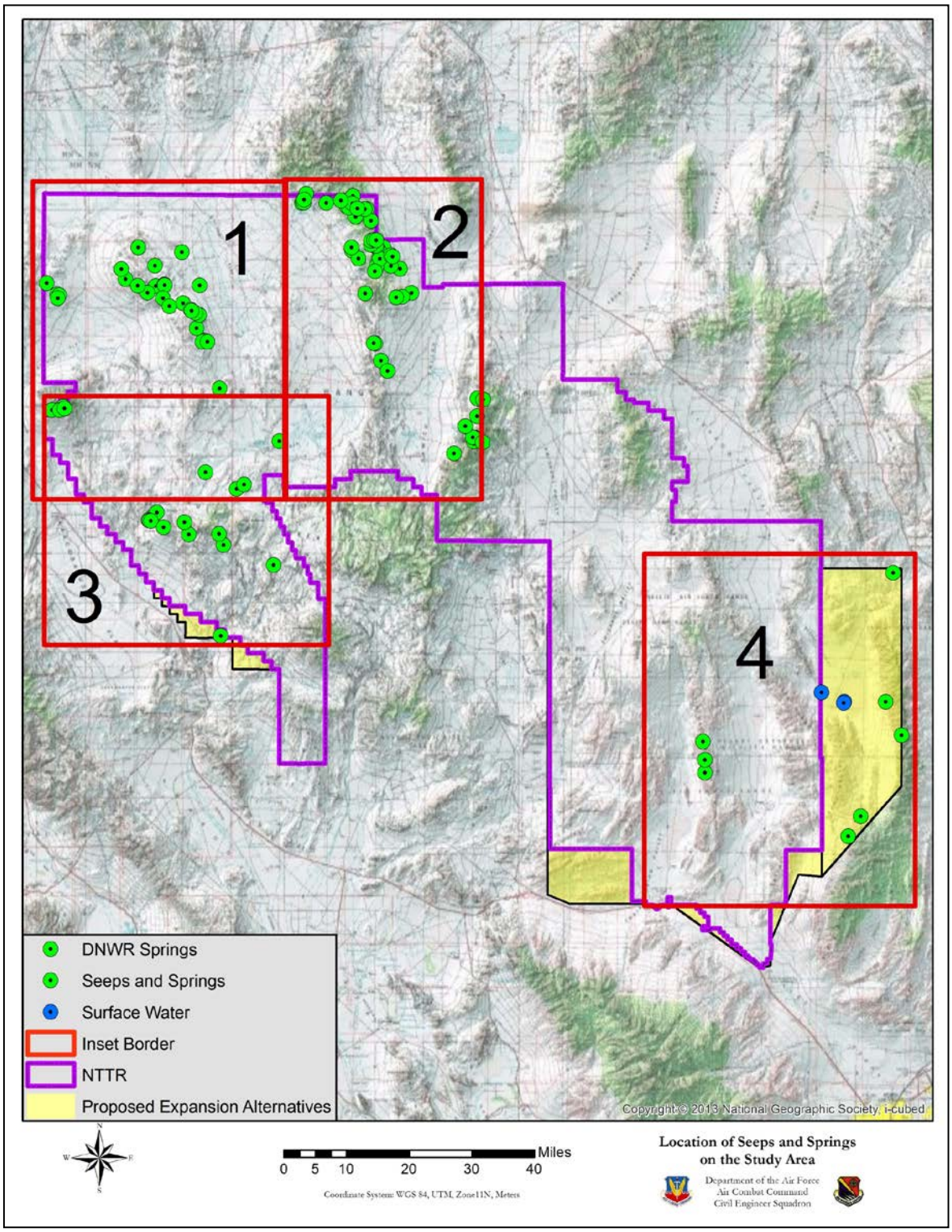


Figure 29. Seeps and springs found on the study area. Red squares indicate boundaries of map groups of seeps and springs illustrated in more detailed maps provided in Figures 9-12.

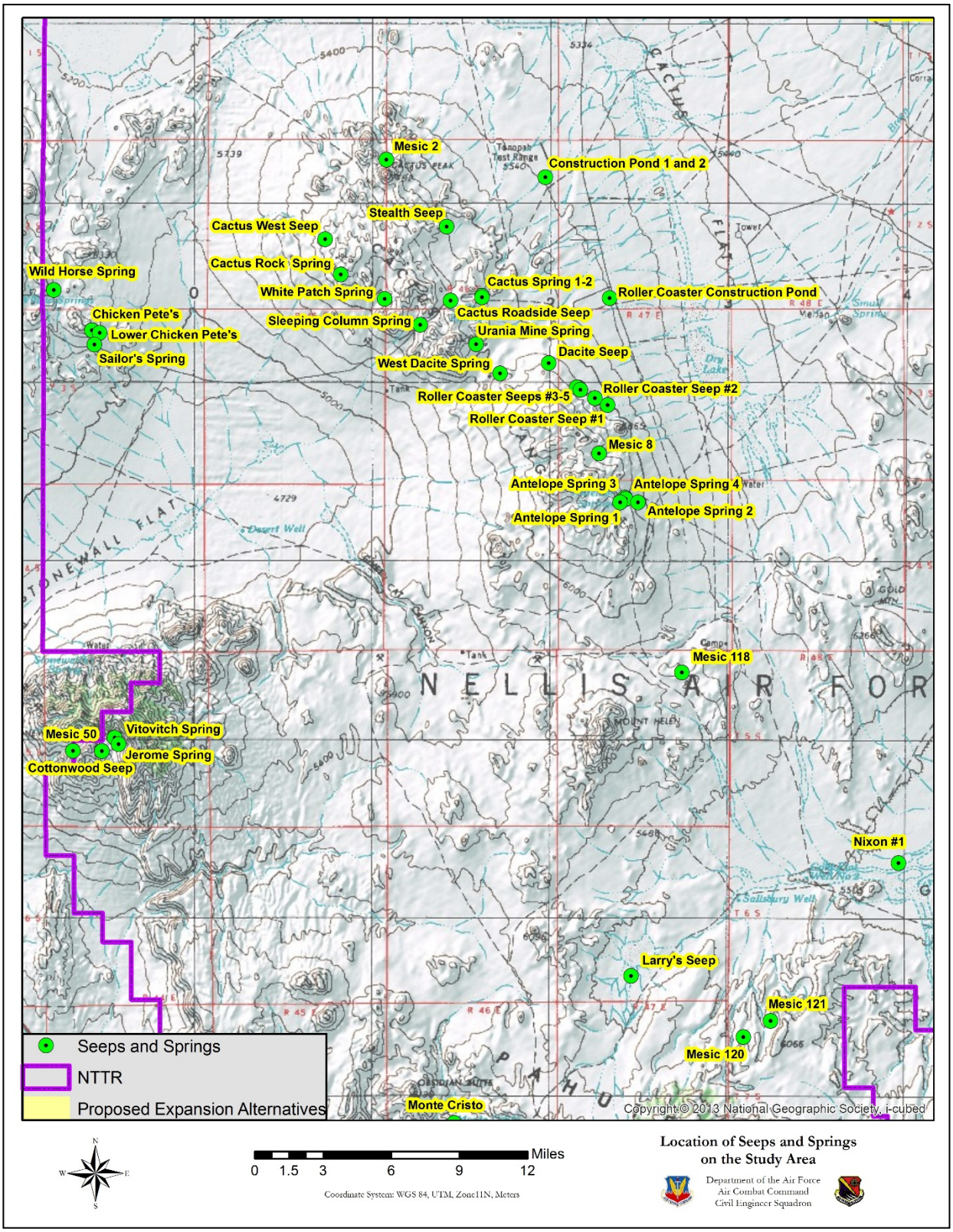


Figure 30. Seeps and springs located in Map Group 1.

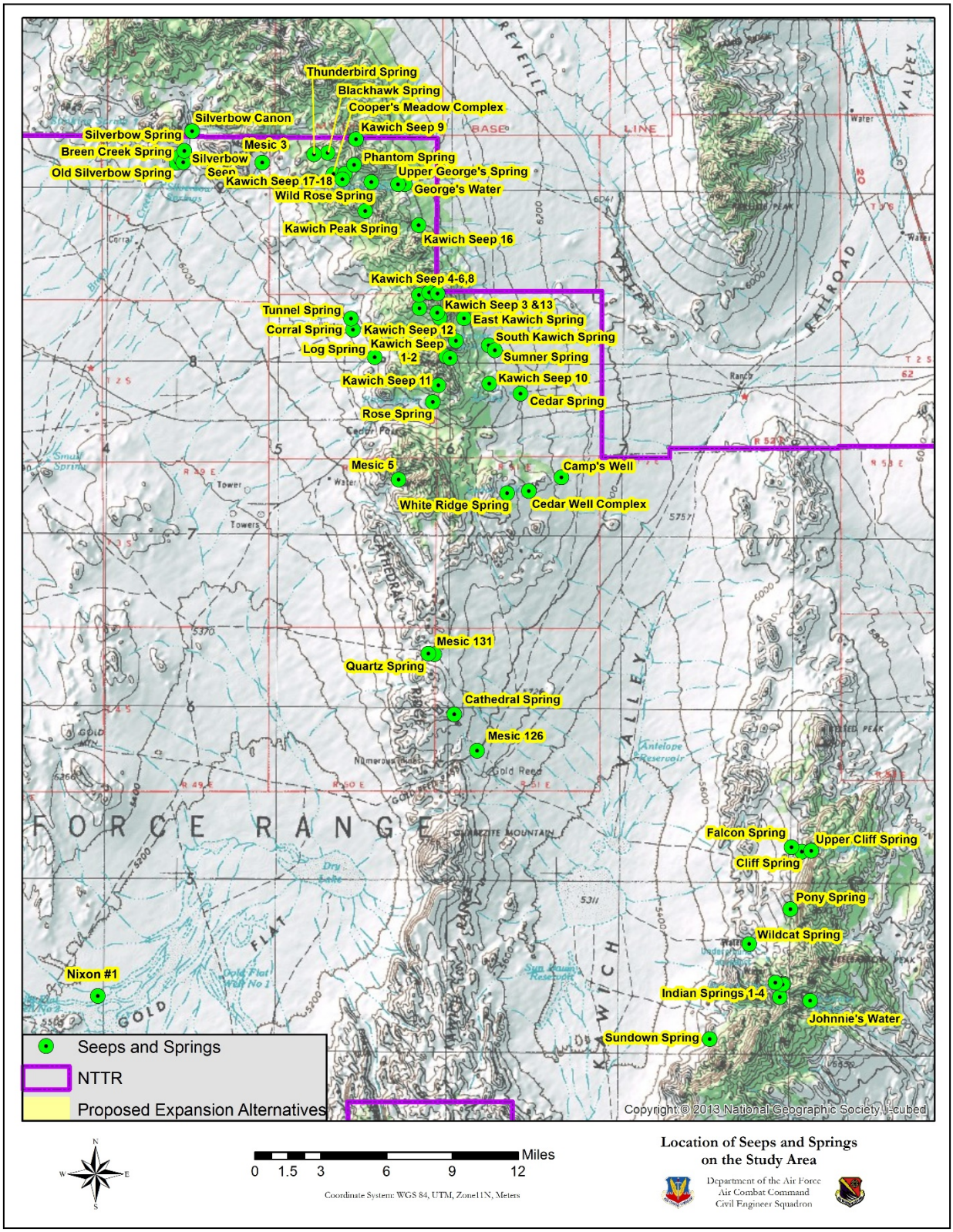


Figure 31. Seeps and springs located in Map Group 2.

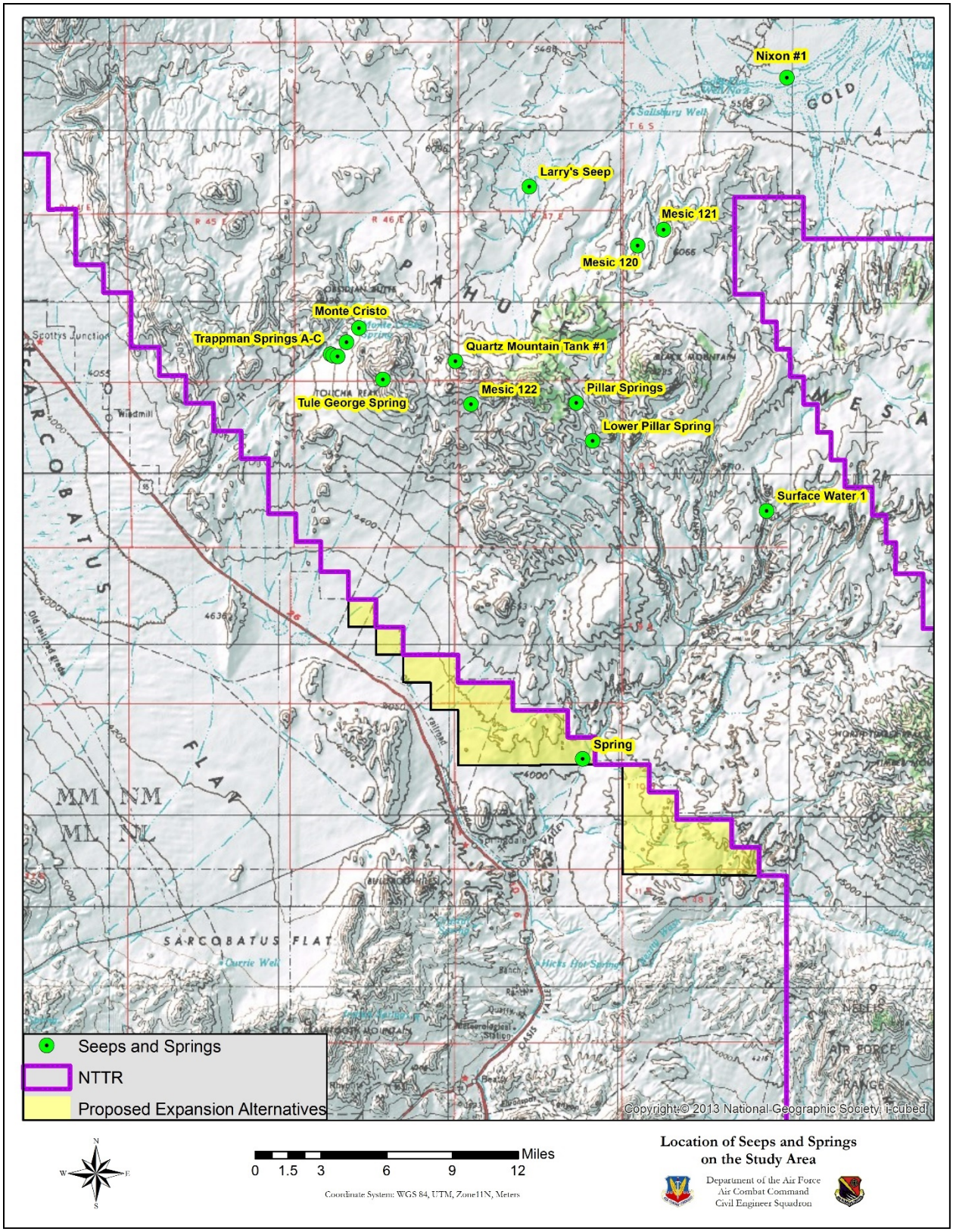


Figure 32. Seeps and springs located in Map Group 3.

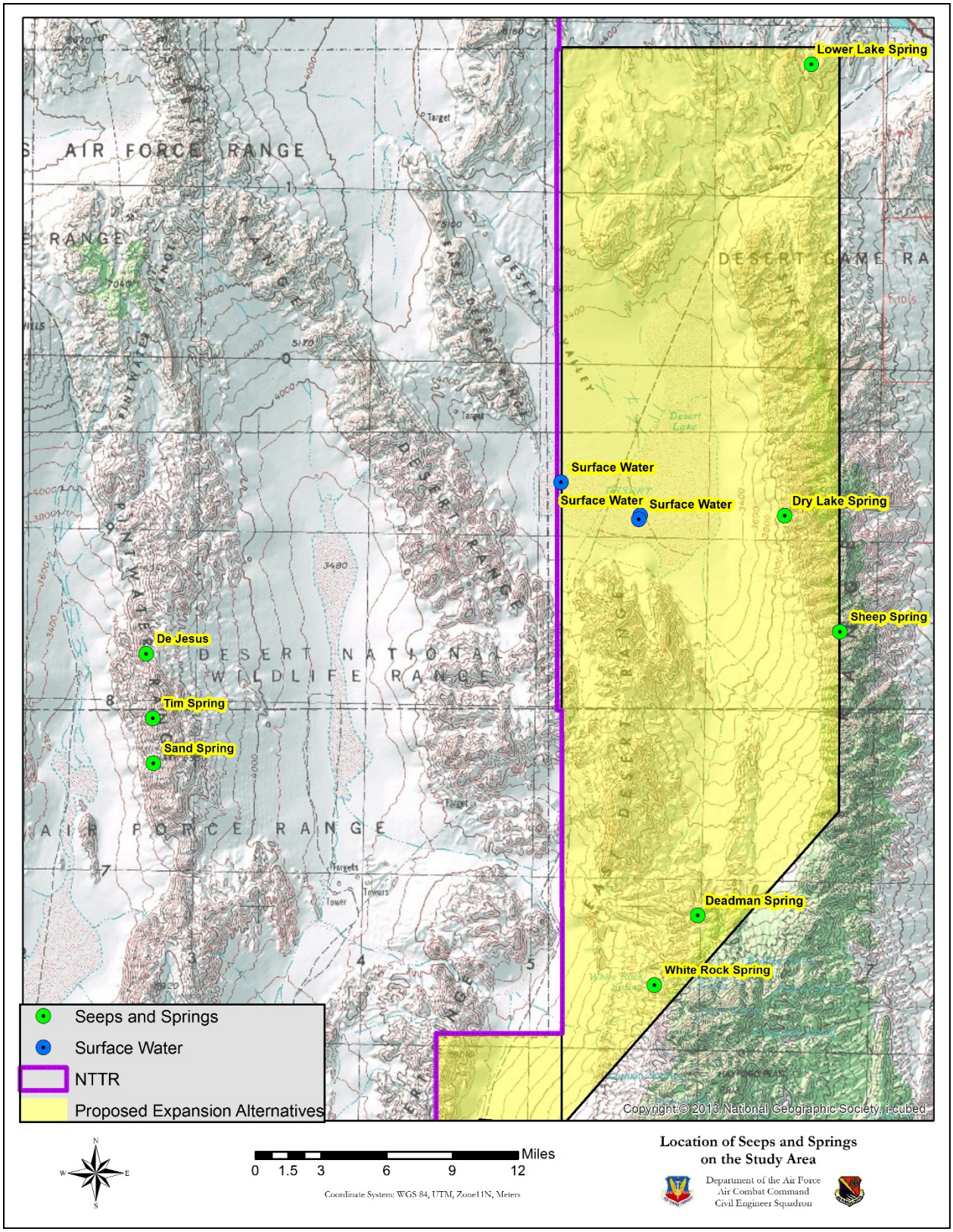


Figure 33. Seeps and springs located in Map Group 4.

Antelope Spring (1, 2, and 4 are Fenced)

Location: Antelope Spring 1: 524090 E 4163701 N
Antelope Spring 2: 524140 E 4163629 N
Antelope Spring 3: 523827 E 4163439 N
Antelope Spring 4: 524826 E 4163446 N
Elevation: 6,188 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides);* spikerush *(Eleocharis sp.);* softstem bulrush (*Schoenoplectus tabernaemontani*); rubber rabbitbrush (*Ericameria nauseosa*); Mormon tea (*Ephedra viridis*); threadleaf snakeweed (*Gutierrezia microcephala*)



Antelope Spring 1 on September 5, 2011.

Antelope Spring is a set of four springs located southeast of Antelope Peak in the Cactus Range in Sagebrush Key Habitat. Antelope Spring includes four separate springs named Antelope Spring 1, Antelope Spring 2, Antelope Spring 3, and Antelope Spring 4. The TRC Mariah and Associates report (TRC Mariah Associates, 1996) estimated flow for the springs as low flow at 0.006 cfs. According to the Dames and Moore wetland survey (Dames and Moore, 1996), Antelope Spring 2 was heavily impacted by horse use, and the presence of a healthy 50-foot tall cottonwood tree at the site indicated more water had historically been available. In 1995, Antelope Spring 4 was a small pool of standing water. Depressions, contours, and small spots of damp soil indicated that the site may have been previously inundated to a greater extent by rainfall or higher water table caused by rainfall. The Antelope Springs were inspected again on May 24, 2009. The cottonwood tree discussed in the 1996 wetlands report (Dames and Moore, 1996) was still present at Antelope Spring 2. All of the springs were dominated by spike rush, beardless wildrye, and softstem bulrush. The springs appeared to support a healthier vegetative community compared to 1995, probably due to the installation of a fence at Springs 1, 2, and 4. Antelope Spring 3, not protected by a fence, was located in an area that contained the remains of historic structures and a grove of junipers. An area of green, mesic vegetation was present, but no evidence was observed of moist or saturated soils. Antelope Spring 3 is likely an intermittent seep. The springs were again inspected in 2011 and were still in good condition with no significant changes in vegetation or hydrology.

Antelope Spring water rights were originally held by James M. Daniels, who transferred the water rights to the Air Force in December 1968. James Daniels applied for appropriation of water rights March 1950, a permit was issued in January 1953, and certification was given in January 1955. John Jay Casey filed a protest on this application at the time of filing.

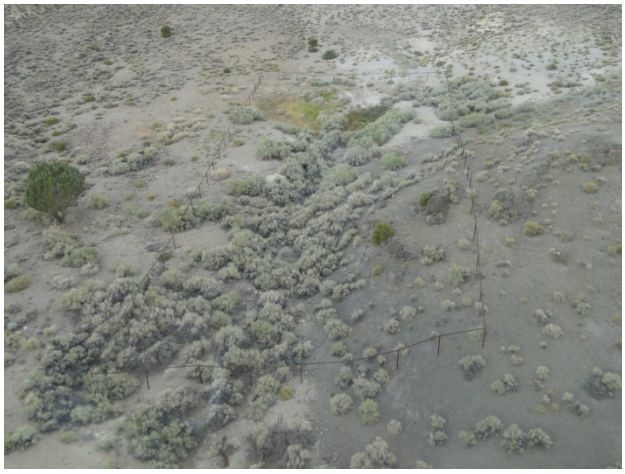


Antelope Spring 2 in 2011.

The protest was overruled and the permit issued, limiting the number of cattle to 300 and horses to 10. The spring feature was originally developed by creating two cuts in the land. The water was then conveyed through two 200 foot 2-inch pipes to two troughs. The original feature discharged 4.85 acre feet of water annually. The spring feature was created by ditching the land in two places, forcing the water to flow out through two, 200-foot pipes into concrete troughs at 4.85 acre feet annually.



Antelope Spring 3 in 2011.



Antelope Spring 4 in 2011.

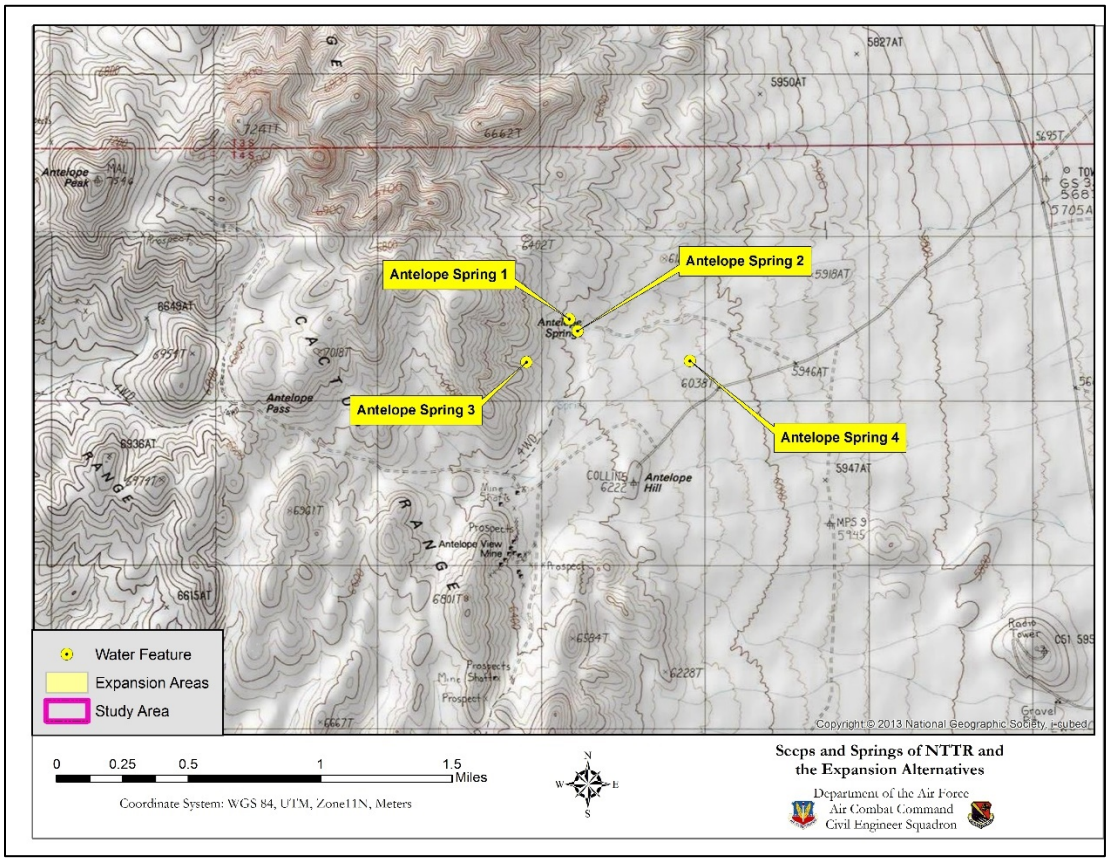


Figure 34. Topographic map showing the location of Antelope Spring 1, 2, 3, and 4.

Table 14. Results of field and laboratory analyses of water sampled at Antelope Spring 2. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	37.5	11.6
Fluoride (mg/L)	4	0.56	0.39
Nitrate/Nitrite (mg/L)	11	0.13	0.5
Sulfate (mg/L)	500	229	34.6
Aluminum (mg/L)	0.2	1.64	0.342
Arsenic (mg/L)	0.01	0.02	0.01
Calcium (mg/L)	-	159	81.9
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.004
Iron (mg/L)	0.6	1.67	0.36
Lead (mg/L)	0.015	ND	0.002
Magnesium (mg/L)	150	22.9	9.3
Manganese (mg/L)	0.1	1.04	0.073
Sodium (mg/L)	-	48.8	39.6
Zinc (mg/L)	5	ND	0.013
Hardness (mg/L)	-	491	243
pH	6.5-8.5	7.3	6.66
Turbidity (NTU)	-	151	-
Dissolved Oxygen (%)	-	21.3	14.8
Conductivity (mS/cm)	-	1.039	0.437
Salinity (ppt)	-	0.59	-
Temperature of water (°C)	-	19	13.9

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014 and 2015, Antelope Spring 2 was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum, arsenic, iron and manganese, were found to be below the maximum contaminant level (MCL) and pose no threat to wildlife. In 2014, four constituents were higher than the MCL. In 2015, only aluminum was slightly higher than the MCL and arsenic was at the MCL. Most important, it appears that all of the constituents decreased in concentration in 2015. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Breen Creek Spring

Location: 543883 E 4191621 N
Elevation: 6,312 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*); narrowleaf willow (*Salix exigua*); big sagebrush (*Artemisia tridentata*)



Breen Creek Spring in 2011.

Breen Creek Spring is the southern-most source of the Silverbow seep and spring complex, and is located in the northeast portion of Cactus Flats on the foothills of the Kawich Range in Sagebrush Key Habitat.

During the September 2, 2011, survey, the spring flow was estimated at 1-3 gallons per minute. A mild sulfur odor was detected from the water, potentially due to anaerobic conditions and hydric soils. Upland vegetation around the spring appeared green and vigorous. The spring has been dry and inactive from 2012-2015, possibly due to drought conditions during that time period.

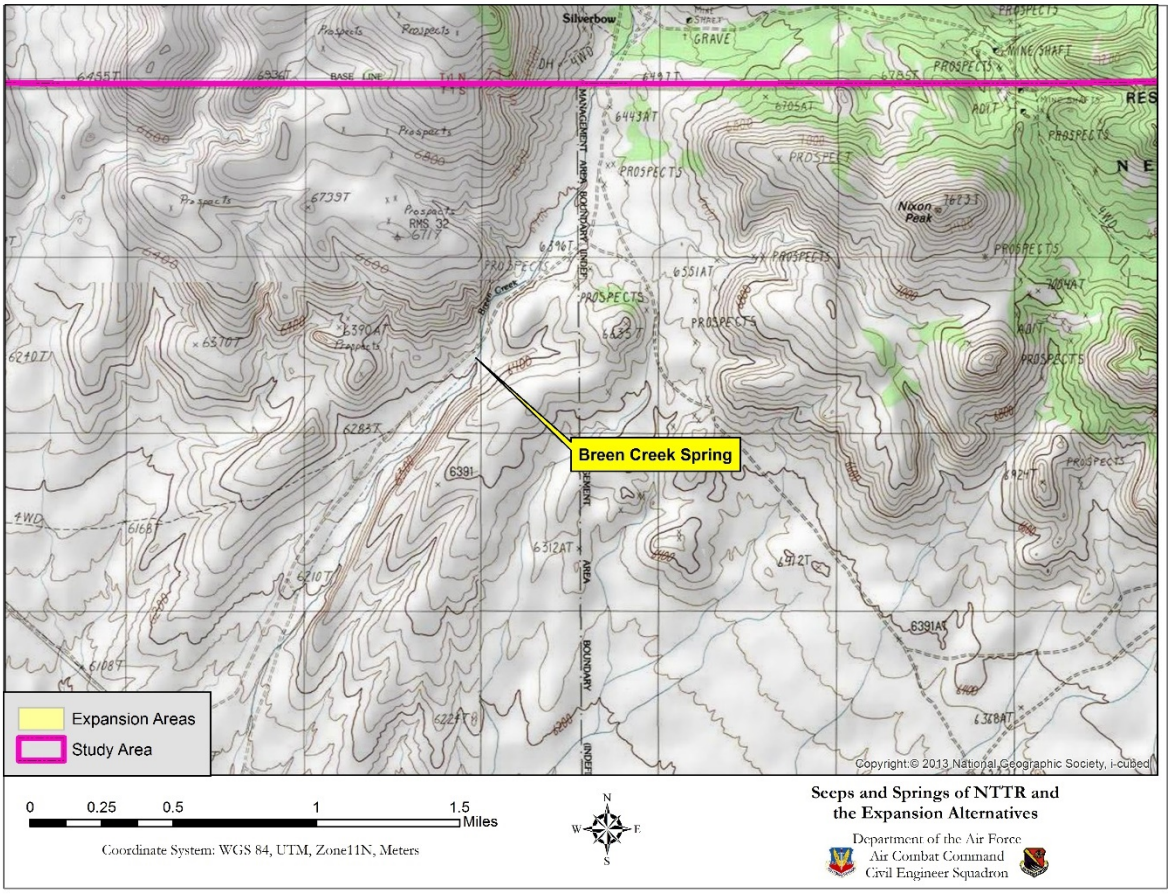


Figure 35. Topographic map showing the location of Breen Creek Spring.

Cactus Rock Spring

Location: 508158 E 4176128 N
Elevation: 6,537 ft. MSL
Dominant Plants: Barren ground



Cactus Rock Spring in 2014

Cactus Rock Spring is located on the west slope of the northwestern side of the Cactus Range in Sagebrush Key Habitat. Cactus Rock Spring was observed during a 2009 survey conducted in cooperation with BLM and NDOW to locate springs that may require fencing. This spring is used extensively by wildlife. The ground immediately around the spring head was mostly barren, and the majority of the perennial vegetation in the surrounding area was rubber rabbitbrush. The survey recommended this spring be fenced to protect the water source. The spring was inspected in 2014 and 2015. In both years, the spring was at a fairly low rate of flow (<1 liter/min), and extensive damage from wild horses was observed.

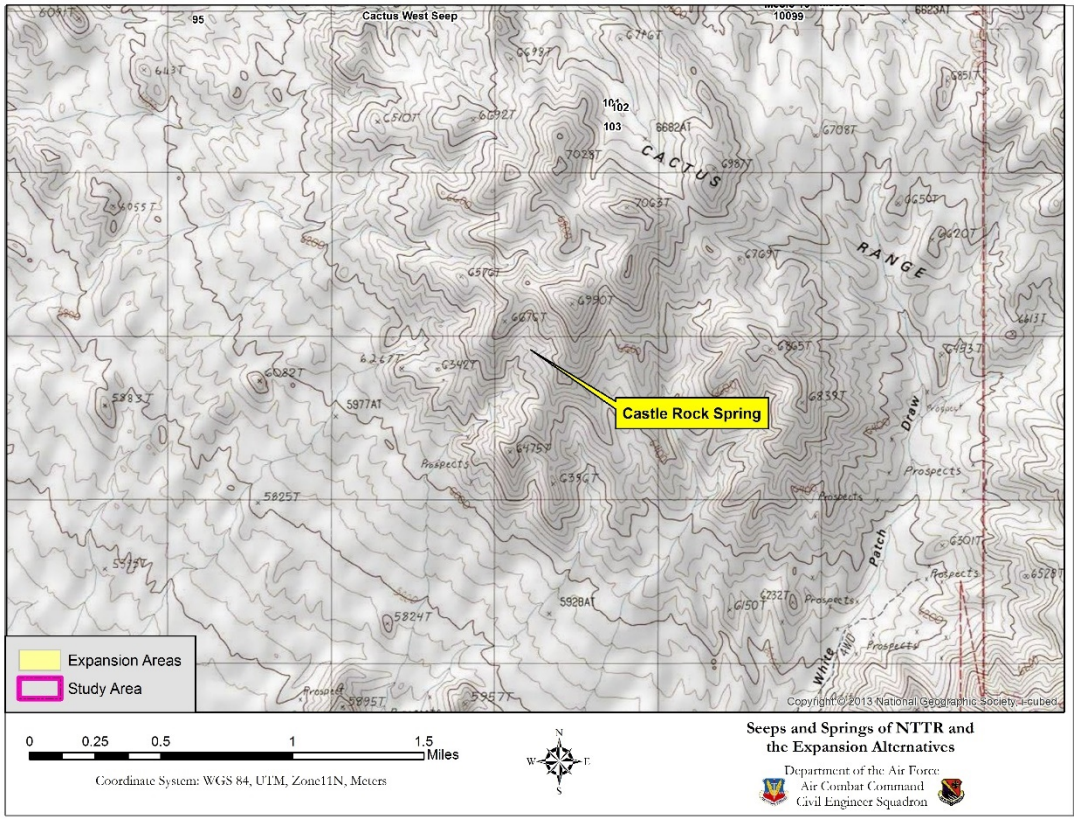


Figure 36. Topographic map showing the location of Cactus Rock Spring.

Table 15. Results of field and laboratory analyses of water sampled at Cactus Rock Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	32.4	38.1
Fluoride (mg/L)	4	0.44	0.51
Nitrate/Nitrite (mg/L)	11	0.9	ND
Sulfate (mg/L)	500	78.6	85.2
Aluminum (mg/L)	0.2	0.07	0.053
Arsenic (mg/L)	0.01	ND	0.003
Calcium (mg/L)	-	99.6	43.6
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.002
Iron (mg/L)	0.6	0.08	0.08
Lead (mg/L)	0.015	ND	ND
Magnesium (mg/L)	150	15.8	13.2
Manganese (mg/L)	0.1	0.54	0.034
Sodium (mg/L)	-	40.6	82.2
Zinc (mg/L)	5	ND	0.007
Hardness (mg/L)	-	314	163
pH	6.5-8.5	7.5	7.35
Turbidity (NTU)	-	5.85	-
Dissolved Oxygen (%)	-	35.6	80.2
Conductivity (mS/cm)	-	0.651	0.492
Salinity (ppt)	-	0.41	0.34
Temperature of water (°C)	-	13.4	10.4

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014 and 2015, Cactus Rock Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to the laboratory's protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except manganese, were found to be below the MCL and pose no threat to wildlife. Manganese was only higher than the MCL in 2014. In the long term, high concentrations of manganese can result in nervous disorders (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Cactus Spring (Developed)

Location: Cactus Spring 1: 516055 E 4174969 N
Cactus Spring 2: 516062 E 4174874 N

Elevation: 6,273 ft. MSL

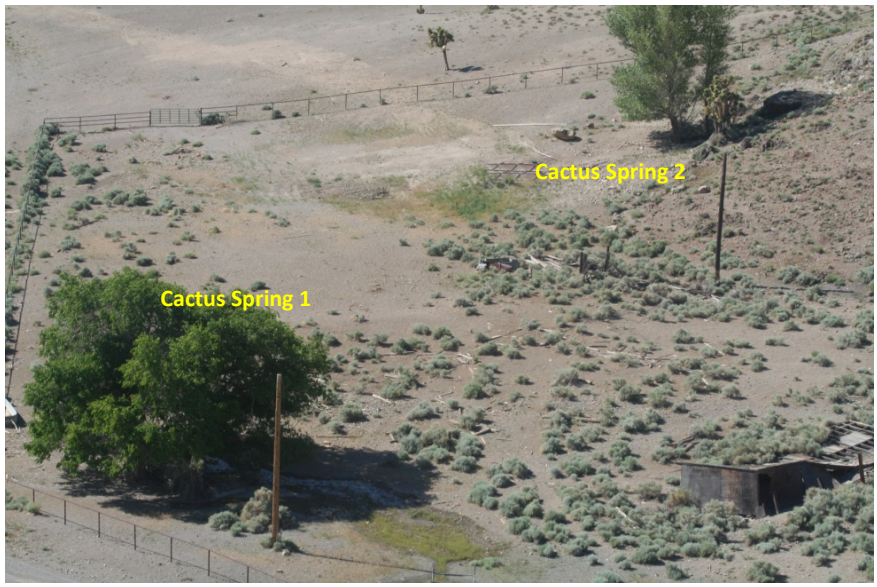
Dominant Plants: Fremont's Cottonwood (Populus fremontii), Chinese elm (Ulmus parvifolia), rubber rabbitbrush (Ericameria nauseosus); threadleaf snakeweed (Gutierrezia microcephala); sanddune wallflower (Erysimum capitatum); cheatgrass (Bromus tectorum); groundcherry (Physalis sp.); spikerush (Eleocharis sp.); water speedwell (Veronica anagallis-aquatica); alkali buttercup (Ranunculus cymbalaria); beardless rabbitsfoot grass (Polypogon viridis)



Cactus Spring 1 showing exclosure fence in 2009.

Cactus Spring is comprised of two water developed springheads 300 feet apart located in the foothills of the Cactus Range south of Cactus Peak in Intermountain Cold Desert Scrub Key Habitat. According to the 1996 wetland report (Dames and Moore, 1996), historic use of this site as a homestead was evidenced by multiple old buildings. Cactus Spring 1, located on the north side of the site, was enhanced and consisted of a small cylindrical pool jacketed with galvanized metal and surrounded by a steel pole fence mounted in concrete. The overflow from this source created an approximately 30-foot stretch of saturated soil, which terminated at the base of a mature Siberian elm tree. Cactus Spring 2, a hillside seep pool on the south side of the site, was surrounded by a fence consisting of metal posts and three strands of barbed wire. A cottonwood tree and a Joshua tree were located at this spring.

Cactus Springs 1 and 2 were visited in April, June, and December of 1996 (Dames and Moore, 1996). During the April visit, no surface flow was observed. In June, however, water flowed into the stock tanks located outside of the exclosure at approximately one gallon per minute. Within the exclosure, water was flowing from the spring head, saturating soils around the head and bringing the overflow pond to a near full capacity. Cactus Spring 1 was also surveyed in 2009. The spring was in good condition but not flowing as strongly as observed in previous years. The site had been seeded with a mixture of Indian grass, four-wing saltbush, and shadscale during the 2009 survey. The site appeared to be in excellent condition during the



Cactus Spring and surrounding area in 2009.

2011 survey. In 2014 and 2015, the spring flow was minimal and much of the wetland species were desiccated.

Cactus Spring water rights were originally certificated by George Wallace Dean; rights were eventually transferred to the U.S. Air Force on an unknown date. The original certification to George Wallace Dean of the Kawich Cattle Company is found under NDWR application 1580, certified in 1918. James Daniels gained most of the Kawich Cattle Company water rights when he purchased assets of the liquidated Kawich Cattle Company in the 1920s. James Daniels applied for appropriation of water rights for the spring in December 1948, a permit was issued in January 1953, and certification was given in January 1955. The spring feature was originally diverted through the use of two wells allowing the water to flow through 500 feet of two-inch pipe to a 20,000-gallon storage tank, then through 80 feet of two-inch pipe to a trough. The original allowed use totaled 7.06 annual acre feet of water (0.010 cfs) for the purpose of watering 300 head of cattle and 15 horses. This application was informally protested in 1948 by John J. Casey; the protest was overruled in January 1953. The spring was sampled and analyzed by the USGS in 1957, 1964, 1966, and 2000. The analyses indicated that the water was good quality with a slightly high mineral content.

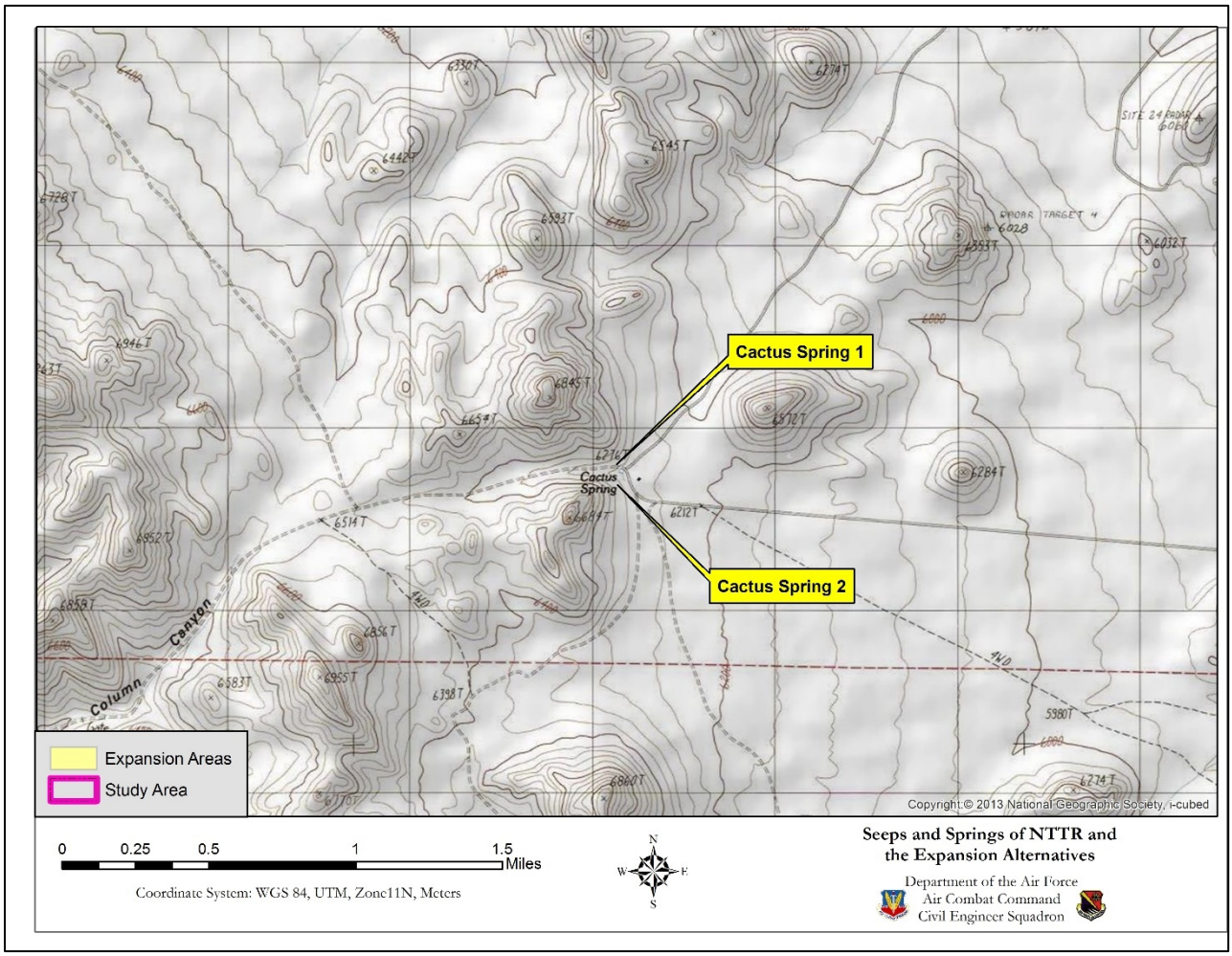


Figure 37. Topographic map showing the location of Cactus Spring 1 and 2.

Table 16. Results of field and laboratory analyses of water sampled at Cactus Spring 1. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	27.4	23.8
Fluoride (mg/L)	4	0.59	0.57
Nitrate/Nitrite (mg/L)	11	ND	ND
Sulfate (mg/L)	500	71.8	59.7
Aluminum (mg/L)	0.2	0.1	0.006
Arsenic (mg/L)	0.01	ND	ND
Calcium (mg/L)	-	52.7	56.7
Chromium (mg/L)	0.1	ND	0.001
Copper (mg/L)	1	ND	0.001
Iron (mg/L)	0.6	0.53	0.18
Lead (mg/L)	0.015	ND	ND
Magnesium (mg/L)	150	7.2	6.7
Manganese (mg/L)	0.1	0.04	0.136
Sodium (mg/L)	-	41.7	57.1
Zinc (mg/L)	5	ND	0.008
Hardness (mg/L)	-	161	169
pH	6.5-8.5	7.16	6.96
Turbidity (NTU)	-	2.45	-
Dissolved Oxygen (%)	-	1.2	36.2
Conductivity (mS/cm)	-	0.48	0.433
Salinity (ppt)	-	0.15	-
Temperature of water (°C)	-	15.1	12.8

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014 and 2015, Cactus Spring 1 was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except manganese, were found to be below the MCL and pose no threat to wildlife. In 2015, manganese levels increased compared to 2014 and they were slightly above the MCL. Long term high concentrations of manganese can result in nervous disorders (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Table 17. Results of field and laboratory analyses of water sampled at Cactus Spring 2. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	27.9	22.5
Fluoride (mg/L)	4	0.78	0.59
Nitrate/Nitrite (mg/L)	11	ND	ND
Sulfate (mg/L)	500	66.1	62.4
Aluminum (mg/L)	0.2	ND	0.114
Arsenic (mg/L)	0.01	ND	0.005
Calcium (mg/L)	-	52.2	78.2
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.005
Iron (mg/L)	0.6	0.03	46
Lead (mg/L)	0.015	ND	0.001
Magnesium (mg/L)	150	7.7	6.7
Manganese (mg/L)	0.1	0.1	0.613
Sodium (mg/L)	-	45.7	60.1
Zinc (mg/L)	5	ND	0.035
Hardness (mg/L)	-	162	223
pH	6.5-8.5	7.14	6.82
Turbidity (NTU)	-	0.56	-
Dissolved Oxygen (%)	-	5.8	59.1
Conductivity (mS/cm)	-	0.48	0.442
Salinity (ppt)	-	0.54	-
Temperature of water (°C)	-	17.6	13.6

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014 and 2015, Cactus Spring 2 was also analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen and samples submitted to Silver State Laboratories for analysis (Nellis Natural Resources Program, 2016B). Table 5 shows the results from both on-site and Silver State Laboratories analyses. All constituents, except iron and manganese, were found to be below the MCL and pose no threat to wildlife. In 2014, both constituents were within the MCL but in 2015 both increased drastically. Iron especially increased and was 76 times the MCL. High iron levels are mostly associated with taste and teeth staining issues. With long term, high concentrations of manganese can result in nervous disorders (EPA, 2003). This may have been an anomaly, but should definitely be sampled in 2016. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Camp's Well (Developed)

Location: 566336 E 4173579 N
Elevation: 6,351 ft. MSL
Dominant Plants: Utah juniper (*Juniperus osteosperma*); rubber rabbitbrush (*Ericameria nauseosa*); salt-lover (*Halogeton glomeratus*)

Camp's Well is a spring located northeast of Cedar Peak in the Kawich Mountain Range in Intermountain Cold Desert Scrub Key Habitat. Camp's Well was developed as a horse watering area with a dugout and troughs. In 2009, the BLM upgraded the site by adding in two new water troughs and a water storage area. During the 2007 survey, no water was observed in the troughs or the dugouts. During the 2011 survey, water was only observed in the new troughs. The general area around Camp's Well was mostly barren because vegetation was apparently heavily impacted by wildlife utilizing the troughs. The spring was surveyed in 2014 and 2015. No free-standing water was observed on the site, but the troughs and tanks were fully functional. The immediate area was heavily damaged by wild horses in the area.



Camp's Well in September 2011

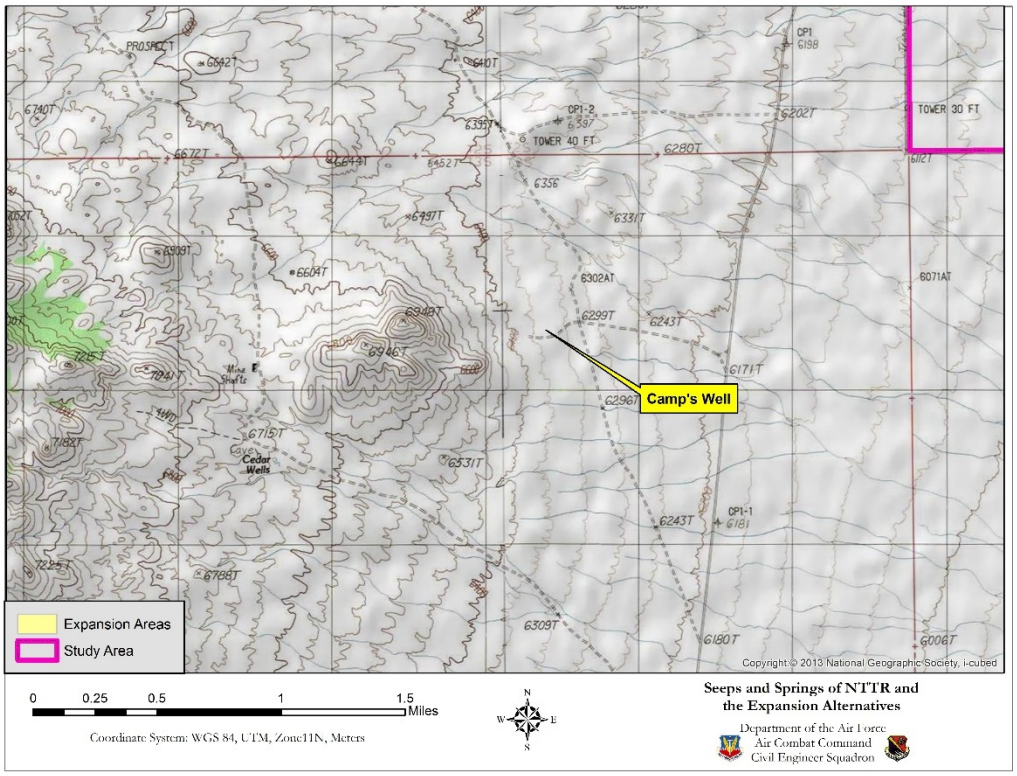


Figure 38. Topographic map showing the location of Camp's Well.

Table 18. Results of field and laboratory analyses of water sampled at Camp's Well. Concentrations exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	42.9	19.3
Fluoride (mg/L)	4	0.39	0.46
Nitrate/Nitrite (mg/L)	11	0.28	0.99
Sulfate (mg/L)	500	84.3	41
Aluminum (mg/L)	0.2	ND	0.009
Arsenic (mg/L)	0.01	ND	0.013
Calcium (mg/L)	-	51.3	43.6
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.005
Iron (mg/L)	0.6	0.02	0.02
Lead (mg/L)	0.015	ND	ND
Magnesium (mg/L)	150	14.6	8.4
Manganese (mg/L)	0.1	ND	ND
Sodium (mg/L)	-	51.5	49.8
Zinc (mg/L)	5	ND	0.003
Hardness (mg/L)	-	188	143
pH	6.5-8.5	7.87	8.31
Turbidity (NTU)	-	1.93	-
Dissolved Oxygen (%)	-	61.7	48.2
Conductivity (mS/cm)	-	0.472	0.350
Salinity (ppt)	-	0.31	0.23
Temperature of water (°C)	-	12.1	11.7

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016D)
ND: Non-Detect

In 2014 and 2015, Camp's Well was analyzed in the Field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016D). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except for arsenic, were found to be below the MCL and pose no threat to wildlife. The level of arsenic detected in 2015 was just slightly above the MCL. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Cathedral Spring

Location: 560311 E 4159762 N
Elevation: 6,511 ft. MSL
Dominant Plants: Rubber rabbitbrush (*Ericameria nauseosa*); big sagebrush (*Artemisia tridentata*); green molly (*Bassia americana)*; Russian thistle (*Salsola* sp.); fringed amaranth (*Amaranthus fimbriatus*)



Cathedral Spring in 2007.

This spring is located on the south end of the Kawich Range in Sagebrush Key Habitat. Cathedral Spring was first surveyed in 2007. The vegetation surrounding the spring is sparse and dominated by Russian thistle and fringed amaranth, plant species known to dominate overgrazed areas. Most of the area around the spring was barren soil. In 2011, no vegetation was present at the spring and most of the surrounding area was dominated by fringed amaranth. Water in the spring appears to be low quality with high turbidity and floating colonies of bacteria or algae. In 2011, the spring was moist with no standing water. In 2014, the spring was nearly completely dry except for a small wet hole containing stagnant water. In 2015, the spring was dry and could not be sampled.

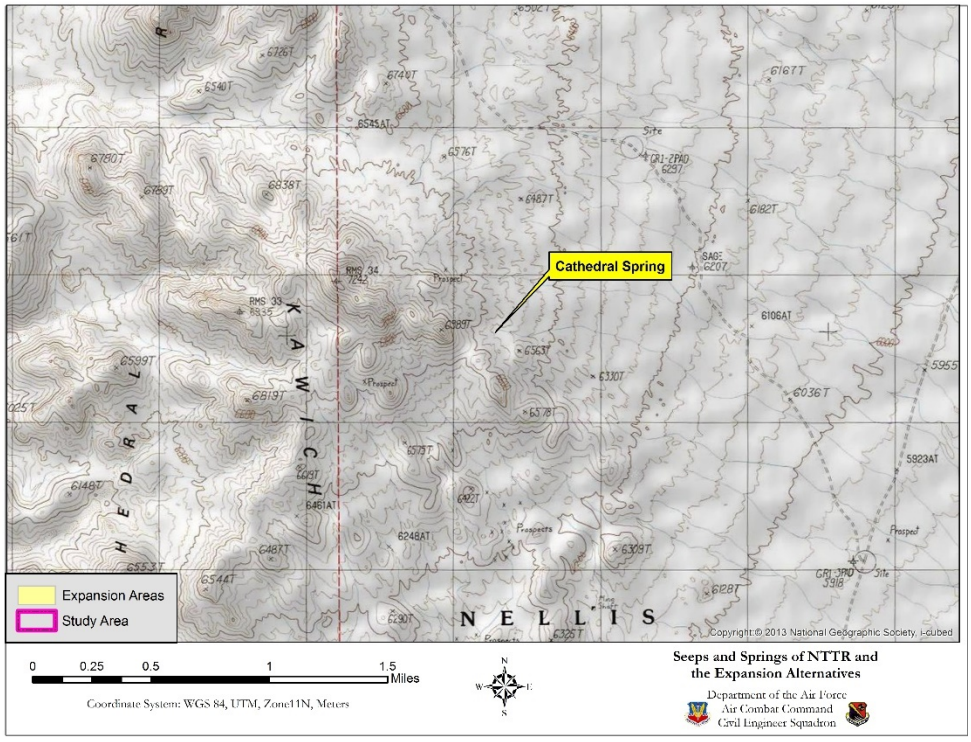


Figure 39. Topographic map showing the location of Cathedral Spring.

Table 19. Results of field and laboratory analyses of water sampled at Cathedral Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015***
Chloride (mg/L)	400	146	-
Fluoride (mg/L)	4	1.5	-
Nitrate/Nitrite (mg/L)	11	ND	-
Sulfate (mg/L)	500	340	-
Aluminum (mg/L)	0.2	ND	-
Arsenic (mg/L)	0.01	ND	-
Calcium (mg/L)	-	69.7	-
Chromium (mg/L)	0.1	ND	-
Copper (mg/L)	1	ND	-
Iron (mg/L)	0.6	ND	-
Lead (mg/L)	0.015	ND	-
Magnesium (mg/L)	150	ND	-
Manganese (mg/L)	0.1	0.19	-
Sodium (mg/L)	-	230	-
Zinc (mg/L)	5	ND	-
Hardness (mg/L)	-	196	-
pH	6.5-8.5	-	-
Turbidity (NTU)	-	-	-
Dissolved Oxygen (%)	-	-	-
Conductivity (mS/cm)	-	-	-
Salinity (ppt)	-	-	-
Temperature of water (°C)	-	-	-

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
Field data could not be taken because an insufficient volume of water was present
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016D)
ND: Non-Detect

In 2015, Cathedral Spring was not analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen because the volume of water present was not sufficient to immerse the sampling probe (Nellis Natural Resources Program, 2016D). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except manganese, were found to be below the MCL and pose no threat to wildlife. With long term, high concentrations of manganese can result in nervous disorders (EPA, 2003) . However, the concentration of manganese was only 0.09 mg/L above the MCL. At this concentration, manganese probably does not pose a problem for wildlife, but should be monitored annually to ensure that it is not increasing over time.

Cedar Spring (Developed)

Location: 563930 E 4178413 N
Elevation: 6,532 ft. MSL
Dominant Plants: Cattail (*Typha* sp.); beardless wildrye (*Leymus triticoides*); sedge (*Carex* sp.); spikerush (*Eleocharis* sp.)



Cedar Spring in 2011

Cedar Spring is located east of the Kawich Mountain Range in south Reveille Valley in Sagebrush Key Habitat. Saturated soils and some standing water were observed at this site in 1996. In 2007, a significant accumulation of water was observed, as well as vegetation damage by wild horses. In September 2011, no water was observed at the spring. Fencing to protect the wetland area of this spring from wild horse grazing and use is recommended. Remote sensing cameras at Cedar Spring have observed mule deer, desert cottontail, black-tailed jackrabbit, coyote, and pronghorn antelope. Birds observed include golden eagle, horned lark, northern harrier, pinyon jay, common raven, and red-tailed hawk.

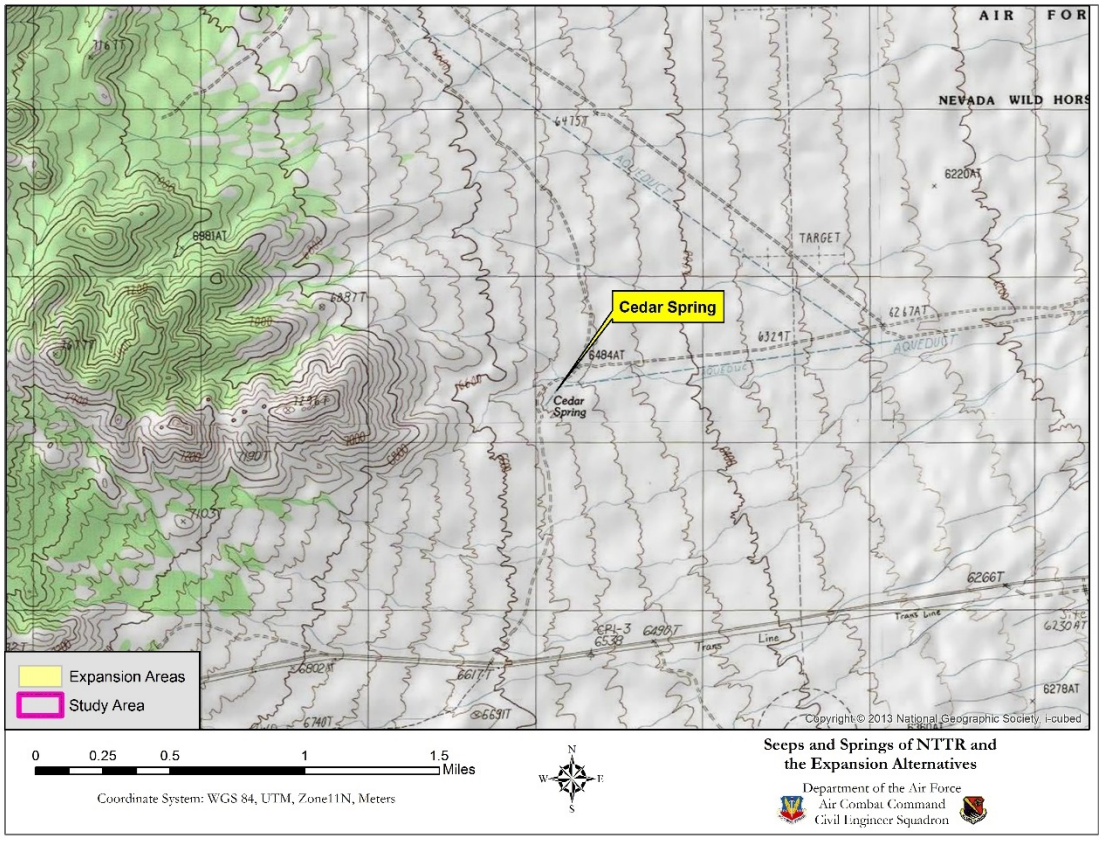


Figure 40. Topographic map showing the location of Cedar Spring.

Cedar Spring water rights were originally certificated by E.W. Fallini, agent for the Fallini Brothers. The ownership of the spring was transferred to the Helen Fallini Trust on an unknown date. The Priority Date for these rights is October 1917. A permit application was submitted in November 1950, issued in March 1951, and certification was awarded in July 1951. The spring feature was originally developed by the construction of a 100-foot tunnel and piping to livestock water troughs. The original allowed use totaled 18.08 annual acre feet of water for the purpose of watering 1,000 head of cattle and 25 horses. Historical improvements at this site included two deeply sunken wells made of approximately 15-foot diameter corrugated metal culverts installed to a 20-foot depth. An excavated area adjacent to the wells (possibly bulldozer working space for well installation), and an excavated pit in a swale embankment were also observed in more recent surveys. The wells include a water line for delivering water to a ranch site several miles east of NTTR in the Reveille Valley.

Table 20. Results of field and laboratory analyses of water sampled at Breen Creek Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	41.9	39.2
Fluoride (mg/L)	4	1.57	1.29
Nitrate/Nitrite (mg/L)	11	ND	ND
Sulfate (mg/L)	500	30.8	44
Aluminum (mg/L)	0.2	1	9.16
Arsenic (mg/L)	0.01	ND	0.022
Calcium (mg/L)	-	55.5	172
Chromium (mg/L)	0.1	ND	0.001
Copper (mg/L)	1	ND	0.002
Iron (mg/L)	0.6	1.12	8.2
Lead (mg/L)	0.015	ND	0.02
Magnesium (mg/L)	150	12.8	17.9
Manganese (mg/L)	0.1	0.13	0.384
Sodium (mg/L)	-	85.4	129
Zinc (mg/L)	5	ND	0.041
Hardness (mg/L)	-	191	503
pH	6.5-8.5	7.38	7.36
Turbidity (NTU)	-	15.25	-
Dissolved Oxygen (%)	-	34.1	30.7
Conductivity (mS/cm)	-	0.69	0.61
Salinity (ppt)	-	0.39	0.42
Temperature of water (°C)	-	18	10

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016D)
ND: Non-Detect

In 2014 and 2015, Cedar Spring was analyzed in the field for pH, temperature, conductivity, salinity, and dissolved oxygen. Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum, iron, lead and manganese, were found to be below the MCL and pose no threat to wildlife. Lead content increased in 2015 from the 2014 measure. Aluminum is usually not a problem for wildlife or humans. High iron levels are mostly associated with taste and teeth staining issues. With long term exposure, high concentrations, manganese can result in nervous disorders (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time. However, almost all constituents in the water samples showed a slight increase in concentration from 2014 to 2015. This is likely due to drought conditions that have occurred in the area from 2012 to 2015. Samples should be taken in 2016 to determine if the concentrations are increasing, especially lead and manganese, which can pose some danger to wildlife.

Cliff Spring (Developed)

Location: 580529 E 4151991 N
Elevation: 6,834 ft. MSL
Dominant Plants: spikerush (*Eleocharis sp.*); rubber rabbitbrush (*Ericameria nauseosa*); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*)



Mine opening and wellhead, containing water, in 2007.

Cliff Spring is located in a mine on the side of a cliff face on the west slope of the Belted Mountain Range in Lower Montane Woodlands Key Habitat. Water from the spring accumulates at the entrance of the mine and is available for wildlife at that location. A well was placed about 30 feet down gradient of the mine entrance. Cliff Spring was surveyed in 1996, 2007, 2008, 2011, 2014, and 2015. During most site visits, water could be seen inside the entrance to the mine. In 2014 and 2015, the water level in the mine was very low, making it inaccessible to large mammals. The water appears to be good quality with a very low flow rate. Water from the spring usually surfaces from a galvanized pipe connected to the well and often overflows into a small stream channel. Water is also conveyed via a plastic pipe to a wildlife water trough about 100 yards south of the wellhead. This area was inhabited by miners in the past, as evidenced by debris and dilapidated structures at the site.

During the 1996 Dames and Moore survey (Dames and Moore, 1996), Cliff Spring was described as originating at an excavated cutout in the base of a cliff on the western face of the Belted Range. The report indicated about six feet west of the excavated hole a galvanized pipe had been buried and described a 3-foot by 20-foot area of saturated soil just down gradient of the mine entrance. This survey also identified another buried pipe and a stock tank in the center of a compacted, non-vegetated flat, approximately 60 feet west of Cliff Spring. This pipe and stock tank was installed by the DOE to develop the spring flow for wild horses. The work was stopped after the first trough was placed. Additionally, the mine water flow

was routed into a pond that was usually full of water through 1999. The NDWR database identifies two historically appropriated springs (applications 2357 and 11605) named Cliff Spring. Application 2357, the older western site was associated with what the USGS identified as Cliff Spring. Water rights were originally held by the Kawich Cattle Association. The rights were eventually transferred to the U.S. Air Force in 1990. The Kawich Cattle Association applied for appropriation of water rights in February 1912, a permit was issued in June 1912, and certification was given in July 1917. Application 11605, the eastern Cliff Spring, appears to be what is referred to as Upper Cliff Spring (see page 161). The application numbers for both Cliff Springs were updated in 1991 to 55321 and 55322, during the transfer of water rights to the U.S. Air Force. Certificate of Appropriation for 55321 states the spring source is unnamed and 0.0124 cfs water is allowed for watering of 400 head of horses, burros, and associated wildlife.

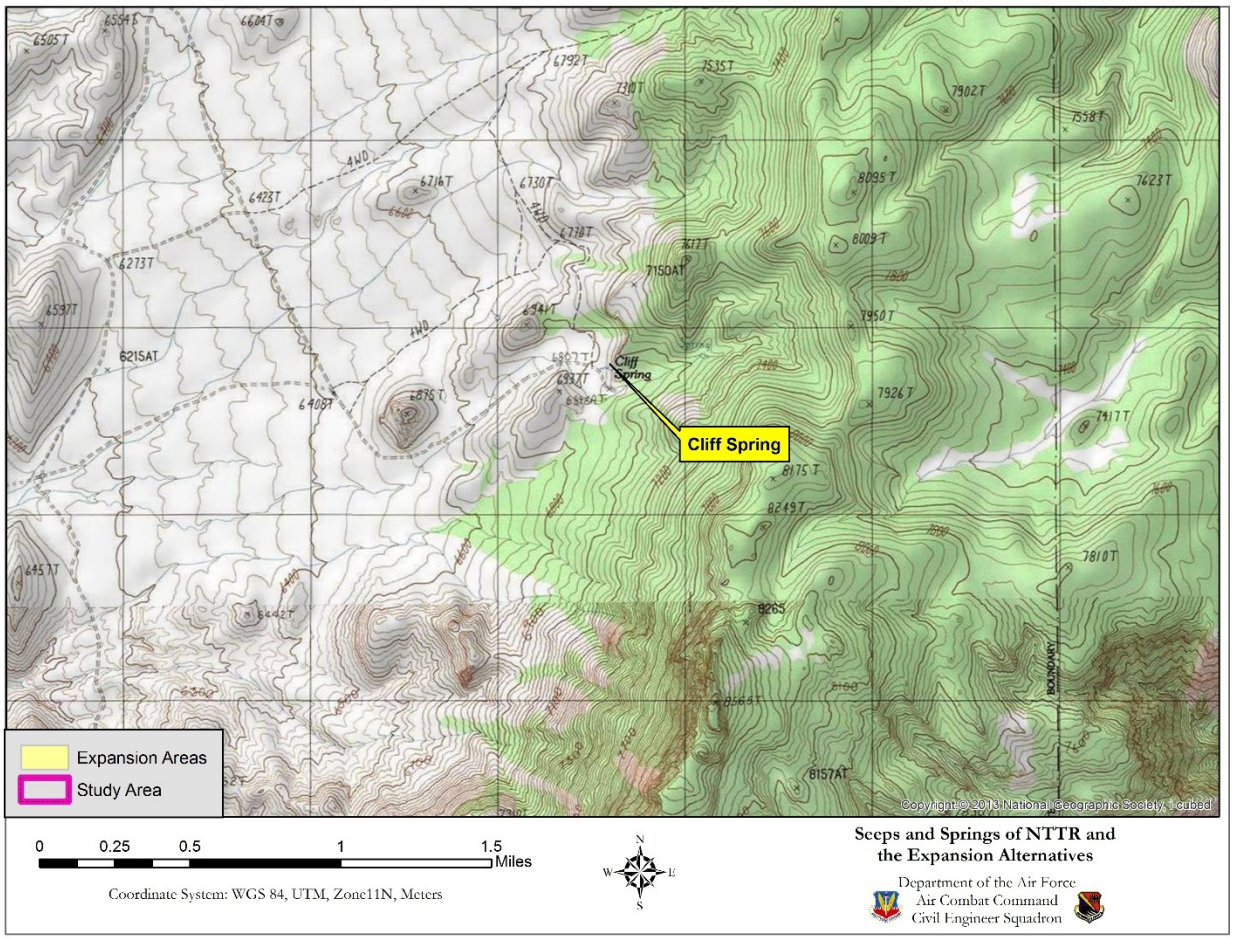


Figure 41. Topographic map showing the location of Cliff Spring.

Table 21. Results of field and laboratory analyses of water sampled at Cliff Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	5.6	6.91
Fluoride (mg/L)	4	ND	0.15
Nitrate/Nitrite (mg/L)	11	ND	ND
Sulfate (mg/L)	500	1	9.5
Aluminum (mg/L)	0.2	0.34	0.112
Arsenic (mg/L)	0.01	ND	ND
Calcium (mg/L)	-	13	6.4
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.001
Iron (mg/L)	0.6	16.4	0.89
Lead (mg/L)	0.015	ND	ND
Magnesium (mg/L)	150	1.87	ND
Manganese (mg/L)	0.1	0.1	0.03
Sodium (mg/L)	-	27.5	37.1
Zinc (mg/L)	5	1.19	0.31
Hardness (mg/L)	-	40.2	19
pH	6.5-8.5	6.81	6.69
Turbidity (NTU)	-	28.7	-
Dissolved Oxygen (%)	-	1.3	51.6
Conductivity (mS/cm)	-	0.253	0.118
Salinity (ppt)	-	0.16	0.08
Temperature of water (°C)	-	12	9.9

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016D)
ND: Non-Detect

In 2014 and 2015, Cliff Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016D). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except for aluminum and iron, were found to be below the MCL and pose no threat to wildlife. Aluminum is usually not a problem for wildlife or humans. High iron levels are mostly associated with taste and teeth staining issues (EPA, 2016). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Corral Spring (Developed)

Location: 554173 E 4182041 N
Elevation: 6,604 ft. MSL
Dominant Plants: Sparsely vegetated area, dominated by big sagebrush (*Artemisia tridentata*)



Corral Spring, as observed on May 25, 2014.

Corral Spring (two spring taps) is located on the west side of the Kawich Mountain Range in Sagebrush Key Habitat. A 1996 survey noted that the spring flowed from a pipe which apparently tapped an underground groundwater source up-gradient of the livestock water troughs (Dames and Moore, 1996). Overflow from the troughs entered an unvegetated pool then seeped down-gradient, creating an area of saturated soils. This survey noted the saturated soils supported a population of cattails and rushes approximately 475 square feet and could be considered a potential wetland (Dames and Moore, 1996). In 2007, the site no longer supported the plant community observed in the 1996 survey. The BLM improved the site after 2007 with new troughs and a water storage tank.

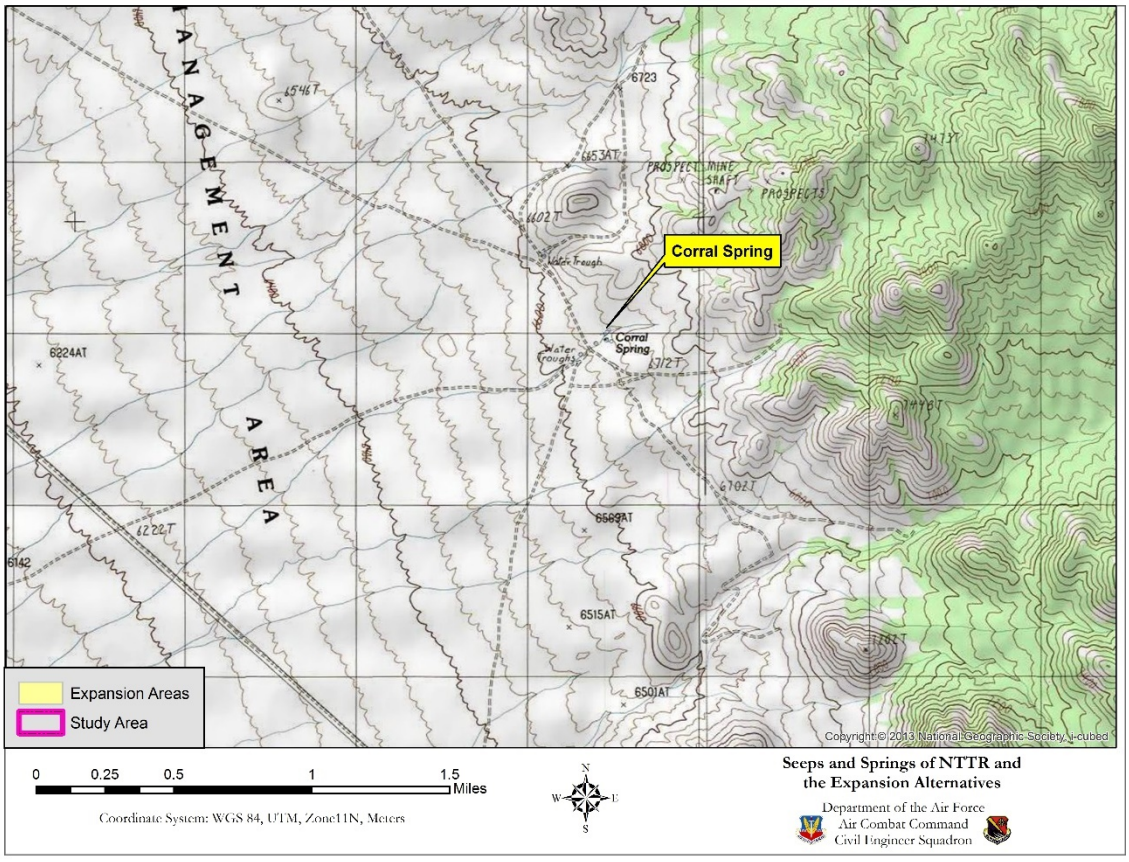


Figure 42. Topographic map showing the location of Corral Spring.

Degradation of the spring by wildlife and/or horses since 1996 was inferred because the lush vegetation described historically was no longer present at the spring during site visits in 2007 and 2011. Lack of the vegetation in 2007-2011 was probably caused by dry conditions and grazing by wild horses and large mammals during those years. No historic records detailing permitting or appropriation of water rights have been located for Corral Spring, despite being identified on USGS topographic maps.

Table 22. Results of field and laboratory analyses of water sampled at Corral Spring.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	44.6	31
Fluoride (mg/L)	4	0.82	1.37
Nitrate/Nitrite (mg/L)	11	ND	ND
Sulfate (mg/L)	500	77.4	65.9
Aluminum (mg/L)	0.2	ND	0.007
Arsenic (mg/L)	0.01	ND	0.009
Calcium (mg/L)	-	53.8	57.9
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.004
Iron (mg/L)	0.6	ND	0.01
Lead (mg/L)	0.015	ND	ND
Magnesium (mg/L)	150	5.9	5.7
Manganese (mg/L)	0.1	ND	0.001
Sodium (mg/L)	-	72.4	91.9
Zinc (mg/L)	5	ND	0.026
Hardness (mg/L)	-	159	168
pH	6.5-8.5	7.07	6.54
Turbidity (NTU)	-	0.61	-
Dissolved Oxygen (%)	-	20	30.1
Conductivity (mS/cm)	-	0.5	0.44
Salinity (ppt)	-	0.31	6.78
Temperature of water (°C)	-	14.1	11.4

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016A)
ND: Non-Detect

In 2014 and 2015, Corral Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016A). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents were found to be below the MCL and pose no threat to wildlife. Additionally, the concentrations appear to be relatively stable with no trends towards increasing or decreasing concentrations.

Dacite Seep

Location: 519806 E 4171207 N

Elevation: 6,311 ft. MSL

Dominat Plants: Rubber rabbitbrush (*Ericameria nauseosa*); Mormon tea (*Ephedra nevadensis*); wild-mustard (species unidentified); phacelia (*Phacelia* sp.); dwarf barley *(Hordeum depressum*); Utah juniper *(Juniperus osteosperma)*



Dacite Seep in 2009.

Dacite Seep is a perennial spring located east of the Cactus Mountain Range in Sagebrush Key Habitat. Dacite Seep was first observed during a desert bighorn sheep survey in the fall of 2008. On May 24, 2009, the spring was inspected and vegetation was characterized. Vegetation surrounding the spring was a sparse population of Utah juniper mixed with rubber rabbitbrush and Mormon tea. The spring emerged from a central source, saturating the surrounding soil. Vegetation at the site was impacted by wildlife, potentially wild horses, making it a candidate for fence protection. Dacite Seep was surveyed in 2015 and found to be completely dry with no sign of water or saturated soils. It appeared to have not had any significant flow in at least a year.

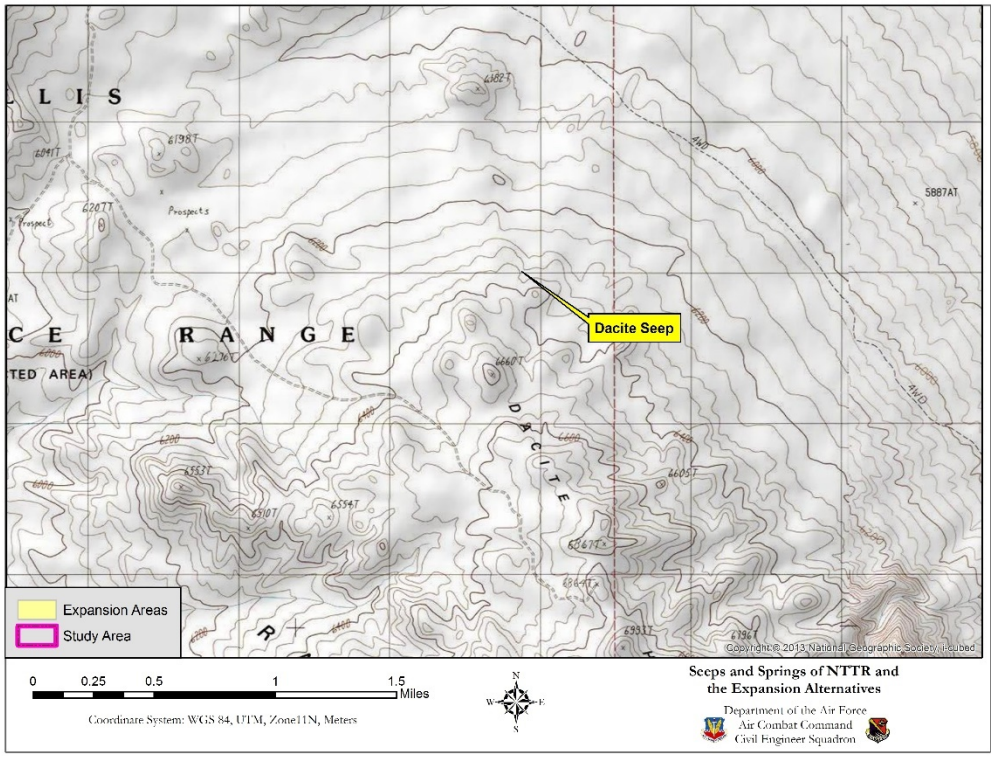


Figure 43. Topographic map showing the location of Dacite Seep.

De Jesus Perennial Spring (Developed)

Location: 4082867 N 626987 E
Elevation: 5,357 ft. MSL
Dominant Plants: Galleta (*Pleuraphis rigida*); desert needlegrass (*Achnatherum speciosum*); Indian ricegrass (*Achnatherum hymenoides*); Nevada ephedra (*Ephedra nevadensis*); shadscale (*Atriplex confertifolia*)

De Jesus is a spring fed wildlife water development located in the southern region of the Pintwater Mountain Range in the southeast corner of Range 64A in Mojave Mid-Elevation Mixed Desert Scrub key habitat. Spring water is stored in a tank and fed to several troughs for wildlife use. This spring is widely used by various wildlife species and is one of the most active wildlife water developments on the South Range.



De Jesus Spring located on the west side of the Pintwater Mountain Range.

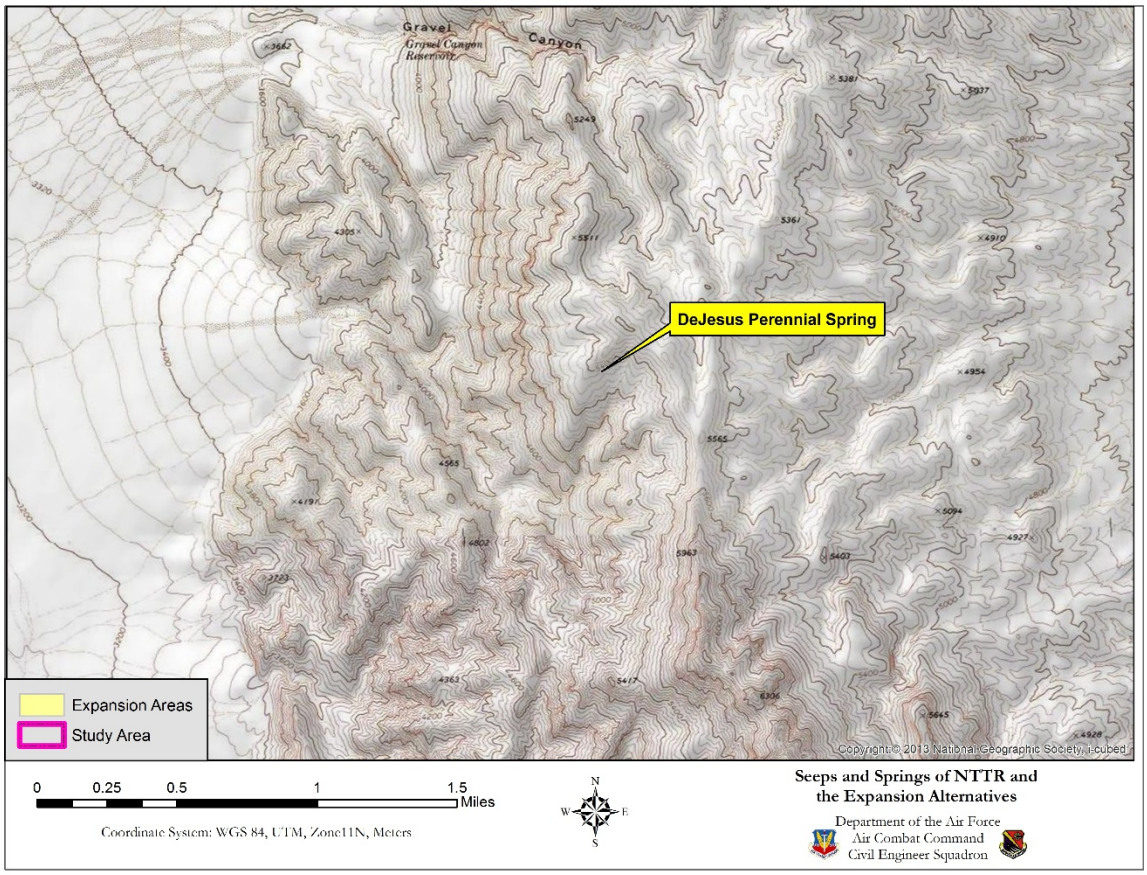


Figure 44. Topographic map showing the location of De Jesus Spring development.

Table 23. Results of field and laboratory analyses of water sampled at De Jesus on September 6, 2014. Constituents exceeding MCL's are highlighted in yellow.

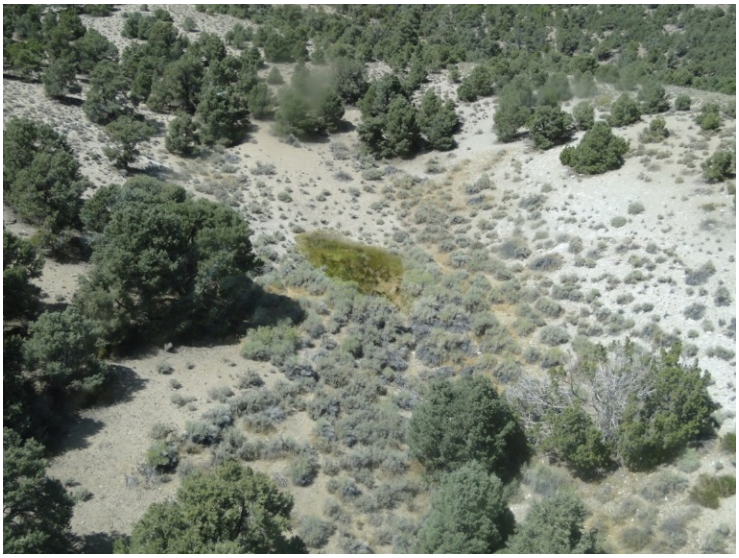
NAME	MCL (mg/L)*	2014**
Chloride (mg/L)	400	21.5
Fluoride (mg/L)	4	0.45
Nitrate/Nitrite (mg/L)	11	5.76
Sulfate (mg/L)	500	46.4
Aluminum (mg/L)	0.2	0.56
Arsenic (mg/L)	0.01	0.01
Calcium (mg/L)	-	50.1
Chromium (mg/L)	0.1	ND
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	2.1
Lead (mg/L)	0.015	ND
Magnesium (mg/L)	150	22.7
Manganese (mg/L)	0.1	0.05
Sodium (mg/L)	-	27.5
Zinc (mg/L)	5	ND
Hardness (mg/L)	-	219
pH	6.5-8.5	8.37
Turbidity (NTU)	-	6.31
Dissolved Oxygen (%)	-	78
Conductivity (mS/cm)	-	0.571
Salinity (ppt)	-	0.26
Temperature of water (°C)	-	28

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016C)
ND: Non-Detect

In 2015, water samples were not collected for this site. De Jesus Spring was analyzed in the field by NNRP biologists in 2014 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016C). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table are the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum and iron, measured for De Jesus Spring were found to be below the MCL and pose no threat to wildlife. Aluminum and iron were above the MCL. As discussed before, aluminum usually does not pose threats to wildlife except at very high concentrations. Additionally, iron is only a problem because it causes water to have bad flavor and tends to stain teeth. Both of these should not be an issue for wildlife. However, this water should be sampled annually to ensure that these constituents are not increasing.

East Kawich Spring

Location: 560608 E 4182740 N
Elevation: 7,175 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); softstem bulrush (*Schoenoplectus tabernaemontani*); pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*); big sagebrush (*Artemisia tridentata*); rubber rabbitbrush (*Ericameria nauseosa*)



East Kawich Spring habitat observed on September 3, 2011.

East Kawich Spring is located on the east side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. East Kawich Spring was originally observed during a large mammal survey on September 3, 2011. The spring is located in an open area of pinyon-juniper with the surrounding plant community comprised of big sagebrush and rubber rabbitbrush. The seep itself supported a healthy, green stand of beardless wildrye and bulrush. Water was present during the September 3, 2011, survey, and appeared to be a perennial spring.

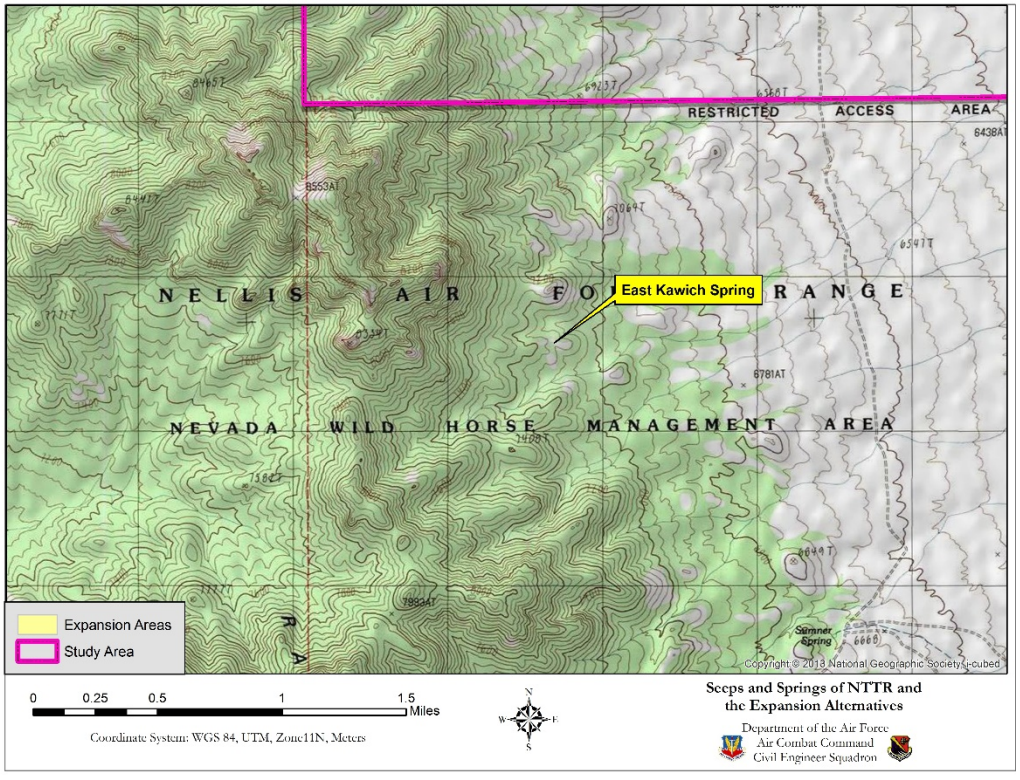


Figure 45.Topographic map showing the location of East Kawich Spring.

Table 24. Results of field and laboratory analyses of water sampled at East Kawich Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**
Chloride (mg/L)	400	51.6
Fluoride (mg/L)	4	0.68
Nitrate/Nitrite (mg/L)	11	ND
Sulfate (mg/L)	500	135
Aluminum (mg/L)	0.2	ND
Arsenic (mg/L)	0.01	ND
Calcium (mg/L)	-	36.9
Chromium (mg/L)	0.1	ND
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	0.13
Lead (mg/L)	0.015	ND
Magnesium (mg/L)	150	3.2
Manganese (mg/L)	0.1	0.21
Sodium (mg/L)	-	67.3
Zinc (mg/L)	5	ND
Hardness (mg/L)	-	105
pH	6.5-8.5	6.77
Turbidity (NTU)	-	17
Dissolved Oxygen (%)	-	63.1
Conductivity (mS/cm)	-	0.403
Salinity (ppt)	-	0.23
Temperature of water (°C)	-	16.2

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016A)
ND: Non-Detect

Water samples were not collected for this site in 2015. East Kawich Spring was analyzed in the field by NNRP biologists in 2014 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016A). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except for manganese, were found to be below the MCL and pose no threat to wildlife. The level of manganese detected was twice the MCL. With long term exposure, high concentrations of manganese can result in nervous disorders (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

George's Water (Developed)

Location: 557119 E 4190474 N
Elevation: 6,947 ft. MSL
Dominant Plants: Narrowleaf willow (*Salix exigua*); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



2007 photograph of George's Water showing the well and willows.

George's Water is located on the east side of the Kawich Mountain Range in Lower Montane Woodland Key Habitat. This spring has been inspected on many occasions for various wildlife and vegetation surveys and typically has been found to be wet or flowing during the winter and spring months, but usually dry in the summer. Pygmy rabbit scat and burrows were observed around drier areas, which support a population of big sage growing three to four feet tall. During a sage grouse survey in April of 2006, the site was observed to be saturated with water from snow melt and the adjacent stream was flowing. A second visit in May 2007, revealed very dry conditions with no standing water or saturated soils evident at the spring head. However, a healthy population of narrow leaf willows were observed adjacent to the spring head, indicative of a shallow water table.

During a 1996 visit, Dames and Moore (Dames and Moore, 1996) noted, "strong winds in the narrow canyon made a safe landing impossible, so a visual inspection was made. No water was observed at the area indicated as the source on maps. Some intermittent water in a stream bed below the marked source was apparent. Grasses at the site were withered and dry. At present, this site does not appear to represent a potential wetland." A BLM (1995) report states that this water resource is ". . . used outside of the NRC area for livestock and [is] maintained by Mr. Joseph P. Fallini, Jr. Potential actions for this site include (i) determine whether or not the water allotment is still being used for watering cattle according to the conditions specified in the BLM-issued permit, and return any flow-volume in excess of what is actually being used (the excess to be used at the spring source); and (ii) if feasible, install a pipeline-fed bermed pond feature similar to that which occurs at Sumner Spring, for use by native wildlife and horses."



Pygmy rabbit captured by remote sensing cameras at George's Water.

George's Water has not been appropriated, according to NDWR. The vested rights were originally held by the Helen Fallini Living Trust. That trust and the Fallini 1983 Trust are listed as the original and current owners. The priority date for this spring is January 1870, the filing date is listed as January 2007, with a Return Date of April 2007. The USGS map

indicates an aqueduct once existed to convey water away from the spring. The original allowed use totaled an unknown amount of annual acre feet of water for the purpose of watering 1,000 head of cattle and 25 horses. A surveyors drawing was also unavailable.

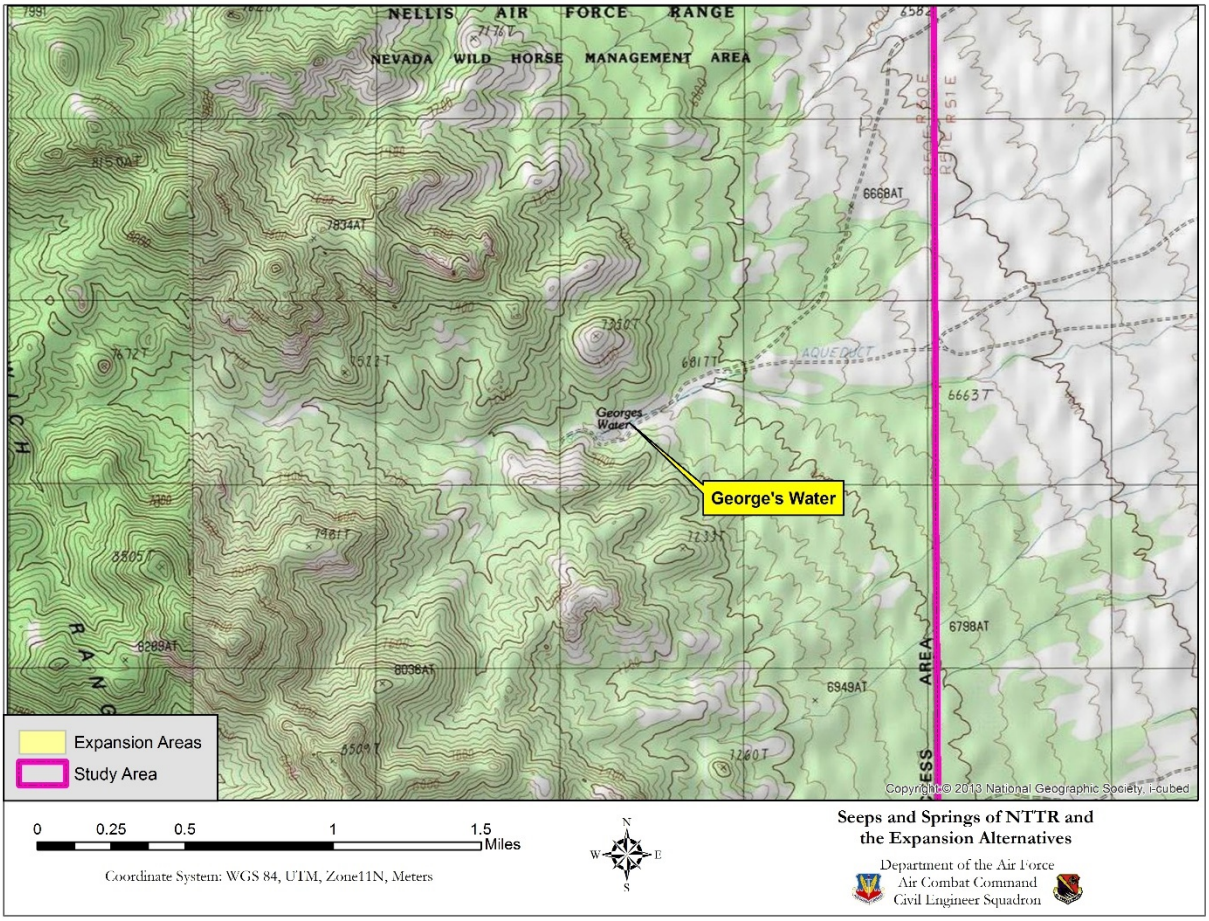


Figure 46. Topographic map showing the location of George's Water.

The USGS sampled the spring water in 1985, 1998, and 2000 (Table 3). Sampling analysis shows an increase in alkalinity, but temporal observation indicates that this is likely due to the time of year samples were taken. Freshwater often becomes more alkaline in higher temperatures. Water at this spring has not been analyzed during the last two sampling events in 2014 and 2015 because the spring was not producing water.

Table 25. Water quality for George's Water according to USGS data collected in 1985, 1998, and 2000 (Dames and Moore, 1996).

Item	11 Jan 1985	15 Jan 1985	29 Apr 1998	15 May 2000 Sample 1	15 May 2000 Sample 2	15 May 2000 Sample 3
Ag, Dissolved (ug/L)				0.16	0.16	
Al, Dissolved (ug/L)				44.44	32.40	
As, Dissolved (ug/L)				1.87	1.93	
Ba, Dissolved (ug/L)				16.1	15.88	
Ca, Dissolved (mg/L)	20		16.7			17.2
Cd, Dissolved (ug/L)				0.0149	0.0062	
Cl, Dissolved (mg/L)	5.8		4			4.7
Cr, Dissolved (ug/L)				0.0578	0.125	
Cu, Dissolved (ug/L)				0.254	0.257	
F, Dissolved (mg/L)			0.3			
HCO_3, Dissolved (mg/L)	92.6		72			1.1
Li, Dissolved (ug/L)				10.4	10.3	
Mg, Dissolved (mg/L)	3.12		2.7			2.7
Mn, Dissolved (ug/L)				0.20	0.188	
Na, Dissolved (ug/L)	15		14			14.2
NO_3, Dissolved (ug/L)	0.97					0.09
Pb, Dissolved (ug/L)				0.04	0.04	
SO_4, Dissolved (ug/L)	11.1		9			8.8
Specific Conductance (Units/Mil)	188	179				159
Specific Conductance--Field (Units/Mil)	210		161			
U, Dissolved (ug/L)				0.574	0.584	
Water Temperature (°C)	6		10.1			10
Zn, Dissolved (ug/L)				0.622	0.650	

Indian Spring 4

Location: 579055 E 4144377 N
Elevation: 6,746 ft. MSL
Dominant Plants: Curl-leaf mountain mahogany (*Cercocarpus ledifolius*); golden sedge (*Carex aurea*); beardless rabbitsfoot grass (*Polypogon viridis*); Gambel oak (*Quercus gambelii*); rubber rabbitbrush (*Ericameria nauseosa*); big sagebrush (*Artemisia tridentata*); spik-erush (*Eleocharis sp.*)



Indian Spring 4

Indian Spring 4 is located in the channel of an ephemeral stream in the Belted Range in Lower Montane Woodlands Key Habitat. Indian Spring 4 contained a small pool of water and supported a dense stand of spike rush and water bentgrass in 2009. Visually, the water quality appeared to be good.

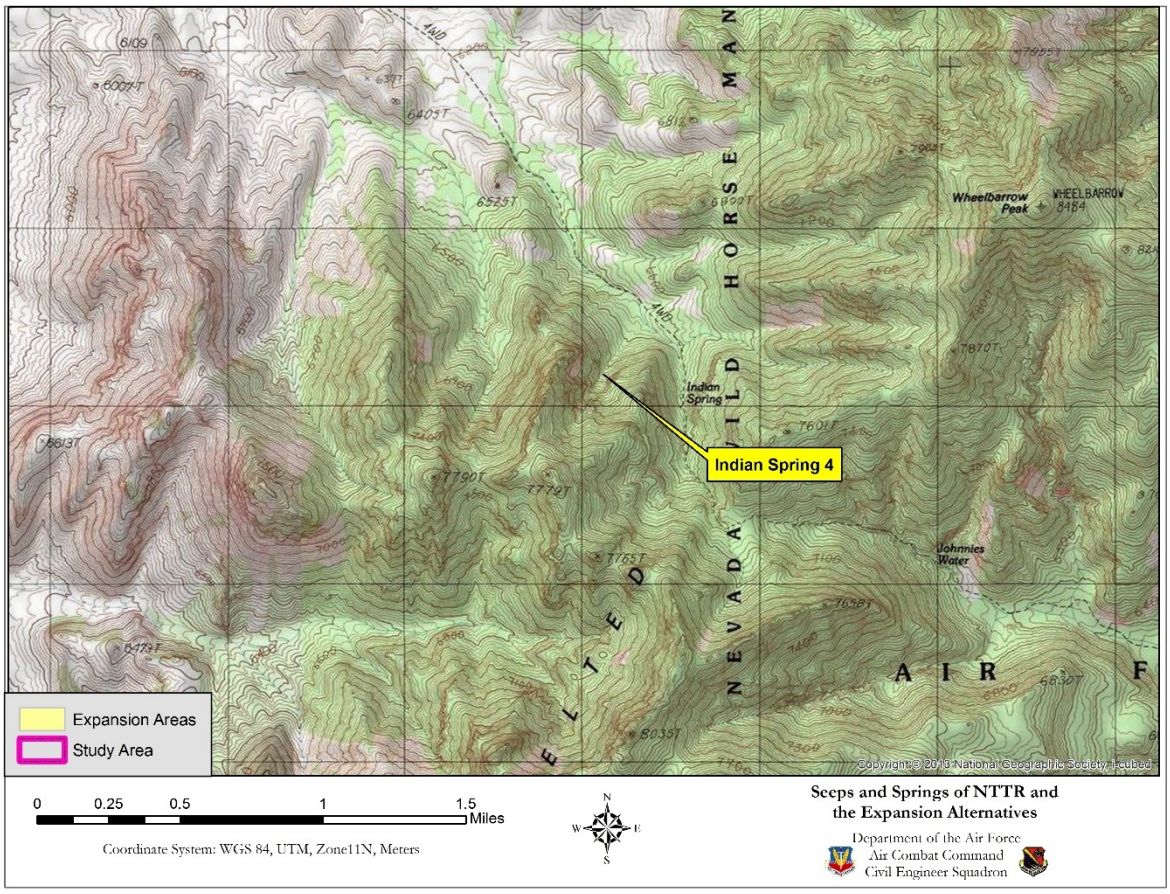


Figure 47. Topographic map showing the location of Indian Spring 4.

Jerome Spring (Developed)

Location: 494571 E 4150242 N
Elevation: 6,945 ft. MSL
Dominant Plants: Narrowleaf willow (Salix exigua); spikerush (Eleocharis sp.); softstem bulrush (Schoenoplectus tabernaemontani); big sagebrush (Artemisia tridentata); Utah juniper (Juniperus osteosperma); singleleaf pinyon pine (Pinus monophylla)



Jerome Spring in September 2011.

Jerome Spring is located in the southern canyon on Stonewall Mountain in Lower Montane Woodlands Key Habitat. Access to Jerome Spring is accomplished on foot. The feature contained some surface water during the 2011 survey.

Dames and Moore (Dames and Moore, 1996) observed this spring consisted of a pair of seeps flowing about 0.007 cfs, maintaining saturated soils in a 75-foot by 60-foot depression. A third seep without flow was also observed 100 feet to the north. Soils in the historic stream channel were also saturated during the 1995 visit. A depression located below the most productive seep indicated water once accumulated in that area. The surface water in the historic stream channel near the seeps, along with adjacent saturated soil, was reported to be a potential wetland approximately one acre in size. The report indicated the site had been impacted by horse use. Because of its remote, high elevation location, the site appeared to be an excellent water source for a relatively wide variety of wildlife, including reptiles, many bird species, and mammalian fauna. The spring was visited in 2014 and 2015 and was flowing in the upper reaches both times.

Jerome Spring water rights were originally held by the Kawich Cattle Company. The rights were transferred to the Nellis Air Force Base on an unknown date. The Kawich Cattle Company applied for appropriation of water rights in January 1920, a permit was issued in June 1920, and certification was given in November 1923. The spring feature was originally impounded with an earthen dam to create a stock watering pond. The original allowed use totaled

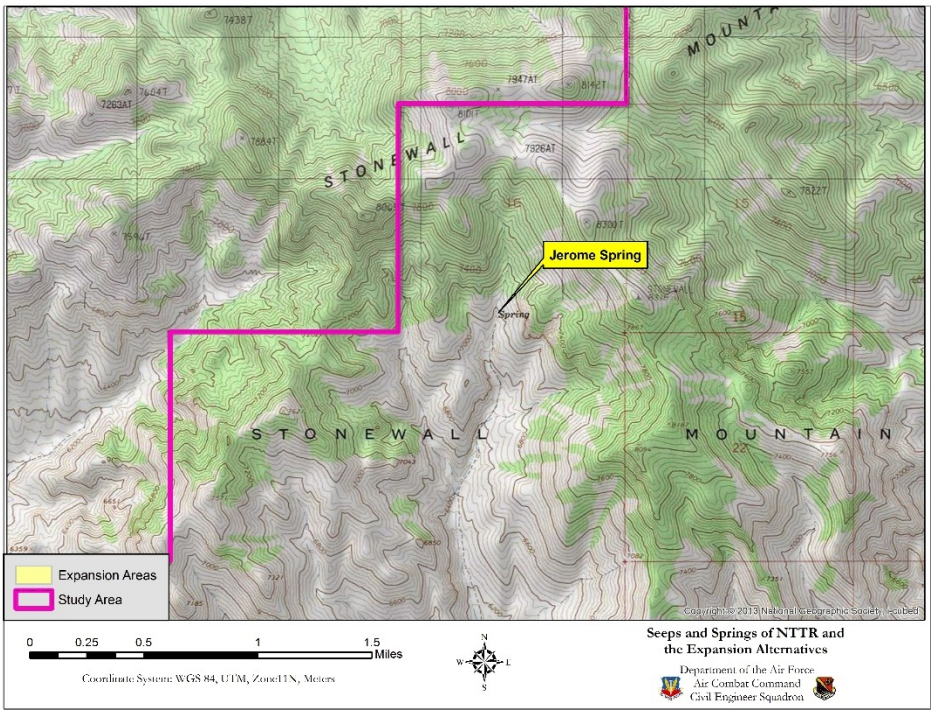


Figure 48. Topographic map showing the location of Jerome Spring.

2.18 annual acre feet of water and a flow rate of 0.025 cfs, substantially higher than the flow rate observed in 1996 (Dames and Moore, 1996), for the purpose of watering 100 head of cattle. The appropriation was last transferred to James M. Daniels on May 24, 1949.

Table 26. Results of field and laboratory analyses of water sampled at Jerome Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	Did	22.3
Fluoride (mg/L)	4	Not	0.17
Nitrate/Nitrite (mg/L)	11	Take	ND
Sulfate (mg/L)	500	Sample	13
Aluminum (mg/L)	0.2		0.126
Arsenic (mg/L)	0.01		0.002
Calcium (mg/L)	-		35
Chromium (mg/L)	0.1		ND
Copper (mg/L)	1		0.004
Iron (mg/L)	0.6		0.92
Lead (mg/L)	0.015		0.001
Magnesium (mg/L)	150		8.4
Manganese (mg/L)	0.1		0.033
Sodium (mg/L)	-		369
Zinc (mg/L)	5		0.007
Hardness (mg/L)	-		122
pH	6.5-8.5		7.4
Turbidity (NTU)	-		1.4
Dissolved Oxygen (%)	-		60.5
Conductivity (mS/cm)	-		250
Salinity (ppt)	-		0.16
Temperature of water (°C)	-		13

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014, water samples were not collected for this site. Jerome Spring was analyzed in the field by NNRP biologists in 2015 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table are the results from both on-site and Silver State Laboratories analyses. All constituents, except iron, measured for Jerome Spring were found to be below the MCL and pose no threat to wildlife. Iron was slightly higher than the MCL. High iron levels are mostly associated with taste and teeth staining issues (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Johnnie's Water

Location: 581096 E 4143339 N
Elevation: 6,561 ft. MSL
Dominant Plants: Bluegrass (*Poa* sp.); black sagebrush (*Artemisia nova*); Indian ricegrass (*Achnatherum hymenoides*); Nevada ephedra (*Ephedra nevadensis*); winterfat (*Krascheninnikovia lanata*); James' galleta (*Pleuraphis jamesii*)

Johnnie's Water is located on the east slope of the Belted Mountain Range in Lower Montane Woodlands Key Habitat. The spring was appropriated by R.E. Bower on May 18, 1917, for watering livestock. At that time, the appropriated flow was 0.025 cfs. The last transfer of the Certificate of Appropriation was noted on July 14, 1948, from J.H. Clark to Sam Watkins. The NDWR database indicates Sam Watkins is still the water rights holder.

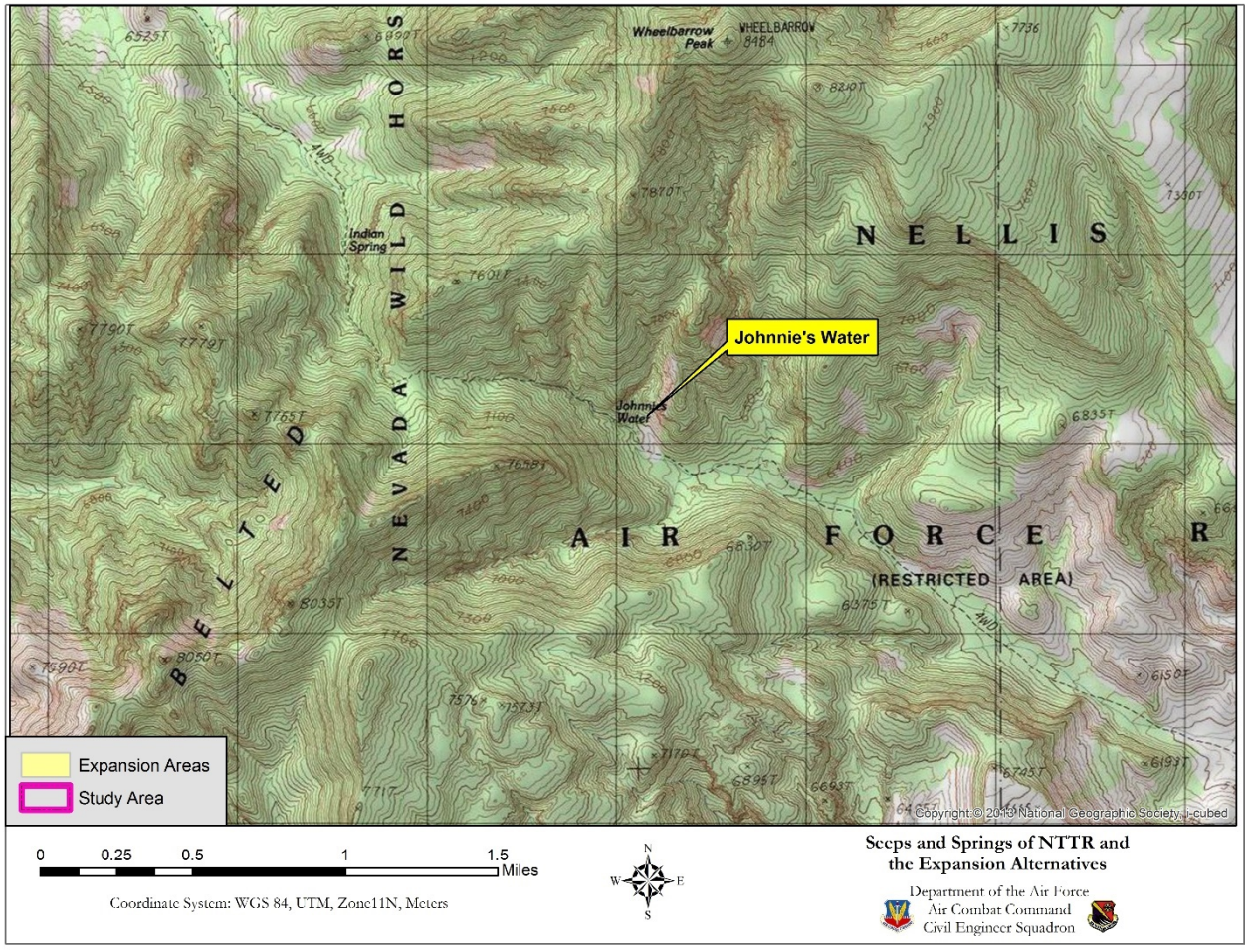


Figure 50. Topographic map showing the location of Johnnie's Water.

Kawich Seep 3

Location: 3A: 559060 E 4183057 N
3B: 558832 E 4183128 N
Elevation: 3A: 7,936 ft. MSL 3B: 7,906 ft. MSL
Plant Community: Beardless wildrye (*Leymus triticoides*); squarestem spikerush (*Eleocharis quadrangulata*); softstem bulrush (*Schoenoplectus tabernaemontani*); singleleaf pinyon pine *(Pinus monophylla)*; Utah juniper (*Juniperus osteosperma*)

Kawich Seep 3 is actually a seep (3A) and perennial spring (3B) less than 800 feet from each other. They are located on the east side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Kawich Seep 3A appears to be a seep located in a draw up-gradient of the main spring, Kawich Seep 3B. Pooling surface water was observed in the middle of the spring vegetation at Kawich Seep 3B. Upland areas surrounding the spring and seep were mostly pinyon pine with scattered Utah juniper and some big sagebrush. In 2011, the seep area appeared much drier than in past visits, and an area further up-gradient of the seep appeared to be greener than the lower parts, possibly indicating the area of seepage had moved.



Kawich Seep 3A observed in 2011



Kawich Seep 3B with standing water, observed in 2009

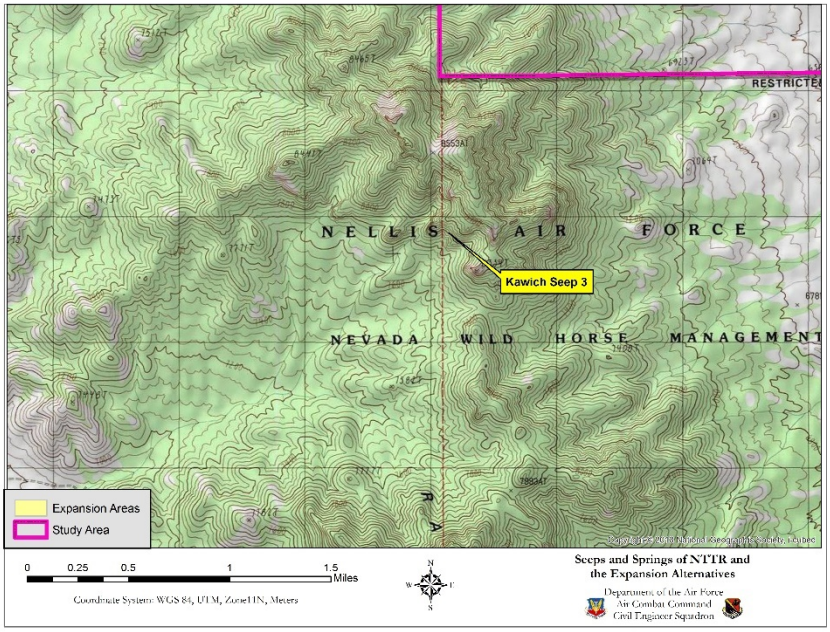


Figure 51. Topographic map showing the location of the Kawich Seep 3A and 3B.

Log Spring

Location: 555447 E 4180458 N
Elevation: 6,745 ft. MSL
Dominant Plants: Annual rabbitsfoot grass (*Polypogon monspeliensis*); pondweed (*Potamogeton spp.*); beardless wildrye (*Leymus triticoides*); rubber rabbitbrush (*Ericameria nauseosa*); big sagebrush (*Artemisia tridentata*); fourwing saltbush (*Atriplex canescens*); cheatgrass (*Bromus tectorum*); cattail (*Typha* sp.)



2009 photo of Log Spring

Log Spring is located on the west side of the Kawich Mountain Range, in the northern half of Range EC East, over one mile southeast of Corral Spring, in a Sagebrush habitat. In 1996, a reportedly wet year, Log Spring was observed flowing into a shallow pool and a small area of saturated soil. The size of the pool during the October 1996 survey was approximately six feet by thirty feet, with a maximum depth of eight inches. The site had been trampled by wildlife and was barren of vegetation around the pool. The limited vegetation at the spring head included rabbitsfoot grass, pondweed, and wildrye. Rabbitbrush, big sagebrush, and cheatgrass vegetated the area beyond the spring head. During

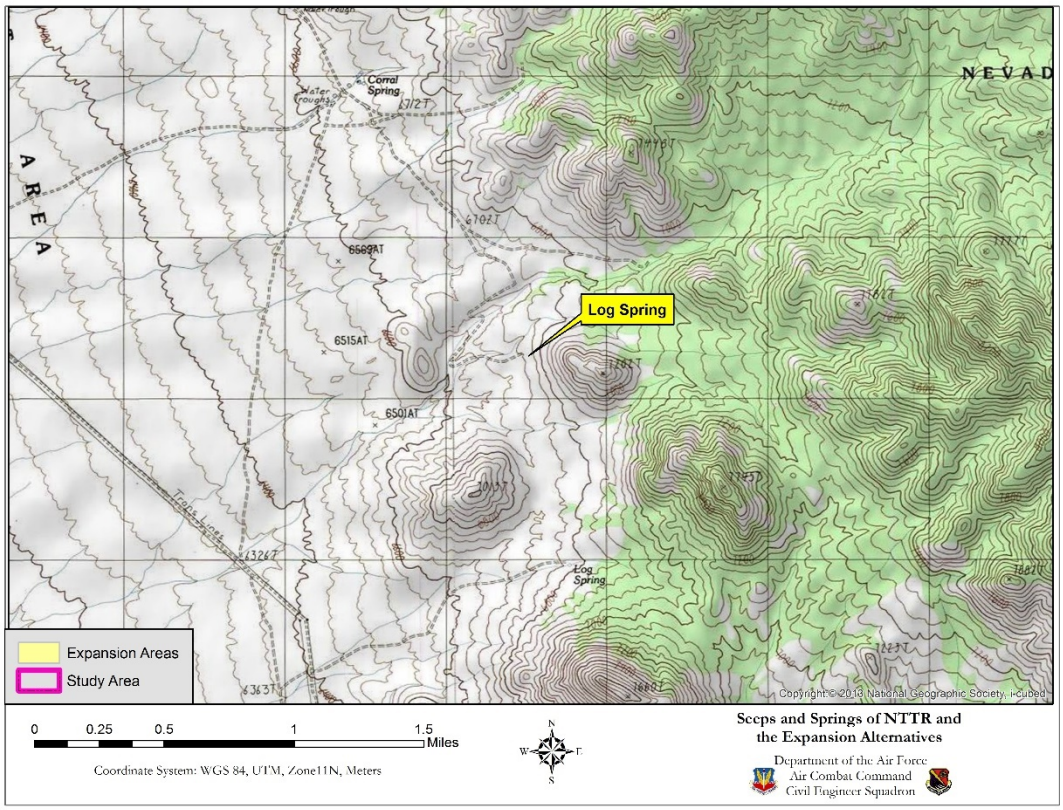


Figure 52. Topographic map showing the location of Log Spring.

the 2007 survey, also reported as a wet year, the spring appeared less extensive than reported in 1996. The vegetation observed in 2007 was similar to that observed in 1996, dominated by four-winged saltbush and rabbitbrush. Significant degradation of the area from grazing and trampling was also observed. In 2009, the spring and pond again contained visually less water, but the survey was conducted in September after a dry summer. Similarly, in 2011, only moist soil was observed, but the area was apparently still under heavy use by wild horses and pronghorn. Large herds of pronghorn were observed in the area during this survey. The overall value of the site as a watering resource for wildlife was assessed as moderate only due to degradation by wild horses. This site could be restored to a healthy spring plant community by use of fencing configured in a manner to allow wildlife access to standing water without damaging the wetland area. Historical permitting and certification of water rights for this spring were not found in the NDWR database. The location of this spring matches a spring that was named Harley Spring in the past. Historic photographs of Log Spring are identical to that of Harley Spring. The NNRP determined that the location of Log Spring on USGS topographic maps was incorrect and that the true location was that of Harley Spring. Thus, the decision was made to name the feature "Log Spring" and list "Harley Spring" as being synonymous with "Log Spring".

Table 27. Results of field and laboratory analyses of water sampled at Log Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	39.8	21.8
Fluoride (mg/L)	4	0.76	0.66
Nitrate/Nitrite (mg/L)	11	1.07	0.34
Sulfate (mg/L)	500	37.6	23.3
Aluminum (mg/L)	0.2	0.62	0.455
Arsenic (mg/L)	0.01	ND	0.01
Calcium (mg/L)	-	30.6	17.3
Chromium (mg/L)	0.1	ND	0.001
Copper (mg/L)	1	ND	0.001
Iron (mg/L)	0.6	1.42	0.24
Lead (mg/L)	0.015	ND	ND
Magnesium (mg/L)	150	3.5	2.4
Manganese (mg/L)	0.1	0.02	0.008
Sodium (mg/L)	-	38	49.7
Zinc (mg/L)	5	ND	0.006
Hardness (mg/L)	-	91	53
pH	6.5-8.5	7.59	8.39
Turbidity (NTU)	-	3.2	-
Dissolved Oxygen (%)	-	67.5	97.6
Conductivity (mS/cm)	-	0.321	0.268
Salinity (ppt)	-	0.19	0.16
Temperature of water (°C)	-	14.5	15.9

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014 and 2015, Log Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016A). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum and iron, were found to be below the MCL and pose no threat to wildlife. Aluminum was above the MCL for both years. Aluminum is usually not a problem for wildlife or humans. Iron was above the MCL only in 2014. High levels of iron are usually associated with causing water to have bad flavor and may cause teeth staining (EPA, 2016). Aluminum is only slightly higher than the accepted MCL and probably does not pose immediate danger to wildlife. In 2015, both aluminum and iron showed lower concentrations compared to 2014; however, all constituents should be monitored on an annual basis to ensure that they are not increasing.

Lower Chicken Pete's

Location: 494637 E 4172869 N
Elevation: 5,449 ft. MSL
Dominant Plants: Shadscale (*Atriplex confertifolia*); Joshua tree (*Yucca brevifolia*); threadleaf snakeweed (*Gutierrezia microcephala*)



Lower Chicken Pete's on May 31, 2009

Lower Chicken Pete's is located just north of Stonewall Flats in Intermountain Cold Desert Scrub Key Habitat. Lower Chicken Pete's was flowing when surveyed on May 18, 2007, and May 31, 2009. Vegetation was sparse around the spring, with scattered threadleaf snakeweed and one mature Joshua tree present. The spring originated in a pool about six feet in diameter, flowing approximately 40 to 50 feet before percolating into the soil. The spring appears to be an excellent source of water for wildlife, but forage and cover is sparse. Field observations indicate that the spring is mostly used by small mammals, birds, reptiles, and, occasionally, large mammals travelling through the area. This spring was inspected in 2014 and 2015 and found to be dry with no flow.

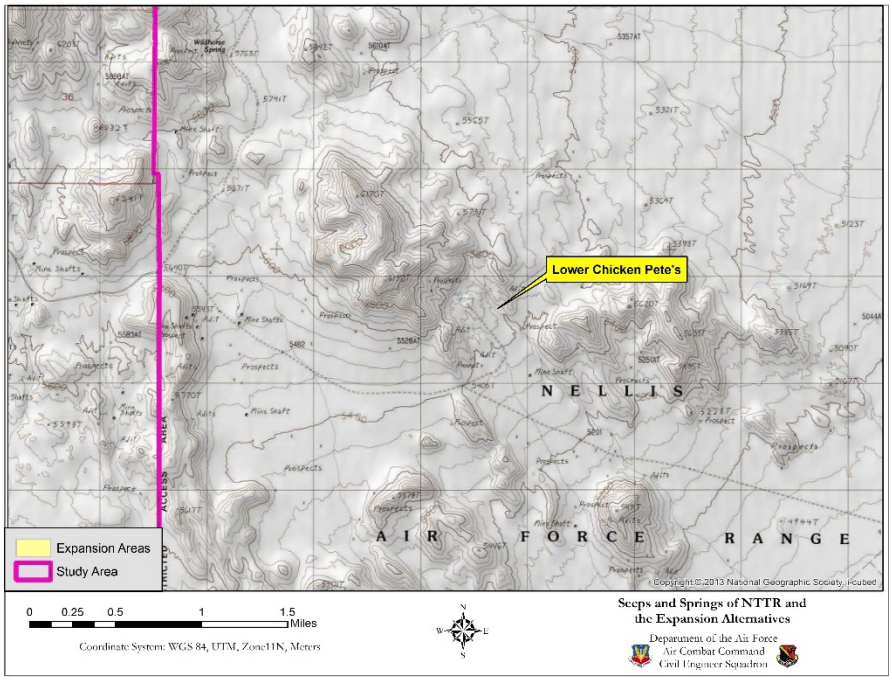


Figure 53. Topographic map showing the location of Lower Chicken Pete's.

Monte Cristo Spring (Developed)



2007 aerial view of Monte Cristo Spring

Location: 514577 E 4128662 N
Elevation: 5,159 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); softstem bulrush (*Schoenoplectus tabernaemontani*); big sagebrush (*Artemisia tridentata*); cheesebush (*Hymenoclea salsola*); Indian ricegrass (*Achnatherum hymenoides*); desert needlegrass (*Achnatherum speciosum*)

Monte Cristo Spring is located on the northwest side of Tolicha Peak in Sagebrush Key Habitat. The 1996 Dames and Moore wetland survey (Dames and Moore, 1996) described this spring as a remote site with difficult access by vehicle, though it is relatively close to the Tolicha Peak Electronic Combat Range facilities. Access during the 1996 survey was by helicopter, which minimized ground disturbance. The spring supports a 6 foot by 75-foot area of rushes, native grasses, and salt grass, with a few standing pools. The saturated soils precipitated alkaline salts to the surface, excluding the establishment of vegetation. Small pits dug to approximately one and one-half feet in these areas encountered the water table. Two empty, abandoned stock tanks were located adjacent to the saturated area. Evidence of coyote and badger visitation were observed.

Monte Cristo Spring water rights were originally held by the Kawich Cattle Association (1919). The Kawich Cattle Association applied for a permit in April 1916 and the permit was issued in August 1916. The spring changed hands several times before being certificated in May 1938 to Albert M. Johnson, Bessie M. Johnson, and Walter Scott. In 1968, the spring was assigned to L.C. Colvin; the Colvin Cattle Company still holds the rights to the water. The spring was originally developed from a 120-foot-long open cut with a 15-foot face, with the water piped 130 feet to an iron trough. The original allowed use totaled

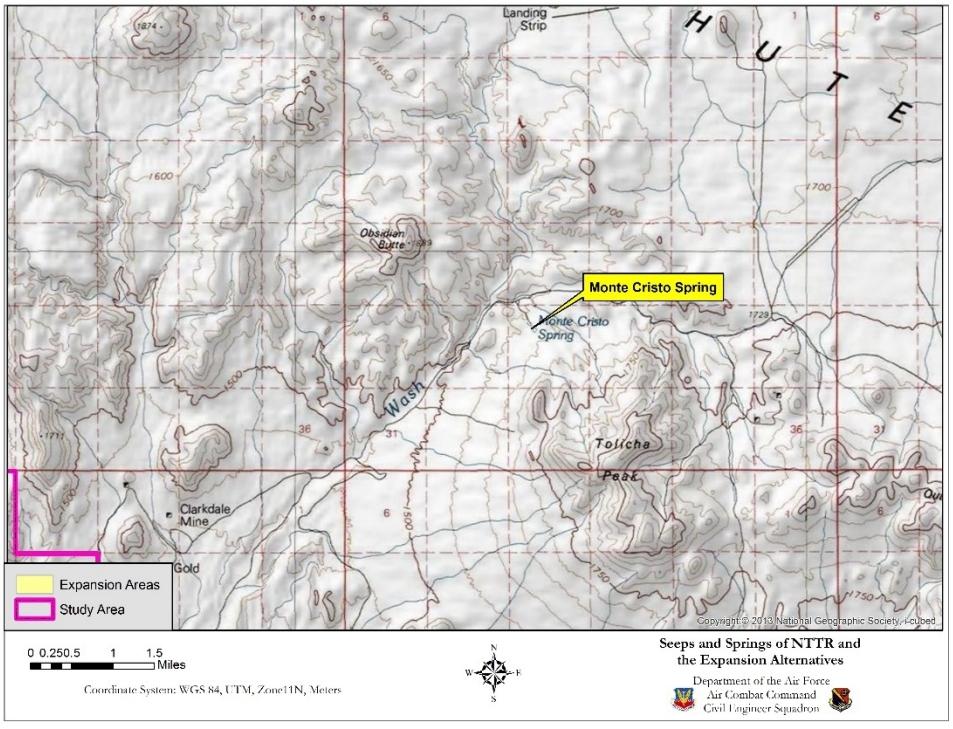


Figure 54. Topographic map showing the location of Monte Cristo Spring.

2.18 annual acre feet of water (0.0027 cfs) for the purpose of watering 200 horses and 150 cattle.

Table 28. Results of field and laboratory analyses of water sampled at Monte Cristo Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	25	32.7
Fluoride (mg/L)	4	0.27	0.79
Nitrate/Nitrite (mg/L)	11	0.78	1.31
Sulfate (mg/L)	500	21.6	21.9
Aluminum (mg/L)	0.2	0.22	26.3
Arsenic (mg/L)	0.01	ND	0.009
Calcium (mg/L)	-	3.07	24.8
Chromium (mg/L)	0.1	ND	0.003
Copper (mg/L)	1	ND	0.006
Iron (mg/L)	0.6	0.19	20.7
Lead (mg/L)	0.015	ND	0.007
Magnesium (mg/L)	150	ND	14.5
Manganese (mg/L)	0.1	0.03	1.69
Sodium (mg/L)	-	48.1	124
Zinc (mg/L)	5	ND	0.05
Hardness (mg/L)	-	7.67	122
pH	6.5-8.5	7.8	8.67
Turbidity (NTU)	-	5.87	-
Dissolved Oxygen (%)	-	49.1	83.5
Conductivity (mS/cm)	-	0.288	0.315
Salinity (ppt)	-	0.18	0.17
Temperature of water (°C)	-	13	19.36

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016E)
ND: Non-Detect

In 2014 and 2015, Monte Cristo Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016E). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum, iron, and manganese, were found to be below the MCL and pose no threat to wildlife. Aluminum is usually not a problem for wildlife or humans. High iron levels are mostly associated with taste and teeth staining issues. With long term, high concentrations, manganese can result in nervous disorders (EPA, 2016). Aluminum is usually not a problem for wildlife or humans. pH level indicated that the water was slightly alkaline. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Phantom Spring

Location: 554172 E 4191574 N
Elevation: 7,584 ft. MSL
Dominant Plants: Softstem bulrush (*Schoenoplectus tabernaemontani*); spikerush (*Eleocharis sp.);* sedge (*Carex* sp.); beardless wildrye (*Leymus triticoides*); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Phantom Spring as observed on September 4, 2011

Phantom Spring is located on the west side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. This spring was surveyed in 2007 and 2011. The vegetation was dominated by sedges, spikerush, and beardless wildrye, indicating persistent mesic conditions. No surface water was observed during the 2007 survey. In 2011, the site appeared greener, indicating more moisture in the soils, although surface water was not observed.

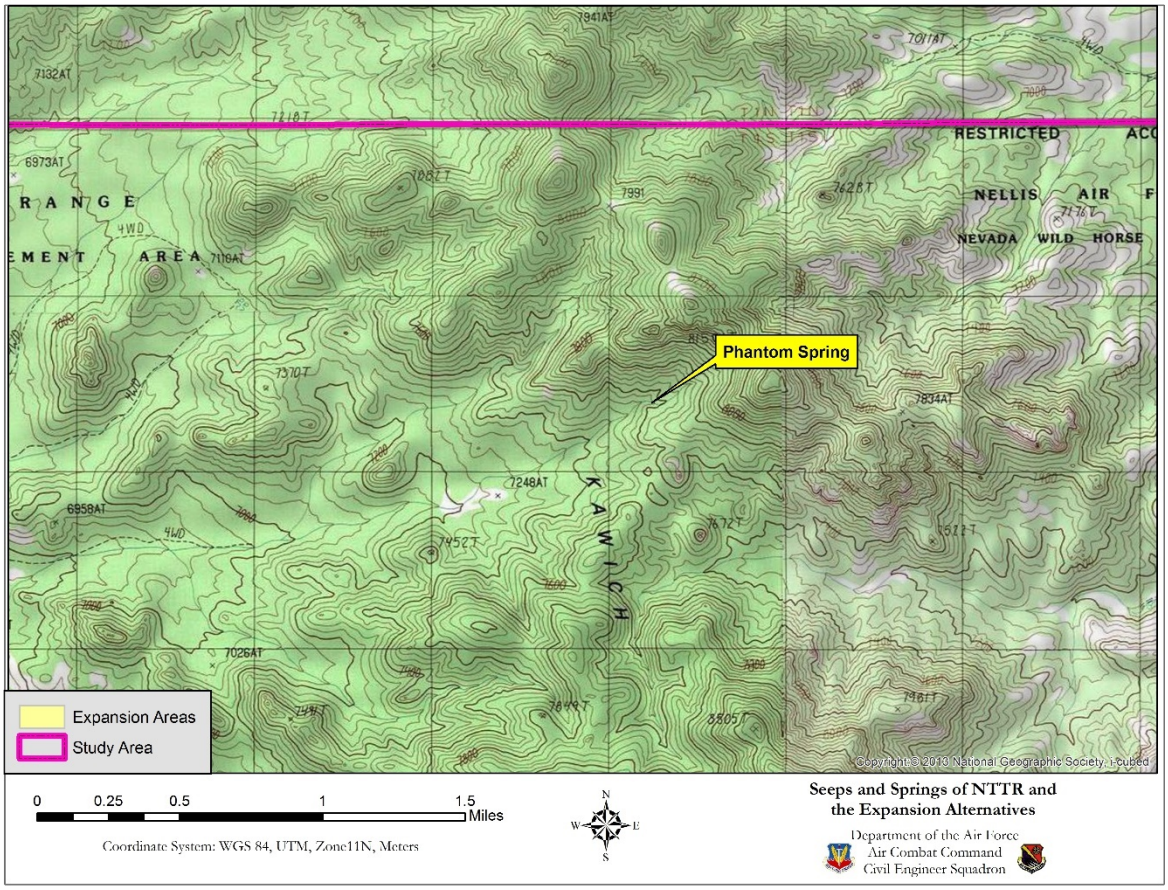
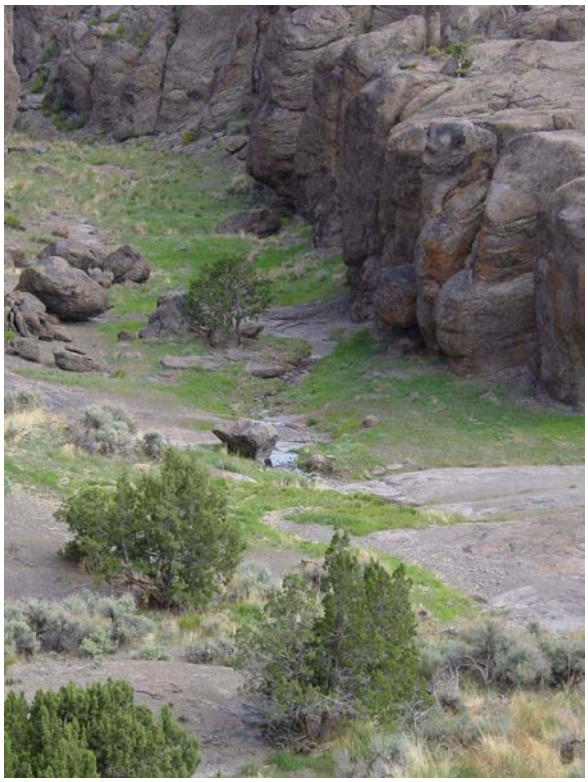


Figure 55. Topographic map showing the location of Phantom Spring.

Pillar Springs (Developed)

Location: 527295 E 4124301 N
Elevation: 5,685 ft. MSL
Dominant Plants: green ephedra (*Ephedra viridis*); seep monkeyflower (*Mimulus guttatus*); sedge (*Carex* sp.); big sagebrush (*Artemisia tridentata*); rubber rabbitbrush (*Ericameria nauseosa*); desert paintbrush (*Castilleja angustifolia* var. *dubia*); antelope bitterbrush (*Purshia tridentata*); cheatgrass (*Bromus tectorum*); red brome (*Bromus rubens*); beardless wildrye (*Elymus triticoides*)



Flow down canyon from Pillar Springs

Pillar Springs is a collection of seeps and springs with one main perennial spring in the upper watershed of the West Fork of Thirsty Canyon southwest of Black Mountain in Sagebrush Key Habitat. During the 1995 wetlands survey (Dames and Moore, 1996), evidence indicated that the spring was used extensively by wildlife and served an important function as a water source in this area. Excellent cover was available for both large and small wildlife using the water due to the canyon structure. Surveys conducted in 2007, 2009, 2011, 2014, and 2015 confirmed Pillar Spring is an excellent site for wildlife. Herds of desert bighorn sheep have been observed in the vicinity of the spring and in the surrounding area. Much of this area appears to be used as a lambing area for desert bighorn. Additionally, the area is a good habitat for raptors and migratory birds. An active golden eagle nest was observed downstream of the spring in 2011. During each survey, water was observed flowing and collecting in several ponds. Flow was much lower during the 2009 survey, likely due to unseasonably dry conditions. Vegetation is typical of canyon habitat, dominated by Utah juniper, big sagebrush, rubber rabbitbrush and antelope bitterbrush. The vegetation at the spring was mostly seep monkeyflower, beardless wildrye, spikerush, and other sedges and rushes. In 2014, flow was slightly less than had been observed in the past. Flow of the spring was very good in 2015 and the water appeared to be good quality. In 2014, a mountain lion and his mate were observed at Pillar



Pillar Spring as observed August 29, 2014

Spring. Fresh kills were observed around the spring area in 2013 and 2014. Evidence indicated that the mountain lion had moved out of the area in 2015.

Pillar Spring water rights were originally held by James M. Daniels. James M. Daniels applied for appropriation of water rights in March 1950, a permit was issued in January 1957, and certification was given in March 1958. Spring waters were originally piped a short distance to a rock basin for stock watering. The original allowed use totaled 7.86 annual acre feet of water (0.011 cfs) for the purpose of watering 350 head of cattle. A protest was filed by John J. Casey at the time of permit request, and overruled in January 1953. The rights were assigned to L.C. Colvin in December 1968. The current water rights holder is the Colvin Cattle Company. Water was sampled by the USGS in 2000. Analyses indicated the water was of good quality.

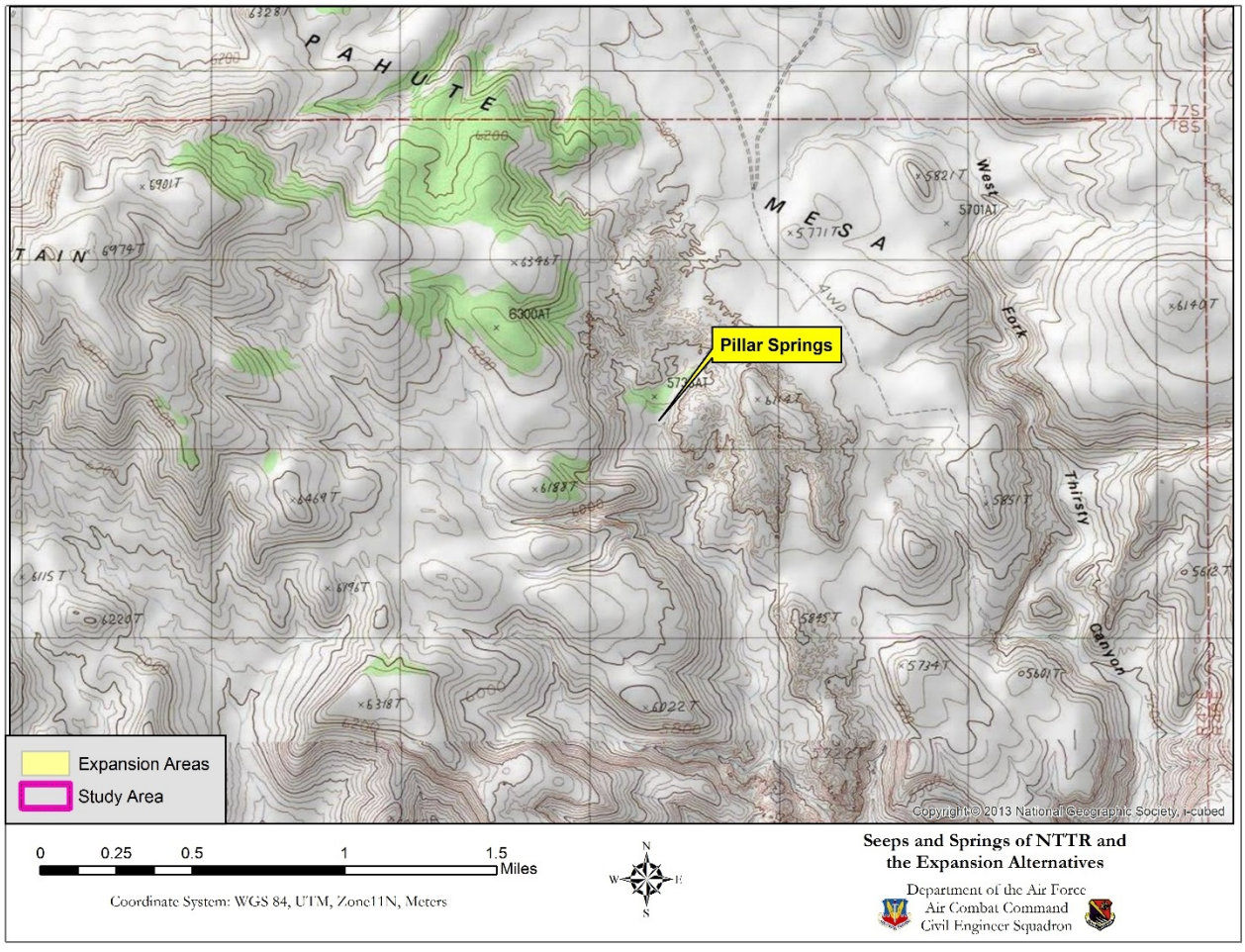


Figure 56. Topographic map showing the location of Pillar Springs.

Table 29. Results of field and laboratory analyses of water sampled at Pillar Springs. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	3.72	10.4
Fluoride (mg/L)	4	6.49	1.67
Nitrate/Nitrite (mg/L)	11	ND	ND
Sulfate (mg/L)	500	3.93	3.92
Aluminum (mg/L)	0.2	0.22	0.377
Arsenic (mg/L)	0.01	ND	0.003
Calcium (mg/L)	-	25.6	11.7
Chromium (mg/L)	0.1	ND	0.001
Copper (mg/L)	1	ND	0.001
Iron (mg/L)	0.6	4.82	3.5
Lead (mg/L)	0.015	ND	0.004
Magnesium (mg/L)	150	6.8	2.5
Manganese (mg/L)	0.1	0.77	0.512
Sodium (mg/L)	-	13.1	11.6
Zinc (mg/L)	5	ND	0.017
Hardness (mg/L)	-	91.9	40
pH	6.5-8.5	6.8	6.24
Turbidity (NTU)	-	5.38	-
Dissolved Oxygen (%)	-	112.2	57.9
Conductivity (mS/cm)	-	0.283	0.097
Salinity (ppt)	-	0.13	0.05
Temperature of water (°C)	-	27	16

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016E)
ND: Non-Detect

In 2014 and 2015, Pillar Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016E). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except fluoride, aluminum, iron, and manganese, were found to be below the MCL and pose no threat to wildlife. When fluoride is high in water, this can lead to tooth discoloration. High iron levels are mostly associated with taste and teeth staining issues. With long term, high concentrations, manganese can result in nervous disorders (EPA, 2003). Aluminum is usually not a problem for wildlife or humans. pH levels indicate that the water is slightly acid. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Pony Spring (Developed)

Location: 579886 E 4148643 N
Elevation: 6,885 ft. MSL
Dominant Plants: spikerush (*Eleocharis* sp.); softstem bulrush (*Schoenoplectus tabernaemontani*)



Pony Spring on September 4, 2011.

Pony Spring is located on the west slope of the Belted Mountain Range in Lower Montane Woodlands Key Habitat. Pony Spring was surveyed in 2007, 2009, 2011, 2014, and 2015. Each time, water was observed accumulating and flowing. Spike rush and softstem bulrush dominate most of the spring area. Vegetation damage by wildlife was evident during the 2007 and 2011 surveys. A dugout and associated pipeline (about 0.5 miles downgradient of the spring) was excavated in the past to hold water, but was dry at the time of the survey. Pony Spring was driest during the 2011 survey, but still supported a small area of standing water and areas of green vegetation. Vegetation in the area beyond the spring was dominated by pinyon pine and Utah juniper with scattered big sagebrush and rubber rabbitbrush in open areas. In 2014 and 2015, the area around the spring was very dry, but some water was present in the spring proper. Flow was much less than has been observed in the past.

Based on the identified location provided by NDWR and the historically noted location as compared to Cliff Spring, this spring was historically appropriated as Pony Spring. Pony Spring water rights were originally held by Floyd R. and Carlton P. Lamb, who transferred the water rights to the U.S. Air Force on an unknown date. Floyd R. and Carlton P. Lamb applied for appropriation of water rights in August 1946, a permit was issued in August 1947, and certification was given in May 1949. Water from a 30-ft. tunnel was conveyed via pipeline to a concrete watering trough. The original allowed use totaled 4.48 annual acre feet of water for the purpose of watering 200 head of cattle.



Pony Spring dugout

Table 30. Results of field and laboratory analyses of water sampled at Pony Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	0.1	14.5	14.3
Fluoride (mg/L)	0.1	0.27	0.35
Nitrate/Nitrite (mg/L)	0.1	ND	0.39
Sulfate (mg/L)	0.1	19.7	15.1
Aluminum (mg/L)	0.05	ND	0.033
Arsenic (mg/L)	0.01	ND	0.002
Calcium (mg/L)	1	23.5	19.1
Chromium (mg/L)	0.01	ND	ND
Copper (mg/L)	0.01	ND	0.001
Iron (mg/L)	0.01	0.02	0.06
Lead (mg/L)	0.01	ND	ND
Magnesium (mg/L)	1	4.56	3.5
Manganese (mg/L)	0.01	ND	0.006
Sodium (mg/L)	10	24.8	58.9
Zinc (mg/L)	0.01	ND	0.003
Hardness (mg/L)	-	77.5	62
pH	6.5-8.5	6.74	6.38
Turbidity (NTU)	-	0.12	-
Dissolved Oxygen (%)	-	38.5	38.4
Conductivity (mS/cm)	-	0.275	0.230
Salinity (ppt)	-	0.17	0.15
Temperature of water (°C)	-	12.4	10.8

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016D)
ND: Non-Detect

In 2014 and 2015, Pony Spring was analyzed in the field by NNRP biologists for pH, temperature , conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016D). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. Many of the constituents were found to be above the MCL for both years. High chloride and sulfate levels produce a salty taste to the water. When fluoride is too high in the water, tooth discoloration can happen. High iron levels are mostly associated with taste and teeth staining issues (EPA, 2016). Nitrates/nitrites were slightly higher than MCLs in 2015, and should be monitored annually. Most of the constituent concentrations appear to be relatively consistent from 2014 to 2015 and are just an indication of water quality. Thus, the quality of this water seems to be marginal, but not dangerous to wildlife. At this time, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

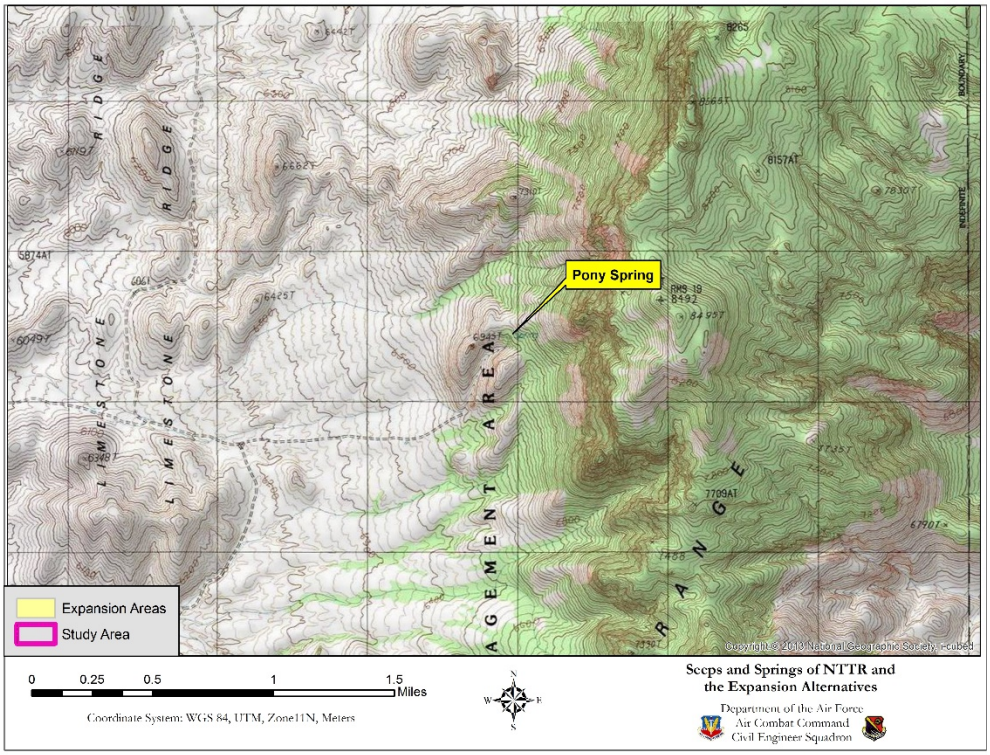


Figure 57. Topographic map showing the location of Pony Spring and its dugout.

Sand Perennial Spring (Developed)

Location: 4076455 N 627515 E
Elevation: 4,140
Dominant Plants: desert needlegrass (*Achnatherum speciosum*); shadscale (*Atriplex confertifolia*); white bursage (*Ambrosia dumosa*); creosote bush (*Larrea tridentata*); Mojave yucca (*Yucca Schidigera*); squirreltail (*Elymus elymoides*)



Water trough at the base of Sand Spring

Sand Spring is a perennial spring located in a canyon on the west slope of the Pintwater Mountain Range in Cliffs and Canyons Key Habitat. Water seeps from crevices in several locations along the cliff face into a catchment and trough for wildlife watering. The water then flows to a storage tank which also collects some runoff to supplement spring flow during low flow periods. Sand Spring water rights were originally applied for, and are still held by, the USFWS. The original allowed use totaled 0.03 annual acre feet of water for the purpose of wildlife watering. A permit was applied for in October 1950, and awarded March 1951, and certification was given April 1952.



Storage tank at the base of Sand Spring for wildlife water collection

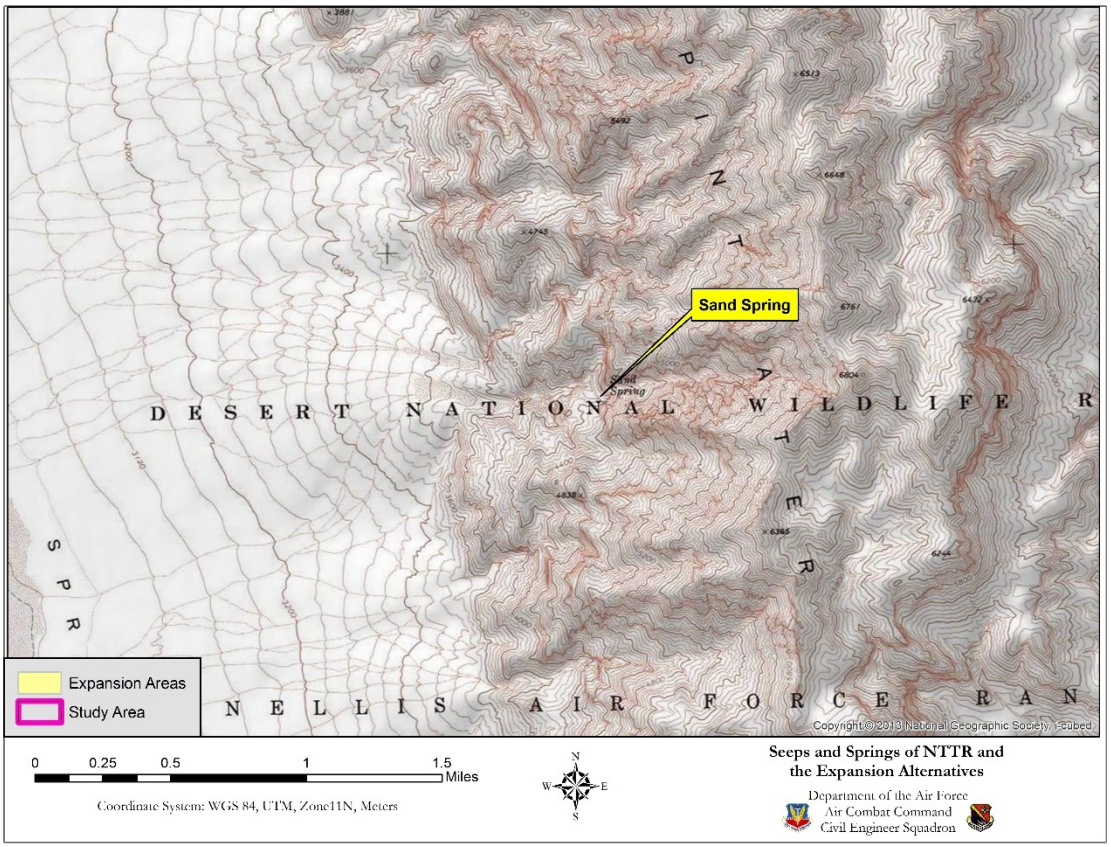


Figure 58. Topographic map showing the location of Sand Spring.

Silverbow Spring

Location: 544324 E 4192315 N
Elevation: 6,377 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*); narrowleaf willow (*Salix exigua*); Woods' rose (*Rosa woodsii*); wild mint (*Mentha arvensis*); seep monkeyflower (*Mimulus guttatus*); big sagebrush (*Artemisia tridentata*); Utah juniper (*Juniperus osteosperma*)



Silverbow Spring as observed during the 2011 survey

Silverbow Spring is part of the Silverbow seep and spring complex, and it is the northern-most spring in the complex. It is located in the Breen Creek channel, on the west side of the Kawich Mountain Range, in Range EC West, in sagebrush habitat. Silverbow Spring was flowing approximately five gallons per minute during the September 2011 survey. This spring supports perennials and annuals, including field mint and seep monkeyflower. Water quality appeared to be excellent, and the spring was in very good condition. The area supports a diverse population of wildlife including occasional occurrences of Greater Sage Grouse. During the 2014 and 2015 surveys, the spring was completely dry and water samples were not obtained. This spring is located in the area where sage grouse were observed three times in the summer of 2011.

This spring was certificated as "Silver Bow" under NDWR application number 13625, certificate number 3956. The original vested right in the spring was held by John J. Casey for the purpose of watering 600 cattle and 200 horses. The priority for this vested right is January 1880; a permit request was filed in January 1951, awarded in January 1953, and certification given in August 1953 (under application 13625). The date of transfer from John J. Casey to the United States of America, current right owner, is not known. No protests were filed on the vested right, but a protest was filed on the permit application. The January 1953 ruling stated, "Application 13625 was filed by John J. Casey on January 29, 1951 for the waters of Silver Bow Spring and was protested by James Daniels. The protest is overruled and a permit will be issued upon receipt of the statutory fee."

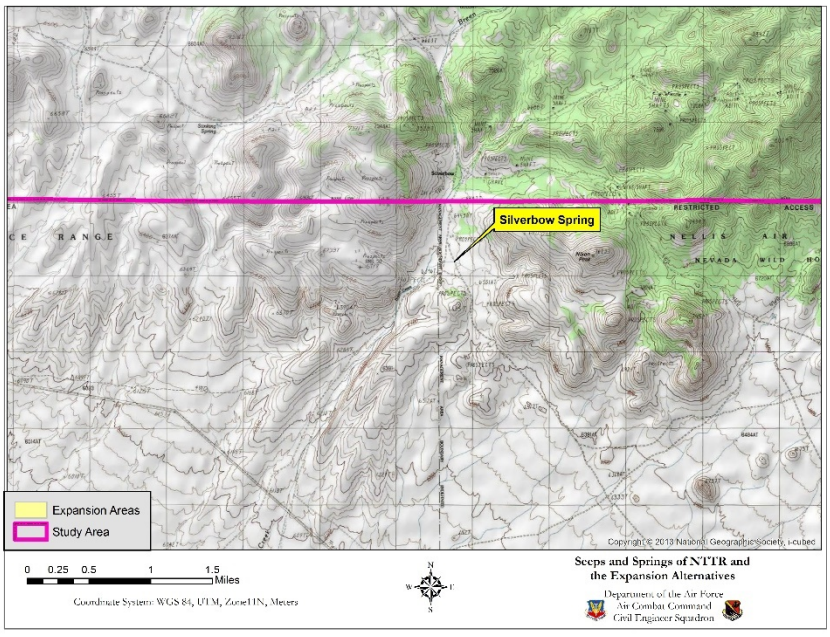


Figure 59. Topographic map showing the location of Silverbow Spring.

Sleeping Column Spring (Fenced)

Location: 5126605 E 4173328 N;
Elevation: 6,124 ft. MSL
Dominant Plants: shadscale saltbush (*Atriplex confertifolia*); fourwing saltbush (*Atriplex canescens*); spikerush (*Eleocharis sp*); softstem bulrush (*Schoenoplectus tabernaemontani*); rubber rabbitbrush (*Ericameria nauseosa*); cattail (*Typha sp.*)



Sleeping Column Spring in 2011

Sleeping Column Spring is located in Sleeping Column Canyon in the Cactus Mountain Range in Sagebrush Key Habitat. Sleeping Column Spring was first photographed in 1995 for the Dames and Moore wetlands survey (Dames and Moore, 1996). It was also photographed in 1997, 2009, and 2011. According to the 1996 wetland survey (Dames and Moore, 1996), the original source was a hillside spring. This spring consisted of a series of pools piped to a horse trough and a lower pool with an outflow. Although moist soil was present on the hillside, the actual source appeared to be a larger pool located 15 feet downslope from the original source. The area had been heavily compacted by significant wildlife use. Dominant wetland vegetation was limited to submergent and emergent macrophytes and algae, with some grasses growing in the standing water. Junipers, saltbush, rabbitbrush, and Joshua trees were scattered around the area. The May 2009 survey found the spring to be dry, in contrast to past observations, although a healthy stand of spikerush and softstem bulrush were observed in the main part of the spring. Saltbush and rubber rabbitbrush were observed along the perimeter of the spring. Although the spring is protected by a fence, it is still recovering from wildlife damage, as evidenced by the areas of bare ground. Water and cattails were also present in 2011 (U.S. Air Force, 2017).

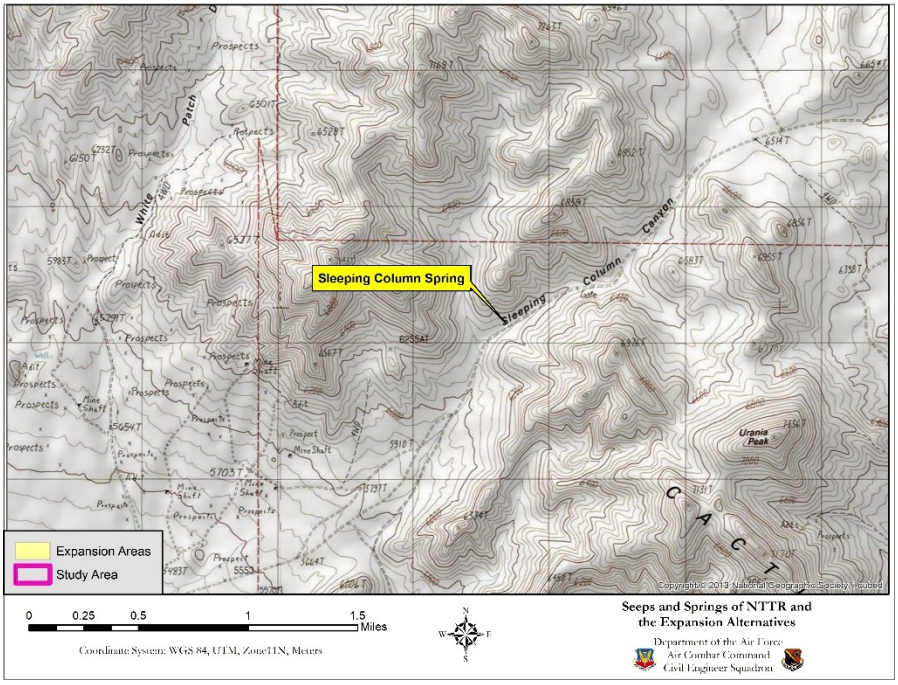


Figure 60. Topographic map showing the location of Sleeping Column Spring.

Table 31. Results of field and laboratory analyses of water sampled at Sleeping Column. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	39.7	31.7
Fluoride (mg/L)	4	0.86	1.27
Nitrate/Nitrite (mg/L)	11	ND	ND
Sulfate (mg/L)	500	704	592
Aluminum (mg/L)	0.2	ND	0.012
Arsenic (mg/L)	0.01	ND	ND
Calcium (mg/L)	-	230	287
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.001
Iron (mg/L)	0.6	0.04	0.14
Lead (mg/L)	0.015	ND	ND
Magnesium (mg/L)	150	24.5	20.6
Manganese (mg/L)	0.1	0.17	0.058
Sodium (mg/L)	-	70	82.1
Zinc (mg/L)	5	0.04	0.16
Hardness (mg/L)	-	675	801
pH	6.5-8.5	7.36	7.06
Turbidity (NTU)	-	0.96	-
Dissolved Oxygen (%)	-	44.3	54.1
Conductivity (mS/cm)	-	1.436	1.114
Salinity (ppt)	-	0.77	-
Temperature of water (°C)	-	21.6	13.6

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014 and 2015, Sleeping Column was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except sulfate and manganese, were found to be below the MCL and pose no threat to wildlife. Sulfate levels were above the MCL in both years, but dropped considerably in 2015. Manganese was only slightly higher than the MCL in 2014. Long term exposure to high concentrations of manganese can result in nervous disorders (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time. The spring was surveyed in 2014 and 2015. Flow was less than previously observed, but substantial water was still present.

South Kawich Spring

Location: 562064 E 4181186 N
Elevation: 6,797 ft. MSL
Dominant Plants: Spike bentgrass (*Agrostis exarata*); rush (*Juncus sp*.); pinyon pine *(Pinus monophylla)*; Utah juniper (*Juniperus osteosperma)*

South Kawich Spring is located on the east side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. South Kawich Spring was originally observed during a raptor helicopter survey in 2008. On September 6, 2009, the site was revisited and photographed. The spring was flowing slowly at that time, and it supported an area of saturated soil and wetland vegetation approximately 60 feet in diameter. Vegetation was dominated by spike bentgrass and an unidentified species of rush. A very dense stand of pinyon pine and Utah juniper surrounded the spring area. In 2014, the spring was completely dry, but mesic vegetation was present.



South Kawich Spring as observed from the helicopter during the 2009 survey

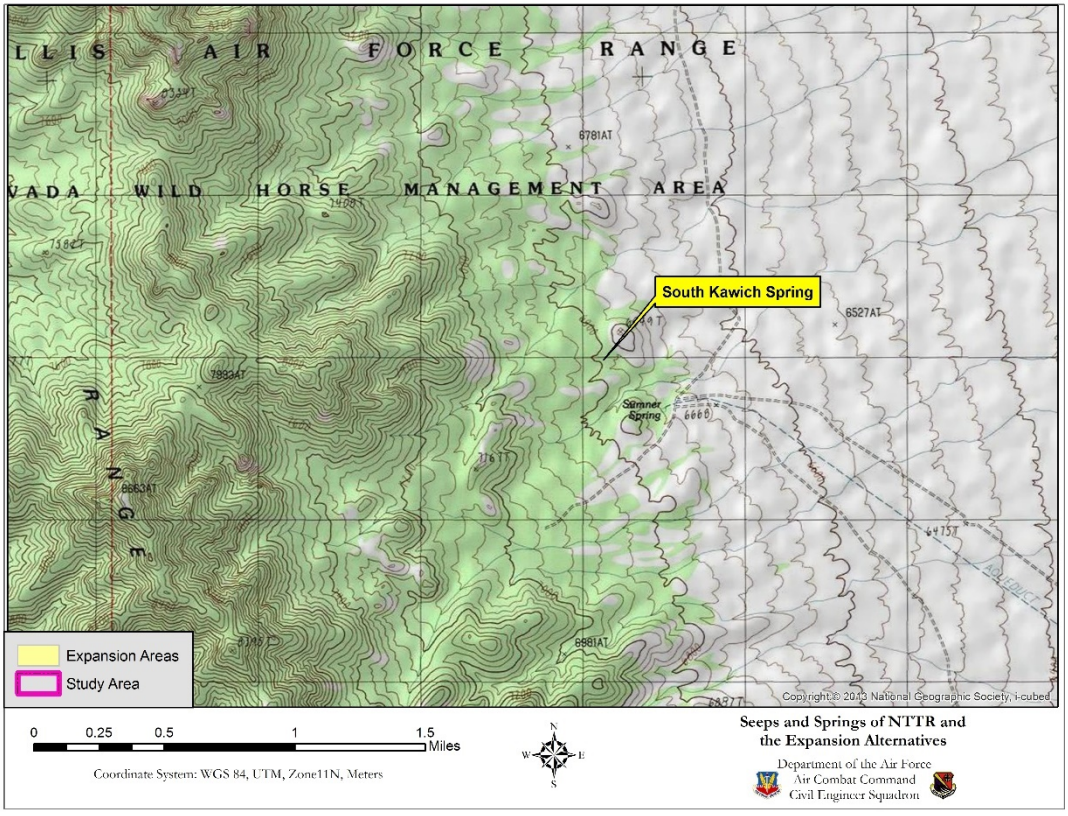


Figure 61. Topographic map showing the location of South Kawich Spring.

Stealth Seep (Fenced)

Location: 514080 E 4178816 N
Elevation: 6,218 ft. MSL
Dominant Plants: Cattail (*Typha* sp.); softstem bulrush (*Schoenoplectus tabernaemontani*); spikerush (*Eleocharis* sp.); beardless wildrye *(Leymus triticoides*); saltcedar (*Tamarix ramosissima*); rubber rabbitbrush (*Ericameria nauseosa*); shadscale (*Artemisia confertifolia*)



Stealth Seep in 2011. Dense, healthy vegetation as compared to 1997, likely due to fence installation.

Stealth Seep is an isolated spring located east of the Cactus Mountain Range in Sagebrush Key Habitat. Stealth Seep is protected from wildlife damage by a fence. In a 1997 survey, the spring was flowing, with a large area of accumulated, open water. Water from the spring flowed 100 to 200 feet before disappearing into the soil. During the 2009 survey, the spring was relatively dry, with no flowing or standing water, but an area of saturated soils dominated by spikerush, cattail, and softstem bulrush inside the fenced area. An area outside of the fence supported a healthy stand of beardless wildrye. During the 2011 survey, vegetation was dense and healthy, and of similar composition to previous surveys. A tamarisk tree was present on one of the banks of the wetland area. Grazed areas around the spring were dominated by rubber rabbitbrush and shadscale. The spring was inspected in 2014 and was in excellent condition. Due to access issues, the spring could not be surveyed in 2015.

According to the 1996 wetland survey report (Dames and Moore, 1996), this site exemplified how water sources could be deteriorated by heavy wildlife use. The original source was the most westerly of two depressions, but it no longer had surface water. Approximately 30 feet to the east, a horizontal pipe was partially submerged in a circular pool about 15 feet in diameter. No flow could be observed coming from the pipe. Downstream from the pool, the ground was moist for approximately 60 feet to the east. An abandoned water trough was observed nearby. The soil around the site had been severely damaged by wild horse use, primarily trampling. No plants were growing within approximately 100 feet of the water source. The water

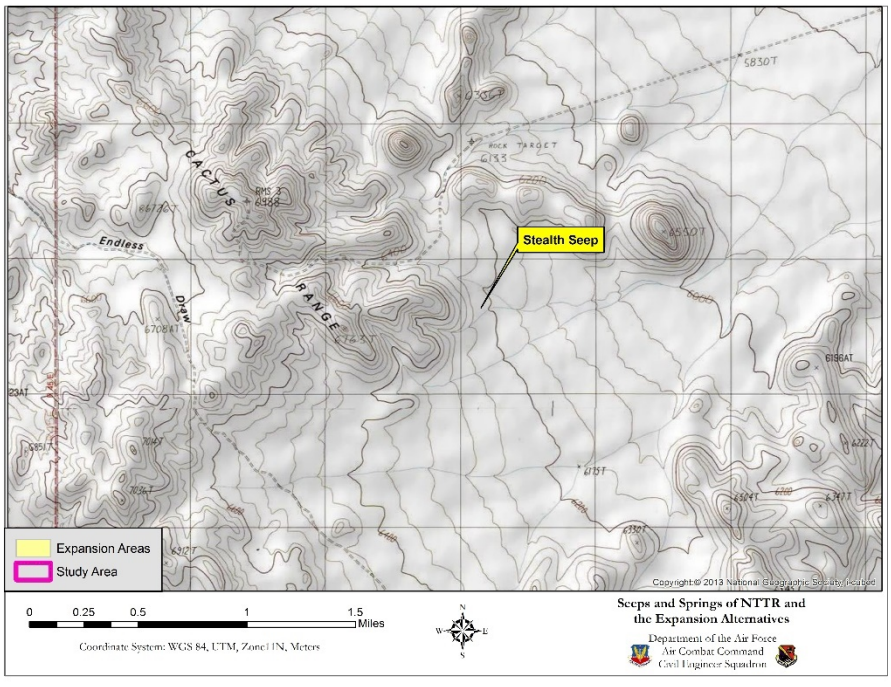


Figure 62. Topographic map showing the location of Stealth Seep.

source was apparently sufficient to attract horses but was so limited that the horses often had to wait to drink. It appears the horses denuded the surrounding area of vegetation. The USGS sampled the spring water again in 2006. The analysis showed the quality of the water to be acceptable. Stealth Seep may have been called Horse Trough Spring at one time. Horse Trough Spring was originally identified by the USGS on October 21, 1983, but has not been located since. In 2011, the Horse Trough Spring area was carefully surveyed, and the only surface water identified in the vicinity was Stealth Seep, which is located approximately 650 feet southwest of the reported location for Horse Trough Spring.

Table 32. Results of field and laboratory analyses of water sampled at Stealth Seep.

NAME	MCL (mg/L)*	2014**
Chloride (mg/L)	400	36
Fluoride (mg/L)	4	0.45
Nitrate/Nitrite (mg/L)	11	1.34
Sulfate (mg/L)	500	40
Aluminum (mg/L)	0.2	ND
Arsenic (mg/L)	0.01	ND
Calcium (mg/L)	-	42.2
Chromium (mg/L)	0.1	ND
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	0.01
Lead (mg/L)	0.015	ND
Magnesium (mg/L)	150	6.5
Manganese (mg/L)	0.1	ND
Sodium (mg/L)	-	43.2
Zinc (mg/L)	5	ND
Hardness (mg/L)	-	132
pH	6.5-8.5	6.85
Turbidity (NTU)	-	2.59
Dissolved Oxygen (%)	-	4
Conductivity (mS/cm)	-	0.407
Salinity (ppt)	-	0.25
Temperature of water (°C)	-	13.9

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2015, water samples were not collected for this site. Stealth Seep was analyzed in the field by NNRP biologists in 2014 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents were found to be below the MCL and pose no threat to wildlife.

Surface Water 13

Location: 558446 E 4170336 N
Elevation: 6,626 ft. MSL
Dominant Plants: Coyote tobacco (*Nicotiana attenuata*); rubber rabbitbrush (*Ericameria nauseosa*); blue grama (*Bouteloua gracilis*); desert pepperweed (*Lepidium fremontii*); cheatgrass (*Bromus tectorum*); spike bentgrass (*Agrostis exarata*); rusty molly (*Bassia californica*); prairie Junegrass (*Koeleria macrantha*); Mexican rush (*Juncus mexicanus*); big sagebrush (*Artemisia tridentata)*; Cooper's goldenbush (*Ericameria cooperi*); sand dropseed (*Sporobolus cryptandrus*)



Surface Water 13 as observed on May 24, 2014

Surface Water 13 is located at the confluence of several ephemeral streams in the Kawich Mountain Range in Sagebrush Key Habitat. At the time of the 2007 survey, it was difficult to determine if the accumulation and flow of water at Surface Water 13 originated from a groundwater source or from melting snow. During the 2009 survey, the water level was much lower and indicated a possible groundwater source. Field sampling results from September 6, 2009, indicated that the water was in good condition. Surface Water 13 was visited again on September 3, 2011. The spring did not contain water and appeared to have been dry for a long period of time. In 2014, the site was completely filled with water and was in excellent condition.

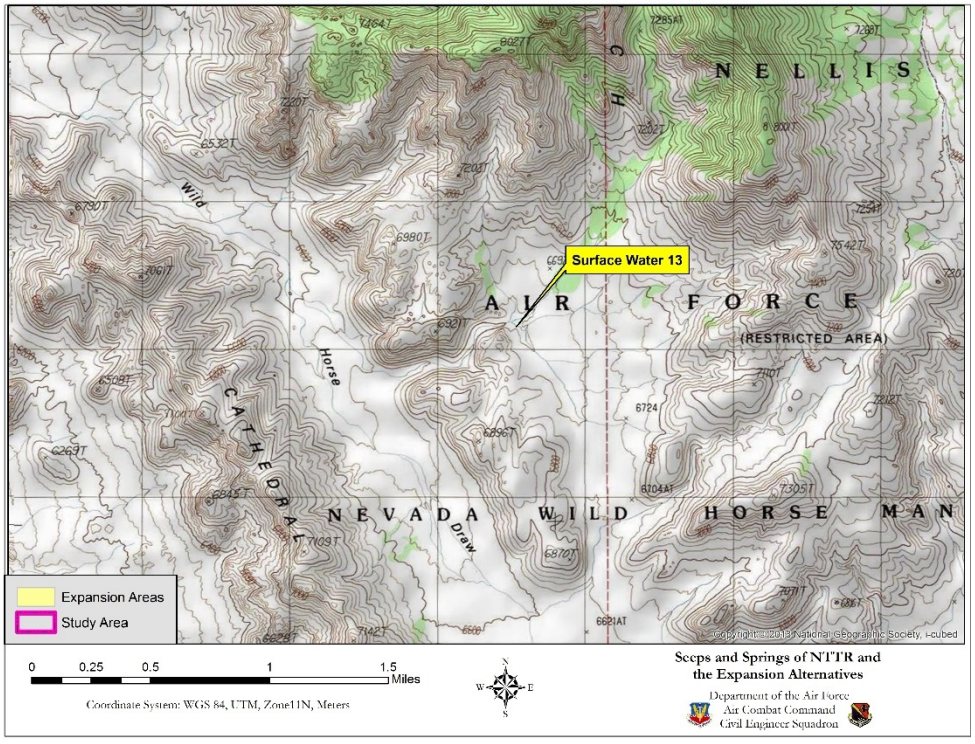


Figure 63. Topographic map showing the location of Surface Water 13.

Table 33. Results of field and laboratory analyses of water sampled at Surface Water 13. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**
Chloride (mg/L)	400	2.51
Fluoride (mg/L)	4	0.22
Nitrate/Nitrite (mg/L)	11	ND
Sulfate (mg/L)	500	5.37
Aluminum (mg/L)	0.2	0.88
Arsenic (mg/L)	0.01	ND
Calcium (mg/L)	-	11.9
Chromium (mg/L)	0.1	ND
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	0.52
Lead (mg/L)	0.015	ND
Magnesium (mg/L)	150	2.1
Manganese (mg/L)	0.1	0.01
Sodium (mg/L)	-	5.2
Zinc (mg/L)	5	ND
Hardness (mg/L)	-	38
pH	6.5-8.5	9.11
Turbidity (NTU)	-	11.5
Dissolved Oxygen (%)	-	78.1
Conductivity (mS/cm)	-	0.095
Salinity (ppt)	-	0.05
Temperature of water (°C)	-	16.8

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016D)
ND: Non-Detect

In 2015, water samples were not collected for this site. Surface Water 13 was analyzed in the field by NNRP biologists in 2014 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016D). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum, were found to be below the MCL and pose no threat to wildlife. Aluminum is usually not a problem for wildlife or humans (EPA, 2016). The pH was at a high level of alkalinity, which is not uncommon for surface waters containing algae. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Sumner Spring (Developed)

Location: 562413 E 4180904 N
Elevation: 6,729 ft. MSL
Dominant Plants: Cattail (*Typha sp.*); spike rush (*Eleocharis sp*.)



Sumner Spring wells, 2007

Sumner Spring is located on the east side of the Kawich Mountain Range, approximately one-quarter mile southeast of South Kawich Spring in Lower Montane Woodlands Key Habitat. The spring is occasionally incorrectly identified as Summer Spring in historic documents and on topographic maps.

According to previous reports by Dames and Moore (Dames and Moore, 1996), the primary surface water feature was a substantial human-made, bermed pond within a small ravine. The pond was supplied by a one-quarter inch diameter pipe that diverted only a small portion of the water from a system of deeply-excavated collection wells. These wells appeared to access subterranean springs and/or ground water sources and routed most of the water into a pipe system for delivery to a ranch site located several miles away in Reveille Valley. In 1996, the pond supported aquatic plants including pondweed, cattail, rush, and buttercup. The pond and peripheral saturated area was approximately 1,450 square feet in size. In 2007, the spring was flowing but the dugout was almost completely dry, with dormant populations of rushes and cattail. During the 2011 survey, water was observed in the wells and could be heard flowing in the well structures, but no water was accumulating in the dugout below the spring. In 2014 and 2015, the spring was essentially dry with only a small amount of water dripping out of the well pipe. Samples were taken from the well cistern located upgradient of the dugout in 2014 and from a small wet area below the drain pipe in 2015.The priority date for the vested rights in this spring is listed as January 1870 in the NDWR database. The first Certificate of Appropriation was signed in 1923, for an Ira Murdock, manager of the United Cattle and Packing Company (TRC Mariah Associates, 1996). In 1938, the United Cattle and Packing Company assigned the appropriation to the Fallini Brothers. A State of Nevada Certificate of Appropriation was signed to the Fallini Brothers in 1951. The 1923 appropriation was then assigned by Harvey Titus and family to Harold Lake and H. H. Ormesher in 1963; it was not recorded when the appropriation was assigned to Harvey Titus or if the Fallini

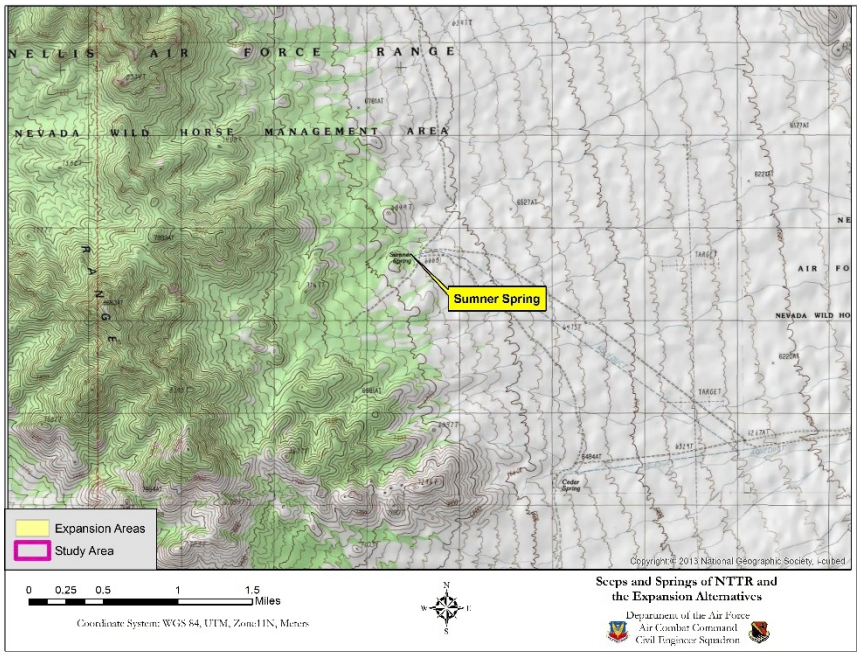


Figure 64. Topographic map showing the location of Sumner Spring.

Brothers were involved. The NDWR database states the vested rights for the spring were transferred to the Fallini 1983 Trust in January 2007, from the Helen Fallini Living Trust. No date was provided for the ownership transfer to the Helen Fallini Living Trust. Both Trusts are listed as the current and original owner in the database.

The USGS topographic map indicates an aqueduct, described as a pipeline in both Certificates of Appropriation, once existed to convey water to the east, away from the spring, and connected to the Cedar Spring Aqueduct. The original allowed use totaled an unknown amount of annual acre feet of water for the purpose of watering 1,000 head of cattle and 25 horses.

Table 34. Results of field and laboratory analyses of water sampled at Sumner Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	49.1	21.2
Fluoride (mg/L)	4	0.31	0.42
Nitrate/Nitrite (mg/L)	11	0.23	0.61
Sulfate (mg/L)	500	88.9	50
Aluminum (mg/L)	0.2	ND	0.223
Arsenic (mg/L)	0.01	ND	0.004
Calcium (mg/L)	-	62.3	69.4
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.006
Iron (mg/L)	0.6	0.07	0.56
Lead (mg/L)	0.015	ND	ND
Magnesium (mg/L)	150	8.7	8.5
Manganese (mg/L)	0.1	ND	0.031
Sodium (mg/L)	-	13.4	51.2
Zinc (mg/L)	5	ND	0.136
Hardness (mg/L)	-	191	208
pH	6.5-8.5	7.59	7.67
Turbidity (NTU)	-	0.54	-
Dissolved Oxygen (%)	-	57	51.3
Conductivity (mS/cm)	-	0.453	0.393
Salinity (ppt)	-	0.27	0.27
Temperature of water (°C)	-	15.3	9.76

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016A)
ND: Non-Detect

In 2014 and 2015, Sumner Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016A). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except for aluminum, were found to be below the MCL and pose no threat to wildlife. Aluminum is usually not a problem for wildlife or humans. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Thunderbird Spring

Location: 551841 E 4192170 N
Elevation: 7,096 ft. MSL
Dominant Plants: Softstem bulrush (*Schoenoplectus tabernaemontani*); spikerush (*Eleocharis* sp.); Mexican rush (Juncus mexicanus); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Thunderbird Spring September 2011

Thunderbird Spring is located on the east slope of the Kawich Mountain Range near the northern border of Range EC East in Lower Montane Woodlands habitat. A significant accumulation of standing water was observed at the spring during the 2007 survey. Dames and Moore (1996) reported that the spring supported a 3-foot by 60-foot stream, which was about an inch deep. Dames and Moore (1996) also observed an adjacent 100-foot by 328-foot area of saturated soils, going more than 16 inches below the surface, indicating that an extensive underground water source was present. This was also observed in 2007. Dames and Moore (1996), stated the inundated area was one of the few examples of a mountain meadow present on NTTR with sufficient moisture to support grasses. The margin of the saturated soils was clearly delineated by sagebrush and juniper growth. In 1995, the surface water and saturated soils area totaled 2,900 square feet. Horses had utilized this water source and appear to have more recently depleted the available surface water through trampling of surrounding soils. The sites value as habitat for native wildlife was evidenced by visible signs of large mammals, including mountain lion, coyote, and pronghorn antelope.

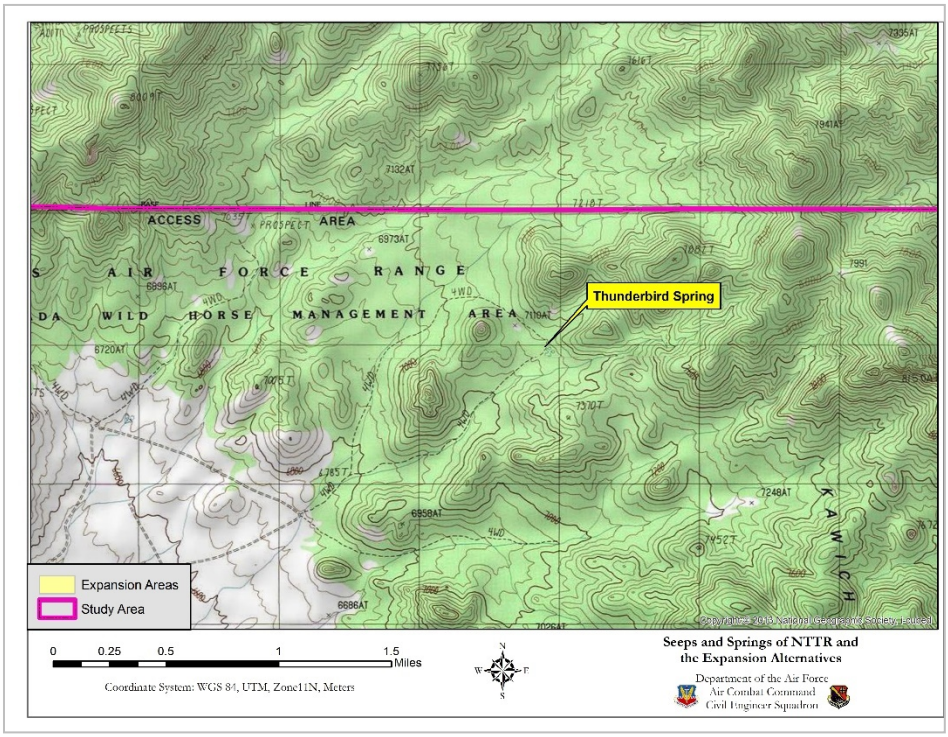


Figure 65. Topographic map showing the location of Thunderbird Spring.

Field observations indicated that the spring has not changed significantly over the last

ten years. In fact, it appears that horse damage was less significant compared to that observed in the 1996 photos. The water was clear with some filamentous algae. Like many of the other springs in 2007, most of the vegetation was showing severe drought stress; however, this spring still contained a small pool with a significant population of algae. This site meets the criteria of a wetland, but would likely be considered isolated and non-jurisdictional by the USACE. The 1996 Water Requirements Study of the Nellis Air Force Base (TRC Mariah, 1996) indicates that this spring has not been appropriated by the NDWR to any federal entity. The spring was again observed on September 4, 2011. At that time, the spring was dry and no water was observed. Vegetation in the area of the spring was green, indicating the soils were probably moist or wet.

Water quality appeared to be good based on water samples collected by the USGS in 1988 and 2000.

Table 35. Water quality for Thunderbird Spring as determined by the USGS (Dames and Moore, 1996).

Item	2 Jan 1988	2 Dec 2000
Ca, Dissolved (mg/L)	9	8.5
Cl, Dissolved (mg/L)	1	1
Fe, Dissolved (mg/L)	0.01	
F, Dissolved (mg/L)	0.16	
HCO_3, Dissolved (mg/L)	40	46
Li, Dissolved (mg/L)	0.005	
Mg, Dissolved (mg/L)	28.0	26.5
K, Dissolved (mg/L)	2.90	2.93
Na, Dissolved (mg/L)	13.0	13.3
NO_3, Dissolved (ug/L)		19.9
SO_4, Dissolved (mg/L)	7.0	9.1
Specific Conductance (Units/Mil)	360	368
Specific Conductance--Field (Units/Mil)	340	362
Sr, Dissolved (mg/L)	0.09	
Water Temperature (°C)	4.0	5.9

Tim Perennial Spring (Developed)

Location: 4079092 N 627442 E
Elevation: 4,760 ft. MSL
Dominant Plants: big galleta (*Pleuraphis rigida*); desert needlegrass (*Achnatherum speciosum*); Indian ricegrass (*Achnatherum hymenoides*); Nevada ephedra (*Ephedra nevadensis*); shadscale (*Atriplex confertifolia*); creosote bush (*Larrea tridentata*)



Tim Spring

Tim Spring is a perennial spring located in the Pintwater Mountain Range in Cliffs and Canyons Key Habitat. Tim Spring water rights were originally applied for, and are still held by, the USFWS. This spring is found in a wash and produces a small amount of water. The original allowed use totaled 0.40 annual acre feet of water for the purpose of wildlife watering. The original spring was walled-in and water was conveyed via a pipeline to a 55-gallon watering tank. A permit was applied for in October 1950, awarded March 1951, and certification was given April 1952.

This spring has been inspected several times by the NNRP since 2005. At no time has it been flowing or has it contained any measurable water. Vegetation located in the area of the spring is mesic, but not species normally associated with perennial water sources. However, NDOW and the USFWS have data indicating that the NNRP has probably not been surveying the right location. According to NDOW, surface water has been observed consistently over the years with water present in troughs since 1996. This further indicates that NNRP surveys probably missed the mark because no troughs were observed. In 2016, NDOW measured flow to be 18.1-22.19 gallons per hour. Additionally, significant

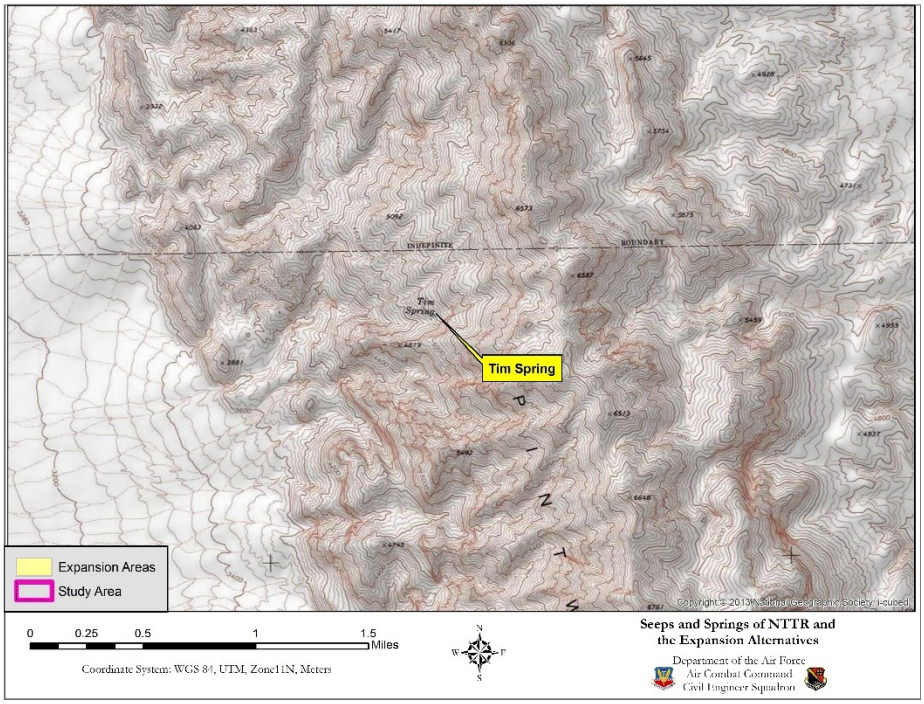


Figure 66. Topographic map showing the location of Tim Spring.

populations of obligate wetland plants including *Juncus mexicanus, Mimulus guttatus, and Polypogan monspeliensis* were observed. The spring is considered an important water feature for bighorn sheep, especially in the summer. The spring is considered the largest natural source of water in the Pintwater Range and very important for wildlife.

Trappman Spring (Developed)

Location: A: 512914 E 4127133 N
B: 513061 E 4127061 N
C: 513326 E 4127010 N
Elevation: 4,993 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); softstem bulrush (*Schoenoplectus tabernaemontani*); fourwing saltbush (*Atriplex canescens*); green ephedra (*Ephedra viridis*); spiny menodora (*Menodora spinescens*); buckwheat (*Eriogonum* sp.); cheesebush (*Hymenoclea salsola*); big sagebrush (*Artemisia tridentata*); desert needlegrass (*Achnatherum speciosum*); purple threeawn (*Aristida purpurea*)



Trappman Spring in 2007

Trappman Spring is a group of three springs (A, B, and C) located on the west side of Tolicha Peak in Mojave Mid-Elevation Mixed Desert Scrub Key Habitat. Several springs and stream drainages are located at this site. Dominant grasses appear to be desert needlegrass and purple threeawn. Three additional springs are located downslope of the other springs. Spike rush dominates the area around the three springs.

Dames and Moore (Dames and Moore, 1996) stated that this site consisted of a small seep with very little surface water. The area of saturated soil observed during the October 1995 survey was approximately 3 ft. x 21 ft., with 3 ft. x 6 ft. of surface water. The site is located in non-native grassland habitat with some fourwing saltbush. Rabbit's foot grass was an abundant species on the seep, along with other native and non-native grasses. Signs of wildlife included coyote scat and rodent burrows. In 2014 and 2015, the site was extremely dry with no free-standing water and no saturated soils.



Corral at Trappman Spring B in 2007

Trappman Spring water rights were originally held by T.H. Chatom and J.J. Vignolo. They transferred the water rights to Neal Cook, the current rights holder according to the NDWR database, on an unknown date. T.H. Chatom and J.J. Vignolo applied for a permit in July 1918, the permit was issued in December 1918, and certification was given in November 1923. The water was originally piped 250 feet to five iron troughs. The original allowed use totaled 10.86 annual acre feet of water for the purpose of watering 250 to 500 head of cattle.

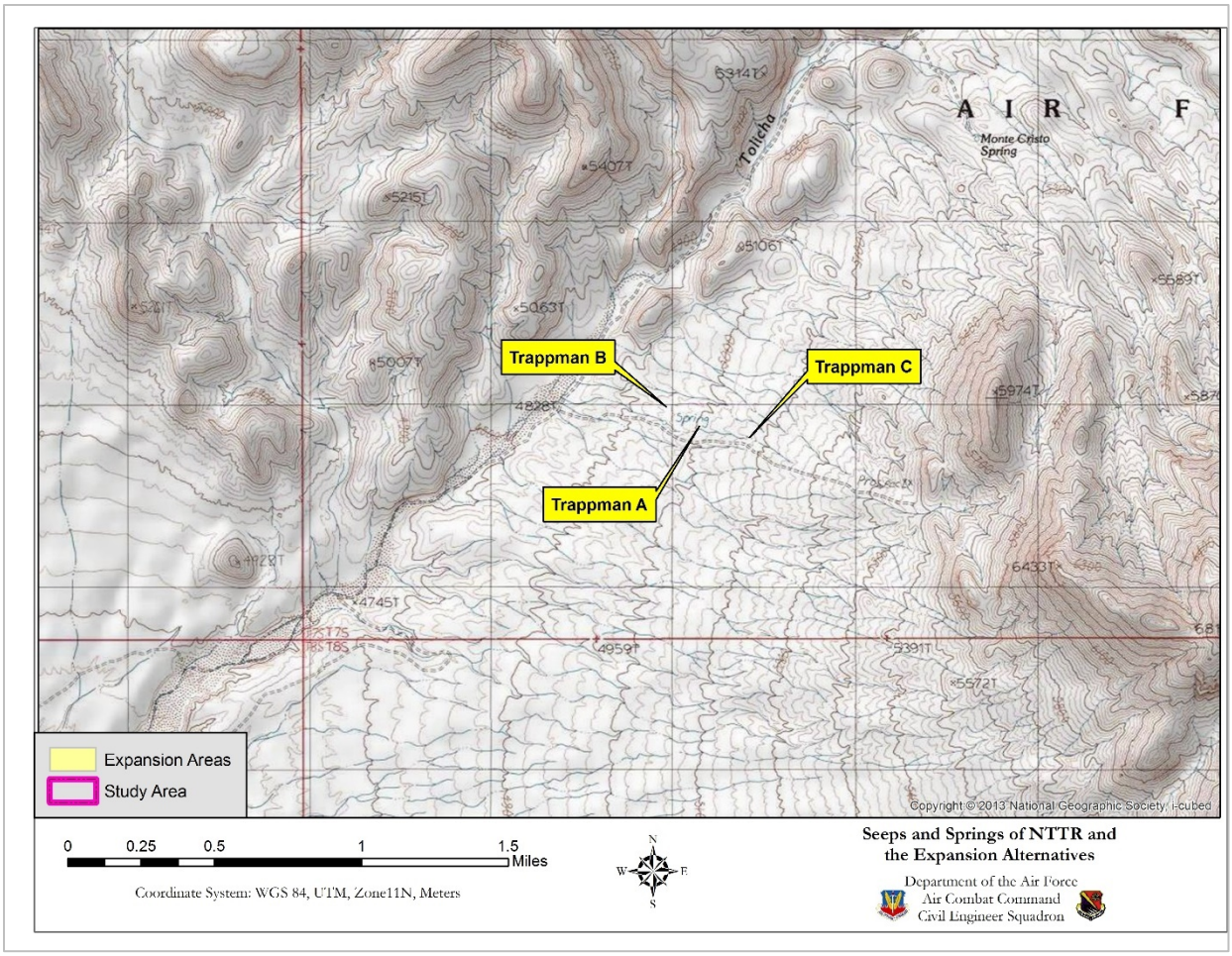


Figure 67. Topographic map showing the location of Trappman Spring A, B and C.

Tule George Spring

Location: 515976 E 4125669 N
Elevation: 6,420 ft. MSL
Dominant Plants: Rubber rabbitbrush (*Ericameria nauseosa*); spike bentgrass (*Agrostis exarata*); annual rabbitsfoot grass (*Polypogon monspeliensis*), James' galleta (*Pleuraphis jamesii*)



Tule George Spring in 2011

Tule George Spring is located south of Tolicha Peak in Sagebrush Key Habitat. Tule George Spring was located during the 1995 wetlands survey (Dames and Moore, 1996). However, only empty livestock troughs were observed at that time. The 2011 survey found the spring flowing despite extremely dry conditions. The spring is located under a cliff overhang and difficult to observe from the air. Observations indicate the spring is perennial and supports a relatively large area of saturated soils. Because of the scarcity of water in this area, this spring is an important source of water for wildlife. The spring was surveyed in 2014 and 2015 and found to be flowing and an important site for desert bighorn sheep to drink and rest.

The certificate of appropriation was issued in November 21, 1923 to T.H. Chatom and J.J. Vignolo for "works of diversion and use." The appropriated flow was 0.0019 cfs, indicating that the flow was not very high. The deed was transferred from Earnest P. and Mary A. Porter to Neal Cook on October 30, 1947. No further records have been found. The spring was designated as MAI-10S by Moriah and Associates (1996).

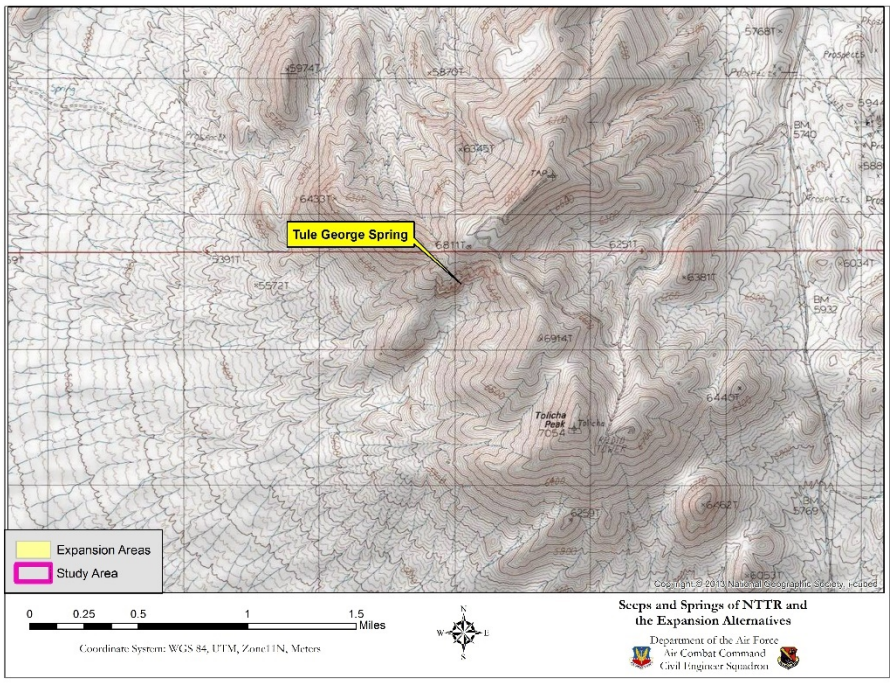


Figure 68. Topographic map showing the location of Tule George Spring.

Table 36. Results of field and laboratory analyses of water sampled at Tule George Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	13.2	11.5
Fluoride (mg/L)	4	0.78	0.73
Nitrate/Nitrite (mg/L)	11	2.18	4.18
Sulfate (mg/L)	500	19.9	13.7
Aluminum (mg/L)	0.2	34.1	89.9
Arsenic (mg/L)	0.01	ND	0.008
Calcium (mg/L)	-	30.7	73.1
Chromium (mg/L)	0.1	ND	0.004
Copper (mg/L)	1	0.03	0.002
Iron (mg/L)	0.6	15.8	35
Lead (mg/L)	0.015	0.09	0.004
Magnesium (mg/L)	150	12	23.1
Manganese (mg/L)	0.1	2.41	4.79
Sodium (mg/L)	-	50.3	135
Zinc (mg/L)	5	1.21	0.075
Hardness (mg/L)	-	126	278
pH	6.5-8.5	8.24	7.76
Turbidity (NTU)	-	97.3	-
Dissolved Oxygen (%)	-	15.1	2.1
Conductivity (mS/cm)	-	0.318	0.203
Salinity (ppt)	-	0.17	0.12
Temperature of water (°C)	-	19.21	15.02

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016E)
ND: Non-Detect

In 2014 and 2015, Tule George Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016E). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum, iron, lead and manganese, were found to be below the MCL and pose no threat to wildlife. High iron levels are mostly associated with taste and teeth staining issues. With long term, high concentrations, manganese can result in nervous disorders (EPA, 2003). Aluminum is usually not a problem for wildlife or humans. Lead was slightly above MCLs in 2014, but was below MCLs in 2015. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Tunnel Spring (Developed)

Location: 554045 E 4182679 N
Elevation: 6,620 ft. MSL
Dominant Plants: sparsely vegetated big sagebrush (*Artemisia tridentata*)



Tunnel Spring trough and water storage area in 2011, after BLM improvements

Tunnel Spring is located on the west side of the Kawich Mountain Range, less than one-half mile north of Corral Spring in Sagebrush Key Habitat. The current purpose of this spring is wildlife watering. In 2007, the spring area contained one horse trough, which allowed water to flow along the ground surface a short distance before being absorbed into the soil. Between 2007 and 2009, the BLM replaced the trough and added water storage to the area. During a 2009 survey, the source of the spring was observed as a depression and shallow cave which contained saturated soil, but no standing water. Little or no vegetation existed around the troughs. The spring was again visited in 2011 and was observed actively flowing with the vegetation still being impacted by wildlife.

Historical information for Tunnel Spring was not available in the NDWR database. Tunnel Spring information was included in the NDWR database, but the waters had not been certificated. The original vested right on the spring was held by John J. Casey for the purpose of watering 200 cattle and 50 horses. The appropriation of this vested right was on January 1880. A permit application was submitted in August 1950, but no permit approval date was noted in the NDWR database. The date of transfer from John J. Casey to

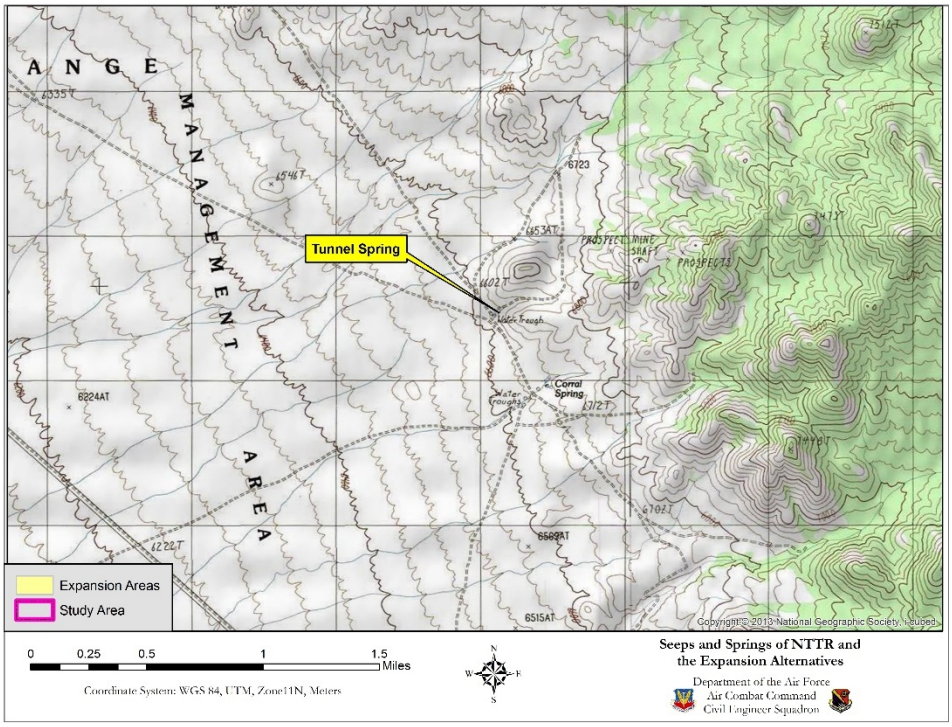


Figure 69. Topographic map showing the location of Tunnel Spring.

the BLM, current right owner, is unknown. The NDWR database did not provide a survey map drawing for this spring.

Table 37. Results of the analysis of water samples taken from Tunnel Spring in 2014 and 2015. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015(May)**	2015(Sept)**
Chloride (mg/L)	400	32.2	27.3	30.5
Fluoride (mg/L)	4	0.78	0.92	0.83
Nitrate/Nitrite (mg/L)	11	ND	ND	ND
Sulfate (mg/L)	500	70	57.2	81.7
Aluminum (mg/L)	0.2	ND	0.01	0.008
Arsenic (mg/L)	0.01	ND	0.015	0.02
Calcium (mg/L)	-	60.6	65.2	63.6
Chromium (mg/L)	0.1	ND	ND	0.002
Copper (mg/L)	1	ND	0.002	0.003
Iron (mg/L)	0.6	0.03	0.19	ND
Lead (mg/L)	0.015	ND	ND	ND
Magnesium (mg/L)	150	7.7	7.6	8.1
Manganese (mg/L)	0.1	ND	0.048	0.003
Sodium (mg/L)	-	34.3	55.6	49
Zinc (mg/L)	5	0.02	0.069	0.021
Hardness (mg/L)	-	183	194	192
pH	6.5-8.5	7.99	8.14	8.24
Turbidity (NTU)	-	0.77	-	0.41
Dissolved Oxygen (%)	-	54.7	58.8	67.2
Conductivity (mS/cm)	-	0.514	0.410	0.438
Salinity (ppt)	-	0.28	0.27	0.23
Temperature of water (°C)	-	18.6	11.8	20

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016A)
ND: Non-Detect

In 2014 and 2015, Tunnel Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016A). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except for arsenic, were found to be below the MCL and pose no threat to wildlife. In 2014, arsenic was not detected in the water sample taken, but in 2015 arsenic was measured just slightly above the MCL. The concentration of arsenic is showing an increasing trend and should be monitored on an annual basis. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Vitovitch Spring

Location:495682 E 4149883 N
Elevation: 6,968 ft. MSL
Dominant Plants: Wood's rose (*Rosa* woodsii); seep monkeyflower (*Mimulus guttatus);* annual rabbitsfoot grass (*Polypogon monspeliensis*); singleleaf pinyon pine (*Pinus monophylla*); Mormon tea (*Ephedra viridis*); big sagebrush (*Artemisia tridentata*); Utah juniper (*Juniperus osteosperma*)



Vitovitch Spring in 2015

Vitovitch Spring is located on the south side of Stonewall Mountain in Cliffs and Canyons Key Habitat. Vitovitch Spring is a relatively large area of saturated soils and mesic vegetation. The spring head has always been observed flowing with standing water present, and is considered a perennial spring. During the 2011 survey, the spring was in excellent condition. The spring appears to be an important source of water for wildlife.

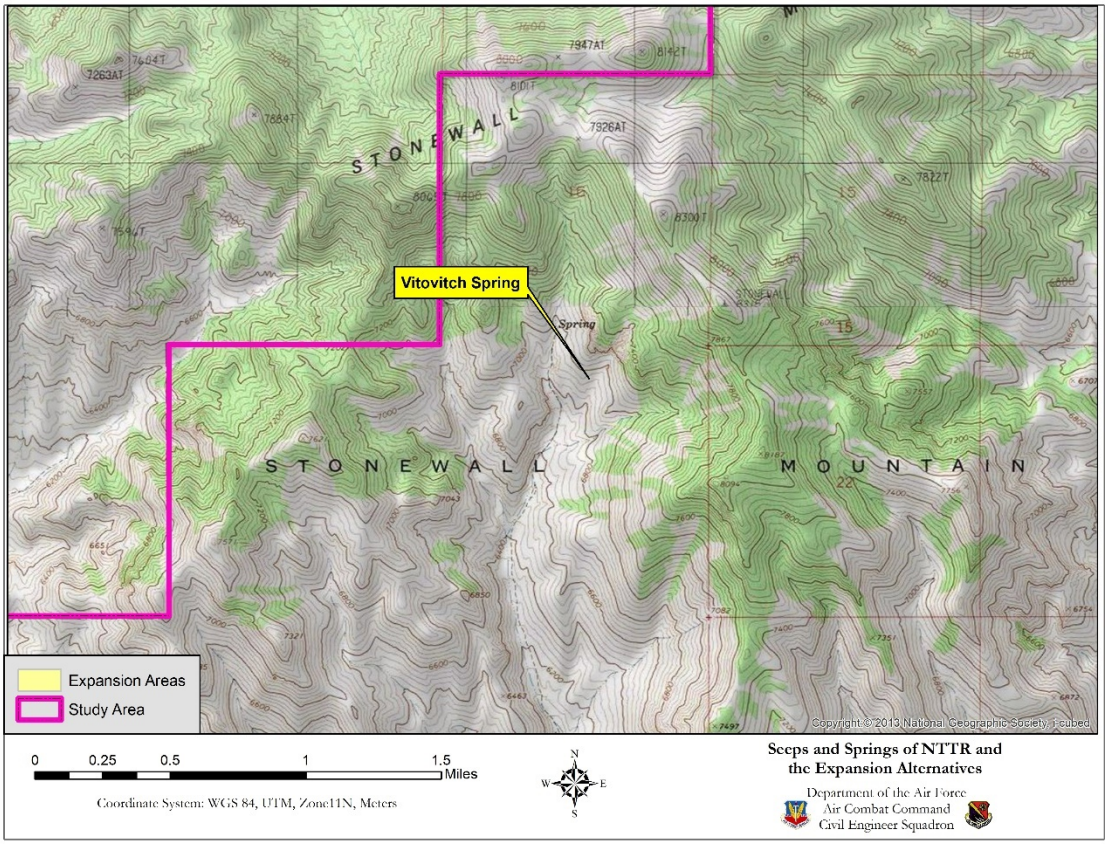


Figure 70. Topographic map showing the location of Vitovitch Spring.

Table 38. Results of field and laboratory analyses of water sampled at Vitovitch Spring Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	Did	9.84
Fluoride (mg/L)	4	Not	0.18
Nitrate/Nitrite (mg/L)	11	Take	0.14
Sulfate (mg/L)	500	Sample	13.2
Aluminum (mg/L)	0.2		0.74
Arsenic (mg/L)	0.01		0.006
Calcium (mg/L)	-		23.2
Chromium (mg/L)	0.1		ND
Copper (mg/L)	1		0.002
Iron (mg/L)	0.6		0.86
Lead (mg/L)	0.015		0.003
Magnesium (mg/L)	150		4.7
Manganese (mg/L)	0.1		0.2
Sodium (mg/L)	-		22.1
Zinc (mg/L)	5		0.009
Hardness (mg/L)	-		77.3
pH	6.5-8.5		7.46
Turbidity (NTU)	-		10.3
Dissolved Oxygen (%)	-		84.3
Conductivity (mS/cm)	-		0.178
Salinity (ppt)	-		0.09
Temperature of water (°C)	-		21

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

Vitovitch Spring was analyzed in the field in 2015 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table contains the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum, iron and manganese, measured for Vitovitch Spring were found to be below the MCL and pose no threat to wildlife. Aluminum, iron and manganese were slightly higher than the MCL. Aluminum is usually not a problem for wildlife or humans. High iron levels are mostly associated with taste and teeth staining issues. With long term, high concentrations, manganese can result in nervous disorders (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

West Dacite Spring

Location: 517072 E 4170624 N
Elevation: 6,029 ft. MSL
Dominant Plants: Barren ground



West Dacite Spring and surrounding habitat in March 2009

West Dacite Spring is located in the central portion of the Cactus Mountain Range in Sagebrush Key Habitat. West Dacite Spring was surveyed in 2009 and 2011, and contained standing water on both occasions. The spring originates at the base of a limestone outcrop. The area surrounding the spring has been heavily impacted by wildlife, with little to no herbaceous vegetation present. Scattered Joshua trees are found in the area surrounding the spring pool. The feature is an important water source for wildlife in the area and would be an excellent candidate for fencing to support habitat restoration.

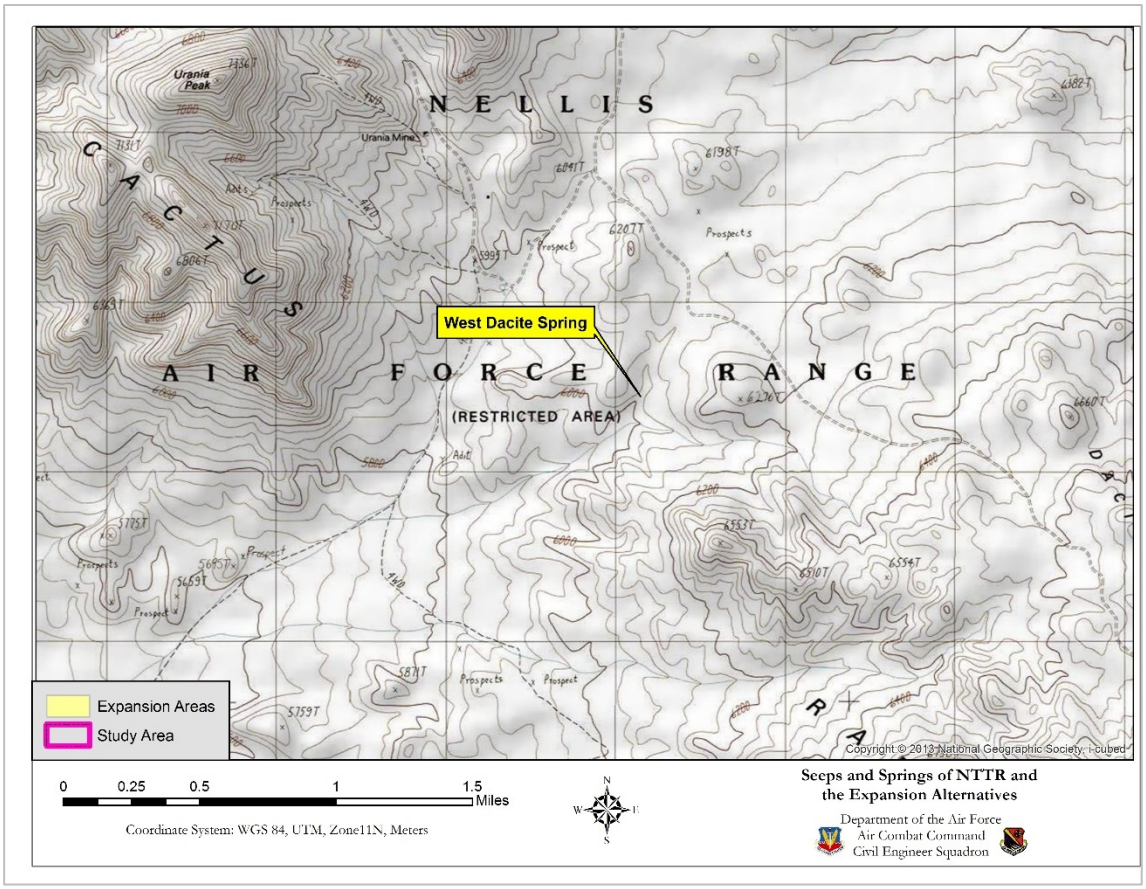


Figure 71. Topographic map showing the location of West Dacite Spring.

Wild Horse Spring (Developed)

Location: 492066 E 4175268 N
Elevation: 5,755 ft. MSL
Dominant Plants: spikerush (*Eleocharis sp.*); softstem bulrush (*Schoenoplectus tabernaemontani*); narrowleaf willow (*Salix exigua*); rubber rabbitbrush (*Ericameria nauseosa*)



Wild Horse Spring corral in May 2009

Wild Horse Spring is located in the Goldfield Hills in Intermountain Cold Desert Scrub Key Habitat. During the May 2009 survey, the spring area was green and soils were saturated in the main flow channel. The spring was not flowing, and no standing water was observed. The old corral fence was still present, and the new fence, constructed to protect the spring, was in excellent condition, allowing the development of a healthy wetland plant community across most of the saturated area. The upper portion of the spring was dry and characterized by desiccated vegetation. Water appeared to be emerging from the ground down gradient

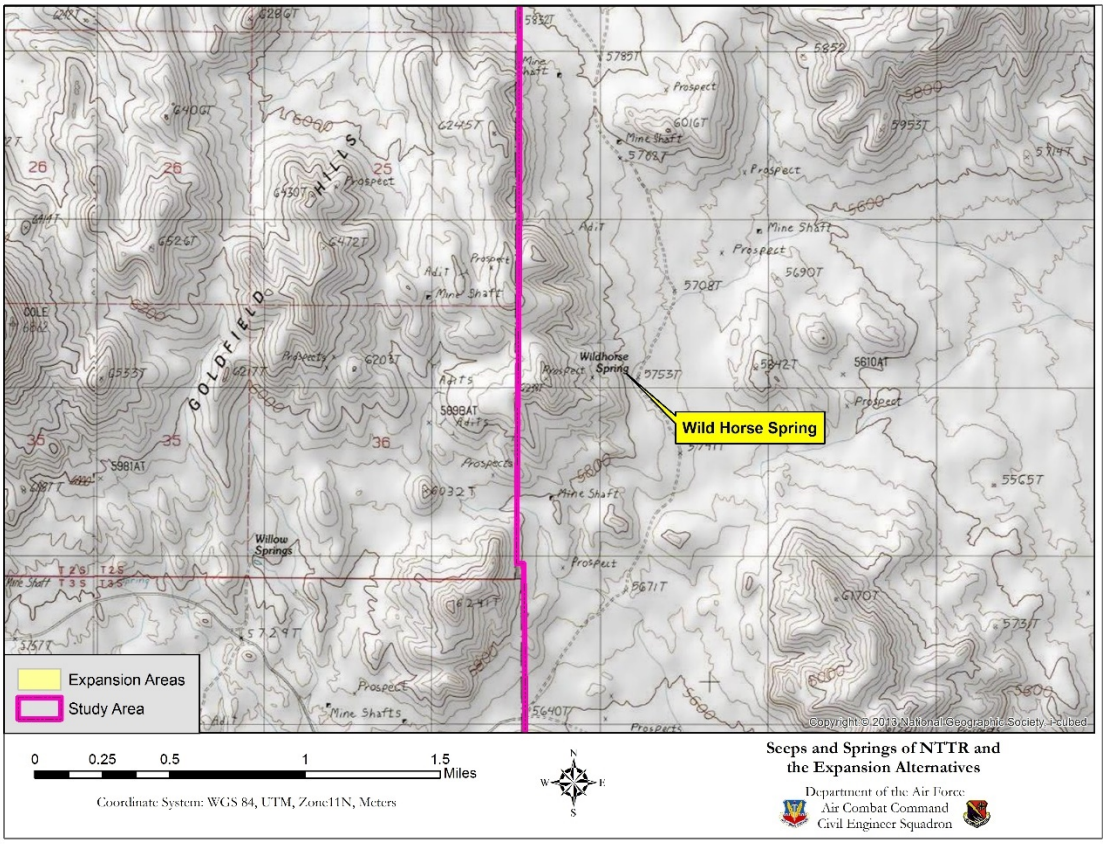


Figure 72. Topographic map showing the location of Wild Horse Spring.

of the original source. Dominant vegetation was spikerush, softstem bulrush, and other rushes and sedges. The spring was surveyed and sampled in 2014 and 2015. It appeared to be drier, but still supported saturated soils and some standing water.

The 1995 wetland survey described the spring as having a source originating from a rock cliff, forming a small pool, then flowing toward a trough and corral (Dames and Moore, 1996). The area of standing water and saturated soil was approximately 15-feet by 120-feet and heavily impacted by horse and burro use. No wetland vegetation was present during the December 1995 survey. Dames and Moore (Dames and Moore, 1996) considered the overall value of the site as a watering resource for wildlife as moderate, despite heavy usage by horses and burros. They felt the spring source had potential for higher quality habitat if protected.

Wild Horse Spring water rights were originally held by George McKenna, who transferred the water rights to the U.S. Air Force on an unknown date. The spring feature was originally developed for irrigation and stock watering. A permit was applied for in April 1916, the permit was issued in August 1916, and certification was granted in September 1929. The water was accessed through a 50-foot cut and 18-foot tunnel in a bank and conveyed 200 feet through 1-1/2 inch pipe to a shallow tank for watering 100 head of cattle and 10 horses. Originally, tank overflow was conveyed through ditches to irrigate a garden; however, the garden referenced in the original permit is not covered in the Certificate of Appropriation. The allowed use totaled 2.46 annual acre feet of water (0.0035 cfs).

Table 39. Results of field and laboratory analyses of water sampled at Wild Horse Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014	2015
Chloride (mg/L)	400	65.9	37.2
Fluoride (mg/L)	4	0.33	0.37
Nitrate/Nitrite (mg/L)	11	0.15	1.76
Sulfate (mg/L)	500	51.2	39.5
Aluminum (mg/L)	0.2	0.76	0.296
Arsenic (mg/L)	0.01	0.02	0.013
Calcium (mg/L)	-	46	29.7
Chromium (mg/L)	0.1	ND	0.001
Copper (mg/L)	1	ND	0.003
Iron (mg/L)	0.6	0.8	0.48
Lead (mg/L)	0.015	ND	0.001
Magnesium (mg/L)	150	6.59	4.2
Manganese (mg/L)	0.1	0.22	0.41
Sodium (mg/L)	-	40	62.8
Zinc (mg/L)	5	ND	0.014
Hardness (mg/L)	-	142	91
pH	6.5-8.5	6.74	6.53
Turbidity (NTU)	-	3.3	-
Dissolved Oxygen (%)	-	8.2	36.5
Conductivity (mS/cm)	-	0.391	0.303

NAME	MCL (mg/L)*	2014	2015
Salinity (ppt)	-	0.24	4.75
Temperature of water (°C)	-	13.9	12.5

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)

****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)

ND: Non-Detect

In 2014 and 2015, Wild Horse Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum, arsenic, iron, and manganese were found to be below the MCL and pose no threat to wildlife. Aluminum is usually not a problem for wildlife or humans. High iron levels are mostly associated with taste and teeth staining issues. Long term, high concentrations of manganese can result in nervous disorders (EPA, 2003). Chronic dosage of arsenic can cause neurological problems (slow reactions, numbness of extremities) and impact gastrointestinal function, etc. The guideline value of 10 µg/l is retained as the goal amount of arsenic in drinking water and is the amount of arsenic that if given in continuous doses, malformations and death in mammals can be seen (Eisler, Arsenic Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, 1988; World Health Organization, 2011). These constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Sundown Spring

Location: 575260 E 4141055 N
Elevation: 6,110 ft. MSL
Dominant Plants: Bluegrass (*Poa* sp.); black sagebrush (*Artemisia nova*); Indian ricegrass (*Achnatherum hymenoides*); Nevada ephedra (*Ephedra nevadensis*); winterfat (*Kraschenninnikovia lanata*); James' galleta (*Pleuraphis jamesii*)



Sundown Spring May 25, 2015. Flow was slightly better than 2014.

Sundown Spring is located on the west side of the Belted Mountain Range in Lower Montane Woodlands Key Habitat. Sundown Spring appears to originate under a large rock along crevices in bedrock. Water flows along a solid bedrock channel which transitions to a gravel channel. The stream flow disappears for a short distance in the gravel channel, then reappears downstream. The spring has significant accumulations of water and appears to be an important source of water for wildlife. The spring was surveyed in 2014 and 2015 and flow was decreased, but the spring appeared to be in good condition.

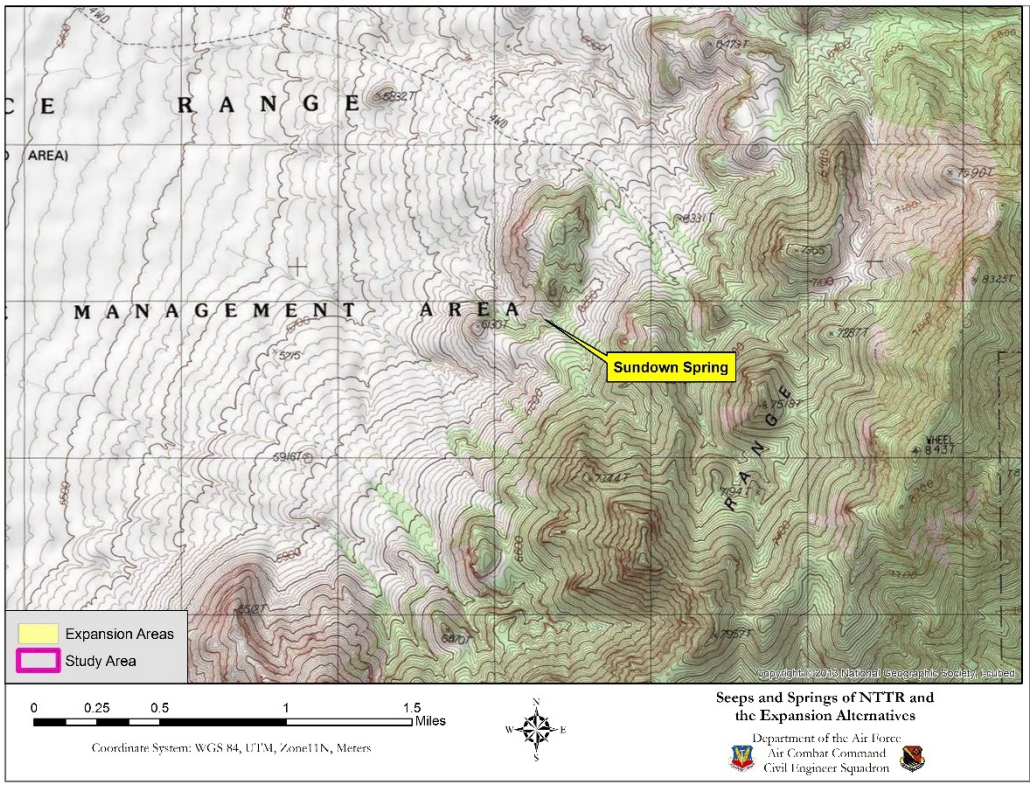


Figure 73. Topographic map showing the location of Sundown Spring.

Table 40. Results of field and laboratory analyses of water sampled at Sundown Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	0.1	8.1	3.05
Fluoride (mg/L)	0.1	0.26	ND
Nitrate/Nitrite (mg/L)	0.1	ND	ND
Sulfate (mg/L)	0.1	0.32	3.87
Aluminum (mg/L)	0.05	ND	0.113
Arsenic (mg/L)	0.01	ND	0.003
Calcium (mg/L)	1	17.6	11
Chromium (mg/L)	0.01	ND	0.001
Copper (mg/L)	0.01	ND	0.002
Iron (mg/L)	0.01	0.05	0.08
Lead (mg/L)	0.01	ND	ND
Magnesium (mg/L)	1	3.43	2.2
Manganese (mg/L)	0.01	0.05	0.088
Sodium (mg/L)	10	8.48	5.3
Zinc (mg/L)	0.01	ND	0.002
Hardness (mg/L)	-	58.1	37
pH	6.5-8.5	9.27	8.96
Turbidity (NTU)	-	1.95	-
Dissolved Oxygen (%)	-	98.1	109
Conductivity (mS/cm)	-	0.151	0.115
Salinity (ppt)	-	0.07	0.05
Temperature of water (°C)	-	23.4	-

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016D)
ND: Non-Detect

In 2014 and 2015, Sundown Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016D). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. Like Pony Spring, which is in the same general area as this spring, many of the constituents were found to be above the MCL for both years. High chloride and sulfate levels produce a salty taste to the water. When fluoride is too high in the water, tooth discoloration can happen. High iron levels are mostly associated with taste and teeth staining issues. (EPA, 2016) Since we saw similar results at Pony Spring, this may indicate that the aquifer feeding these springs does not produce good quality water. The pH was high (alkaline) both years. However, at the concentrations found at this site, these constituents probably do not pose a problem for wildlife. This spring should be carefully monitored on an annual basis to ensure that concentrations are not increasing.

Cactus Roadside Seep

Location: 514299 E 4174681 N
Elevation: 6,487 ft. MSL
Dominant Plants: Shadscale (*Atriplex confertifolia*); big sagebrush (*Artemisia tridentata)*; fourwing saltbush (*Atriplex canescens*); Utah juniper (*Juniperus osteosperma*); rubber rabbitbrush (*Ericameria nauseosa*)



Cactus Roadside Seep in May 2009

Cactus Roadside Seep is located at the east end of Sleeping Column Canyon on the east side of the Cactus Mountain Range in Sagebrush Key Habitat. Standing or flowing water was not observed at Cactus Roadside Seep during the 2009 survey. Most of the vegetation around the spring was desiccated. The site is easily identified by the presence of a grove of Utah junipers and scattered rubber rabbitbrush. It appears to be an old mine shaft that periodically fills with water, which overflows onto the surrounding land. In 2011, the central portion of the seep contained saturated soil and a small portion of standing water. Cactus Roadside Seep appears to have a central point source, making it a spring, and was therefore concluded to be an intermittent spring. The spring was surveyed in 2014 and 2015 and was completely dry both years.

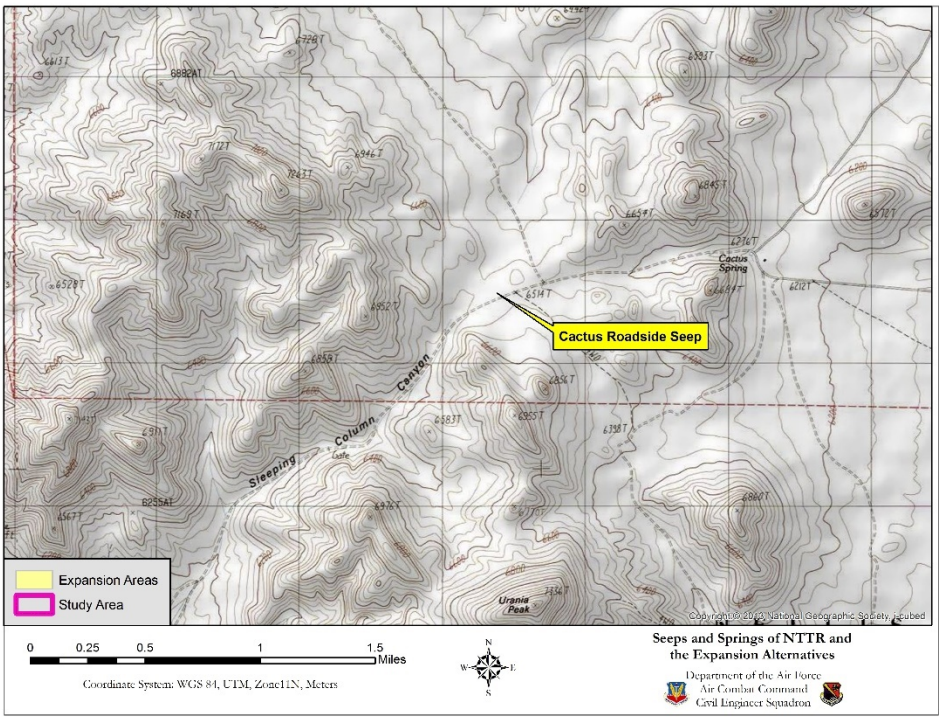


Figure 74. Topographic map showing the location of Cactus Roadside Seep.

Cedar Well Complex (Developed)

Location: 564448 E 4172773 N
Elevation: 6,709 ft. MSL
Dominant Plants: **S**ingleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*); big sagebrush (*Artemisia tridentata*); rubber rabbitbrush (*Ericameria nauseosa*)



Surrounding vegetation and habitat at Cedar Well Complex

Cedar Well Complex is located on the east slope of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Cedar Well complex is an area that appeared to have been developed in the past for livestock watering. A historic well, pipes, watering troughs, and other debris are present, but not in use. The site was visited in 2011 and no water was observed; however, there was evidence of past water, likely present during wet seasons, and the origin appeared to be a cave under a Utah juniper. The site was again visited in 2014 and was extremely dry with no surface water or saturated soils observed.

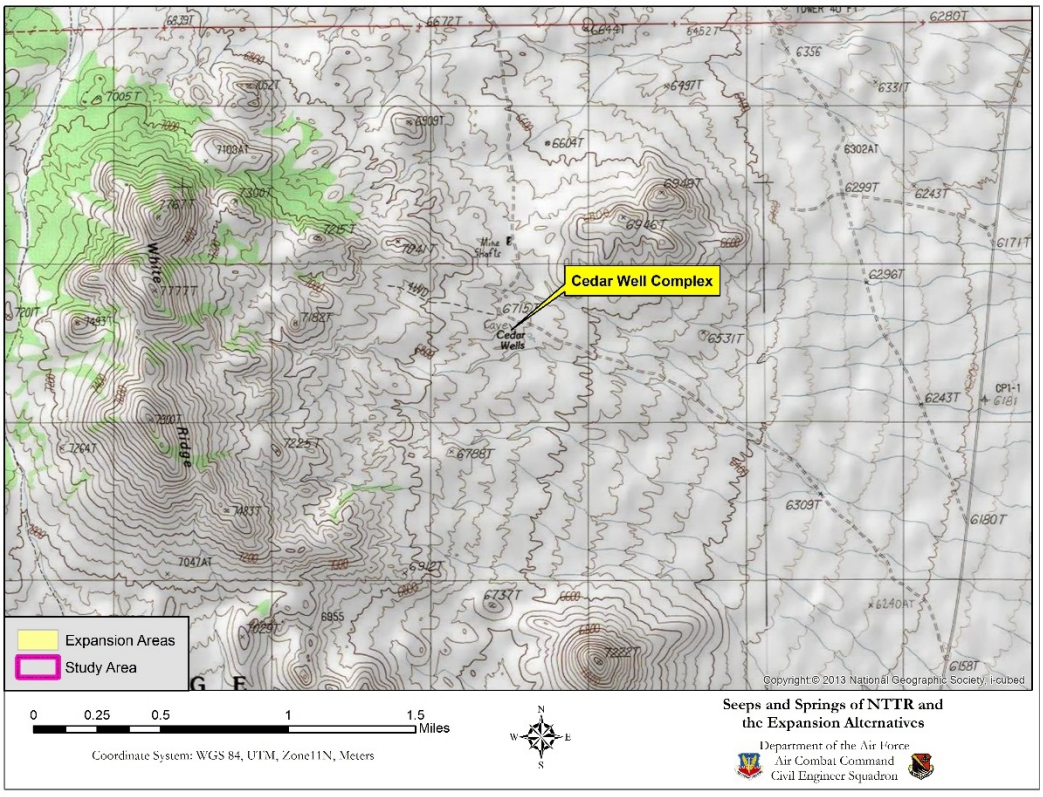


Figure 75. Topographic map showing the location of Cedar Well Complex.

Cooper's Meadow Complex

Location: 552987 E 4191041 N
Elevation: 7,175 ft. MSL
Dominant Plants: Softstem bulrush (*Schoenoplectus tabernaemontani*); spikerush (*Eleocharis* sp.); sedges (*Carex* sp.); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Cooper's Meadow Complex potential point source sampled in 2014

Cooper's Meadow Complex is located on the west side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. The site is easy to identify from the air due to the open treeless area and relatively dense stand of sedges and rushes growing across the surface around the spring head. The size of the site and the lack of a specific water source indicate this may be a seep and/or spring complex.

Dominant plants include spike rush mixed with sedges and bluegrass. The dominant brush species is big sage. The plant community beyond the open area is pinyon/juniper. The only observed accumulation of water is two and a half feet in diameter and flows into sandbar willow and other wetland vegetation. In 2011, the spring was dry, but vegetation was still fairly green. Water was sampled from a small pool of water in 2014. Most of the spring was extremely dry at the time of sampling.

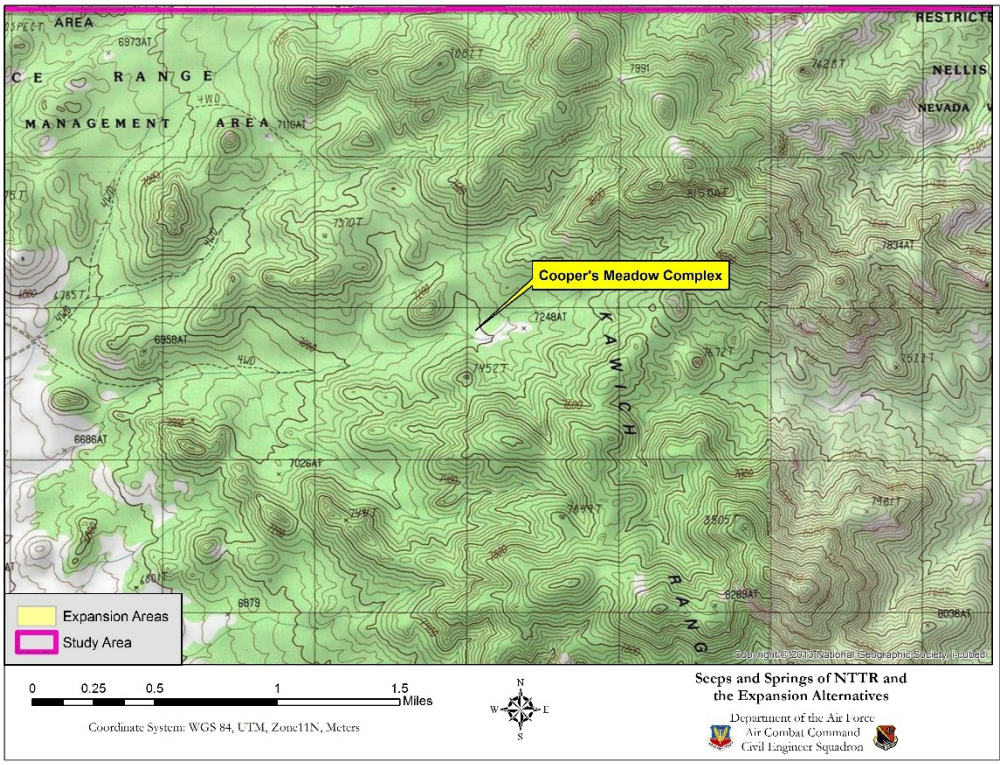


Figure 76. Topographic map showing the location of Cooper's Meadow Complex.

Table 41. Results of field and laboratory analyses of water sampled at Cooper's Meadow Complex.

NAME	MCL (mg/L)*	2014**
Chloride (mg/L)	400	10.5
Fluoride (mg/L)	4	0.27
Nitrate/Nitrite (mg/L)	11	ND
Sulfate (mg/L)	500	15.3
Aluminum (mg/L)	0.2	ND
Arsenic (mg/L)	0.01	ND
Calcium (mg/L)	-	34.8
Chromium (mg/L)	0.1	ND
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	0.14
Lead (mg/L)	0.015	ND
Magnesium (mg/L)	150	3.6
Manganese (mg/L)	0.1	0.01
Sodium (mg/L)	-	30.9
Zinc (mg/L)	5	ND
Hardness (mg/L)	-	102
pH	6.5-8.5	7.24
Turbidity (NTU)	-	2.82
Dissolved Oxygen (%)	-	17.2
Conductivity (mS/cm)	-	0.276
Salinity (ppt)	-	0.18
Temperature of water (°C)	-	10.4

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016A)
ND: Non-Detect

In 2015, water samples were not collected for this site due to dry conditions (no water was present). Cooper's Meadow Complex was analyzed in the field by NNRP biologists in 2014 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016A). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table are the results from both on-site and Silver State Laboratories analyses. All constituents measured for Cooper's Meadow Complex were found to be below the MCL and pose no threat to wildlife.

Falcon Spring

Location: 579924 E 4152255 N
Elevation: 6,692 ft. MSL
Dominant Plants: Softstem bulrush (*Schoenoplectus tabernaemontani*); spikerush (*Eleocharis sp.*); beardless wildrye (*Leymus triticoides*)



Falcon Spring in September 2011.

Falcon Spring is located east of the Belted Range in Lower Montane Woodlands Habitat. Falcon Spring emerges as a seep near a rock outcrop and the water is piped to a horse watering trough. Surface water was present at the outcrop during the Dames and Moore October 1996 wetlands survey (Dames and Moore, 1996), but the trough was dry. Saturated soil was also present but did not support wetland vegetation, as the site had been heavily disturbed by wildlife. The overall value of the site as a watering resource for wildlife is assessed as moderate. Falcon Spring was again surveyed in 2011. Soils in the spring were moist, but not saturated, and no standing water was observed. Vegetation was green and dominated by the mesic species; softstem bulrush, spikerush, and beardless wildrye. Limited damage by wildlife was observed. The spring has not been surveyed since 2011.

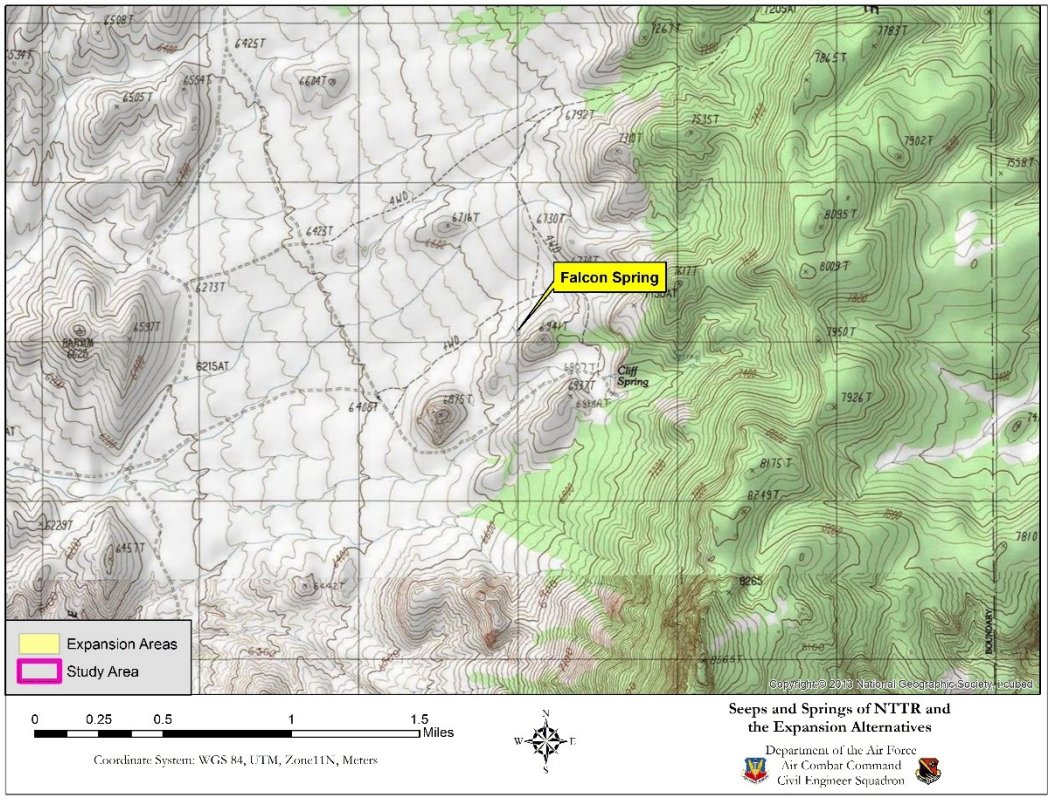


Figure 77. Topographic map showing the location of Falcon Spring.

Indian Springs 1, 2, and 3

Location: Indian Spring 1: 579325 E 4143544 N
Indian Spring 2: 579531 E 4144317 N
Indian Spring 3: 579474 E 4144269 N

Elevation: 7,161 ft. MSL
Dominant Plants: Bluegrass (*Poa* sp.); black sagebrush (*Artemisia nova);* Indian ricegrass (*Achnatherum hymenoides*); Nevada ephedra (*Ephedra nevadensis*); winterfat (*Krascheninnikovia lanata*), James' galleta (*Pleuraphis jamesii*)

The Indian Springs are located in a narrow canyon of pinyon-juniper on the western slopes of the Belted Mountain Range in Lower Montane Woodlands Key Habitat. Indian Springs 1, 2, and 3 were first identified in 1995 during the Dames and Moore wetland surveys (Dames and Moore, 1996). Dames and Moore found the spring source in a small rock cave. No water flow was observed during that survey. Two wooden posts had been installed in the cave, apparently to support the overhanging rock. Algae and a few emergent macrophytes were present in the standing water. A three-inch-deep pool was observed outside the small cave; the pool and peripheral saturated area meet the criteria of being an isolated wetland. Wildlife impacts to the spring were also observed during the survey. These springs have not been photographed since the 1995 field work. A survey conducted in October 2012 was unable to locate the springs. The springs were not surveyed in 2014 and 2015 due to access issues.

The USGS sampled Indian Spring 1 and 2 in 1985 and 2000 **(Dames and Moore, 1996)**.

Table 42. Water quality for Indian Spring 1 in May 1985 and July 2000, from USGS collected data
(Dames and Moore, 1996).

Item	15 May 1985	11 July 2000
Alkalinity as HCO3	173	
Ca, Dissolved (mg/L)	30	36.7
Cl, Dissolved (mg/L)	9.4	8.3
HCO3, Dissolved (mg/L)		160
K, Dissolved (mg/L)	0.9	4.9
Mg, Dissolved (mg/L)	7.1	6.4
Na, Dissolved (mg/L)	39	18.7
NO_3, Dissolved (mg/L)	0.75	
SO_4, Dissolved (mg/L)	31	19.8
Specific Conductance (µS/cm)	356/360	299
pH	8.1	7.52

Table 43. Water quality for Indian Spring 2 in July 2000, from USGS collected data
(Dames and Moore, 1996)**.**

Item	11 July 2000
Ca, Dissolved (mg/L)	36.7
Cl, Dissolved (mg/L)	8.3
HCO3, Dissolved(mg/L)	160
K, Dissolved (mg/L)	4.9
Mg, Dissolved (mg/L)	6.4
Na, Dissolved (mg/L)	18.7
NO3, Dissolved (mg/L)	0.75
pH	7.5
SO_4, Dissolved (mg/L)	19.8
Specific Conductance (µS/cm)	299

NDWR database shows Indian Springs water rights, application 2359, were originally held by the Kawich Cattle Association, which transferred the water rights to the U.S. Air Force on an unknown date. The Kawich Cattle Association applied for appropriation of water rights in February 1912, a permit was issued in June 1912, and certification was given in July 1914. Water not conveyed to another place of use was conserved and fed a small reservoir. Water was delivered from the reservoir through a pipe. The original allowed use totaled 2.82 annual acre feet of water for the purpose of watering an unknown number of stock. This application is believed to be Indian Spring 1, based on the measurements from the original surveyor's map. The Nevada State Engineer identifies a second Indian Spring, application 11608. The original surveyor's drawing places both Indian Springs in the same location, which is believed to be as identified on the USGS topographic map, and in the same location as Indian Spring 1. Indian Spring application 11608 water rights were originally held by Carlton P. and Floyd R. Lamb, who transferred the water rights to Nellis Air Force Base on an unknown date. Carlton P. and Floyd R. Lamb applied for appropriation of water rights in June 1946, a permit was issued in August 1947, and certification was given in May 1949. Water was delivered from the cut-based spring half a mile through a 1 1/2-inch pipe to a metal trough. Water was then conveyed another half mile from the metal trough to a concrete trough through one-inch pipe. The original allowed use totaled 4.54 annual acre feet of water for the purpose of watering 200 head of cattle.

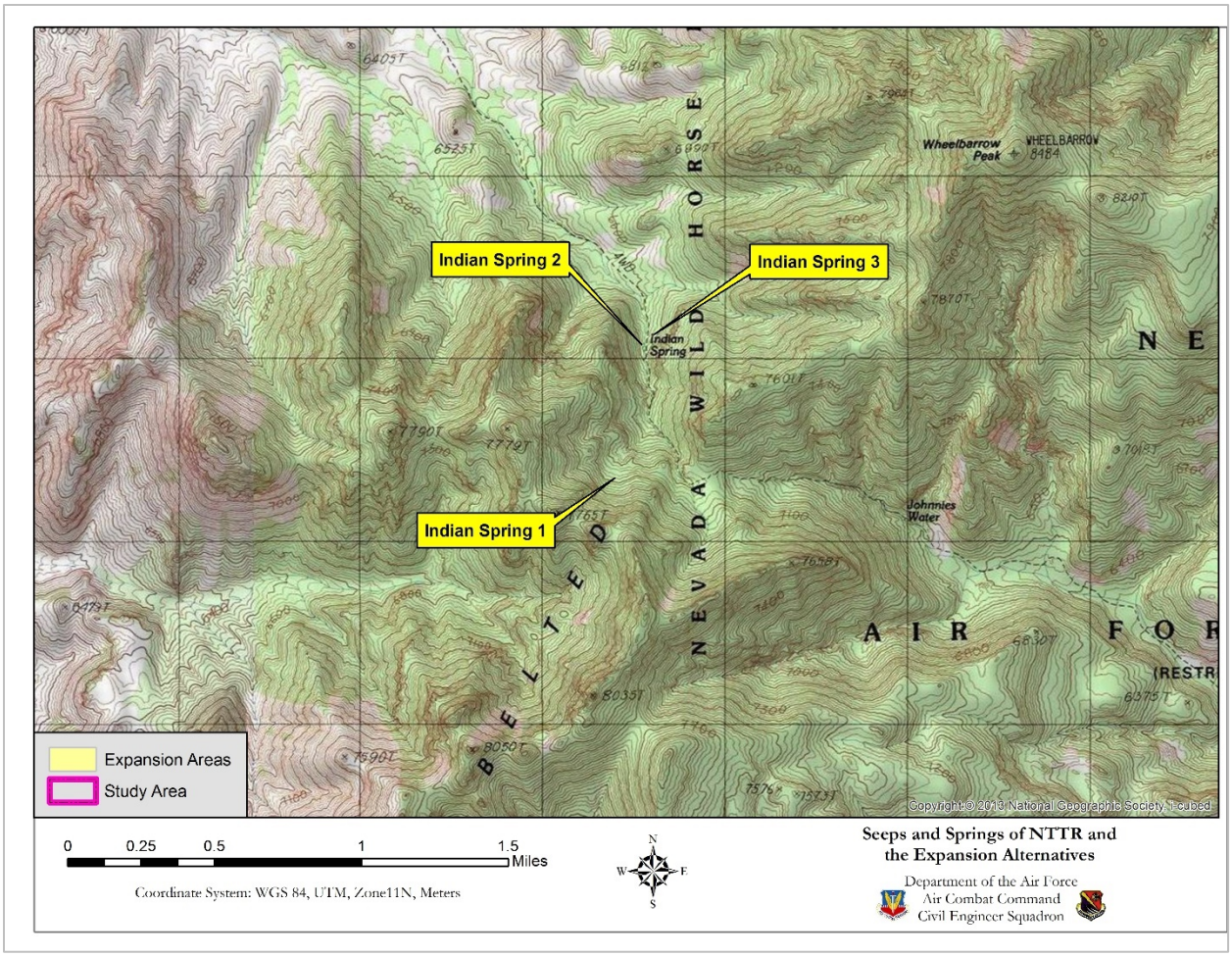


Figure 78. Topographic map showing the locations of Indian Spring 1, 2 and 3.

Kawich Peak Spring

Location: 554836 E 4188905 N
Elevation: 7,805 ft. MSL
Dominant Plants: **S**pikerush (*Eleocharis* sp.); sedges (*Carex* sp.); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Kawich Peak Spring flowing stream spring 2007

Kawich Peak Spring is located on the east side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. In 2007, dead pinyon pines were observed adjacent to the spring, possibly indicating recently saturated conditions or indicating a recent change in hydrology. Water was observed flowing from the spring during the survey. Dominant vegetation during the visit was spike rush and other sedges. The helicopter was unable to land due to the density of trees and brush, and inclination of slope. In 2011, the spring appeared to be wet, but no standing water was observed. Vegetation was green and healthy.

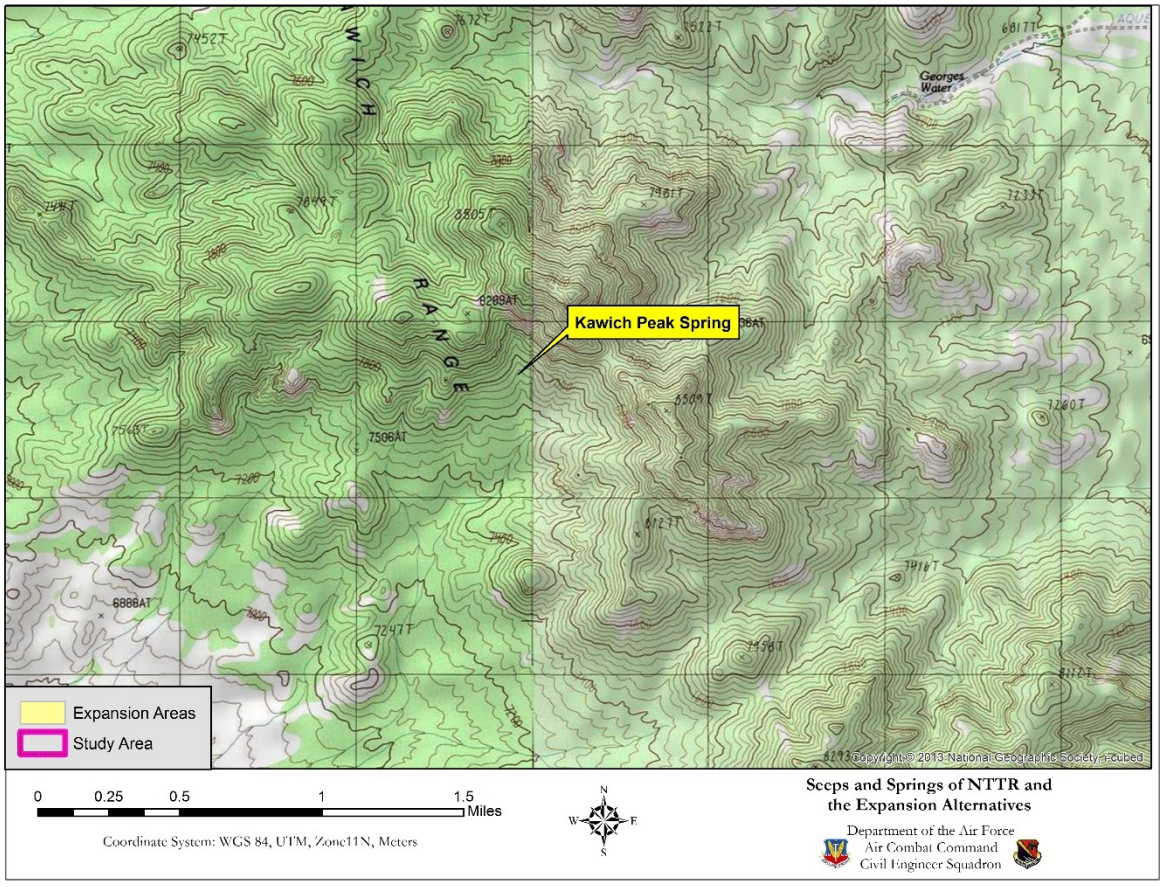


Figure 79. Topographic map showing the location of Kawich Peak Spring.

Old Silverbow Spring

Location: 544067 E 4191988 N
Elevation: 6,348 ft. MSL
Dominant Plants: Geyer's willow (*Salix geyeriana*); narrowleaf willow (*Salix exigua*); Woods' rose (*Rosa woodsii*); big sagebrush (*Artemisia tridentata*) and Utah juniper (*Juniperus osteosperma*)



September 2011 survey of Old Silverbow Spring showing sagebrush, willow, and juniper at the site.

Old Silverbow Spring is located in the Silverbow seep and spring complex, in the northwestern portion of Cactus Flats, approximately one-quarter mile east of Silverbow Spring in Sagebrush Key Habitat. Old Silverbow Spring is located in Breen Creek channel, according to historic coordinates. The site supports mesic vegetation and appears to have saturated soils and even standing water in the winter months and when Breen Creek is flowing or when the water table is high. The site currently supports a healthy stand of Geyer's willow. "Silver Bow Spring" was originally appropriated by John J. Casey. After several deed exchanges, P.T.P. Inc., a Nevada Corporation, transferred the water rights to the United States of America in June 1964. The spring feature was originally developed by means of a 12-inch perforated pipe 12 feet long buried three feet in rock and gravel. The water was conveyed through 17,000 feet of two-inch pipe to troughs and reservoirs on an established ranch. The original allowed use totaled 21.73 annual acre feet of water for the purpose of watering 1,500 head of cattle and 200 horses. A protest was filed by James Daniel in 1951, and overruled by the Nevada State Engineer, on January 2, 1953.

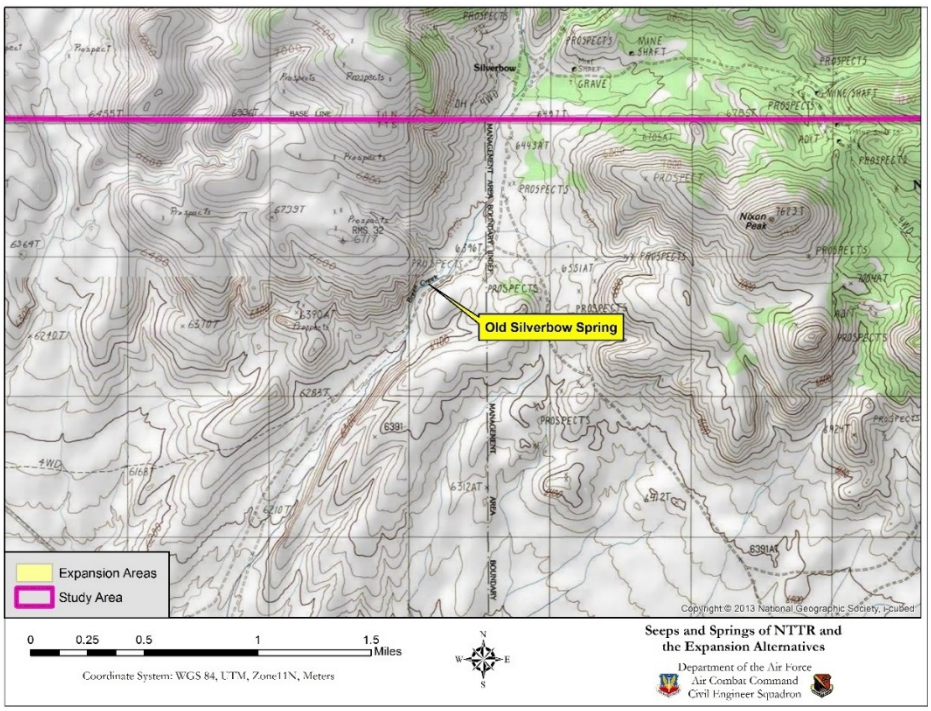
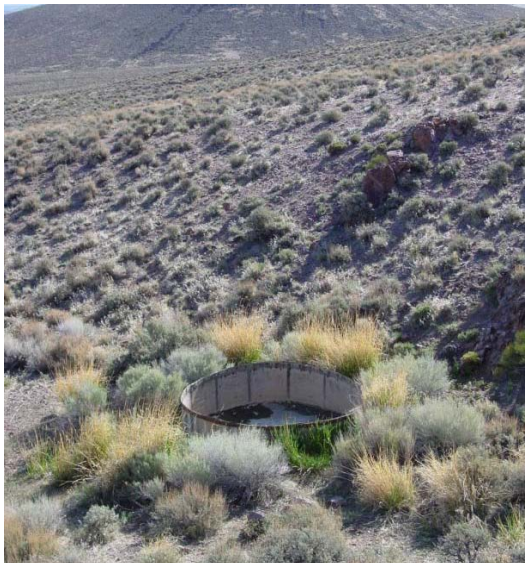


Figure 80. Topographic map showing the location of Old Silverbow Spring.

Quartz Mountain Tank #1 (developed)

Location: 520216 E 4126743 N
Elevation: 6,153 ft. MSL
Dominant Plants: Blackbrush (*Coleogyne ramosissima*); green ephedra (*Ephedra* viridis); burrobush (*Ambrosia dumosa*); James' galleta (*Pleuraphis jamesii*); buckwheat (*Eriogonum* sp.); beardless wildrye (*Elymus* triticoides); Indian ricegrass (*Achnatherum hymenoides*); desert needlegrass (*Achnatherum speciosum*)



Quartz Mountain Tank #1 in September 2009

Quartz Mountain Tank #1 on the north side of Quartz Mountain is in Sagebrush Key Habitat. Quartz Mountain Tank #1 is a water storage tank fed by a relatively weak intermittent spring. The spring was not active during the 2007 survey; only areas of moist soil and green vegetation were present at the spring site. The surrounding area plant community is composed predominantly of blackbrush, green ephedra, burrobush, and buckwheat. Grasses included beardless wildrye with smaller populations of Indian ricegrass, galleta, and desert needlegrass. Condition of the site had not changed during the 2011 survey.

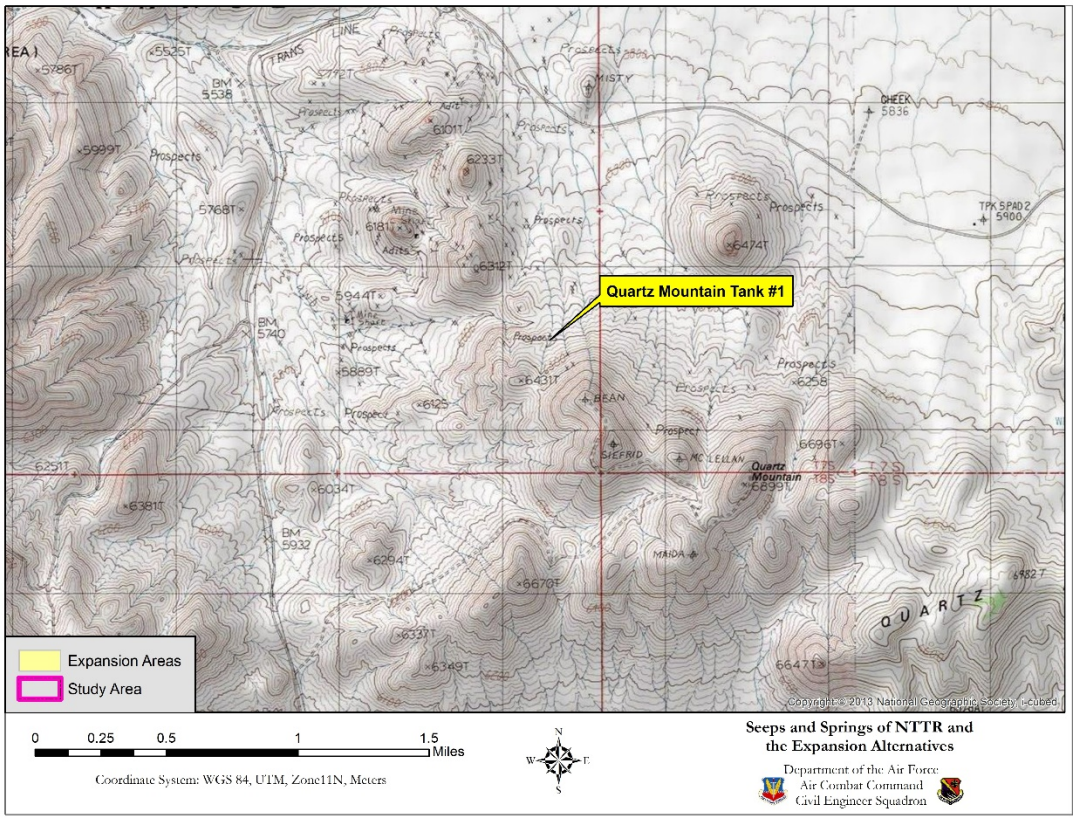


Figure 81. Topographic map showing the location of Quartz Mountain Tank #1.

Quartz Spring

Location: 558683 E 4163306 N
Elevation: 6,543 ft. MSL
Dominant Plants: Shadscale saltbush (*Atriplex confertifolia*); James' galleta (*Pleuraphis jamesii*); greasewood (*Sarcobatus vermiculatus*); big sagebrush (*Artemisia tridentata*); Mormon tea (*Ephedra viridis*)



Quartz Spring in 2007

Quartz Spring is located in the Kawich Mountain Range on the north side of Trailer Pass Road in Intermountain Cold Desert Scrub Key Habitat. Quartz Spring appears to be ephemeral, flowing in the late winter and early spring and drying out in the summer. The spring was flowing in 2007 and several pools of water were present. No vegetation was growing at the spring source due to the bedrock/gravel surface. The surrounding area was dominated by greasewood, galleta, big sagebrush, Mormon tea, and shadscale. In 2009, the site was revisited, and no water was observed. The spring was identified by the presence of mesic vegetation around the source. In 2011, the spring was dry, probably because the survey was conducted in late summer during the dry season.

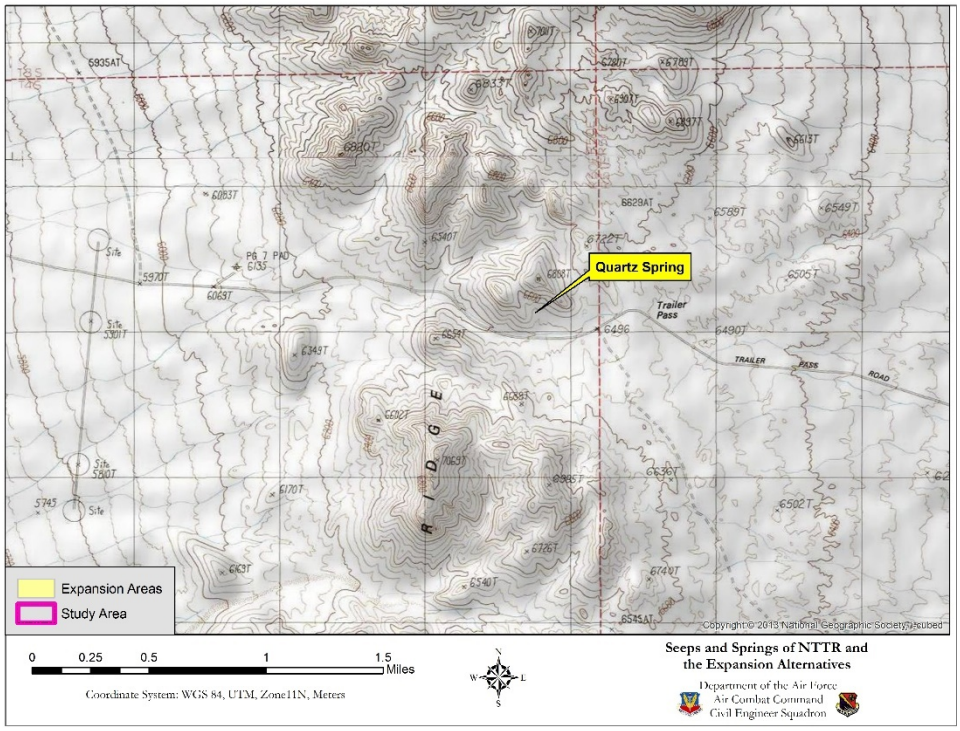


Figure 82. Topographic map showing the location of Quartz Spring.

Rose Spring (Developed)

Location: 558838 E 4177885 N
Elevation: 7,106 ft. MSL
Dominant Plants: Utah juniper (*Juniperus osteosperma*); rubber rabbitbrush (*Ericameria nauseosa*); beardless wildrye (*Leymus triticoides*); singleleaf pinyon pine (*Pinus monophylla*)



Rose Spring in 2011.

Rose Spring is located east of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. The spring site can be accessed from Rose Spring Road, off Cedar Pass Road. In 2005, BLM re-built and re-developed the spring as a primary water source for the wild horse herd on NTTR. An excavated area containing the well is located at the spring site and may have been a catchment for water from the spring. No running or standing water was observed during the 2007, 2009, or 2011 surveys. Evidence of past water accumulation was observed adjacent to the well. An opening in the wall of the excavated area is likely the location of the spring head, but flow has not been observed during recent surveys (2014 and 2015). This may indicate that installation of the well depleted the spring of water by lowering the water table. The spring may still flow intermittently, but the well is apparently producing water most of the year. Trampling of surrounding vegetation was also observed. According to Dames and Moore (Dames and Moore, 1996), "*the well observed at the site is a pipe system, which is tapping a subterranean source. Information in Table 6 of a BLM (1995) report states: "Pipeline between the two troughs (3.5 miles) was replaced in May 1994 and 1,000 ft section of pipeline was replaced below the collection box. There is no surface flow or soil saturation associated with the excavation, although there is some alkaloid surface incrustation, likely resultant from evapotranspiration of soil solution earlier in the season. A ravine to the west of the pipeline and excavation contains a mesic area of grasses, such as galleta, and herbs. A 1 m^2 area has been dug down, possibly by deer, within the ravine and approximately a liter of water has filled*

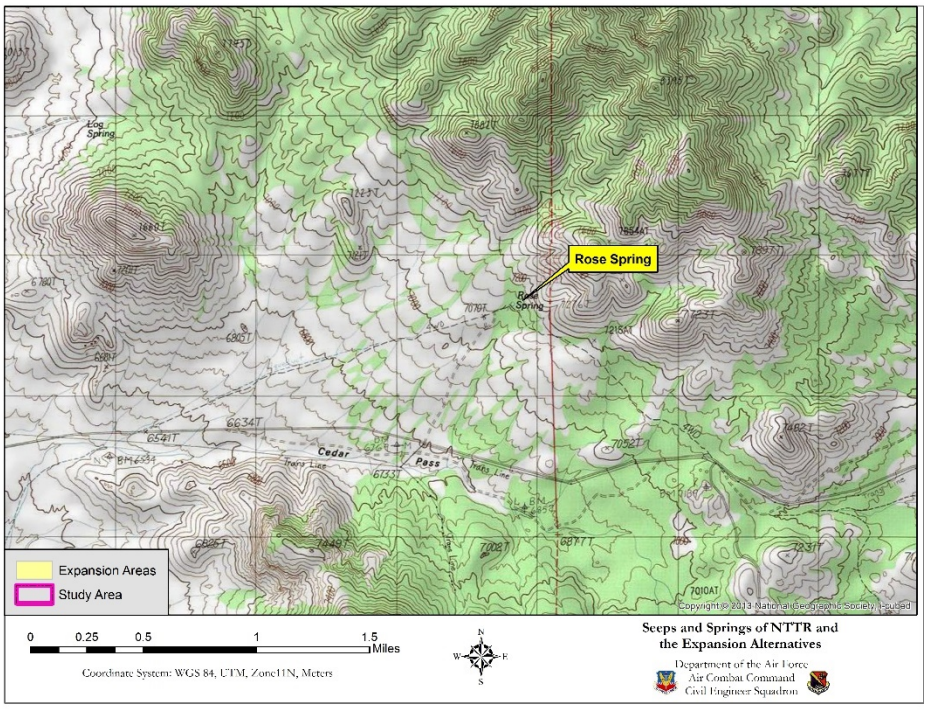


Figure 83. Topographic map showing the location of Rose Spring.

in the resultant depression. It is uncertain whether this area is hydrologically continuous with the source area supplying the pipe system, or if it is autonomous. The mesic area is not considered potential wetland. The overall value of the site as a watering resource for wildlife is assessed as poor due to the lack of readily available surface water." The NDWR database referred to Rose Spring as "Rose or Wild Horse" Spring, but does not explain why. Rose (or Wild Horse) Spring has not been certificated. The original vested right for the spring was held by John J. Casey for the purpose of watering 600 cattle and 80 horses. The priority for this vested right is January 1879; a permit was applied for in August 1950, but no permit award date was noted. The date of transfer from John J. Casey to the BLM, current right owner, is not known.

Sailor's Spring (developed)

Location: 494342 E 4172223 N
Elevation: 5,430 ft. MSL
Dominant Plants: Shadscale saltbush (*Atriplex confertifolia*); water jacket (*Lycium andersonii*); silver cholla (*Cylindropuntia echinocarpa*); cheesebush (*Hymenoclea salsola*); Indian ricegrass (*Achnatherum hymenoides)*; blackbrush (*Coleogyne ramosissima*); burrobush (*Ambrosia dumosa*); spiny menodora (*Menodora spinescens*); Mormon tea (*Ephedra viridis*)



Entrance to Sailor's Spring

Sailor's Spring is located west of northern Stonewall Flats in Intermountain Cold Desert Scrub Key Habitat. Sailor's Spring was first inspected on May 25, 2009. The spring is well-hidden in a small cave covered with vegetation. The entrance to the cave is bare ground, likely due to use by small mammals and birds. It does not appear horses or bighorn sheep are able to access the water. Water was present in 2009 at the time of the surveys but was not flowing. In 2014 and 2015, the spring was dry with no evidence of water. The plant community around the spring consisted of upland desert species, indicating the spring does not flow beyond the cave mouth for significant periods of time. A water tank was present at the site indicating that the spring may have flowed in the past. No information on water rights were found in the NDWR database.

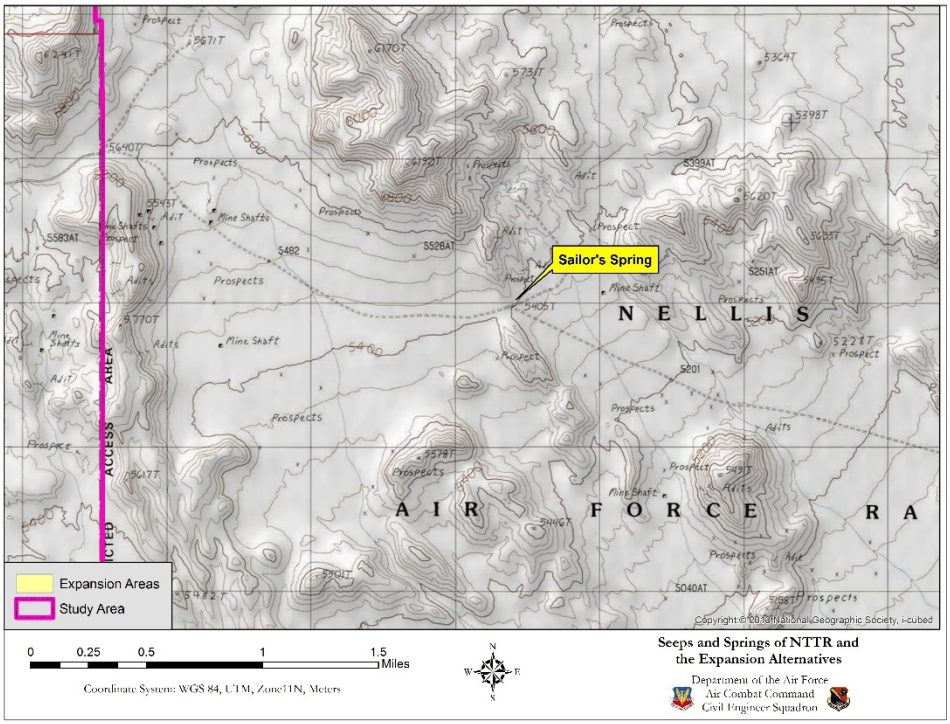
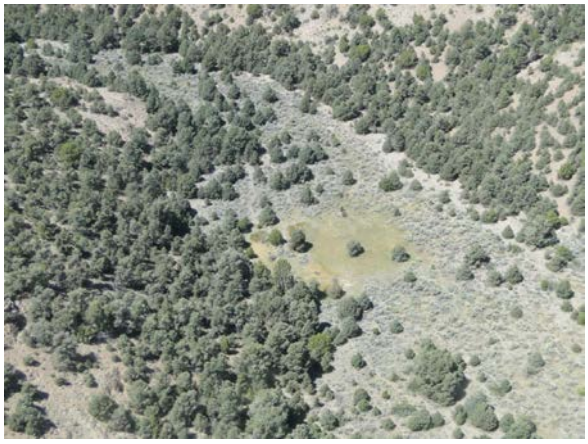


Figure 84. Topographic map showing the location of Sailor's Spring.

Upper George's Spring

Location: 556731 E 4190458 N
Elevation: 6,989 ft. MSL
Dominant Plants: Spikerush (*Eleocharis* sp.); sedges (*Carex* sp.); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Upper George's Water, September 4, 2011

Upper George's Water is a relatively large spring and associated wet meadow located on the east side of the Kawich Mountain Range, one-quarter mile west of George's Water in Lower Montane Woodlands Key Habitat. During the 2007 survey, the site was dry but showed evidence of intermittent flowing water in at least two locations. The spring supports a healthy stand of spike rush and sedges. In 2011, the spring was also dry, but the presence of relatively healthy wet meadow vegetation was observed. This spring has been observed at various times of the year and often flows until mid-May. When the spring is flowing, the wet meadow is saturated with standing water in places. Water from the spring flows into a nearby wash which flows to George's Water. At George's Water, the stream picks up additional spring volume and often flows one to two miles. This is one of the more stable intermittent springs on NTTR. In 2014 and 2015, this spring was dry with no running water.

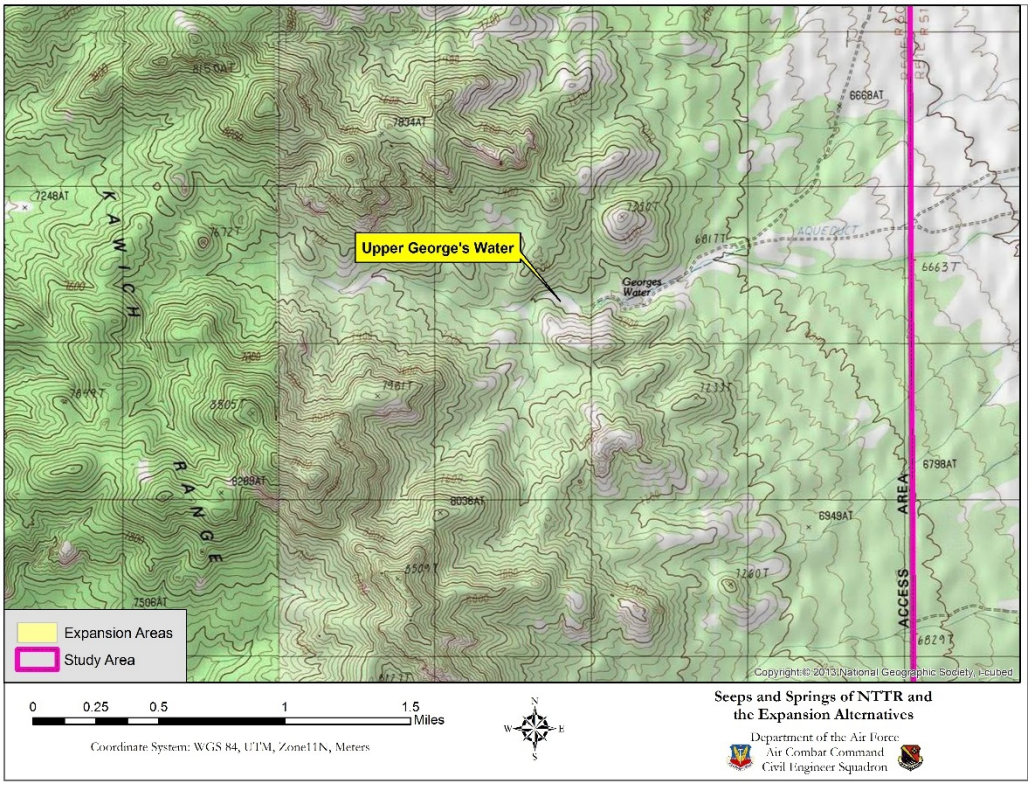


Figure 85. Topographic map showing the location of Upper George's Water.

Urania Mine Spring (Fenced)

Location: 515740 E 4172253 N
Elevation: 6,266 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); sedges (*Carex sp.*); rushes (*Juncus sp.*)



Urania Mine Spring in 2011.

Urania Mine Spring is located in the central Cactus Mountain Range in Sagebrush Key Habitat. According to the 1995 wetland survey (Dames and Moore, 1996), Urania Mine Spring emerged from the base of a rock, collected in a small pool, before absorbing into saturated soils approximately 30 feet down a hill, feeding a cottonwood tree. Dames and Moore observed vegetative community damage from extensive wildlife use, and recommended fencing to protect the spring. In 2009, water was again observed at the site, and the cottonwood tree was in excellent condition and a small area of spike rush had developed. In 2011, the spring was dry and no water or saturated soils were observed. Due to this, the spring was determined to be intermittent. In 2014, the spring was small and sulfidic with vegetation around the spring appearing desiccated. In 2015, the spring was in similar dry condition with just a very small hole containing less than a pint of water. The water was sulfidic and appeared to contain silver nitrate or similar compounds.

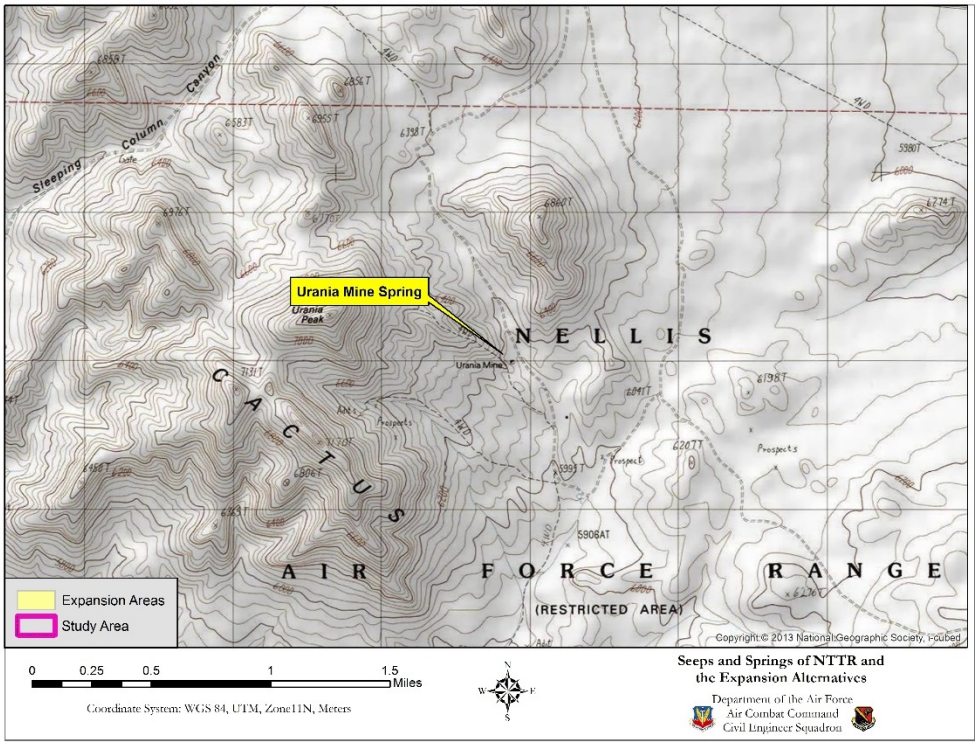


Figure 86. Topographic map showing the location of Urania Mine Spring.

Table 44. Results of field and laboratory analyses of water sampled at Urania Mine Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**	2015**
Chloride (mg/L)	400	19.4	25.1
Fluoride (mg/L)	4	1.39	2.51
Nitrate/Nitrite (mg/L)	11	ND	ND
Sulfate (mg/L)	500	1797	1731
Aluminum (mg/L)	0.2	ND	2.03
Arsenic (mg/L)	0.01	ND	0.006
Calcium (mg/L)	-	459	370
Chromium (mg/L)	0.1	ND	ND
Copper (mg/L)	1	ND	0.004
Iron (mg/L)	0.6	0.16	20.1
Lead (mg/L)	0.015	ND	0.004
Magnesium (mg/L)	150	30.4	71.1
Manganese (mg/L)	0.1	2.58	4.92
Sodium (mg/L)	-	74.7	124
Zinc (mg/L)	5	ND	0.027
Hardness (mg/L)	-	1271	1217
pH	6.5-8.5	6.47	6.42
Turbidity (NTU)	-	4.49	-
Dissolved Oxygen (%)	-	16.1	8.7
Conductivity (mS/cm)	-	2.403	1.389
Salinity (ppt)	-	1.43	-
Temperature of water (°C)	-	18.5	16.4

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)***Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014 and 2015, Urania Mine Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except sulfate, aluminum, iron and manganese, were found to be below the MCL and pose no threat to wildlife. High levels of sulfate generally cause intestinal problems such as diarrhea and, subsequently, dehydration. This sulfate may be associated with silver from mining operations (as indicated by the black precipitate in the water). Chronic doses of silver may have minor effects on liver function, kidneys, and can cause cardiac enlargement (Eisler, Silver Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, 1996). Long term exposure to high concentrations of manganese can result in nervous disorders (EPA, 2003). High iron levels are mostly associated with taste and teeth staining issues. At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

White Patch Spring

Location: 510614 E 4174767 N
Elevation: 6,177 ft. MSL
Dominant Plants: Softstem bulrush (*Schoenoplectus tabernaemontani*); beardless wildrye (*Leymus triticoides*)

White Patch Spring is located in White Patch Draw on the west side of the Cactus Mountain Range in Sagebrush Key Habitat. White Patch Spring was wet at the time of the October 2011 survey. Vegetation was dominated by softstem bulrush and beardless wildrye. The spring was located in the vicinity of several mine shafts and structures. No photographs were taken of the spring during the survey.

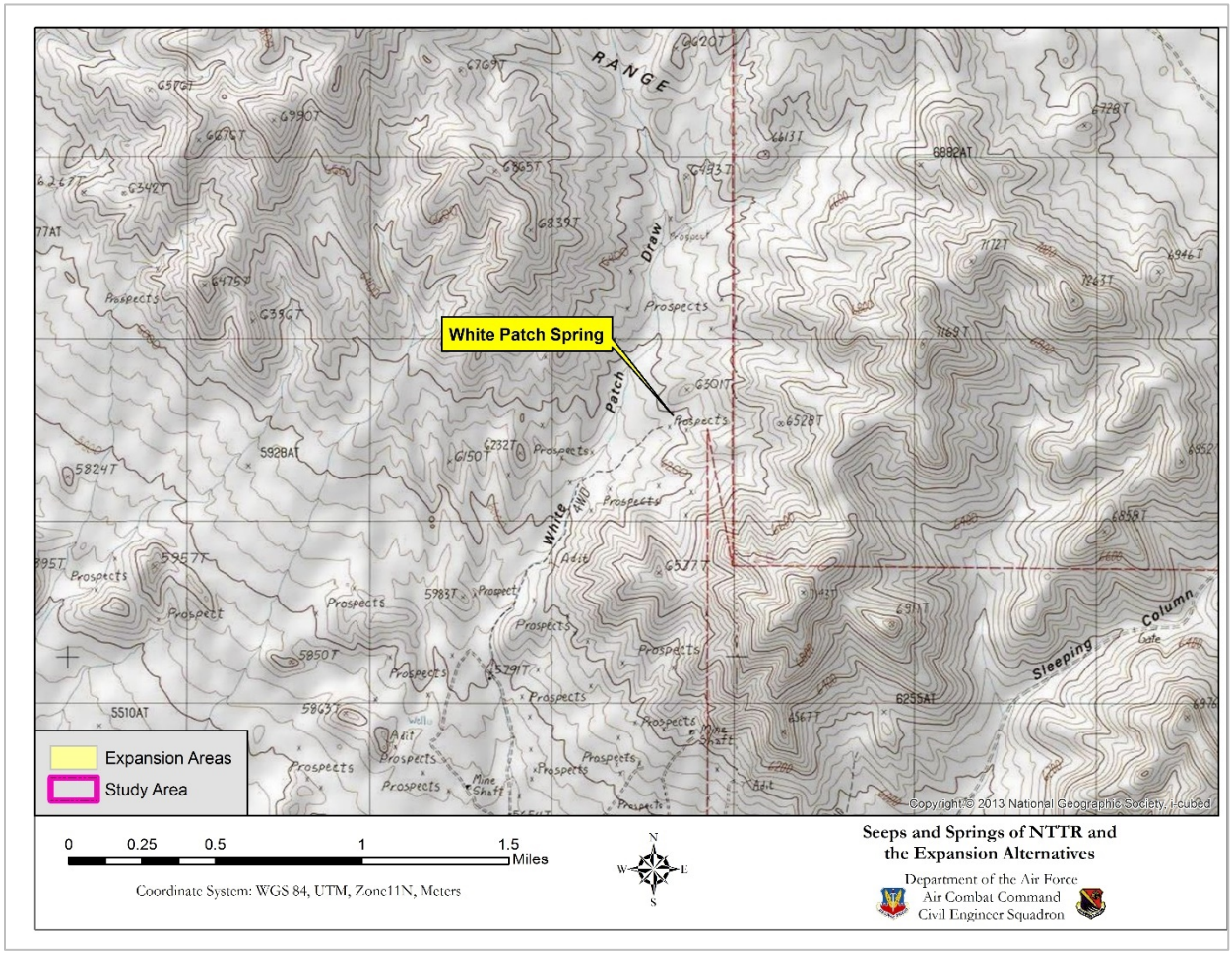


Figure 87. Topographic map showing the location of White Patch Spring.

Table 45. Results of field and laboratory analyses of water sampled at White Patch Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**
Chloride (mg/L)	400	5.64
Fluoride (mg/L)	4	0.13
Nitrate/Nitrite (mg/L)	11	0.34
Sulfate (mg/L)	500	28.3
Aluminum (mg/L)	0.2	ND
Arsenic (mg/L)	0.01	ND
Calcium (mg/L)	-	40.4
Chromium (mg/L)	0.1	ND
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	0.56
Lead (mg/L)	0.015	ND
Magnesium (mg/L)	150	7.74
Manganese (mg/L)	0.1	0.26
Sodium (mg/L)	-	4.31
Zinc (mg/L)	5	ND
Hardness (mg/L)	-	133
pH	6.5-8.5	7.62
Turbidity (NTU)	-	0.31
Dissolved Oxygen (%)	-	74
Conductivity (mS/cm)	-	0.284
Salinity (ppt)	-	0.17
Temperature of water (°C)	-	16

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2014, White Patch Spring was analyzed in the field by NNRP biologists for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except manganese, were found to be below the MCL and pose no threat to wildlife. Long term exposure to high concentrations of manganese can result in nervous disorders (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

White Ridge Spring

Location: 563198 E 4172642 N
Elevation: 6,971 ft. MSL
Dominant Plants: Singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



White Ridge Spring springhead

White Ridge Spring is located on the eastern slope of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. White Ridge Spring flow is fairly constant for a distance of about 1,400 feet, before being absorbed into stream channel gravel. The spring originates in a gravelly substrate, flowing across a gravelly streambed in a grassy meadow. The remainder of the stream course is mostly bedrock. In 2011, the entire length of the spring was dry. In 2014, the spring was flowing, but flow was minimal.

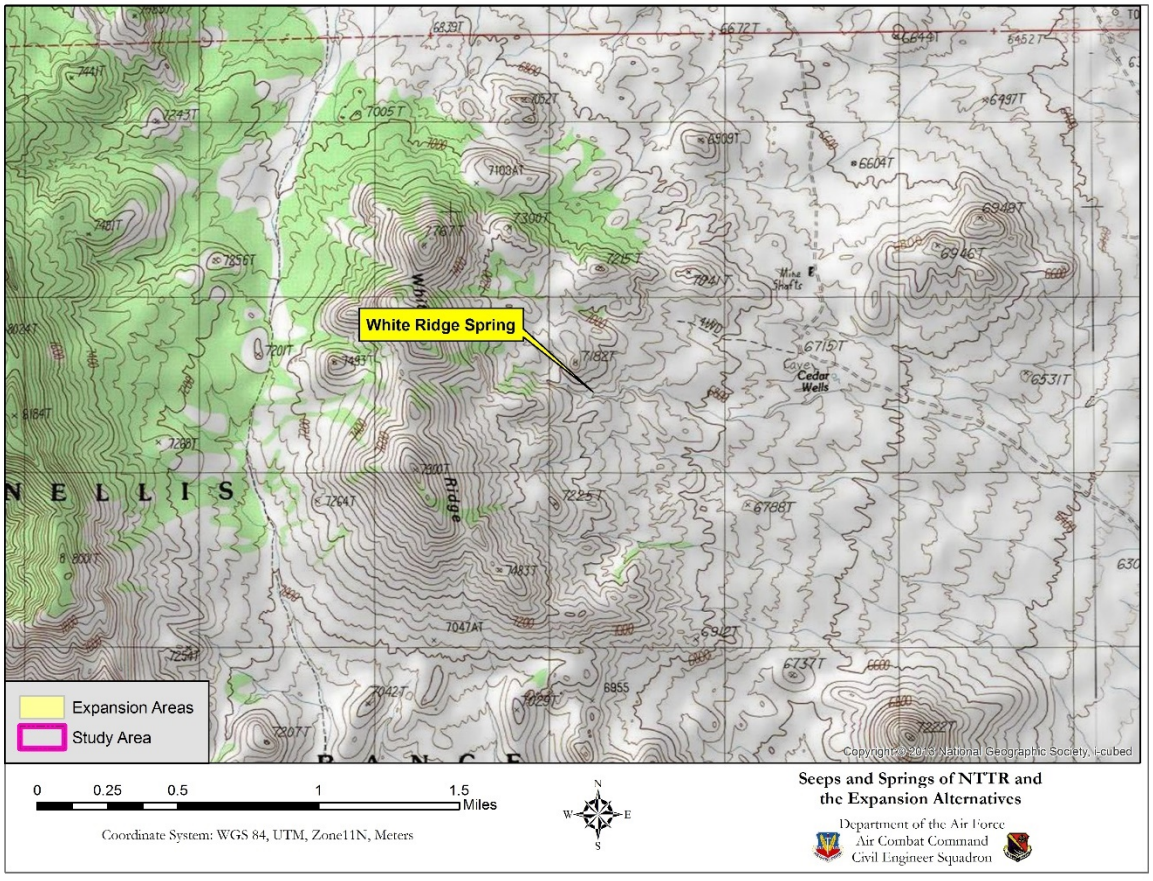


Figure 88. Topographic map showing the location of White Ridge Spring.

Table 46. Results of field and laboratory analyses of water sampled at White Ridge Spring.

NAME	MCL (mg/L)*	2014**
Chloride (mg/L)	400	2.57
Fluoride (mg/L)	4	0.11
Nitrate/Nitrite (mg/L)	11	ND
Sulfate (mg/L)	500	2.63
Aluminum (mg/L)	0.2	0.1
Arsenic (mg/L)	0.01	ND
Calcium (mg/L)	-	10.6
Chromium (mg/L)	0.1	ND
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	0.05
Lead (mg/L)	0.015	ND
Magnesium (mg/L)	150	2.4
Manganese (mg/L)	0.1	ND
Sodium (mg/L)	-	13.1
Zinc (mg/L)	5	ND
Hardness (mg/L)	-	36
pH	6.5-8.5	8.12
Turbidity (NTU)	-	0.97
Dissolved Oxygen (%)	-	53.3
Conductivity (mS/cm)	-	0.107
Salinity (ppt)	-	0.07
Temperature of water (°C)	-	11.1

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016D)
ND: Non-Detect

In 2015, water samples were not collected for this site. White Ridge Spring was analyzed in the field by NNRP biologists in 2014 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016D). Water samples were collected and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents were found to be below the MCL and pose no threat to wildlife.

Wild Rose Spring

Location: 555182 E 4190584 N
Elevation: 7,278 ft. MSL
Dominant Plants: Wood's rose (*Rosa woodsii*); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Wild Rose Spring on September 4, 2011

Wild Rose Spring is located on the east side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Similar to Upper George's Spring, Wild Rose Spring is in the upper reaches of the watershed flowing into George's Water. In 2007, the spring contained water flowing in about 100 feet of channel on the south side of the spring source. The site is dominated by a dense population of Wood's rose, making site access difficult. The water appears to be clear and of good quality. The area is potential pygmy rabbit habitat. During the 2011 survey, the spring area was green, but no flowing water was observed, indicating that the spring is likely intermittent.

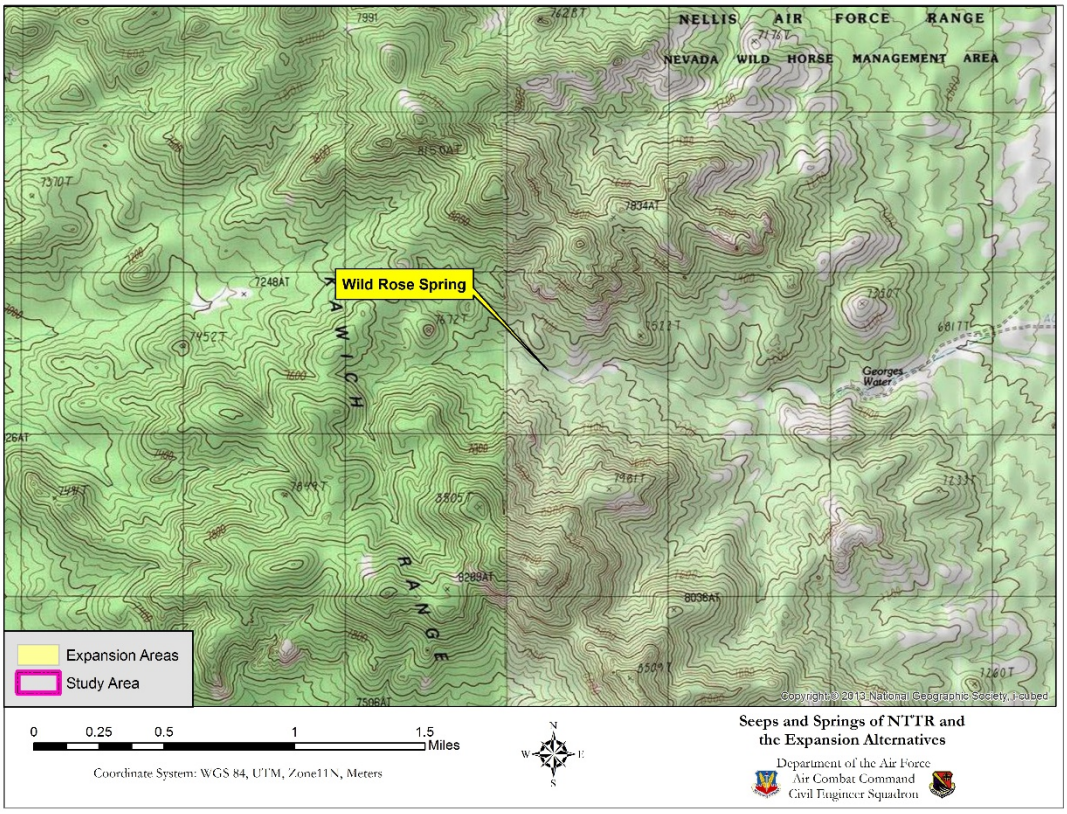


Figure 89. Topographic map showing the location of Wild Rose Spring.

Wildcat Spring (Developed)

Location: 577502 E 4146613 N
Elevation: 5,990 ft. MSL
Dominant Plants: Big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*); rubber rabbitbrush (*Ericameria nauseosa*)



Wildcat Spring and associated troughs

Wildcat Spring is located west of the Belted Mountain Range in Sagebrush Key Habitat. During the 2009 survey, the spring appeared to be dry. Stock tanks and troughs were all dry. Vegetation was mostly dominated by big sage and scattered pinyon pine and Utah juniper. The mesic vegetation that normally grows in the area of the spring was mostly desiccated and/or dead. In 2011, the spring appeared to be in the same dry state as it was in 2009. It was obvious that the spring produced water in the past because of the presence of tanks, troughs, and a corral and other fencing materials. It appears that the spring is now dry or intermittent at best. The site was surveyed in 2014 and found to be dry with no surface water or saturated soils.

Wildcat Spring water rights were originally held by the Clay Springs Cattle Company, who transferred the water rights to the USAF on May 11, 1955. A permit was applied for in April 1916, the permit was issued in September 1916, and certification was given in February 1923. The spring feature was originally developed for stock watering. The water was collected through a four foot by five foot tunnel, then conveyed 536 feet through iron pipe to galvanized troughs for watering 100 head of cattle. The allowed use totaled 2.46 annual acre feet of water (0.003 cfs).

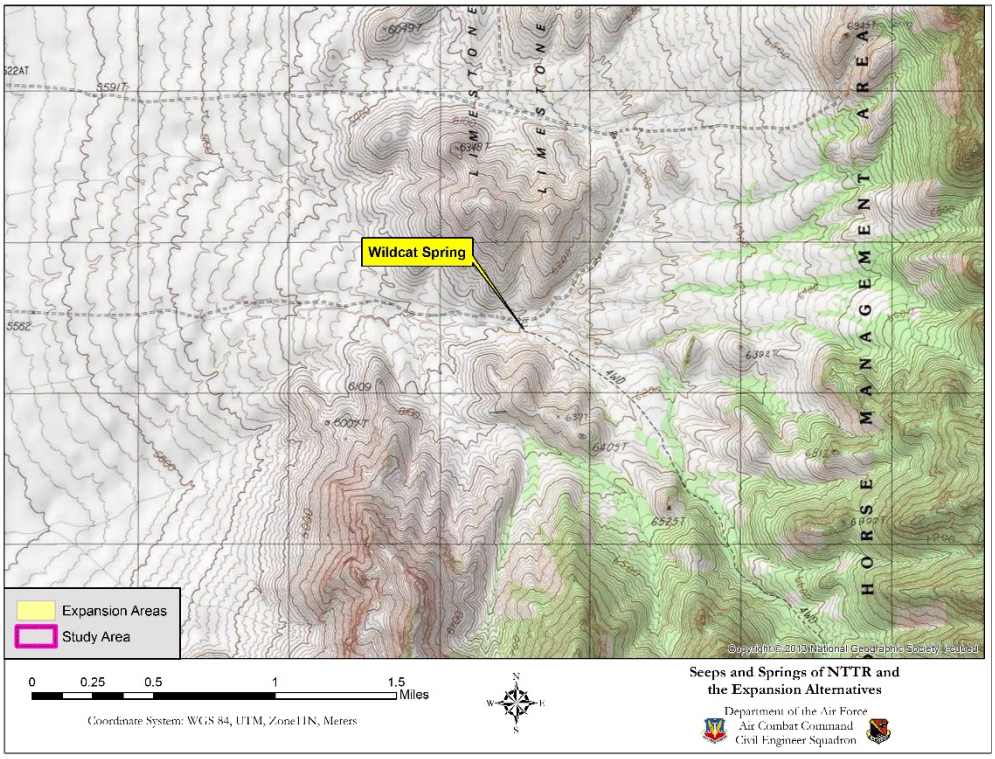


Figure 90. Topographic map showing the location of Wildcat Spring.

Chicken Pete's

Location: 494210 E 4173015 N
Elevation: 5,601 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*); rubber rabbitbrush (*Ericameria nauseosa*); common reed (*Phragmites australis*)



Chicken Pete's showing the healthy stand of willow.

Chicken Pete's is located just north of Stonewall Flats east of the Goldfield Hills in Intermountain Cold Desert Scrub Key Habitat. Chicken Pete's was first observed during a small mammal survey in July 2007 and revisited in May 2009. The spring was dry during both surveys but supported a healthy stand of common reed and Geyer willow. The vegetation community suggested the site contained saturated soils for a sufficient amount of time to allow wetland vegetation to establish and is likely a perennial seep. The seep was surveyed in 2014 and 2015 and found to be in the same condition as previous years with no sign of saturated soils or standing water.

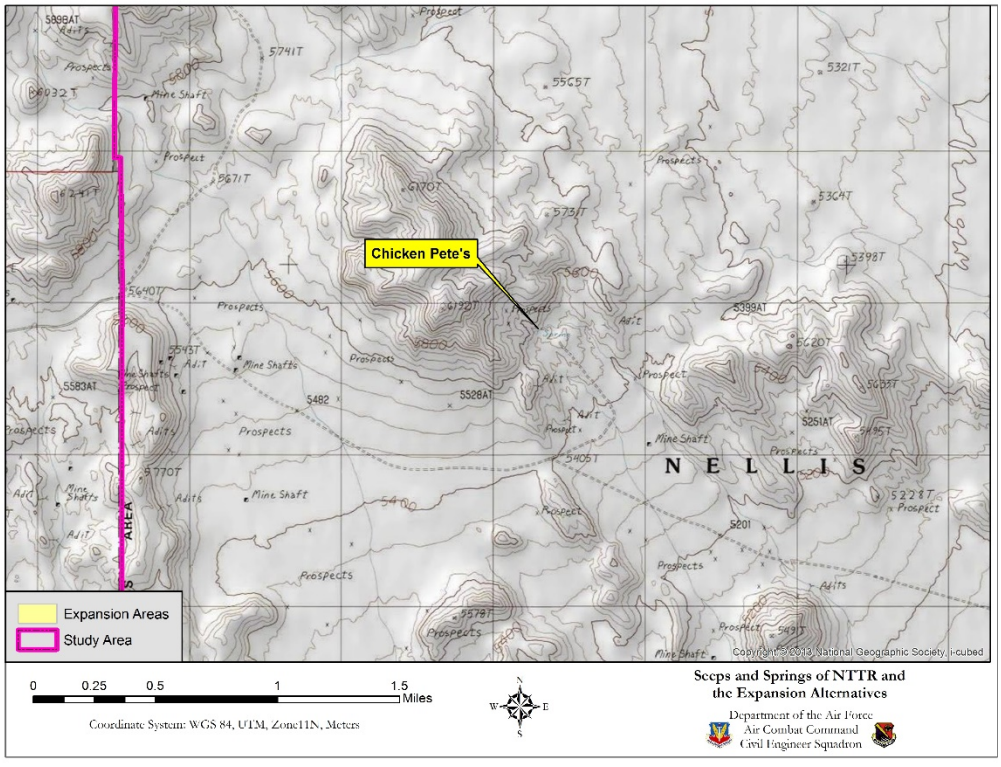


Figure 91. Topographic map showing the location of Chicken Pete's.

Kawich Seep 1

Location: 559588 E 4180523 N
Elevation: 7,965 ft. MSL
Dominant Plants: Curl-leaf mountain mahogany (*Cercocarpus ledifolius*); mountain big sagebrush (*Artemisia vaseyana*); snowberry (*Symphoricarpos spp.*); antelope bitterbrush (*Purshia tridentata*); Sandberg bluegrass (*Poa secunda*); Utah juniper (*Juniperus osteosperma*); singleleaf pinyon pine (*Pinus monophylla*)



Kawich Seep 1 viewed from a helicopter in 2009

Kawich Seep 1 is a large seep located in the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Like most of the seeps in the Kawich Range, the plant community is dominated by sedges, spike rush, and some beardless wildrye. The surrounding vegetation is a pinyon-juniper plant community, typical of the area. During the September 2009 survey, much of the vegetation in the seep showed drought stress.

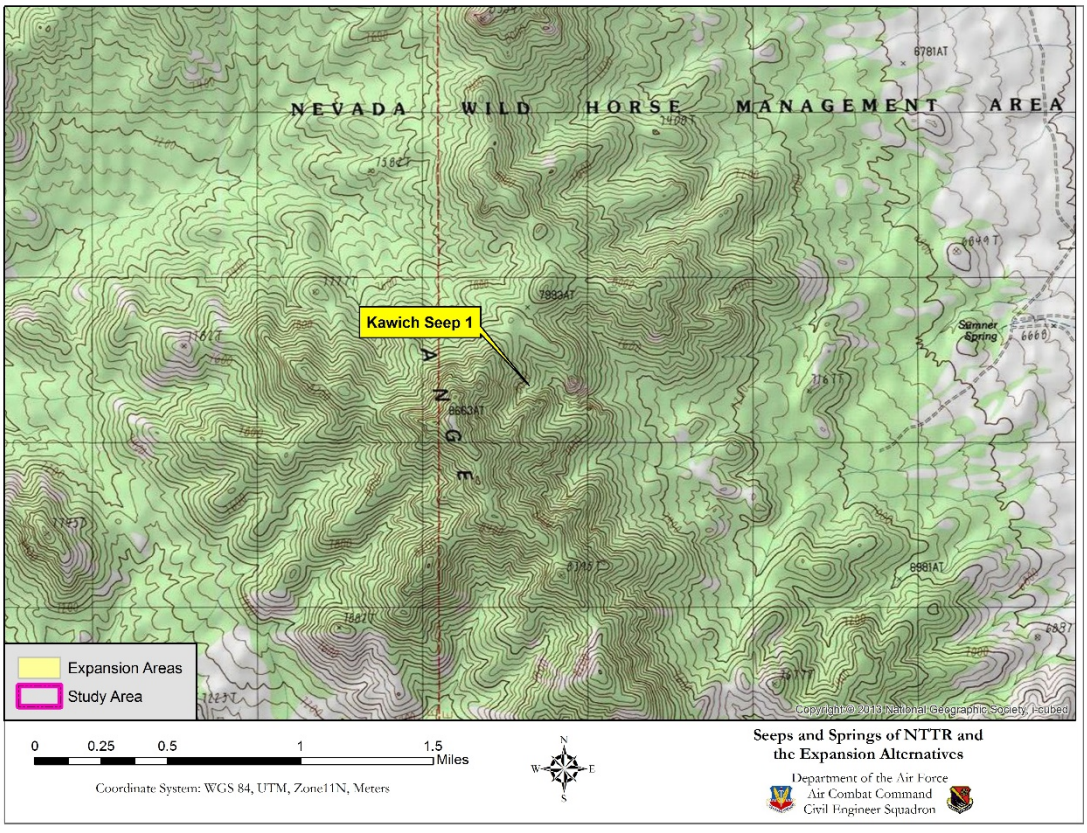


Figure 92. Topographic map showing the location of Kawich Seep 1.

Kawich Seep 2

Location: 559817 E 4180442 N
Elevation: 7,805 ft. MSL
Dominant Plants: Narrowleaf willow (*Salix exigua*); beardless wildrye (*Leymus triticoides*); spikerush (*Eleocharis* sp.); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Kawich Seep 2 in 2011

Kawich Seep 2 is a small seep in the Kawich Mountain Range 800 feet southeast of Kawich Seep 1 in Lower Montane Woodlands Key Habitat. The seep was surveyed in September 2009 and appeared to be in good condition. No open water was observed. In 2011, the site appeared to support the original seep as well as two additional seeps. The up-gradient seep was dominated by narrowleaf willow while the other seeps contained mostly herbaceous species.

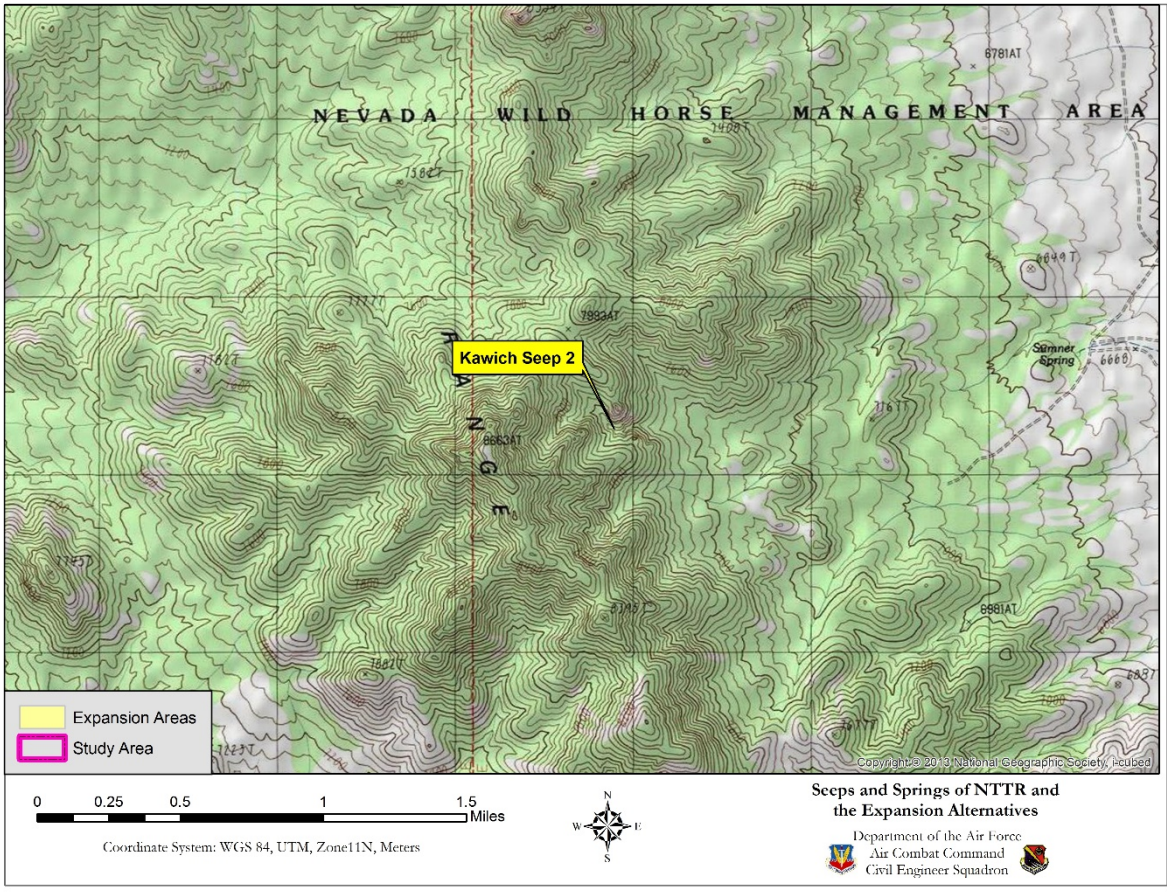


Figure 93. Topographic map showing the location of Kawich Seep 2.

Kawich Seep 16

Location: 557933 E 4188102 N
Elevation: 7,073 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); spikerush (*Eleocharis* sp.); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Kawich Seep 16 area of saturated soil and beardless wildrye and spike rush

Kawich Seep 16 is located on the east slope of the Kawich Mountain Range in Lower Montane Woodland Key Habitat. In 2007, the seep seemed to be an area of saturated soil supporting a dense stand of beardless wildrye and spike rush. The seep is not directly accessible by helicopter and ground surveys were not possible in 2007. In 2011, the seep appeared to be relatively dry with some young, green vegetation beginning to grow. The surrounding valley supports a dense pinyon-juniper plant community.

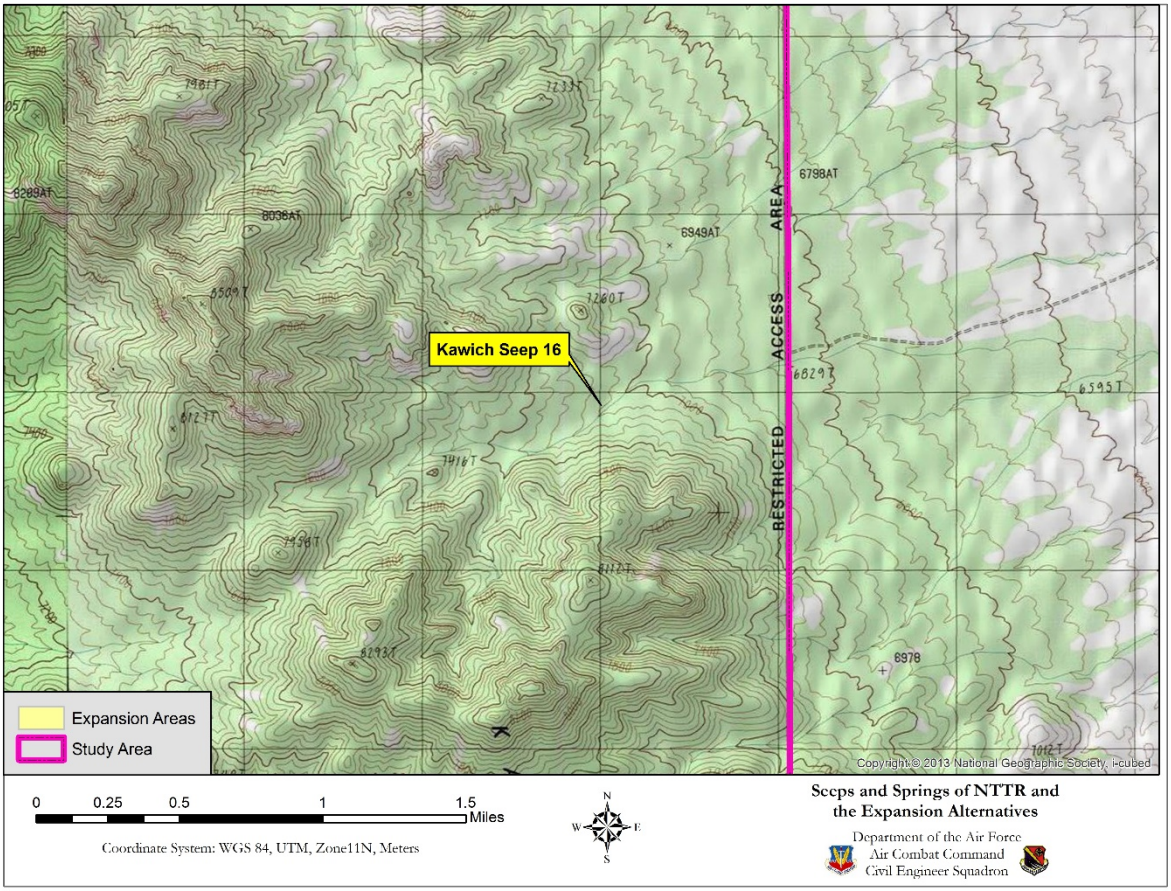


Figure 94. Topographic map showing the location of Kawich Seep 16.

Roller Coaster Seep #2 (Fenced)

Location: 522392 E 4169259 N
Elevation: 6,187 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); rubber rabbitbrush (*Ericameria nauseosa*); big sagebrush (*Artemisia tridentata*); blackbrush (*Coleogyne ramosissima*)

Roller Coaster Seep #2 is located in the Dacite Hills of the Cactus Mountain Range in Sagebrush Key Habitat. This seep has been protected from over-grazing by a fence. Vegetation in the seep area is mostly spikerush, with the surrounding area being dominated by big sagebrush, blackbrush, and rubber rabbitbrush. The seep was surveyed in 2014 and found to be dry with no saturated soils or standing water.



Roller Coaster Seep #2 in 2011

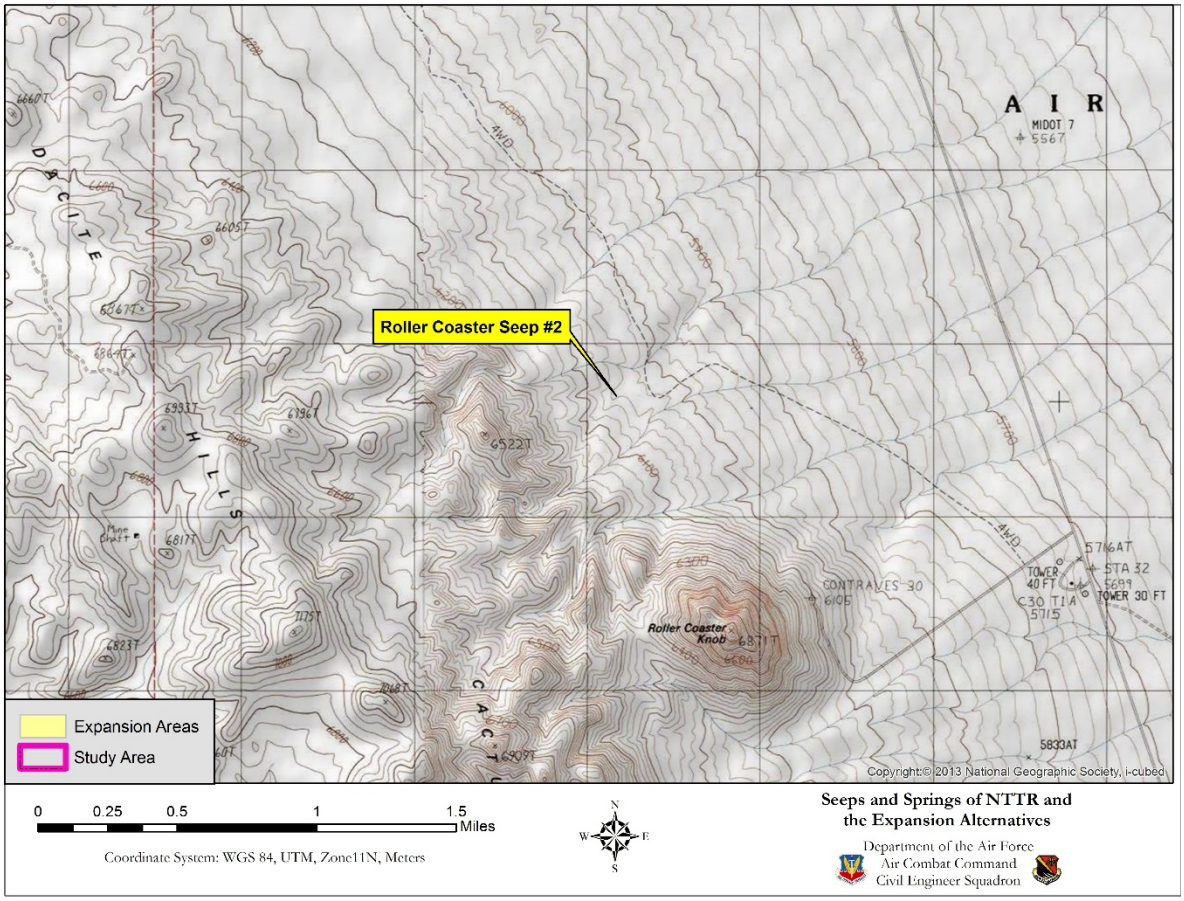


Figure 95. Topographic map showing the location of Roller Coaster Seep #2.

Roller Coaster Seep #3 (Fenced)

Location: 521481 E 4169851 N
Elevation: 6,289 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); rubber rabbitbrush (*Ericameria nauseosa*)

Roller Coaster Seep #3 is located in the Dacite Hills of the Cactus Mountain Range in Sagebrush Key Habitat. Vegetation around the fenced seep is mostly rubber rabbitbrush, with spikerush found in the seep. The seep was surveyed in 2014 and contained some standing water and supported healthy vegetation. In 2015, the seep was found to be dry with no saturated soils or standing water.



Roller Coaster Seep #3 in 2011

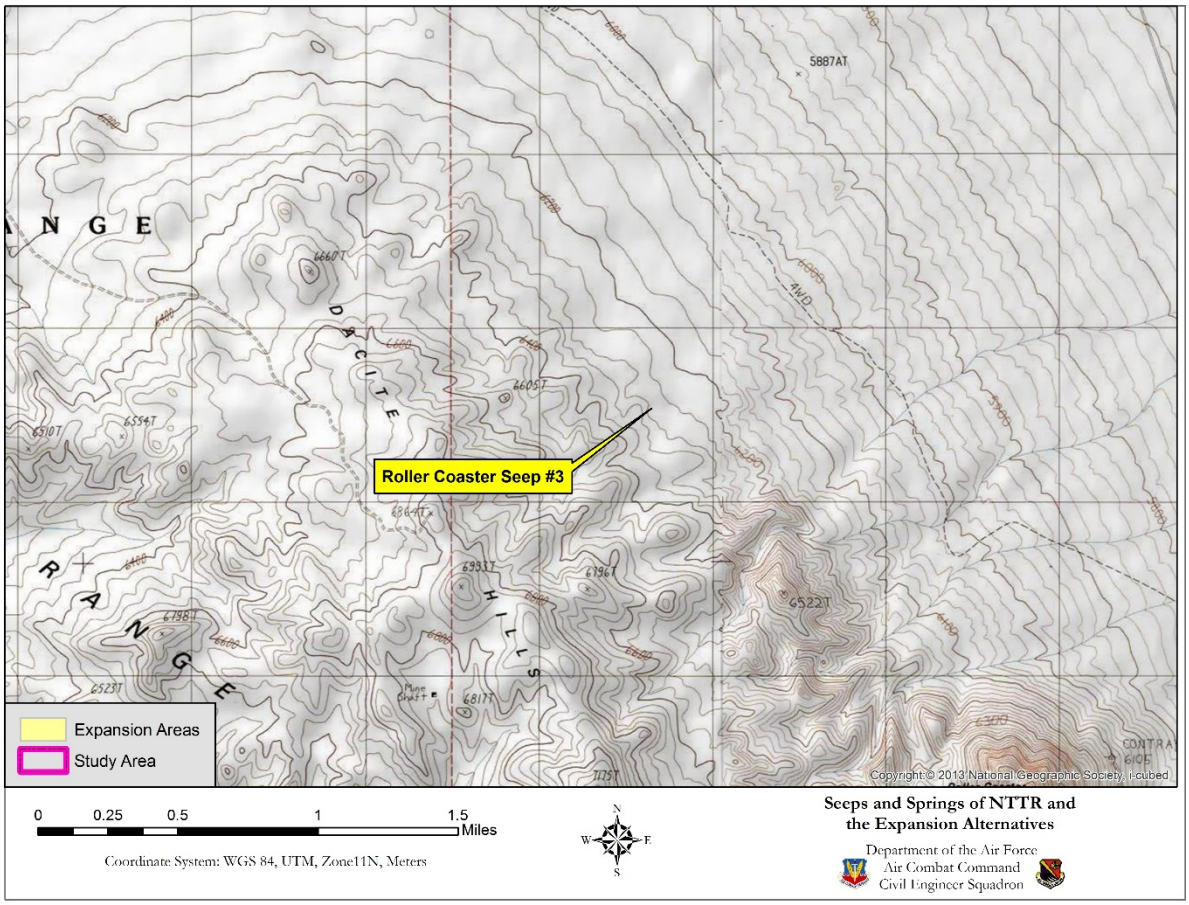


Figure 96. Topographic map showing the location of Roller Coaster Seep #3.

Table 47. Results of field and laboratory analyses of water sampled at Roller Coaster Seep #3. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014	2015
Chloride (mg/L)	400	24	Did
Fluoride (mg/L)	4	0.36	Not
Nitrate/Nitrite (mg/L)	11	ND	Take
Sulfate (mg/L)	500	457	Sample
Aluminum (mg/L)	0.2	ND	
Arsenic (mg/L)	0.01	ND	
Calcium (mg/L)	-	222	
Chromium (mg/L)	0.1	ND	
Copper (mg/L)	1	ND	
Iron (mg/L)	0.6	0.1	
Lead (mg/L)	0.015	ND	
Magnesium (mg/L)	150	27.3	
Manganese (mg/L)	0.1	0.08	
Sodium (mg/L)	-	31	
Zinc (mg/L)	5	ND	
Hardness (mg/L)	-	667	
pH	6.5-8.5	6.87	
Turbidity (NTU)	-	0.38	
Dissolved Oxygen (%)	-	14.2	
Conductivity (mS/cm)	-	1128	
Salinity (ppt)	-	0.7	
Temperature of water (°C)	-	15.2	

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016B)
ND: Non-Detect

In 2015, water samples were not collected for this site. Roller Coaster Seep #3 was analyzed in the field by NNRP biologists in 2014 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016B). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents were found to be below the MCL and pose no threat to wildlife.

Roller Coaster Seep #4 (Fenced)

Location: 521386 E 4169866 N
Elevation: 6,289 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); rubber rabbitbrush (*Ericameria nauseosa*)

Roller Coaster Seep #4 is located in the Dacite Hills of the Cactus Mountain Range in Sagebrush Key Habitat. Vegetation around the fenced seep is mostly rubber rabbitbrush, with spikerush found in the seep.



Roller Coaster Seep #4 in 2011

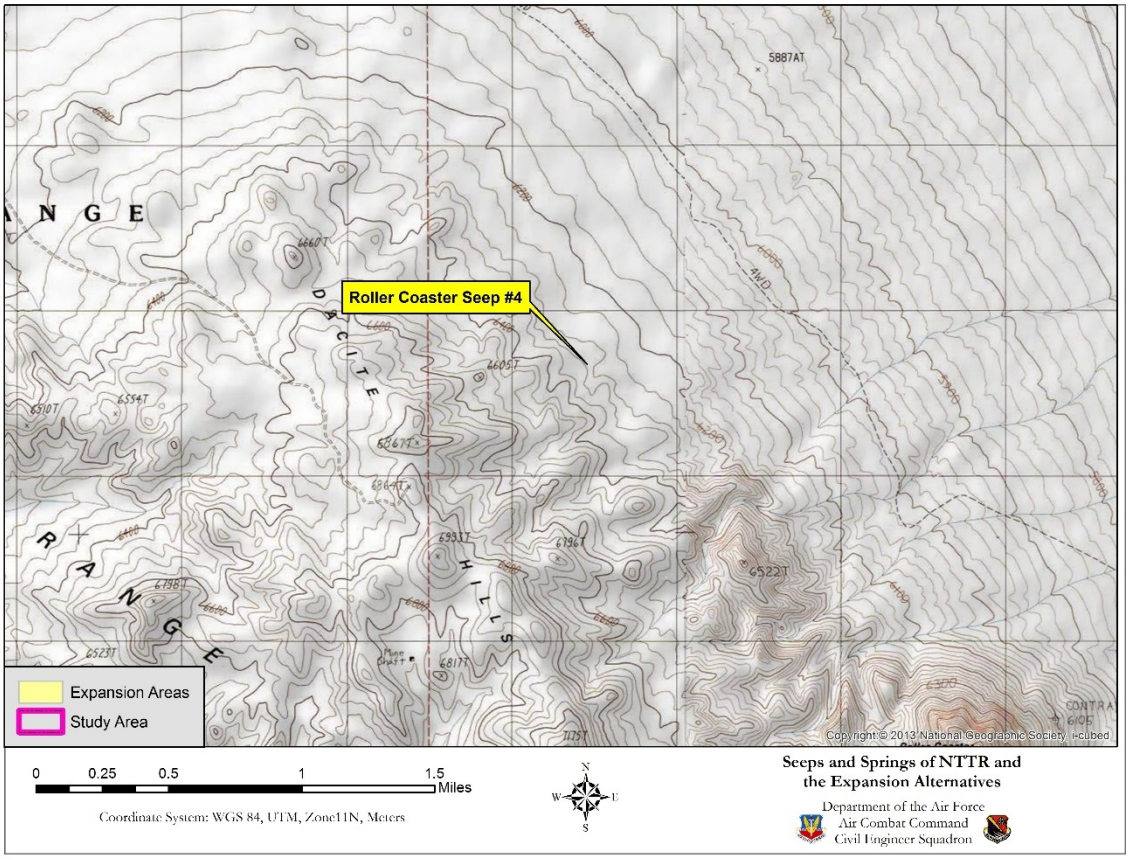


Figure 97. Topographic map showing the location of Roller Coaster Seep #4.

Blackhawk Spring

Location: 552639 E 4192247 N
Elevation: 7,348 ft. MSL
Dominant Plants: Softstem bulrush (*Schoenoplectus tabernaemontani*); spikerush (*Eleocharis* sp.); big sagebrush (*Artemisia tridentata*), singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Blackhawk Spring, September 4, 2011

Blackhawk Spring is a seep located in the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Blackhawk Spring is actually a seep, due to the lack of a visual source of water. Based on the 1996 wetland report (Dames and Moore, 1996), this remote site, inaccessible by vehicle, had two small pools. The pools supported herbaceous vegetation including rabbitsfoot grass, spikerush, dandelion, and wild rose, which usually require hydric soils and are indicative of a wetland. Historically, the site contained a berm and a corral. The surrounding vegetation is dominated by sagebrush and pinyon-juniper woodland. The seep was considered a relatively pristine site with little disturbance. Its value as wildlife habitat was considered quite high due to the availability of water, absence of human activity, and nearby vegetative cover. No sign of horse use was observed during the 1996 survey.

The seep was surveyed in April 2007, and had water flowing down the cliff side. Vegetation appeared to be dominated by bulrush and sedges. The seep was again located during the 2011 survey; however, no surface water was present, and the only evidence of a seep was green vegetation dominated by sedges with some beardless

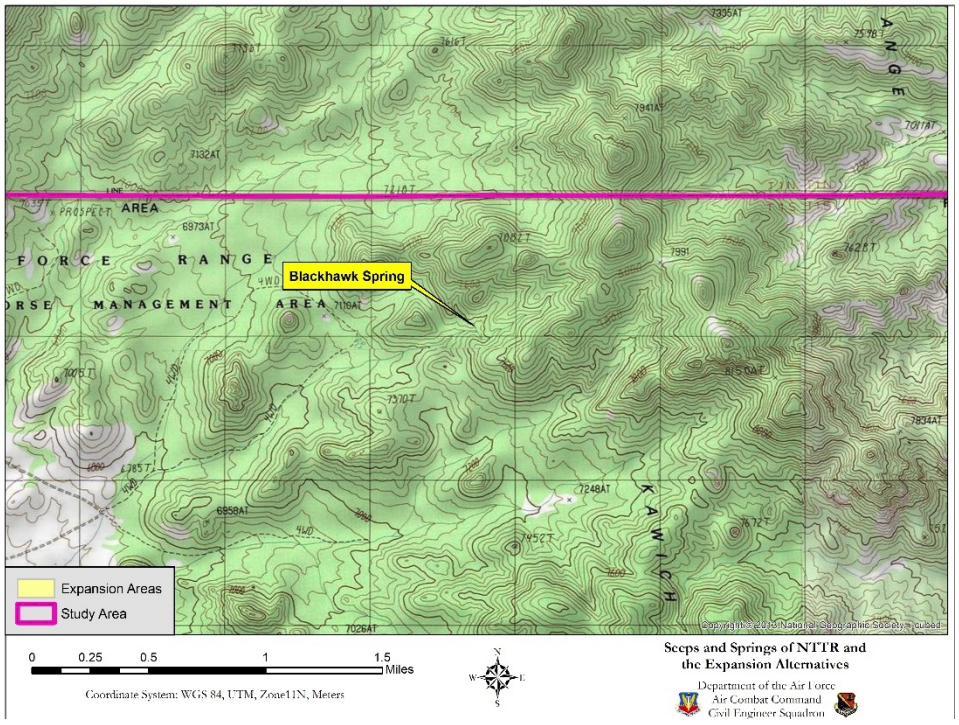


Figure 98. Topographic map showing the location of Blackhawk Spring.

wildrye. The seep is located at the base of a rocky outcrop in a big sagebrush/pinyon-juniper plant community. Sufficient water was present in 2014 to allow for water samples to be taken. The spring was not sampled in 2015.

Table 48. Results of field and laboratory analyses of water sampled at Blackhawk Spring. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2014**
Chloride (mg/L)	400	145
Fluoride (mg/L)	4	0.21
Nitrate/Nitrite (mg/L)	11	ND
Sulfate (mg/L)	500	332
Aluminum (mg/L)	0.2	ND
Arsenic (mg/L)	0.01	ND
Calcium (mg/L)	-	37.9
Chromium (mg/L)	0.1	ND
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	0.76
Lead (mg/L)	0.015	ND
Magnesium (mg/L)	150	4.4
Manganese (mg/L)	0.1	0.2
Sodium (mg/L)	-	29.5
Zinc (mg/L)	5	ND
Hardness (mg/L)	-	113
pH	6.5-8.5	6.9
Turbidity (NTU)	-	2.4
Dissolved Oxygen (%)	-	44.8
Conductivity (mS/cm)	-	0.262
Salinity (ppt)	-	0.18
Temperature of water (°C)	-	9.29

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV*** (Nellis Natural Resources Program, 2016A)
ND: Non-Detect

In 2015, water samples were not collected for this site. Blackhawk Spring was analyzed in the field by NNRP biologists in 2014 for pH, temperature, conductivity, salinity, and dissolved oxygen (Nellis Natural Resources Program, 2016A). Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table shows the results from both on-site and Silver State Laboratories analyses. All constituents, except iron and manganese, were found to be below the MCL and pose no threat to wildlife. High iron levels are mostly associated with taste and teeth staining issues. With long term exposure, high concentrations of manganese can result in nervous disorders (EPA, 2003). At the concentrations found at this site, these constituents probably do not pose a problem for wildlife, but they should be monitored annually to ensure that they are not increasing over time.

Cactus West Seep

Location: 507263 E 4178106 N
Elevation: 6,383 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*)



Cactus West Seep in 2011

Cactus West Seep is located in western Cactus Mountain Range in Intermountain Cold Desert Scrub Key Habitat. Cactus West Seep was surveyed in May 2009 and September 2011. The seep supports a relatively healthy stand of beardless wildrye. No saturated soils or standing water were observed during either survey. Wild horses were observed in the area, and several wildlife trails were noted leading to the seep, indicating it may provide water for the local horses. Based on this evidence, it was concluded the feature is likely an intermittent seep, providing surface water only in early spring.

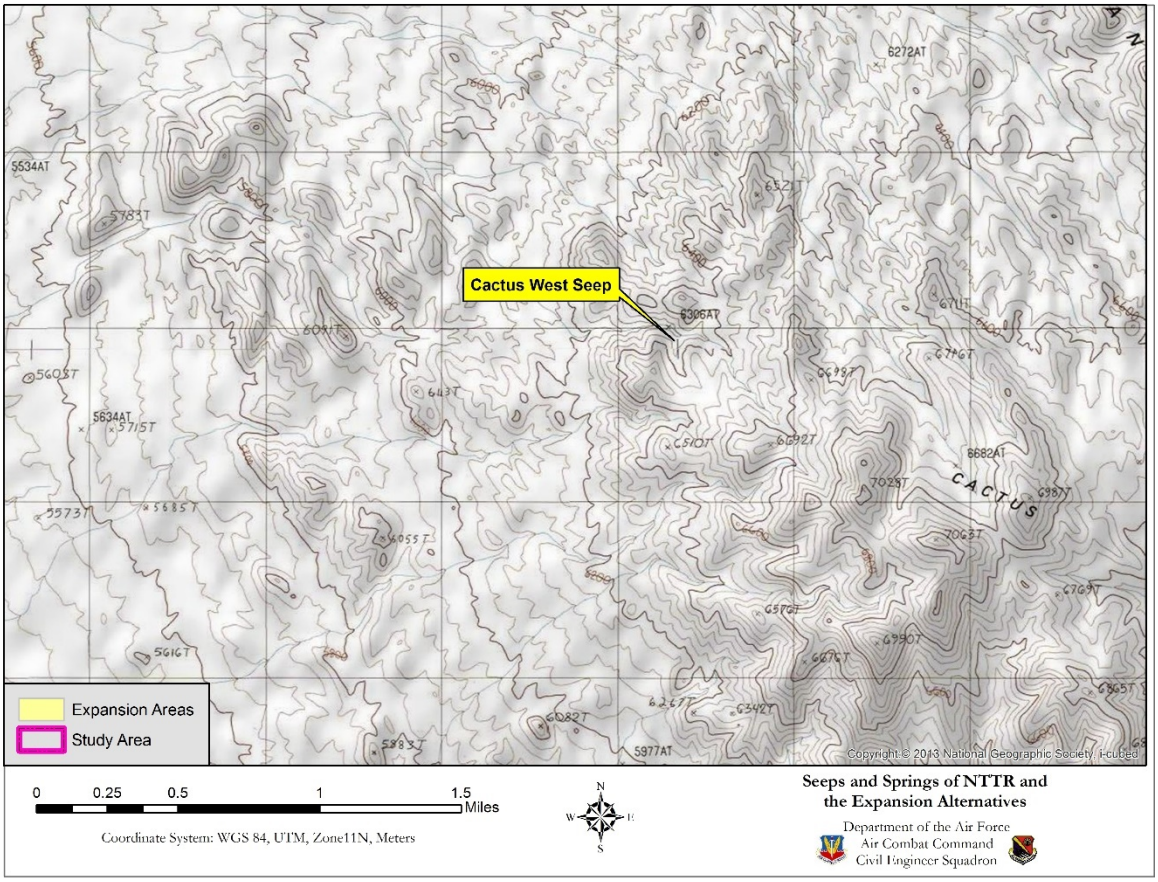


Figure 99. Topographic map showing the location of Cactus West Seep.

Cottonwood Seep

Location: 493090 E 4149535 N
Elevation: 6,451 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides);* singleleaf pinyon pine (*Pinus monophylla*); Mormon tea (*Ephedra viridis*); Fremont cottonwood (*Populus fremontii)*



Cottonwood Seep in 2011

Cottonwood Seep is located on the west side of Stonewall Mountain in Lower Montane Woodlands Key Habitat. Cottonwood Seep was not confirmed until 2011, when it was found to be relatively dry. Most of the cottonwood trees surrounding the seep appeared dead or dying, with some re-growth observed. The water source appears to be an intermittent seep with declining flow, as evidenced by the dying cottonwood trees and encroachment of pinyon pine.

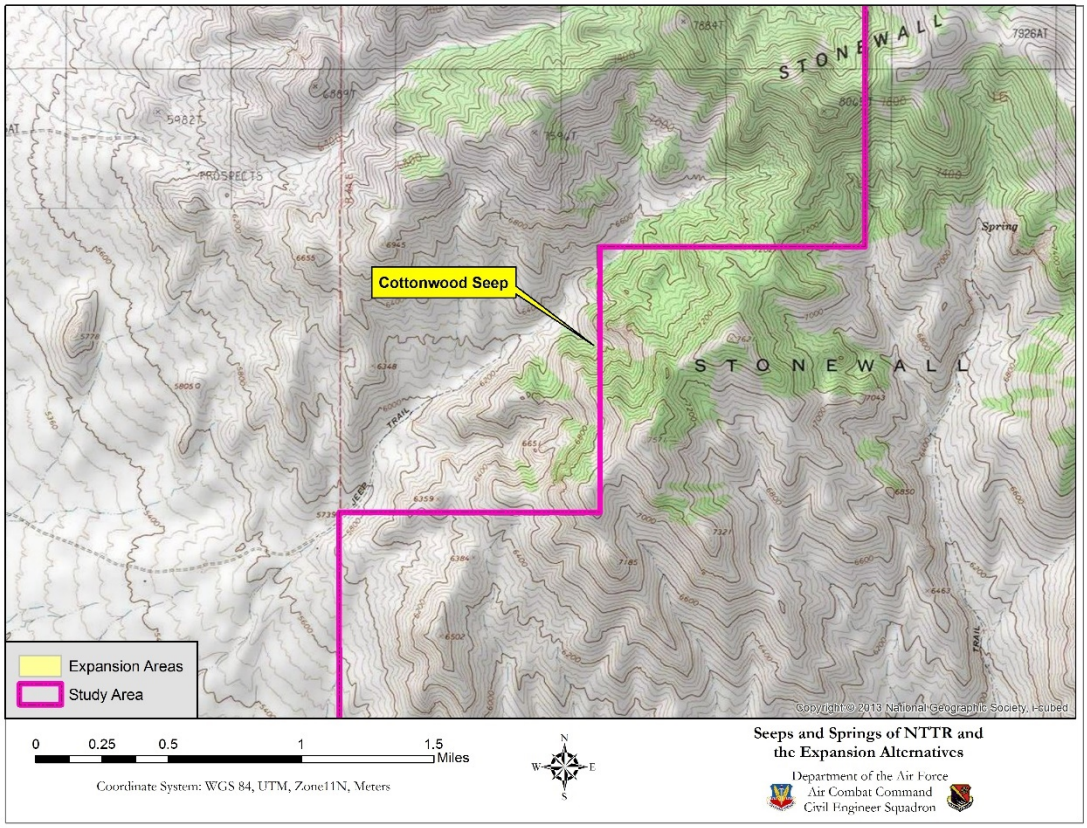


Figure 100. Topographic map showing the location of Cottonwood Seep.

Kawich Seep 4

Location: 558021 E 4183303 N
Elevation: 7,896 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); sedge (*Carex* sp.); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Saturated soils as evidenced by the presence of hydrophytes at Kawich Seep 4, September 3, 2011

Kawich Seep 4 is located on the west slope of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Flowing water was not observed at this seep during surveys. The surrounding plant community was mostly pinyon pine with some scattered Utah juniper and big sagebrush. The dominant vegetation in the area of the seep appeared to be beardless wildrye. During the September 3, 2011, survey, the seep soils were saturated and appeared to support a dense population of sedge. The site was classified as a healthy intermittent seep.

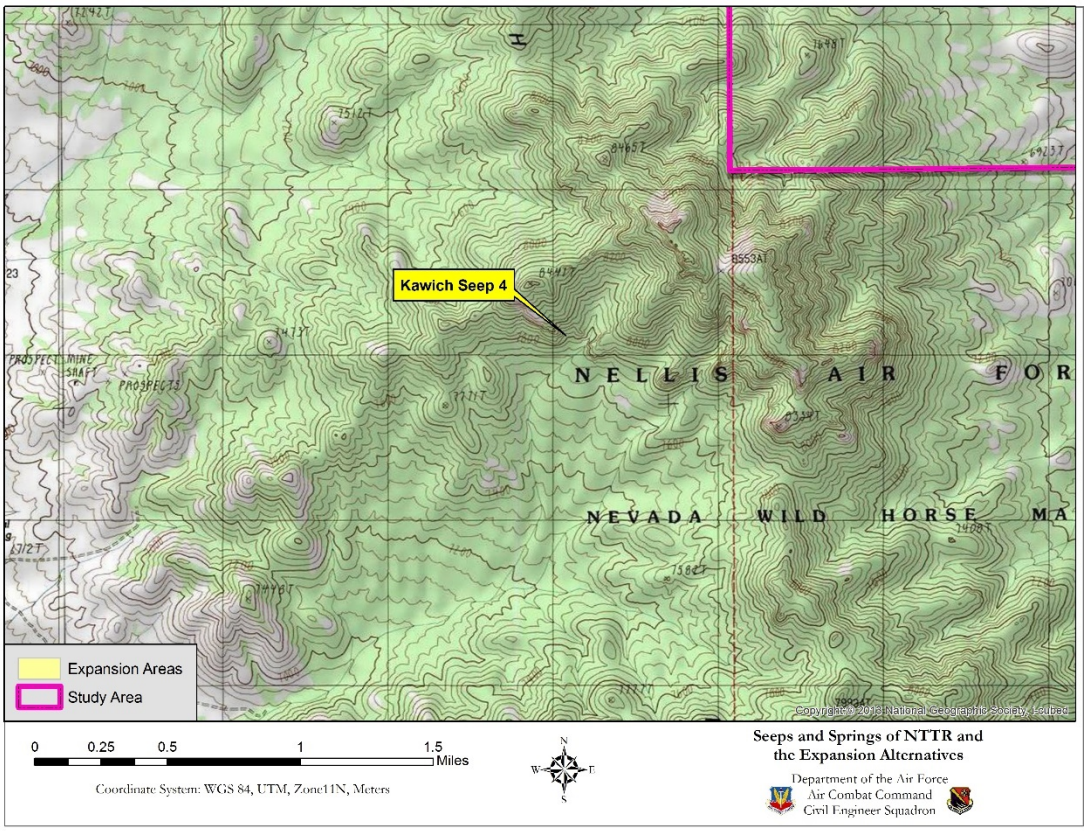


Figure 101. Topographic map showing the location of Kawich Seep 4.

Kawich Seep 5

Location: 557978 E 4184080 N
Elevation: 7,782 ft. MSL
Dominant Plants: Sedges (*Carex* sp.); rushes (*Juncus* sp.); beardless wildrye (*Leymus triticoides*); spikerush (*Eleocharis* sp.); narrowleaf willow (*Salix exigua*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Kawich Seep 5, September 3, 2011

Kawich Seep 5 is located on the eastern slope of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Kawich Seep 5 is comprised of two seeps located in a drain. Both seeps appear to be dominated by beardless wildrye, spikerush, and other sedges. The down-gradient seep supports a healthy population of willow, likely narrowleaf willow. The surrounding area supports a typical pinyon-juniper community with pinyon pine being much more dominant than Utah juniper. A large area of dead pine trees was observed adjacent to the seep, possibly indicating a recent change in hydrology. In 2011, the seep was still evident, but much drier. Vegetation appeared to be mostly sedges and rushes.

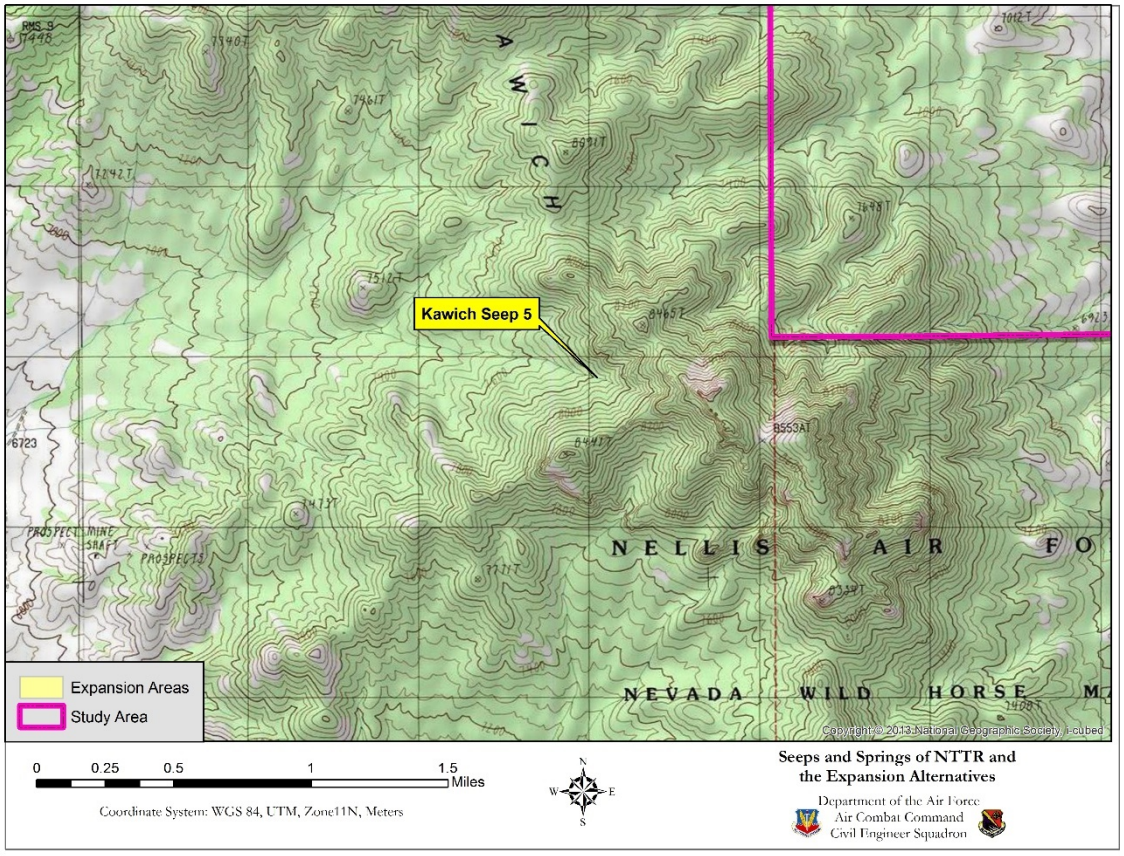


Figure 102. Topographic map showing the location of Kawich Seep 5.

Kawich Seep 6

Location: 558582 E 4184229 N
Elevation: 8,313 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); sedge (*Carex* sp.); singleleaf pinyon pine *(Pinus monophylla)*; Gambel oak *(Quercus gambelii)*; Utah juniper (*Juniperus osteosperma);* big sagebrush *(Artemisia tridentata)*

Kawich Seep 6 is small seep located on the eastern slope of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Flowing water has not been observed at this seep. The dominant vegetation appeared to be beardless wildrye and sedges. The surrounding plant community was pinyon pine with scattered Utah juniper, Gambel oak, and big sagebrush.



Kawich Seep 6, September 4, 2011

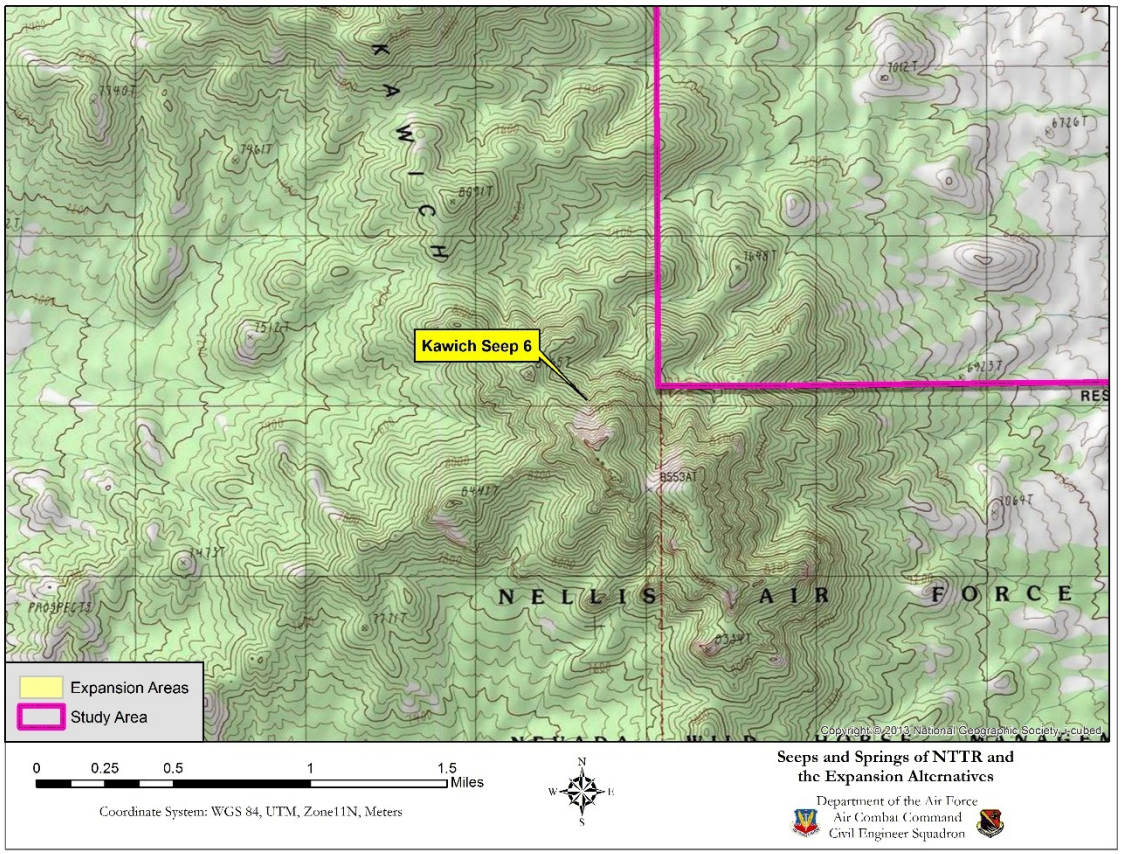


Figure 103. Topographic map showing the location of Kawich Seep 6.

Kawich Seep 8

Location: 559059 E 4184159 N
Elevation: 7,981 ft. MSL
Dominant Plants: Curlleaf mountain mahogany (*Cercocarpus ledifolius*); mountain big sagebrush (*Artemisia vaseyana*); snowberry (*Symphoricarpos spp.*); antelope bitterbrush (*Purshia tridentata*); Mormon tea (*Ephedra viridis*); Sandberg bluegrass (*Poa secunda*)



One of the seeps at Kawich Seep 8.

Kawich Seep 8 is located on the east slope of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Kawich Seep 8 is comprised of three different seeps located in close proximity to each other. Each seep supports dense populations of sedges, beardless wildrye, and spike sedge. One seep supports a healthy population of an unidentified species of willow. The surrounding plant community is pinyon-juniper with some big sage and ephedra.

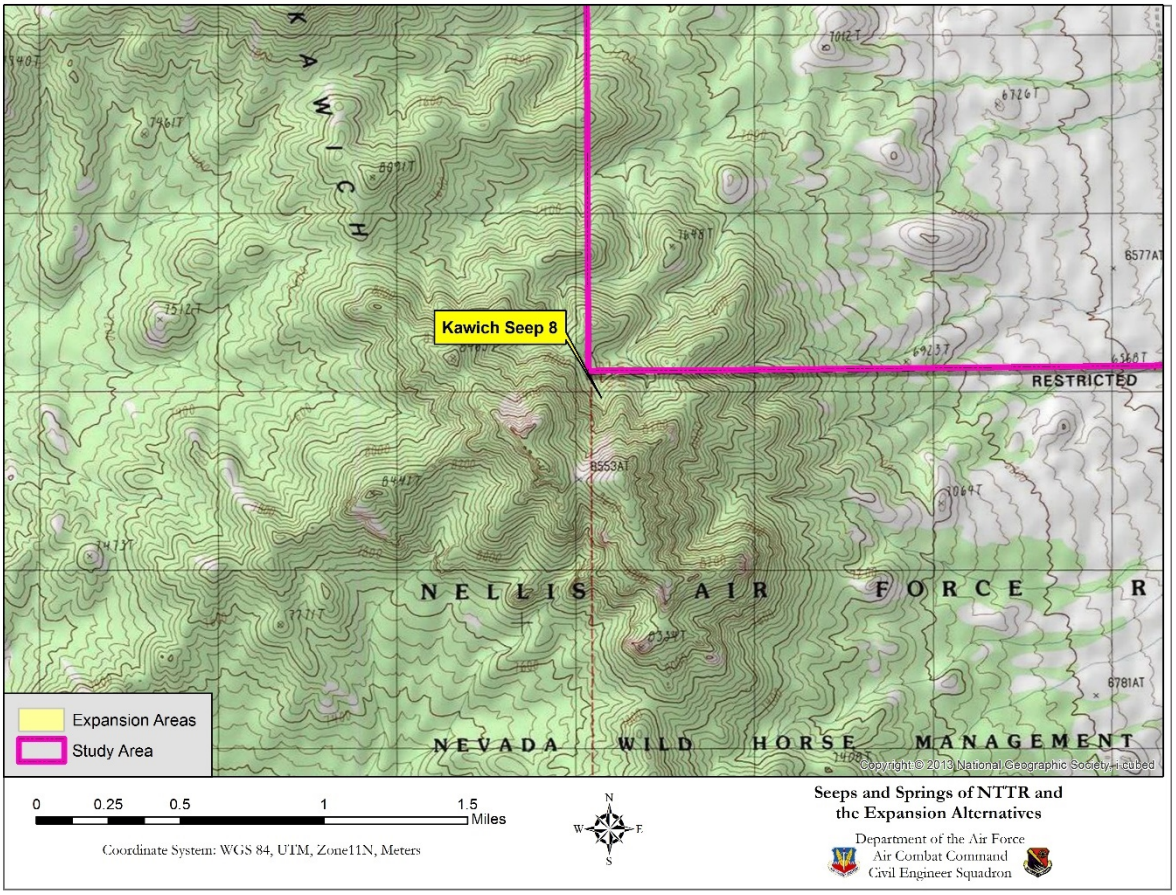


Figure 104. Topographic map showing the location of Kawich Seep 8.

Kawich Seep 9

Location: 554273 E 4193056 N
Elevation: 7,552 ft. MSL
Dominant Plants: Narrowleaf willow (*Salix exigua*); spikerush (*Eleocharis sp*.); Mexican rush (*Juncus mexicanus*); beardless wildrye (*Leymus triticoides*)



Kawich Seep 9 in 2009

Kawich Seep 9 is located in the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. The seep lies in a shallow canyon on the mountain slope. It supports a population of narrowleaf willow, spikerush, Mexican rush, and beardless wildrye. The upland community adjacent to the seep is pinyon-juniper, with some of the pinyon pines dying in vicinity of the spring. This may indicate the spring is relatively new with a modification in the area's hydrology causing tree mortality.

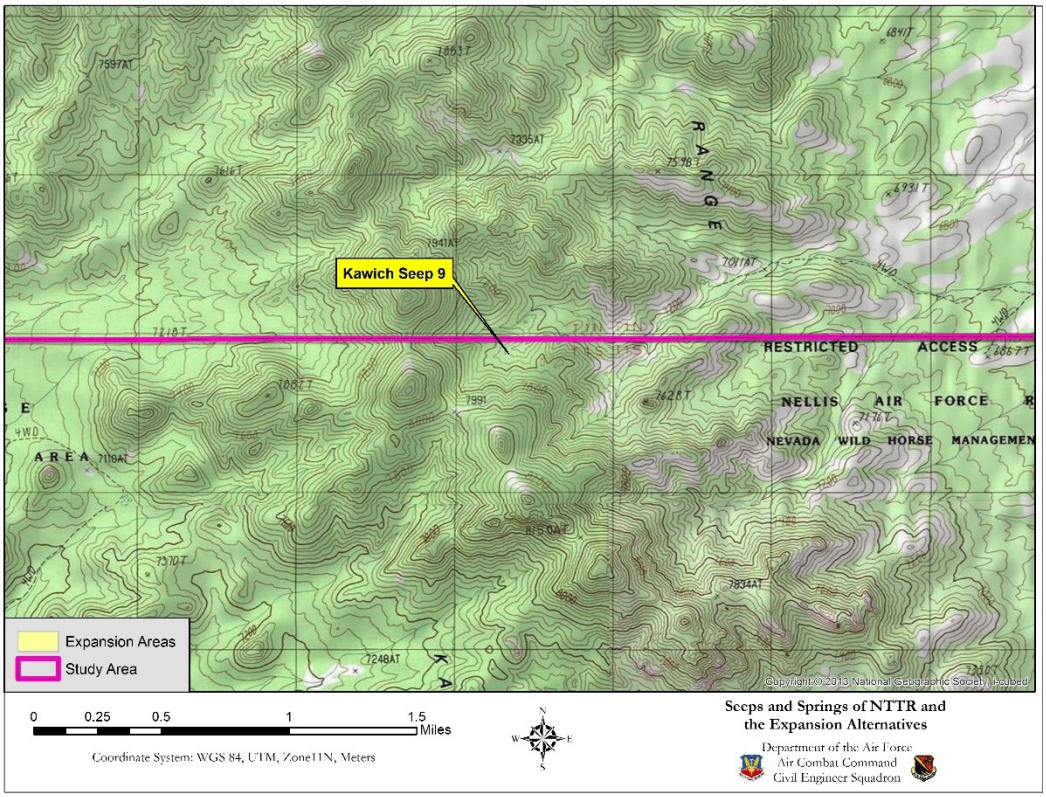


Figure 105. Topographic map showing the location of Kawich Seep 9.

Kawich Seep 10

Location: 562113 E 4178967 N
Elevation: 6,962 ft. MSL
Dominant Plants: Singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*); beardless wildrye (*Leymus triticoides*); big sagebrush (*Artemisia tridentata*)

Kawich Seep 10 is located on the east side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Kawich Seep 10 is likely an intermittent seep, with a small area of open water observed in 2007. An area of saturated soils seems to support a small population of rushes. In 2011, water was not observed, but vegetation appeared green and healthy.



Kawich Seep 10 in 2011

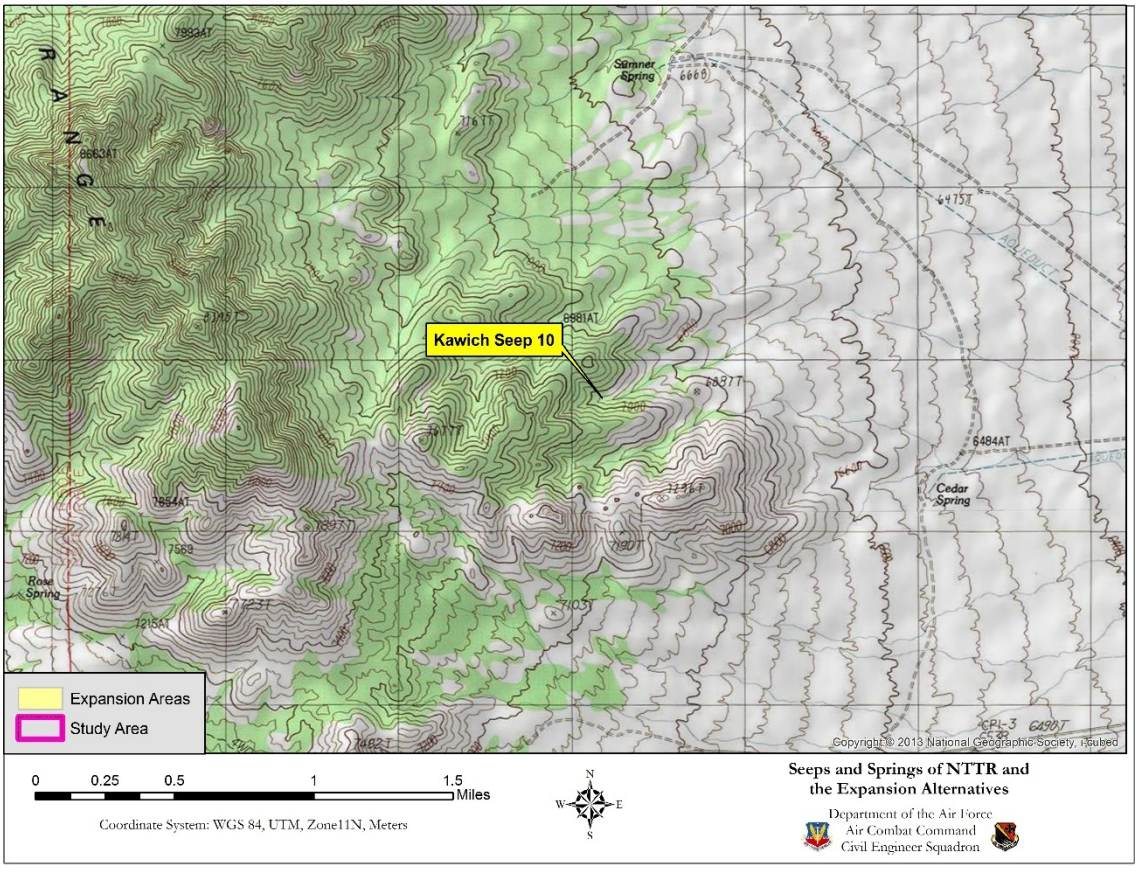


Figure 106. Topographic map showing the location of Kawich Seep 10.

Kawich Seep 11

Location: 559148 E 4178847 N
Elevation: 7,660 ft. MSL
Dominant Plants: Sedges (*Carex sp.*); narrowleaf willow (*Salix exigua*); Geyer willow (*Salix geyeriana*)



Kawich Seep 11 on September 3, 2011

Kawich Seep 11 is a small seep located in eastern Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Kawich Seep 11 supports a small population of willows and sedges, indicating that it is a persistent source of water. The seep is surrounded by dead trees, perhaps due to a change in site hydrology. This could indicate the seep is either expanding or relatively new. The seep was surveyed in 2007 and 2011, and appeared to be in the same condition during both surveys. Soils were moist, but no standing water was observed. The seep appears to be intermittent.

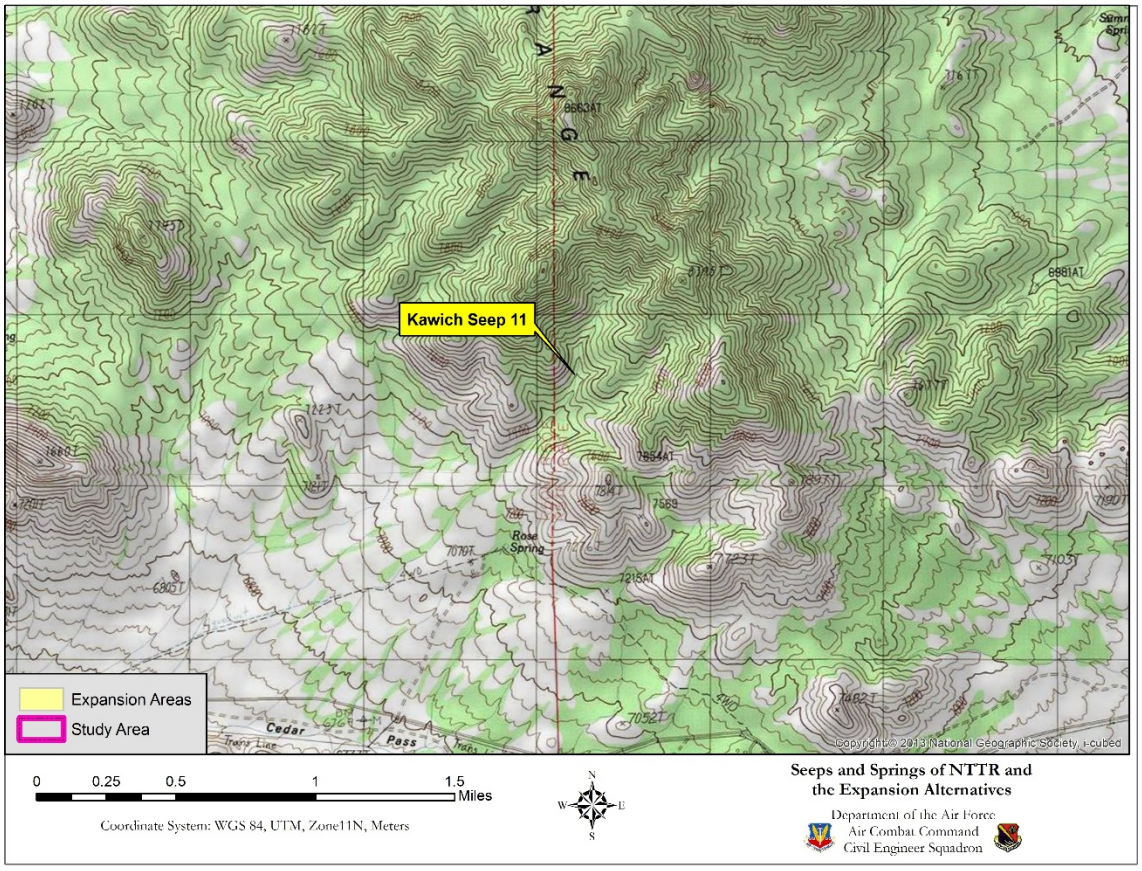


Figure 107. Topographic map showing the location of Kawich Seep 11.

Kawich Seep 12

Location: 560157 E 4181428 N
Elevation: 7,598 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); spikerush (*Eleocharis* sp.); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)

This seep is located on the east side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Kawich Seep 12 appeared dry during the 2007 survey but was dominated by a relatively dense stand of beardless wildrye and spikerush, which indicates moist soil conditions. The seep was revisited in 2011, and the vegetation appeared healthy; the herbaceous plants were green and healthy.



Kawich Seep 12 on September 3, 2011

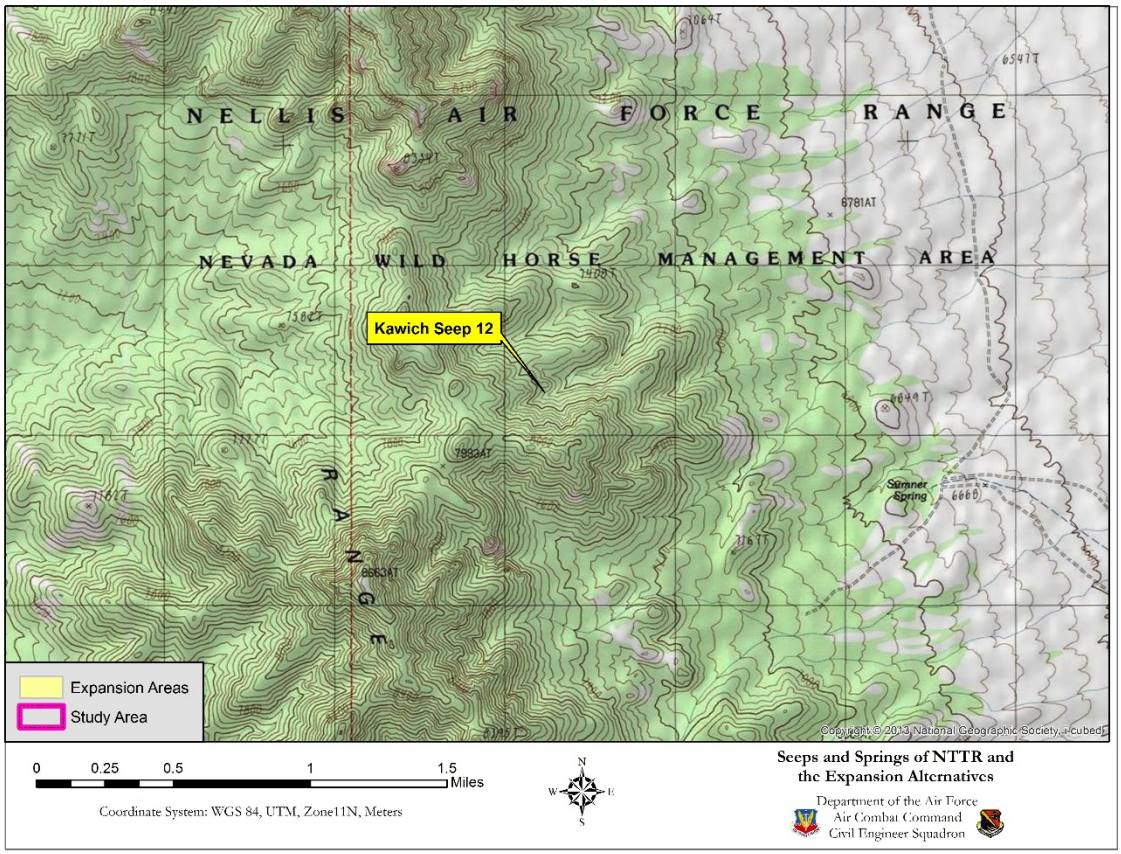


Figure 108. Topographic map showing the location of Kawich Seep 12.

Kawich Seep 13

Location: 559207 E 4182757 N
Elevation: 7,903 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); spikerush (*Eleocharis quadrangulata*); softstem bulrush (*Scirpus taberaeontani*); singleleaf pinyon pine *(pinus monophylla)*; Utah juniper (*Juniperus osteosperma)*



Kawich Seep 13, September 3, 2011

Kawich Seep 13 is located on the east side of the Kawich Mountain Range in Cliffs and Canyons Key Habitat. This seep was first photographed on September 7, 2009. The spring is located on the side of a mountain in a shallow drain. Dominant plants in the spring appeared to be beardless wildrye, spikerush, and softstem bulrush. The seep was revisited in 2011; water was not present. Despite the apparent drier conditions, the area that supported mesic vegetation was larger than in 2009. Due to this finding, it is likely Kawich Seep 13 is a healthy, intermittent seep, possibly most active in the spring.

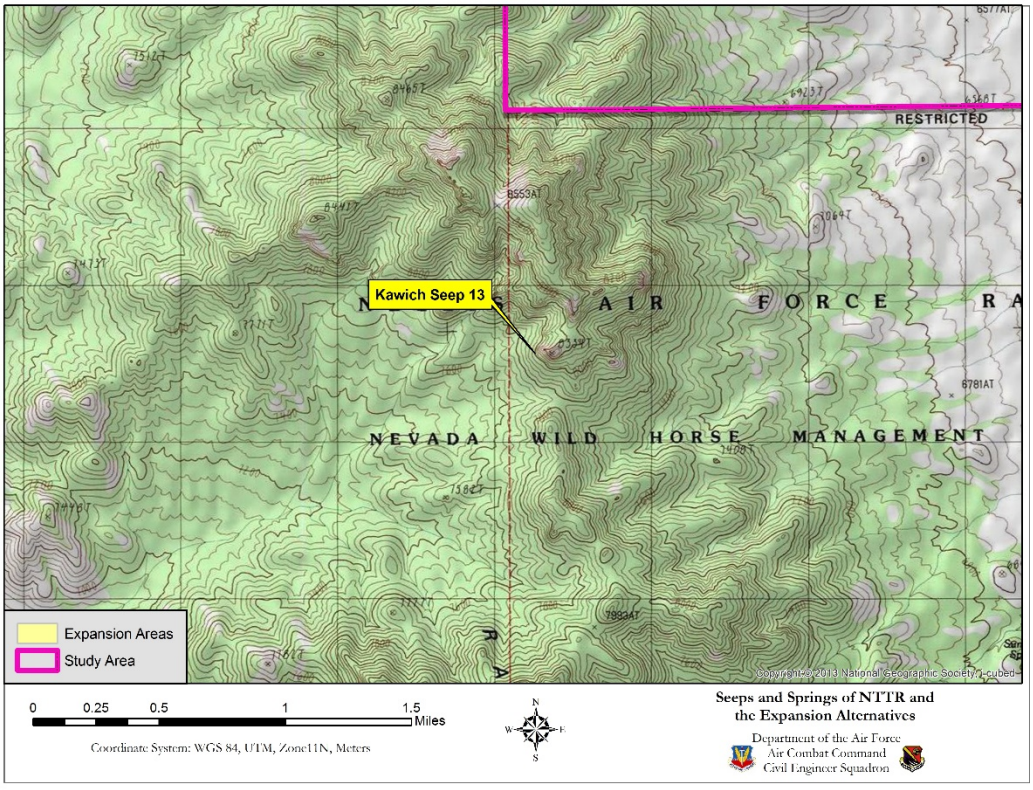


Figure 109. Topographic map showing the location of Kawich Seep 13.

Kawich Seep 14 and Kawich Seep 15

Location: Kawich Seep 14: 559610 E
4183613 N
Kawich Seep 15: 559839 E
4183667 N

Elevation: A: 8,028 ft. MSL B: 7,657 ft. MSL

Dominant Plants: Beardless wildrye (*Leymus triticoides*); spikerush (*Eleocharis quadrangulata*); singleleaf pinyon pine *(Pinus monophylla)*; Utah juniper (*Juniperus osteosperma);* big sagebrush *(Artemisia tridentata)*



Kawich Seep 15, located upgradient of Kawich Seep 14, in 2011

Kawich Seep 14 and 15 are located approximately 800 feet east and west of one another. They are located on the east side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Kawich Seep 14 was first photographed in 2009. In 2011, a second seep was found approximately 800 feet up-gradient (west) of the seep and named Kawich Seep 15. Both seeps are easily observed on infrared satellite imagery. Vegetation is similar, and they are found in the same drainage channel.

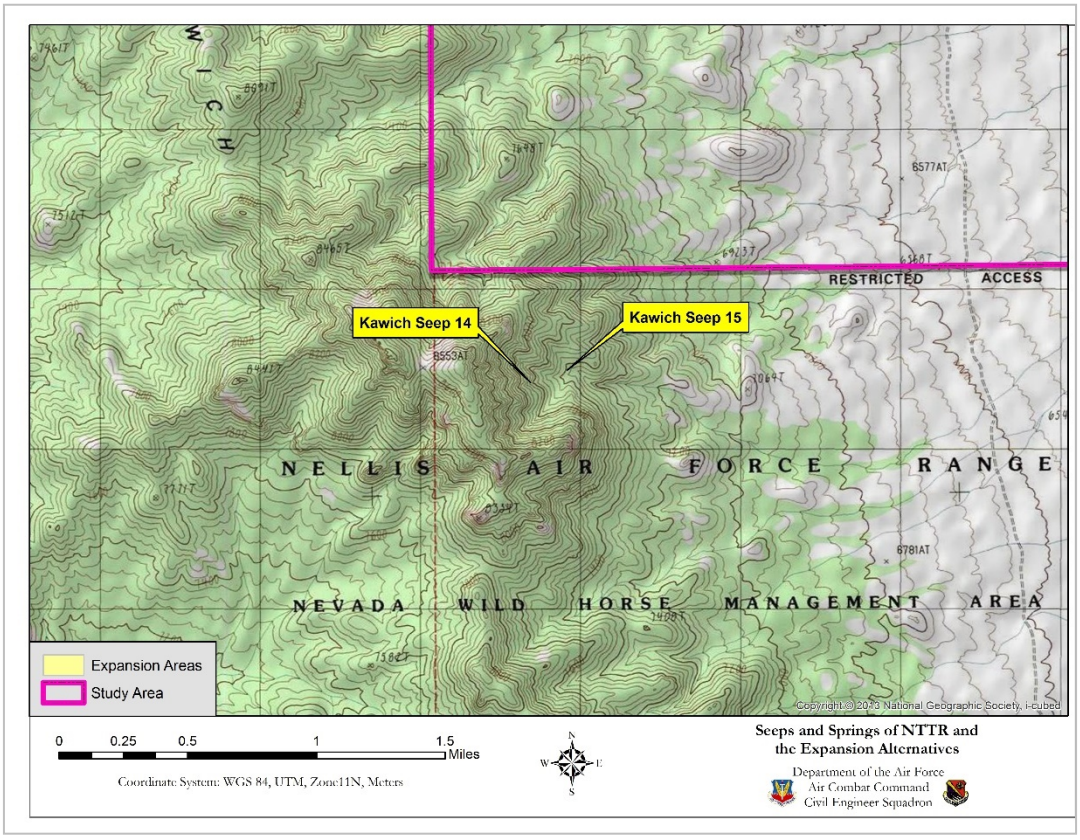


Figure 110. Topographic map showing the location of Kawich Seep 14 and 15.

Kawich Seep 17

Location: 553646 E 4191058 N
Elevation: 7,338 ft. MSL
Dominant Plants: Narrowleaf willow (*Salix exigua*); softstem bulrush (*Schoenoplectus tabernaemontani*); spikerush (*Eleocharis* sp.); sedges (*Carex* sp.); big sagebrush (*Artemisia tridentata*); rubber rabbitbrush (*Ericameria nauseosus*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Kawich Seep 17 on September 4, 2011

Kawich Seep 17 is located on the west side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Surface water was first observed during 2007 with no apparent point source, indicating the water source is likely a seep. No accumulation of surface water was observed, but the composition of the vegetation community indicates the area is wet for extended periods of time. The seep was dominated by a large, dense grove of narrowleaf willows with an adjacent plant community dominated by grasses, bulrush, spikerush, and sedges. On dry uplands surrounding the seep, vegetation community is pinyon-juniper. In 2011, no water was visible, but the willows were green and appeared to have expanded in size. Herbaceous vegetation was not as dominant as it appeared in 2007.

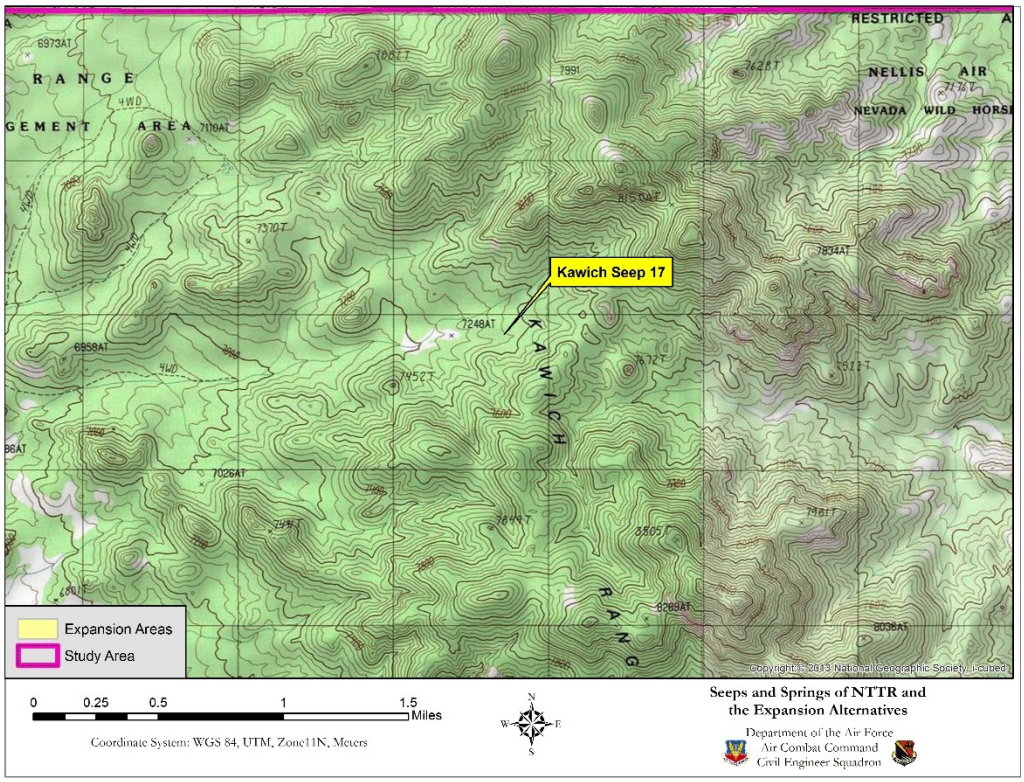


Figure 111. Topographic map showing the location of Kawich Seep 17.

Kawich Seep 18

Location: 553506 E 4190729 N
Elevation: 7,443 ft. MSL
Dominant Plants: Narrowleaf willow (*Salix exigua*); softstem bulrush (*Schoenoplectus tabernaemontani*); spike rush (*Eleocharis* sp.); sedges (*Carex* sp.). Surrounding vegetation dominated by big sagebrush (*Artemisia tridentata*), Pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*)

Kawich Seep 18 is located on the west side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Standing water was observed in 2007. In 2011, the spring was much drier, with no water observed. It is likely Kawich Seep 18 is an intermittent seep.



Kawich Seep 18 on September 4, 2011

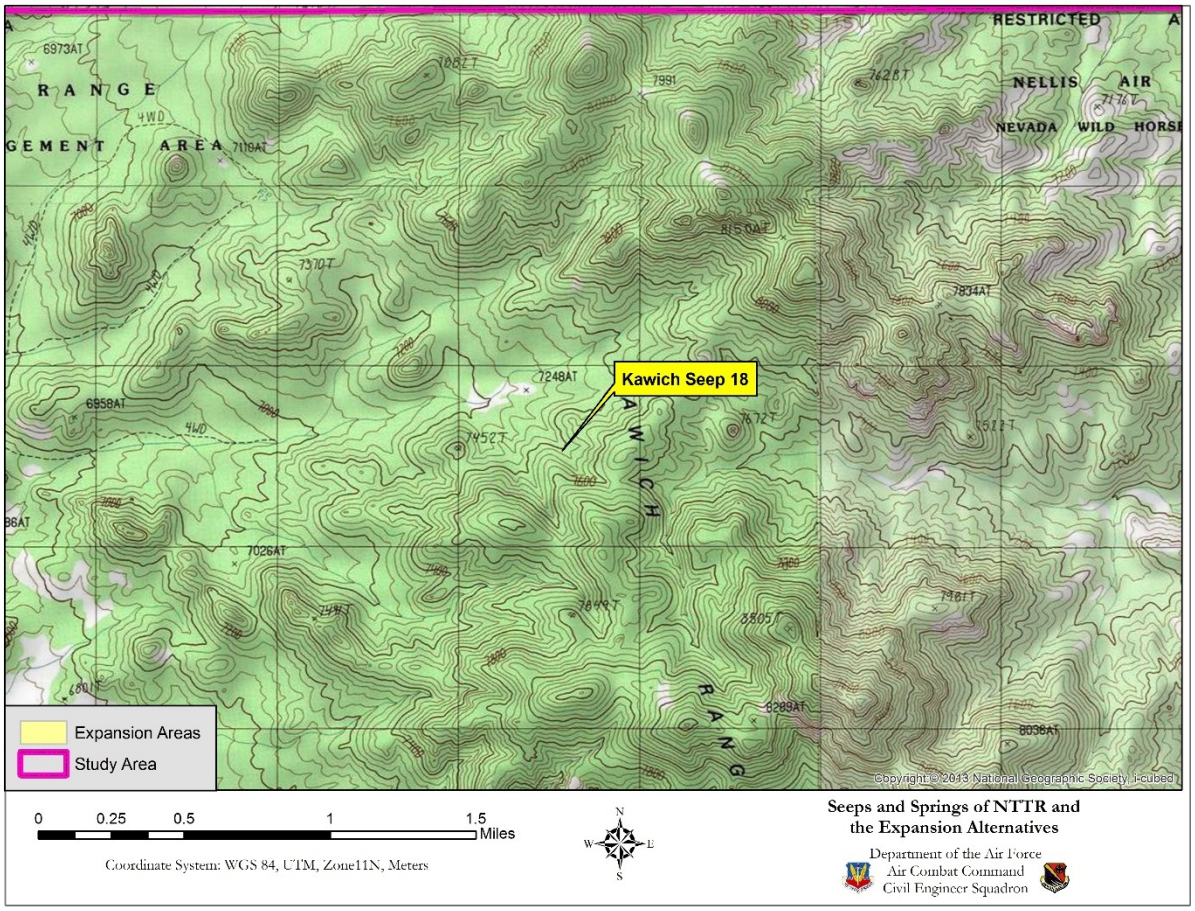


Figure 112. Topographic map showing the location of Kawich Seep 18.

Larry's Seep

Location: 524519 E 4136927 N
Elevation: 5,326 ft. MSL
Dominant Plants: Blackbrush (*Coleogyne ramosissima*); shadscale saltbush (*Atriplex confertifolia*); burrobush (*Ambrosia dumosa*)



Larry's Seep showing the area of water accumulates and evaporation

Larry's Seep is located in a dry lake bed on the south end of Pahute Mesa in Intermountain Cold Desert Scrub Key Habitat. The seep was historically identified as a surface water accumulation. During the Dames and Moore wetland survey in 1996 (Dames and Moore, 1996), no surface water was present. During the 2007 survey, the vegetation at the seep was desiccated. Blackbrush and shadscale saltbush were the dominant plant species with scattered burrobush. The site was again visited in 2011, and was again dry. It was determined the site was likely a seep that emerges when the shallow groundwater table is high and maintains a persistent area of open water until eventually evaporating during the summer. In 2014, the seep was in the same condition as in the past with no evidence of recent inundation.

Larry's Seep water rights were originally held by V.E. Greenwald. The current water rights holder is Effie Siedentopf Spicer, who received the rights in February 1976. V.E. Greenwald applied for a permit in September 1942, the permit was issued in November 1943, and certification was given in October 1948. The open cut spring, with two-foot by five-foot cement box, five feet deep, conveyed water 130 feet to a galvanized iron tank. The original allowed use totaled 3.62 annual acre feet (0.005 cfs) of water for the purpose of watering 150 cattle. None of the structures or pipes described in the historical records have been observed.

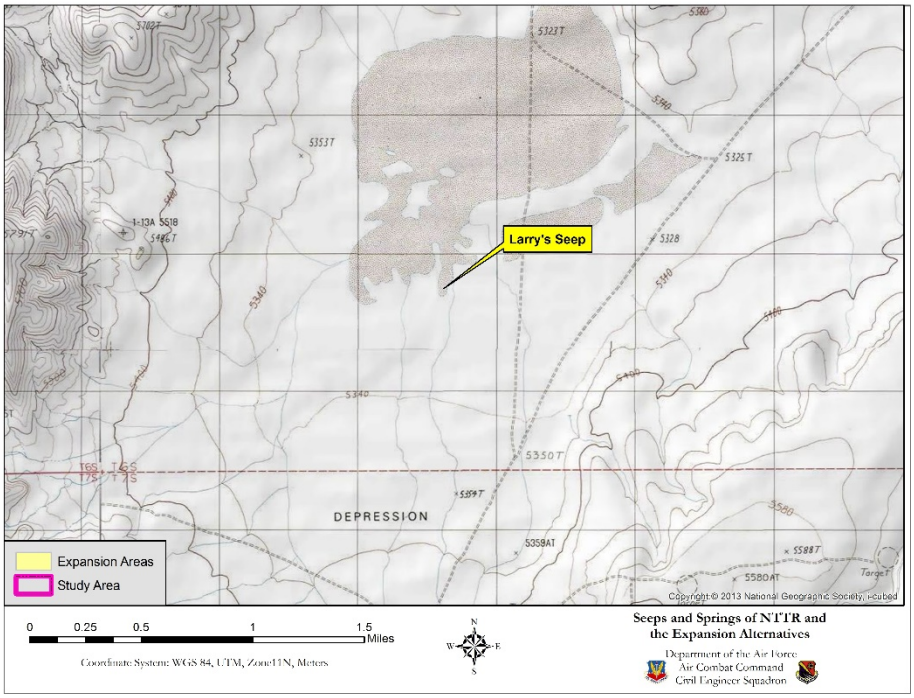


Figure 113. Topographic map showing the location of Larry's Seep.

Lower Pillar Spring

Location: 528266 E 4122117 N
Elevation: 5,420 ft. MSL
Dominant Plants: Desert olive (*Forestiera shrevei)*; big sagebrush (*Artemisia tridentata*); green ephedra (*Ephedra viridis*)

Lower Pillar Spring is located in a tributary for the West Fork of Thirsty Canyon in the Sagebrush Key Habitat. The area is moist most of the year as indicated by the dominance of desert olive at the site. Other species observed along the periphery of the seep included Mormon tea and big sagebrush. The site provides excellent habitat for small mammals and birds. The site was observed in 2014 and was in the same condition with green vegetation and no water or saturated soils.



Lower Pillar Spring as observed from the helicopter during the 2009 survey

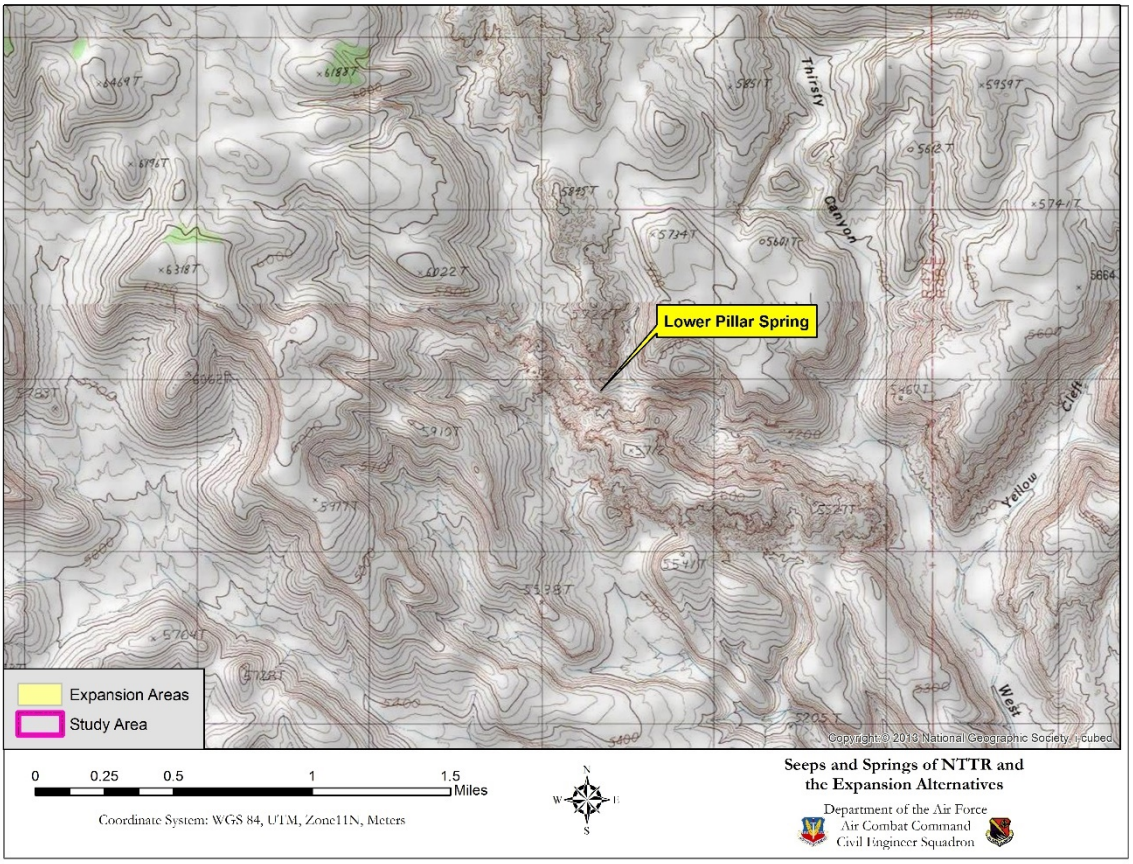
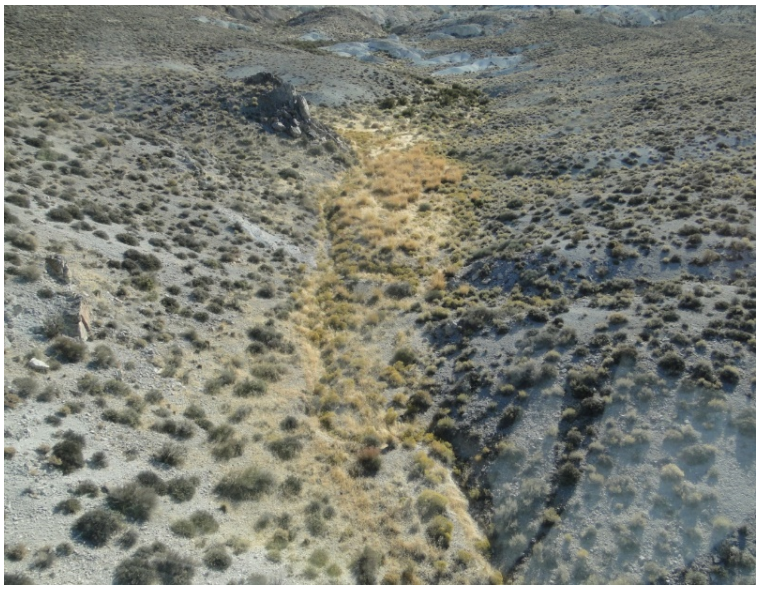


Figure 114. Topographic map showing the location of Lower Pillar Spring.

Mesic 1

Location: 513843 E 4127836 N
Elevation: 5,078 ft. MSL
Dominant Plants: Blackbrush (*Coleogyne ramosissima*); beardless wildrye (*Leymus triticoides*); rubber rabbitbrush (*Ericameria nauseosa*)



Mesic 1 in October 2011

Mesic 1 is located in an ephemeral stream in Intermountain Cold Desert Scrub Key Habitat. Mesic 1 appears to be a seep due to the presence of mesic vegetation, such as beardless wildrye. The seep is located about five feet above the base of the stream channel indicating the source of water is likely an exposed shallow water table and not from surface water associated with the stream. During the 2011 survey, the area was very dry and the mesic vegetation was desiccated.

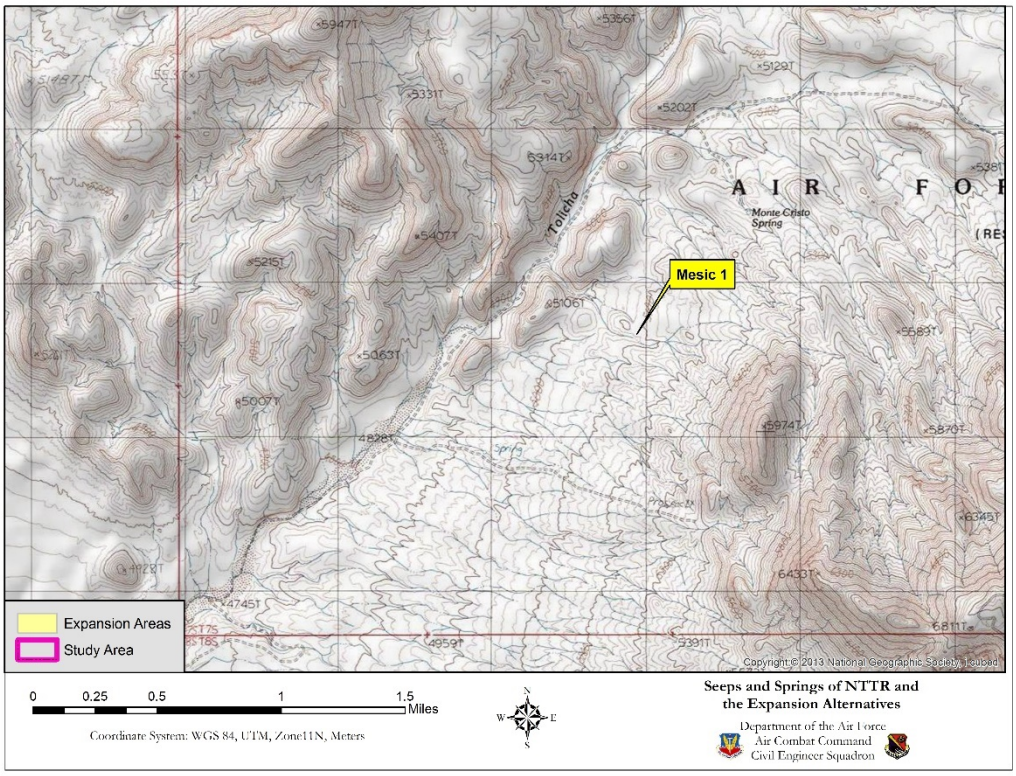


Figure 115. Topographic map showing the location of Mesic 1.

Mesic 2

Location: 510694 E 4182540 N
Elevation: 6,289 ft. MSL
Dominant Plants: Rubber rabbitbrush (*Ericameria nauseosa*); threadleaf snakeweed (*Gutierrezia microcephala*); beardless wildrye (*Leymus triticoides*)

Mesic 2 is located on the north side of Cactus Peak in the upper watershed within the banks of an ephemeral stream in Sagebrush Key Habitat. During the September 2011 survey, the mesic vegetation present was green and appeared healthy, dominated by beardless wildrye. No photographs were taken of this seep.

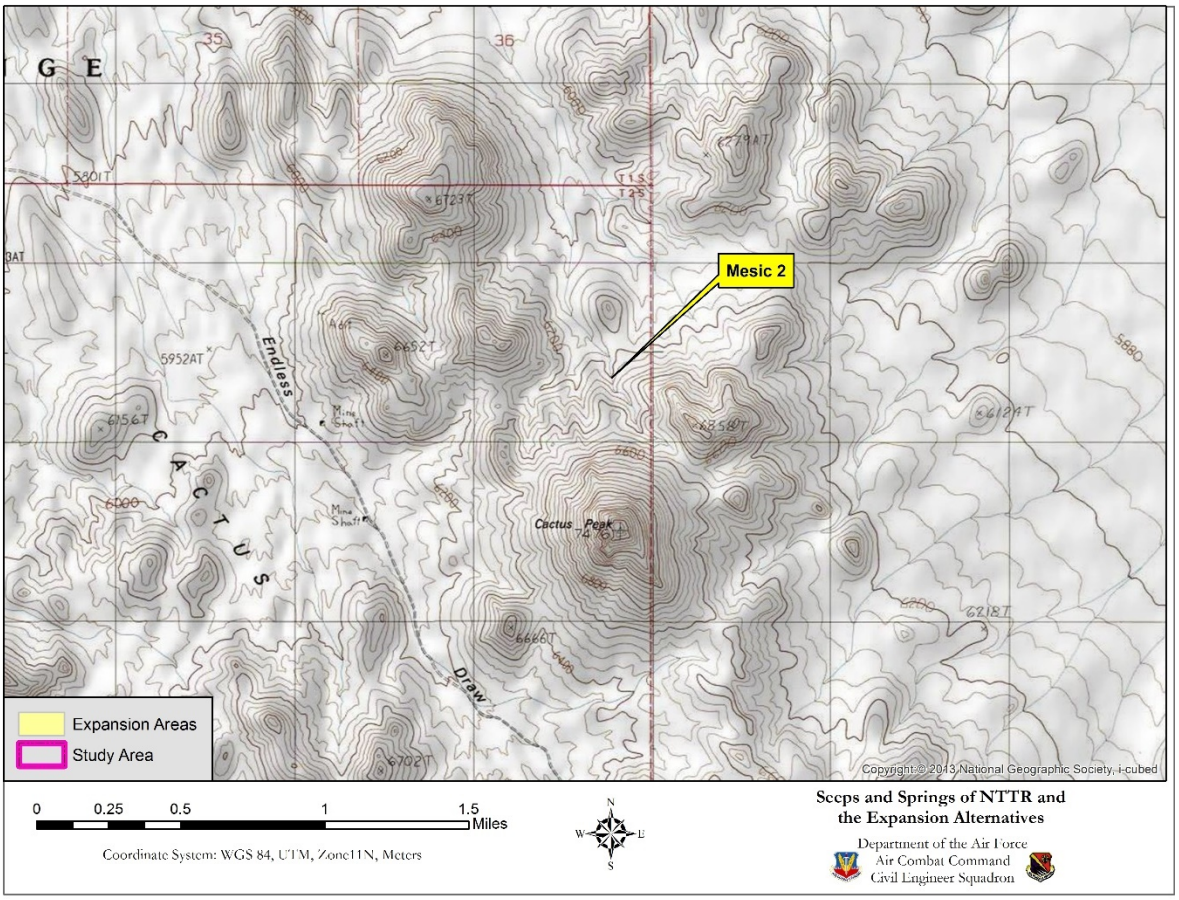


Figure 116. Topographic map showing the location of Mesic 2.

Mesic 3

Location: 548846 E 4191661 N
Elevation: 6,640 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); big sagebrush (*Artemisia tridentata*); spike bentgrass (*Agrostis exarata); w*hitestem goldenbush *(Ericameria discoidea);* Mexican rush *(Juncus mexicanus); s*moothstem blazing star *(Mentzelia laevicaulis)*



Mesic 3 viewed from a helicopter on September 4, 2011

Mesic 3 is located on the west side of the Kawich Mountain Range in Sagebrush Key Habitat. Mesic 3 was the first potential seep or spring identified during the 2007 survey. The site appears to be either a seep or a low-lying area that accumulates snow and runoff during storm events. No evidence of a point source of groundwater was found; however, vegetation composition is characteristic of a mesic environment, indicating a weak seep may be present. The seep was found in an area of scattered Utah juniper, pinyon pine, and big sagebrush. The seep was also observed in September 2009, where the plant community was comprised of beardless wildrye, big sagebrush, spike bentgrass, whitestem goldenbush, Mexican rush, and smoothstem blazingstar. In 2011, the seep was much drier and vegetation was rather sparse. It appeared to be active only in the spring, drying by late summer or early fall.

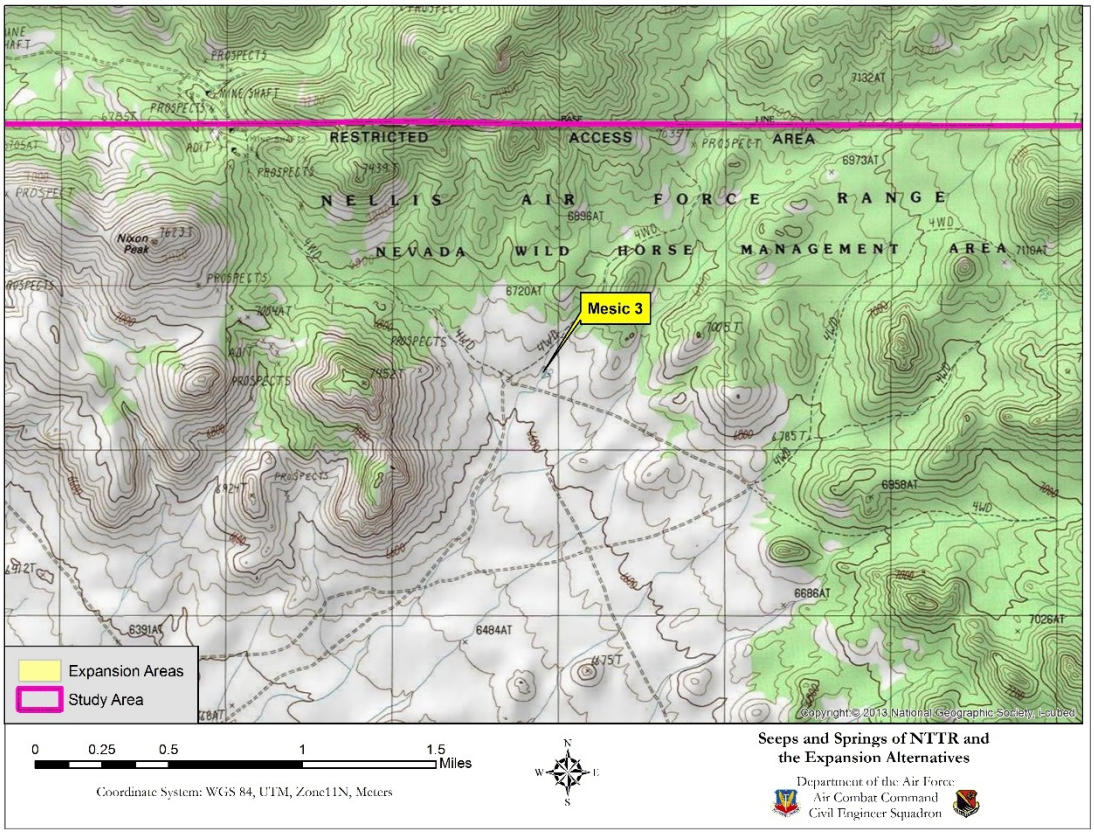


Figure 117. Topographic map showing the location of Mesic 3.

Mesic 5

Location: 556887 E 4173375 N
Elevation: 6,758 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); squarestem spikerush (*Eleocharis quadrangulata*); singleleaf pinyon pine *(Pinus monophylla)*; Utah juniper (*Juniperus osteosperma)*; big sagebrush (*Artemisia tridentata*)



Mesic 5 on September 3, 2011

Mesic 5 is located in a relatively large canyon on the west side of the Kawich Mountain Range in Lower Montane Woodlands Key Habitat. Mesic 5 is a seep with a small area of accumulated water. Saturated areas of soil adjacent to the spring support stands of spikerush and wildrye. In 2011, the seep supported a healthy green stand of grasses, and possibly spikerush, but no standing water was observed. It appears Mesic 5 is an intermittent seep producing water only in the spring or during wet periods.

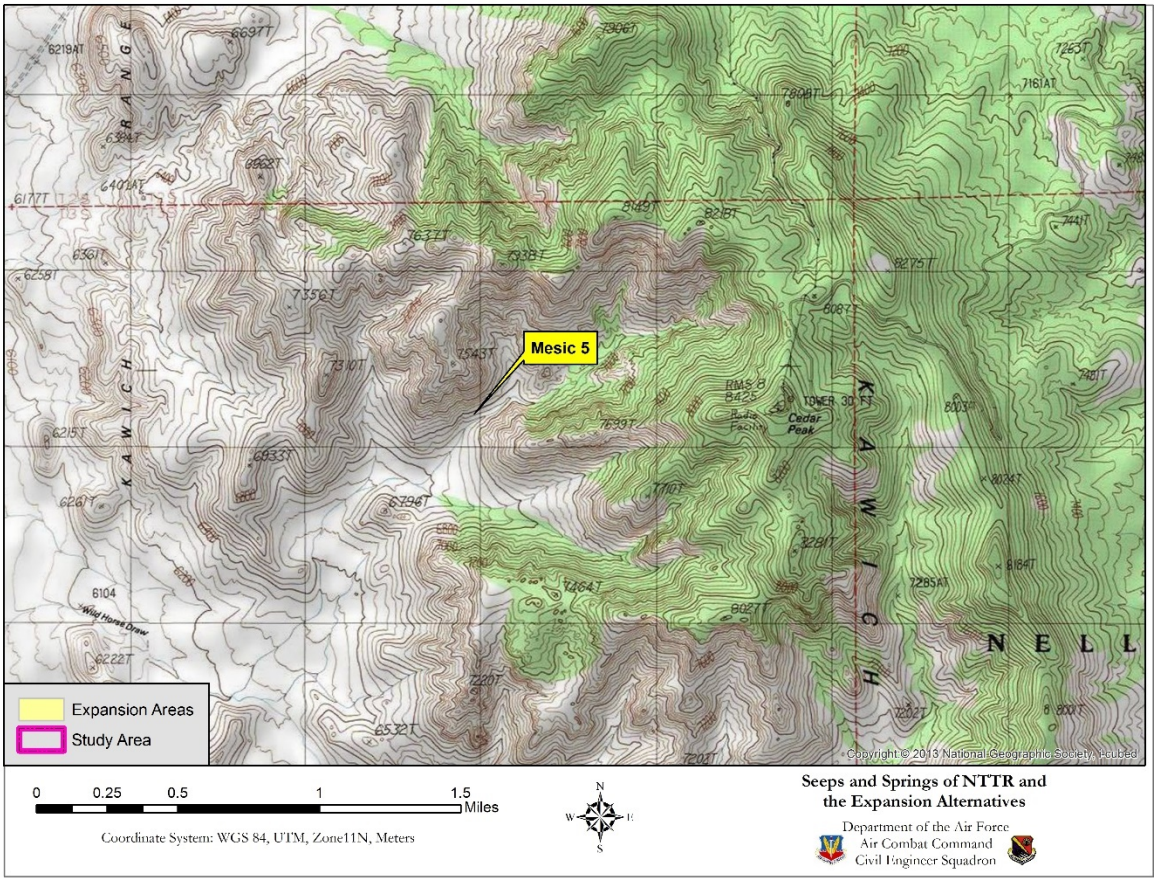


Figure 118. Topographic map showing the location of Mesic 5.

Mesic 8

Location: 522632 E 4166170 N
Elevation: 6,497 ft. MSL

Dominant Plants: Big sagebrush (*Artemisia tridentata*); Greene's rabbitbrush (*Chrysothamnus greenei*); Mormon tea (*Ephedra viridis*); rubber rabbitbrush (*Ericameria nauseosa*); Utah juniper (*Juniperus osteosperma*)



Mesic 8 in May 2009

Mesic 8 is located on the east slope of the Cactus Mountain Range southwest of Roller Coaster Knob in Sagebrush Key Habitat. Mesic 8 was surveyed on May 24, 2009. Three Utah junipers were on the edge of the seep, which also supported a small area of mesic vegetation. At the time of the observation, the seep was completely dry, but the presence of mesic vegetation indicated persistent moist conditions.

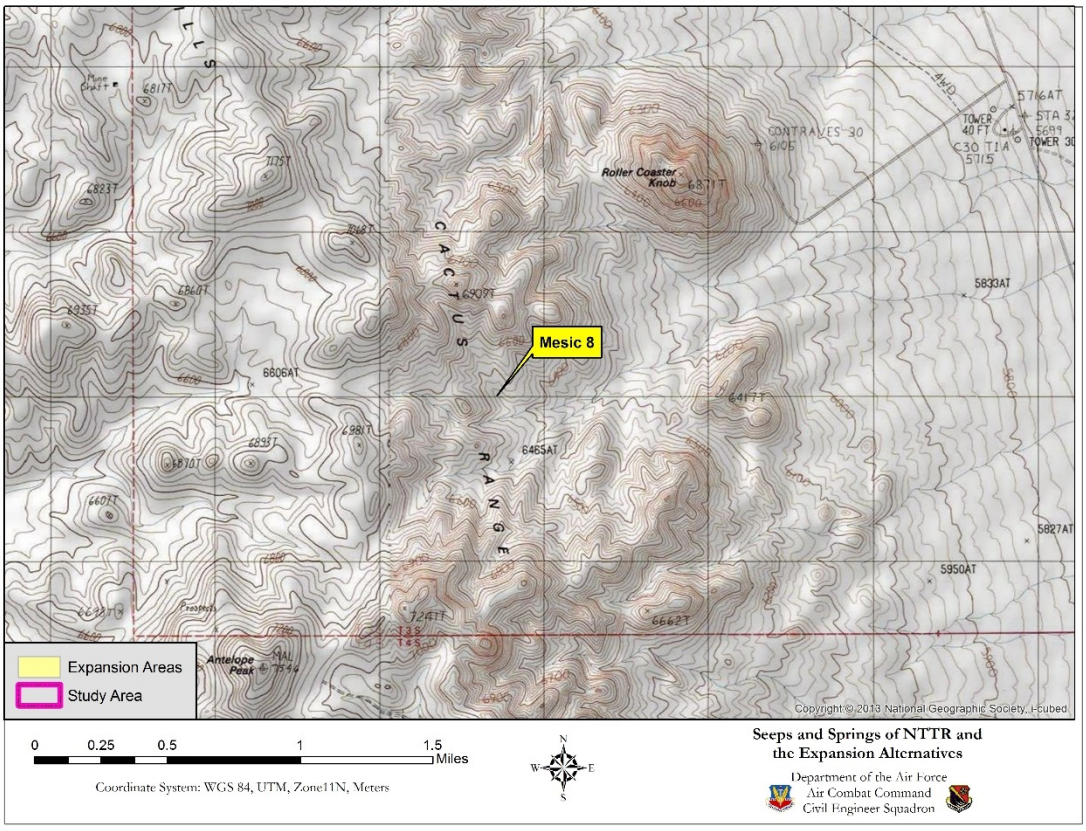


Figure 119. Topographic map showing the location of Mesic 8.

Mesic 50

Location: 494746 E 4149500 N
Elevation: 6,683 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); Utah juniper (*Juniperus osteosperma*); singleleaf pinyon pine (*Pinus monophylla*); big sagebrush (*Artemisia tridentata*); Mormon tea (*Ephedra viridis*)



Mesic 50 in September 2011

Mesic 50 is located on the south side of Stonewall Mountain in a small canyon in Lower Montane Woodlands Key Habitat. Mesic 50 did not have any observable standing or flowing water during the 2007 or 2011 surveys. It was characterized by a stand of beardless wildrye, which would indicate saturated soils at least part of the year. It was concluded water surfaced as an ephemeral seep only during the spring season.

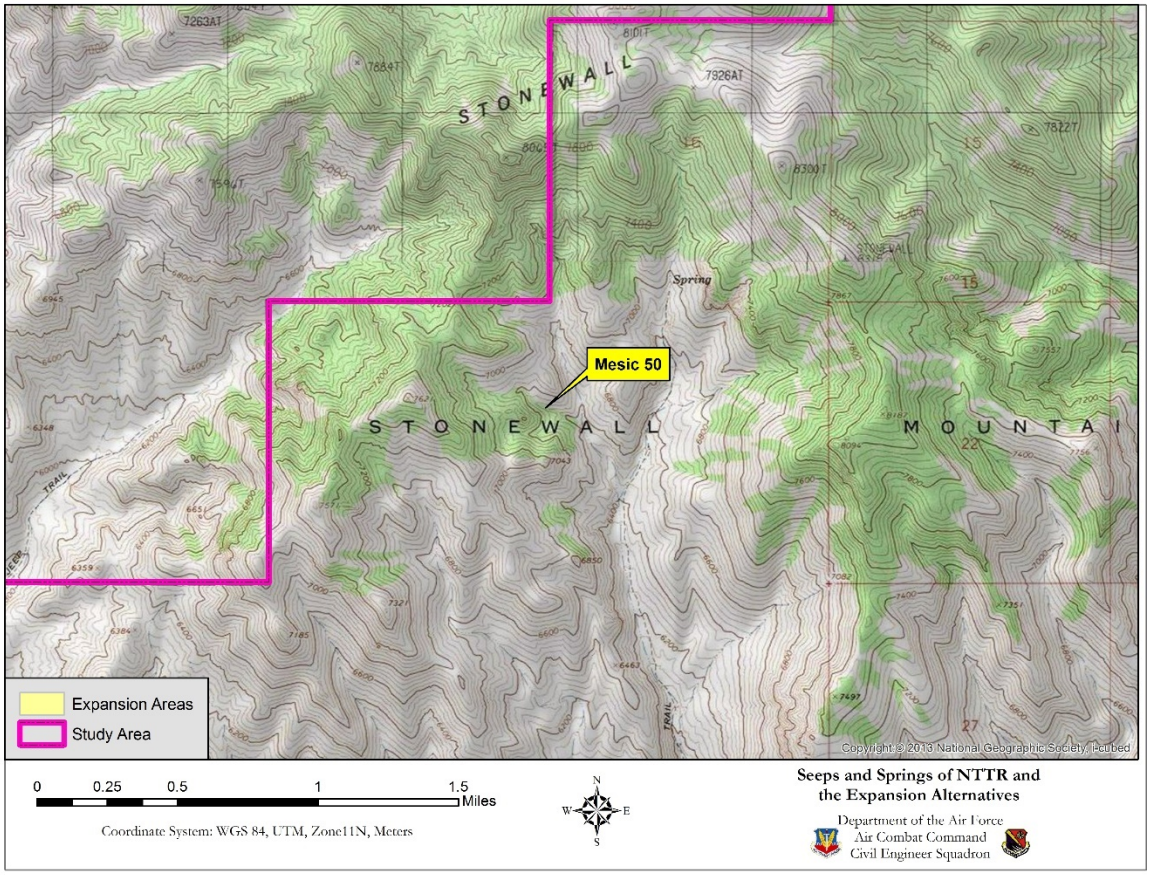


Figure 120. Topographic map showing the location of Mesic 50.

Mesic 118

Location: 527357 E 4153902 N
Elevation: 5,846 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*)

Mesic 118 is located northwest of the Trappman Hills and northeast of Mount Helen in Sagebrush Key Habitat. Mesic 118 was found in the drainage of a shallow canyon and supports a small population of beardless wildrye. The spring was observed on May 24, 2009, and again on September 5, 2011. Due to its location on a slope and the presence of beardless wildrye, it was determined the feature was likely an intermittent seep.



Mesic 118 as observed during the 2009 survey

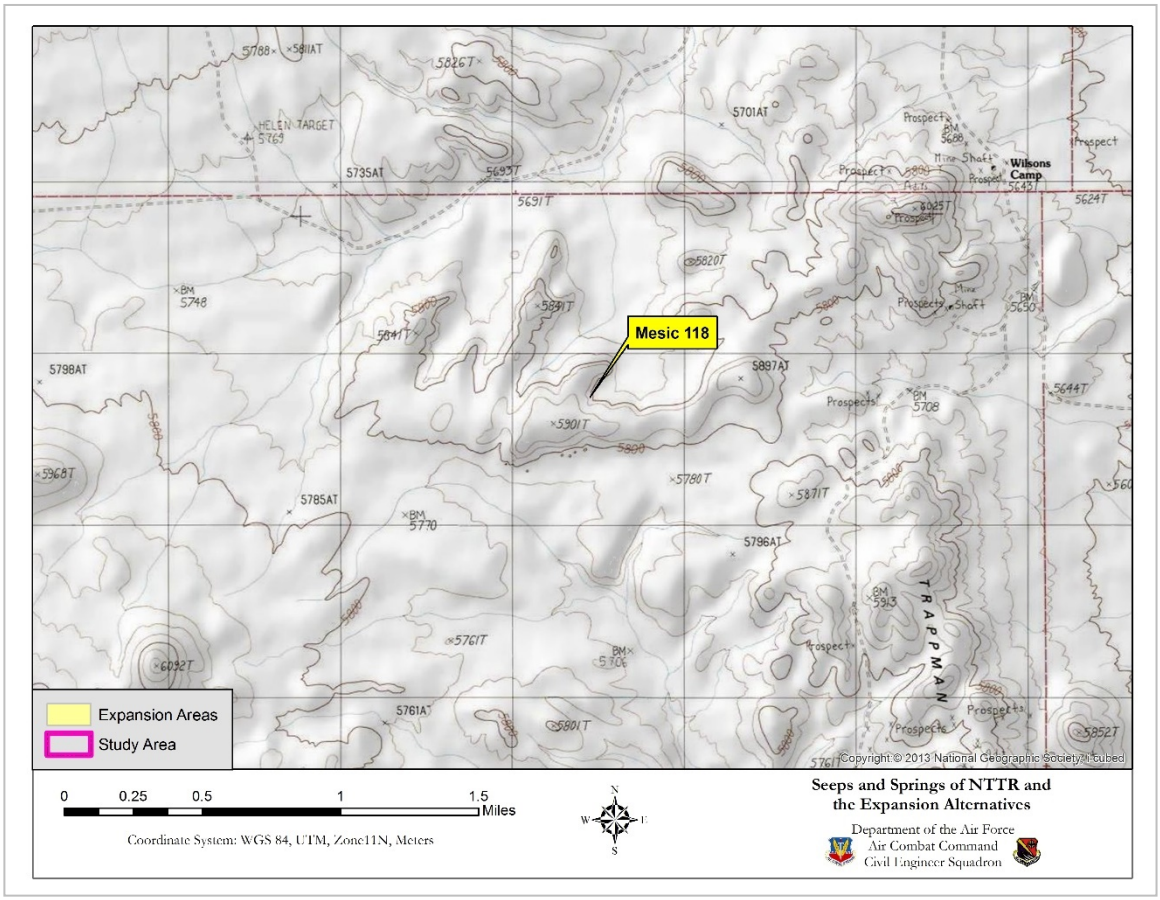


Figure 121. Topographic map showing the location of Mesic 118.

Mesic 120

Location: 530857 E 4133518 N
Elevation: 5,701 ft. MSL
Dominant Plants: Blackbrush (*Coleogyne ramosissima*); beardless Wildrye (*Leymus triticoides*); rubber rabbitbrush (*Ericameria nauseosus*)



Mesic 120 in 2011

Mesic 120 is located in the southern end of Cactus Flats in Sagebrush Key Habitat. Mesic 120 is found in a depression in a relatively open area dominated by blackbrush and rabbitbrush. The spring plant community was dominated by beardless wildrye, which indicates the site is intermittently saturated, and is likely a seep.

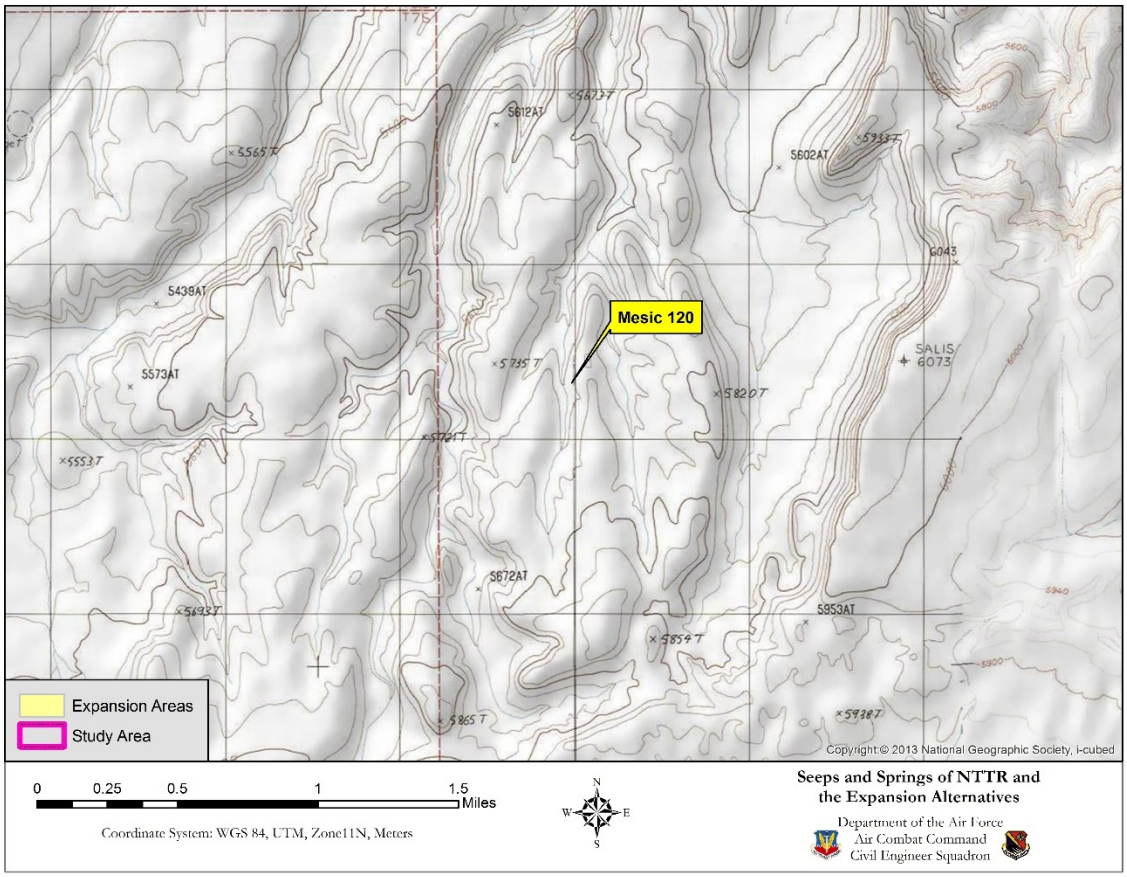


Figure 122. Topographic map showing the location of Mesic 120.

Mesic 121

Location: 532376 E 4134435 N
Elevation: 5,638 ft. MSL
Dominant Plants: Blackbrush (*Coleogyne ramosissima*); beardless wildrye (*Leymus triticoides*); rubber rabbitbrush (*Ericameria nauseosa*); Utah juniper (*Juniperus osteosperma*)



Mesic 121 in 2009

Mesic 121 is located in the southern end of Cactus Flats in Sagebrush Key Habitat. Mesic 121 is an intermittent seep found in a shallow valley and supports a small grove of Utah juniper. Other plants in the area include blackbrush and rabbitbrush. The actual seep area supports a dense population of beardless wildrye, indicating that soil saturation is periodic or intermittent.

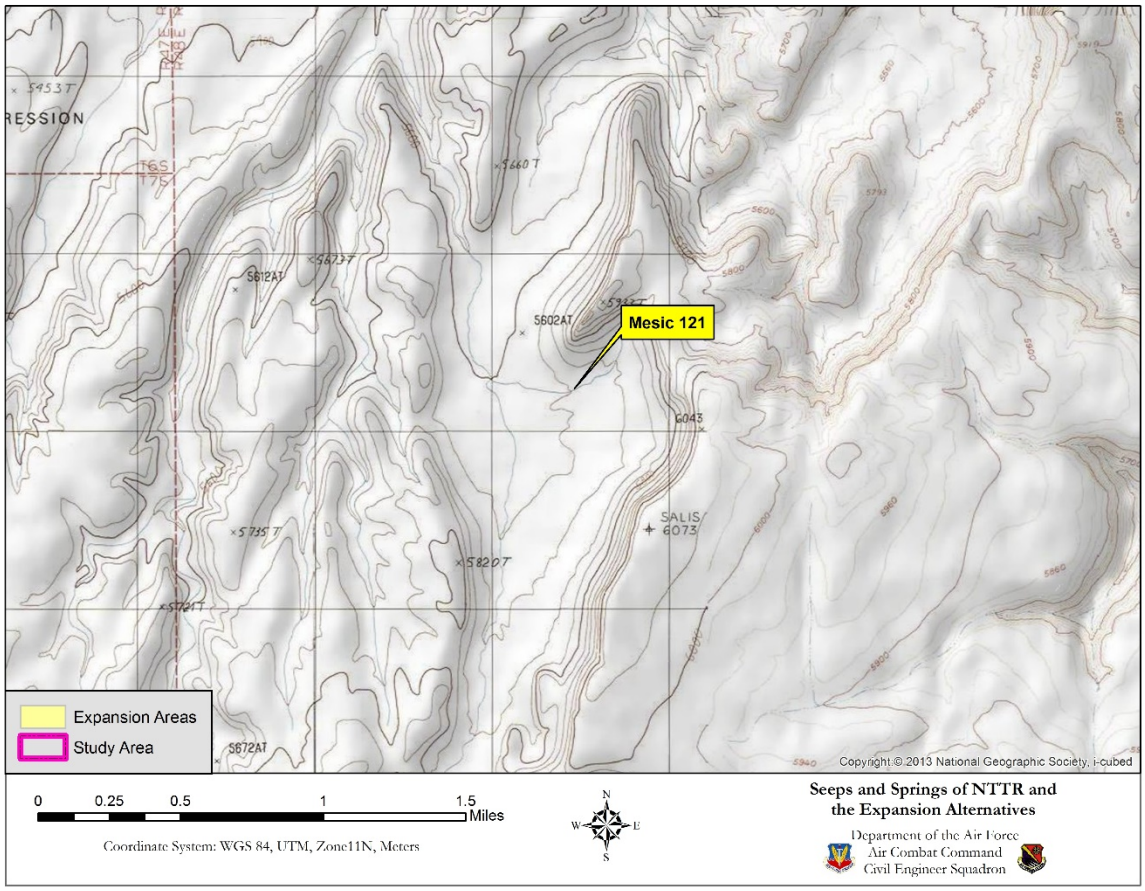


Figure 123. Topographic map showing the location of Mesic 121.

Mesic 122

Location: 521136 E 4124242 N
Elevation: 5,928 ft. MSL
Dominant Plants: Beardless wildrye (*Elymus triticoides*), pinyon pine (*Pinus monophylla*), Utah juniper (*Juniperus osteosperma*), willow (*Salix spp.*), big sagebrush (*Artemisia tridentata*)



Upper end of Mesic 122 with a population of beardless wildrye and other mesic grasses

Mesic 122 is a seep located south of Quartz Mountain in Sagebrush Key Habitat. The upper end of the spring is dominated by beardless wildrye and Utah juniper with scattered big sagebrush. The lower portion of the spring is a mixture of pinyon pine, Utah juniper and a few willows. Outside of the moist areas, the plant community is mostly big sagebrush. The seep appears to be wet during a short period of time in the spring and possibly after significant storm events.

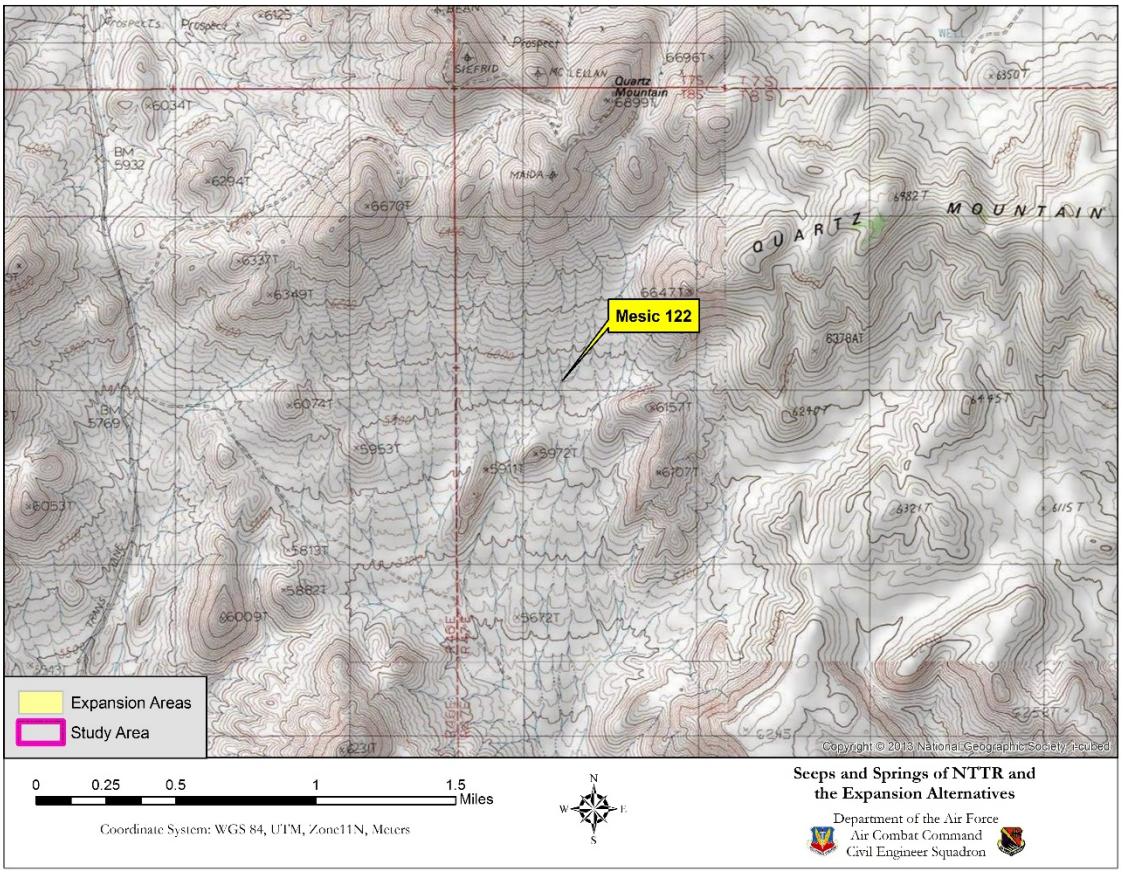


Figure 124. Topographic map showing the location of Mesic 122.

Mesic 126

Location: 561560 E 4157694 N
Elevation: 6,021 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); big sagebrush (*Artemisia tridentata*); rubber rabbitbrush (*Ericameria nauseosa*); Utah juniper (*Juniperus osteosperma*)



Mesic 126 in September 2011

Mesic 126 is located on the east side of the southern end of the Kawich Mountain Range in Intermountain Cold Desert Scrub Key Habitat. Mesic 126 was observed during a helicopter survey in 2009. The area was not closely inspected, but appeared to be dominated by beardless wildrye with no visible water. The spring was again surveyed in September 2011 and the spring was dry but vegetation was still dominated by beardless wildrye. Surrounding plant community included big sagebrush, Utah juniper, and rubber rabbitbrush. It was determined that the site was likely an intermittent seep.

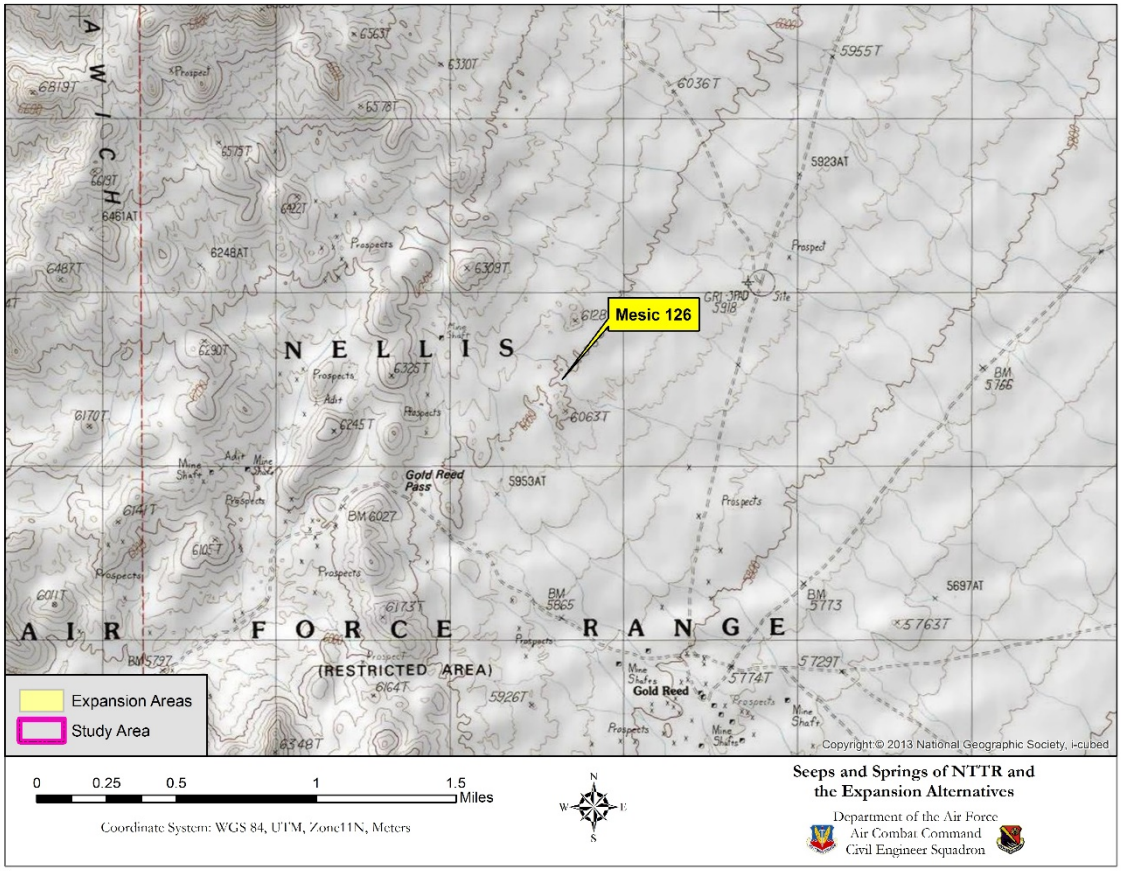


Figure 125. Topographic map showing the location of Mesic 126.

Mesic 131

Location: 559017 E 4163281 N
Elevation: 6,505 ft. MSL
Dominant Plants: Shadscale saltbush (*Atriplex confertifolia*); greasewood (*Sarcobatus vermiculatus*); bud sagebrush (*Picrothamnus desertorum)*; fourwing saltbush (*Atriplex canescens*); beardless wildrye (*Leymus triticoides*)



Mesic 131 in May 2009.

Mesic 131 is located in the Kawich Mountain Range in Sagebrush Key Habitat. Mesic 131 was dry during the 2009 survey. The flow channel was dominated by beardless wildrye, a mesic species which will only grow in soils that are moist or wet for long periods of time. The site was revisited in 2011 and 2014 and, again, appeared to be dry. Observations indicate that this is either an intermittent seep or a persistent accumulation of storm water.

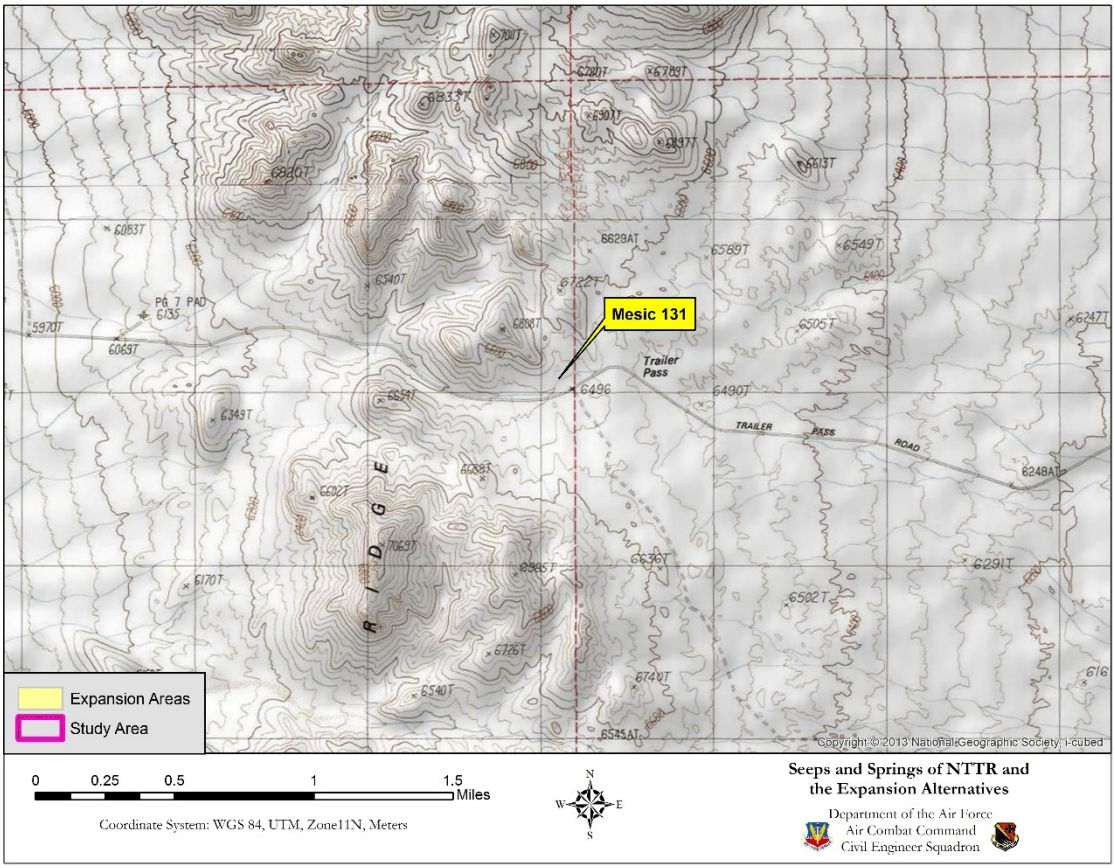


Figure 126. Topographic map showing the location of Mesic 131.

Nixon #1

Location: 539544 E 4143316 N
Elevation: 5,175 ft. MSL
Dominant Plants: Green molly (*Bassia americana*); goldenbush (*Ericameria* sp.); fourwing saltbush (*Atriplex canescens*)



Nixon #1 as observed in 2009. Water has not been observed in this seep since 2009.

Nixon #1 is located in the flats southwest of Jackpot Reservoir in Intermountain Cold Desert Scrub Key Habitat. Nixon #1 contained water in 2009, but surrounding vegetation was desiccated, dominated by green molly, fourwing saltbush, and a species of goldenbush. Evidence of use by wildlife was not observed. All of this indicated the water may be too saline for wildlife. The seep could not be located in 2011. Former Nixon (Water Hole) #2 was not found during the 2009 survey and was removed from the list of springs. The spring was not surveyed in 2014 or 2015.

Nixon #1 is historically known as Nixon Water Hole No. 1. The original vested right in the seep was held by John J. Casey for the purpose of watering 500 cattle. The priority date for this vested right is January 1880; a permit was applied for in August 1950, but no permit award date is given. Proof of Appropriation of Water was provided by the State of Nevada in 1953 to John J. Casey, although a certification date is not provided in the NDWR database. The date of transfer from John J. Casey, or other subsequent right holders, to the United States of America, the current owner, is not known.

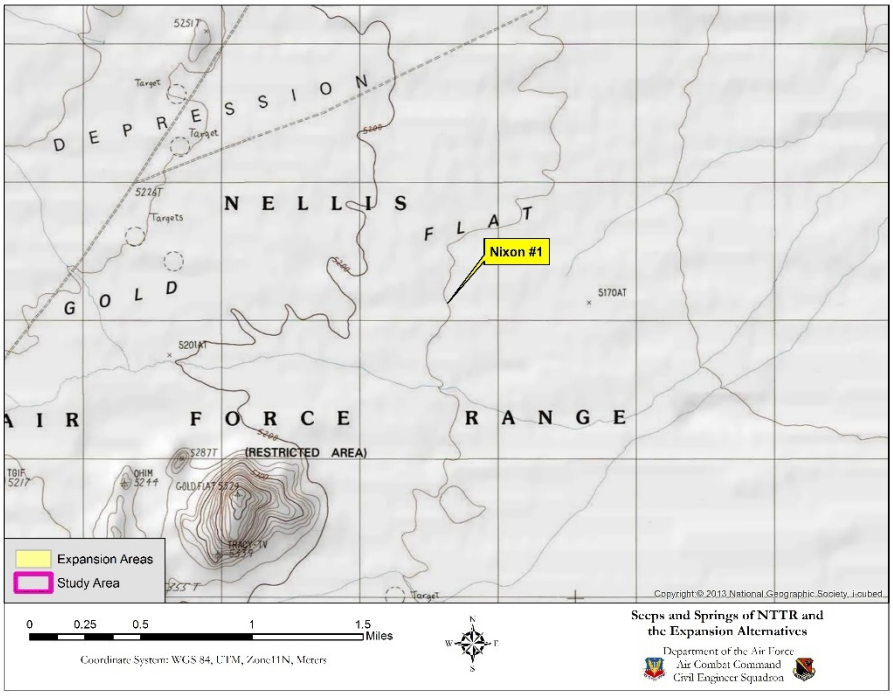


Figure 127. Topographic map showing the location of Nixon #1.

Roller Coaster Seep #1

Location: 523110 E 4168875 N
Elevation: 6,053 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); Mexican rush (*Juncus mexicanus*); rubber rabbitbrush (*Ericameria nauseosa*); beardless wildrye (*Leymus triticoides*)

Roller Coaster Seeps #1 is located in the Dacite Hills of the Cactus Mountain Range in Sagebrush Habitat. Roller Coaster Seep #1 is an intermittent seep located in a shallow valley and supports a narrow channel of mesic vegetation such as spikerush and possibly Mexican rush. This seep is not protected by a fence.



Roller Coaster Seep #1 in 2009

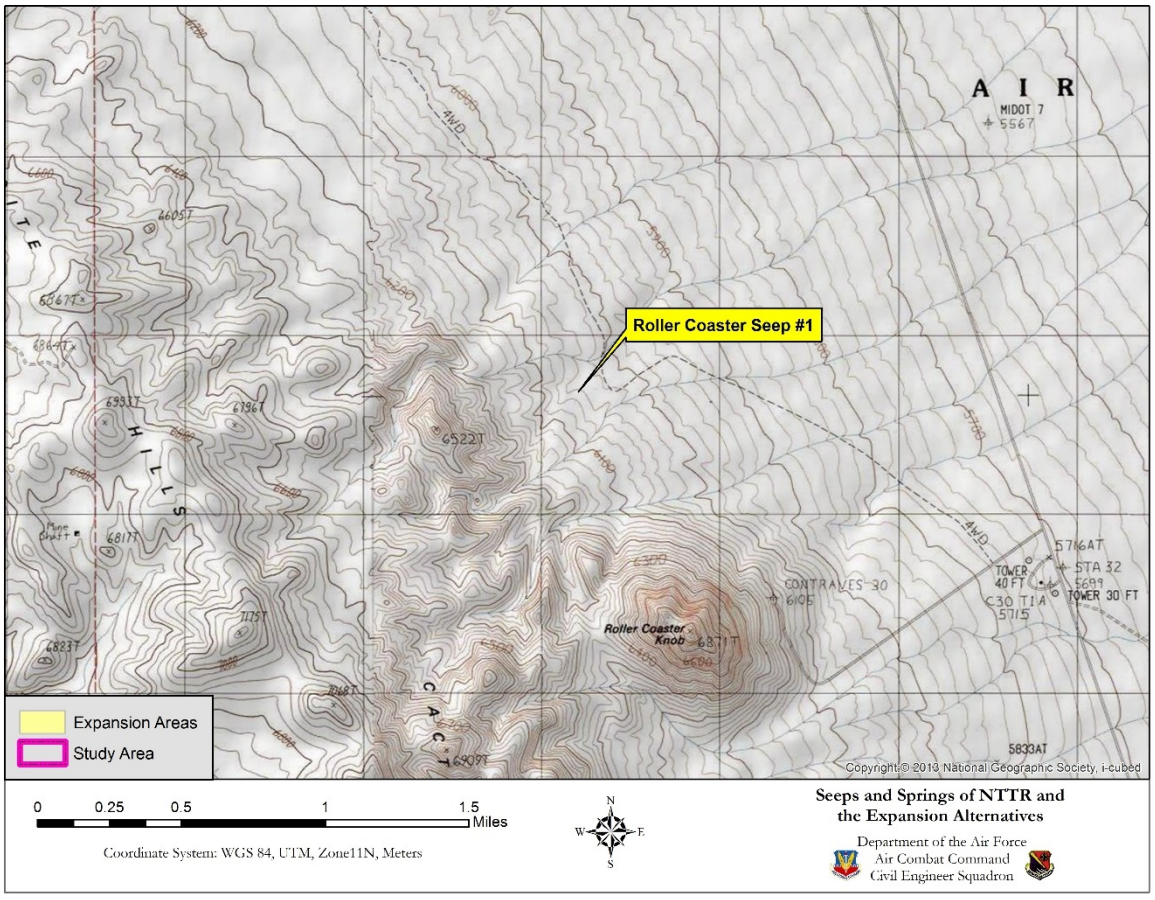


Figure 128. Topographic map showing the location of Roller Coaster Seep #1.

Roller Coaster Seep #5

Location: 521585 E 4169728 N
Elevation: 6,289 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); rubber rabbitbrush (*Ericameria nauseosa*)

Roller Coaster Seeps #5 is located in the Dacite Hills of the Cactus Mountain Range in Sagebrush Habitat. Roller Coaster Seep #5 was a weak, intermittent seep, not as prominent as the other Roller Coaster seeps.



Roller Coaster Seep #5 in 2011

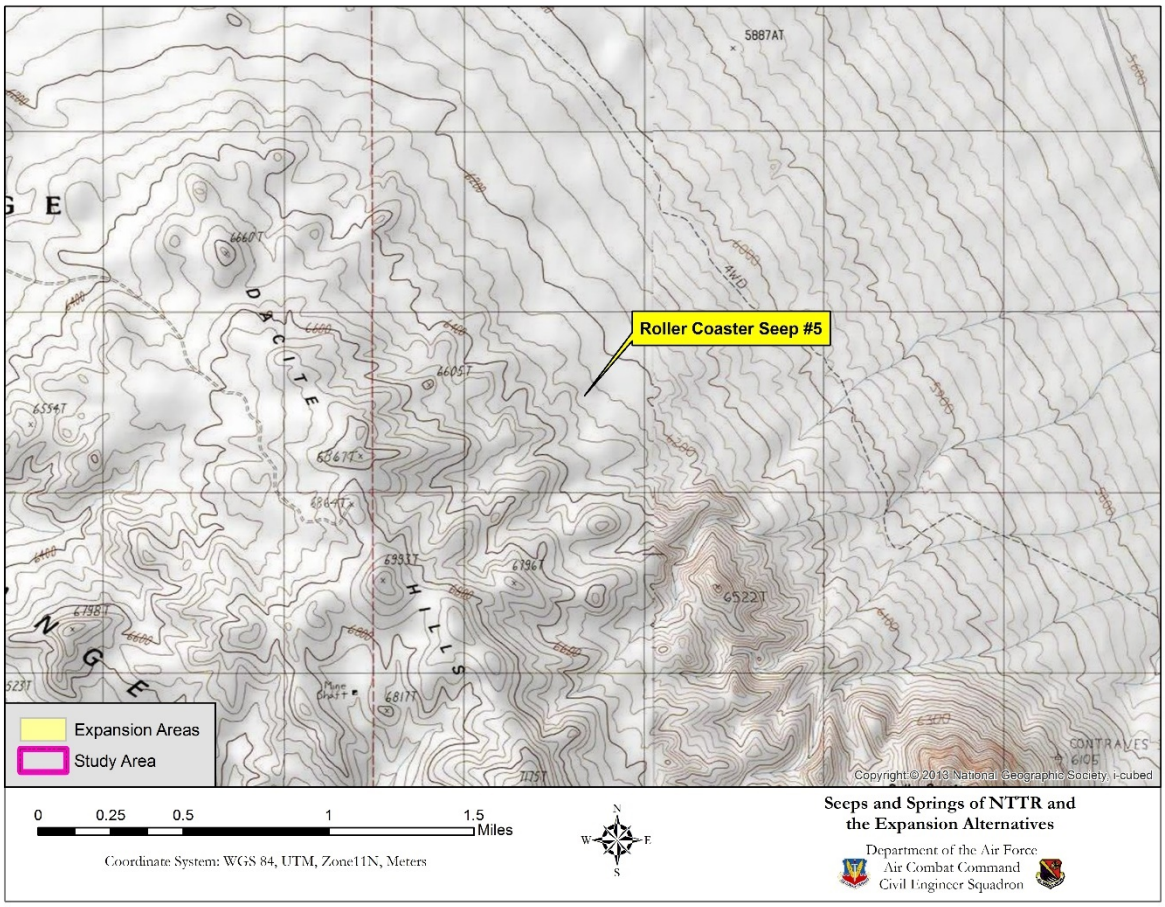


Figure 129. Topographic map showing the location of Roller Coaster Seep #5.

Silverbow Seep

Location: 544268 E 4191658 N
Elevation: 6,409 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*); sedges (*Carex sp.*); Mexican rush (*Juncus mexicanus*), rabbitsfoot grass (*Polypogon viridis*); big sagebrush (*Artemisia tridentata*); Mojave woodyaster (*Xylorhiza tortifolia*); whitestem goldenbush (*Ericameria discoidea);* smoothstem blazingstar (*Mentzelia laevicaulis*)



Silverbow Seep in 2009

Silverbow Seep is located in the Silverbow Seep and Spring Complex, in the northwestern portion of Cactus Flats in Sagebrush Key Habitat. Silverbow Seep is the location of a historically active spring. This seep shows evidence of past spring activity, based on accumulated lime deposits and a persistent water flow channel. The spring does not appear to have been active for some time. The site has been surveyed several times, but water or saturated soils have not been observed. It was kept in the intermittent seep category because it was a flowing spring in the past and may become active again.

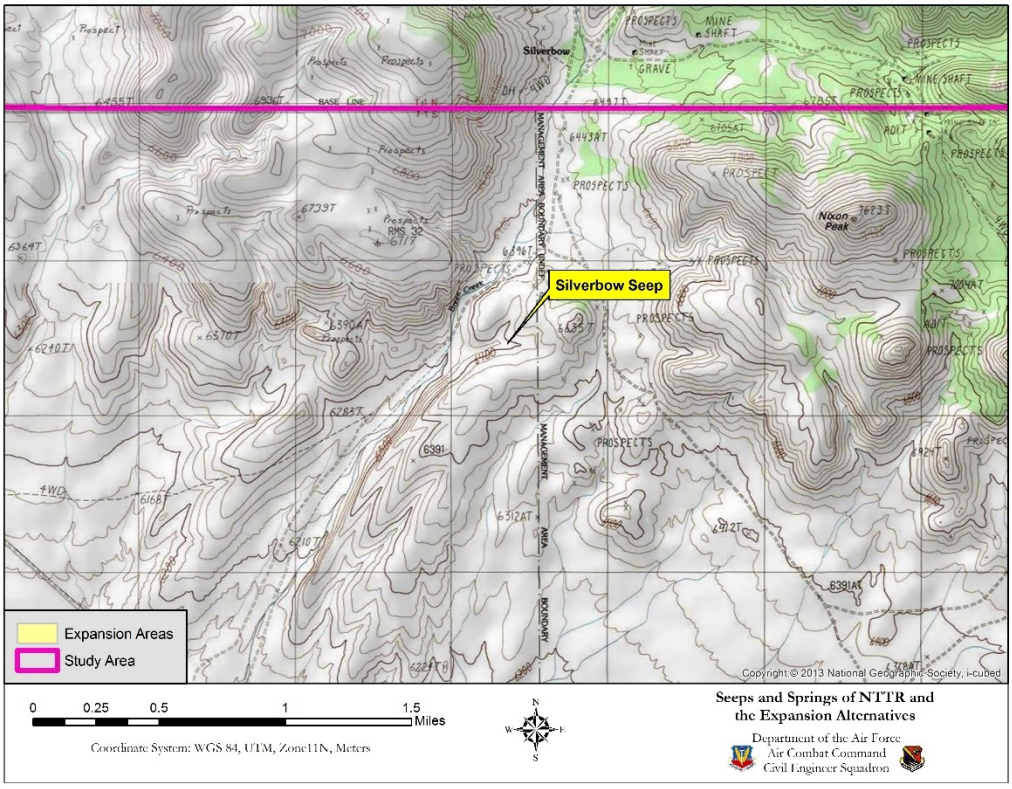


Figure 130. Topographic map showing the location of Silverbow Seep.

Upper Cliff Spring

Location: 581077 E 4152056 N
Elevation: 7,055 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*); beardless wildrye (*Leymus triticoides*); rubber rabbitbrush (*Ericameria nauseosa*); big sagebrush (*Artemisia tridentata*); singleleaf pinyon pine (*Pinus monophylla*); Utah juniper (*Juniperus osteosperma*)



Upper Cliff Spring in September 2011 Survey

Upper Cliff Spring is on the west slope of the Belted Mountain Range in Lower Montane Woodlands Key Habitat. Upper Cliff Spring appears to support two areas of mesic vegetation in a stream channel, dominated by beardless wildrye and spikerush. This surface water feature appears to be a seep because flowing water and a water source was not observed in 2009 or 2011. The site appeared drier during the 2011 survey as compared to 2009. Water may accumulate in the area in the early spring, but standing water has not been observed at the site. The NDWR database identifies two historically appropriated springs (applications 2357 and 11605) named Cliff Spring. Application 2357, the older western site associated with USGS is identified as Cliff Spring. Application 11605 appears to be Upper Cliff Spring. Water rights for this spring were originally held by Carlton P. and Floyd R. Lamb. The rights were eventually transferred to the U.S. Department of Defense (NDWR stated rights holder) in 1990. Carlton P. and Floyd R. Lamb applied for appropriation of water rights in June 1946; a permit was issued in August 1947; and certification was given in May 1949. Water was conveyed from a 40-foot tunnel through 150 feet of pipe to a 1,250-gallon metal storage tank; water was than conveyed to a 12,000-gallon metal storage tank, and then to a metal watering trough. The original allowed use totaled 4.48 annual acre feet of water for the purpose of watering 200 cattle. A protest was filed by A.M. Johnson on October 25, 1946, and overruled on August 8, 1947. The application number for both Cliff Springs were updated in 1991 to 55321 and 55322, during the transfer of water rights to the USAF. Certificate of Appropriation for 55322 states it is an unnamed spring source, with an allowed use of 0.0063 cfs for watering of 200 head of wild horses, burros, and other wildlife. The description of this spring matches the description of the Upper Cliff Spring in application 11605.

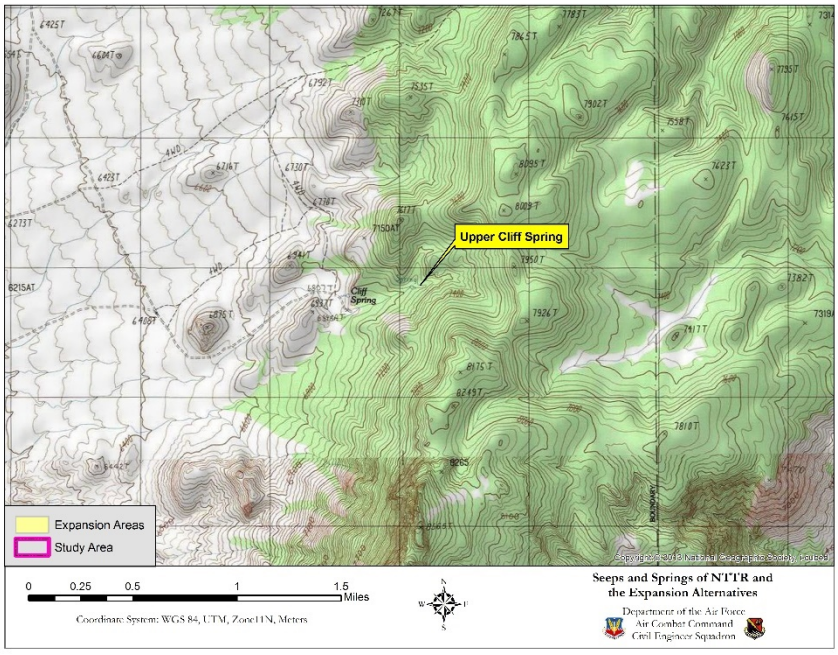


Figure 131. Topographic map showing the location of Upper Cliff Spring.

Surface Water 1

Location: 538479 E 4118086 N
Elevation: 5,216 ft. MSL
Dominant Plants: No Vegetation



Surface Water 1 as observed August 29, 2014

Surface Water 1 is located in a relatively deep, narrow fork of Thirsty Canyon in Mojave/Sonoran Mid-Elevation Mixed Desert Scrub Key Habitat. Surface Water 1 appears to be a persistent accumulation of surface water. The permanent accumulation of water may be due to protection from the sun provided by the steep canyon walls and the depth of the depression. This resource is a very important source of water for bighorn sheep and chukars using Thirsty Canyon, as evidenced by animal observations and sign. The spring is surrounded by bedrock and does not support a plant population. This source has been designated as a perennial surface water due to the persistence of the water, even in dry seasons.

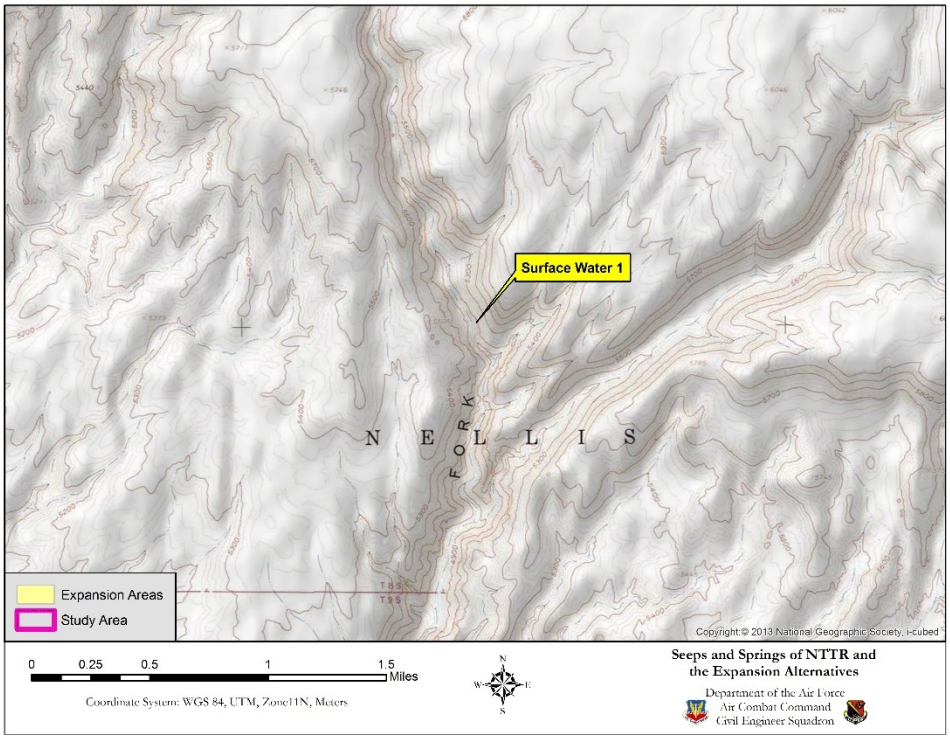


Figure 132. Topographic map showing the location of Surface Water 1.

Construction Ponds 1 and 2

Location: 519595 E 4181578 N
Elevation: 5,587 ft. MSL
Dominant Plants: Saltcedar (*Tamarix ramosissima*); rubber rabbitbrush (*Ericameria nauseosa*); shadscale saltbush (*Atriplex confertifolia*)

Construction Ponds 1 and 2 are located in Cactus Flats in Intermountain Cold Desert Scrub Key Habitat.



Construction Pond 1



Construction Pond 2

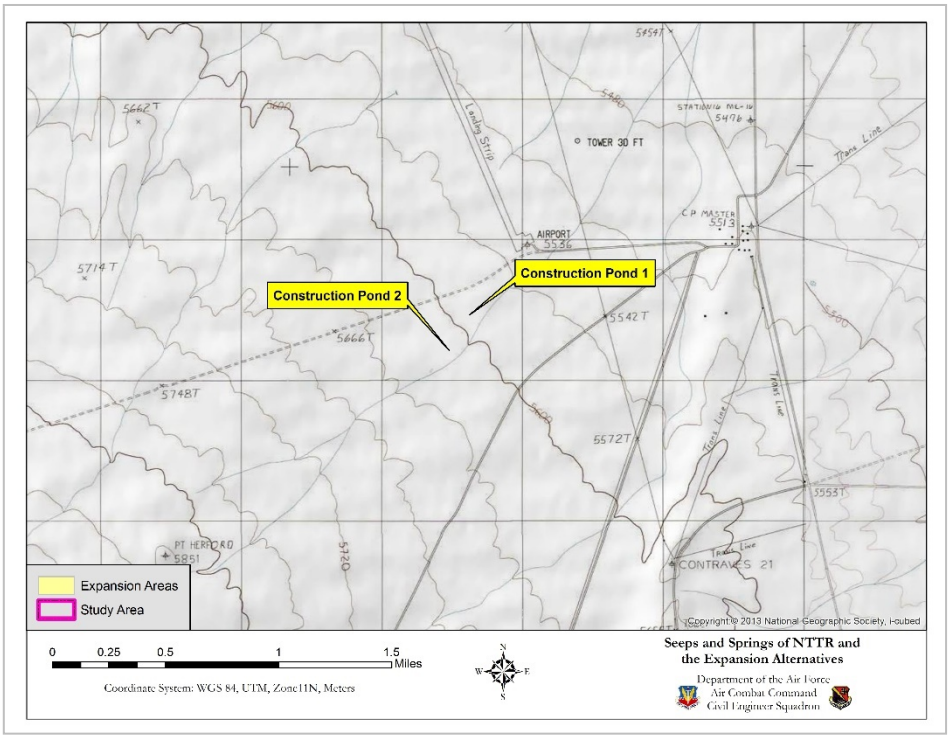


Figure 133. Topographic map showing the location of Construction Ponds 1 and 2.

DOE Construction Pond

Location: 522249 E 4181760 N
Elevation: 5,494 ft. MSL
Dominant Plants: Saltcedar (*Tamarix ramosissima*)

DOE Construction Pond is located more than seven miles east of Cactus Peak southeast of the TTR airport runway in Intermountain Cold Desert Scrub Key Habitat.



DOE Construction Pond

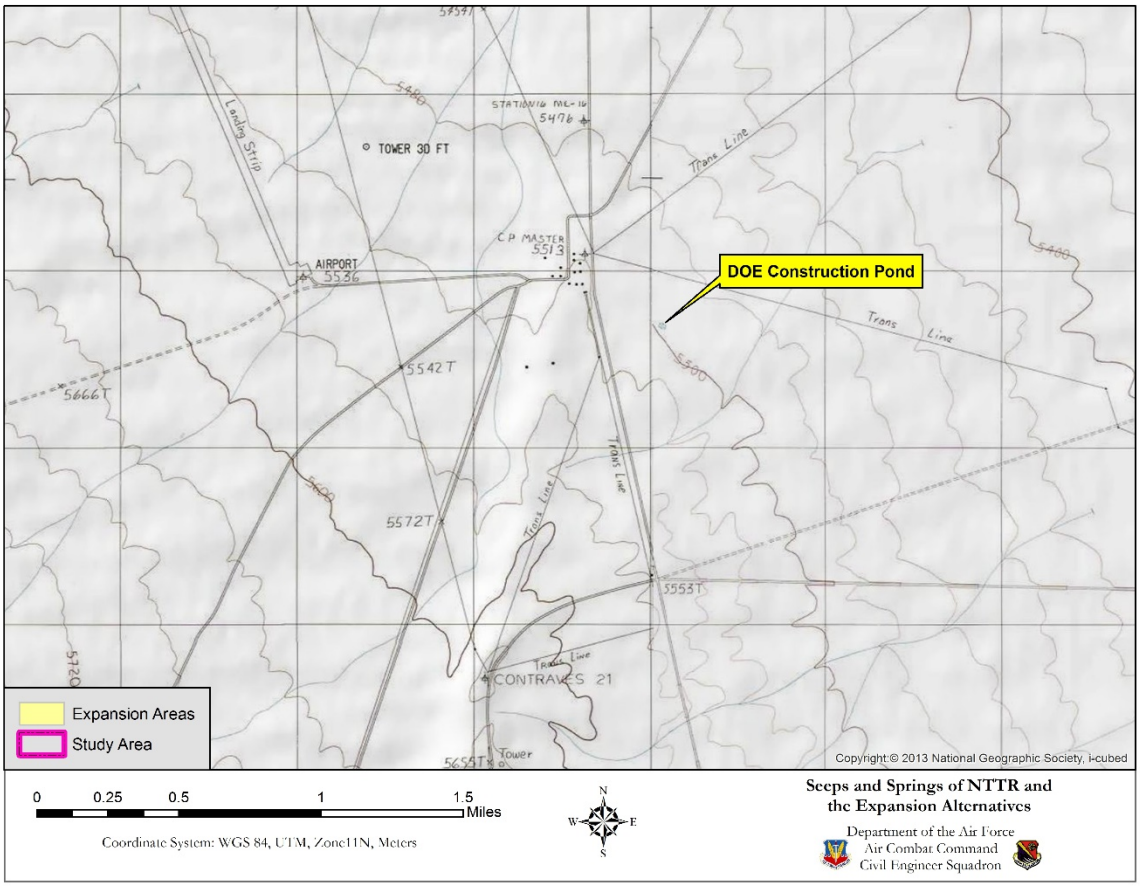


Figure 134. Topographic map showing the location of DOE Construction Pond.

Roller Coaster Construction Pond

Location: 523209 E 4174838 N
Elevation: 5,610 ft. MSL
Dominant Plants: Fremont cottonwood (*Populus fremontii*); softstem bulrush (*Schoenoplectus tabernaemontani*)

Roller Coaster Construction Pond is located east of the Cactus Mountain Range in Intermountain Cold Desert Scrub Key Habitat.



Roller Coaster Construction Pond

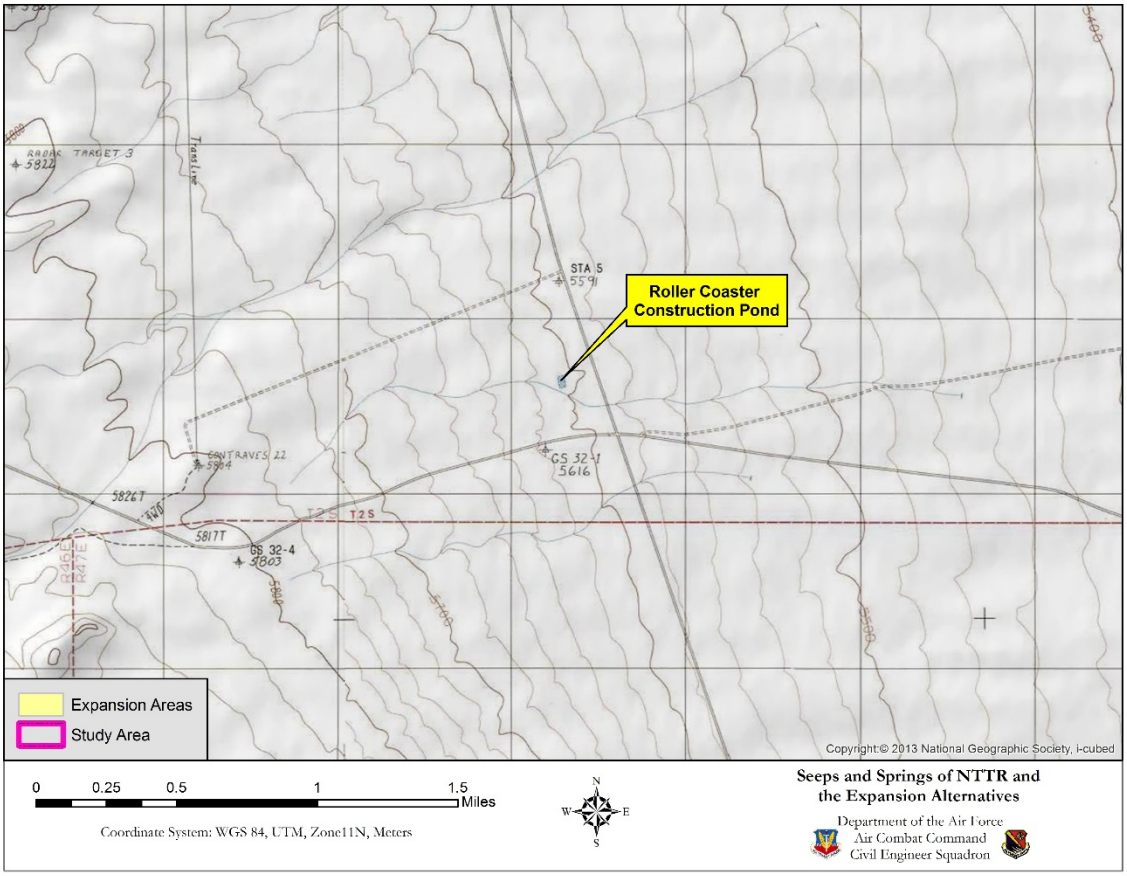


Figure 135. Topographic map showing the location of Roller Coaster Construction Pond.

Unnamed Spring

One unnamed spring is located within the boundaries of Expansion 3A (527741E 4103566N). This spring was not identified during the field surveys. No information was available for this spring, but it appears to be intermittent, based on the vegetation in the vicinity. Figure 137 is a topographic map showing the location of the spring and Figure 138 provides high resolution satellite imagery of the spring.

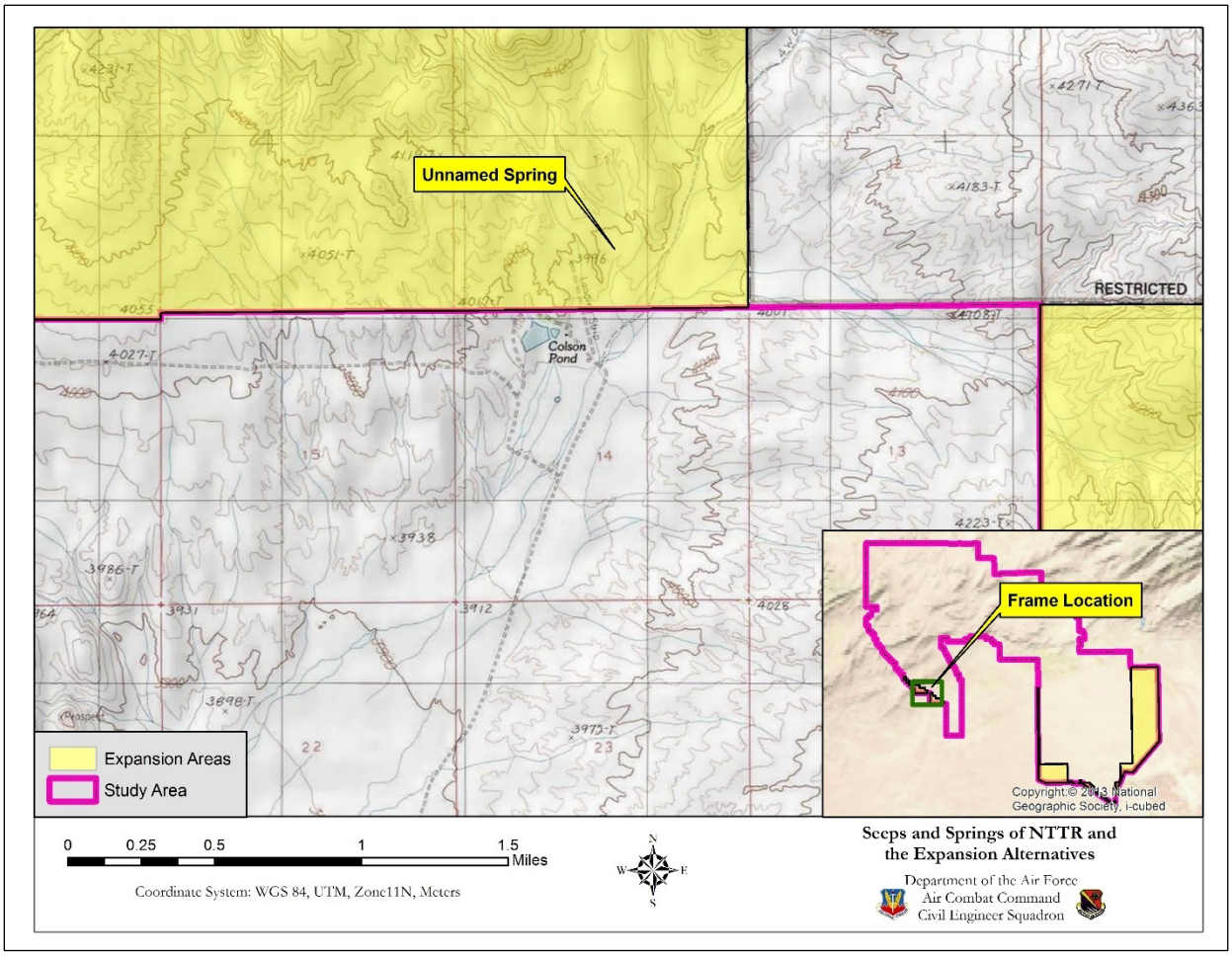


Figure 136. Location of an unnamed spring found in Proposed Alternative 3A.

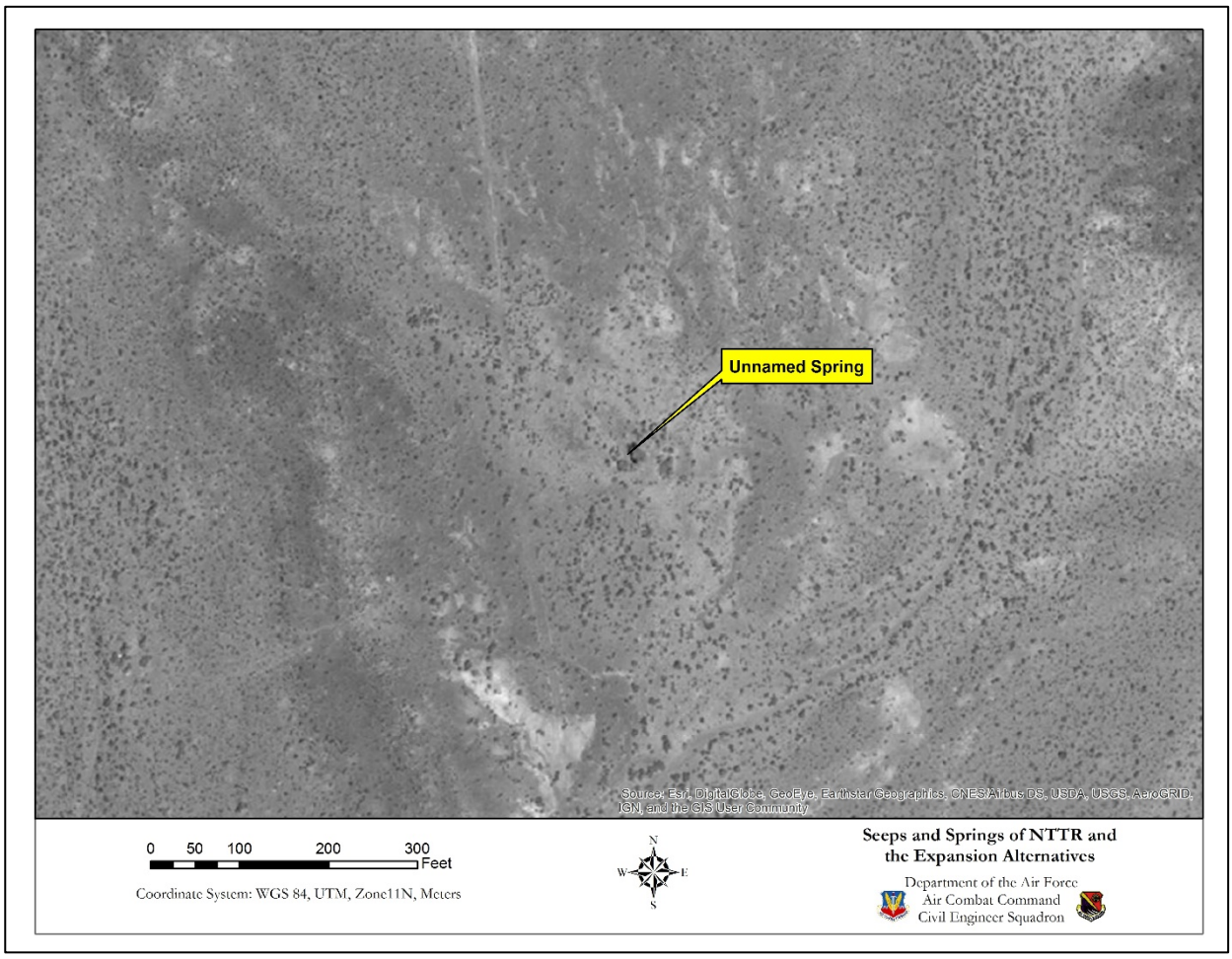


Figure 137. High resolution satellite imagery showing the location of an unnamed spring in Proposed Alternative 3A.

SPRINGS AND SEEPS OF EXPANSION ALTERNATIVE 3B

No seeps, springs or surface waters are located within the boundaries of Expansion 3B.

Sheep Perennial Spring

Location: 4084800 N 667769 E
Elevation: 5,511 ft. MSL
Dominant Plants: Desert almond (prunus fasciculata); apache plume (Fallugia paradoxa); cheatgrass (Bromus tectorum); beardless wildrye (Leymus triticoides)



Sheep Spring trough

Located in Alternative 3C, Sheep is a spring fed wildlife water development located in the northern region of the Sheep Mountain Range on the east border of Range Alamo B and Range Sally in Mojave Mid-Elevation Mixed Desert Scrub key habitat. This spring was originally developed for wildlife watering, which is what it is still used for today. In 1946, U.S Fish and Wildlife Service applied for a permit; in 1949 it was granted. Gravity feeds the water thru an 8 inch iron pipe that is connected to 20 feet of galvanized iron pipe which then takes the water to the trough. The allowed use totaled 0.723966 annual acre feet of water (0.001 cfs). This spring is widely used by various wildlife species.

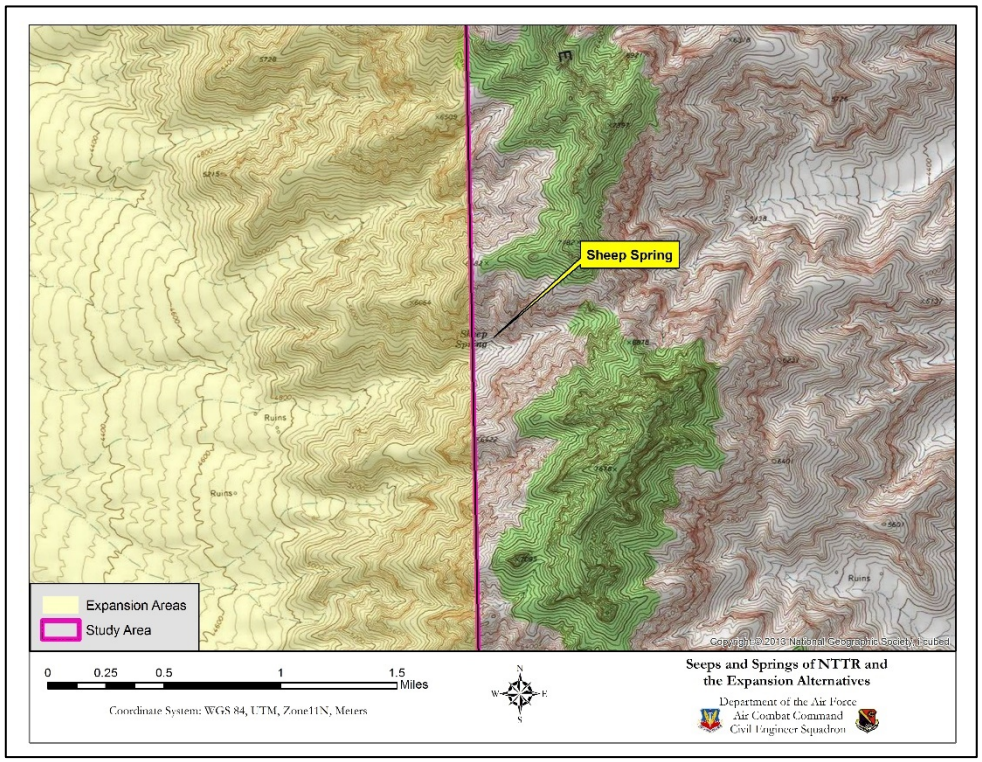


Figure 138. Topographic map showing the location of Sheep Spring.

Table 49. Results of field and laboratory analyses of water sampled at Sheep Spring on August 21, 2016.

NAME	MCL (mg/L)*	2016**
Chloride (mg/L)	400	9.55
Fluoride (mg/L)	4	ND
Nitrate/Nitrite (mg/L)	11	1.18
Sulfate (mg/L)	500	20.0
Aluminum (mg/L)	0.2	0.0594
Arsenic (mg/L)	0.01	0.00166
Calcium (mg/L)	-	32.1
Chromium (mg/L)	0.1	0.00696
Copper (mg/L)	1	ND
Iron (mg/L)	0.6	0.226
Lead (mg/L)	0.015	0.00164
Magnesium (mg/L)	150	41
Manganese (mg/L)	0.1	0.039
Sodium (mg/L)	-	6.66
Zinc (mg/L)	5	0.0154
Hardness (mg/L)	-	249
pH	6.5-8.5	7.3
Turbidity (NTU)	-	3.68
Dissolved Oxygen (%)	-	41
Conductivity (mS/cm)	-	0.45
Salinity (ppt)	-	0.24
Temperature of water (°C)	-	20.4

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV***
ND: Non-Detect

In 2016, Sheep Spring was analyzed in the field by Adams Ecology biologists for pH, temperature, conductivity, salinity, and dissolved oxygen. Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table are the results from both on-site and Silver State Laboratories analyses. All constituents measured for Sheep Spring were found to be below the MCL and pose no threat to wildlife. The spring should be monitored annually to ensure there are no increasing trends.

White Rock Spring

Location: 4063933 N 657246 E
Elevation: 5,917 ft. MSL
Dominant Plants: Fourwing saltbrush *(Atriplex canescens);* desert almond *(Prunus fasciculata);* cheatgrass *(Bromus tectorum)*



White Rock Spring

Located in Alternative 3C area, White Rock is a spring fed wildlife water development located in the southern region of the Sheep Mountain Range in the south corner of Range Alamo C in Mojave Mid-Elevation Mixed Desert Scrub key habitat. This spring was originally developed for watering 100 head of cattle. The allowed use totaled 2.172 annual acre feet of water (0.003 cfs). The orignal permit is held by Frank Allen who applied for the permit in 1913; the permit was issued in 1915; and then granted in 1942. Originally there were 3 troughs made out of logs that were filled by this spring. Each wood trough was between 14-16 feet long and 1.5-3 feet wide. Water was fed through 60 feet of pipe by gravity to get to these troughs. Today there is a re-purposed bathtub collecting the water for the wildlife to use.

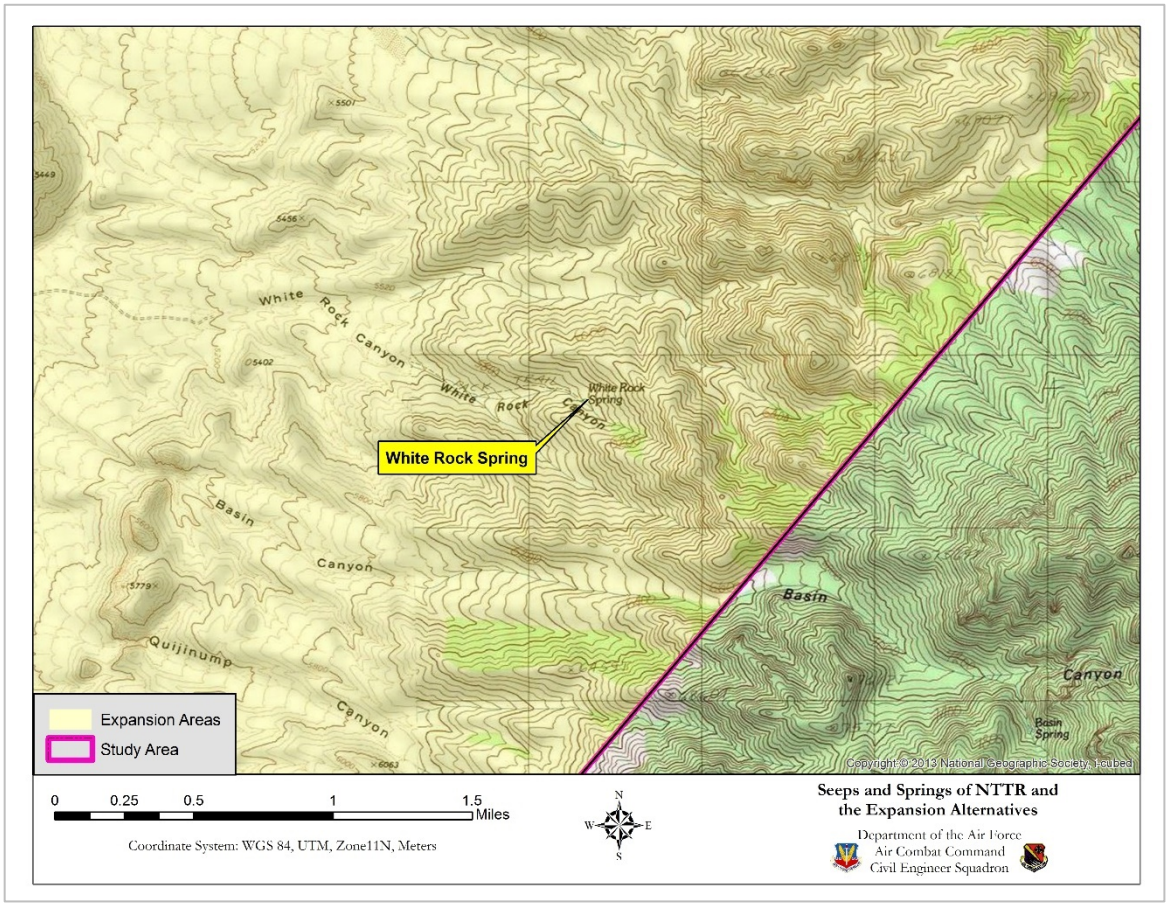


Figure 139. Topographic map showing the location of White Rock Spring.

Table 50. Results of field and laboratory analyses of water sampled at White Rock Spring on August 21, 2016. Constituents exceeding the MCL are highlighted in yellow.

NAME	MCL (mg/L)*	2016**
Chloride (mg/L)	400	9.88
Fluoride (mg/L)	4	0.151
Nitrate/Nitrite (mg/L)	11	0.512
Sulfate (mg/L)	500	10.2
Aluminum (mg/L)	0.2	0.317
Arsenic (mg/L)	0.01	0.00708
Calcium (mg/L)	-	47.5
Chromium (mg/L)	0.1	0.00611
Copper (mg/L)	1	0.00119
Iron (mg/L)	0.6	0.184
Lead (mg/L)	0.015	0.00255
Magnesium (mg/L)	150	34.2
Manganese (mg/L)	0.1	0.0179
Sodium (mg/L)	-	11.2
Zinc (mg/L)	5	0.264
Hardness (mg/L)	-	259
pH	6.5-8.5	7.7
Turbidity (NTU)	-	1.82
Dissolved Oxygen (%)	-	122
Conductivity (mS/cm)	-	0.454
Salinity (ppt)	-	0.23
Temperature of water (°C)	-	22

Las Vegas, NV Water District/US EPA Water Quality Standards (District, 2014 Water Quality Summary, 2014)
****Water samples were analyzed by Silver State Laboratory in Las Vegas, NV***
ND: Non-Detect

In 2016, White Rock Spring was analyzed in the field by Adams Ecology biologists for pH, temperature, conductivity, salinity, and dissolved oxygen. Water samples were collected according to standard protocol and transported to Silver State Laboratories for analysis. The above table are the results from both on-site and Silver State Laboratories analyses. All constituents, except aluminum and arsenic, measured for White Rock Spring were found to be below the MCL and pose no threat to wildlife. Aluminum usually does not pose threats to wildlife except at very high concentrations. At the concentrations found at this site, this constituent probably does not pose a problem for wildlife, but it should be monitored annually to ensure that it is not increasing over time.

Deadman Spring

Location: 4068072 N 659730 E
Elevation: 6,099 ft. MSL

Deadman Spring is located in the Sheep Mountain Range, within the Yellowjacket Canyon in Alamo C, near the southeast boundary. Located in Alternative 3C, the key habitat for this spring is Mojave Mid-Elevation Mixed Desert Scrub with Lower Montane Woodland closely bordering the spring.

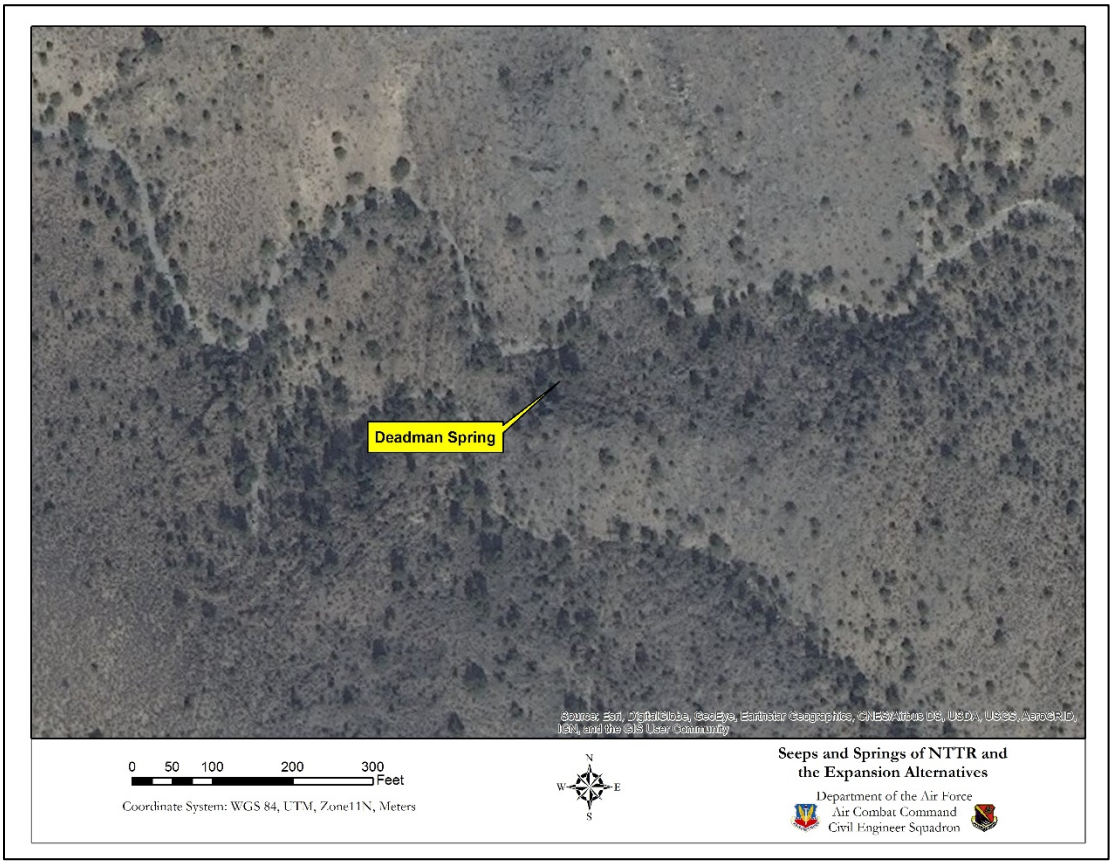


Figure 140. High resolution satellite imagery showing the location of Deadman Spring and the surrounding environment.

Dry Lake Spring

Location: 4091590 N 664410 E
Elevation: 4,343 ft. MSL

Located in Alternative 3C, Dry Lake Spring is located in the northern region of the Sheep Mountain Range along the northeast border of Alamo B in Cliffs and Canyons key habitat. The spring is surrounded by a plant community dominated by *Prunus fasciculata.*

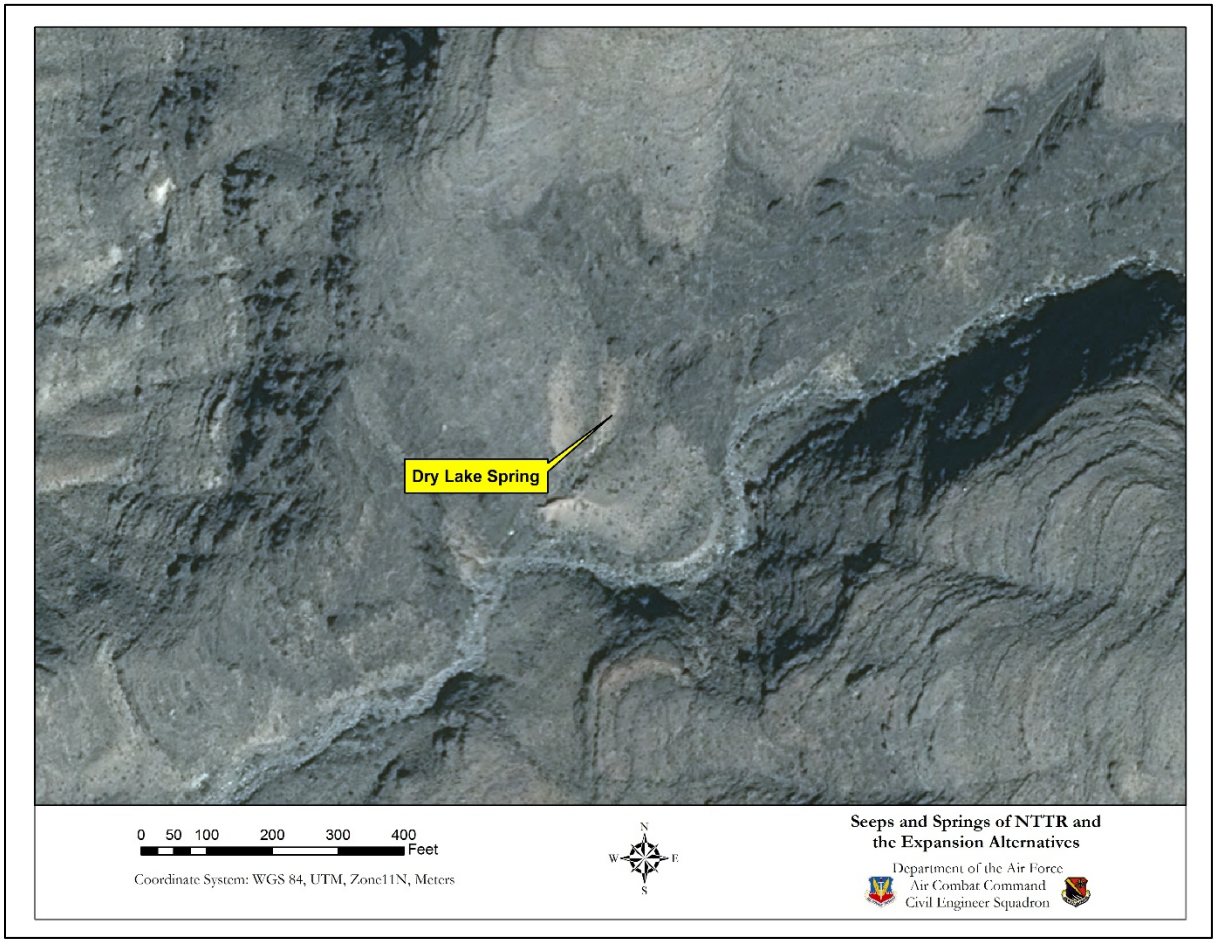


Figure 141. High resolution satellite imagery showing the location of Dry Lake Spring and the surrounding environment.

Lower Lake Spring

Location: 4118004 N 665451 E
Elevation: 3,930 ft. MSL

Located in Alternative 3C, Lower Lake Spring is a spring located in the southern region of the east Pahranagat Mountain Range on the northeast corner border of Alamo C in Mojave Mid-Elevation Mixed Desert Scrub key habitat.

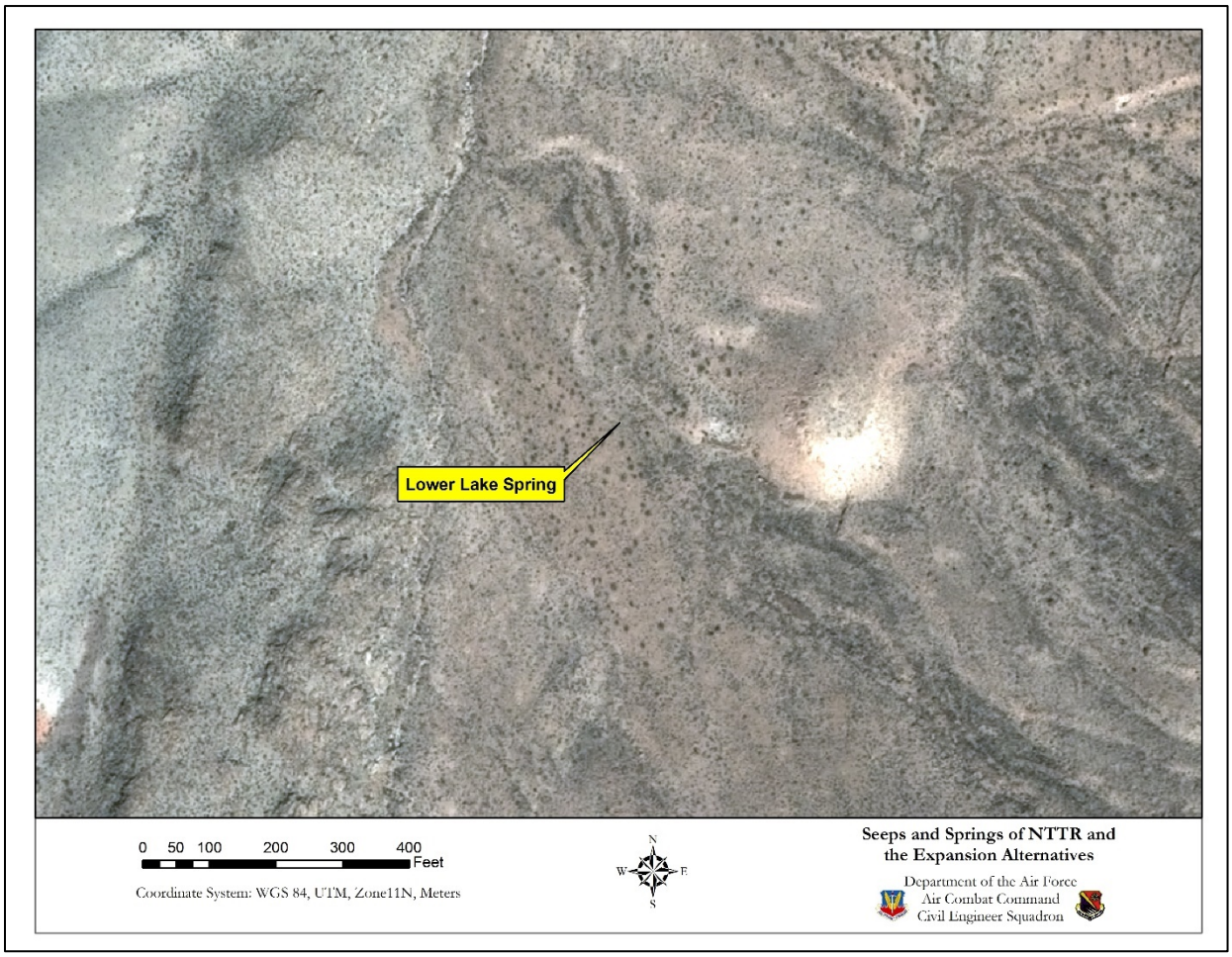


Figure 142. High resolution satellite imagery showing the location of Lower Lake Spring and the surrounding environment.

Three ephemeral surface waters are located in the dry lake located in the center of Proposed Alternative 3C (Figures 117-120). These waters were not surveyed in the field, but appear to be manmade catchments that accumulate water originating from storm events. These surface waters probably provide a temporary source of water for wildlife and vegetation after storm events. Satellite imagery indicates that the vegetation around the surface water features is probably mesic and dominated by *Suaeda moquinii and Atriplex canescens.*

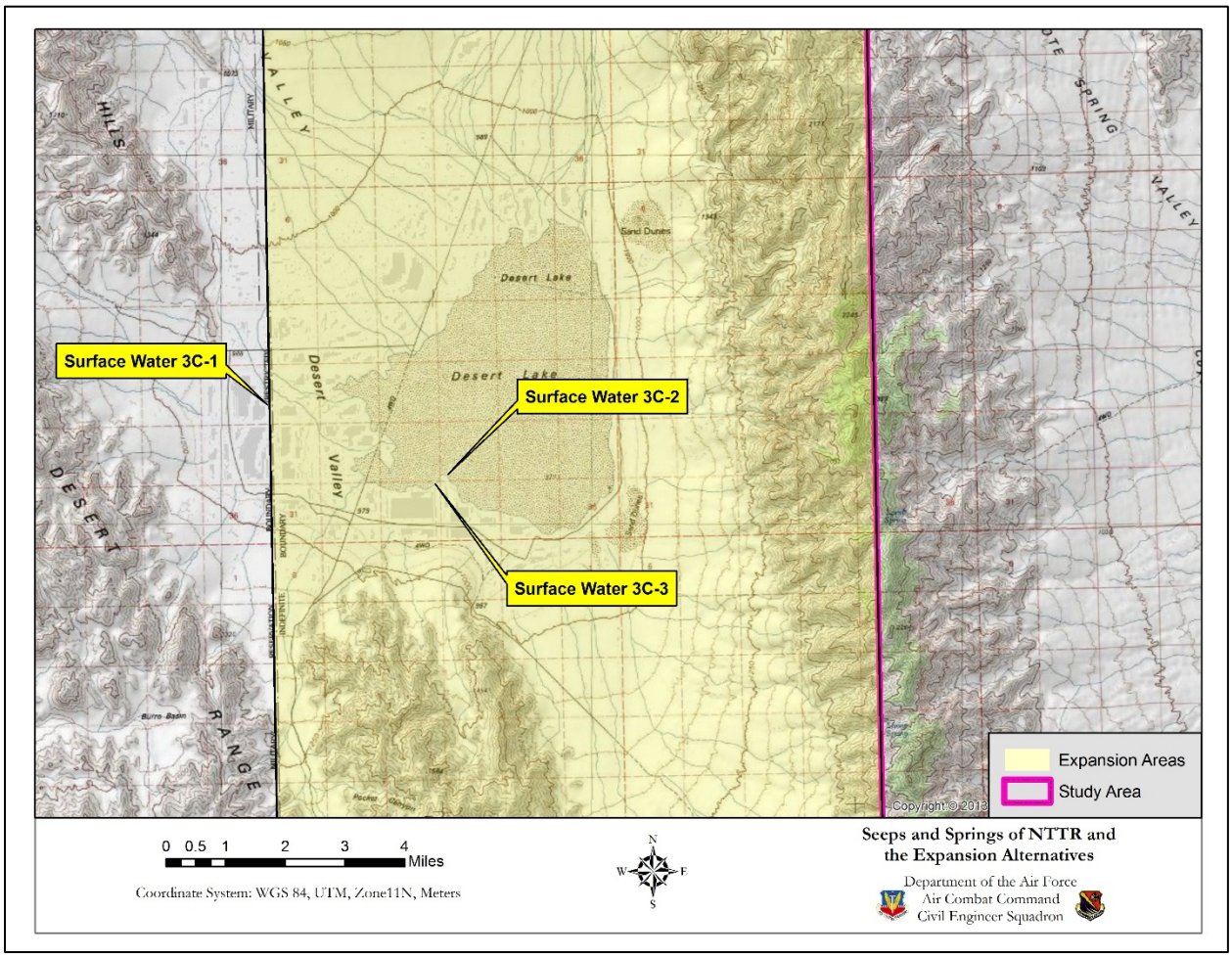


Figure 143. Topographic map showing the location of surface waters located in the dry lake in Alternative 3C.

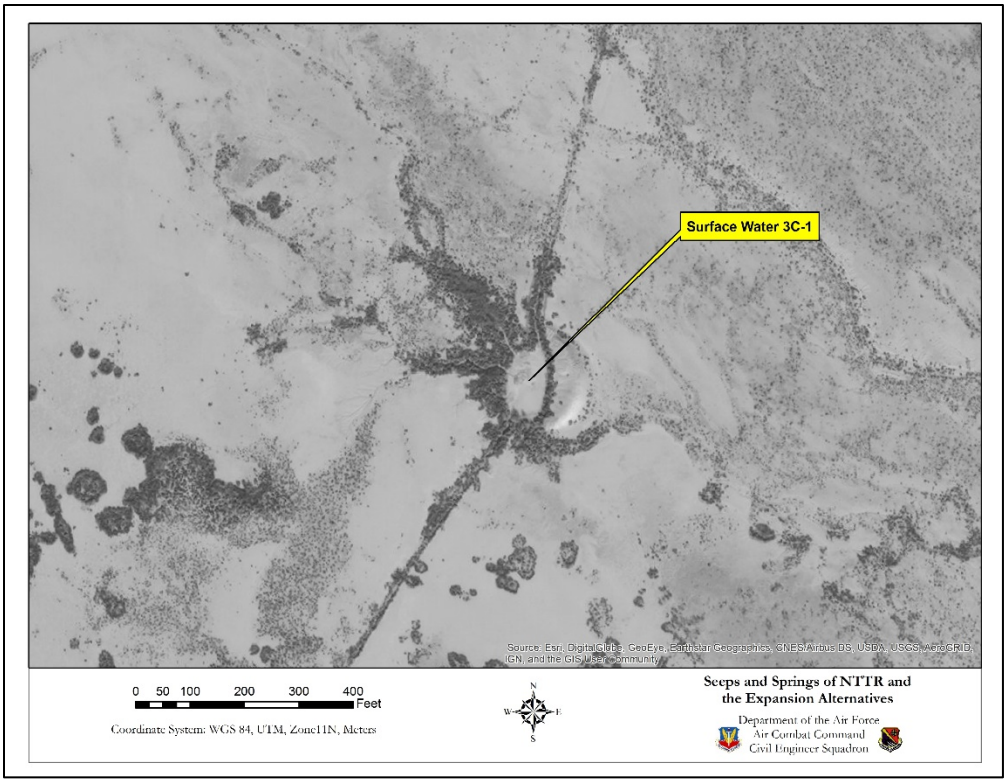


Figure 144. High resolution satellite imagery showing the location of Surface Water 3C-1 in Proposed Alternative 3C.

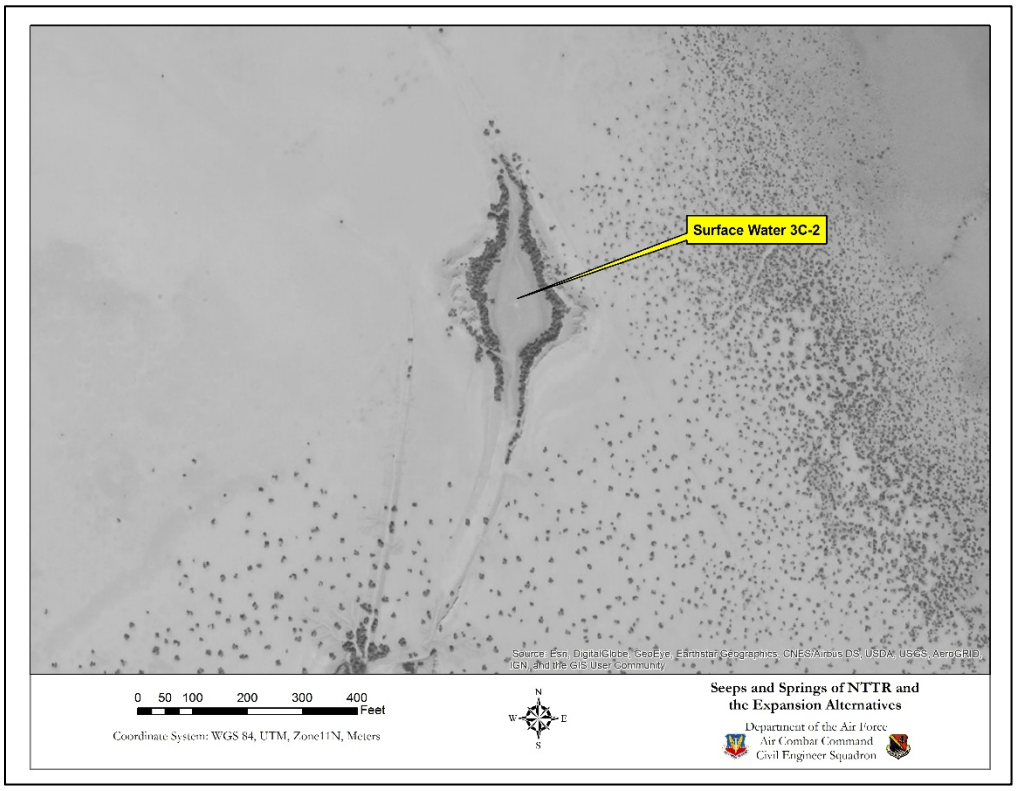


Figure 145. High resolution satellite imagery showing the location of Surface Water 3C-2 in Proposed Alternative 3C.

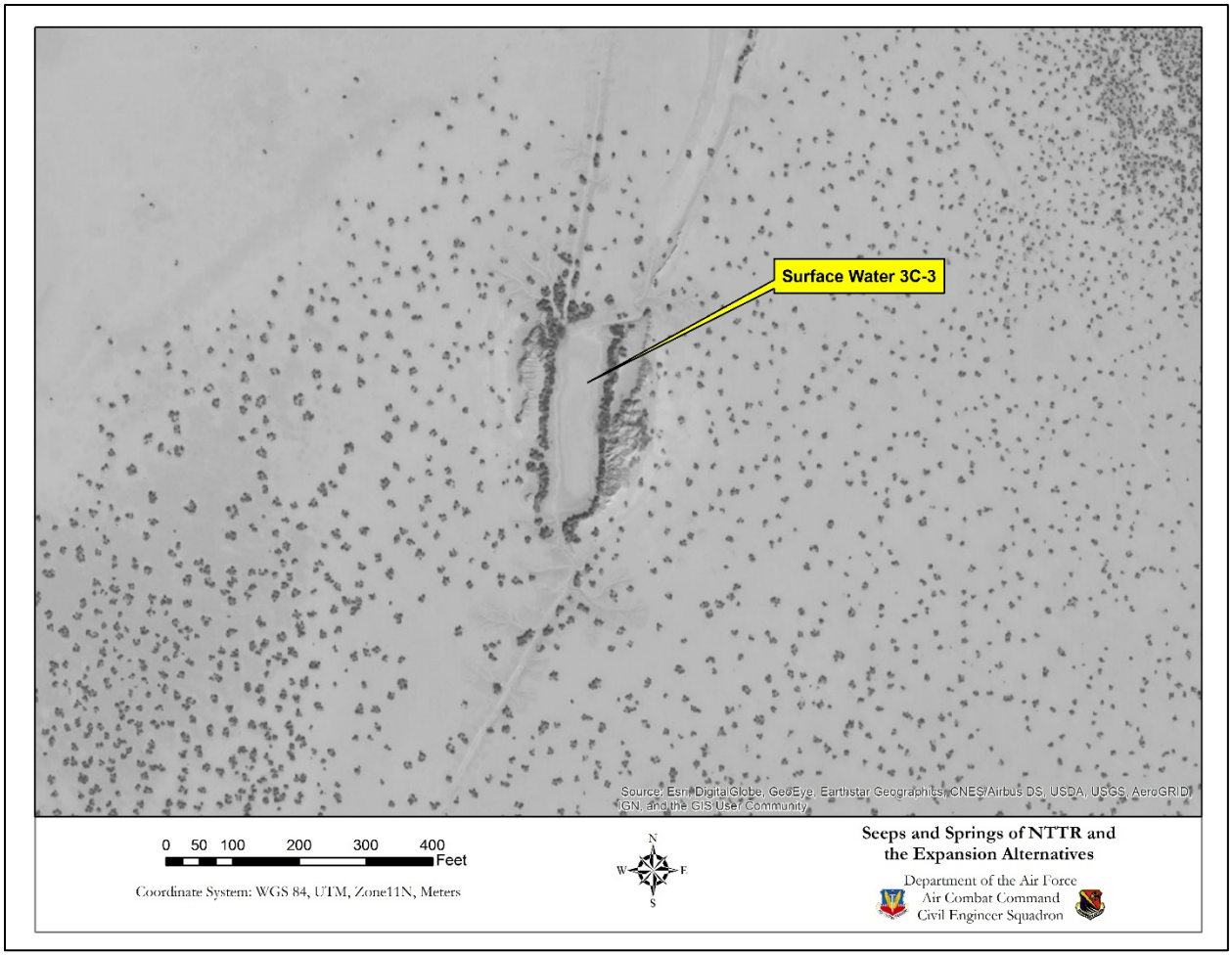


Figure 146. High resolution satellite imagery showing the location of Surface Water 3C-3 in Proposed Alternative 3C.

The location of new seeps and springs identified by satellite imagery in 2013 are shown in Figure 117. These seeps and springs should be surveyed again in the future to confirm their status and provide more detailed characterization. All of the water features are named by a spring number and have not been officially named until their status is confirmed. Other features may be observed in the imagery for each of the springs in the pages that follow, but those have either been previously identified or were ruled out as a seep or spring in this study.

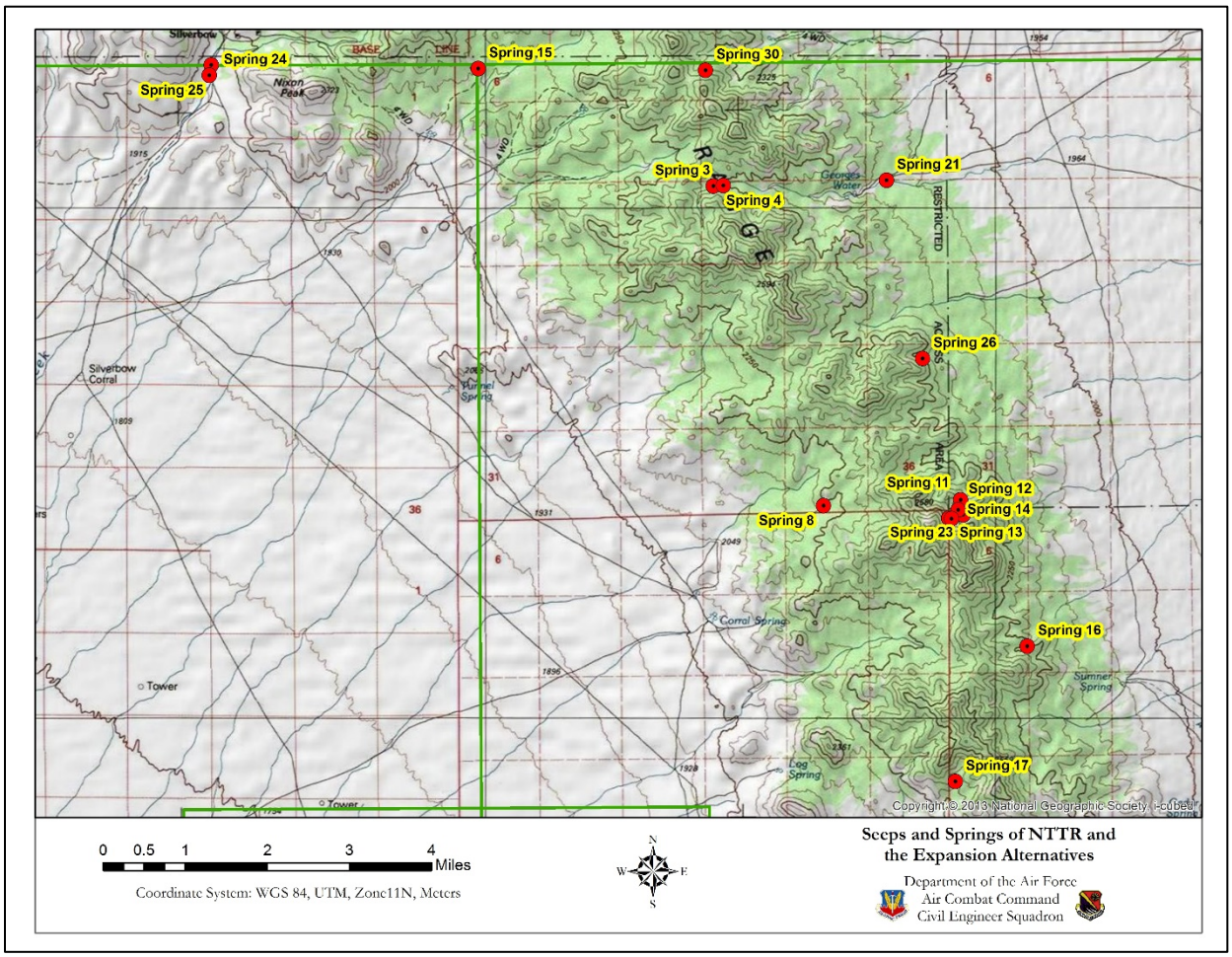


Figure 147. Location of seeps and springs identified and characterized during ground truth surveys for potential water features located by false color satellite imagery.

Spring 3

Location: 554400 E 4190633 N
Elevation: 7436 ft. MSL
Dominant Plants: Geyer Willow (*Salix geyeriana*)

Spring 3 is located due west of George's Water on the Kawich Mountain Range. It was characterized as an intermittent seep dominated by Geyer willows. The seep was surrounded by a plant community dominated by pinyon pines (*Pinus monophylla*). Pines located in the seep were dead, which is indicative of a recently established shallow water table.



Spring 3 as observed in September 2013

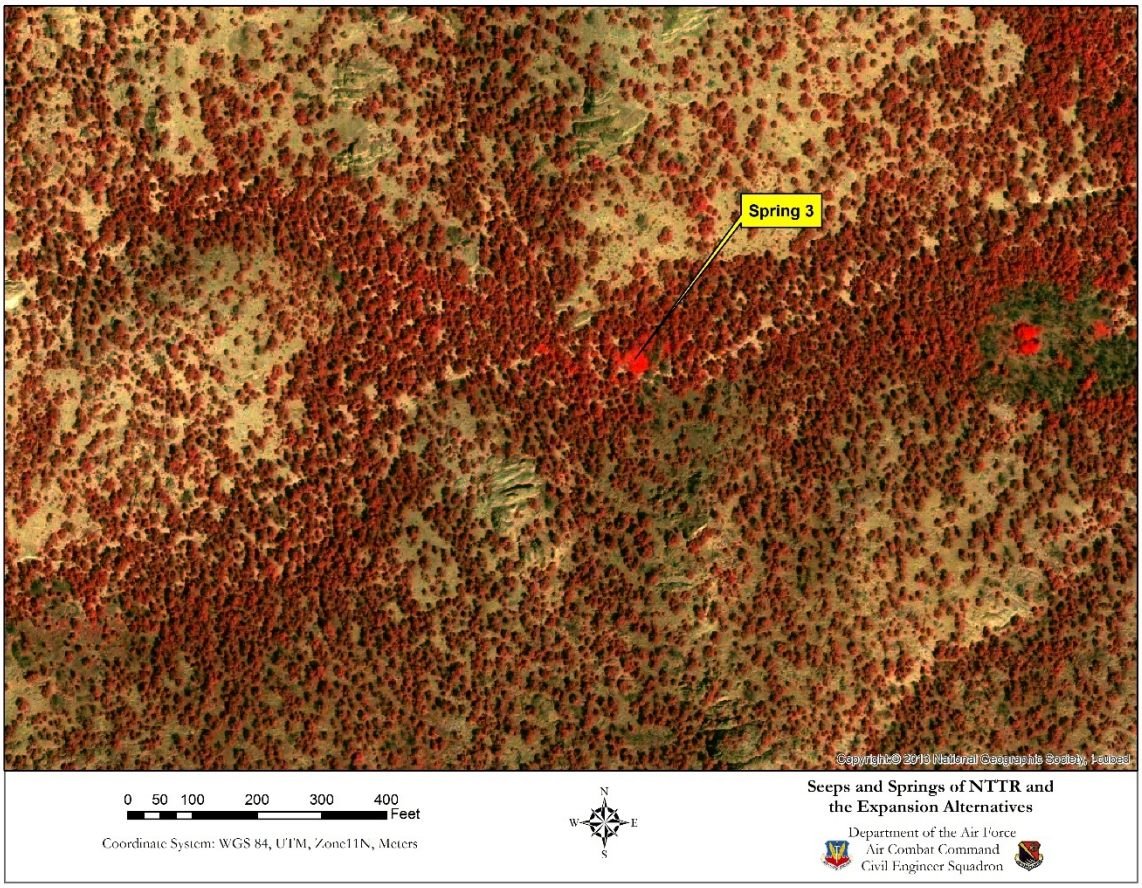


Figure 148. False color high resolution satellite imagery showing the location of Spring 3 in the Kawich Range.

Spring 4

Location: 554596 E 4190642 N
Elevation: 7480 ft. MSL
Dominant Plants: Beardless wildrye (*Leymus triticoides*)

Spring 4 is located due west of George's Water on the Kawich Mountain Range about 650 ft. east of Spring 3. It was characterized as an intermittent seep dominated by beardless wildrye. The seep was surrounded by a plant community dominated by pinyon pines (*Pinus monophylla*). Like Spring 3, pines located in the seep were dead, which is indicative of a recently established shallow water table.



Spring 4 as observed in September 2013

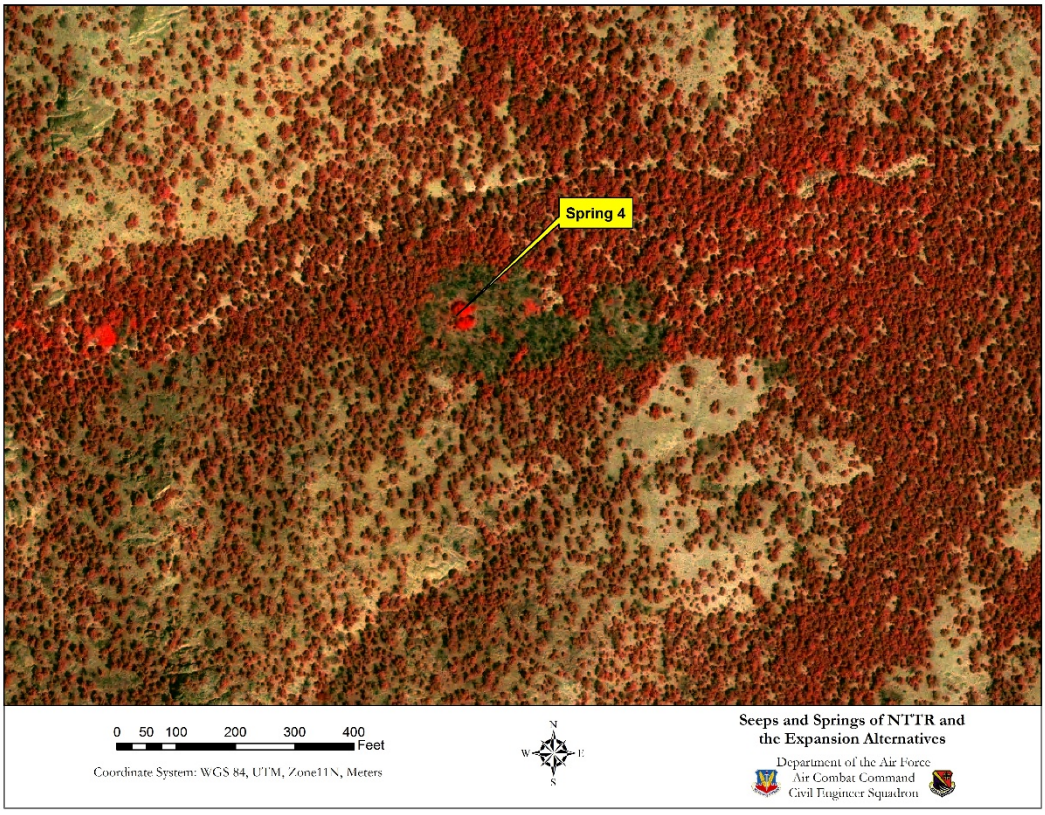


Figure 149. False color high resolution satellite imagery showing the location of Spring 4 in the Kawich Range.

Spring 8

Location: 556563 E 4184359 N
Elevation: 7232 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*), beardless wildrye (*Leymus triticoides*), rubber rabbitbrush (*Ericameria nauseosa*)

Spring 8 is located on the western side of the Kawich Mountain Range. This intermittent seep lies within a plant community dominated by Geyer willow, a facultative wetland species, and beardless wildrye. A photo of this spring was not taken during the survey.

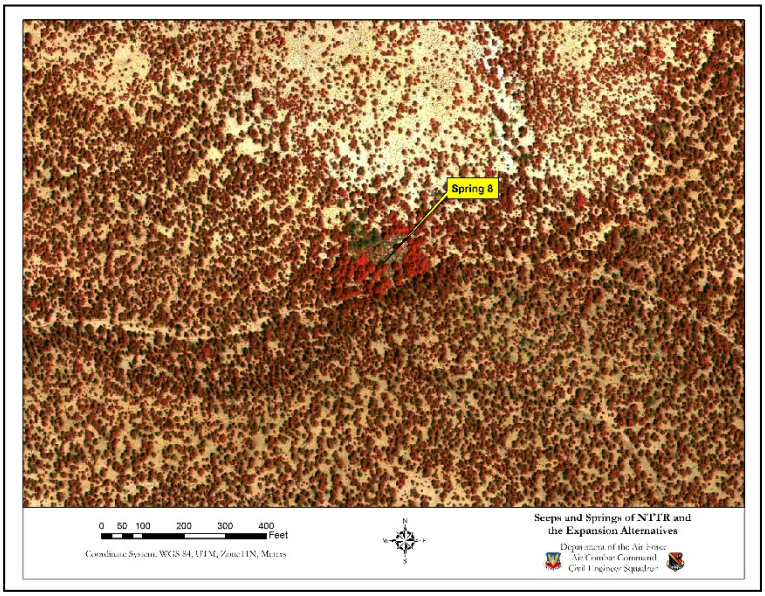


Figure 150. False color high resolution satellite imagery showing the location of Spring 8 in the Kawich Range.

Spring 11

Location: 559255 E 4184475 N
Elevation: 7612 ft. MSL
Dominant Plants: Geyer Willow (*Salix geyeriana*)

Spring 11 is located on the eastern side of the ridgeline of the Kawich Range near four additional seep/spring locations. This appears to be an intermittent seep dominated by Geyer willow. A photograph was not taken of this seep during the September 2013 survey.

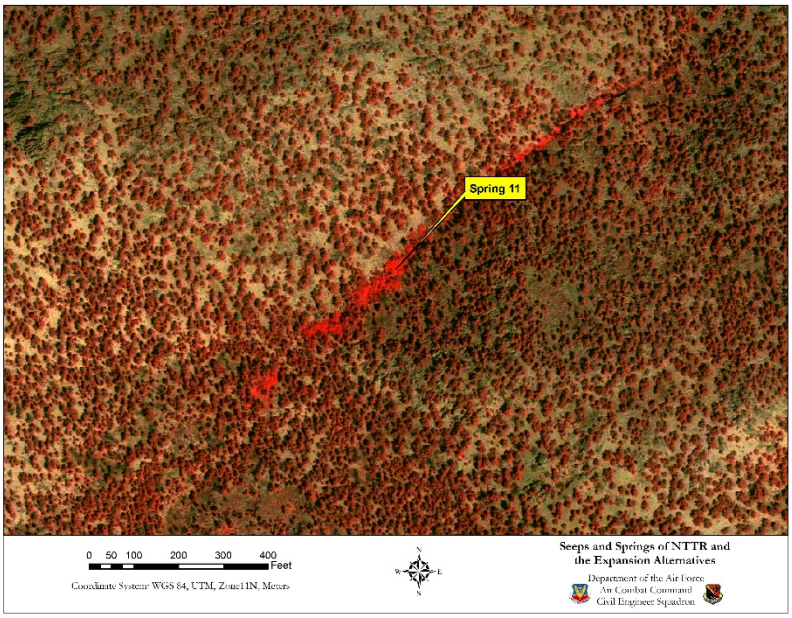


Figure 151. False color high resolution satellite imagery showing the location of Spring 11 in the Kawich Range.

Spring 12

Location: 559302 E 4184182 N
Elevation: 7872 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*), beardless wildrye (*Leymus triticoides*), serviceberry (*Amelanchier sp.*)

Spring 12 is located on the eastern side of the Kawich Mountain Range near four additional seep/spring locations. The water feature appears to be an intermittent seep dominated by spikerush, a facultative wetland plant, as well as mesic vegetation including beardless wildrye and serviceberry. This indicates that the area supports wet conditions for a sufficient period of time to establish a stand of spikerush. No photograph was taken of this seep during the September 2013 survey.

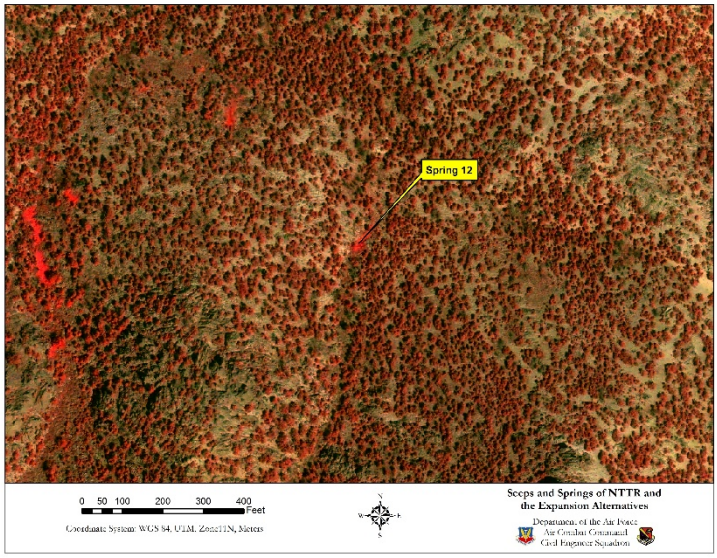


Figure 152. False color high resolution satellite imagery showing the location of Spring 12 in the Kawich Range.

Spring 13

Location: 559021 E 4184115 N
Elevation: 7993 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*), sedges (*Juncus spp.*)

Spring 13 is located on the eastern side of the ridgeline of the Kawich Mountain Range near four additional seep/spring locations. Like Spring 12, Spring 13 appears to be an intermittent seep dominated by spikerush and sedges; species indicative of wetland habitat which supports the identification of this as an intermittent seep. No photographs were taken of this seep during the September 2013 survey.

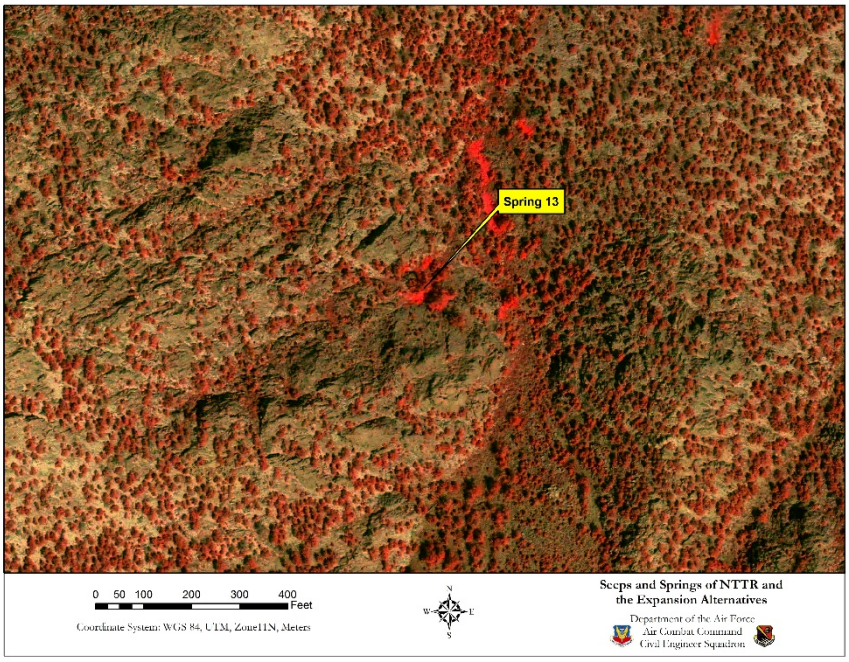


Figure 153. False color high resolution satellite imagery showing the location of Spring 13 in the Kawich Range.

Spring 14

Location: 559073 E 4184104 N
Elevation: 7961 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*), sedges (*Juncus spp.*)

Spring 14 is located on the eastern side of the ridgeline of the Kawich Mountain Range near Spring 13. This seep is dominated by spikerush and sedges, species indicative of wetland habitat characterizing this water feature as an intermittent seep, since no standing water was observed during the survey. No photographs were taken of this seep during the September 2013 survey.

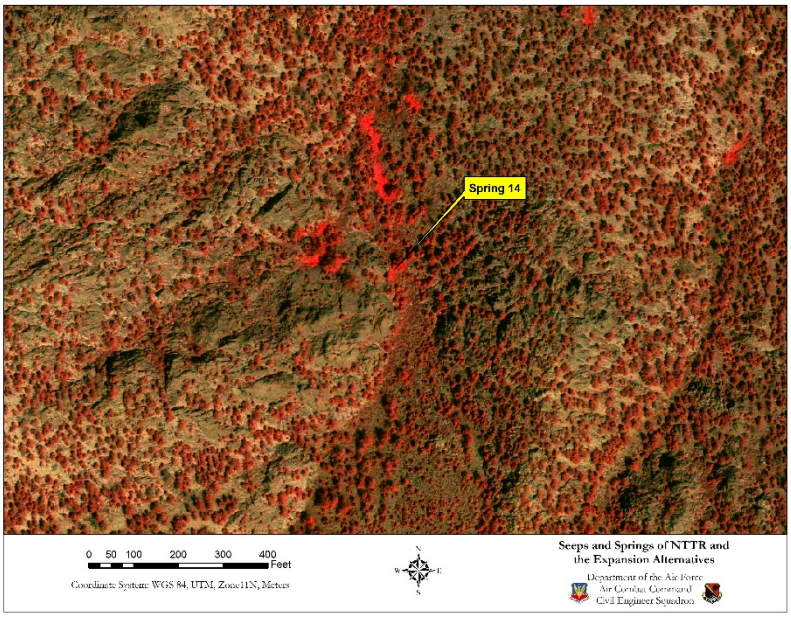


Figure 154. False color high resolution satellite imagery showing the location of Spring 14 in the Kawich Range.

Spring 15

Location: 549788 E 4192933 N
Elevation: 6911 ft. MSL
Dominant Plants: Narrowleaf willow (*Salix exigua*)

Spring 15 is located within the Kawich Mountain Range. The seep is dominated by narrowleaf willow, a species indicative of wetland habitat and, subsequently the identification of this water feature as an intermittent seep. No standing water was observed during the survey and no photographs were taken of the seep.

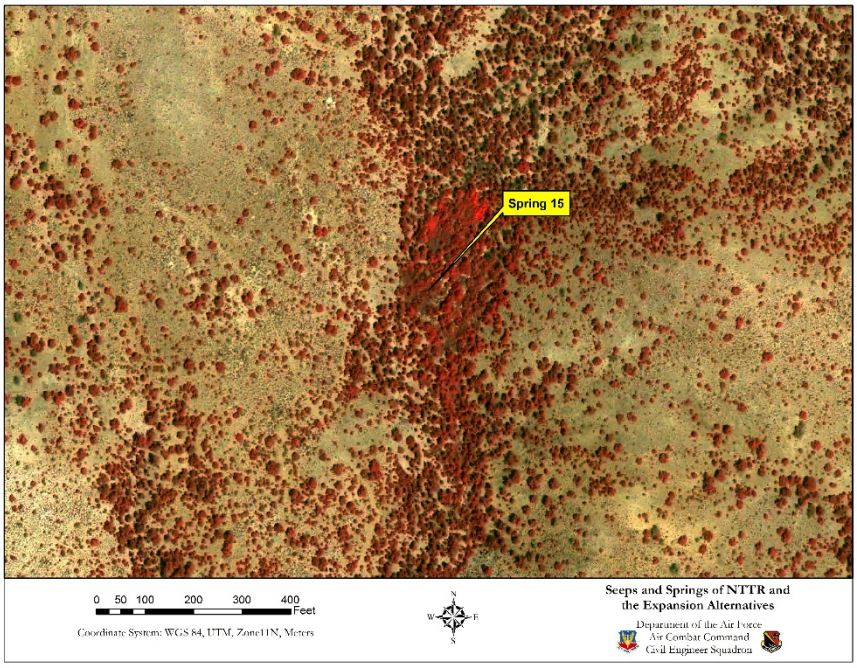


Figure 155. False color high resolution satellite imagery showing the location of Spring 15 in the Kawich Range.

Spring 16

Location: 560562 E 4181607 N
Elevation: 7282 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*)

Spring 16 is located northwest of Sumner Spring on the eastern Kawich Mountain Range ridgeline in Range EC East. The seep is dominated by Geyer willow, a species indicative of wetland habitat. No standing water or saturated soils were observed indicating that the seep is intermittent.



Spring 16 in 2013

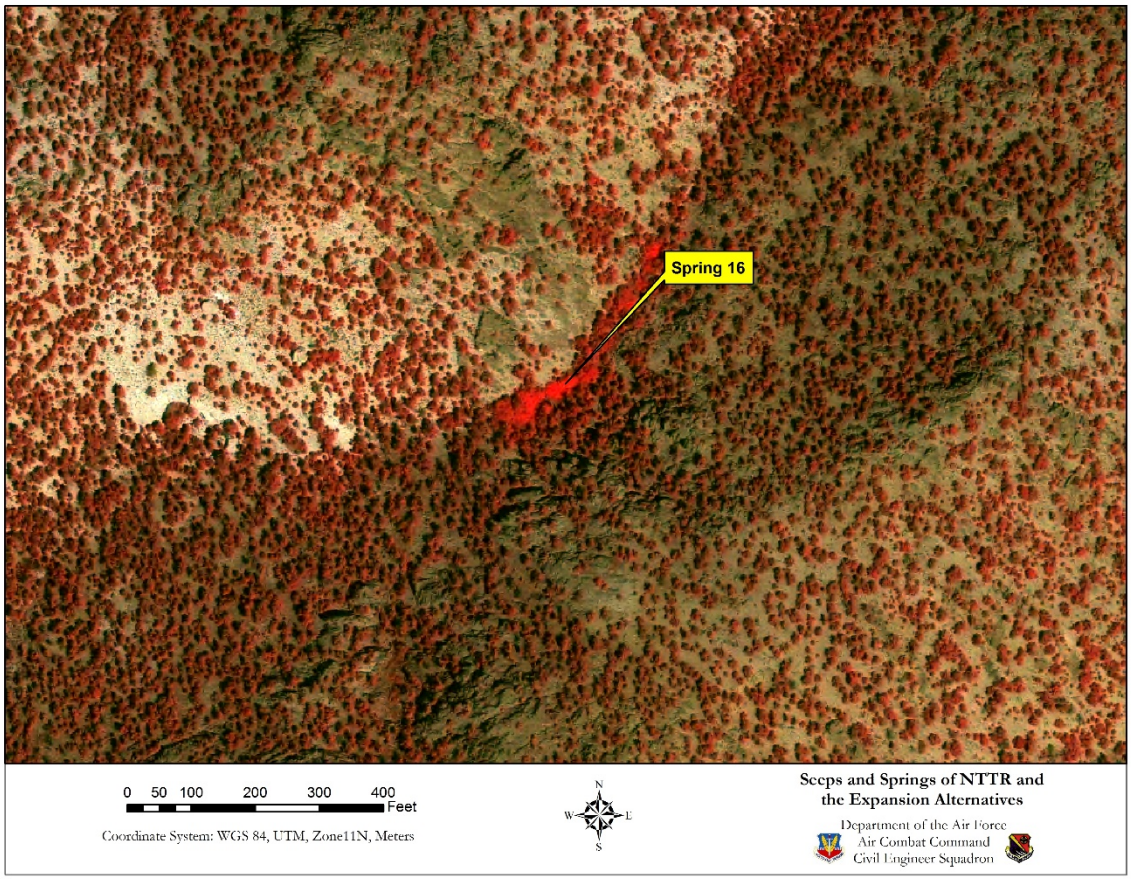


Figure 156. False color high resolution satellite imagery showing the location of Spring 16 in the Kawich Range.

Spring 17

Location: 559148 E 4178952 N
Elevation: 7642 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*)

Spring 17 lies due north of Rose Spring at the southern end of the Kawich Mountain Range in Range EC East. The seep is dominated by Geyer willow, a species common to wetland habitat. Because no standing water or saturated soils were observed, the seep was characterized as intermittent.



Spring 17 in 2013

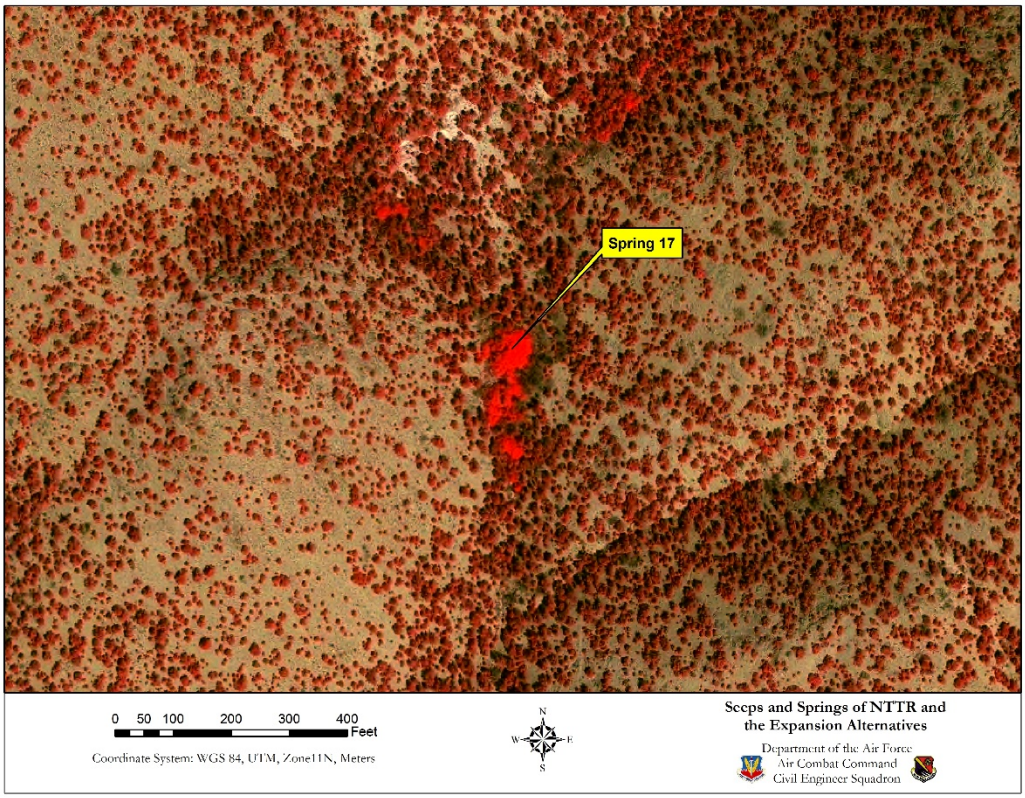


Figure 157. False color high resolution satellite imagery showing the location of Spring 17 in the Kawich Range.

SPRING 21

Location: 557794 E 4190739 N
Elevation: 6799 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*), big sagebrush (*Artemisia tridentata*)

Spring 21 is located downstream of George's Water to the east in the Kawich Mountain Range. The spring is dominated by Geyer willow, a species indicative of wetland habitat, with big sagebrush dominating the area surrounding the seep. This seep may be hydrologically connected to George's Water. Because no saturated soils or standing water was observed during the September 2013 survey, it was determined that the seep was intermittent.



Spring 21 in 2013

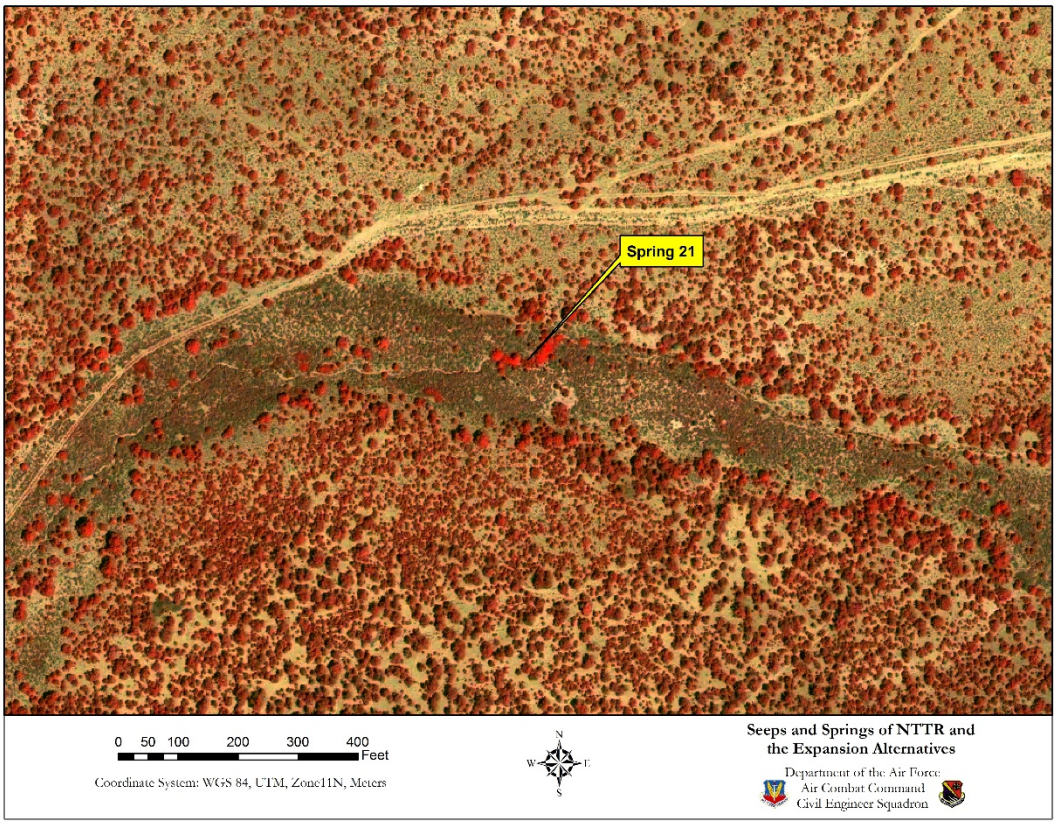


Figure 158. False color high resolution satellite imagery showing the location of Spring 21 in the Kawich Range.

Spring 23

Location: 559207 E 4184282 N
Elevation: 7829 ft. MSL
Dominant Plants: Spikerush (*Eleocharis sp.*), beardless wildrye (*Leymus triticoides*), wild mint (*Mentha arvensis*)

Spring 23 is located on the eastern side of the ridgeline of the Kawich Mountain Range. The spring is dominated by spikerush and wild mint, both of which are facultative wetland plants, and beardless wildrye, a facultative plant. Water was observed in this water feature and it was determined to be a spring.



Spring 23 in 2013

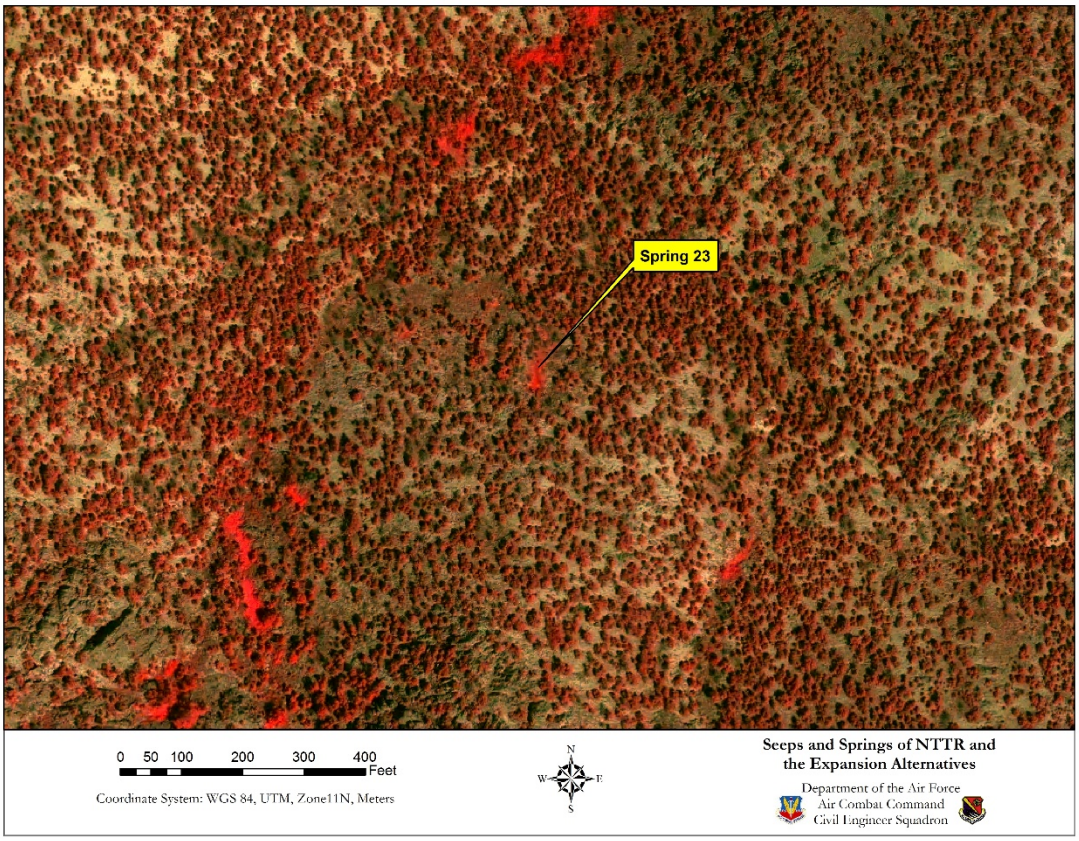


Figure 159. False color high resolution satellite imagery showing the location of Spring 23 in the Kawich Range.

Spring 24

Location: 544556 E 4193001 N
Elevation: 6435 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*), narrowleaf willow (*Salix exigua*)

Spring 24 lies along Breen Creek on the northern boundary of NTTR. The water feature is dominated by Geyer willow and narrowleaf willow; species indicative of wetland habitat. No water was observed at the time of the survey, but evidence indicates that it flows intermittently, probably in the spring. It was determined to designate the feature as an intermittent spring.



Spring 24 in 2013

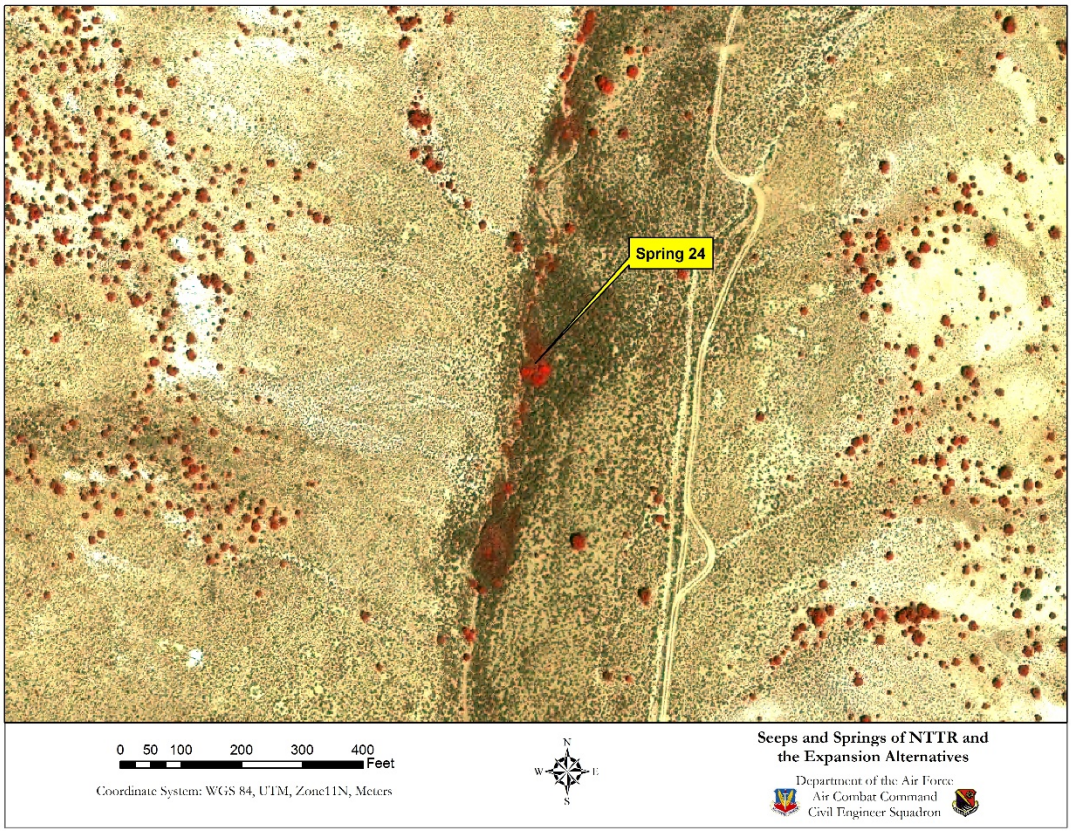


Figure 160. False color high resolution satellite imagery showing the location of Spring 24 in the Kawich Range.

Spring 25

Location: 544515 E 4192816 N
Elevation: 6425 ft. MSL
Dominant Plants: Geyer willow (*Salix geyeriana*), narrowleaf willow (*Salix exigua*)

Spring 25 lies along Breen Creek south of Spring 24. The water feature is dominated by Geyer willow and narrowleaf willow; both species indicative of wetland habitat. No water was observed during the survey and it was determined that the water feature was an intermittent spring.



Spring 25 in 2013

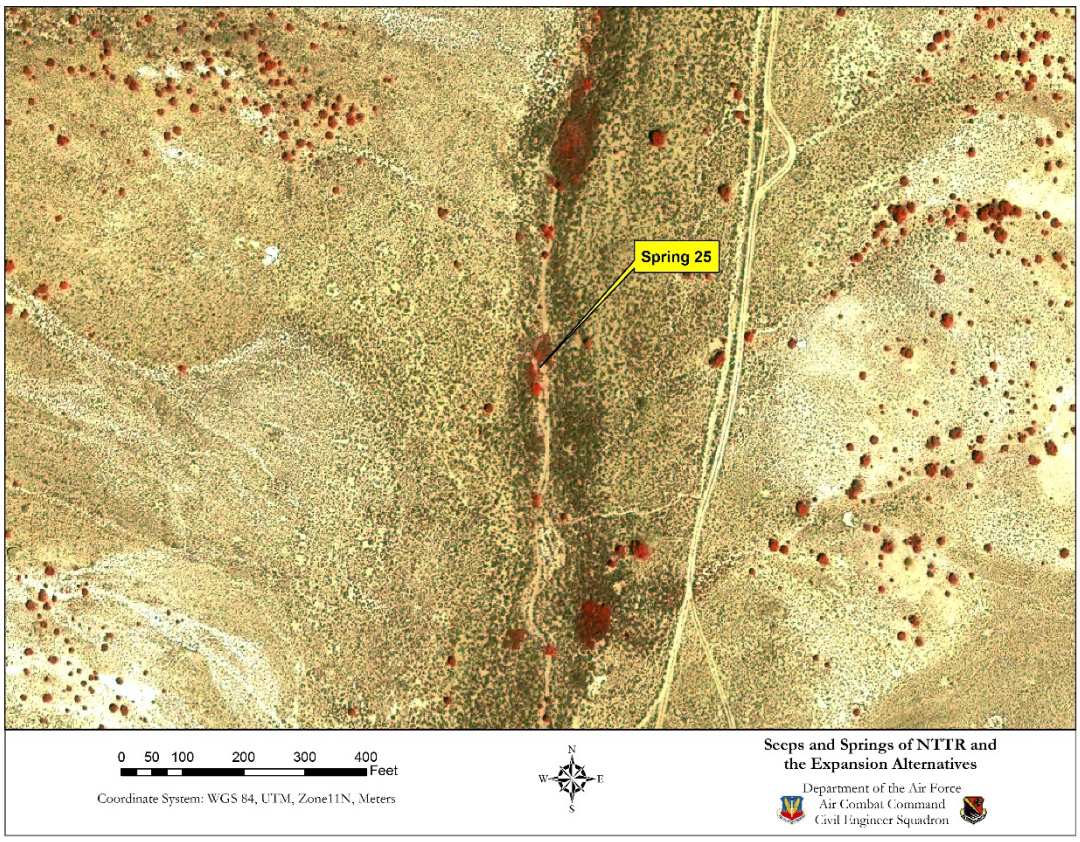


Figure 161. False color high resolution satellite imagery showing the location of Spring 25 in the Kawich Range.

Spring 26

Location: 558508 E 4187249 N
Elevation: 7295 ft. MSL
Dominant Plants: Unidentified grasses, rushes (*Juncus spp.*), sedges (*Carex spp.*)

Spring 26 is located on the eastern side of the Kawich Mountain Range ridgeline. The feature is a perennial spring with water flowing from the base of a nearby cliff. Dominant plants include grasses, rushes, and sedges indicative of wetland habitat. The presence of wetland plants and flowing water determined this feature to be a perennial spring.



Spring 26 in 2013

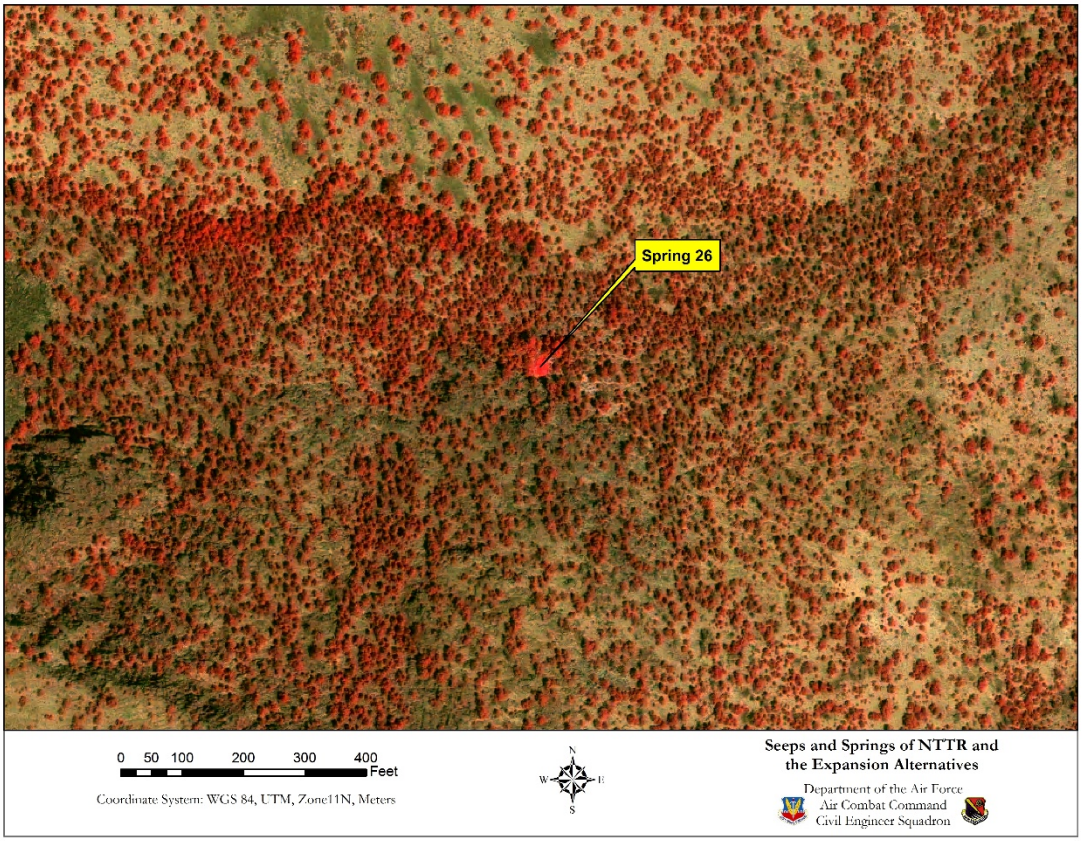


Figure 162. False color high resolution satellite imagery showing the location of Spring 26 in the Kawich Range.

Spring 30

Location: 554248 E 4192903 N
Elevation: 7662 ft. MSL
Dominant Plants: Serviceberry (*Amelanchier sp.*), willow (*Salix sp.*)

Spring 30 is located along the Kawich Range near the NTTR northern boundary. The seep is dominated by willow and serviceberry vegetation, both a sign of moist soils. Because no standing water or saturated soils were observed, it was determined that the feature was an intermittent seep.

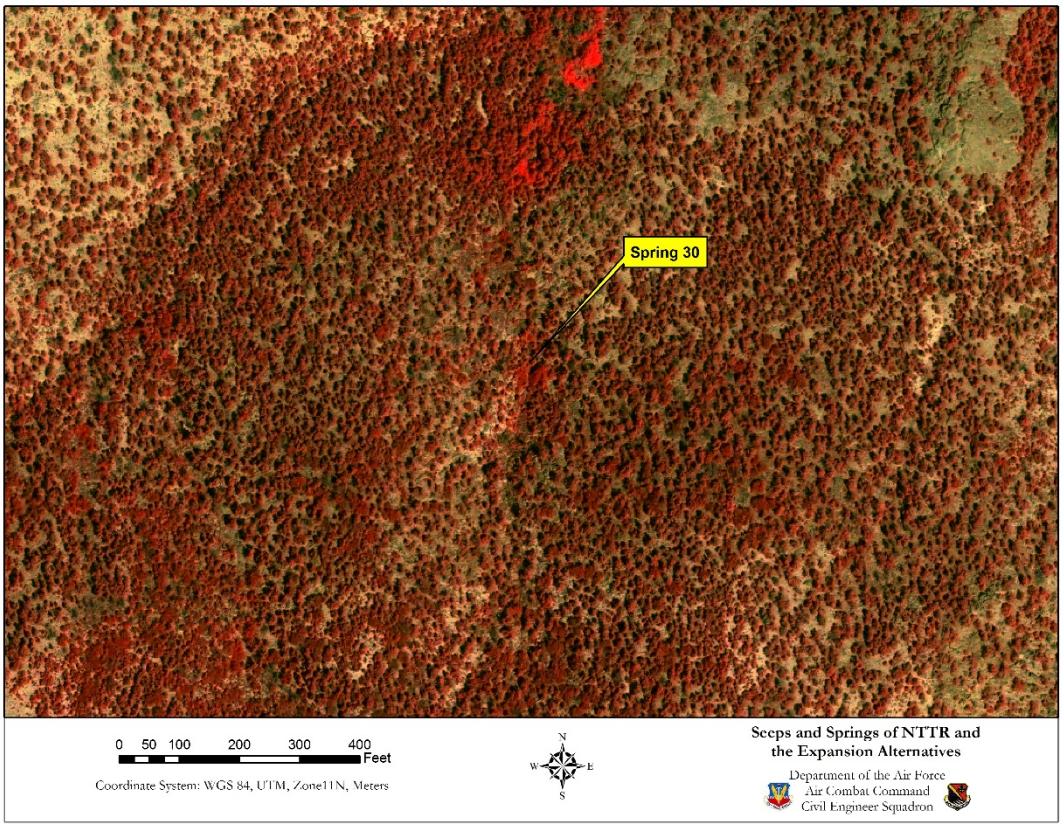


Figure 163. False color high resolution satellite imagery showing the location of Spring 30 in the Kawich Range.

Wildlife water developments or guzzlers are man-made structures generally constructed to accumulate, store and distribute rain water for use by wildlife, especially desert bighorn sheep. Wildlife water developments may also be used to supplement a spring water source or provide better access or storage of water for that source. For the purposes of this report, significant springs considered wildlife water developments are listed with springs and labelled as developed springs. The water for these developments accumulates in a variety of different water catchment systems. Some systems use a polyethylene synthetic rubber (Hypalon) apron, others use a large metal apron, while others use corrugated steel and some use natural slick rock to collect the water. The collected water is gravity fed into storage tanks. Water is then dispensed into a small trough for use by wildlife. These structures are found on the South Range Study Area where they are specifically designed to provide water for desert bighorn sheep.



Polyethylene synthetic rubber apron used to collect rain water for the Foggy Wildlife Water Development on the South Range of NTTR.



Tanks typically used to store water collected from storm events for wildlife water developments.



Typical water trough used to dispense water from the tanks for use by wildlife.

Below is a map of all the wildlife water developments within NTTR and the proposed expansion alternatives. Please note that no wildlife water developments have been constructed on the North Range Project Area as of 2016.

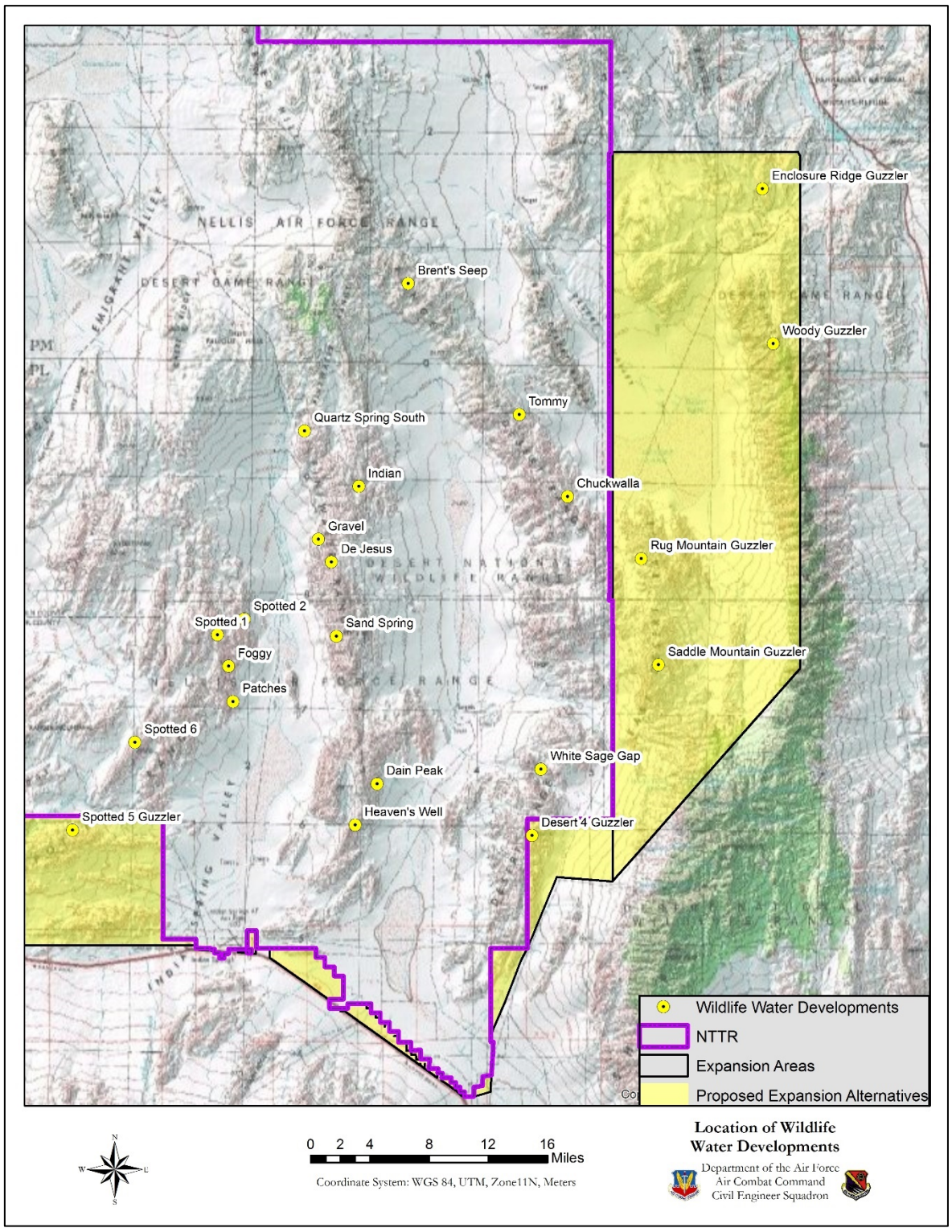


Figure 164. Location of wildlife water developments on the southern project area.

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Lichvar, R., Finnegan, D., Ericsson, M., & Ochs, W. (2006). *Distribution of Ordinary High Water Mark (OHWM) Indicators and Their Reliability in Identifying the Limits of "Waters of the United States" in Arid Southwestern Channels.* U.S. Army Corps of Engineers.

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APPENDIX A

REFERENCE MATERIAL

- **PLAYA METHODOLOGY AND CURVE NUMBER DETERMINATION**
- **EQUATION 613 LAG TIME (HC&DDM)**
- **FIGURE B-2 APPROXIMATE GEOGRAPHIC BOUNDARIES FOR NRCS (SCS) RAINFALL DISTRIBUTIONS**
- **SECTION 503 (HC&DDM)**
- **STANDARD 24-HOUR NRCS RAINFALL DISTRIBUTIONS (TR-55)**
- **TABLE 604 LAG EQUATION ROUGHNESS FACTORS (HC&DDM)**
- **TABLE 702 MANNING'S ROUGHNESS COEFFICIENTS FOR CHANNEL LINING TYPES (HC&DDM)**
- **TABLE 2-1 RUNOFF DEPTH FOR SELECTED CN'S AND RAINFALL AMOUNTS (TR-55)**

S.O. No. 20713-0-0-86SR1

Subject: Nellis AFR - Nevada

Floodplain Inventory

Dry Lake Beds

Sheet No. 1 of 6

Drawing No.

Computed by BWP Checked By LAH Date 7/2/96

Rev GAH 1/27/97 CFC/01/28/97

Baker

Methodology for Dry Lake Beds

1. Use USGS Quadrangle maps (1:100,000 scale) to delineate dry lake bed watersheds
2. Use NOAA Atlas 2, Volume III for Nevada to determine rainfall for 100-year frequency storm event.
3. Use SCS Methodology to determine runoff volume
4. Use USGS Quadrangle maps (1:24,000 scale) to delineate flood boundaries for dry lake bed ponding.
5. Use 100-year, 24-hour rainfall event to estimate runoff volume,
6. 100-year, 24-hour precipitation = 2.6 inches (Average for watershed Fig. 30, NOAA Atlas 2)

* Same methodology utilized for this study, but using updated information. GIS base maps and NOAA Atlas 14 Volume 1 precipitation data.

S.O. No. _____

Subject: Nellis AFR - Nevada
Flood plain Inventory
Dry Lake Beds

Sheet No. 2 of 6

Drawing No. _____

Computed by BWP Checked By LAD Date 7/2/96
Rev. GAH 1/21/97 GFC 1/23/97

Baker

Calculations to determine volume of flow to dry lake beds are based on watershed areas to dry lake bed multiplied by surface water runoff depth (inches) for the 100-year, 24-hour storm event. Surface water runoff depth is based on the SCS curve number and rainfall. To determine the SCS curve number for dry lake bed watersheds, an average curve number based on the hydrologic soil groups and land uses/vegetation of the various regions in north and south ranges of the Nellis Air Force Range was determined as follows:

Hydrologic Soil Groups for the area were identified as:

- Dry Lake Beds = C or D (due to fine-grained, compacted hard, sun-baked deposits in dry lake beds.)
- Collectors/Overland Areas = B or C (due to higher permeability of coarse, granular material in these areas).

Land Uses/Vegetation:

Land use of the Nellis Air Force Range is primarily undeveloped with minor exceptions for buildings and roads for base use. Vegetation varies from grasses and sage brush in the lower elevations to pinyon pines and juniper in some mountainous regions. Much of the vegetation is overgrazed resulting in poor hydrologic conditions. Some areas are bare soil due over-grazing. There is no vegetation in dry lake beds. Southern range also have cactus in addition to

desert grasses due to the more arid conditions near Las Vegas area. Some mountainous areas are bare rock.

Approximation of Curve Numbers:

Land Use	Hyd. Soil Group B	Hyd. Soil Group C	Hyd. Soil Group D
Desert Brush (poor)	80	87	90
Sage Brush (poor)	67	78	83
Pinyon/Juniper (poor)	75	83	87
Bare Rock	96	96	96
Bare Soil	86	91	94

From the above curve numbers, an average curve number of 85 was considered to be most representative of the overall watershed area.

Using the curve number (85) and the rainfall for the 100-year, 24-hour storm event (2.8 inches), runoff is estimated to be 1.42 inches (attached Table 2.1).

To determine the runoff volume, each dry lake bed drainage area was multiplied by the runoff depth of 1.42 inches or 0.12 feet. The dry lake bed watershed areas and estimated runoff volumes are presented in Table 2-1 of this report. The resulting flood boundaries were delineated on the appropriate USGS 7.5' quadrangle maps (Appendix B of this report).

Referenced curve number (CN) value.

2. At a given point on a stream, discharge ordinates of different unit graphs of the same unit time of rainfall excess are mutually proportional to respective volumes.

3. A hydrograph of storm discharge that would result from a series of bursts of excess rain or from continuous excess rain of variable intensity may be constructed from a series of overlapping unitgraphs each resulting from a single increment of excess rain of unit duration.

606.3 Lag Time

Input data for the SCS Dimensionless Unit Hydrograph method (SCS, 1985) consists of a single parameter, TLAG, which is equal to the lag (in hours) between the center of mass of rainfall excess and the peak of the unit hydrograph. For small drainage basins (less than 1 sq mi) in the Clark County area, the lag time may be related to the time of concentration, t_c, by the following empirical relationship:

$$TLAG = 0.6\ t_c \qquad (612)$$

The t_c is computed as presented in Section 602.

For larger drainage basins (greater than 1 sq mi), the lag time (and t_c) is generally governed mostly by the concentrated flow travel time, not the initial overland flow time. In addition, as the basin gets increasingly larger, the average flow velocity (and associated travel time) becomes more difficult to estimate. Therefore, for these basins, the following lag equation is recommended for use in computing TLAG:

Equation used for Tlag Calculations

$$TLAG = 20\ K_n\ (L\ L_c / S^{0.5})^{0.33} \qquad (613)$$

where K_n = Manning's Roughness Factor for the Basin Channels

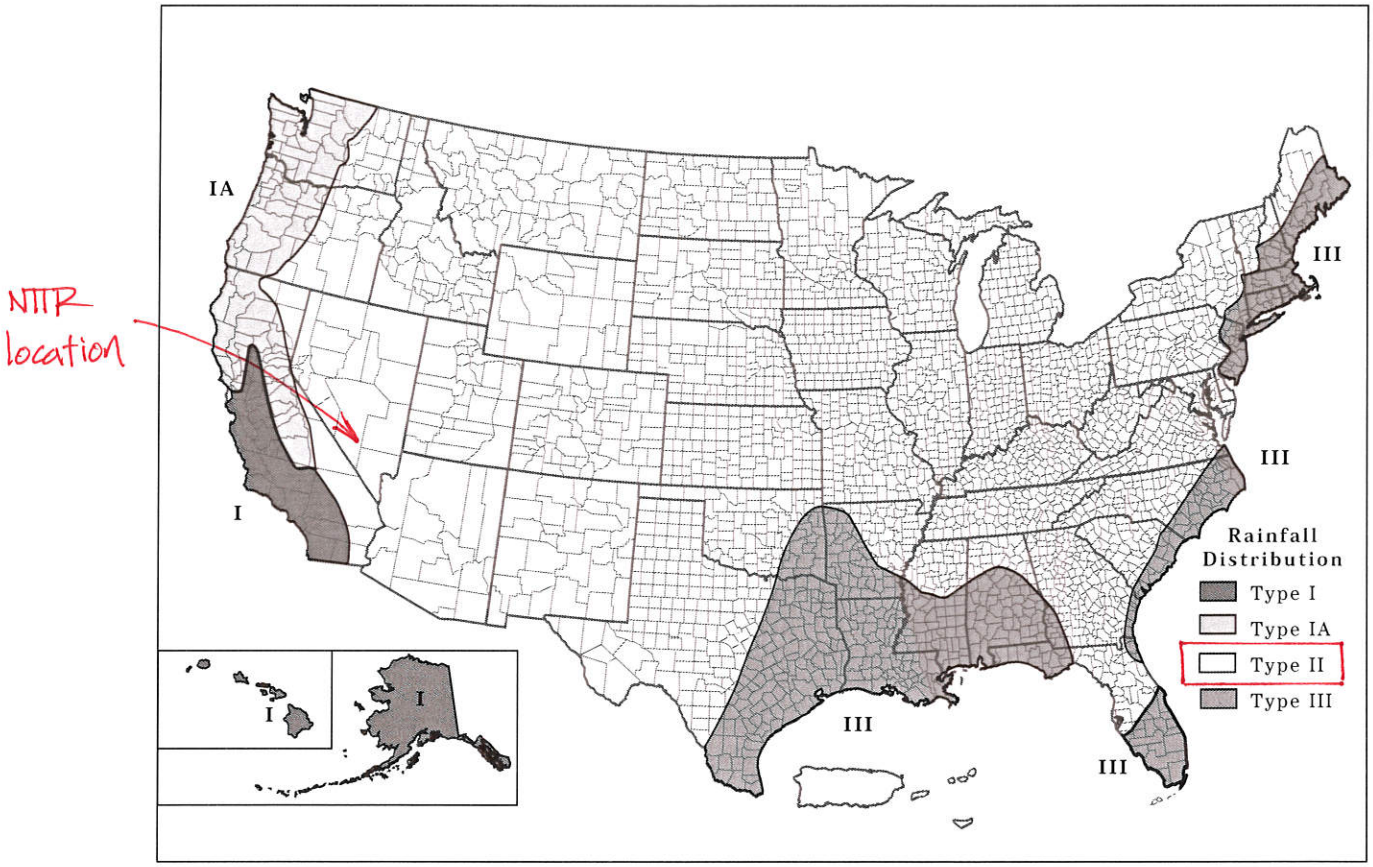
L = Length of Longest Watercourse (mi)

L_c = Length Along Longest Watercourse Measured Upstream to a Point Opposite the Centroid of the Basin (mi)

S = Representative (Average) Slope of the Longest Watercourse (ft per mi)

This lag equation is based on the United States Bureau of Reclamation's (USBR) analysis of the above parameters for several drainage basins in the Southwest desert, Great Basin, and Colorado Plateau area (USBR, 1989). This equation was developed by converting the USBR's S-graph lag equation to a dimensionless unit hydrograph lag equation.

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

SECTION 503

For areas greater than 200 square miles, the ability of the thunderstorm generating mechanisms (i.e., available moisture, strong convective currents, etc.) to sustain a thunderstorm much greater than 200 square miles in diameter is greatly reduced. Therefore, only a portion of an entire drainage basin could be subject to precipitation from the thunderstorm event. Analysis of this effect on runoff peaks and volumes is complicated by the necessity to determine the "storm centering" which produces the greatest peak flow and/or volume at the selected design point. In order to obtain a consistent method of analysis for these areas, the designer shall consult the local entity (and/or the CCRFCD if suggested by the local entity) to determine the appropriate method of analysis and design rainfall area reduction factors for the specific location and basin under consideration.

504 DESIGN STORMS

504.1 General

The design storm within the jurisdiction of the MANUAL shall be a 6-hour duration storm. The 6-hour duration storm is to be used for all HEC-1 runoff modeling in the Clark County area. The exception to the 6-hour design storm duration is when the SCS TR-55 method is used to compute runoff values. For SCS TR-55, a Type II rainfall distribution shall be used in conjunction with the 24-hour rainfall depth as described in TR-55.

504.2 6-Hour Design Storm Distribution

Three different 6-hour storm distributions are to be used as design storms in the Clark County area. The three design storm distributions, labeled SDN 3, SDN 4, and SDN 5, are graphically presented in **Figure 515** and tabularized in **Table 503.** For drainage areas less than 8 square miles in size, use SDN 3. For drainage areas greater than or equal to 8 and less than 12 square miles in size, use SDN 4. For drainage areas greater than or equal to 12 square miles in size, use SDN 5.

505 TIME-INTENSITY-FREQUENCY CURVES FOR RATIONAL METHOD

505.1 General

Procedures stated in Section 502 to obtain and modify the NOAA Atlas 2 rainfall depths must first be done before proceeding with development of time-intensity-frequency curves to be used with Rational Method.

standard 24-hour NRCS rainfall distributions

6-minute interval

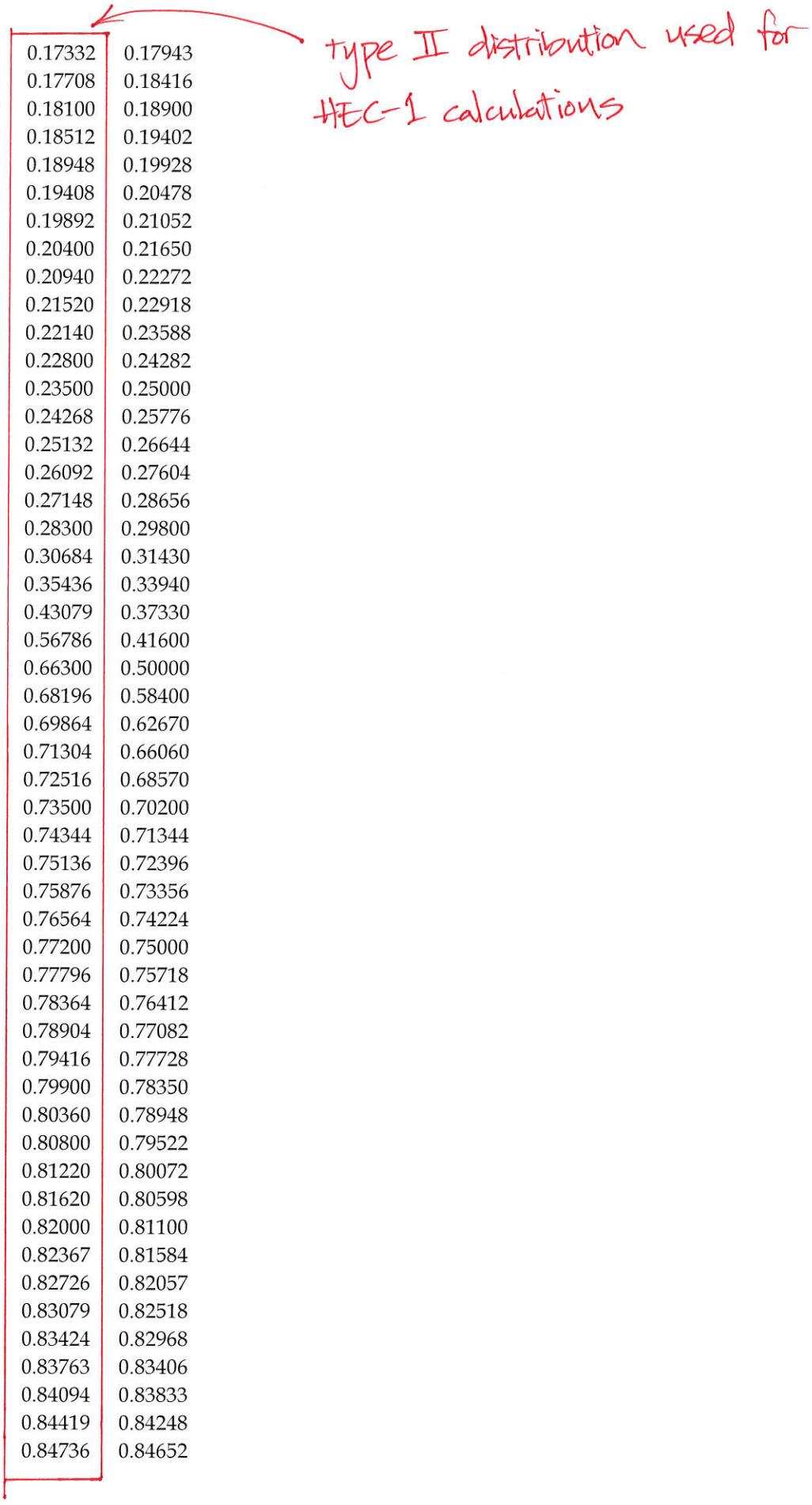
time (hours)	type I 24-hour	type Ia 24-hour	type II 24-hour	type III 24-hour
0.0	0.00000	0.00000	0.00000	0.00000
0.1	0.00174	0.00224	0.00101	0.00100
0.2	0.00348	0.00432	0.00202	0.00200
0.3	0.00522	0.00628	0.00305	0.00300
0.4	0.00697	0.00816	0.00408	0.00400
0.5	0.00871	0.01000	0.00513	0.00500
0.6	0.01046	0.01184	0.00618	0.00600
0.7	0.01220	0.01372	0.00725	0.00700
0.8	0.01395	0.01568	0.00832	0.00800
0.9	0.01570	0.01776	0.00941	0.00900
1.0	0.01745	0.02000	0.01050	0.01000
1.1	0.01920	0.02276	0.01161	0.01100
1.2	0.02095	0.02568	0.01272	0.01200
1.3	0.02270	0.02872	0.01385	0.01300
1.4	0.02446	0.03184	0.01498	0.01400
1.5	0.02621	0.03500	0.01613	0.01500
1.6	0.02797	0.03797	0.01728	0.01600
1.7	0.02972	0.04095	0.01845	0.01700
1.8	0.03148	0.04394	0.01962	0.01800
1.9	0.03324	0.04695	0.02081	0.01900
2.0	0.03500	0.05000	0.02200	0.02000
2.1	0.03677	0.05315	0.02321	0.02101
2.2	0.03858	0.05633	0.02442	0.02203
2.3	0.04041	0.05954	0.02565	0.02307
2.4	0.04227	0.06276	0.02688	0.02412
2.5	0.04416	0.06600	0.02813	0.02519
2.6	0.04608	0.06920	0.02938	0.02627
2.7	0.04803	0.07240	0.03065	0.02737
2.8	0.05001	0.07560	0.03192	0.02848
2.9	0.05201	0.07880	0.03321	0.02961
3.0	0.05405	0.08200	0.03450	0.03075
3.1	0.05611	0.08514	0.03581	0.03191
3.2	0.05821	0.08829	0.03712	0.03308
3.3	0.06033	0.09147	0.03845	0.03427
3.4	0.06248	0.09471	0.03978	0.03547
3.5	0.06466	0.09800	0.04113	0.03669
3.6	0.06687	0.10147	0.04248	0.03792
3.7	0.06911	0.10502	0.04385	0.03917
3.8	0.07138	0.10862	0.04522	0.04043
3.9	0.07367	0.11229	0.04661	0.04171
4.0	0.07600	0.11600	0.04800	0.04300
4.1	0.07835	0.11969	0.04941	0.04431
4.2	0.08070	0.12342	0.05084	0.04563
4.3	0.08307	0.12721	0.05229	0.04697
4.4	0.08545	0.13107	0.05376	0.04832
4.5	0.08784	0.13500	0.05525	0.04969
4.6	0.09024	0.13901	0.05676	0.05107

type II distribution used for HEC-1 calculations.

4.7	0.09265	0.14310	0.05829	0.05247
4.8	0.09507	0.14729	0.05984	0.05388
4.9	0.09751	0.15159	0.06141	0.05531
5.0	0.09995	0.15600	0.06300	0.05675
5.1	0.10241	0.16059	0.06461	0.05821
5.2	0.10487	0.16530	0.06624	0.05968
5.3	0.10735	0.17011	0.06789	0.06117
5.4	0.10984	0.17501	0.06956	0.06267
5.5	0.11234	0.18000	0.07125	0.06419
5.6	0.11485	0.18494	0.07296	0.06572
5.7	0.11737	0.18999	0.07469	0.06727
5.8	0.11990	0.19517	0.07644	0.06883
5.9	0.12245	0.20049	0.07821	0.07041
6.0	0.12500	0.20600	0.08000	0.07200
6.1	0.12761	0.21196	0.08181	0.07363
6.2	0.13034	0.21808	0.08364	0.07530
6.3	0.13317	0.22432	0.08549	0.07703
6.4	0.13610	0.23064	0.08736	0.07880
6.5	0.13915	0.23700	0.08925	0.08063
6.6	0.14230	0.24285	0.09116	0.08250
6.7	0.14557	0.24878	0.09309	0.08443
6.8	0.14894	0.25490	0.09504	0.08640
6.9	0.15241	0.26127	0.09701	0.08843
7.0	0.15600	0.26800	0.09900	0.09050
7.1	0.15966	0.27517	0.10101	0.09263
7.2	0.16334	0.28287	0.10304	0.09480
7.3	0.16706	0.29118	0.10509	0.09703
7.4	0.17082	0.30019	0.10716	0.09930
7.5	0.17460	0.31000	0.10925	0.10163
7.6	0.17842	0.33142	0.11136	0.10400
7.7	0.18226	0.35469	0.11349	0.10643
7.8	0.18614	0.37876	0.11564	0.10890
7.9	0.19006	0.40255	0.11781	0.11143
8.0	0.19400	0.42500	0.12000	0.11400
8.1	0.19817	0.43936	0.12225	0.11666
8.2	0.20275	0.45168	0.12460	0.11943
8.3	0.20775	0.46232	0.12705	0.12232
8.4	0.21317	0.47164	0.12960	0.12532
8.5	0.21900	0.48000	0.13225	0.12844
8.6	0.22523	0.48904	0.13500	0.13167
8.7	0.23185	0.49752	0.13785	0.13502
8.8	0.23885	0.50548	0.14080	0.13848
8.9	0.24623	0.51296	0.14385	0.14206
9.0	0.25400	0.52000	0.14700	0.14575
9.1	0.26233	0.52664	0.15020	0.14956
9.2	0.27139	0.53292	0.15340	0.15348
9.3	0.28119	0.53888	0.15660	0.15752
9.4	0.29173	0.54456	0.15980	0.16167
9.5	0.30300	0.55000	0.16300	0.16594
9.6	0.31942	0.55564	0.16628	0.17032
9.7	0.34542	0.56116	0.16972	0.17482

Type II distribution used for HEC-1 calculations.

9.8	0.38784	0.56656	0.17332	0.17943
9.9	0.46316	0.57184	0.17708	0.18416
10.0	0.51500	0.57700	0.18100	0.18900
10.1	0.53220	0.58198	0.18512	0.19402
10.2	0.54760	0.58685	0.18948	0.19928
10.3	0.56120	0.59163	0.19408	0.20478
10.4	0.57300	0.59635	0.19892	0.21052
10.5	0.58300	0.60100	0.20400	0.21650
10.6	0.59188	0.60576	0.20940	0.22272
10.7	0.60032	0.61044	0.21520	0.22918
10.8	0.60832	0.61504	0.22140	0.23588
10.9	0.61588	0.61956	0.22800	0.24282
11.0	0.62300	0.62400	0.23500	0.25000
11.1	0.62982	0.62836	0.24268	0.25776
11.2	0.63648	0.63264	0.25132	0.26644
11.3	0.64298	0.63684	0.26092	0.27604
11.4	0.64932	0.64096	0.27148	0.28656
11.5	0.65550	0.64500	0.28300	0.29800
11.6	0.66152	0.64889	0.30684	0.31430
11.7	0.66738	0.65272	0.35436	0.33940
11.8	0.67308	0.65651	0.43079	0.37330
11.9	0.67862	0.66026	0.56786	0.41600
12.0	0.68400	0.66400	0.66300	0.50000
12.1	0.68925	0.66773	0.68196	0.58400
12.2	0.69440	0.67148	0.69864	0.62670
12.3	0.69945	0.67527	0.71304	0.66060
12.4	0.70440	0.67910	0.72516	0.68570
12.5	0.70925	0.68300	0.73500	0.70200
12.6	0.71400	0.68665	0.74344	0.71344
12.7	0.71865	0.69027	0.75136	0.72396
12.8	0.72320	0.69386	0.75876	0.73356
12.9	0.72765	0.69744	0.76564	0.74224
13.0	0.73200	0.70100	0.77200	0.75000
13.1	0.73625	0.70473	0.77796	0.75718
13.2	0.74040	0.70838	0.78364	0.76412
13.3	0.74445	0.71198	0.78904	0.77082
13.4	0.74840	0.71551	0.79416	0.77728
13.5	0.75225	0.71900	0.79900	0.78350
13.6	0.75600	0.72245	0.80360	0.78948
13.7	0.75965	0.72586	0.80800	0.79522
13.8	0.76320	0.72926	0.81220	0.80072
13.9	0.76665	0.73263	0.81620	0.80598
14.0	0.77000	0.73600	0.82000	0.81100
14.1	0.77329	0.73939	0.82367	0.81584
14.2	0.77656	0.74277	0.82726	0.82057
14.3	0.77981	0.74613	0.83079	0.82518
14.4	0.78304	0.74948	0.83424	0.82968
14.5	0.78625	0.75281	0.83763	0.83406
14.6	0.78944	0.75613	0.84094	0.83833
14.7	0.79261	0.75943	0.84419	0.84248
14.8	0.79576	0.76271	0.84736	0.84652



14.9	0.79889	0.76598	0.85047	0.85044
15.0	0.80200	0.76924	0.85350	0.85425
15.1	0.80509	0.77248	0.85647	0.85794
15.2	0.80816	0.77571	0.85936	0.86152
15.3	0.81121	0.77892	0.86219	0.86498
15.4	0.81424	0.78211	0.86494	0.86833
15.5	0.81725	0.78529	0.86763	0.87156
15.6	0.82024	0.78845	0.87024	0.87468
15.7	0.82321	0.79160	0.87279	0.87768
15.8	0.82616	0.79474	0.87526	0.88057
15.9	0.82909	0.79786	0.87767	0.88334
16.0	0.83200	0.80096	0.88000	0.88600
16.1	0.83489	0.80405	0.88229	0.88858
16.2	0.83776	0.80712	0.88455	0.89110
16.3	0.84061	0.81018	0.88679	0.89358
16.4	0.84344	0.81322	0.88900	0.89600
16.5	0.84625	0.81625	0.89119	0.89838
16.6	0.84904	0.81926	0.89335	0.90070
16.7	0.85181	0.82226	0.89549	0.90298
16.8	0.85456	0.82524	0.89760	0.90520
16.9	0.85729	0.82821	0.89969	0.90738
17.0	0.86000	0.83116	0.90175	0.90950
17.1	0.86269	0.83410	0.90379	0.91158
17.2	0.86536	0.83702	0.90580	0.91360
17.3	0.86801	0.83992	0.90779	0.91558
17.4	0.87064	0.84281	0.90975	0.91750
17.5	0.87325	0.84569	0.91169	0.91938
17.6	0.87584	0.84855	0.91360	0.92120
17.7	0.87841	0.85140	0.91549	0.92298
17.8	0.88096	0.85423	0.91735	0.92470
17.9	0.88349	0.85704	0.91919	0.92638
18.0	0.88600	0.85984	0.92100	0.92800
18.1	0.88849	0.86262	0.92279	0.92959
18.2	0.89096	0.86539	0.92455	0.93117
18.3	0.89341	0.86815	0.92629	0.93273
18.4	0.89584	0.87089	0.92800	0.93428
18.5	0.89825	0.87361	0.92969	0.93581
18.6	0.90064	0.87632	0.93135	0.93733
18.7	0.90301	0.87901	0.93299	0.93883
18.8	0.90536	0.88169	0.93460	0.94032
18.9	0.90769	0.88435	0.93619	0.94179
19.0	0.91000	0.88700	0.93775	0.94325
19.1	0.91229	0.88963	0.93929	0.94469
19.2	0.91456	0.89225	0.94080	0.94612
19.3	0.91681	0.89485	0.94229	0.94753
19.4	0.91904	0.89744	0.94375	0.94893
19.5	0.92125	0.90001	0.94519	0.95031
19.6	0.92344	0.90257	0.94660	0.95168
19.7	0.9	0.90511	0.94799	0.95303
19.8	0.92776	0.90763	0.94935	0.95437
19.9	0.92989	0.91014	0.95069	0.95569

type II distribution used for HEC-1 calculations

20.0	0.93200	0.91264	0.95200	0.95700
20.1	0.93409	0.91512	0.95330	0.95829
20.2	0.93616	0.91759	0.95459	0.95958
20.3	0.93821	0.92004	0.95588	0.96085
20.4	0.94024	0.92247	0.95716	0.96211
20.5	0.94225	0.92489	0.95844	0.96336
20.6	0.94424	0.92729	0.95971	0.96460
20.7	0.94621	0.92968	0.96098	0.96582
20.8	0.94816	0.93206	0.96224	0.96704
20.9	0.95009	0.93442	0.96350	0.96824
21.0	0.95200	0.93676	0.96475	0.96944
21.1	0.95389	0.93909	0.96600	0.97062
21.2	0.95576	0.94140	0.96724	0.97179
21.3	0.95761	0.94370	0.96848	0.97295
21.4	0.95944	0.94598	0.96971	0.97410
21.5	0.96125	0.94825	0.97094	0.97523
21.6	0.96304	0.95050	0.97216	0.97636
21.7	0.96481	0.95274	0.97338	0.97747
21.8	0.96656	0.95496	0.97459	0.97858
21.9	0.96829	0.95717	0.97580	0.97967
22.0	0.97000	0.95936	0.97700	0.98075
22.1	0.97169	0.96154	0.97820	0.98182
22.2	0.97336	0.96370	0.97939	0.98288
22.3	0.97501	0.96584	0.98058	0.98392
22.4	0.97664	0.96797	0.98176	0.98496
22.5	0.97825	0.97009	0.98294	0.98598
22.6	0.97984	0.97219	0.98411	0.98700
22.7	0.98141	0.97428	0.98528	0.98800
22.8	0.98296	0.97635	0.98644	0.98899
22.9	0.98449	0.97840	0.98760	0.98997
23.0	0.98600	0.98044	0.98875	0.99094
23.1	0.98749	0.98246	0.98990	0.99189
23.2	0.98896	0.98447	0.99104	0.99284
23.3	0.99041	0.98647	0.99218	0.99377
23.4	0.99184	0.98845	0.99331	0.99470
23.5	0.99325	0.99041	0.99444	0.99561
23.6	0.99464	0.99236	0.99556	0.99651
23.7	0.99601	0.99429	0.99668	0.99740
23.8	0.99736	0.99621	0.99779	0.99828
23.9	0.99869	0.99811	0.99890	0.99914
24.0	1.0000	1.0000	1.0000	1.0000

type II distribution used for HEC-1 calculations.

LAG EQUATION ROUGHNESS FACTORS

WATERSHED CHARACTERISTICS	ROUGHNESS FACTOR, Kn
Urbanized Areas: Water courses in the drainage area consist of street, storm sewer, and improved channels.	.015
Natural Areas: Water courses in the drainage area are well defined, unimproved channels or washes. Watershed has minimal vegetation.	.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.	.050

K_n value used for TLAG calculations.

Revision	Date

WRC ENGINEERING

REFERENCE: USACE, Los Angeles District, 1982

TABLE 604

MANNING'S ROUGHNESS COEFFICIENTS FOR CHANNEL LINING TYPES

Channel Material	Roughness Coefficient (n)	
	Normal	Maximum
Corrugated Metal	0.025	0.030
Concrete**		
1) Trowel finish	0.013	0.015
2) Float finish	0.015	0.016
3) Unfinished	0.017	0.020
4) Shotcrete, Good section	0.019	0.023
5) Shotcrete, wavy section	0.122	0.025
Asphalt (use maximum value when cars are present)	0.016	0.020
Soil-Cement	0.020	0.025
Constructed channels with earth or sand bottom, sides of		
1) Clean earth; straight	0.022	0.025
2) Earth with grass and weeds	0.025	0.030
3) Earth with trees and shrubs	0.032	0.040
4) Shotcrete	0.022	0.025
5) Soil-cement	0.025	0.028
6) Concrete	0.020	0.024
7) Dry rubble or riprap	0.033	0.036
Natural channels with sand bottom, sides of	n value used for hydraulic calculations	
1) Trees and shrubs	0.035	0.045
2) Rock	0.032	0.040
Natural channel with rock bottom	0.060	0.090
Overbank floodplains		
1) Desert brush, normal density	0.060	0.080
2) Dense vegetation	0.100	0.160

• Adapted from Chow (1959) and Aldridge and Garrett (1973).
** Manning's Coefficients for Clear Water Only
__ City of Tucson Standards Manual for Drainage Design

Revision	Date

REFERENCE:

TABLE 702

Table 2-1 Runoff depth for selected CN's and rainfall amounts [1/]

Rainfall	Runoff depth for curve number of—												
	40	45	50	55	60	65	70	75	80	85	90	95	98
	inches												
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

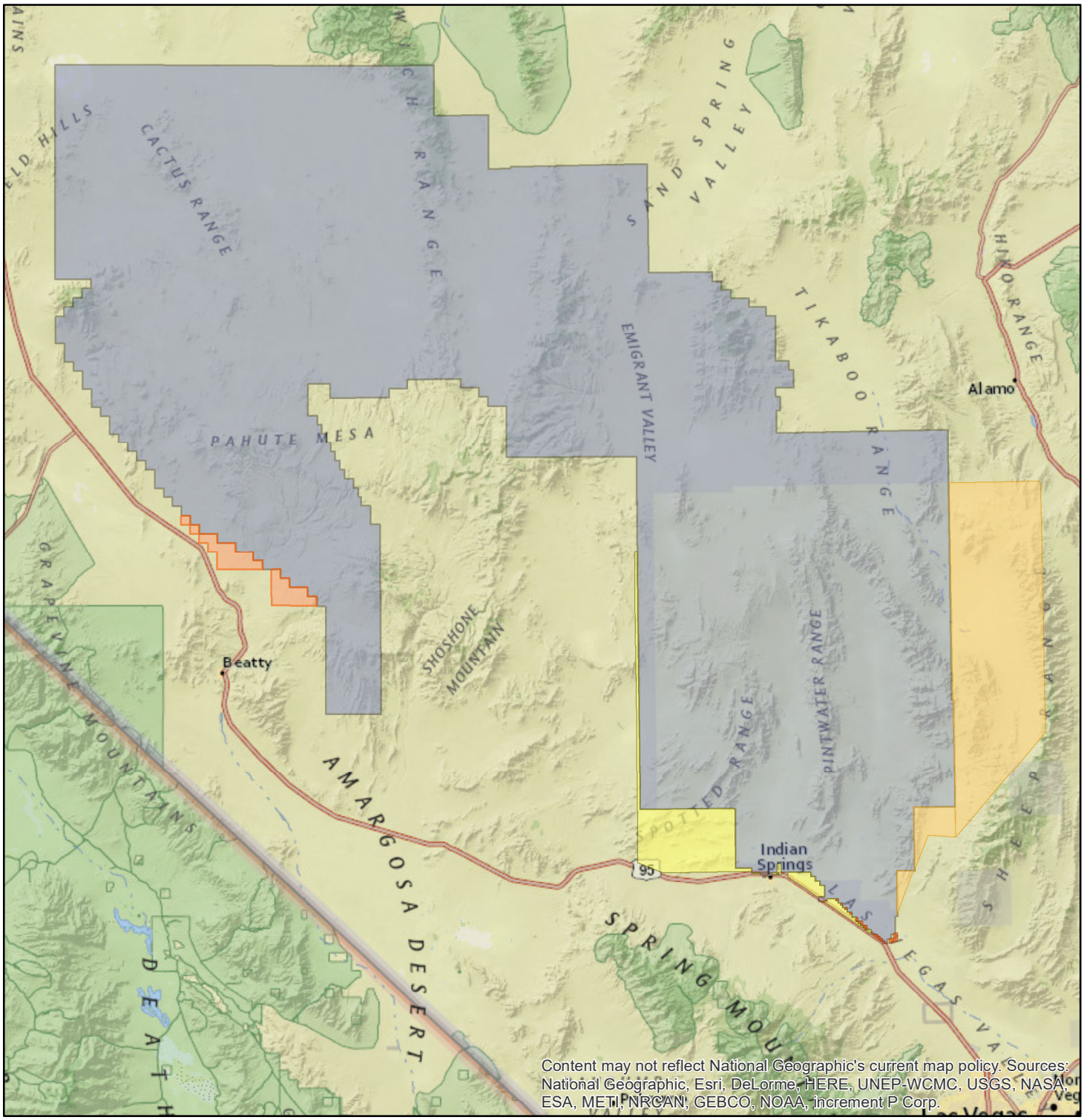
[1/] Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

* This table used for Runoff Interpolation Calculations.

APPENDIX B

FIGURES

- **FIGURE 1.0: GEOGRAPHIC REGIONS OF NTTR**
- **FIGURE 1.1: GEOGRAPHIC REGIONS OF THE NORTH RANGE**
- **FIGURE 1.2: GEOGRAPHIC REGIONS OF THE SOUTH RANGE**
- **FIGURE 2.0: EXTERNALLY AND INTERNALLY DRAINED BASINS**
- **FIGURE 2.1: AIRSPACE AND DRAINAGE BASIN BOUNDARIES**
- **FIGURE 3.0: FLOOD ZONE REFERENCES**
- **FIGURE 3.1: ALTERNATIVE 3A EC SOUTH FLOOD ZONE REFERENCES**
- **FIGURE 3.2: ALTERNATIVE 3B 64C/D AND 65D FLOOD ZONE REFERENCES**
- **FIGURE 4.0: OVERALL HYDRAULIC CROSS SECTIONS**
- **FIGURE 4.1: HYDRAULIC SECTION I**
- **FIGURE 4.2: HYDRAULIC SECTION R1 (WEST)**
- **FIGURE 4.3: HYDRAULIC SECTION R2 (EAST)**
- **FIGURE 4.4: 100 YEAR 24 HOUR RAINFALL DEPTHS**
- **FIGURE 4.5: 500 YEAR 24 HOUR RAINFALL DEPTHS**
- **FIGURE 5.0: HYDROLOGIC BASINS FOR NTTR**
- **FIGURES 5.1 – 5.23: BASINS A – W**
- **FIGURE 6.0: FLOOD ZONES FOR NTTR WITH TOPOGRAPHIC BASE MAP**
- **FIGURES 6.1 – 6.23: FLOOD ZONE FOR BASINS A – W WITH TOPOGRAPHIC BASE MAP**
- **FIGURE 7.0: FLOOD ZONES FOR NTTR WITH AERIAL IMAGE**
- **FIGURES 7.1 – 7.23: FLOOD ZONE FOR BASINS A – W WITH AERIAL IMAGE**
- **FIGURE 8.0: FLOOD ZONE FOR EXPANSION AREAS WITH AERIAL IMAGE**
- **FIGURE 8.1: FLOOD ZONE FOR ALTERNATIVE 3A WITH AERIAL IMAGE**
- **FIGURE 8.2A: FLOOD ZONE FOR ALTERNATIVE 3B 64 C/D AND 65D WITH AERIAL IMAGE**
- **FIGURE 8.2B: FLOOD ZONE FOR ALTERNATIVE 3B 64 C/D AND 65D WITH AERIAL IMAGE**
- **FIGURE 8.3: FLOOD ZONE ALTERNATIVE 3B ADMINISTRATIVE INCORPORATION WITH AERIAL IMAGE**
- **FIGURE 8.4A: FLOOD ZONE FOR ALTERNATIVE 3C ALAMO WITH AERIAL IMAGE**
- **FIGURE 8.4B: FLOOD ZONE FOR ALTERNATIVE 3C ALAMO WITH AERIAL IMAGE**



Legend

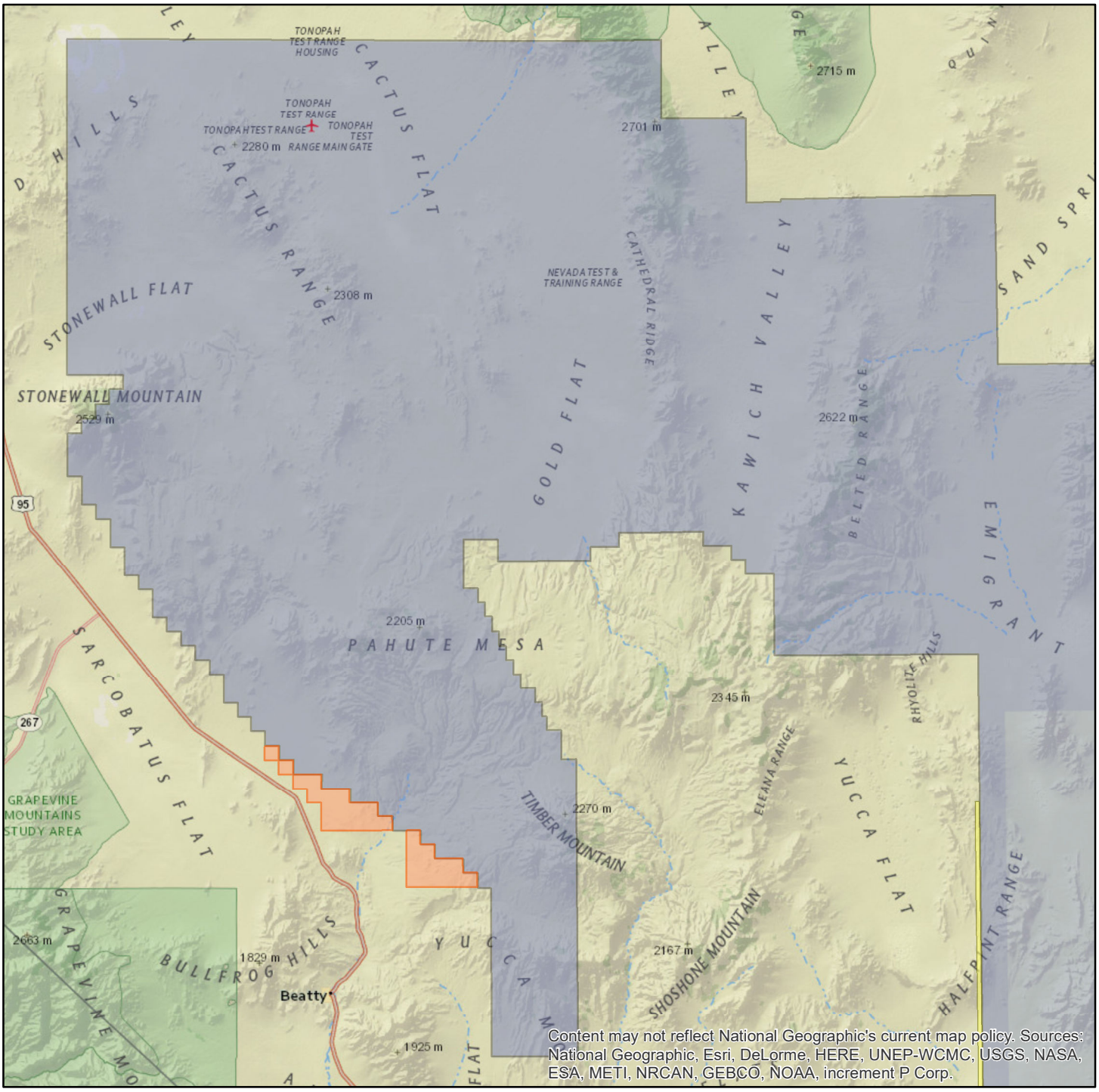
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:1,000,000

0 3 6 12 18 24 Miles

N

Figure 1.0: Geographic Regions of NTTR



Legend

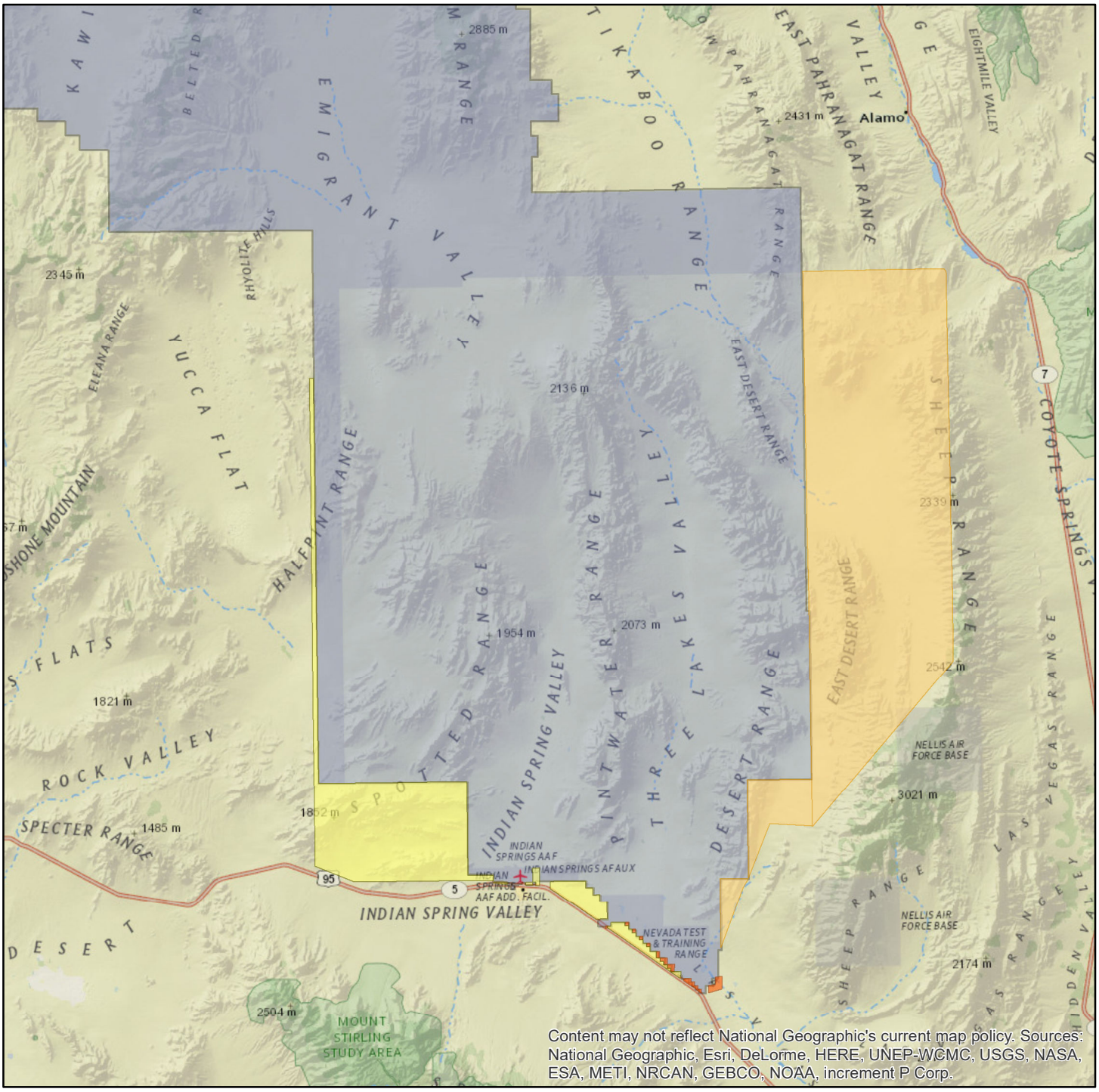
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:650,000

0 2 4 8 12 16 Miles

Figure 1.1: Geographic Regions of the North Range



Legend

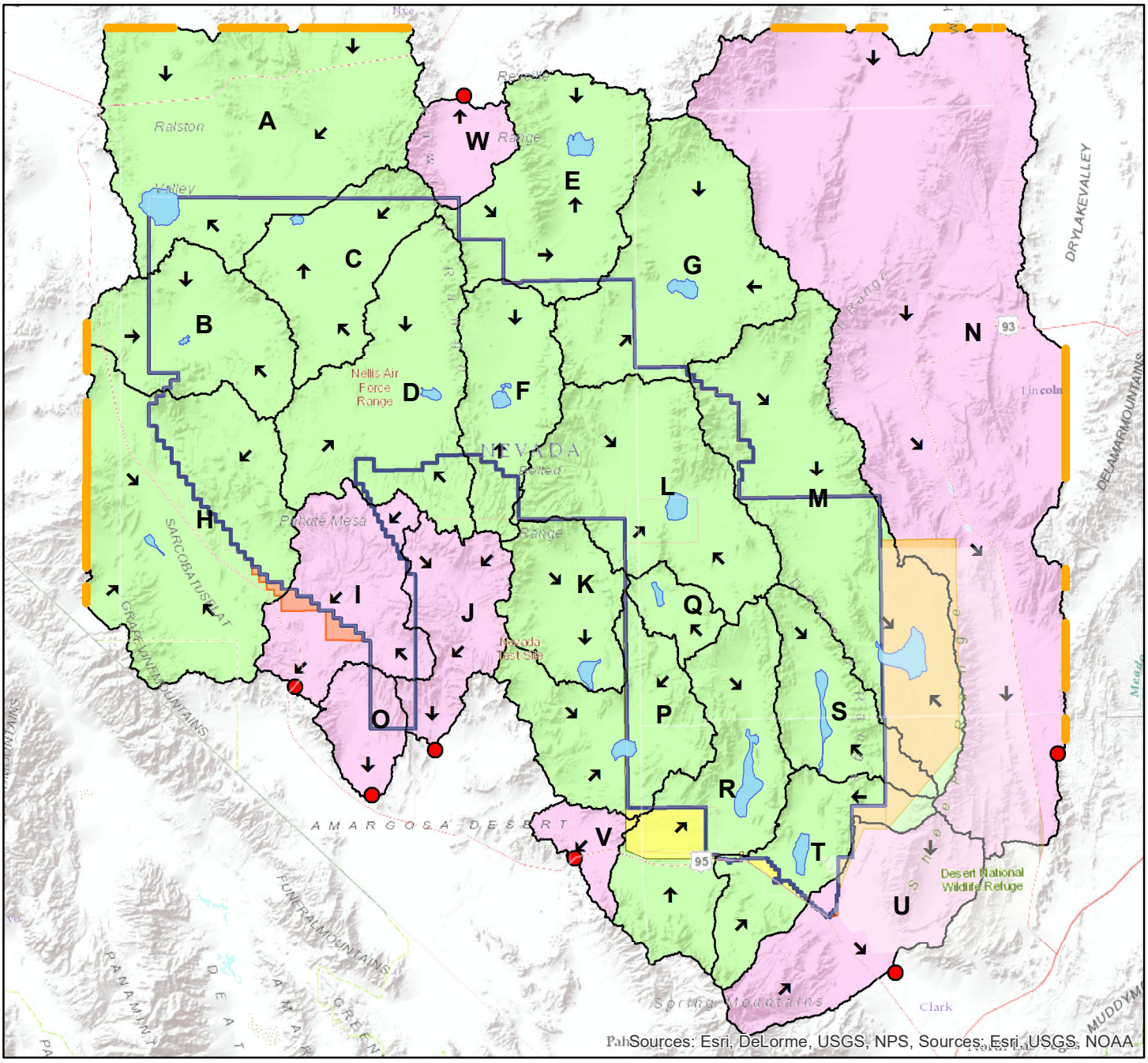
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:650,000

0 2 4 8 12 16 Miles

Figure 1.2: Geographic Regions of the South Range



Legend

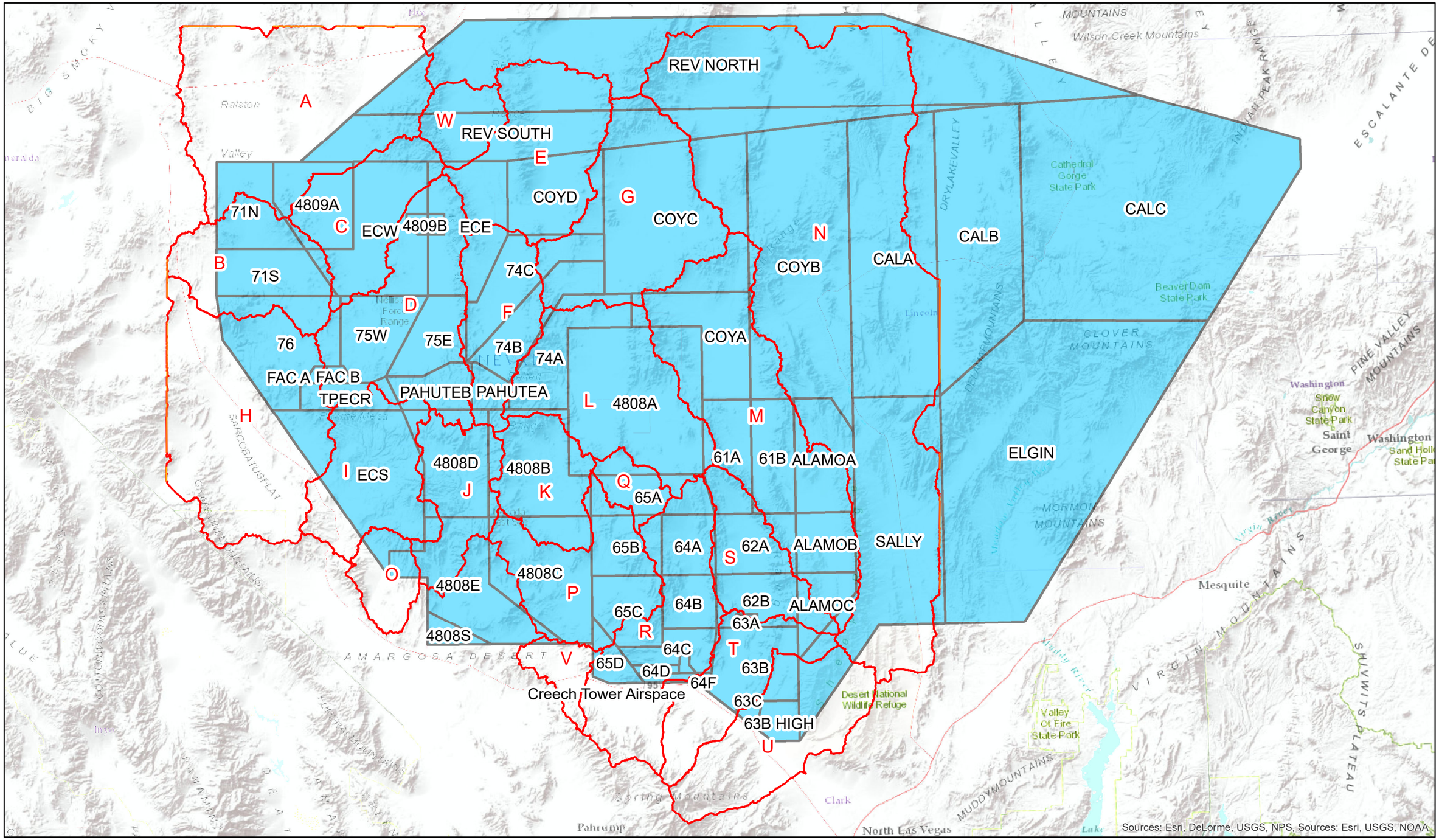
- Basin Outlets for Externally Drained Basins
- Flow Direction
- Limits of DEM data
- Playas for Internally Drained Basins
- Basin Boundary
- Existing NTTR Boundary
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Internally Drained Basins
- Externally Drained Basins

N

1:1,300,000

0 5 10 20 30 40 Miles

Figure 2.0: Externally and Internally Drained Basins



Legend

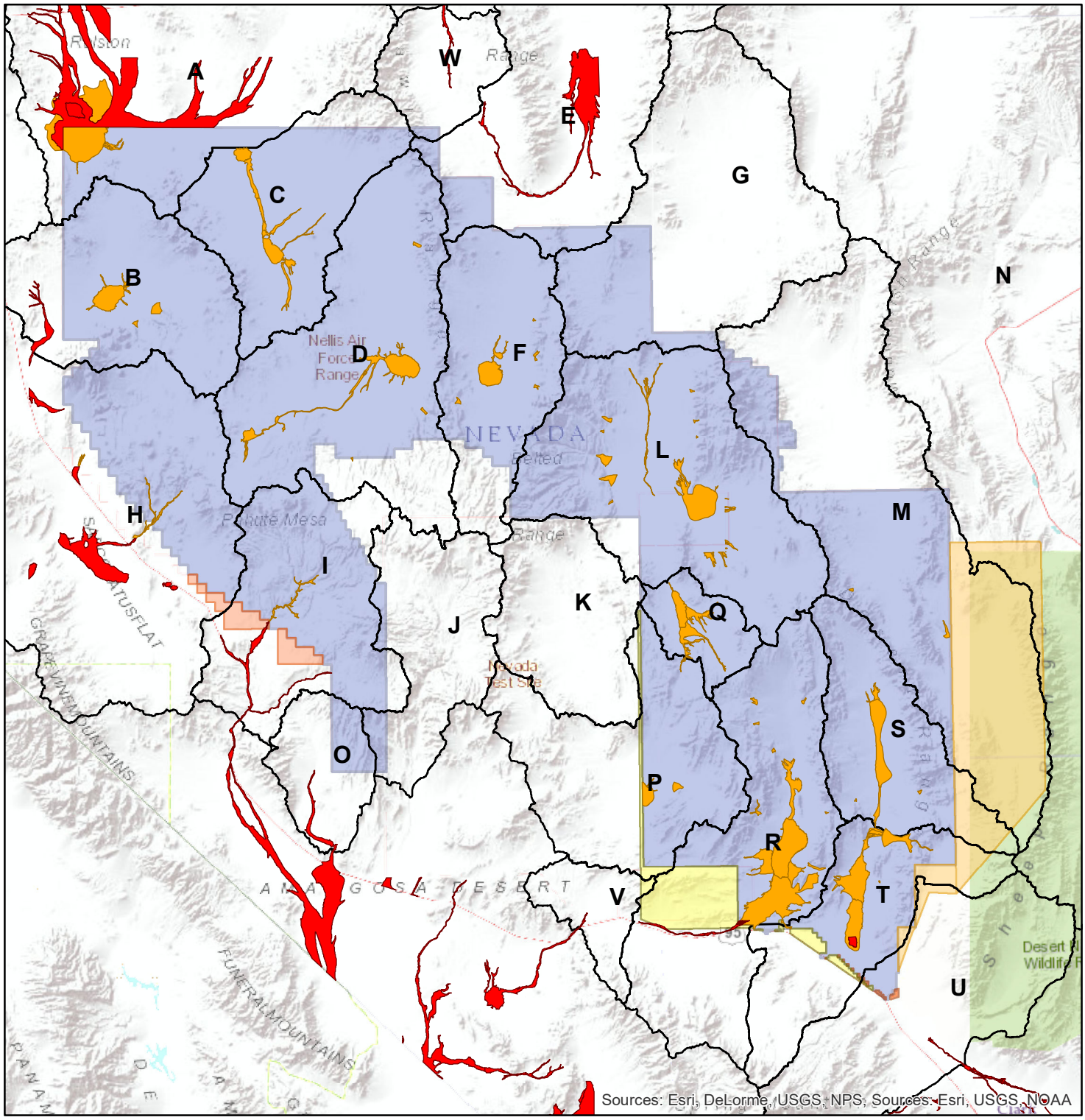
- Limits of DEM Data
- Drainage Basin Boundaries
- NTTR Airspace Boundaries

1:1,000,000

0 10 20 40 60 80 Miles

N

Figure 2.1: Airspace and Drainage Basins Boundaries



Legend

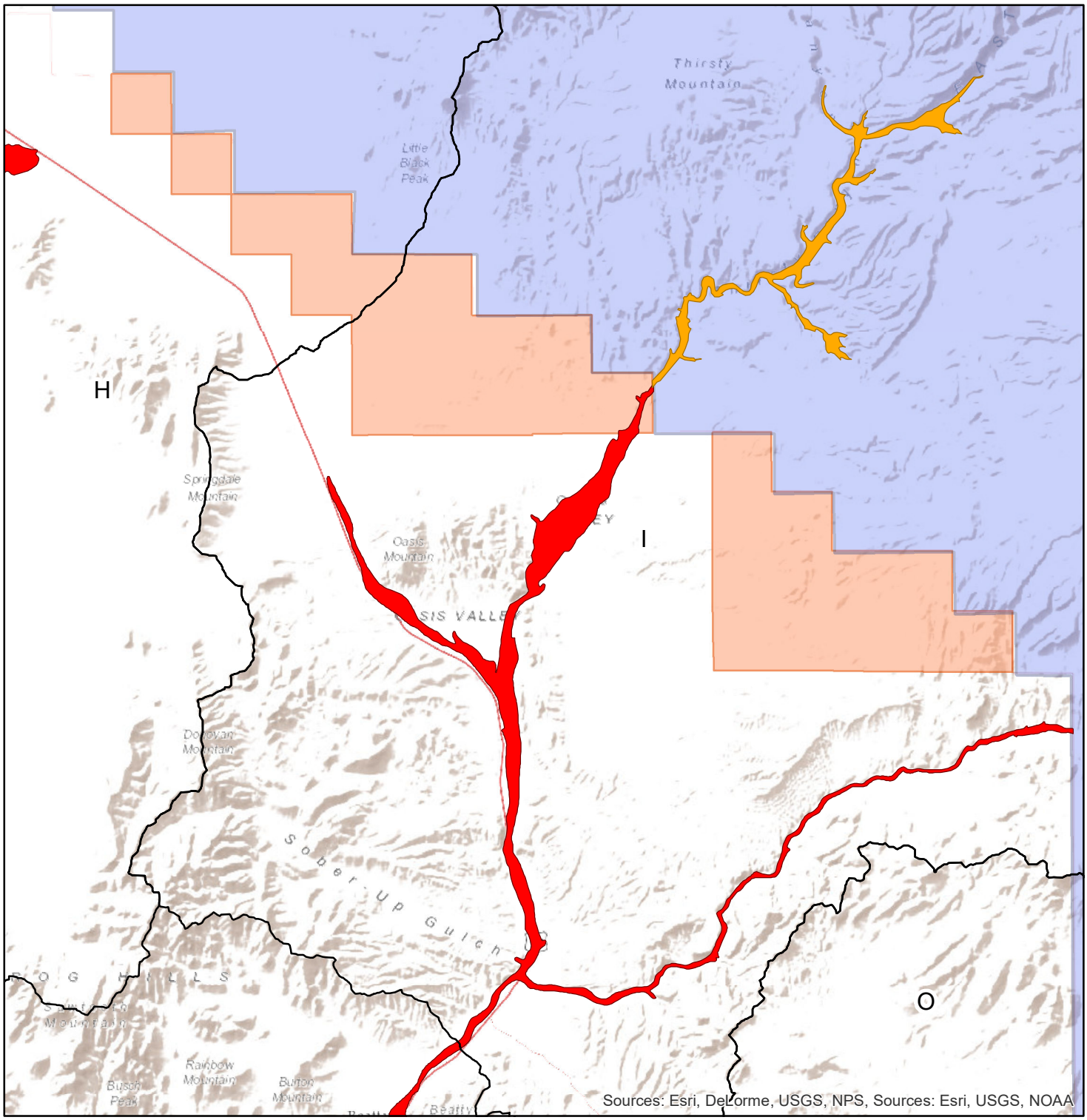
- FEMA Floodzone
- NTTR Floodplain (Floodplain Inventory Report)
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:1,000,000

0 5 10 20 30 40 Miles

N

Figure 3.0: Flood Zone References



Legend

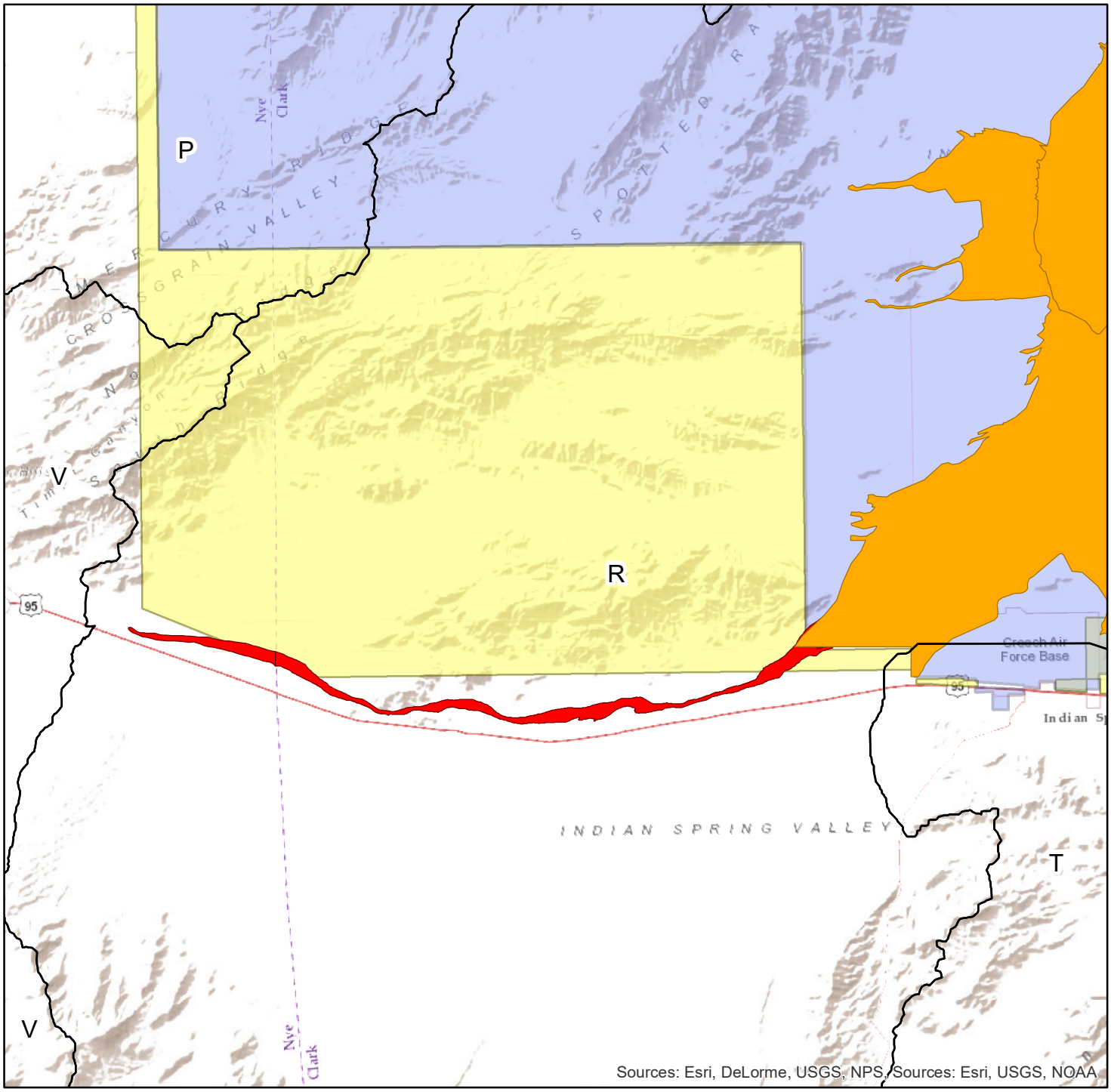
- Basin Boundary
- NTTR Floodplain (Floodpain Inventory Report)
- FEMA Floodzone
- Existing NTTR Boundary
- Alternative 3A Range 77 - EC South Expansion

N

1:150,000

0 0.75 1.5 3 4.5 6 Miles

Figure 3.1: Alternative 3A EC South Flood Zone References



Legend

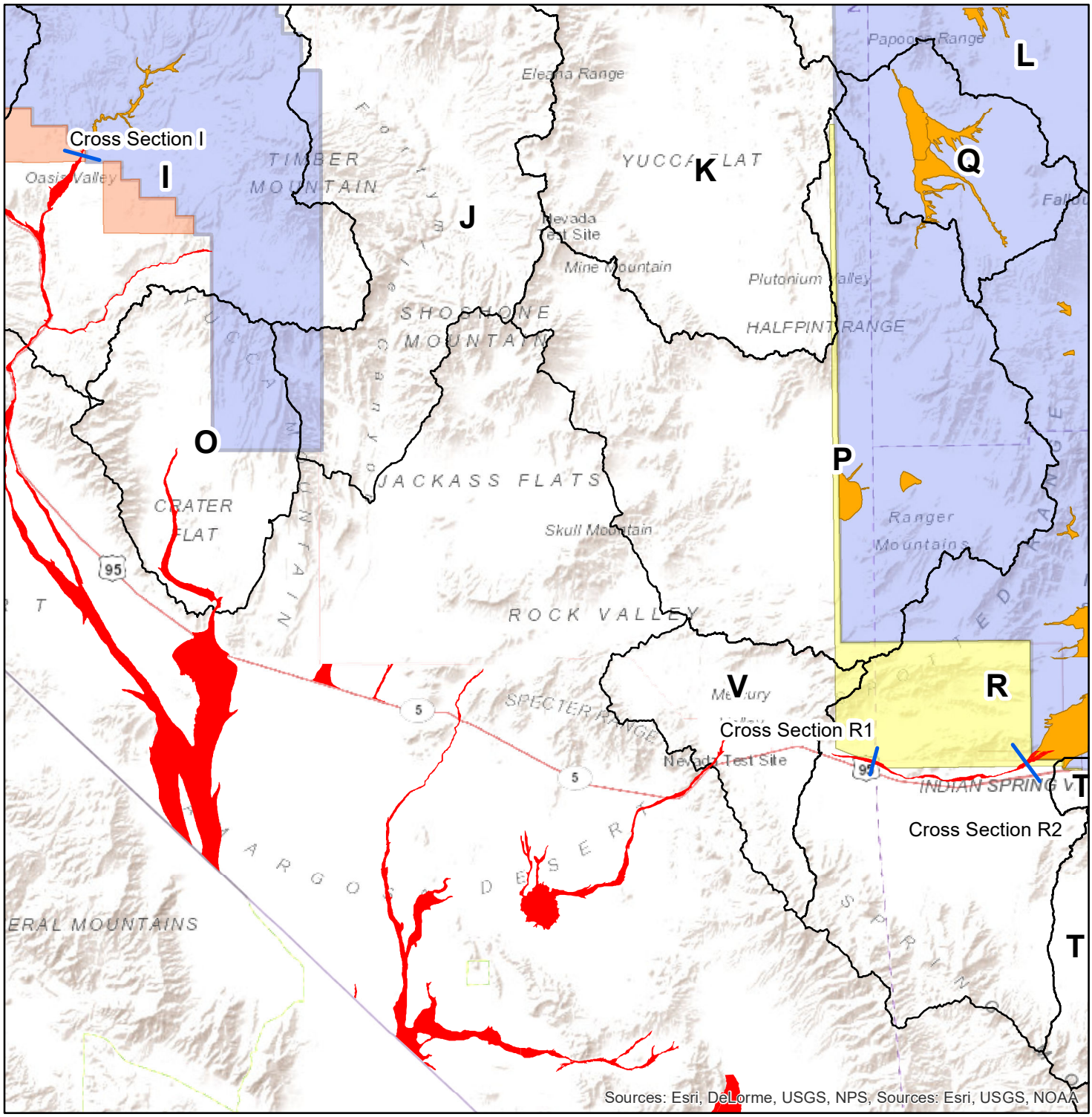
- Basin Boundary
- NTTR Floodplain (Floodplain Inventory Report)
- FEMA Floodzone
- Existing NTTR Boundary
- Alternative 3B 64C/D and 65D Expansion

N

1:150,000

0 1 2 4 6 8 Miles

Figure 3.2: Alternative 3B 64C/D & 65D Flood Zone References



Legend

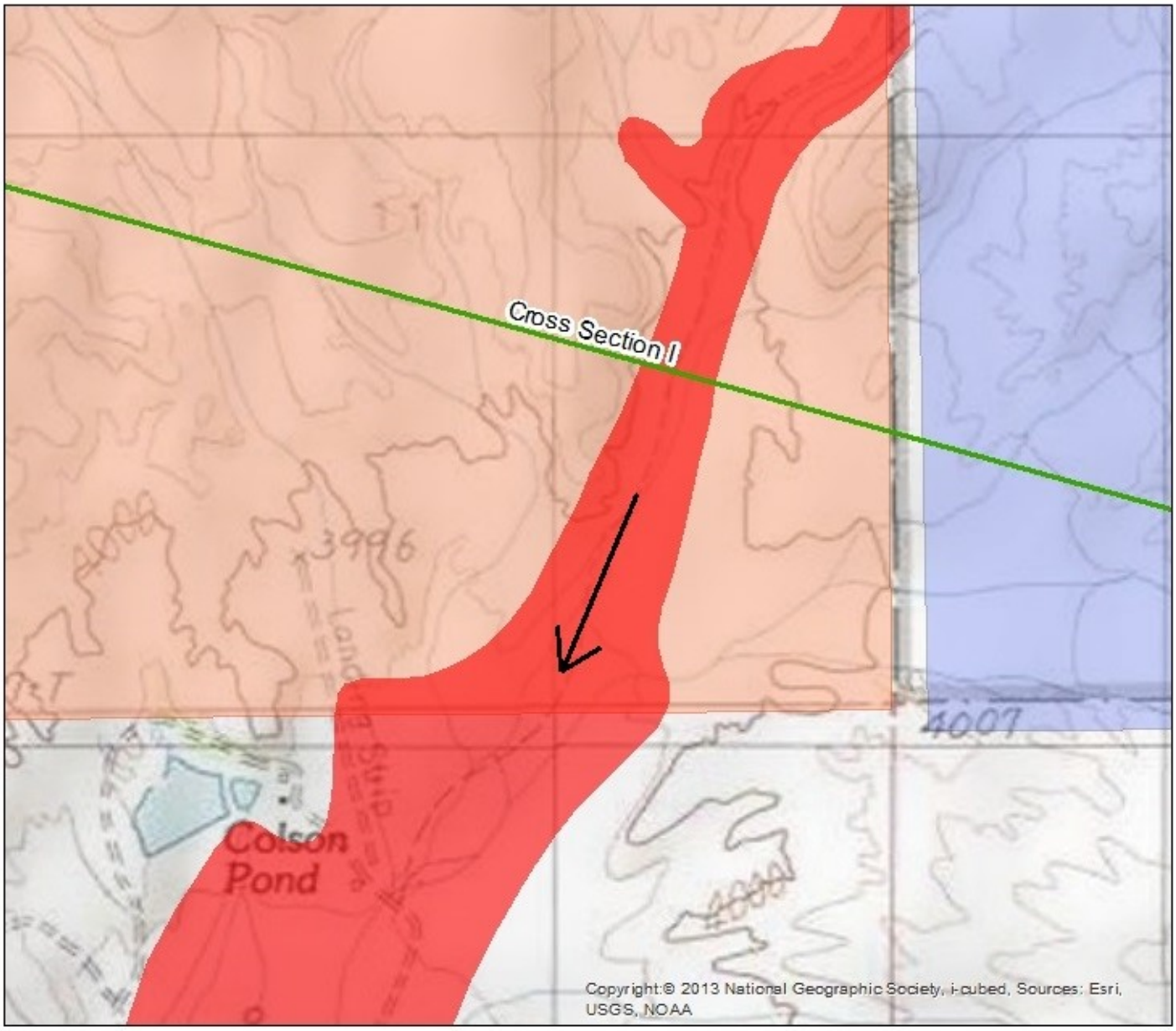
- Hydraulic Cross Section
- Basin Boundary
- FEMA Floodzone
- NTTR Floodplains
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Existing NTTR Boundary

1:500,000

0 2.5 5 10 15 20 Miles

N

Figure 4.0: Overall Hydraulic Cross Sections



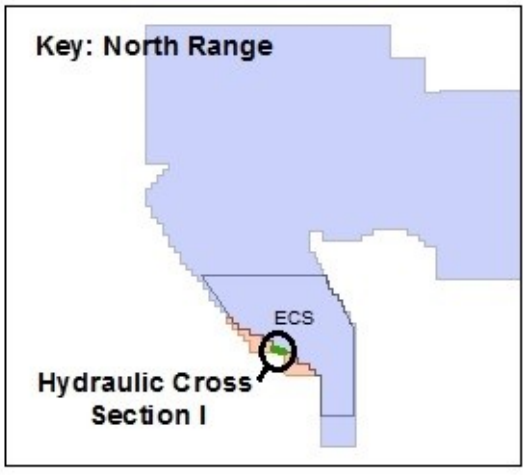
Legend

- Hydraulic Cross Section
- FEMA Flood Zone
- Alternative 3ARange 77 - EC South Expansion
- Existing NTTR Boundary

1:10,000

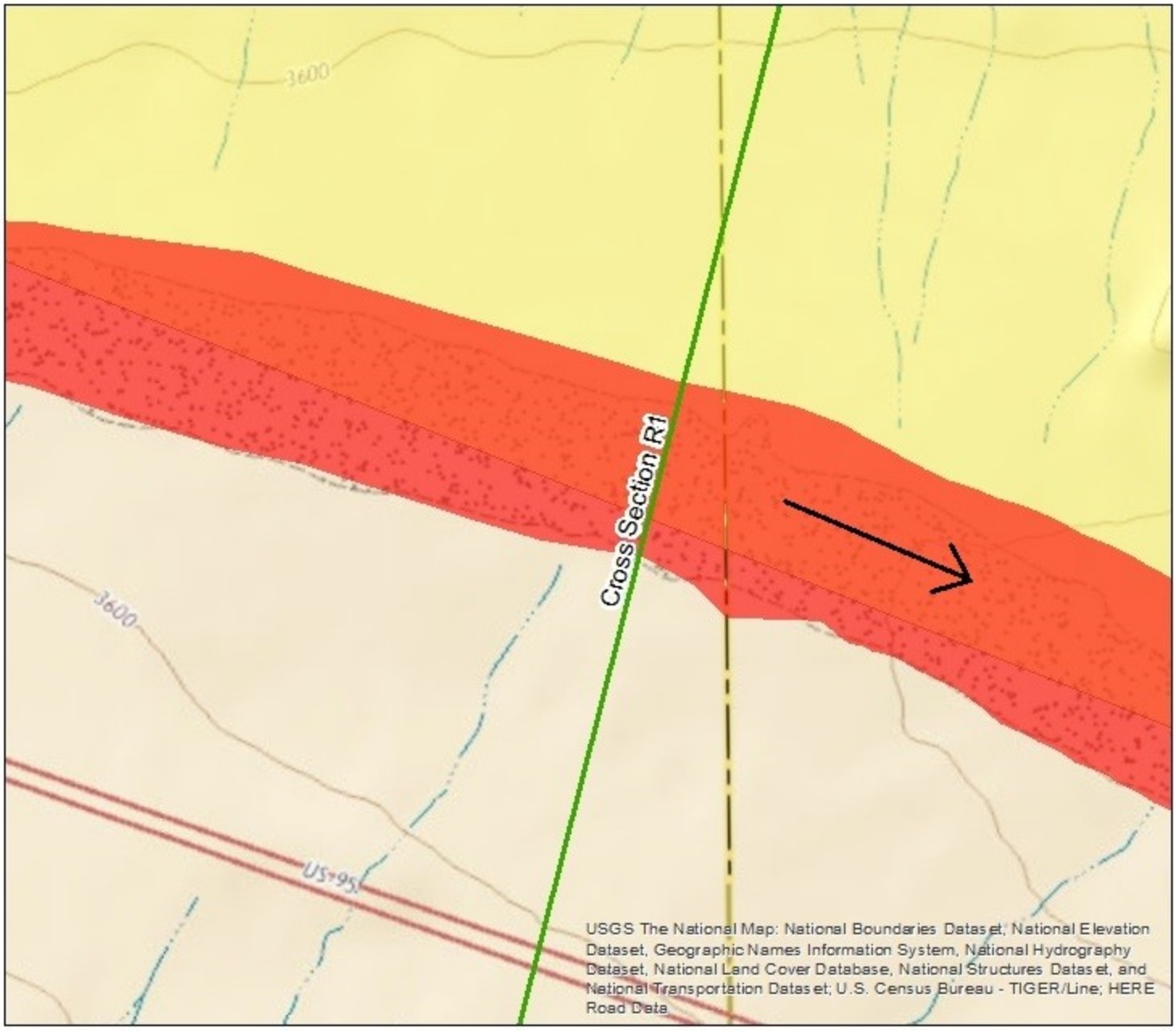
Miles

0 0.05 0.1 0.2 0.3 0.4



N

Figure 4.1: Hydraulic Cross Section I



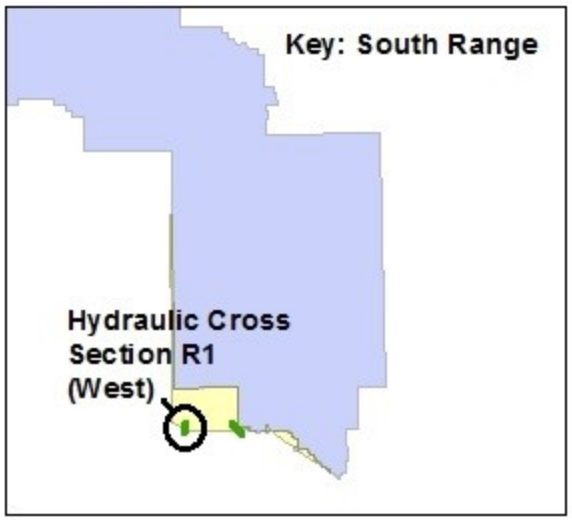
Legend

- Hydraulic Cross Section
- FEMA Flood Zone
- Existing NTTR Boundary
- Alternative 3B 64C D and 65D Expansion

1:10,000

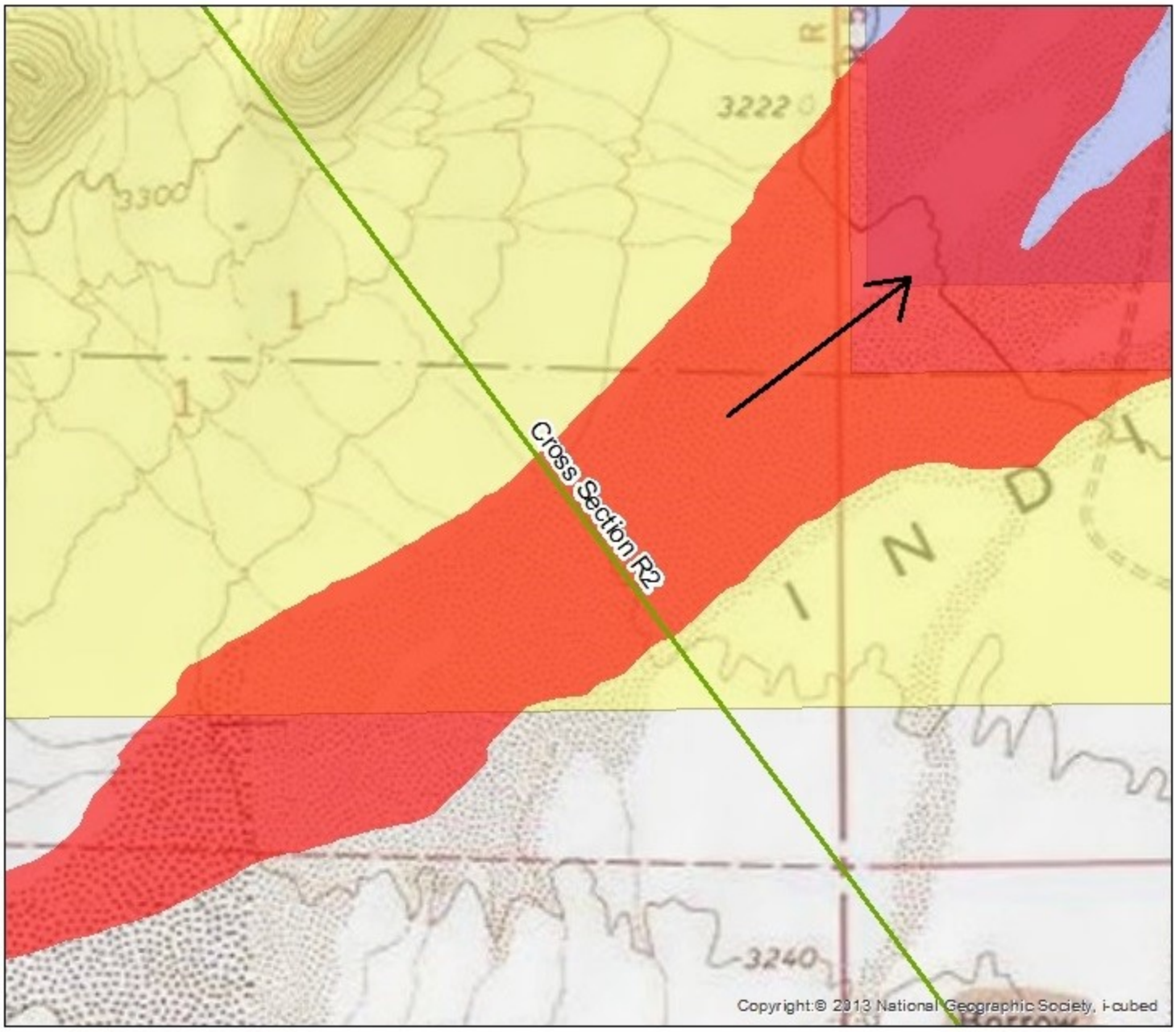
Miles

0 0.05 0.1 0.2 0.3 0.4



N

Figure 4.2: Hydraulic Cross Section R1 (West)



Legend

- Hydraulic Cross Section
- FEMA Flood Zone
- Alternative 3B 64C D and 65D Expansion
- Existing NTTR Boundary

1:10,000

Miles

0 0.05 0.1 0.2 0.3 0.4

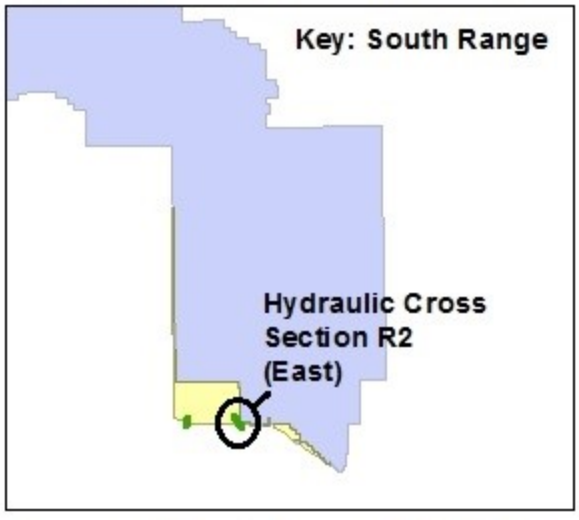


Figure 4.3: Hydraulic Cross Section R2 (East)

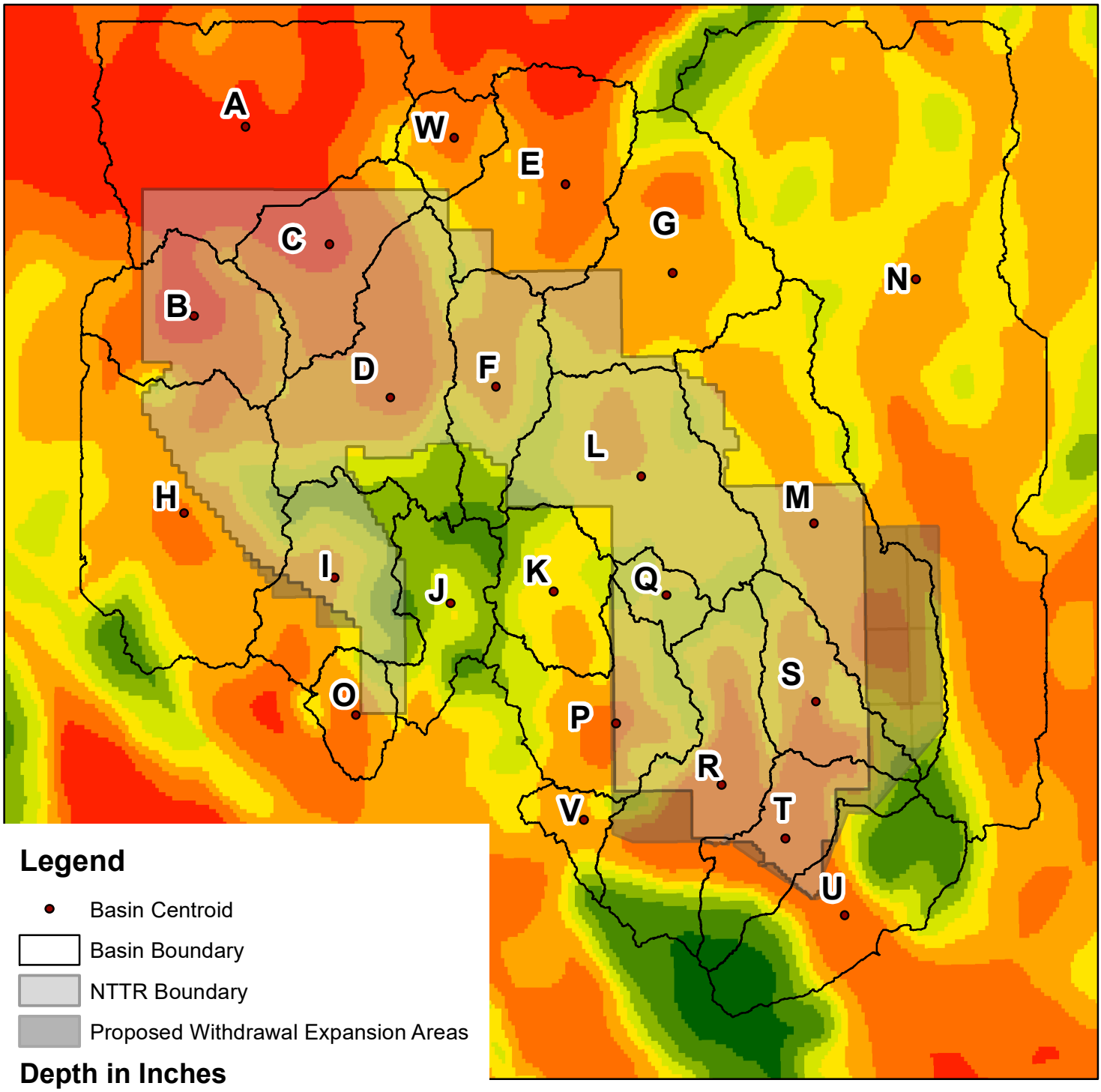


Figure 4.4: 100 yr 24 hr Rainfall Depths

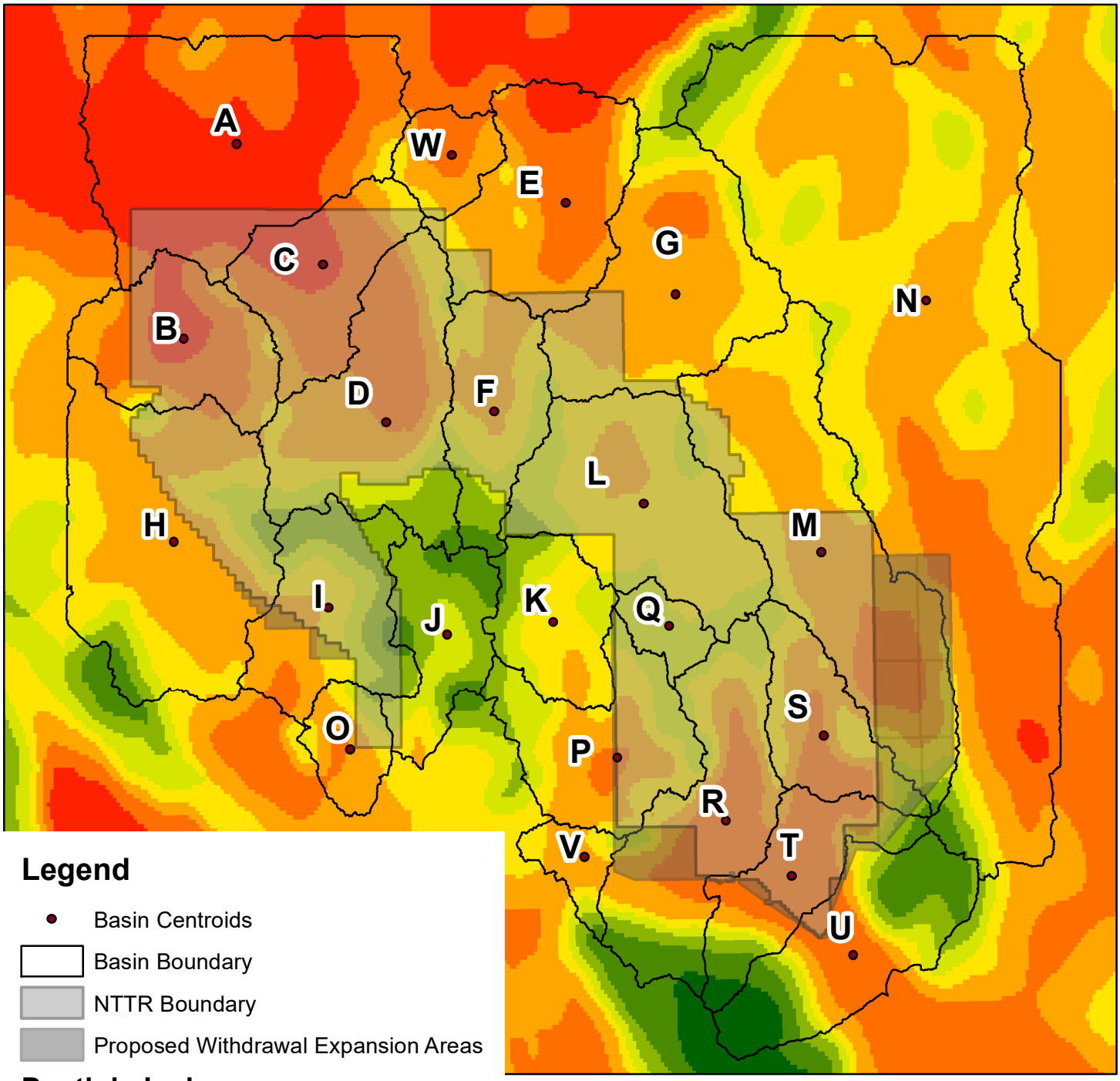
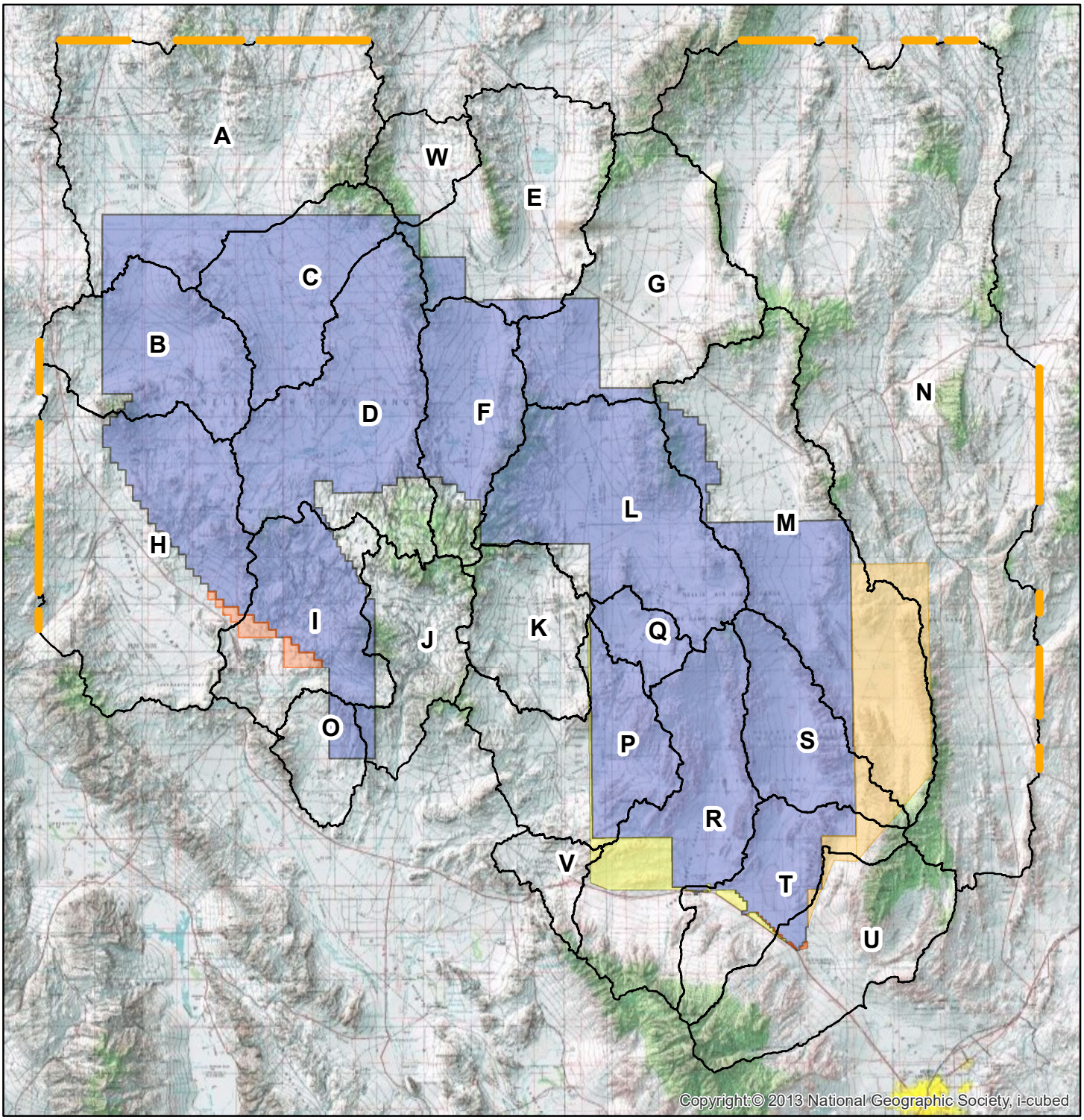


Figure 4.5: 500 yr 24 hr Rainfall Depths



Legend

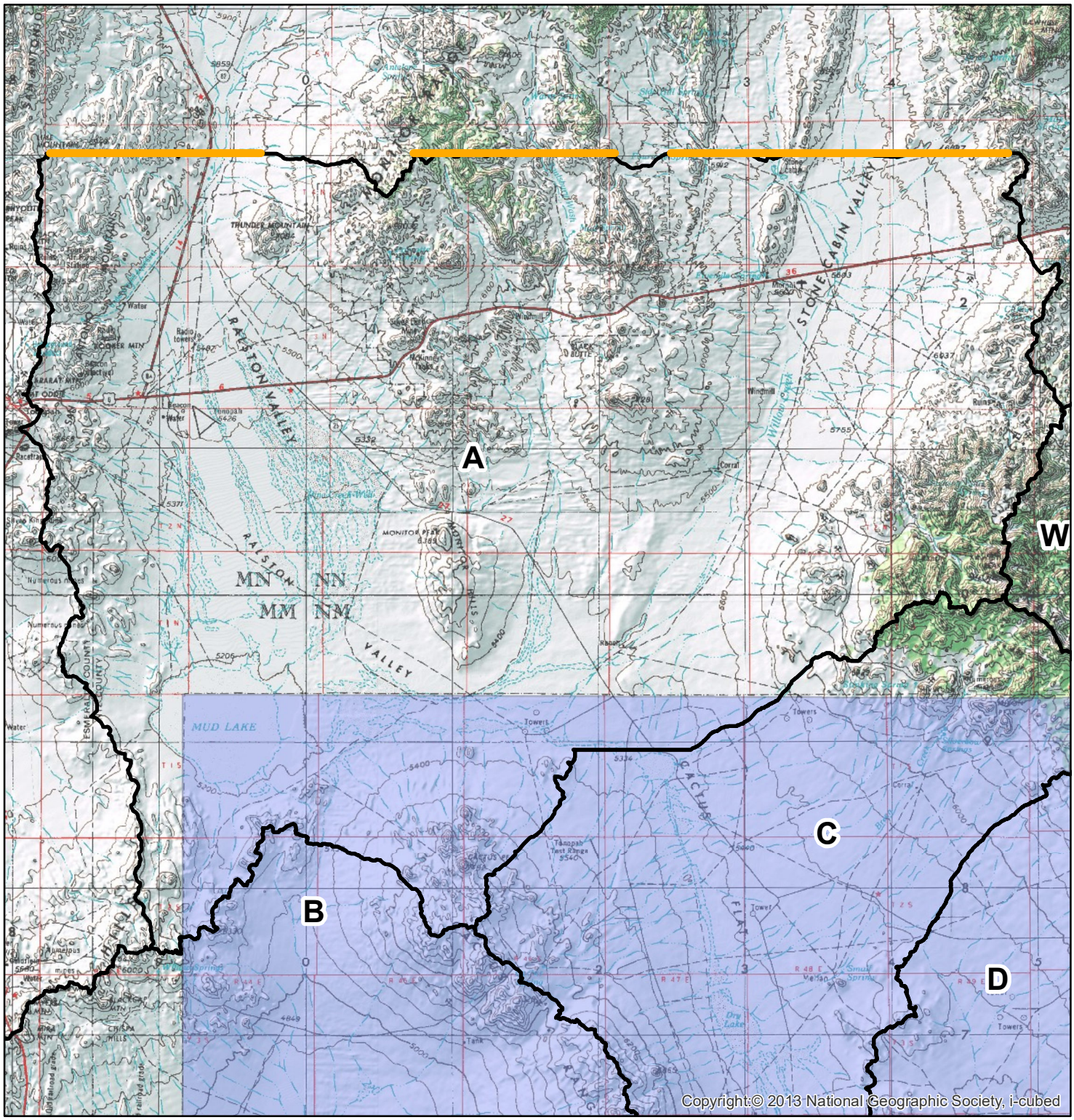
- Limits of DEM data
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:1,200,000

0 4 8 16 24 32 Miles

N

Figure 5.0: Hydrologic Basins for NTTR



Legend

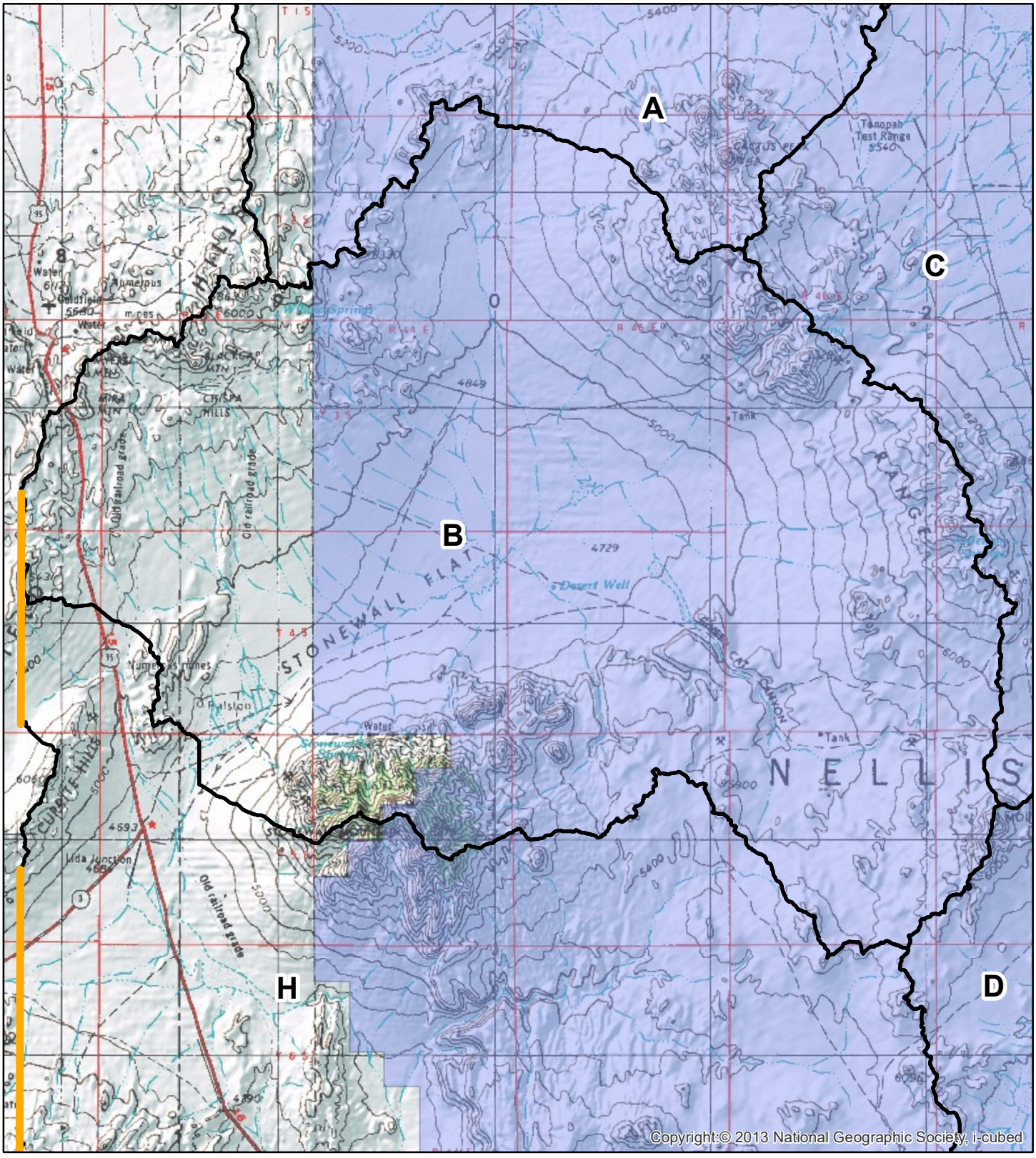
- Limits of DEM Data
- Basin Boundary
- Existing NTTR Boundary

1:375,000

0 1.5 3 6 9 12 Miles

N

Figure 5.1: Basin A



Legend

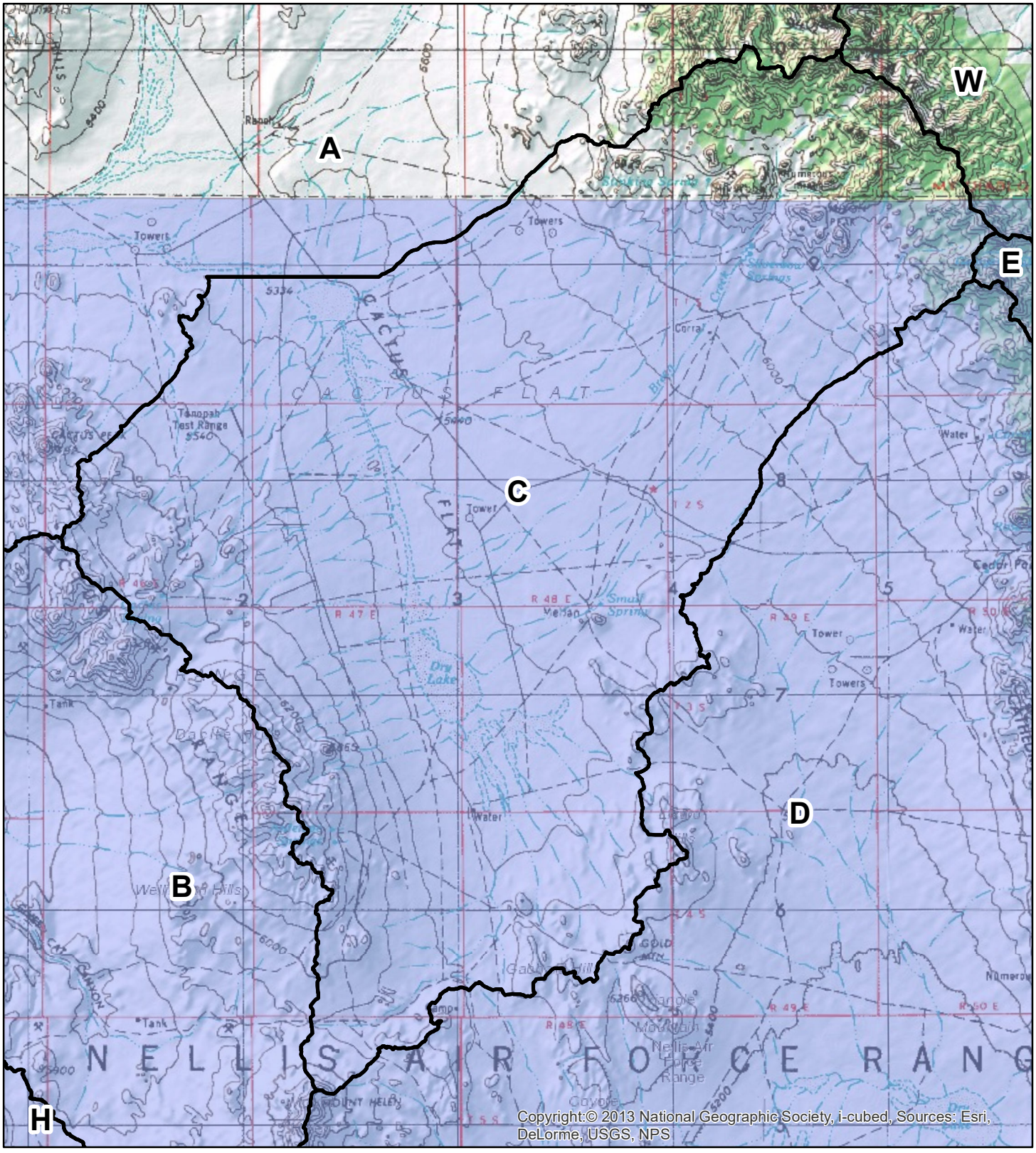
- Limits of DEM Data
- Basin Boundary
- Existing NTTR Boundary

1:250,000

0 1 2 4 6 8 Miles

N

Figure 5.2: Basin B



Legend

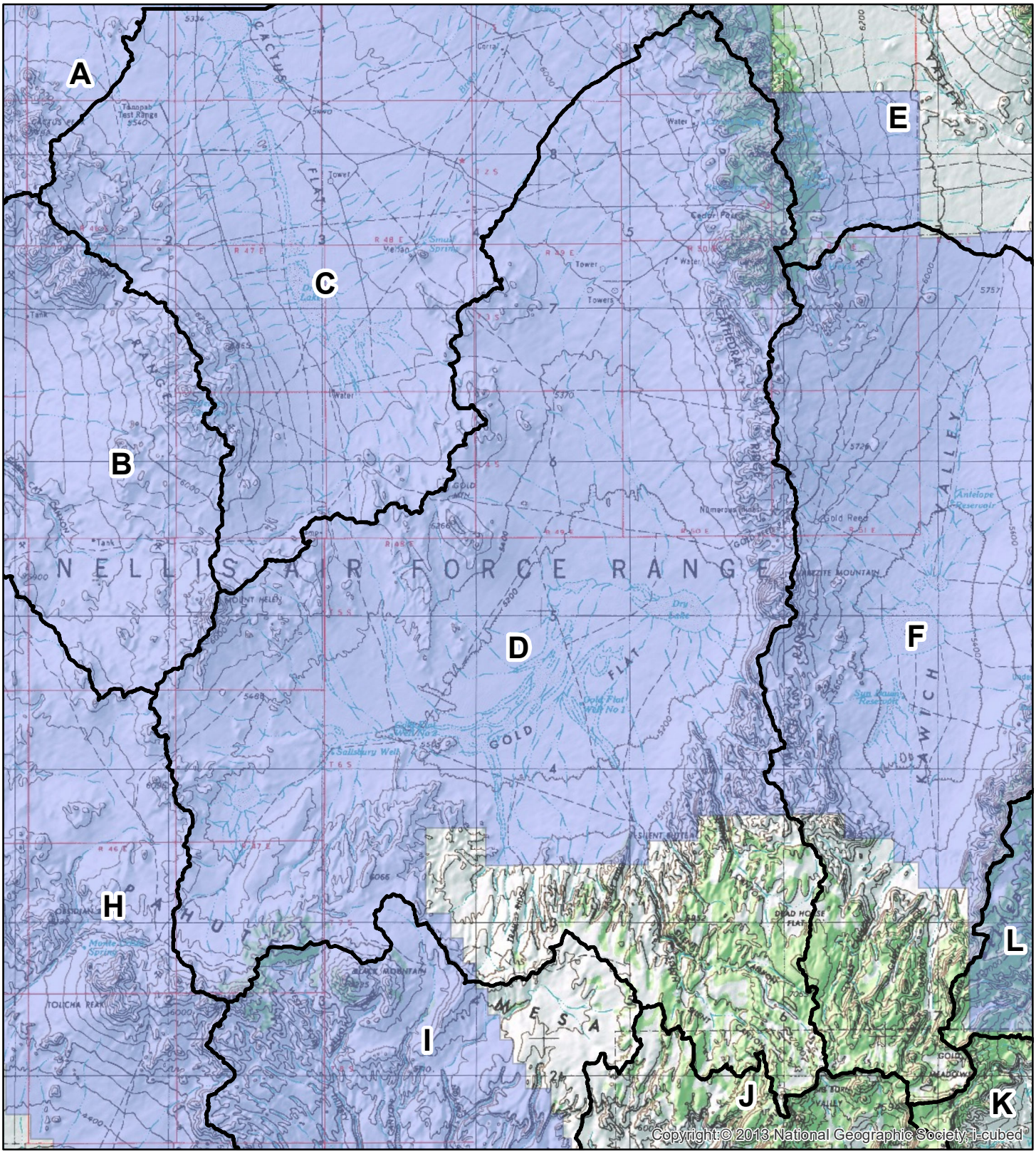
- Basin Boundary
- Existing NTTR Boundary

1:250,000

N

0 1 2 4 6 8 Miles

Figure 5.3: Basin C



Legend

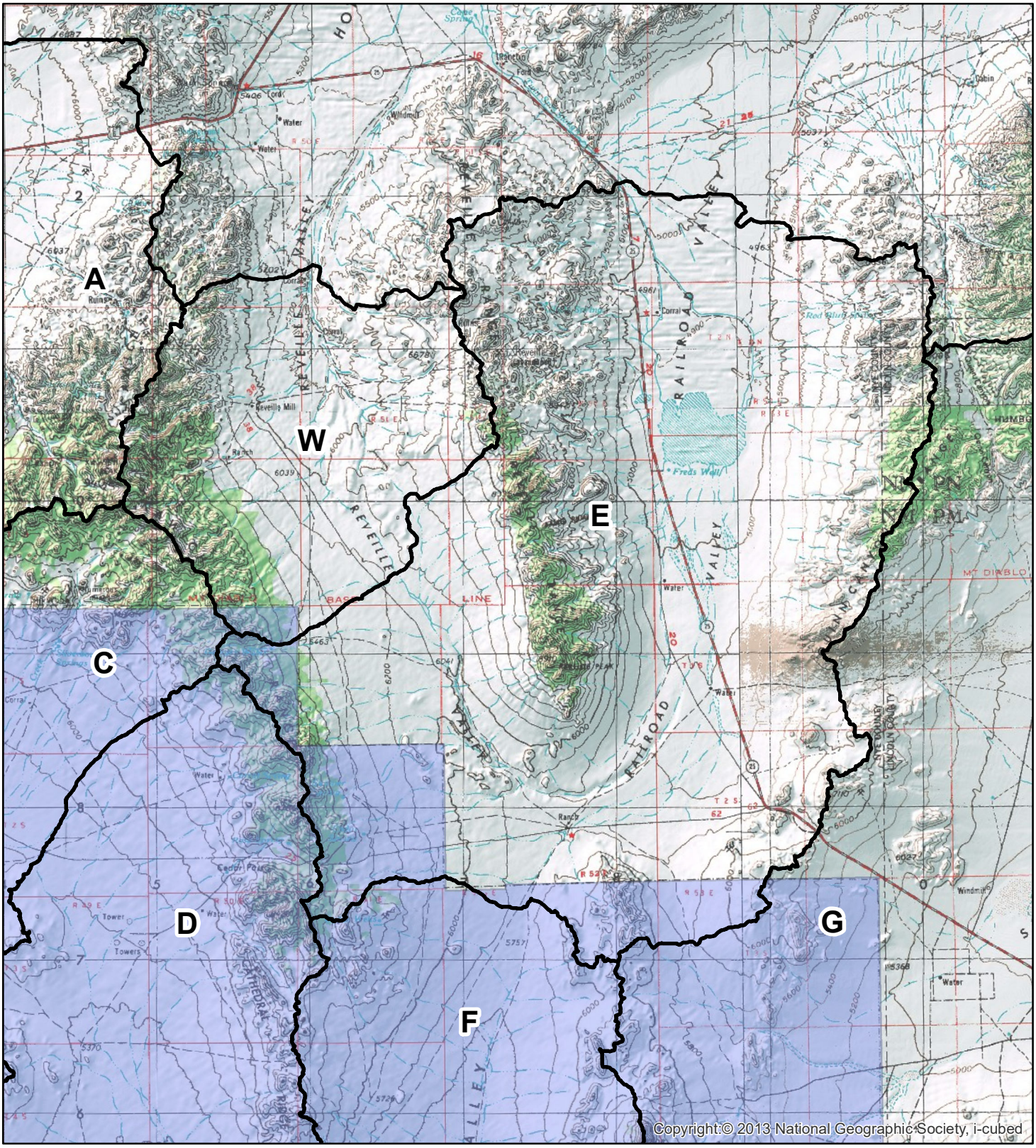
- Basin Boundary
- Existing NTTR Boundary

1:350,000

0 1 2 4 6 8 Miles

N

Figure 5.4: Basin D



Legend

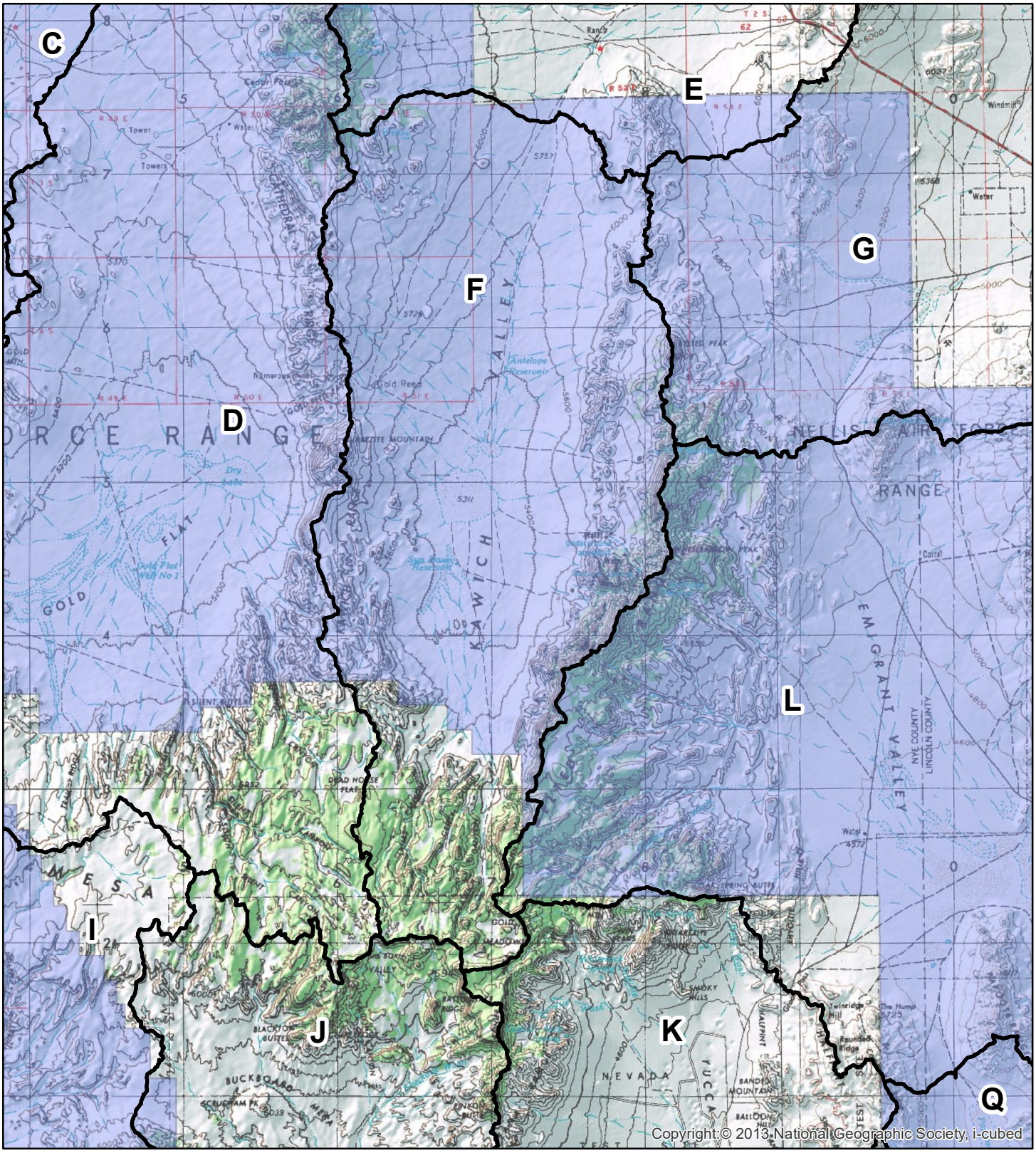
- Basin Boundary
- Existing NTTR Boundary

1:350,000

0 1 2 4 6 8 Miles

N

Figure 5.5: Basin E



Legend

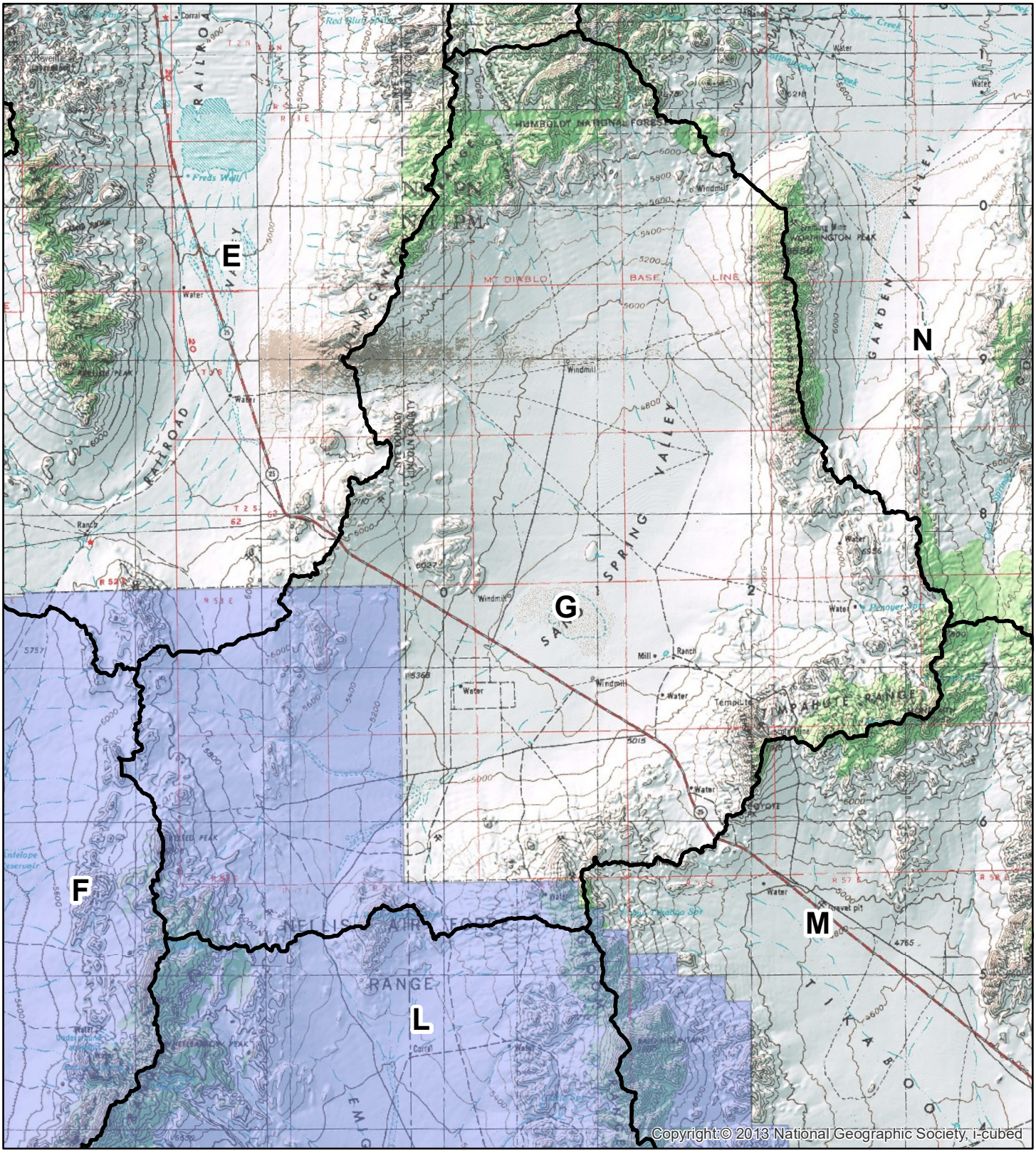
- Basin Boundary
- Existing NTTR Boundary

1:350,000

0 1 2 4 6 8 Miles

N

Figure 5.6: Basin F



Legend

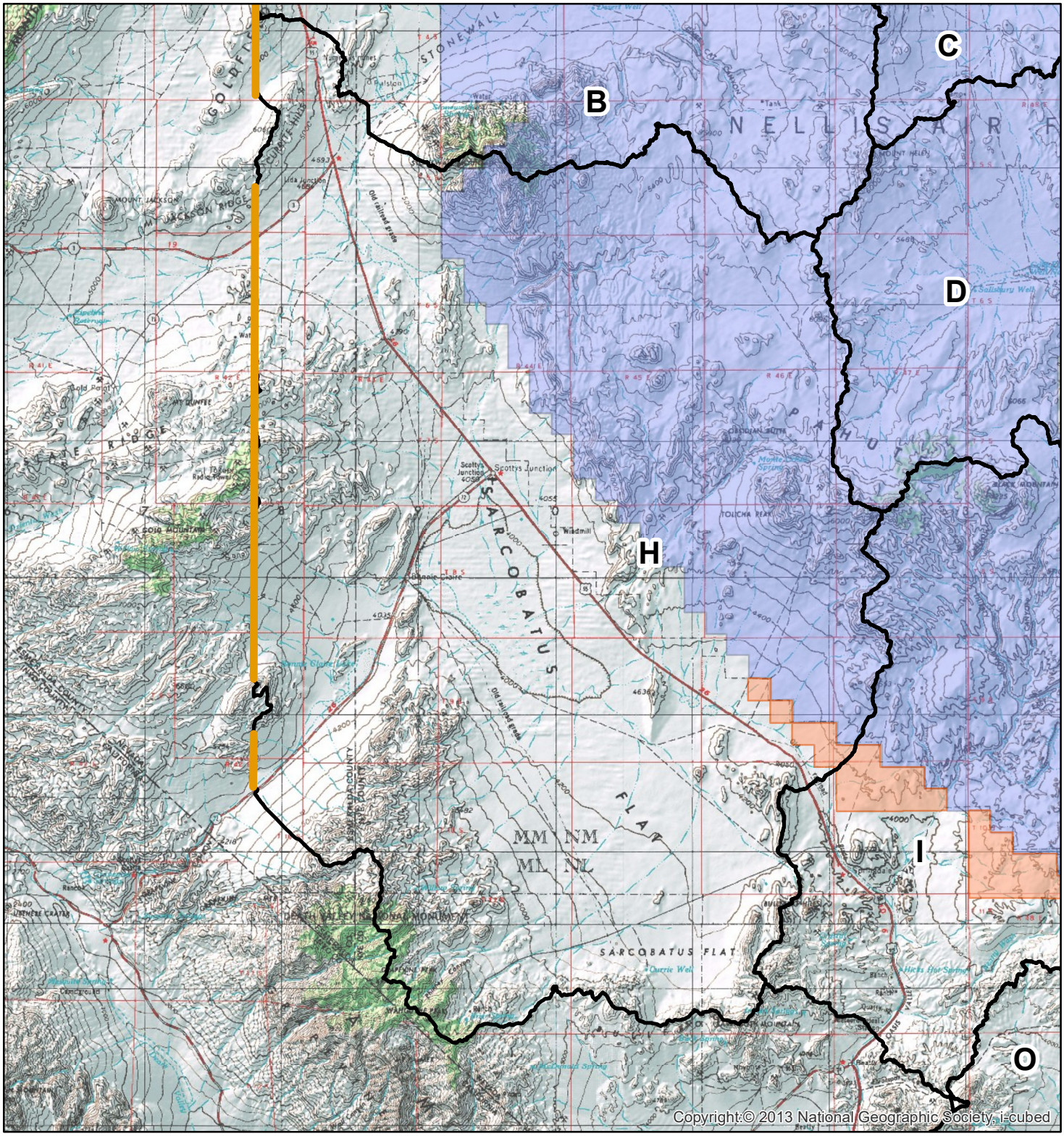
- Basin Boundary
- Existing NTTR Boundary

1:350,000

0 1 2 4 6 8 Miles

N

Figure 5.7: Basin G



Legend

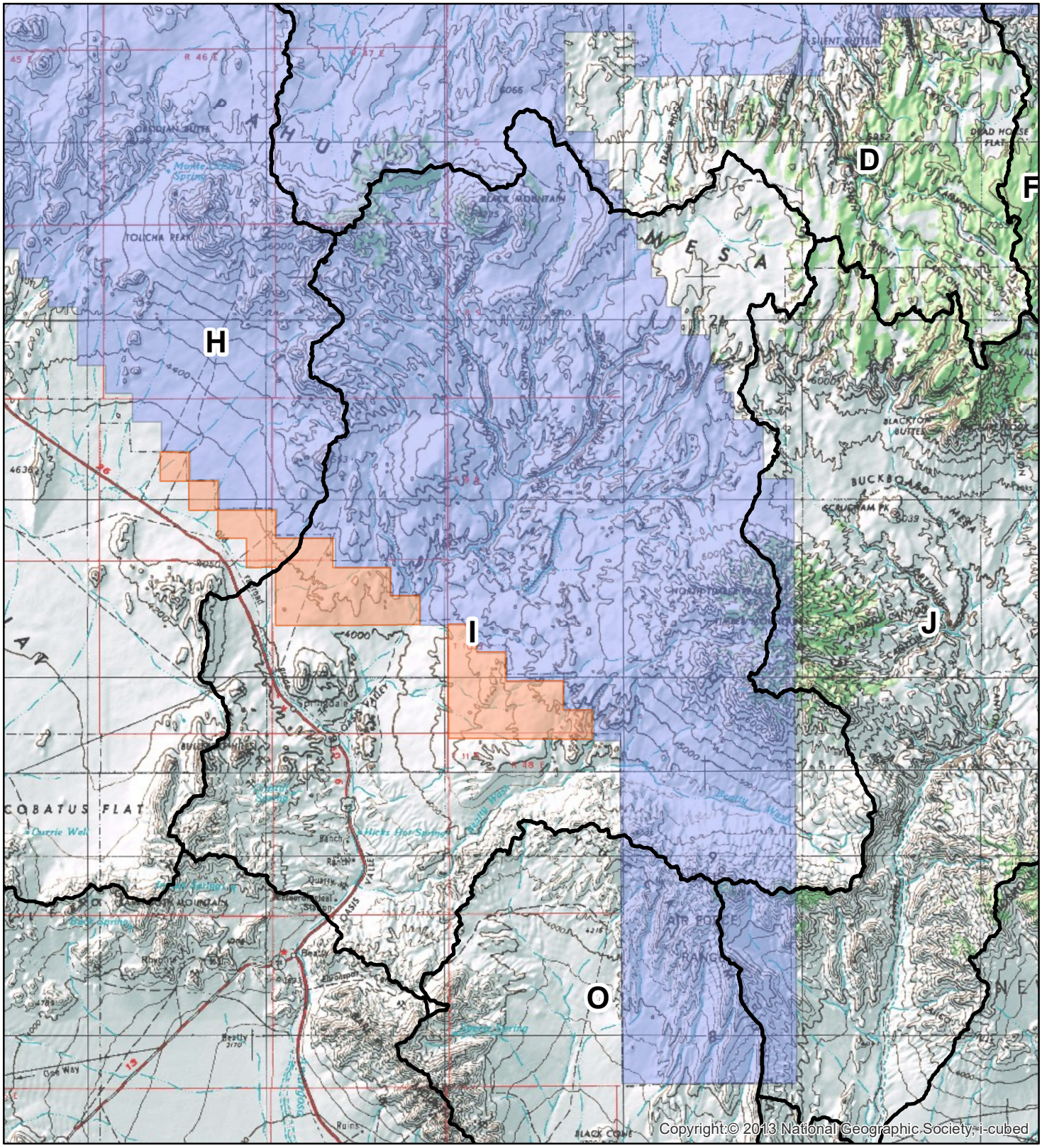
- Limits of DEM Data
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

1:400,000

0 1.5 3 6 9 12 Miles

N

Figure 5.8: Basin H



Legend

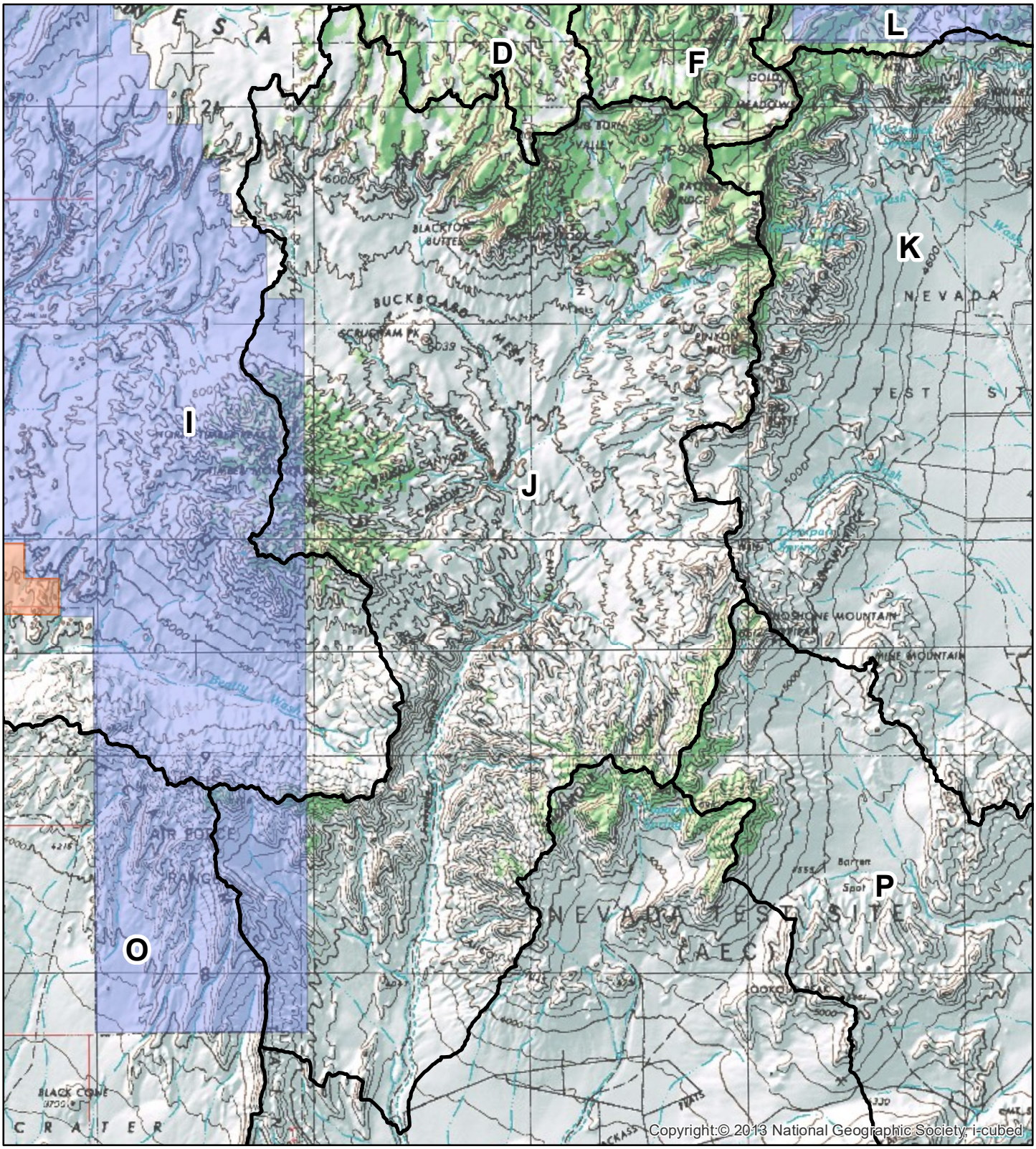
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

1:300,000

0 1 2 4 6 8 Miles

N

Figure 5.9: Basin I



Legend

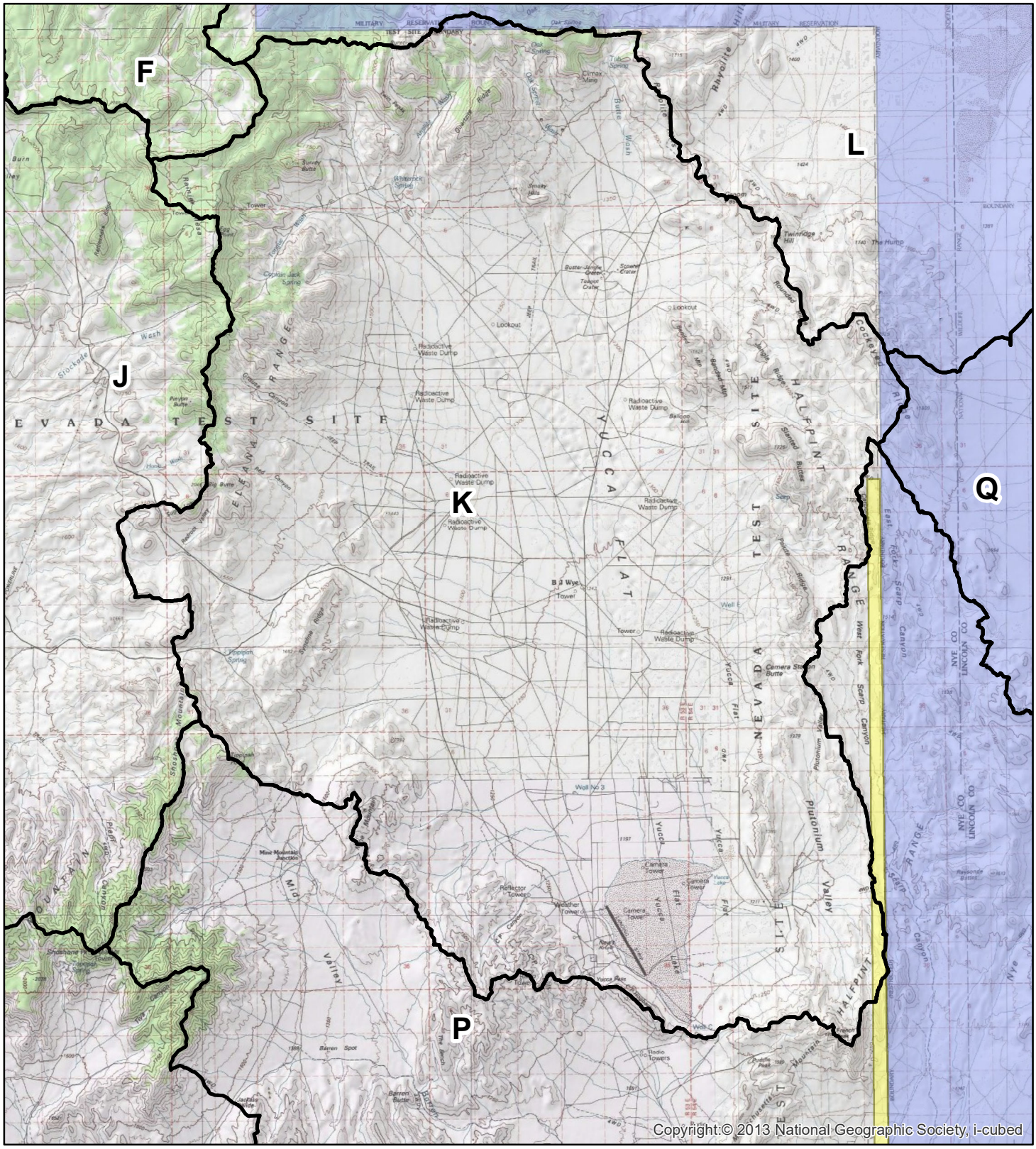
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

1:250,000

0 1 2 4 6 8 Miles

N

Figure 5.10: Basin J



Legend

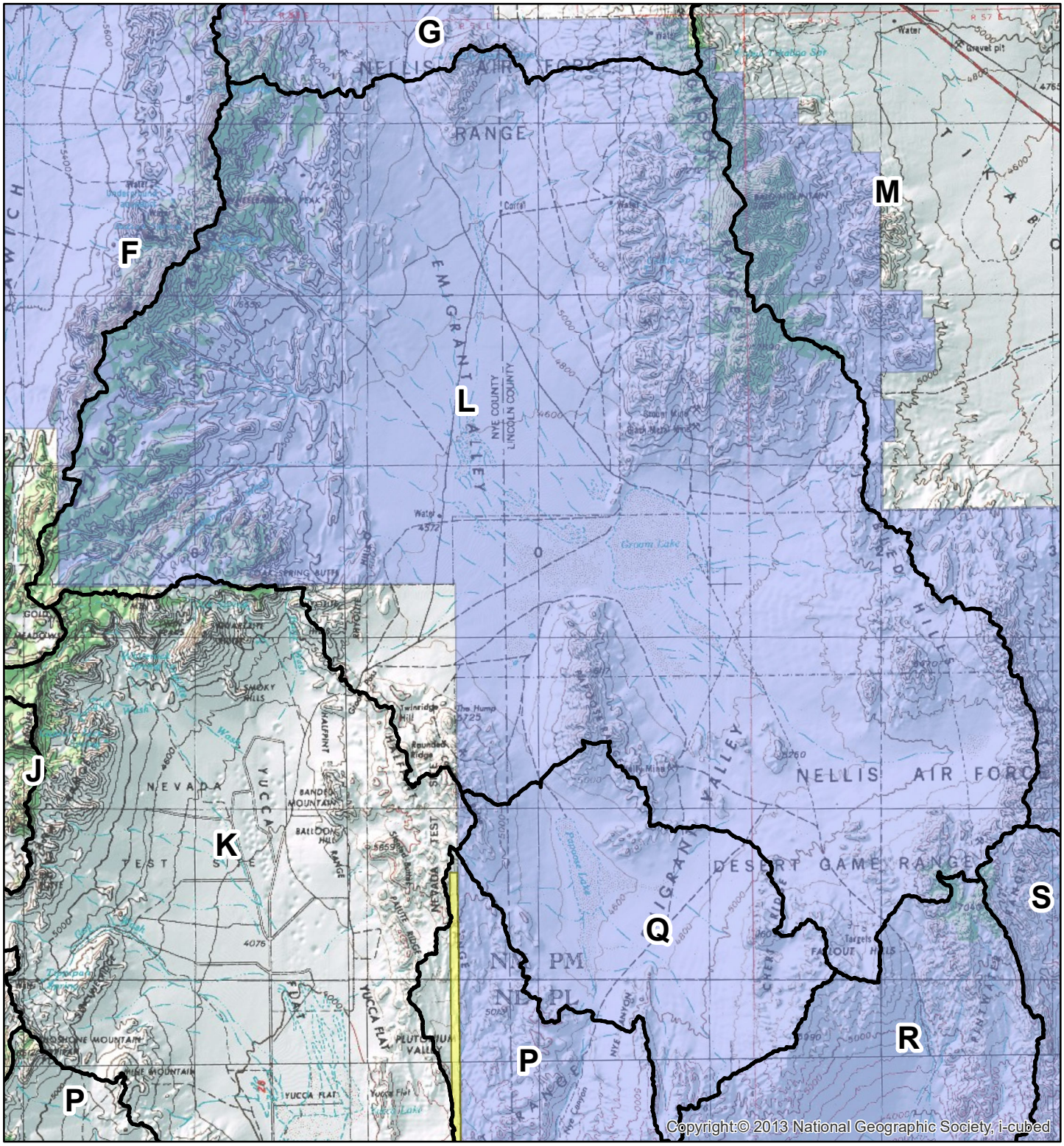
- Basin Boundary
- Alternative 64 C/D and 65 D Expansion
- Existing NTTR Boundary

1:200,000

0 1 2 4 6 8 Miles

N

Figure 5.11: Basin K



Legend

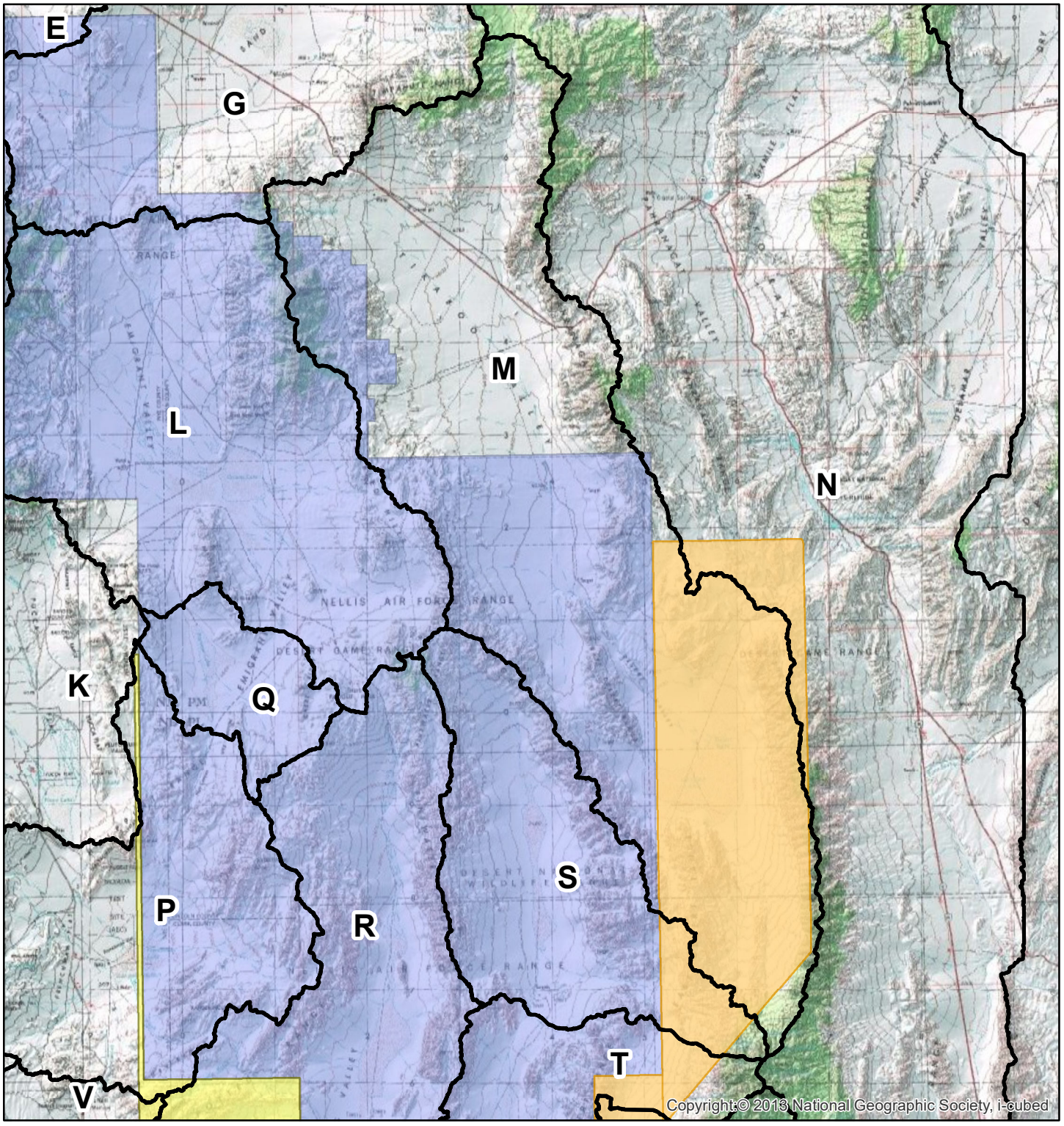
- Basin Boundary
- Alternative 3B 64 C/D and 65D Expansion
- Existing NTTR Boundary

1:325,000

0 1 2 4 6 8 Miles

N

Figure 5.12: Basin L



Legend

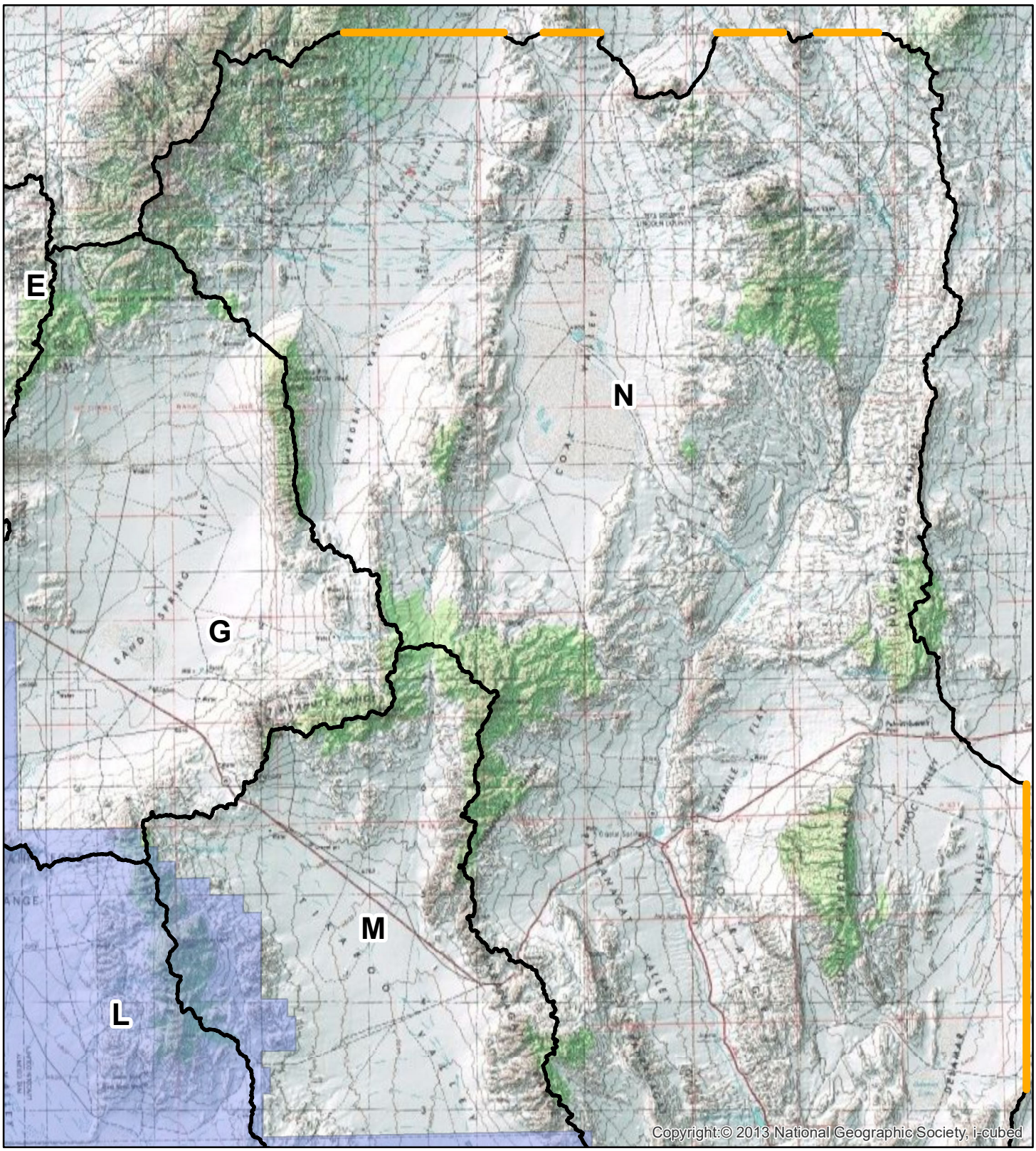
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:600,000

0 2.5 5 10 15 20 Miles

N

Figure 5.13: Basin M



Legend

- Limits of DEM Data
- Basin Boundary
- Existing NTTR Boundary

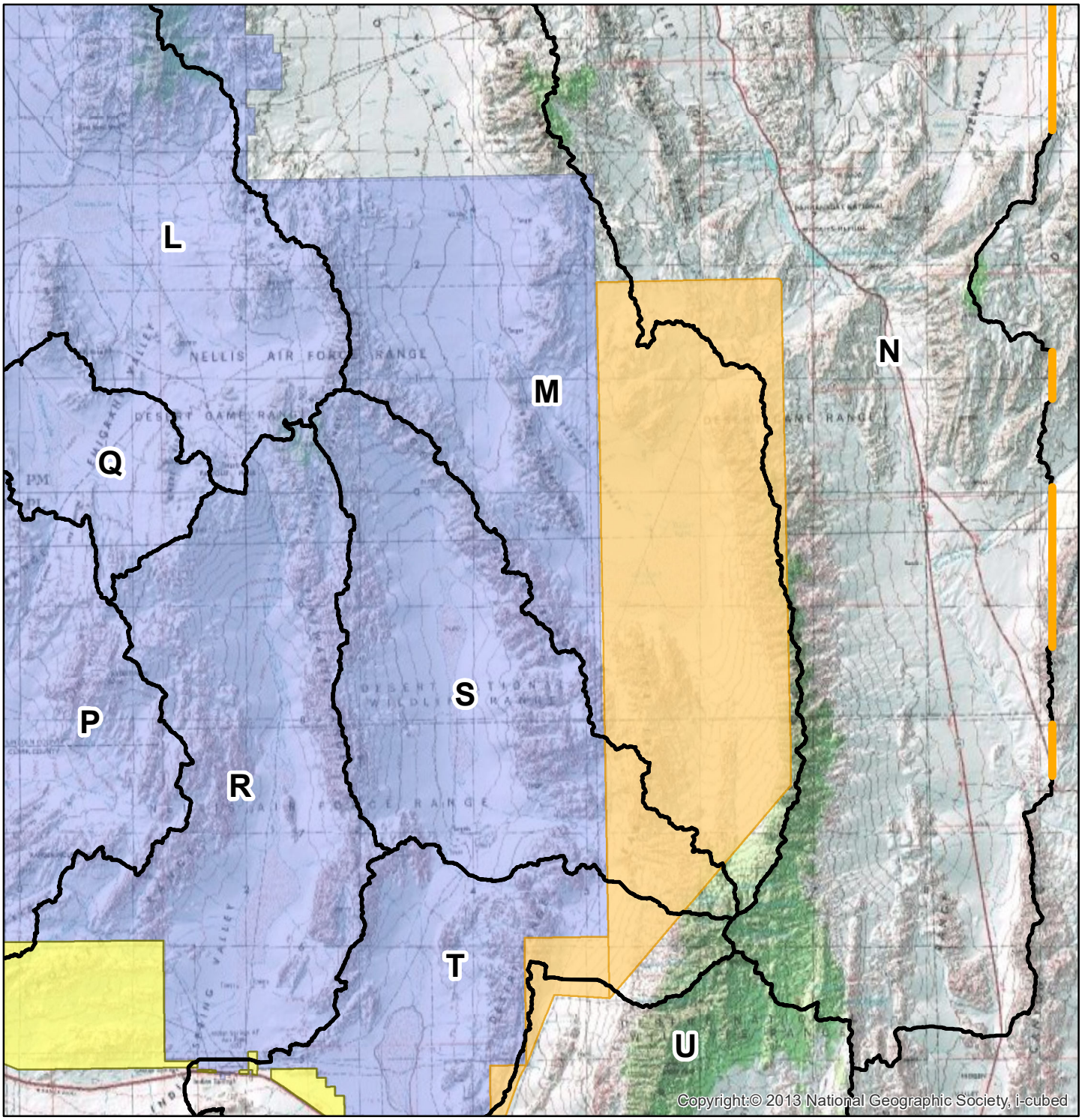
1:500,000

Miles

0 2 4 8 12 16

N

Figure 5.14A: Basin N



Legend

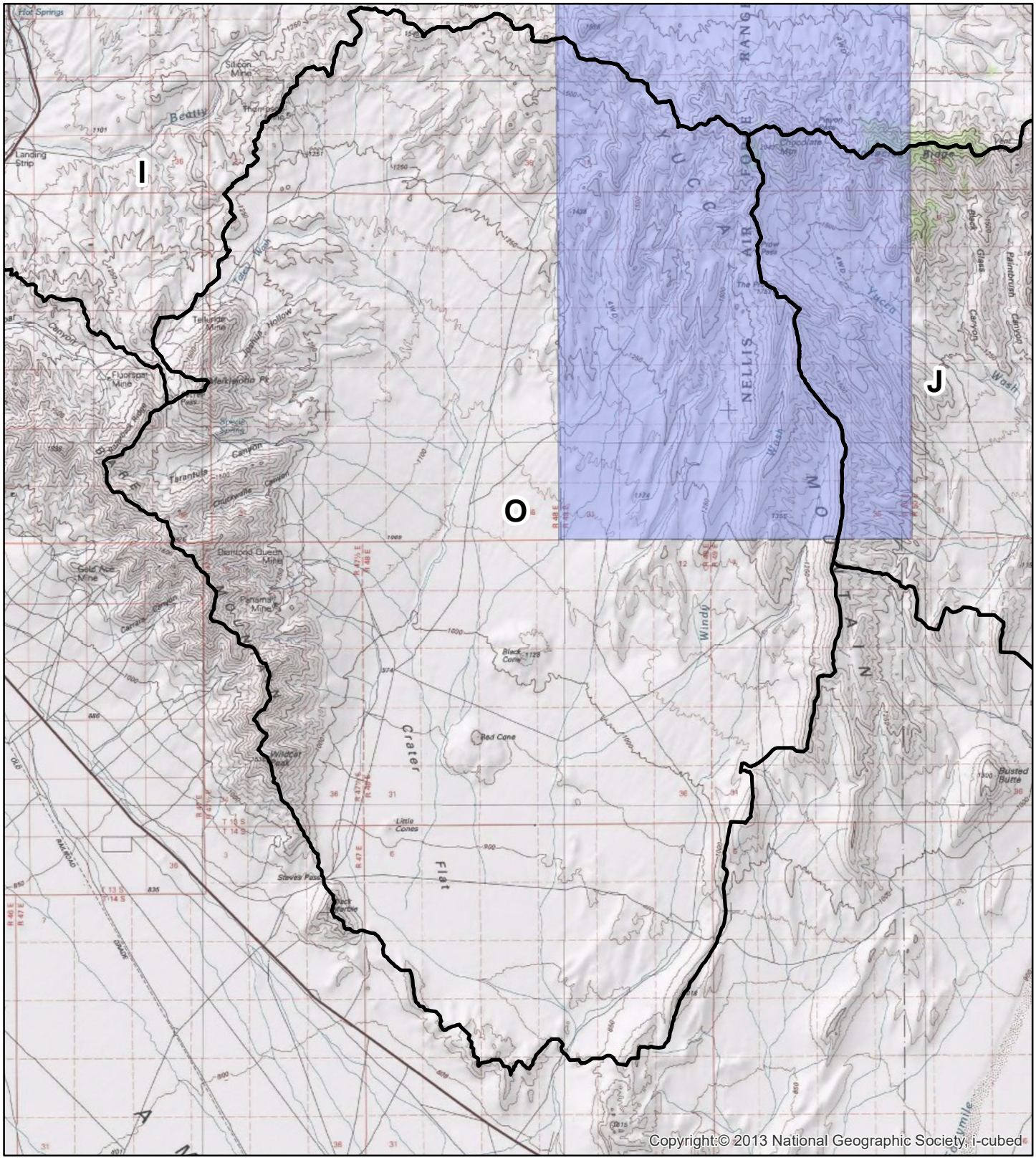
- Limits of DEM Data
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:500,000

0 2 4 8 12 16 Miles

N

Figure 5.14B: Basin N



Legend

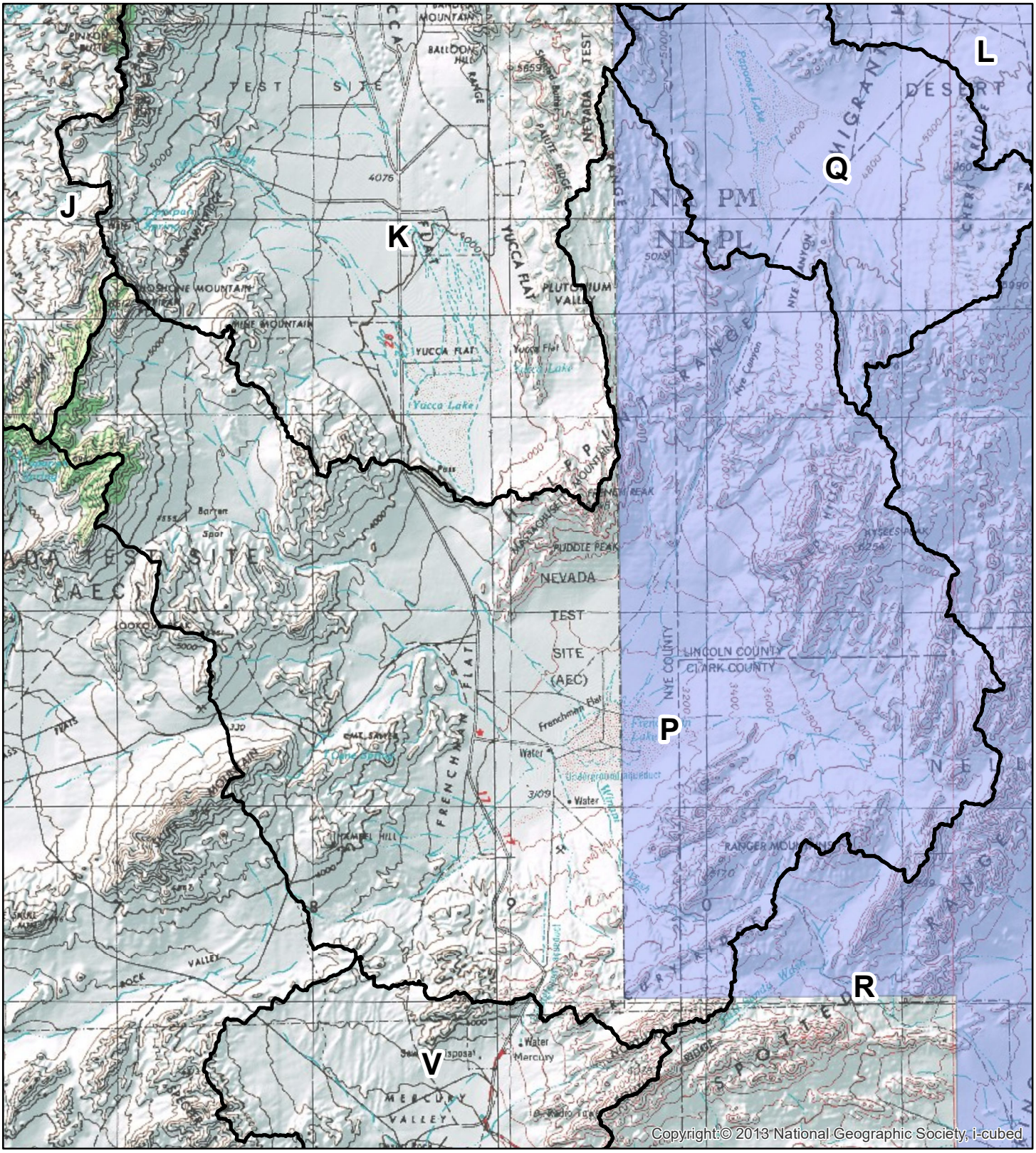
- Basin Boundary
- Existing NTTR Boundary

1:150,000

0 0.5 1 2 3 4 Miles

N

Figure 5.15:Basin O



Legend

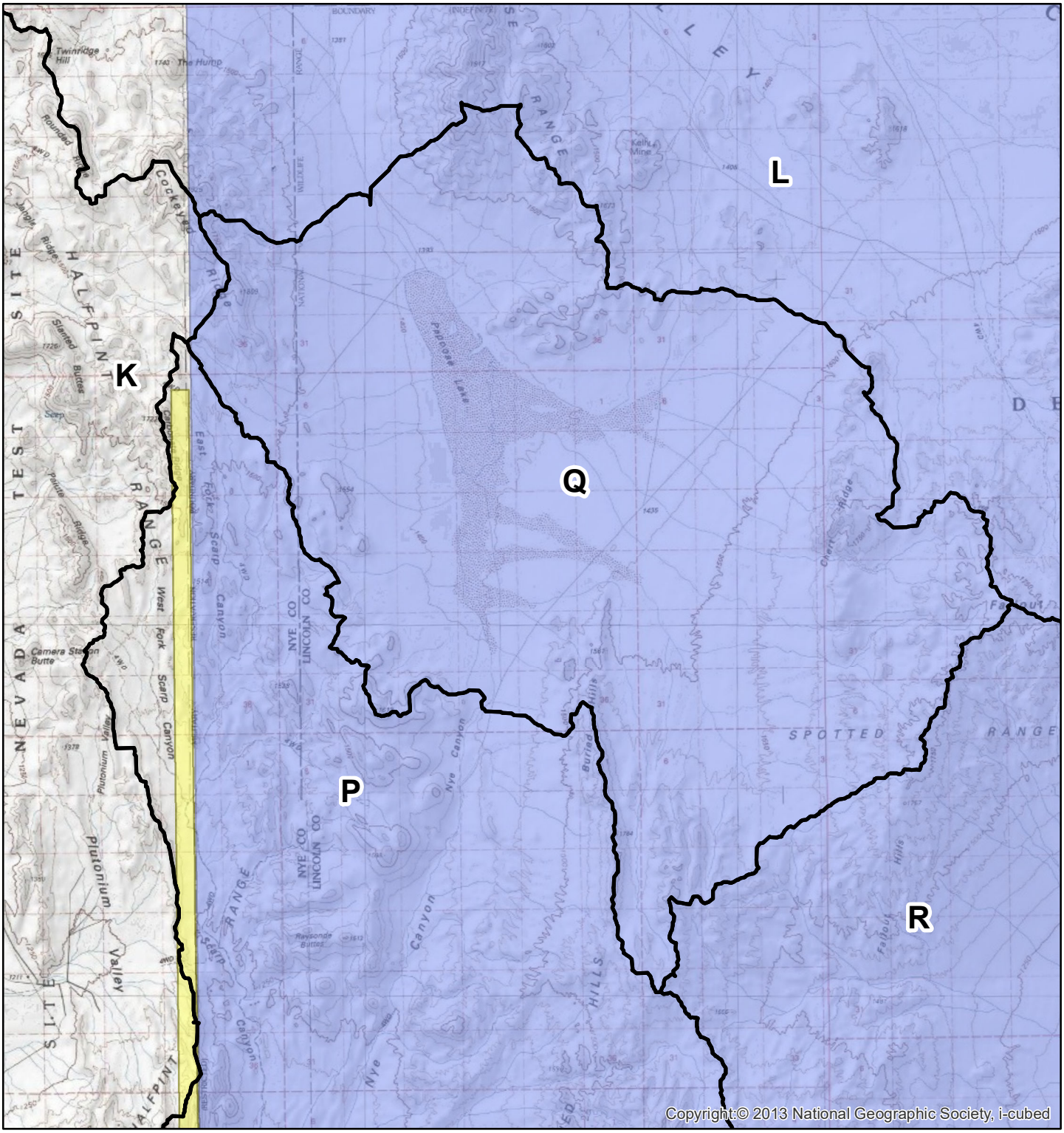
- Basin Boundary
- Existing NTTR Boundary

1:275,000

0 1 2 4 6 8 Miles

N

Figure 5.16: Basin P



Legend

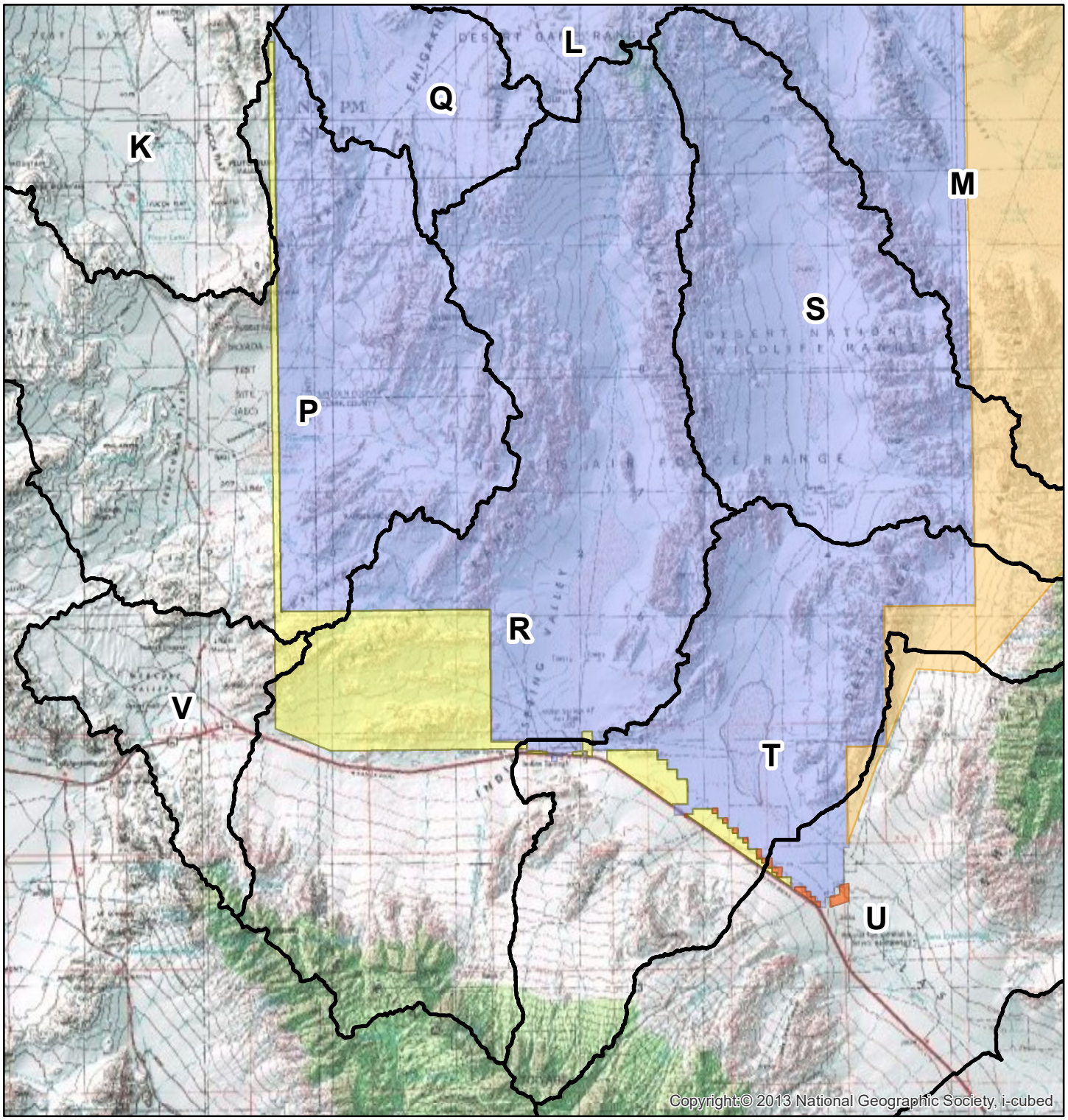
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Existing NTTR Boundary

N

1:150,000

0 0.5 1 2 3 4 Miles

Figure 5.17: Basin Q



Legend

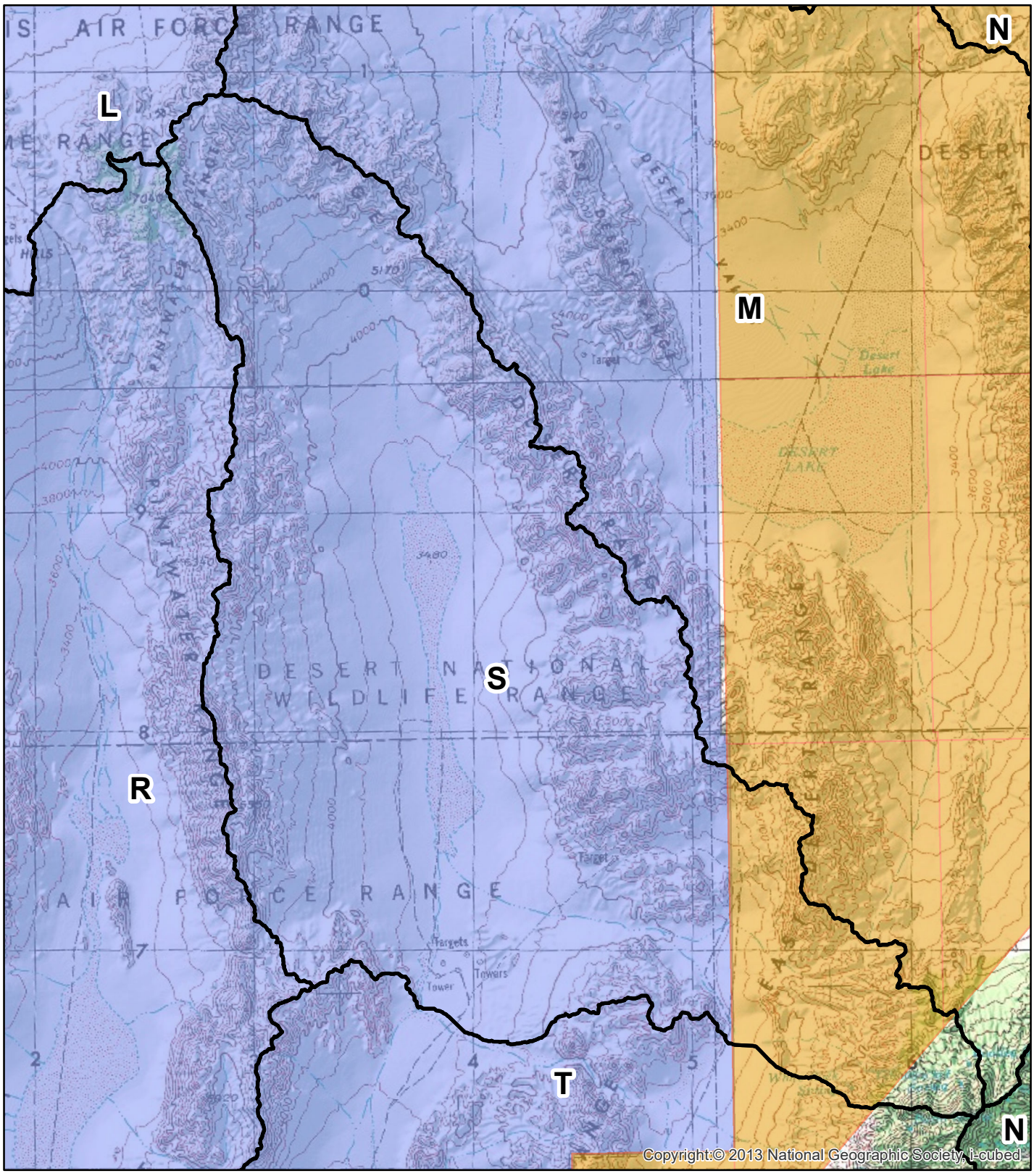
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:450,000

0 2 4 8 12 16 Miles

N

Figure 5.18: Basin R



Legend

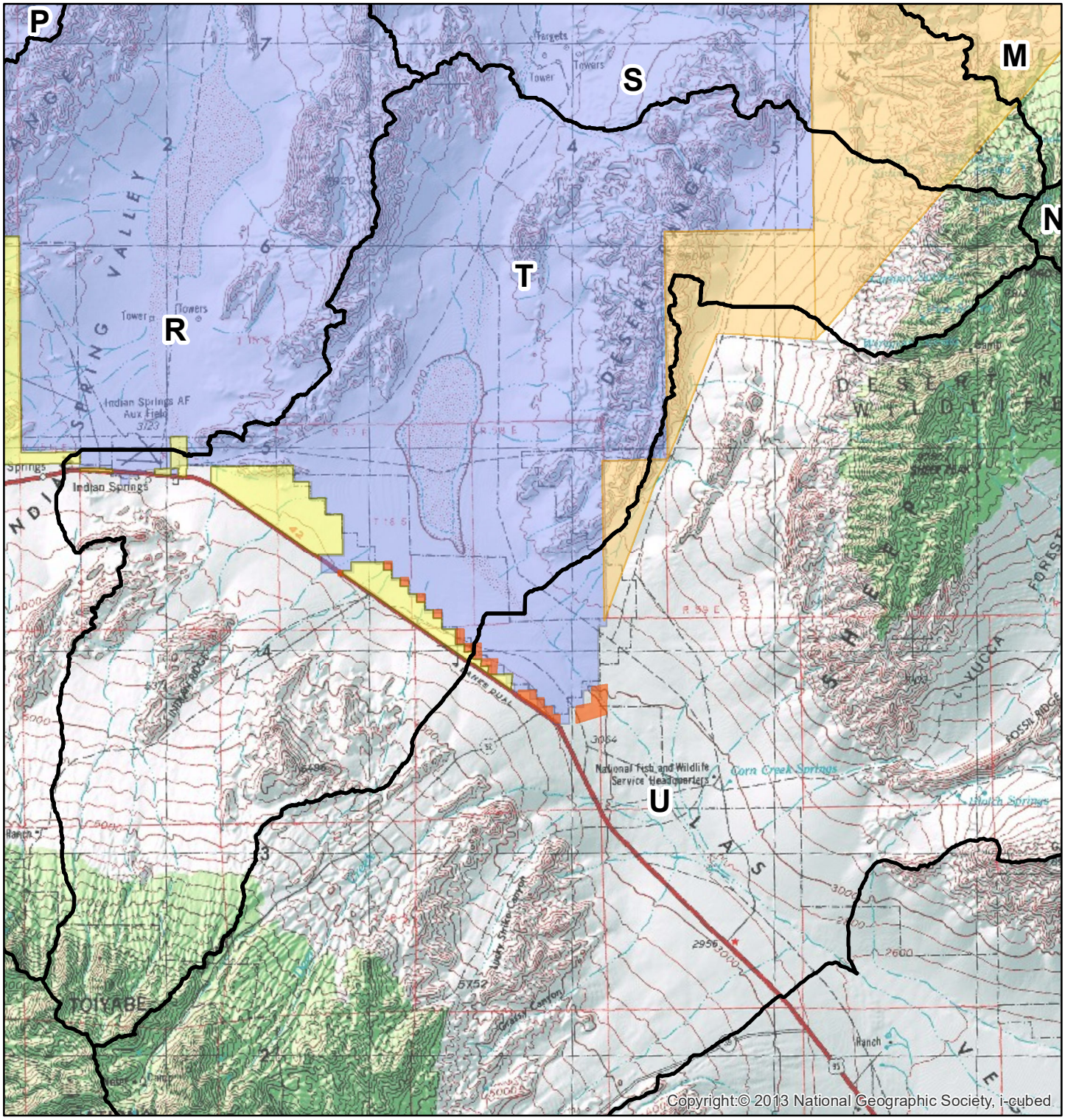
- Basin Boundary
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:250,000

0 1 2 4 6 8 Miles

N

Figure 5.19: Basin S



Legend

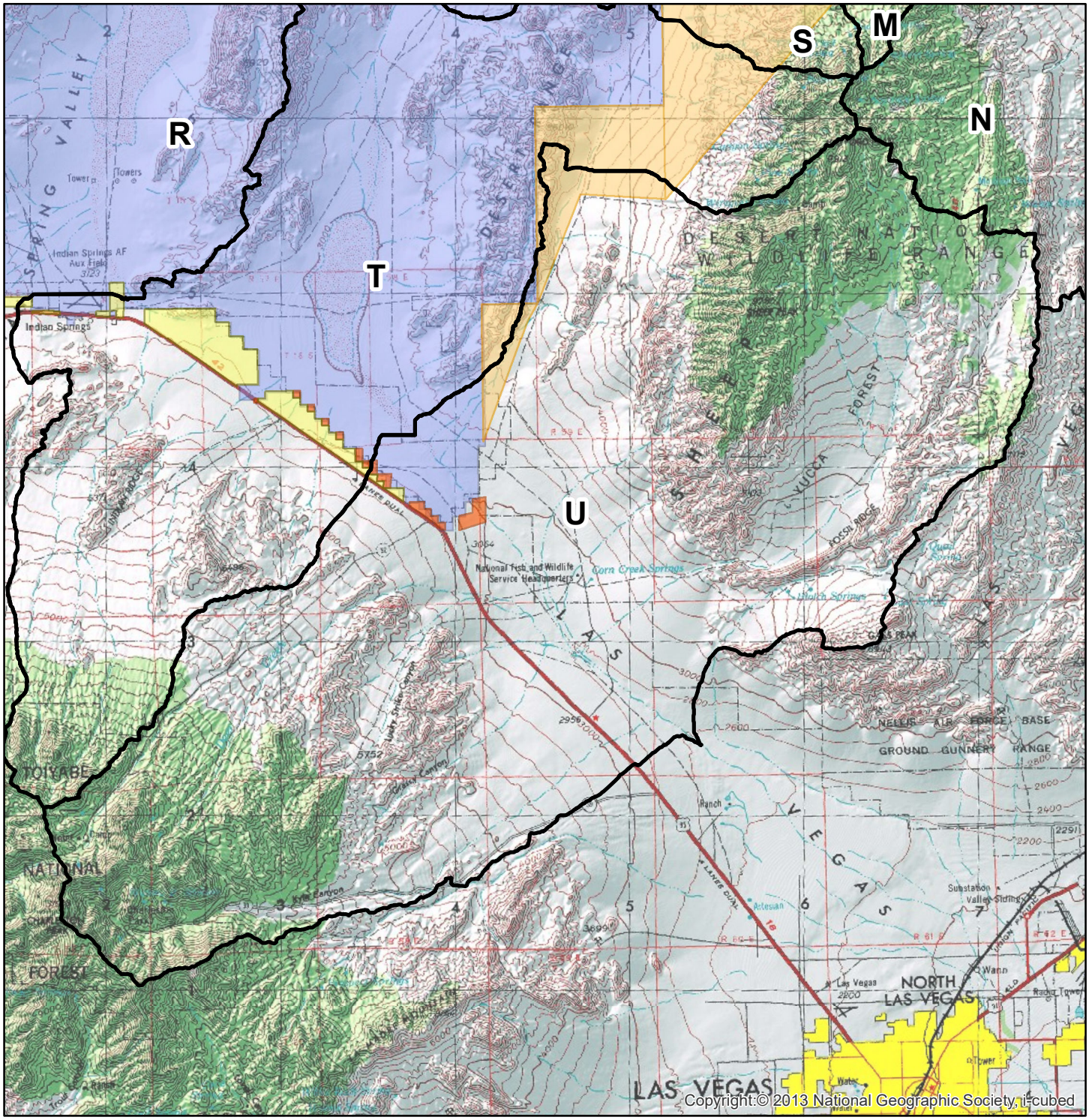
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:275,000

0 1 2 4 6 8 Miles

N

Figure 5.20: Basin T



Legend

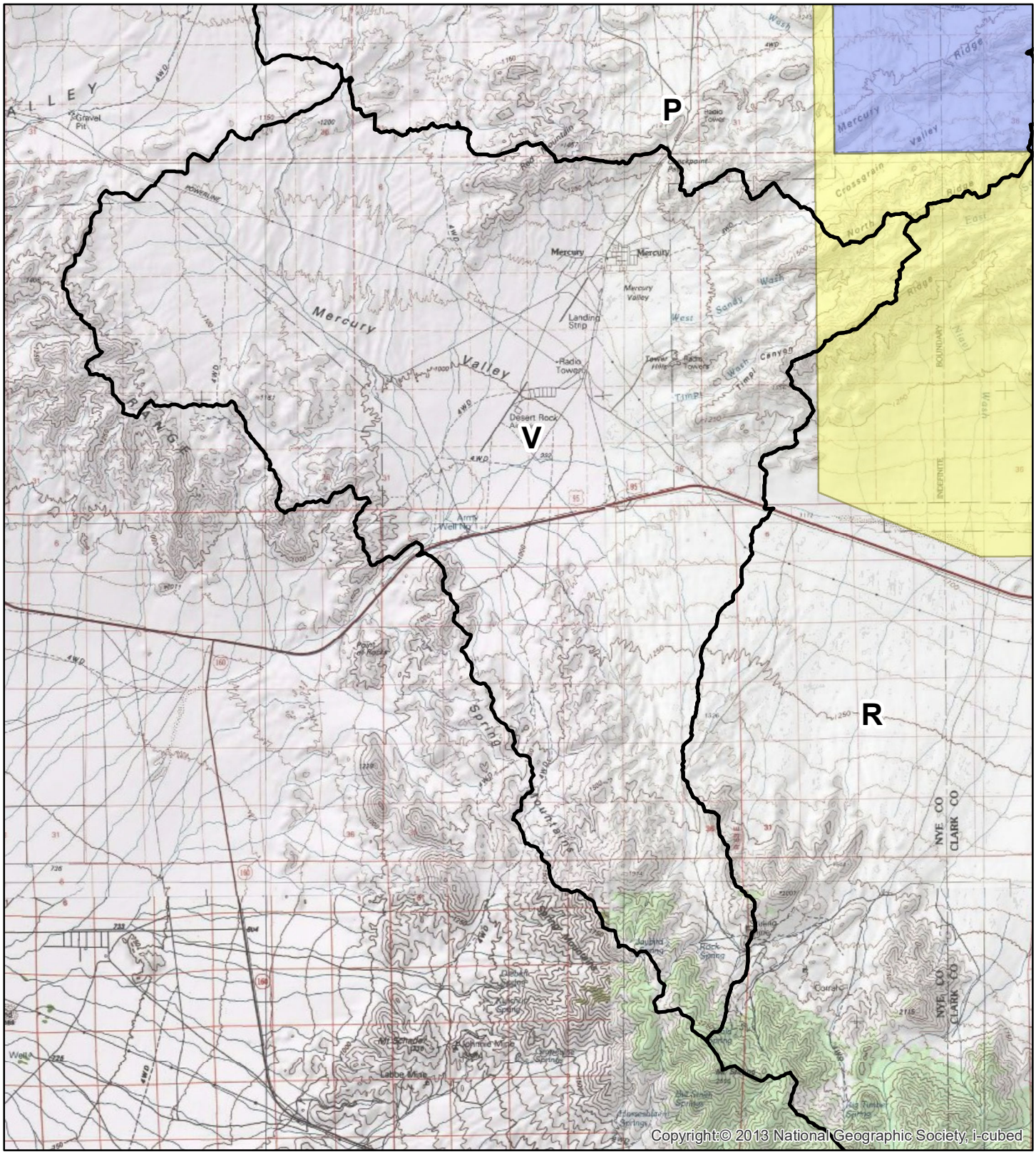
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:325,000

0 1 2 4 6 8 Miles

N

Figure 5.21: Basin U



Legend

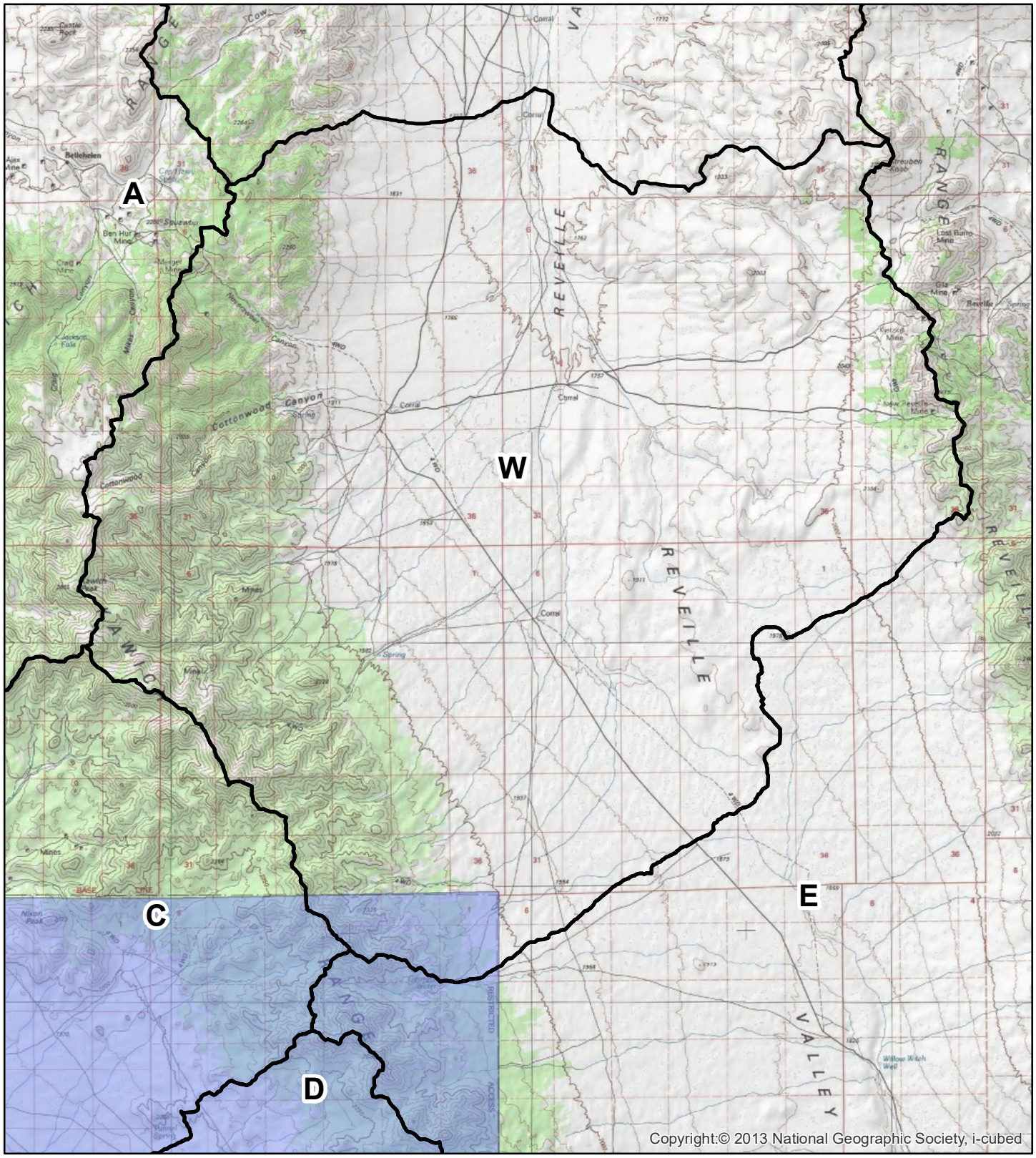
- Basin Boundary
- Alternative 3B 64C/D and 65D Expansion
- Existing NTTR Boundary

1:150,000

0 0.5 1 2 3 4 Miles

N

Figure 5.22: Basin V



Legend

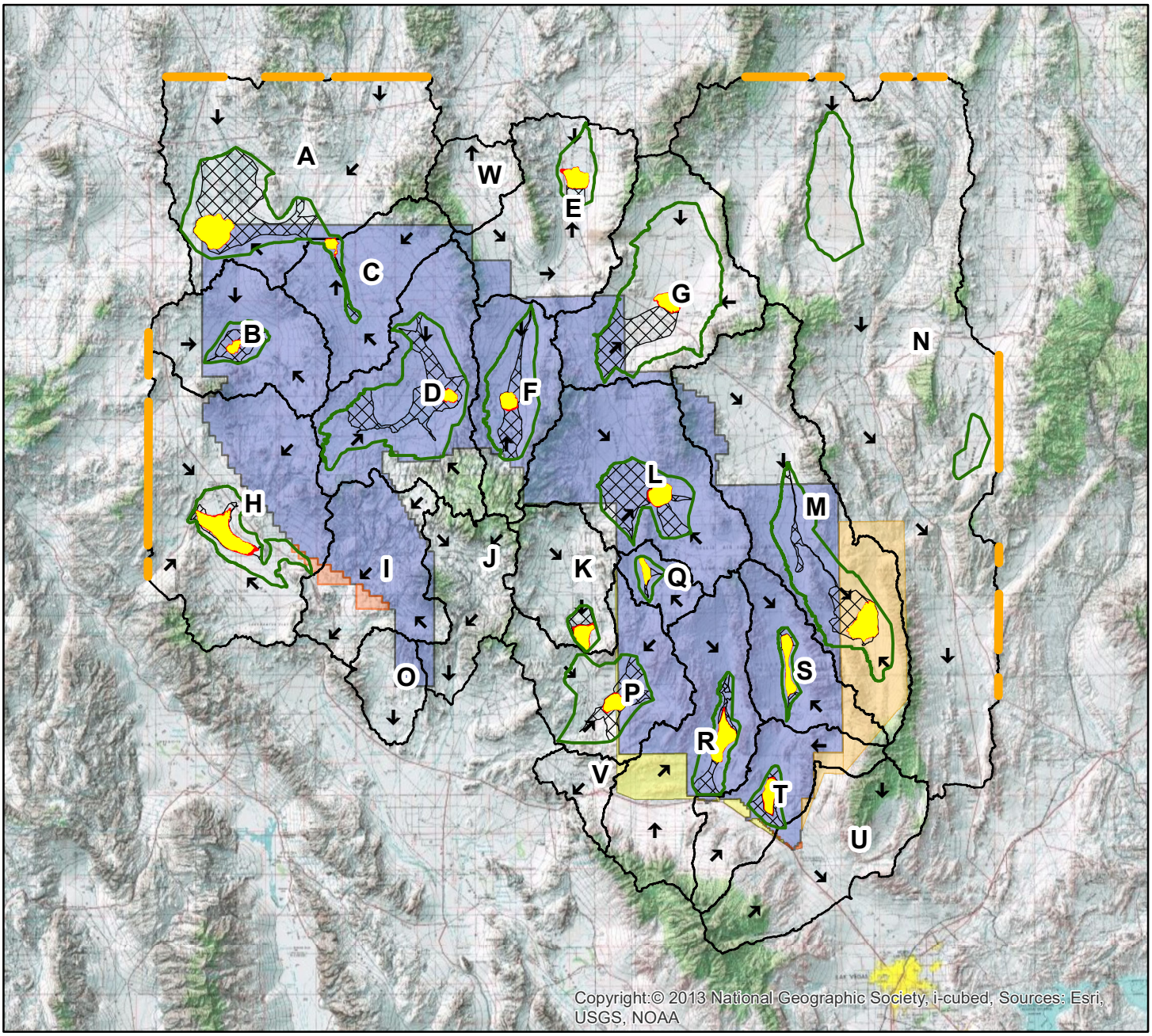
- Basin Boundary
- Existing NTTR Boundary

N

1:150,000

0 0.5 1 2 3 4 Miles

Figure 5.23: Basin W



Legend

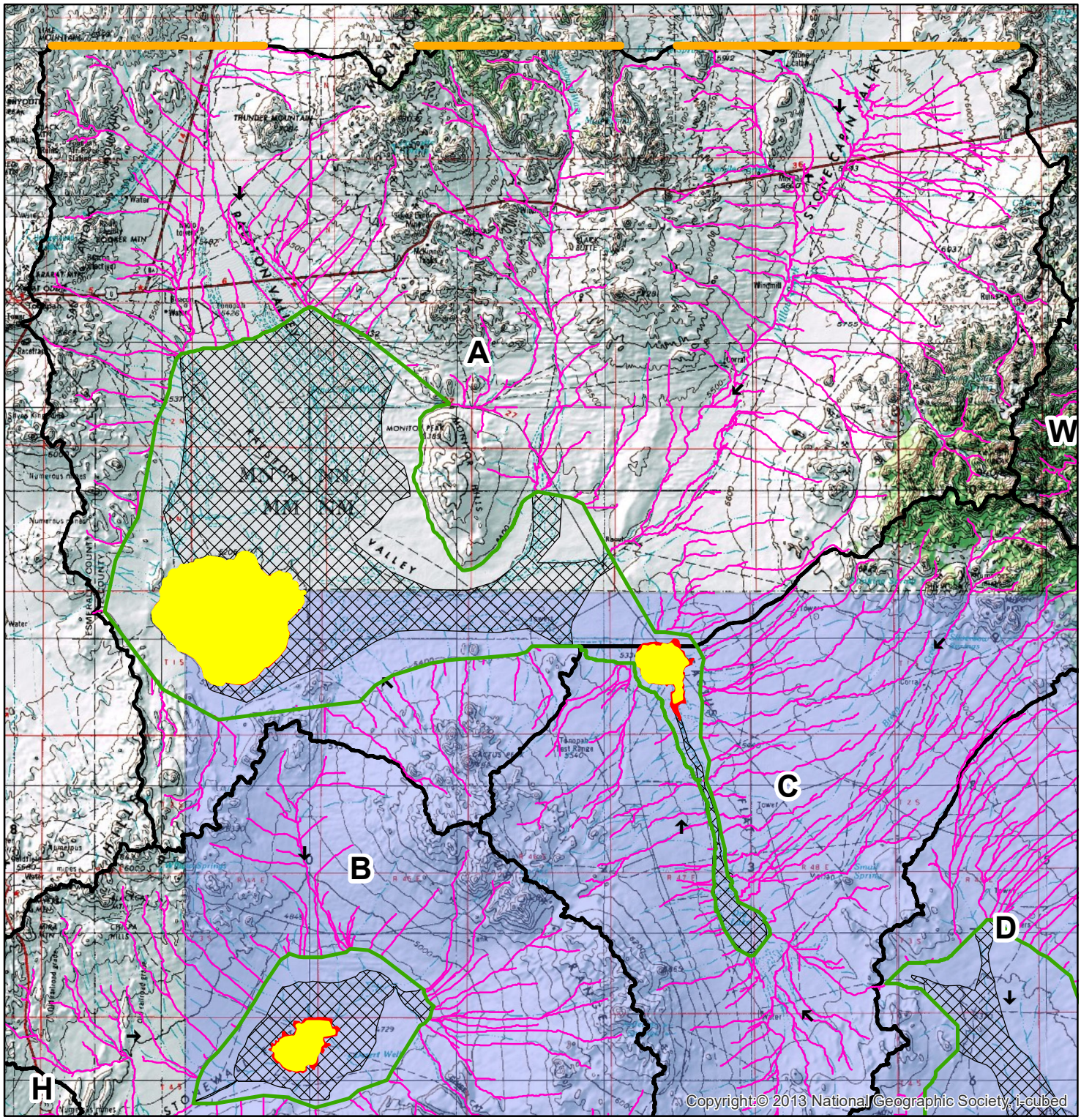
- Limits of DEM data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- 100yrWSE
- 500yrWSE
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:1,500,000

0 5 10 20 30 40 Miles

Figure 6.0: Flood Zones for NTTR with Topographic Base Map



Legend

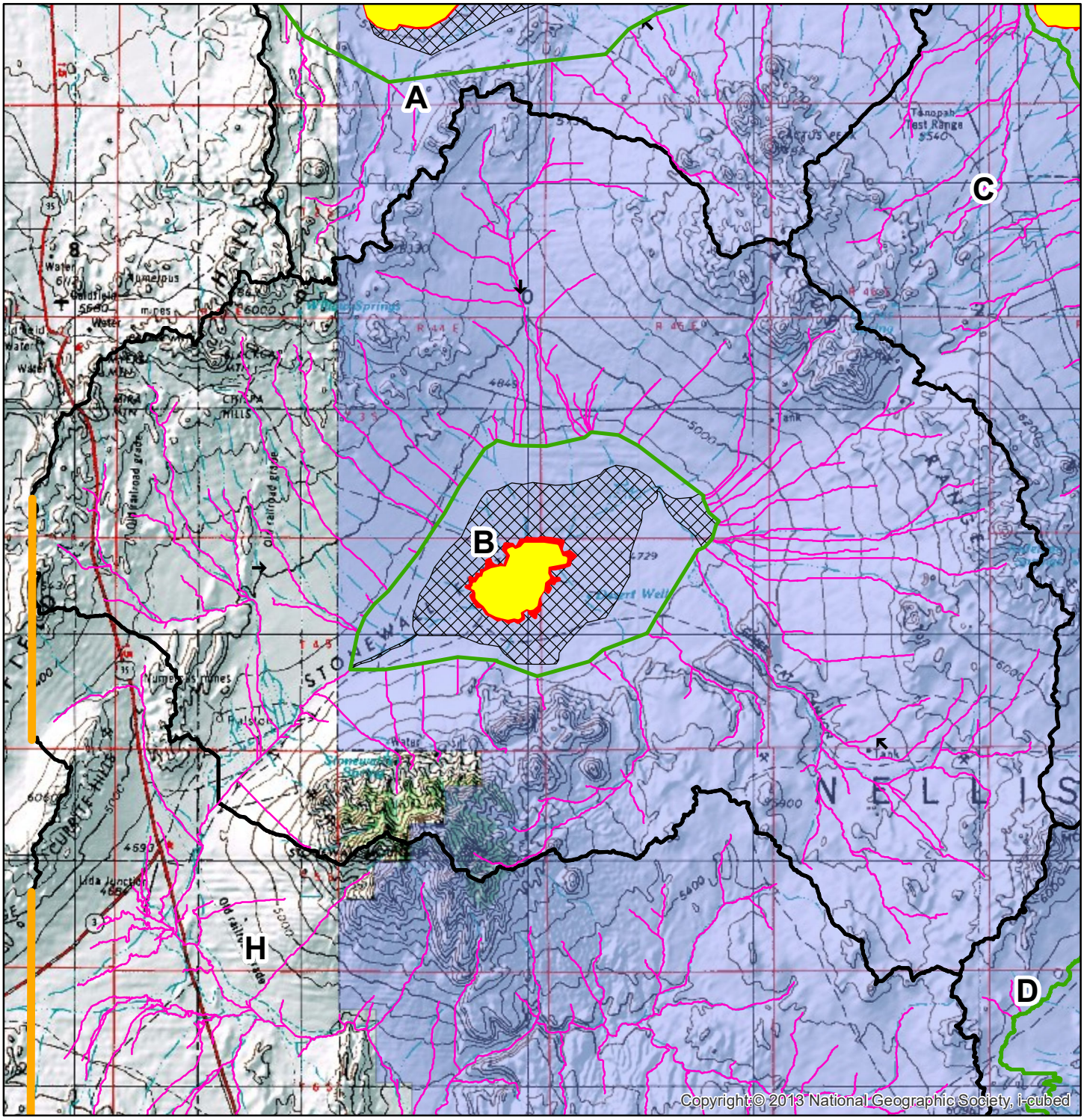
- Limits of DEM Data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

N

1:375,000

0 1.5 3 6 9 12 Miles

Figure 6.1: Flood Zone for Basin A with Topographic Base Map



Legend

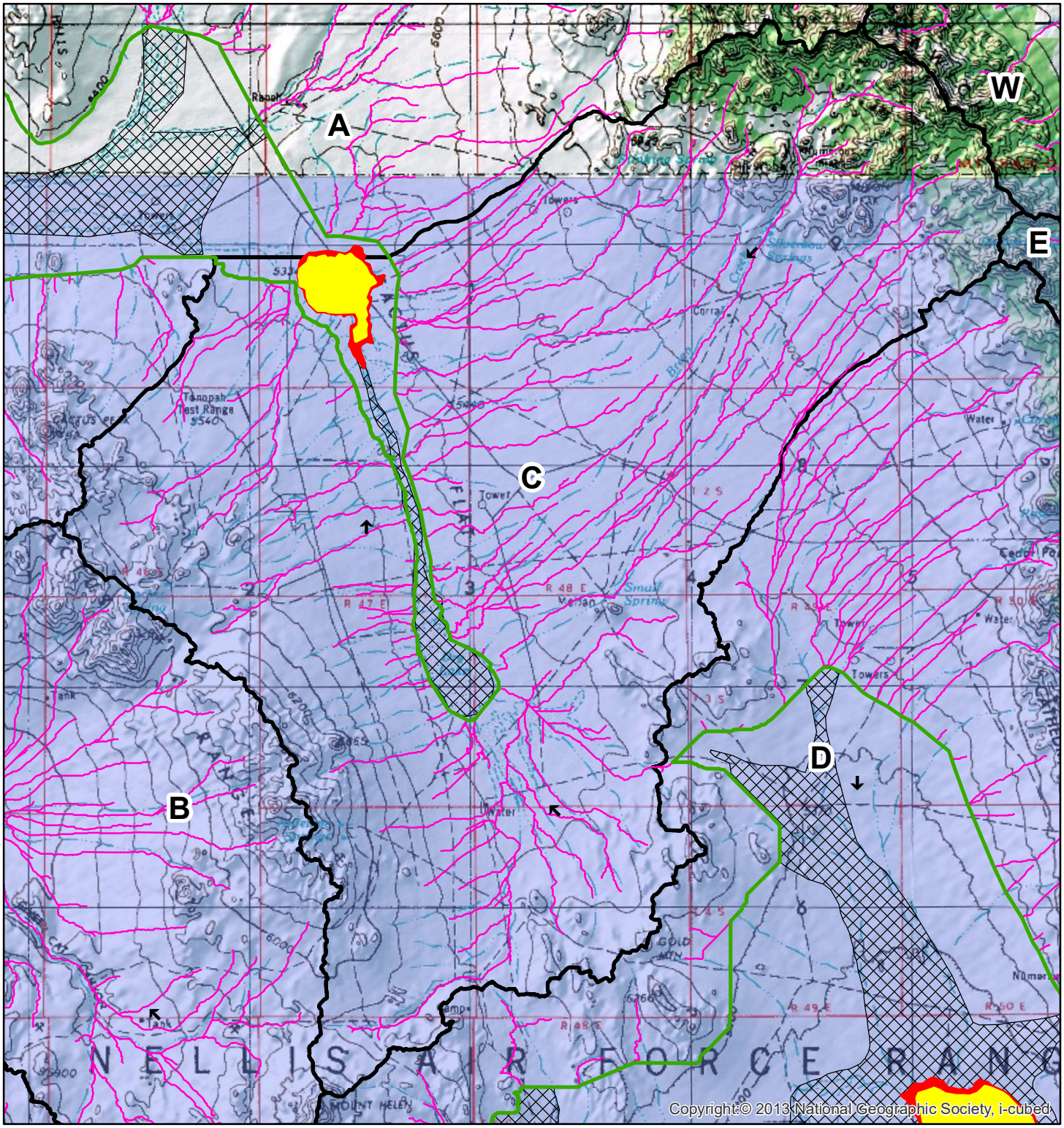
- Limits of DEM Data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

N

1:250,000

0 1 2 4 6 8 Miles

Figure 6.2: Flood Zone for Basin B with Topographic Base Map



Legend

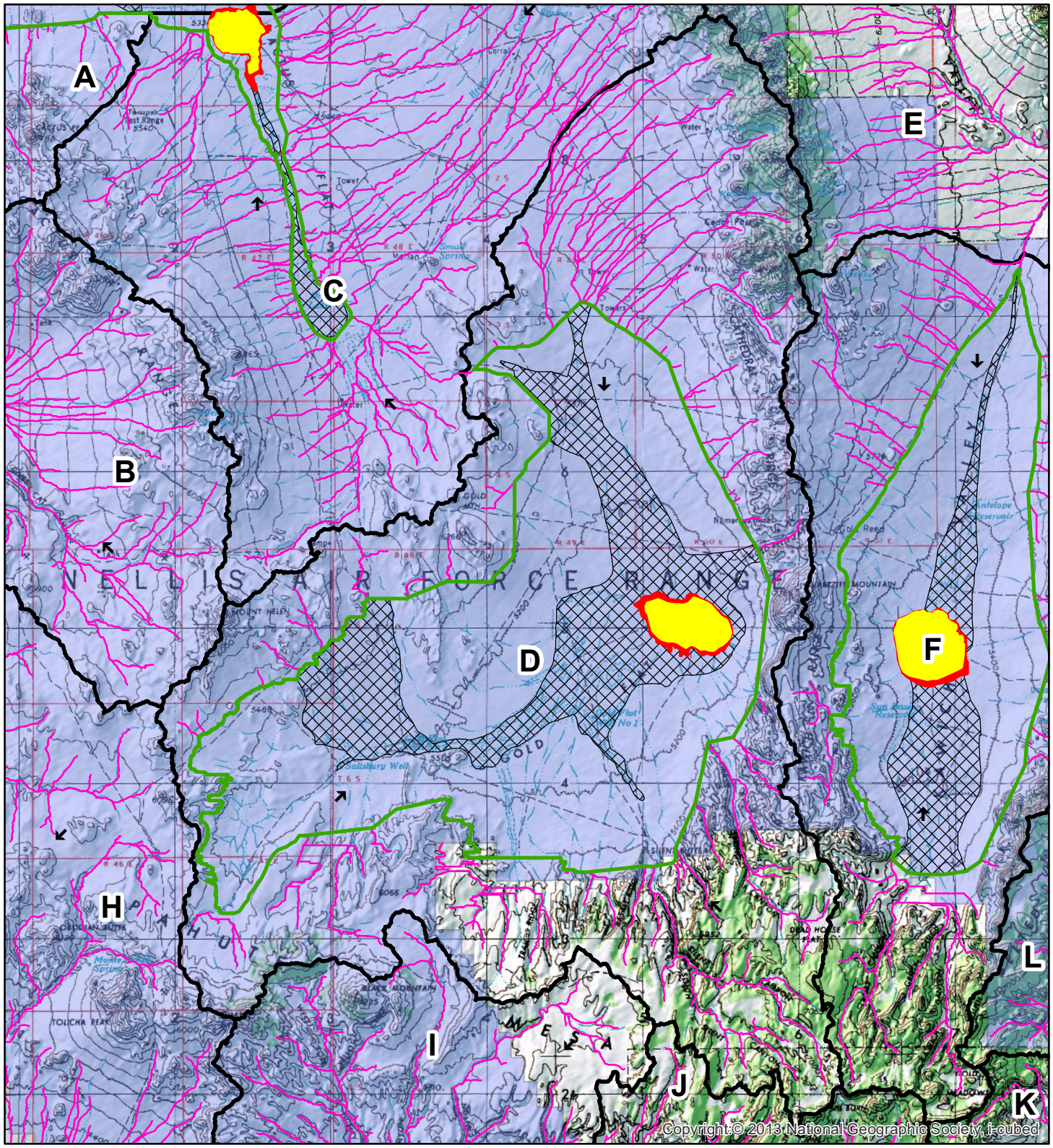
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

1:250,000

0 1 2 4 6 8 Miles

N

Figure 6.3: Flood Zone for Basin C with Topographic Base Map



Legend

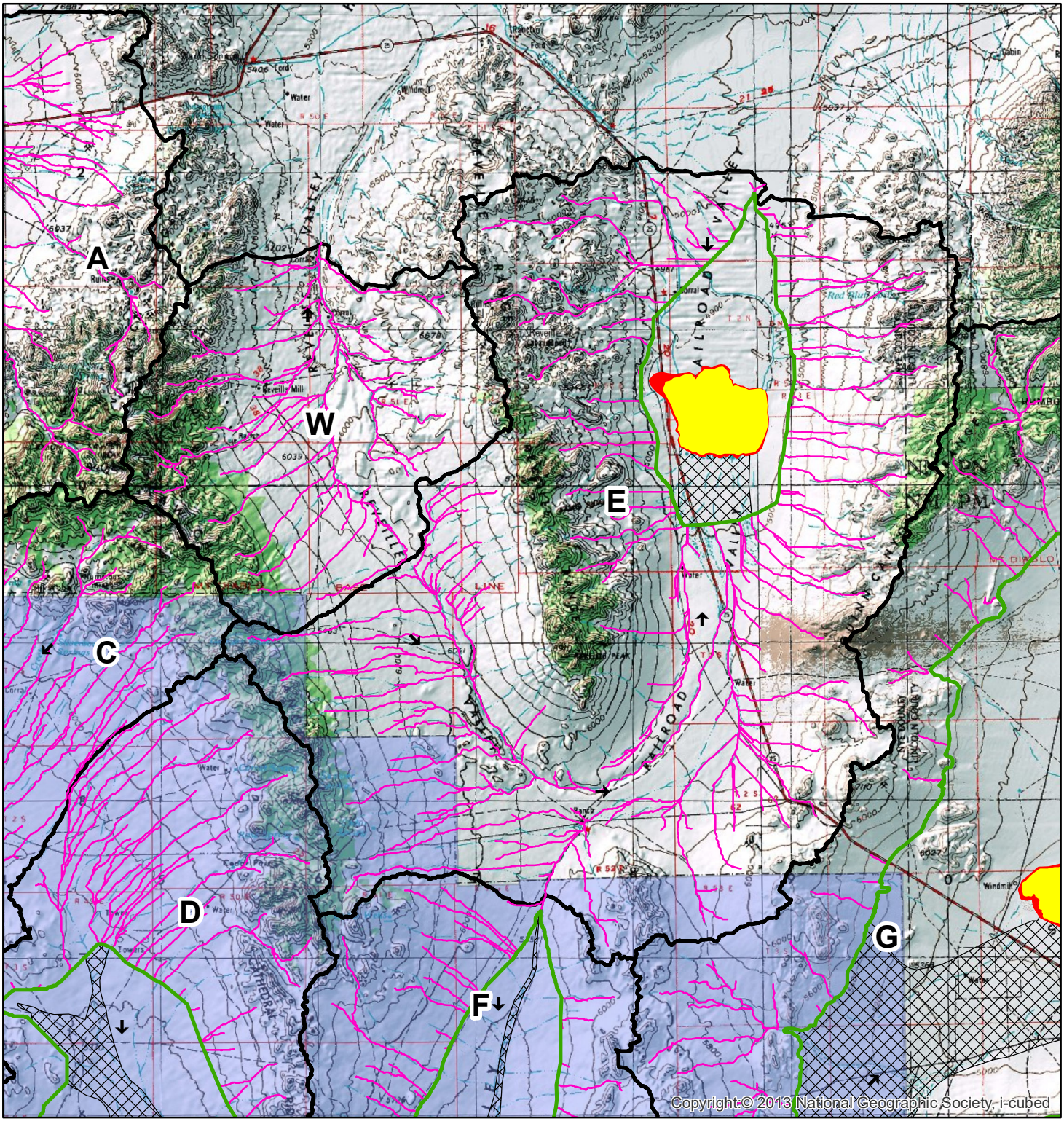
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

N

1:350,000

0 1 2 4 6 8 Miles

Figure 6.4: Flood Zone for Basin D with Topographic Base Map



Legend

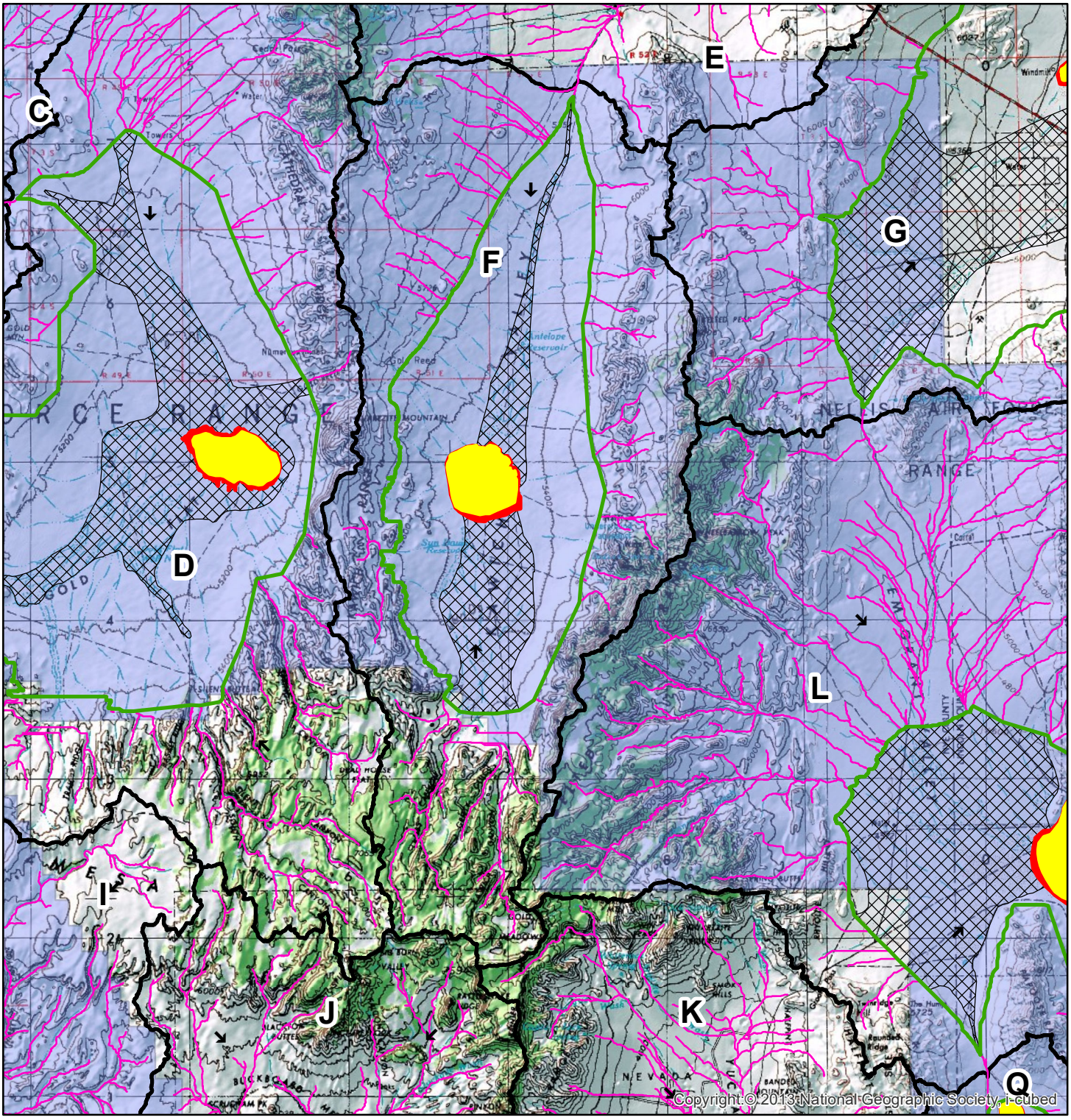
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

1:350,000

0 1 2 4 6 8 Miles

N

Figure 6.5: Flood Zone for Basin E with Topographic Base Map



Legend

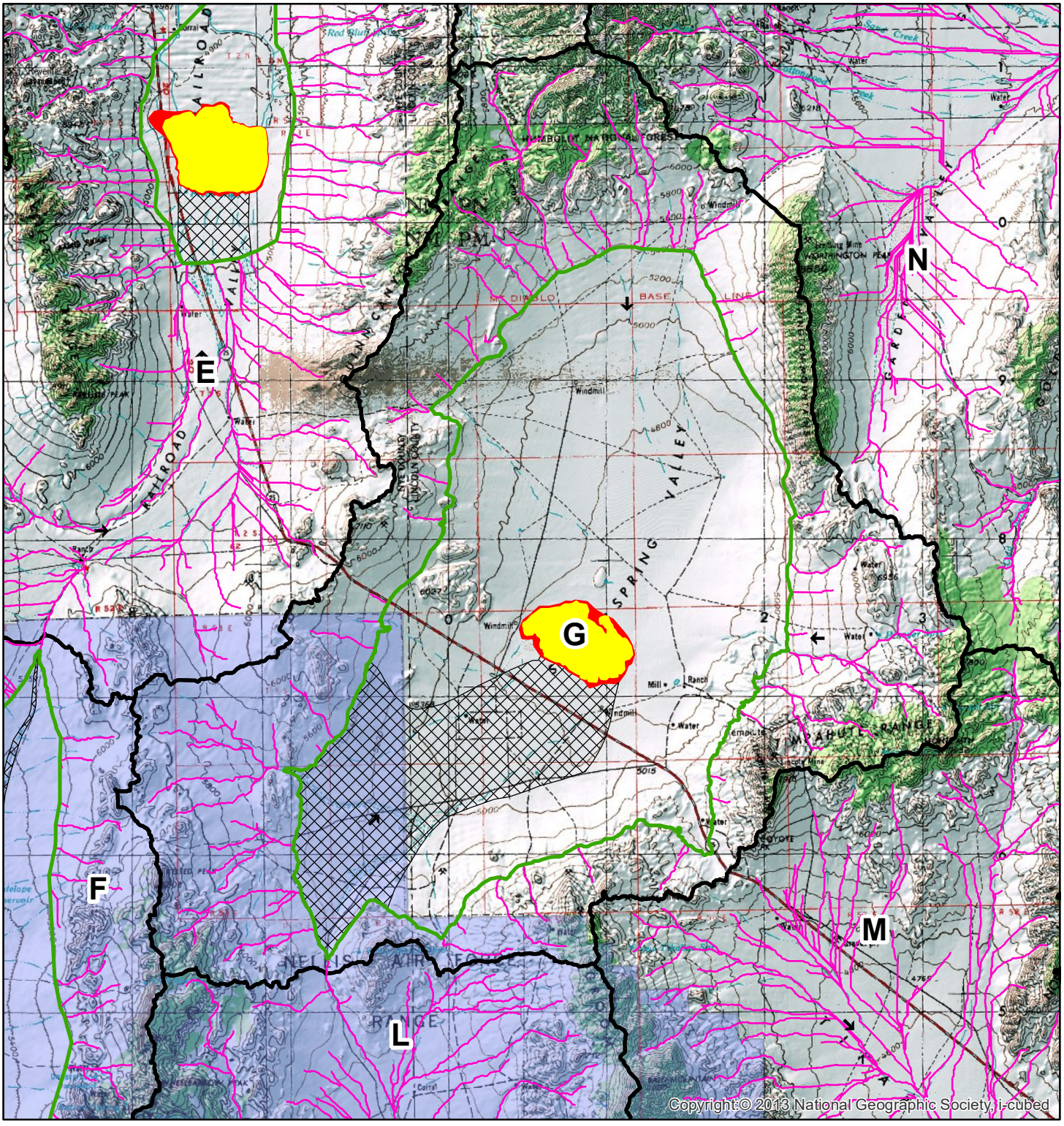
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

1:350,000

0 1 2 4 6 8 Miles

N

Figure 6.6: Flood Zone for Basin F with Topographic Base Map



Legend

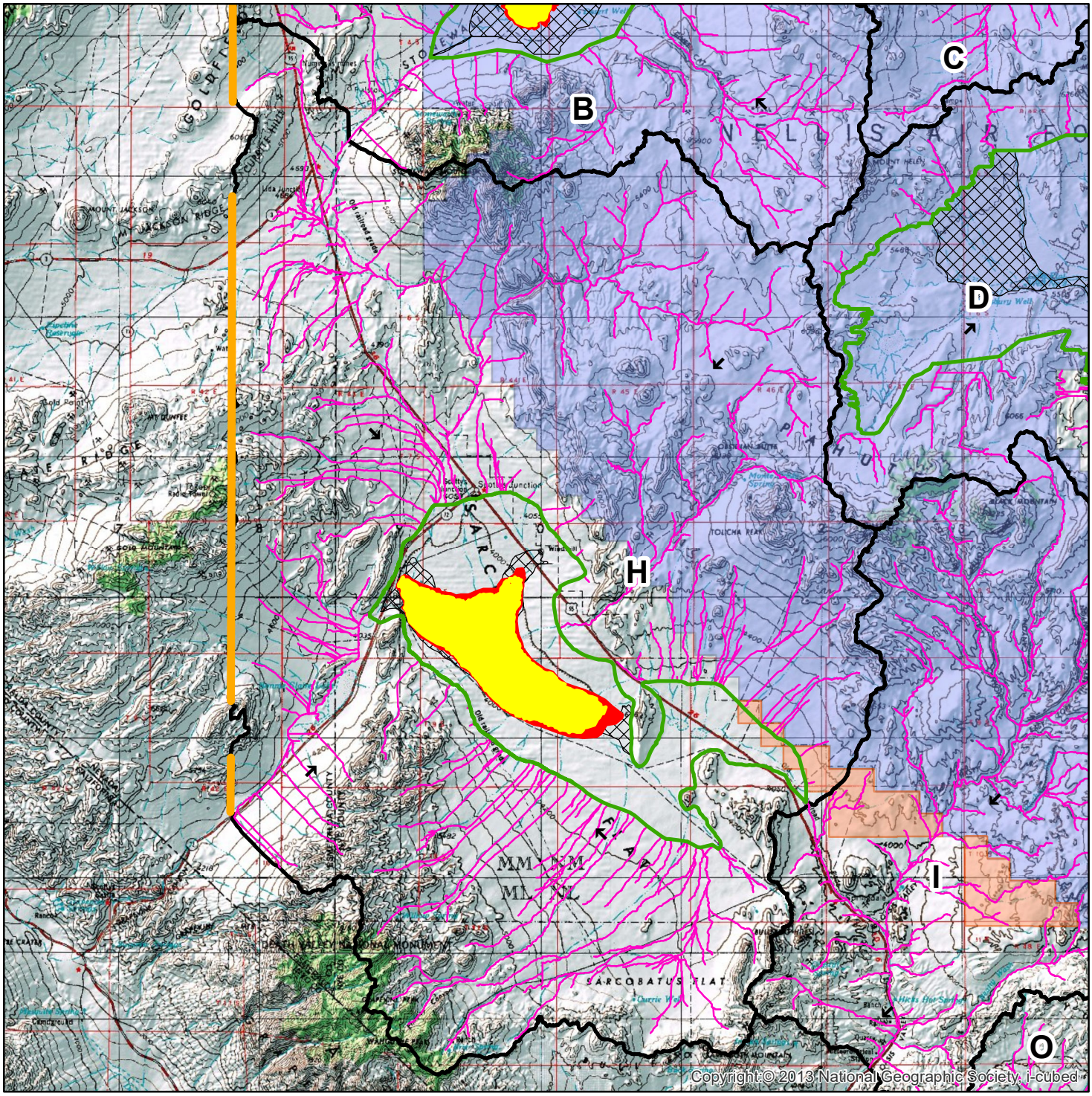
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

1:350,000

0 1 2 4 6 8 Miles

N

Figure 6.7: Flood Zone for Basin G with Topographic Base Map



Legend

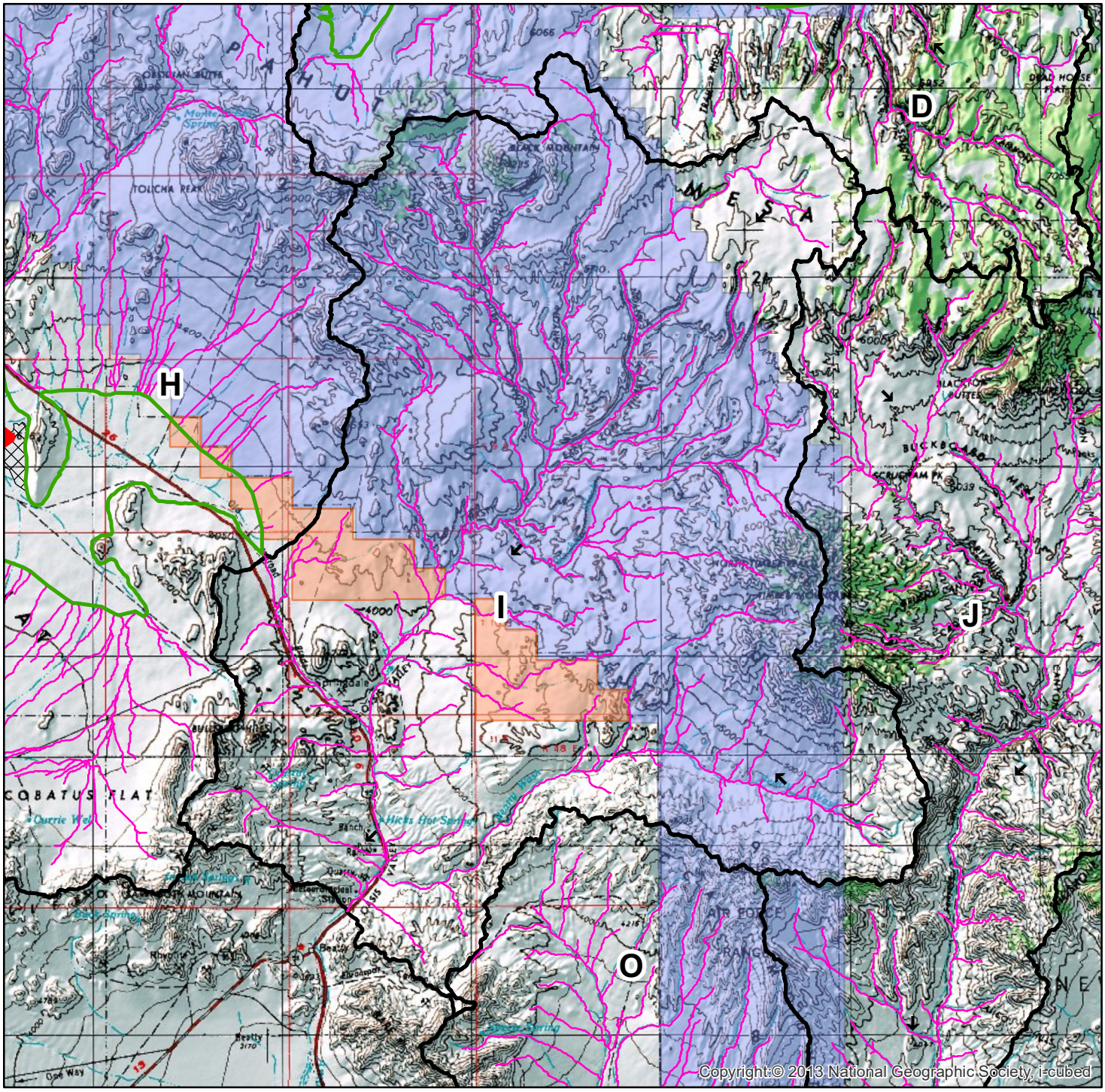
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Limits of DEM Data
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

N

1:400,000

0 1.5 3 6 9 12 Miles

Figure 6.8: Flood Zone for Basin H with Topographic Base Map



Legend

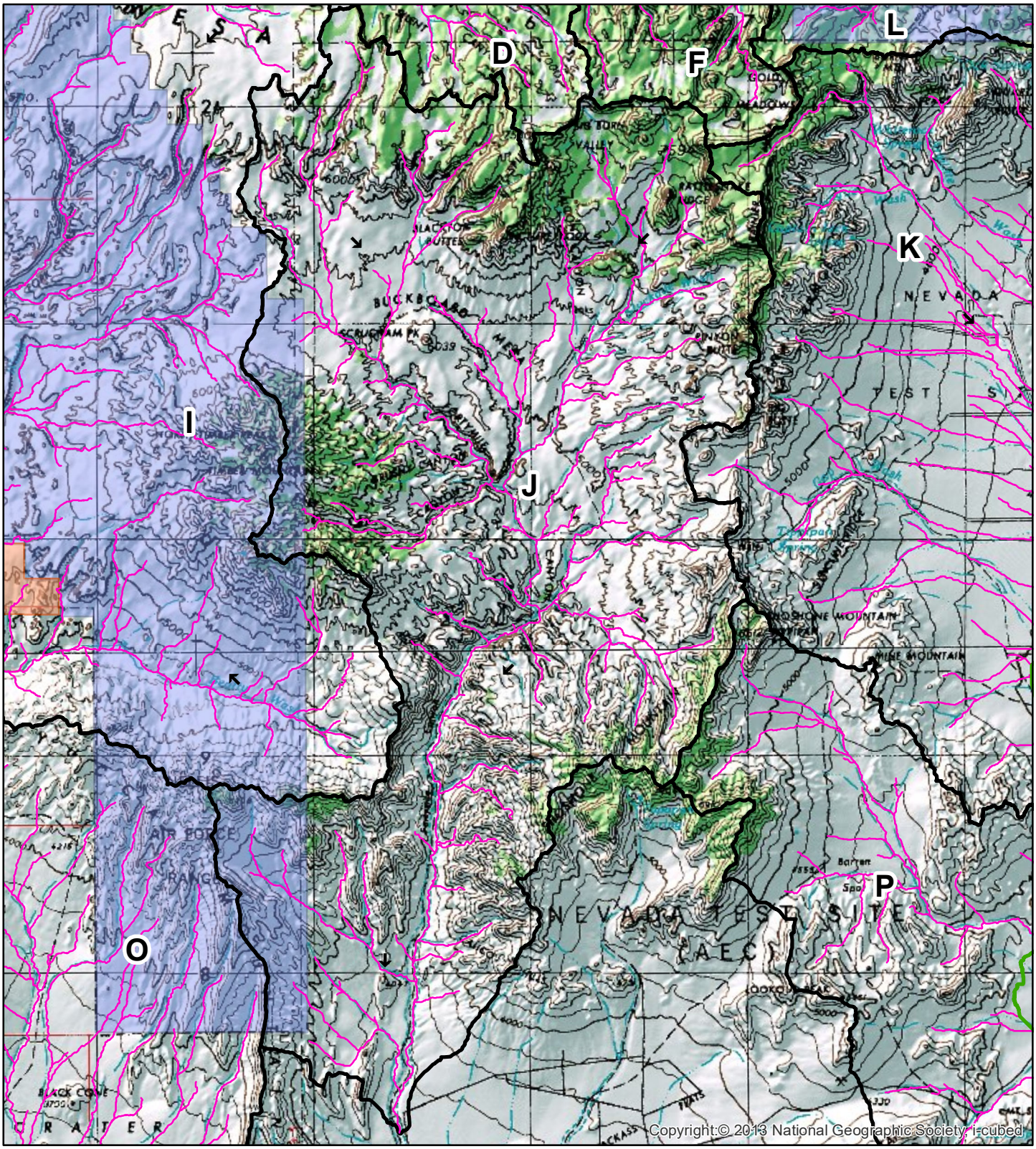
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

N

1:300,000

0 1 2 4 6 8 Miles

Figure 6.9: Flood Zone for Basin I with Topographic Base Map



Legend

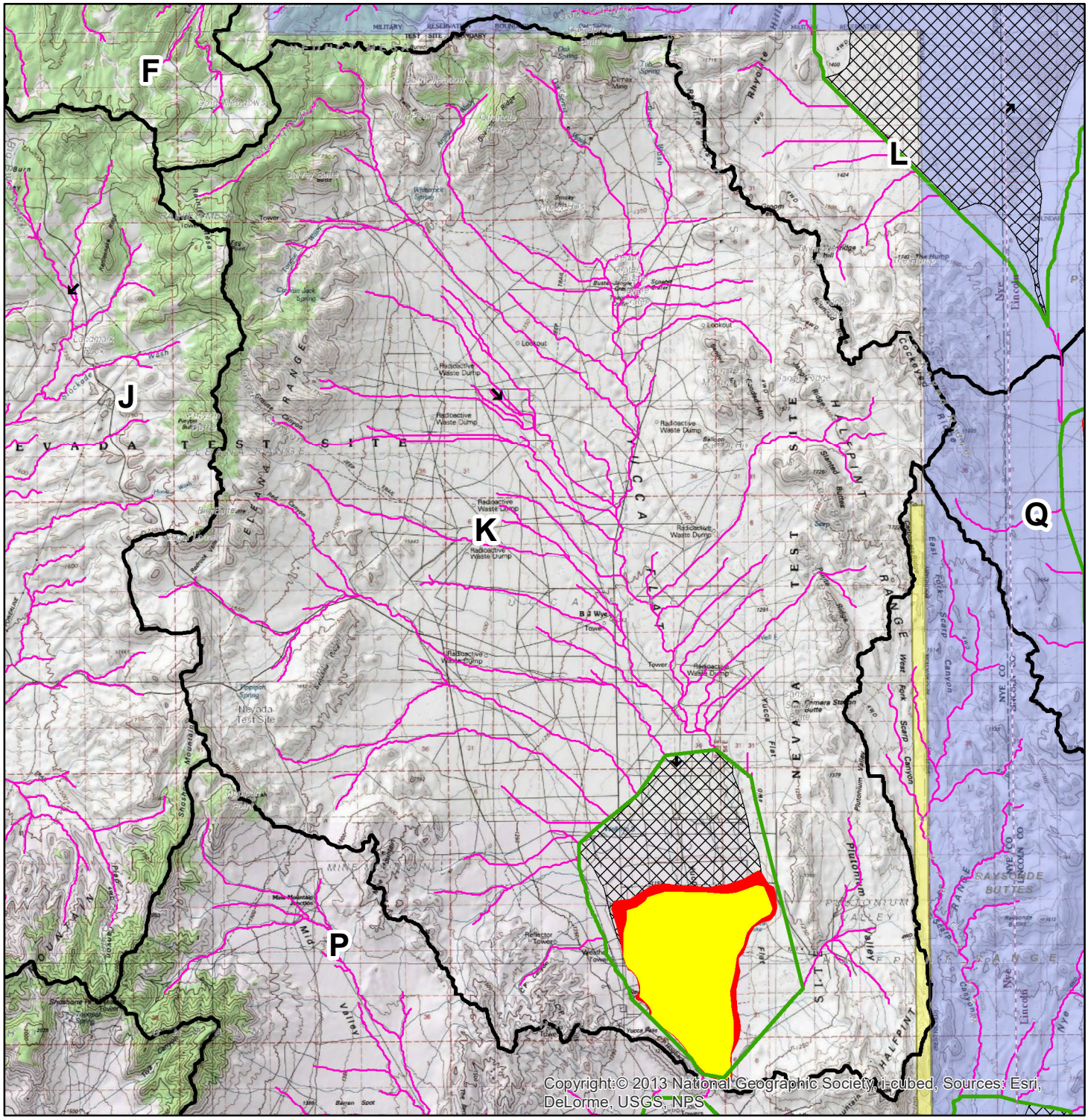
- Flow Direction
- Concentrated Flow Path
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

1:250,000

0 1 2 4 6 8 Miles

N

Figure 6.10: Flood Zone for Basin J with Topographic Base Map



Legend

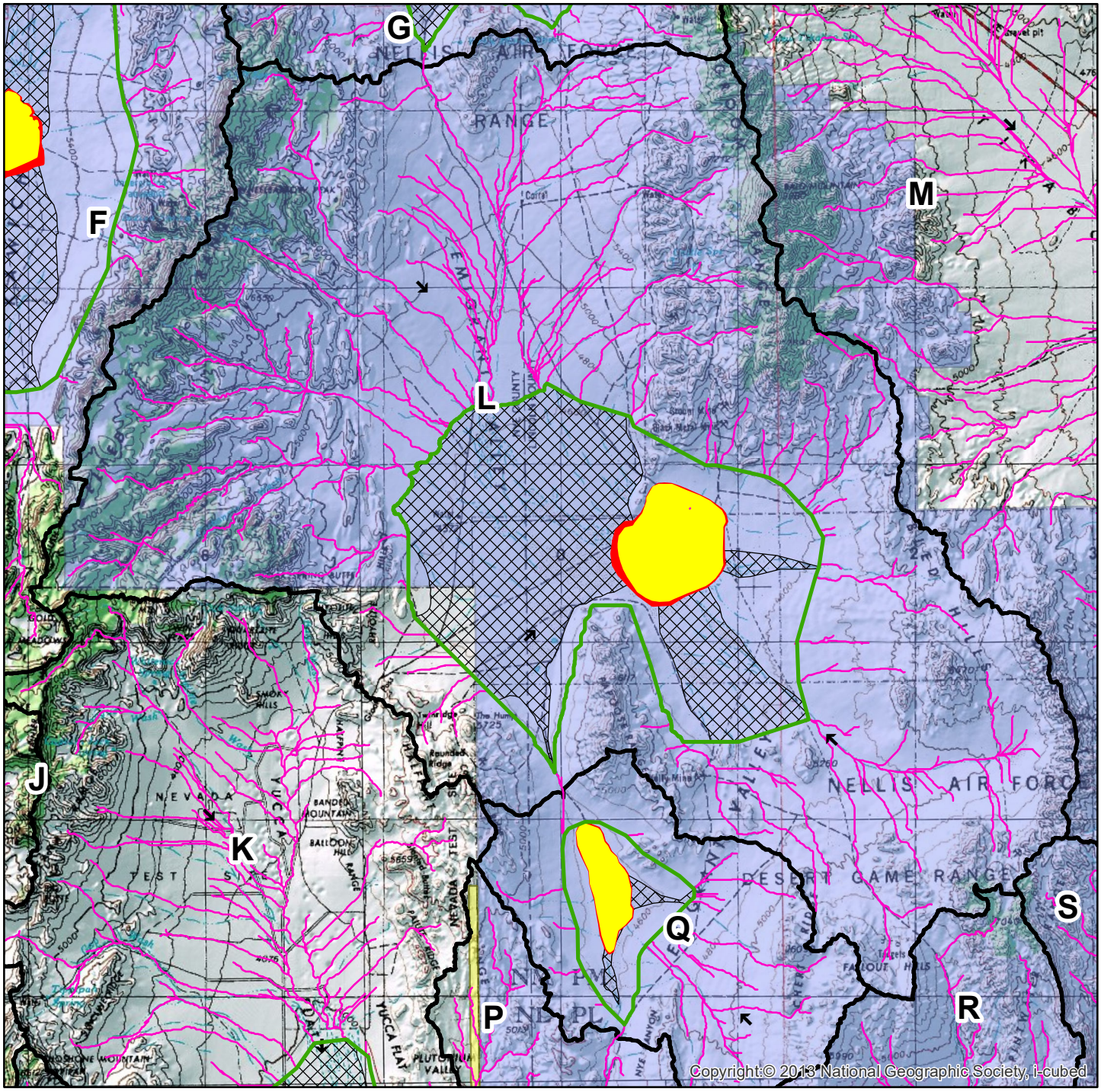
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 64 C/D and 65 D Expansion
- Existing NTTR Boundary

1:200,000

0 1 2 4 6 8 Miles

N

Figure 6.11: Flood Zone for Basin K with Topographic Base Map



Legend

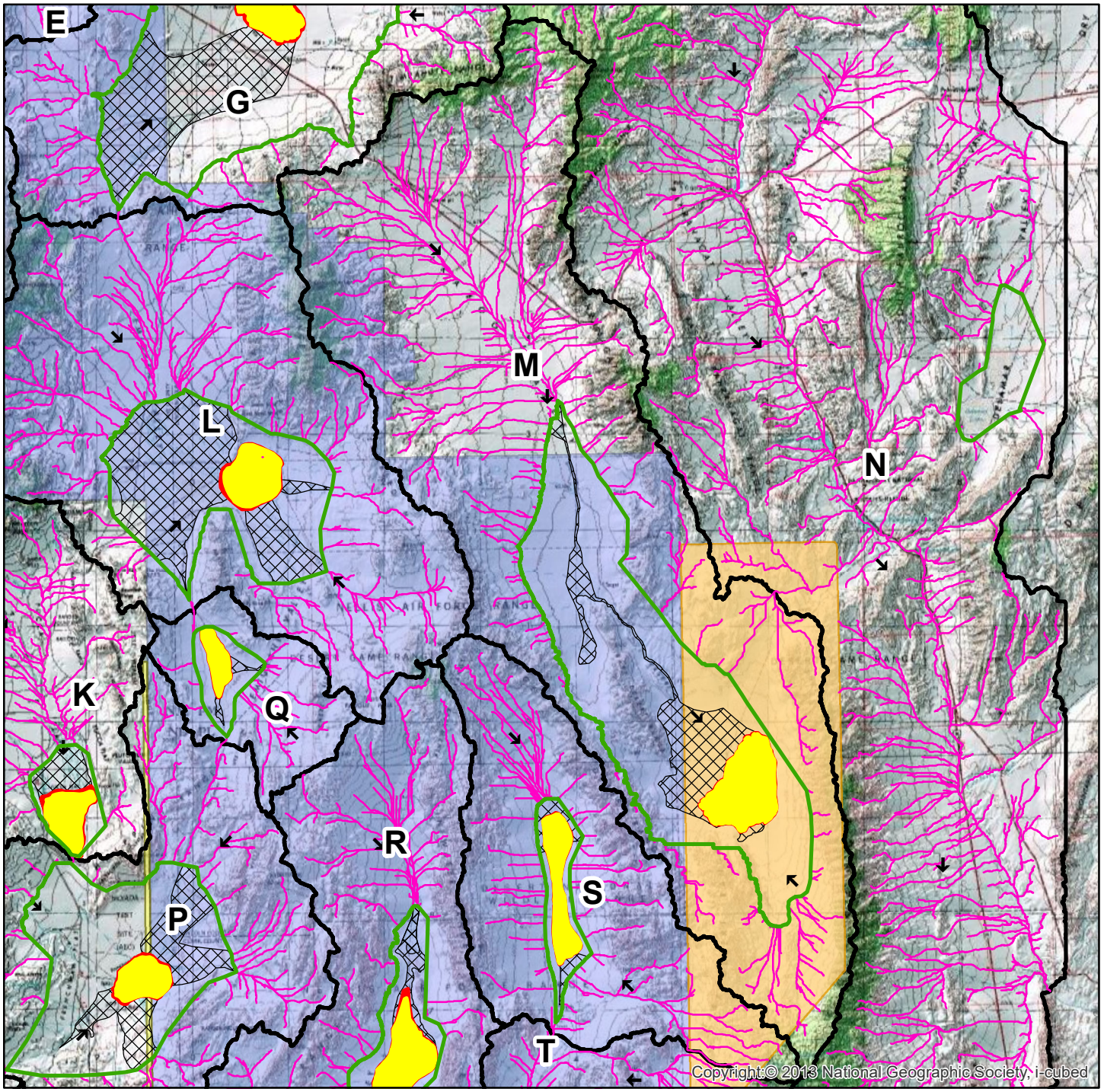
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64 C/D and 65D Expansion
- Existing NTTR Boundary

1:325,000

0 1 2 4 6 8 Miles

N

Figure 6.12: Flood Zone for Basin L with Topographic Base Map



Legend

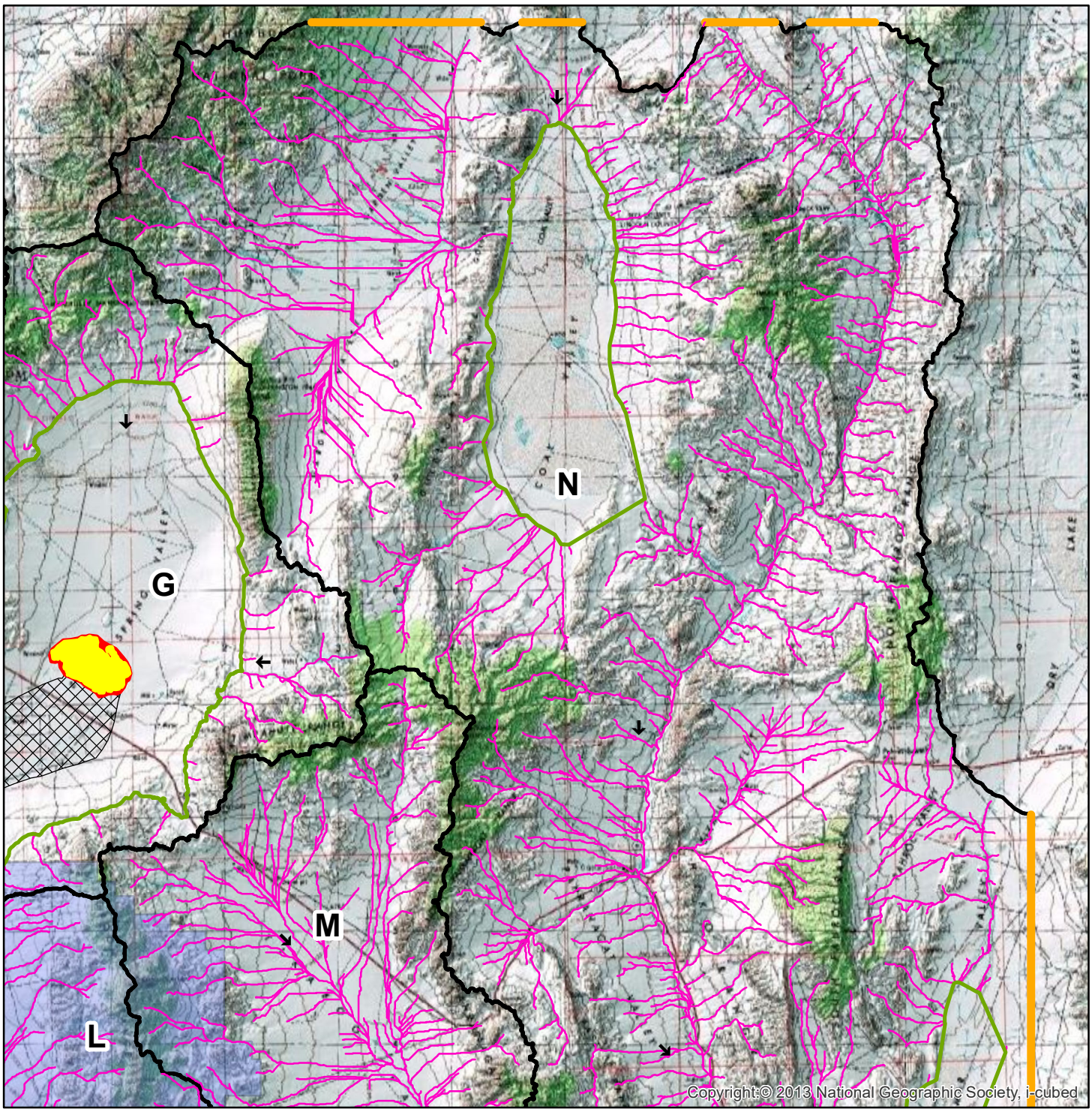
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:600,000

0 2.5 5 10 15 20 Miles

Figure 6.13: Flood Zone for Basin M with Topographic Base Map



Legend

- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100 year water surface elevation
- 500 year water surface elevation
- Alluvial Fan and Floodplain
- Limits of DEM Data
- Basin Boundary
- Existing NTTR Boundary

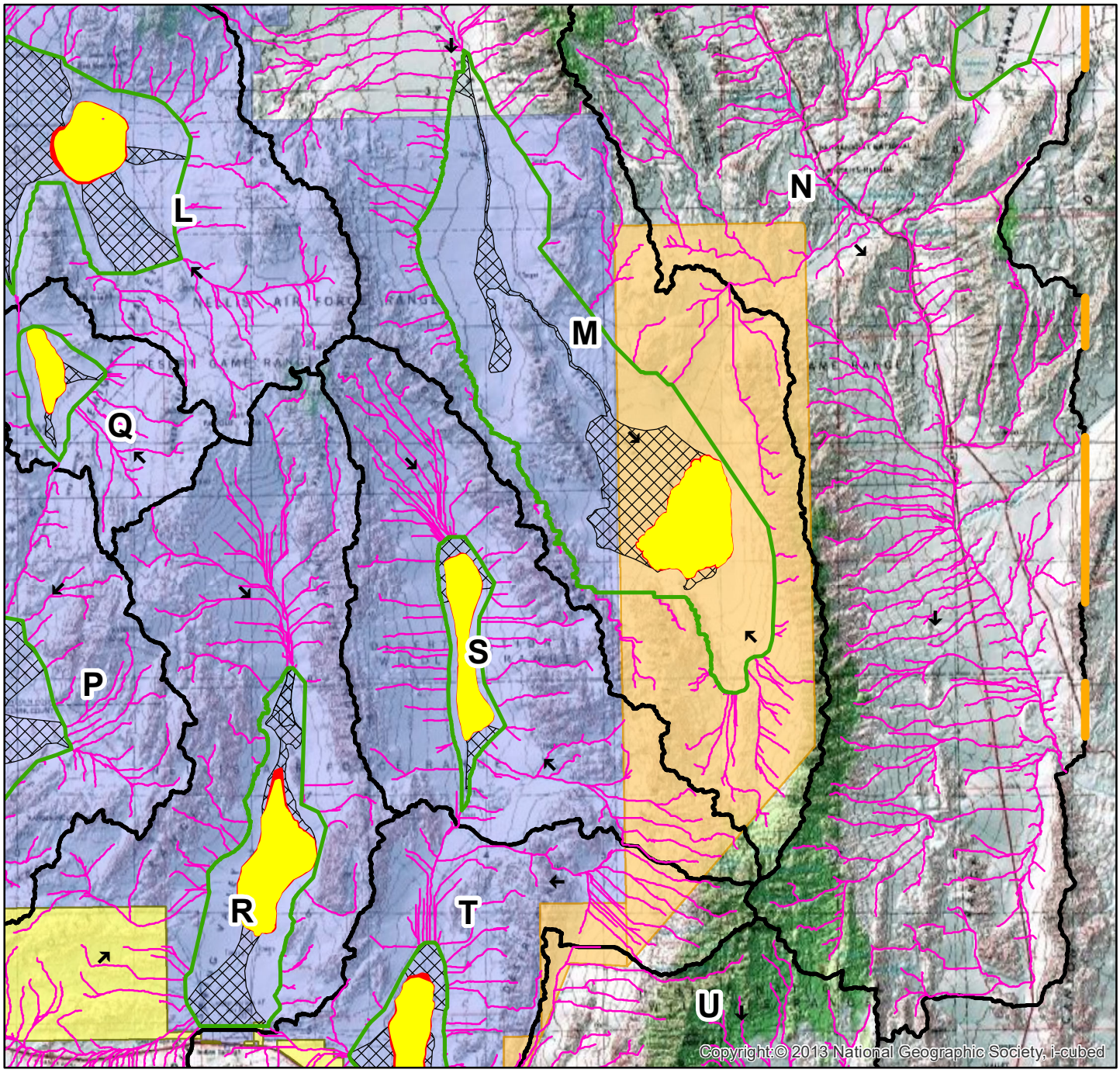
1:500,000

Miles

0 2.5 5 10 15 20

N

Figure 6.14A: Flood Zone for Basin N with Topographic Base Map



Legend

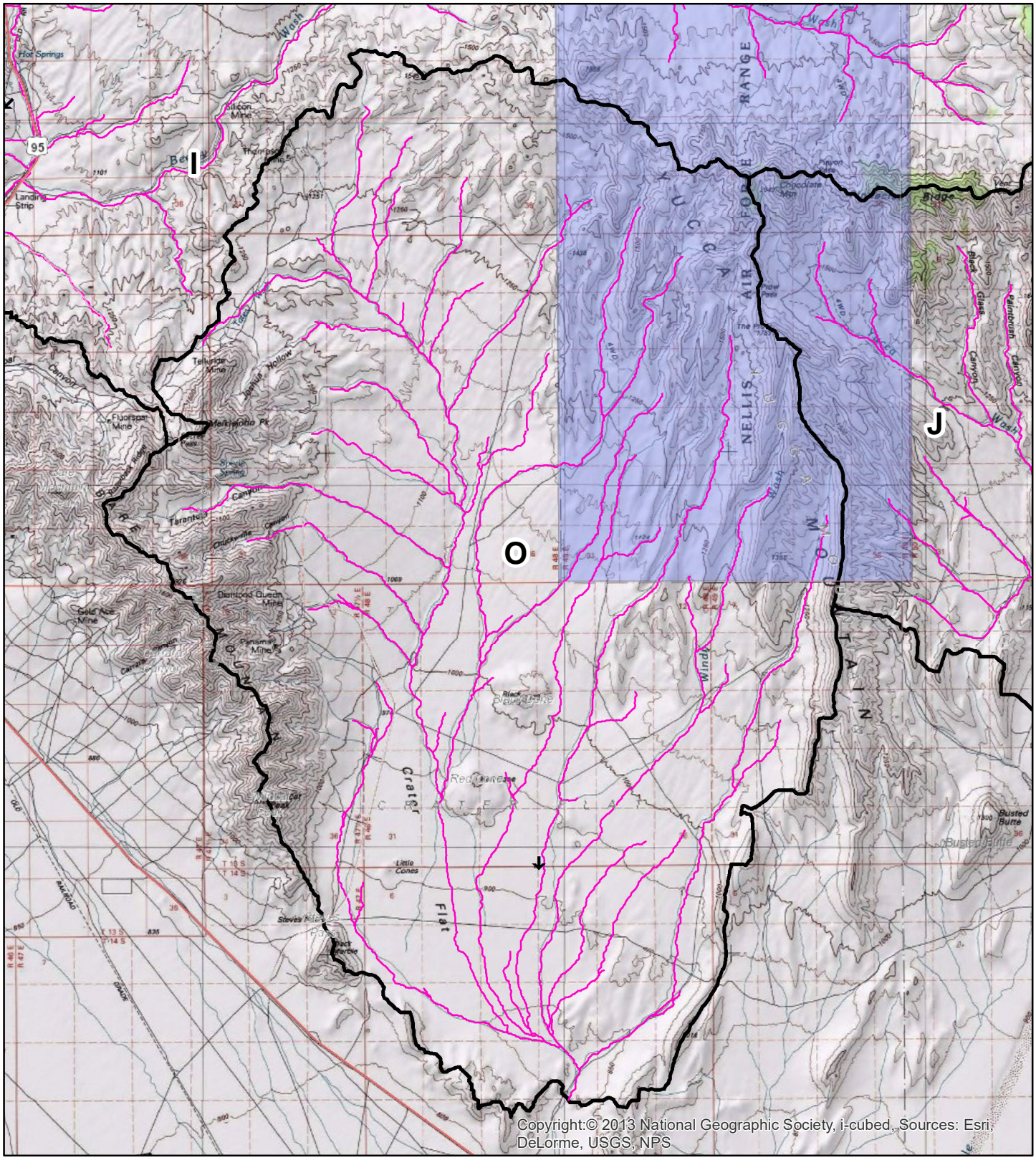
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Limits of DEM Data
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:500,000

0 2.5 5 10 15 20 Miles

Figure 6.14B: Flood Zone for Basin N with Topographic Base Map



Legend

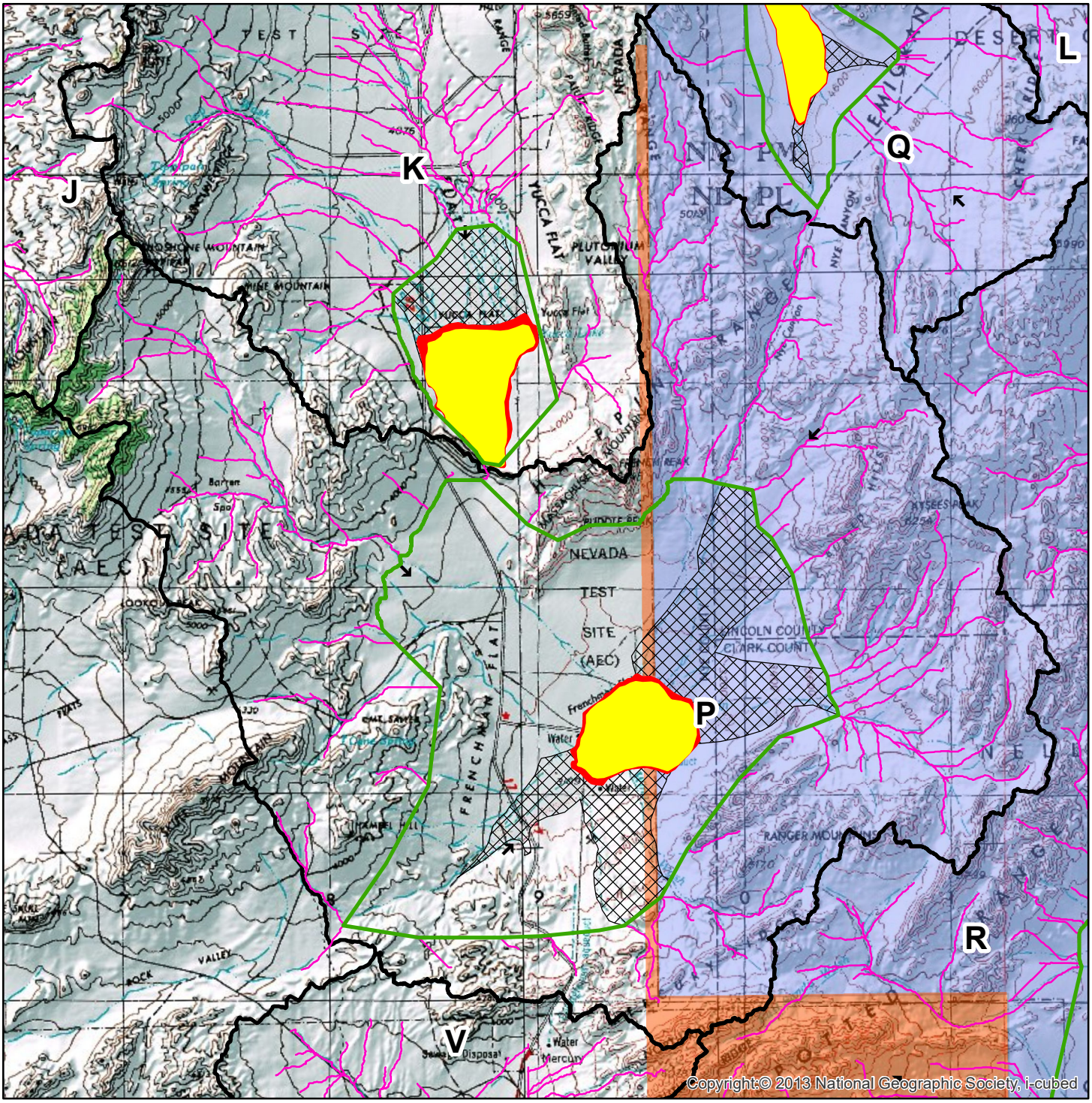
- Flow Direction
- Concentrated Flow Path
- Basin Boundary
- Existing NTTR Boundary

1:150,000

0 0.5 1 2 3 4 Miles

N

Figure 6.15: Flood Zone for Basin O with Topographic Base Map



Legend

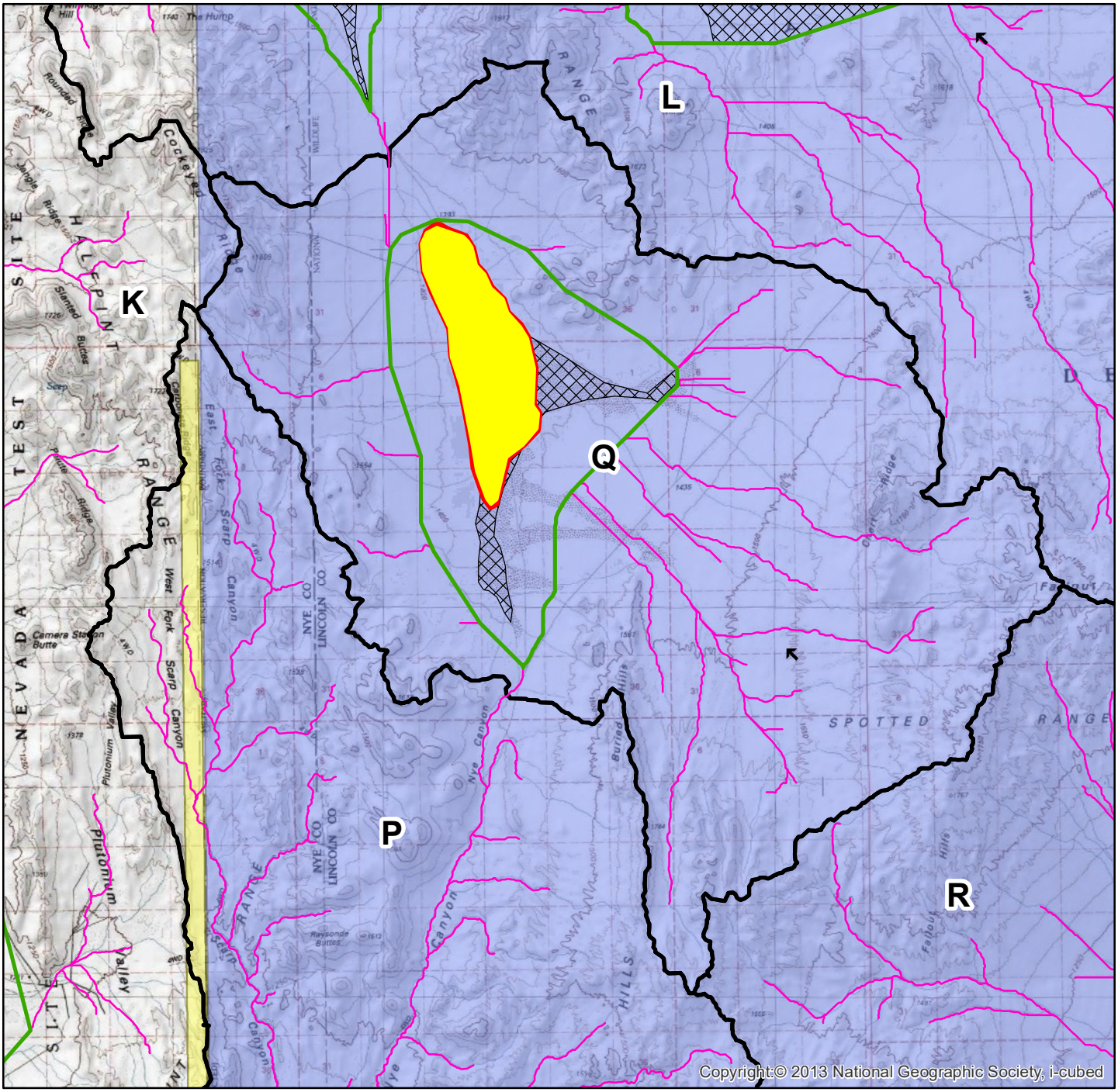
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Proposed Withdrawal Expansion Areas
- Existing NTTR Boundary

1:275,000

0 1 2 4 6 8 Miles

N

Figure 6.16: Flood Zone for Basin P with Topographic Base Map



Legend

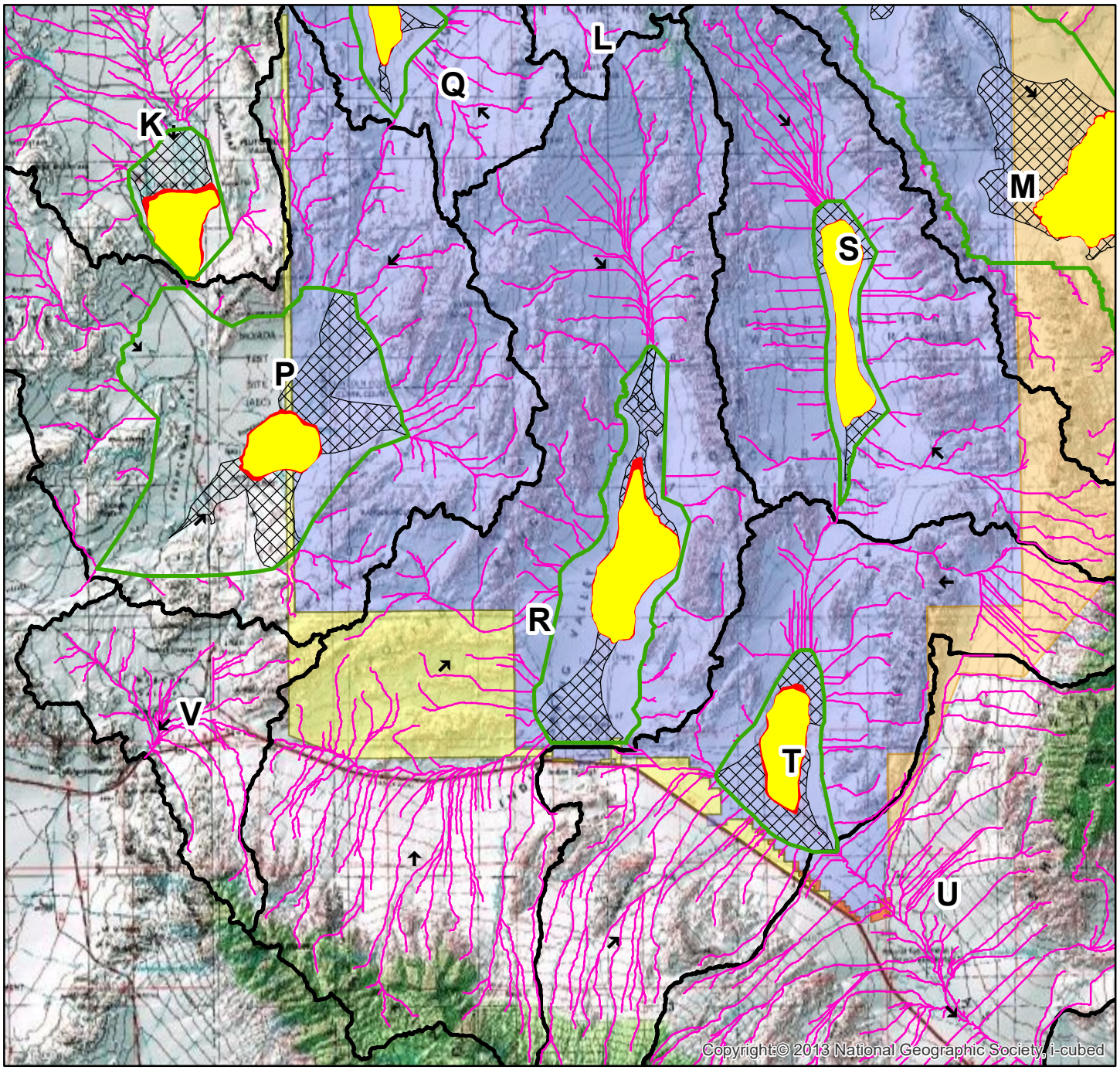
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Existing NTTR Boundary

N

1:150,000

0 0.5 1 2 3 4 Miles

Figure 6.17: Flood Zone for Basin Q with Topographic Base Map



Legend

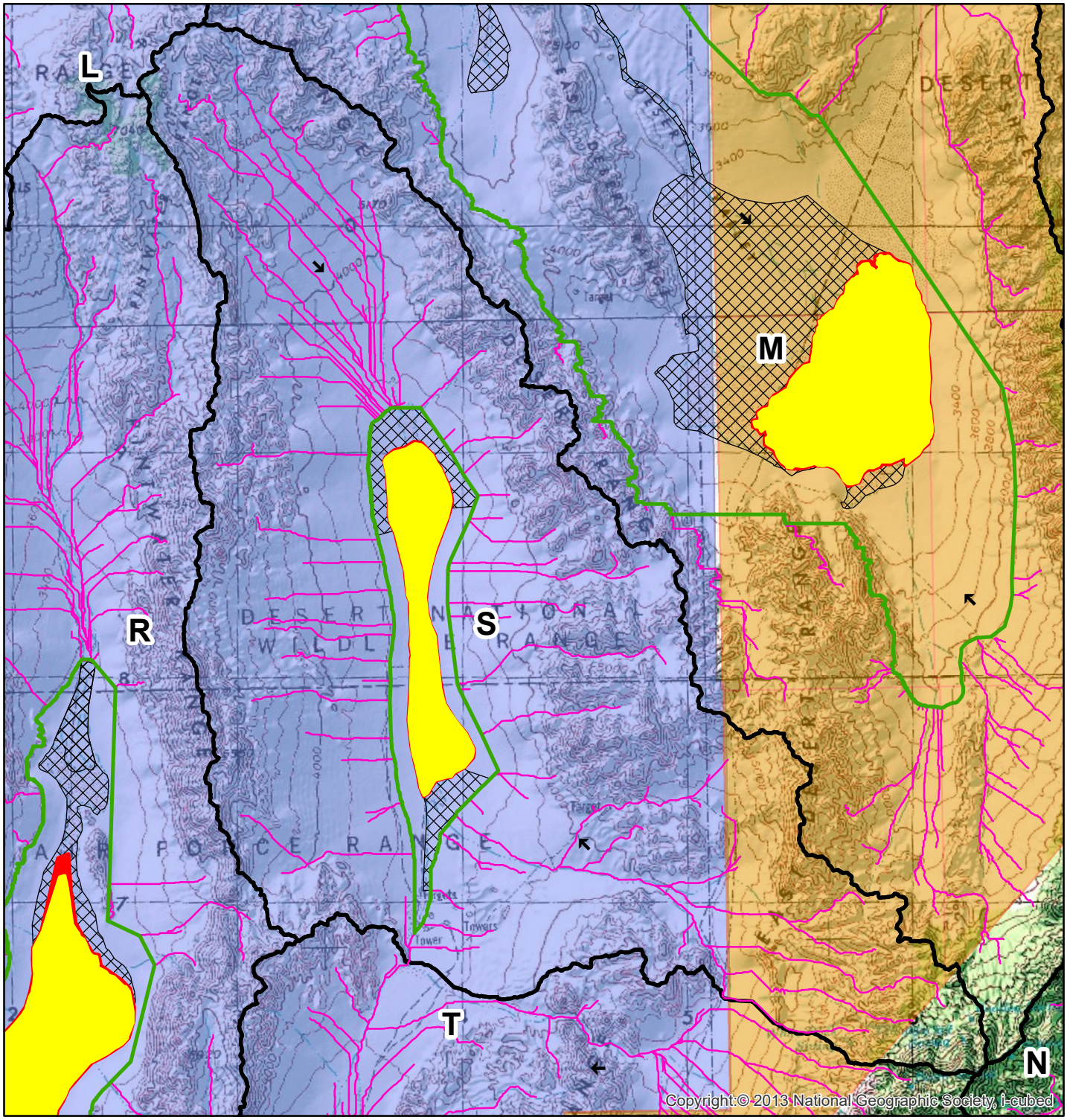
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:450,000

0 2.5 5 10 15 20 Miles

Figure 6.18: Flood Zone for Basin R with Topographic Base Map



Legend

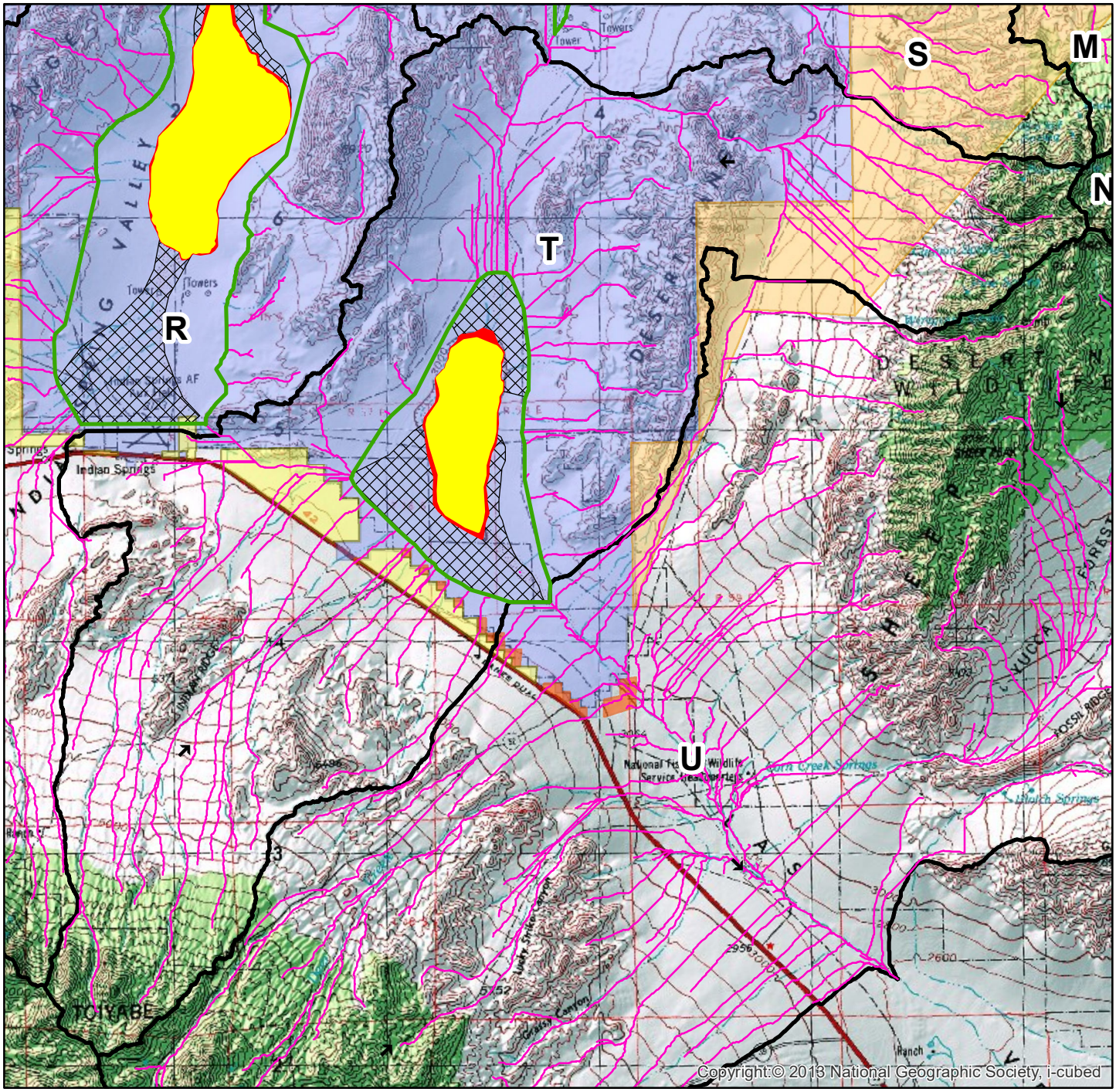
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:250,000

0 1 2 4 6 8 Miles

Figure 6.19: Flood Zone for Basin S with Topographic Base Map



Legend

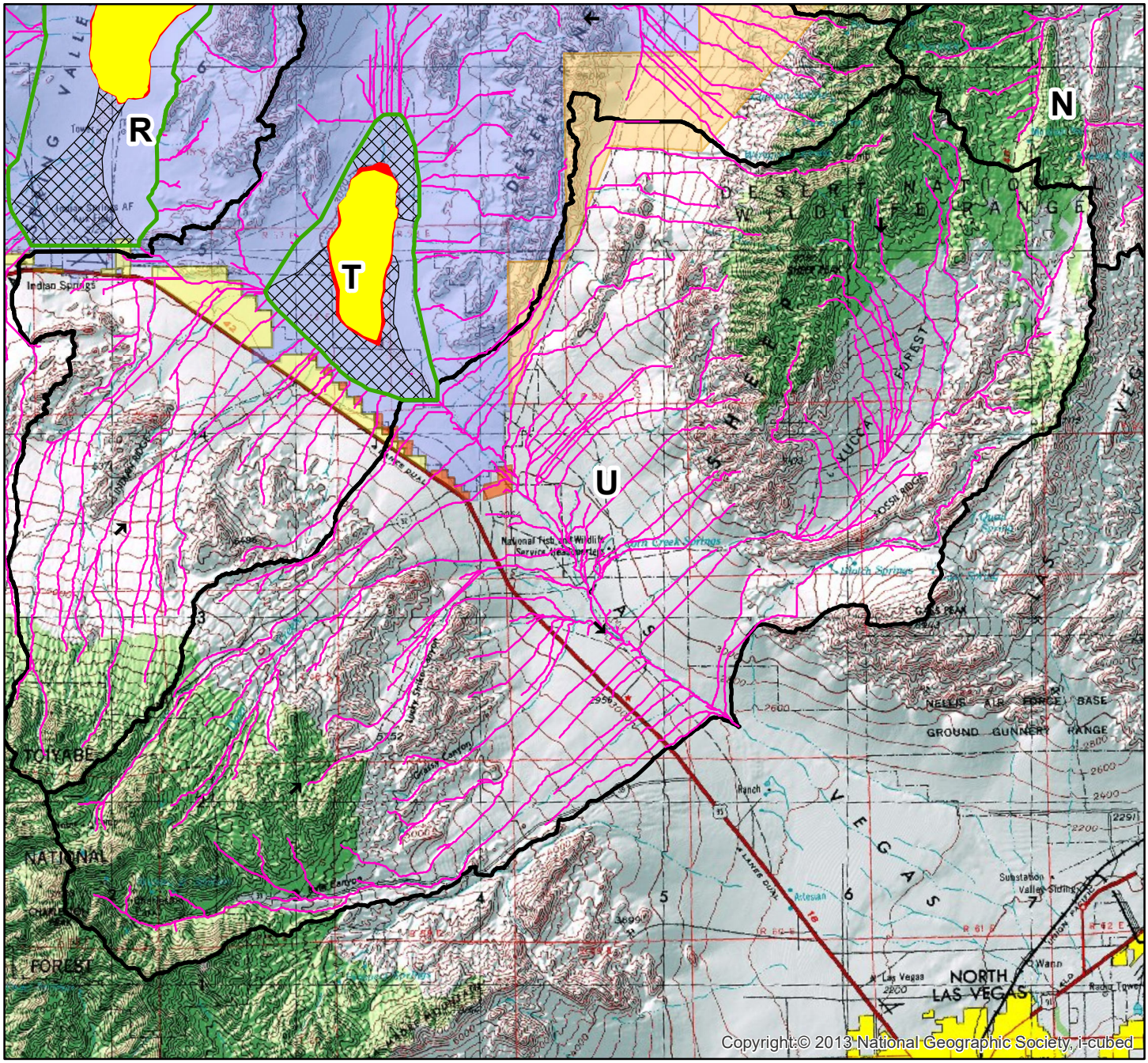
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:275,000

0 1 2 4 6 8 Miles

Figure 6.20: Flood Zone for Basin T with Topographic Base Map



Legend

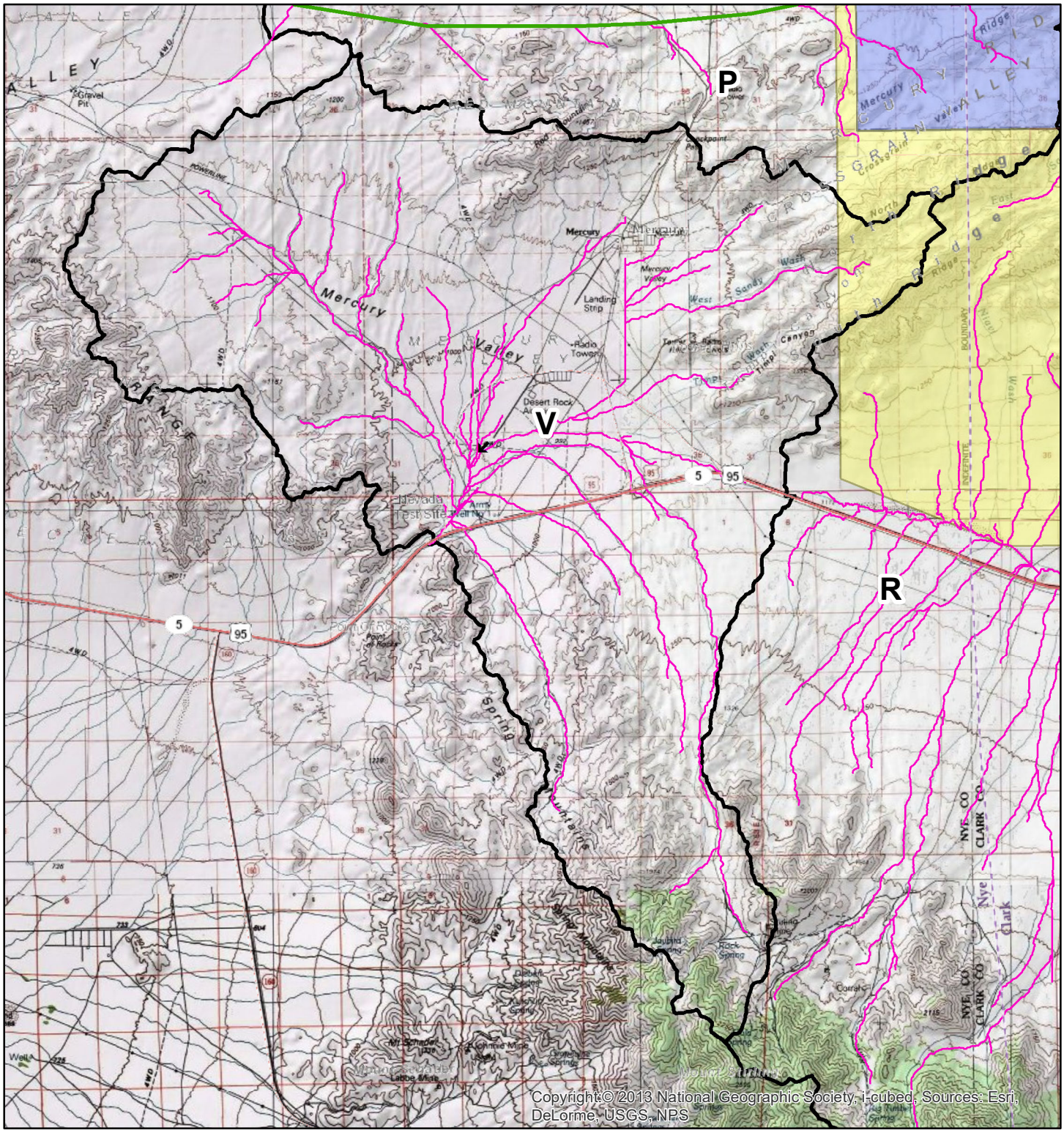
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:325,000

0 1 2 4 6 8 Miles

Figure 6.21: Flood Zone for Basin U with Topographic Base Map



Legend

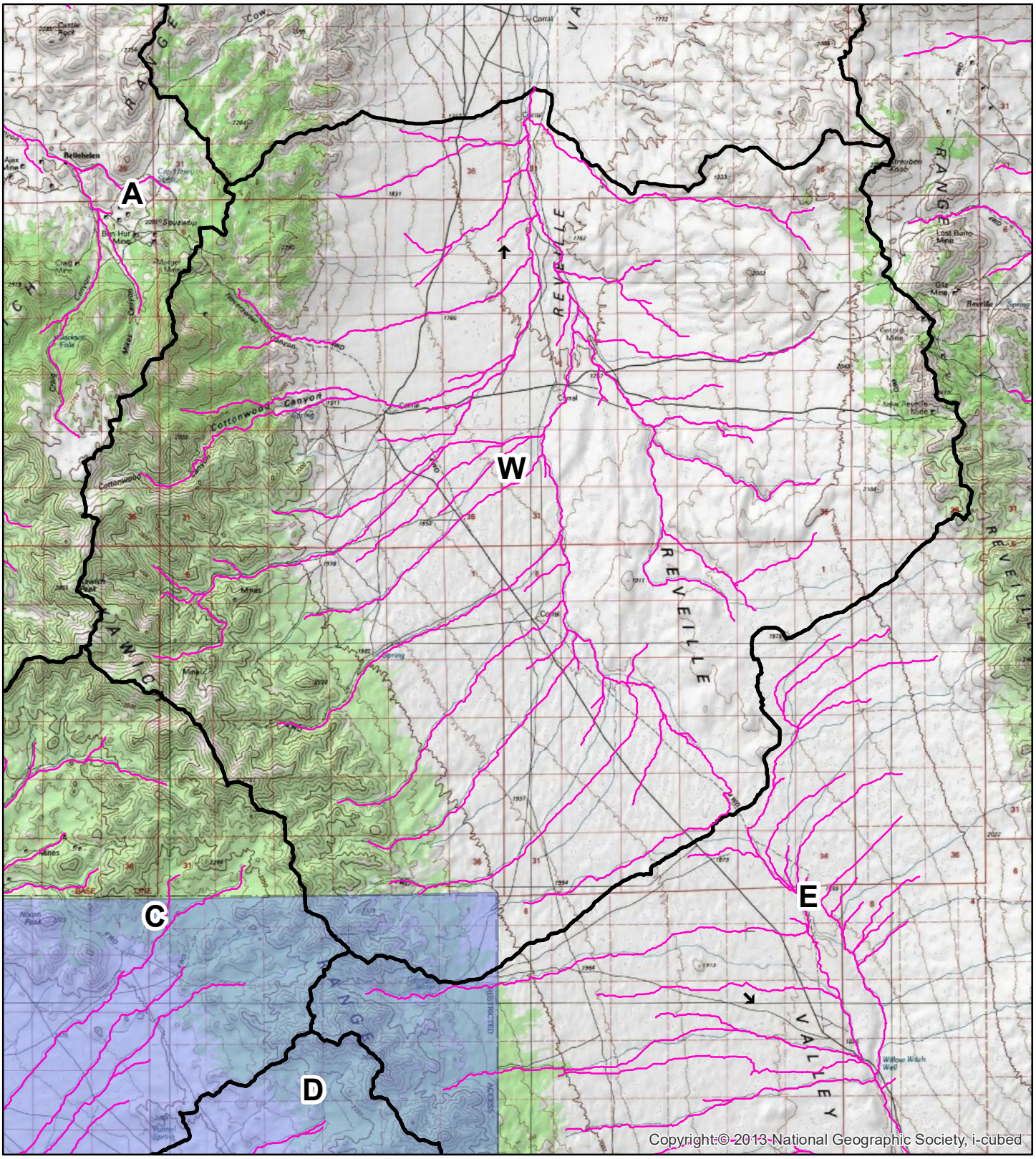
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- Basin Boundary
- Alternative 3B 64C/D and 65D Expansion
- Existing NTTR Boundary

1:150,000

0 0.5 1 2 3 4 Miles

N

Figure 6.22: Flood Zone for Basin V with Topographic Base Map



Legend

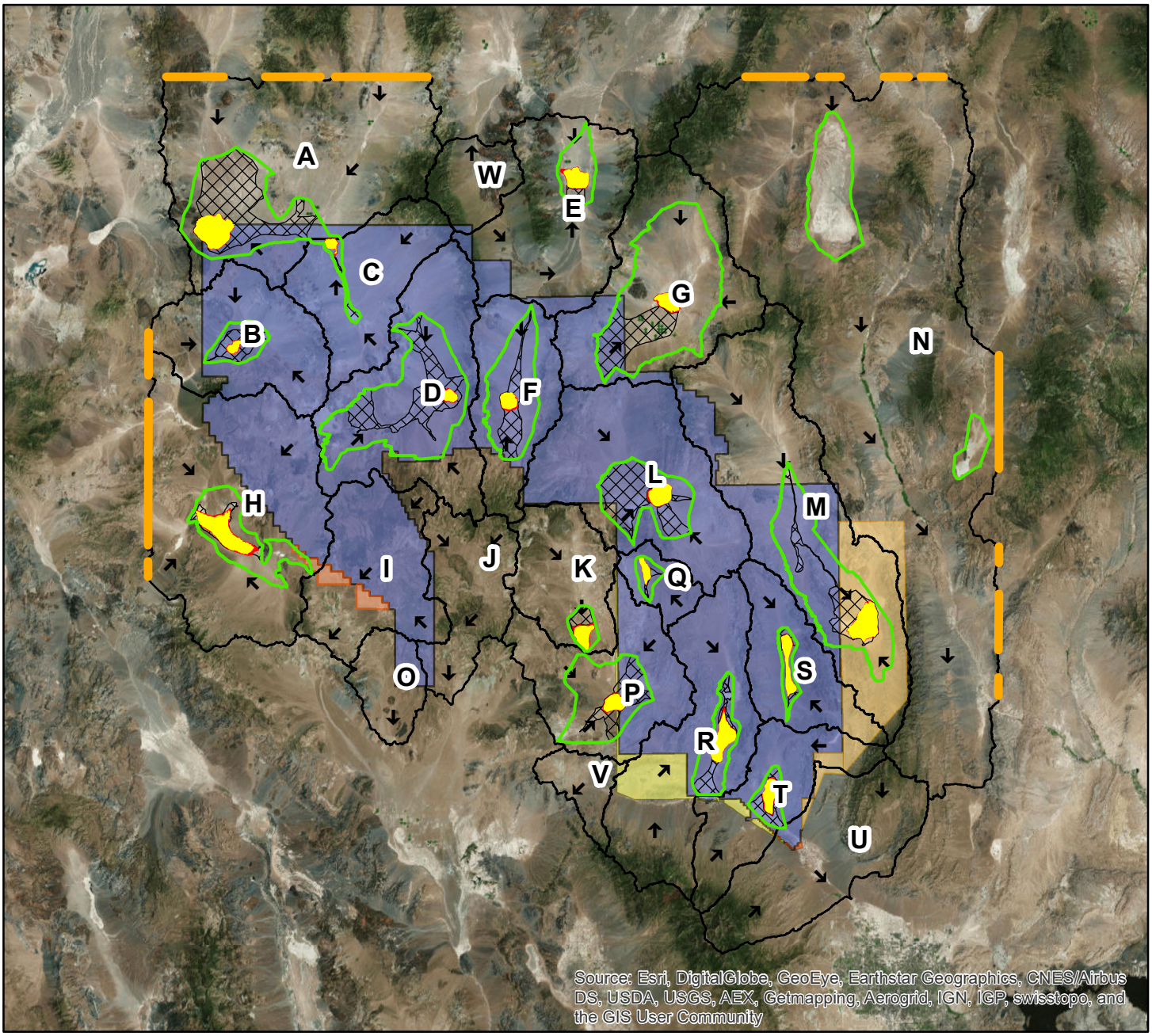
- Flow Direction
- Concentrated Flow Path
- Basin Boundary
- Existing NTTR Boundary

N

1:150,000

0 0.5 1 2 3 4 Miles

Figure 6.23: Flood Zone for Basin W with Topographic Base Map



Legend

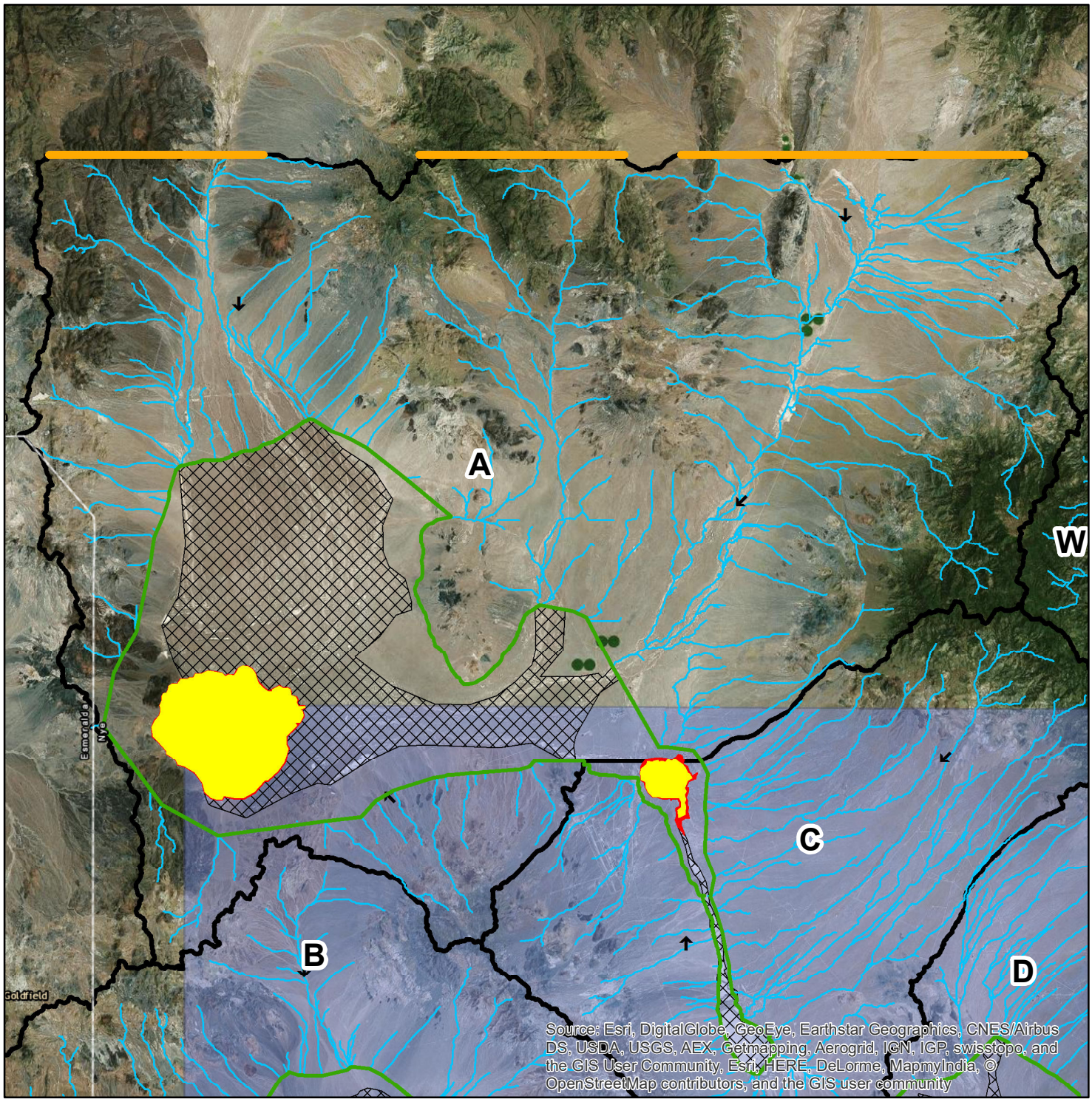
- Limits of DEM data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- 100yrWSE
- 500yrWSE
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:1,500,000

0 5 10 20 30 40 Miles

Figure 7.0: Flood Zones for NTTR with Aerial Image



Legend

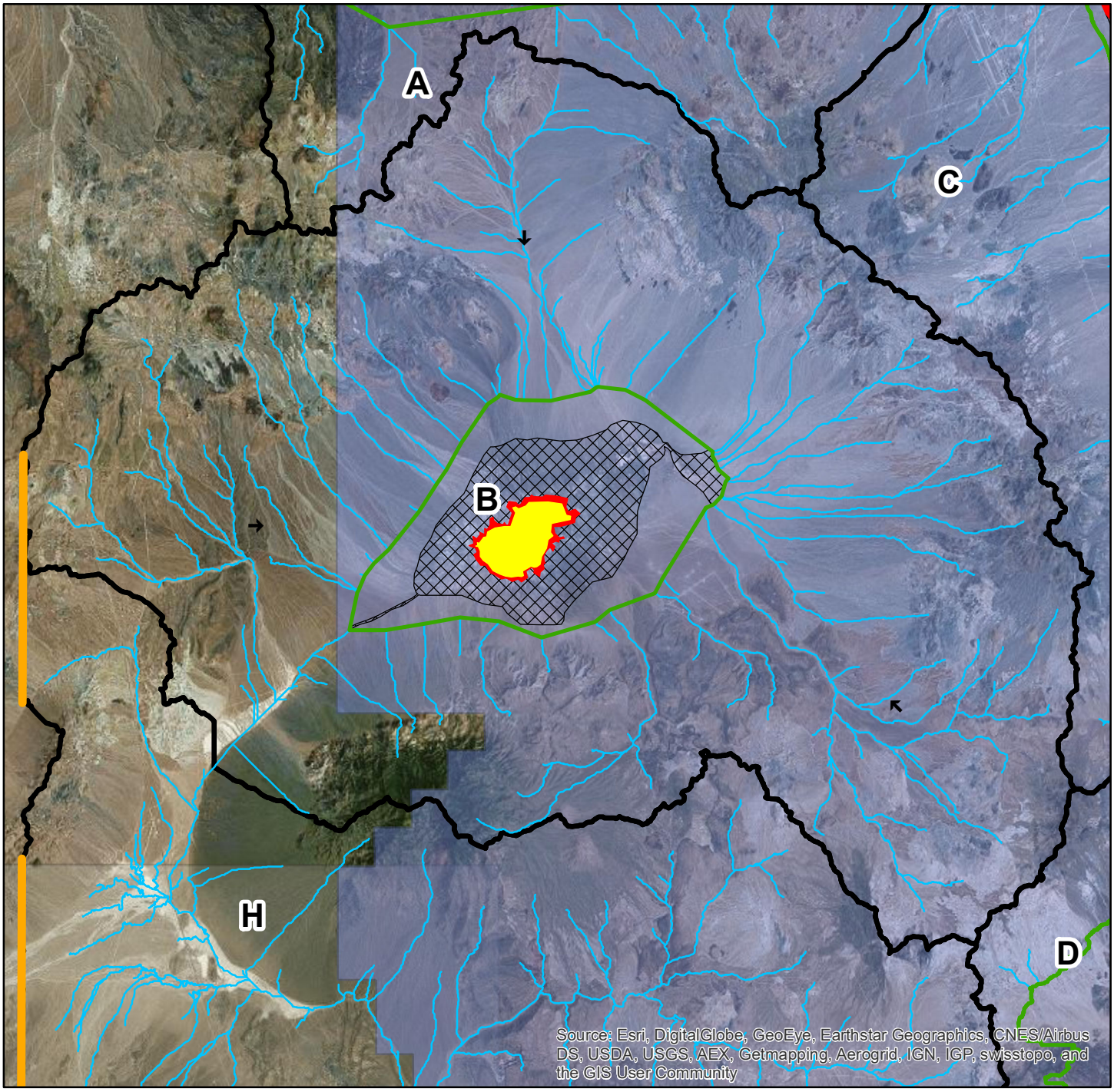
- Limits of DEM Data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

N

1:375,000

0 1.5 3 6 9 12 Miles

Figure 7.1: Flood Zone for Basin A with Aerial Image



Legend

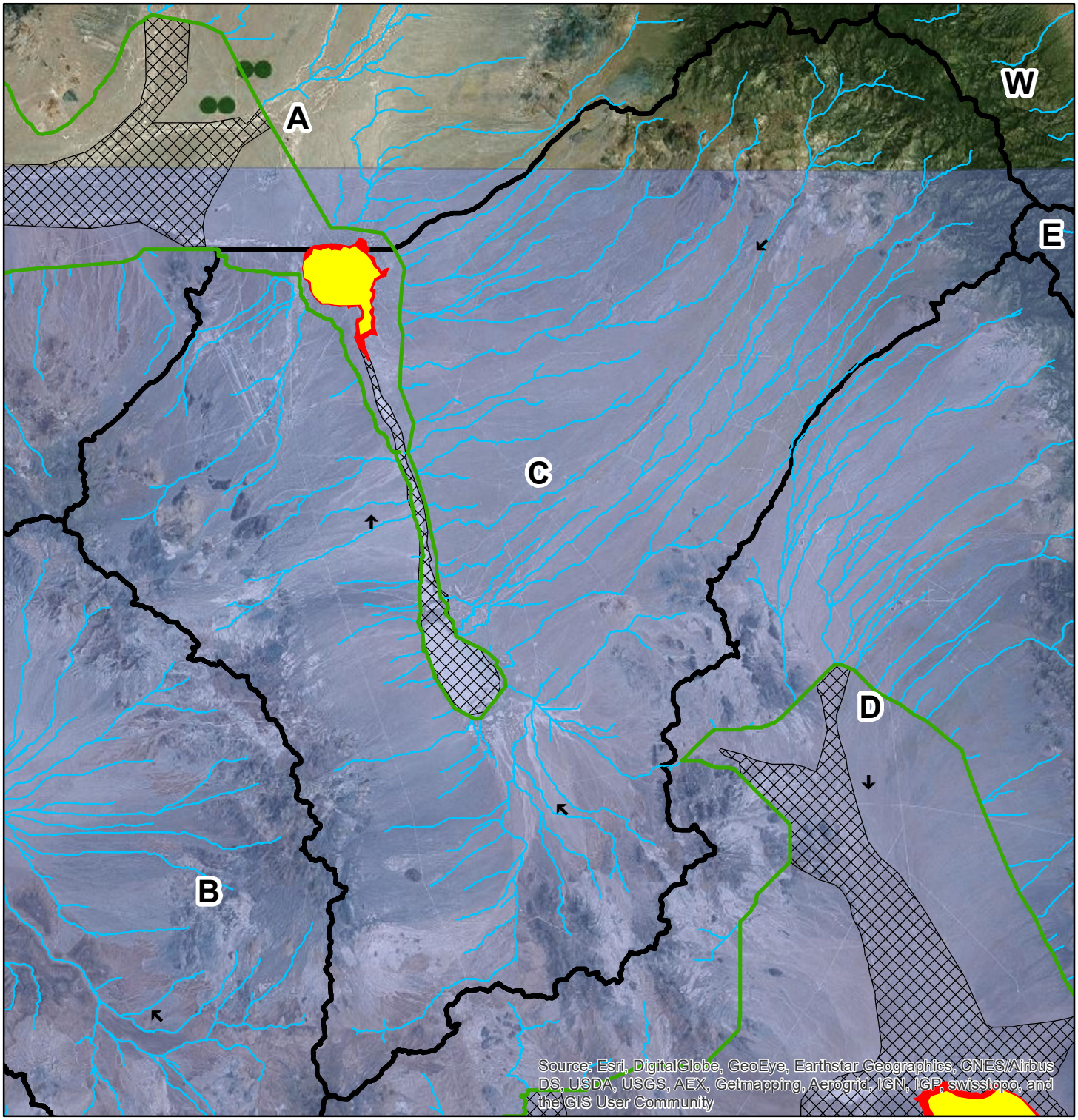
- Limits of DEM Data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

N

1:250,000

0 1 2 4 6 8 Miles

Figure 7.2: Flood Zone for Basin B with Aerial Image



Legend

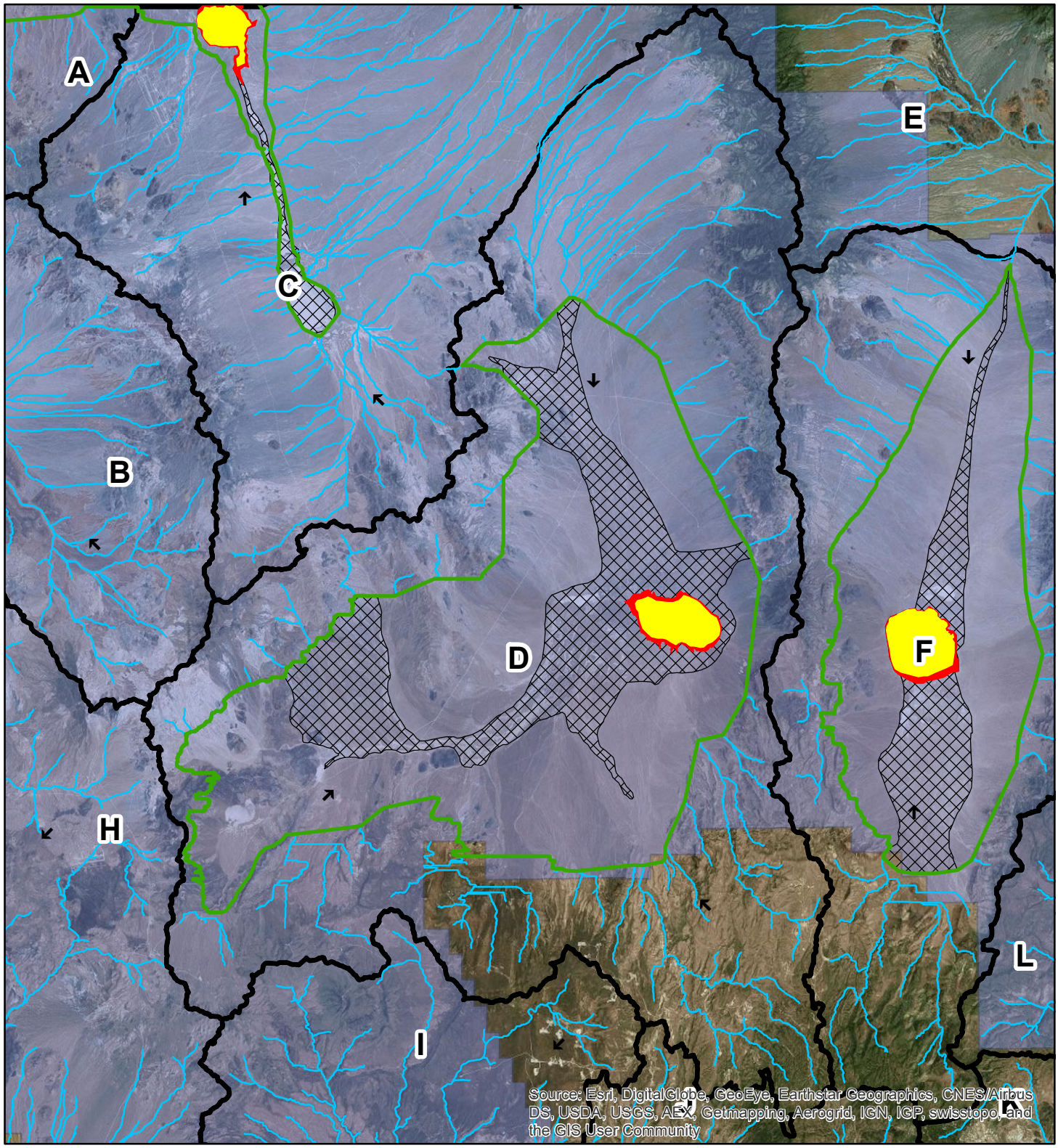
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

1:250,000

0 1 2 4 6 8 Miles

N

Figure 7.3: Flood Zone for Basin C with Aerial Image



Legend

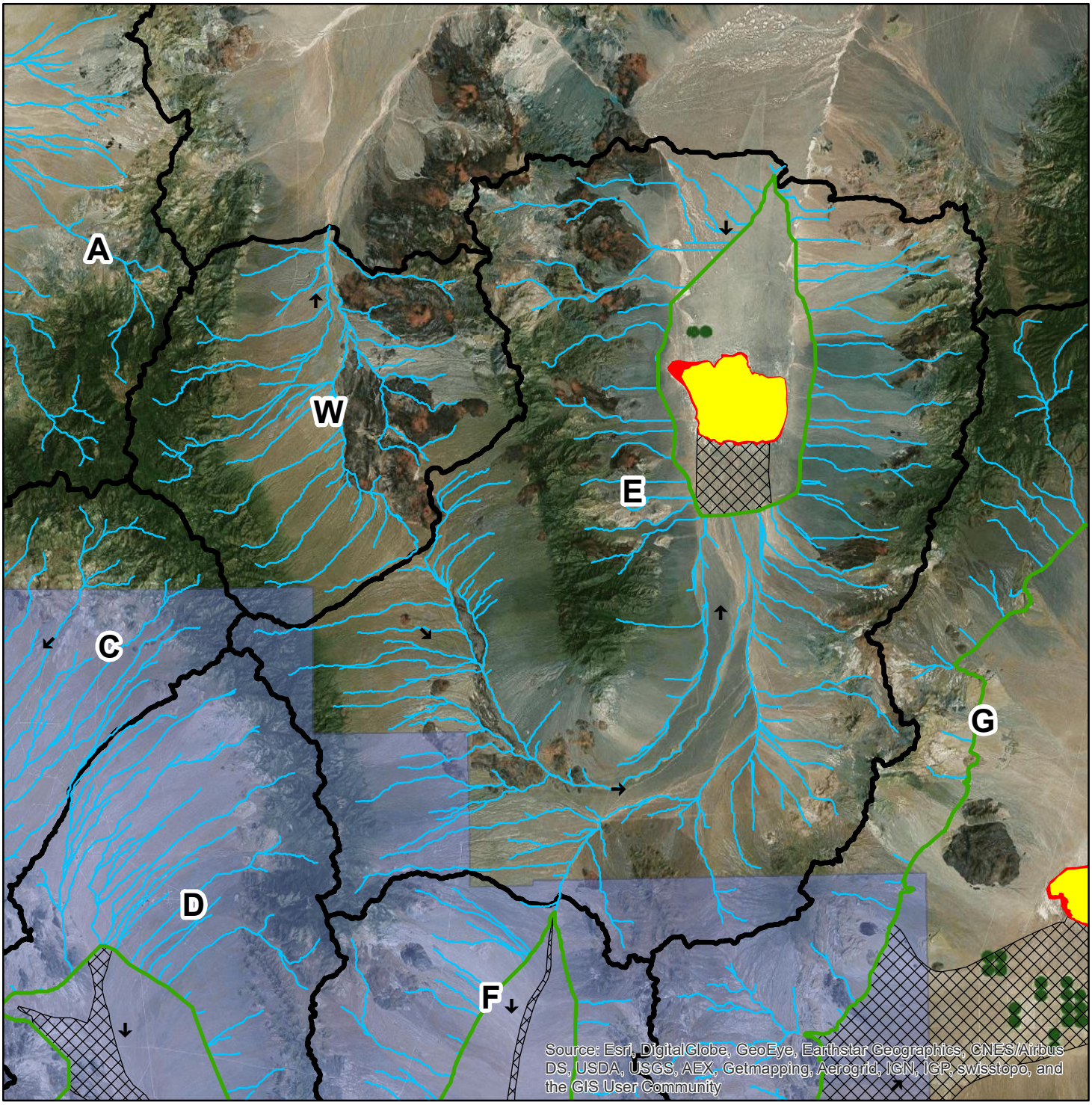
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

1:350,000

0 1 2 4 6 8 Miles

N

Figure 7.4: Flood Zone for Basin D with Aerial Image



Legend

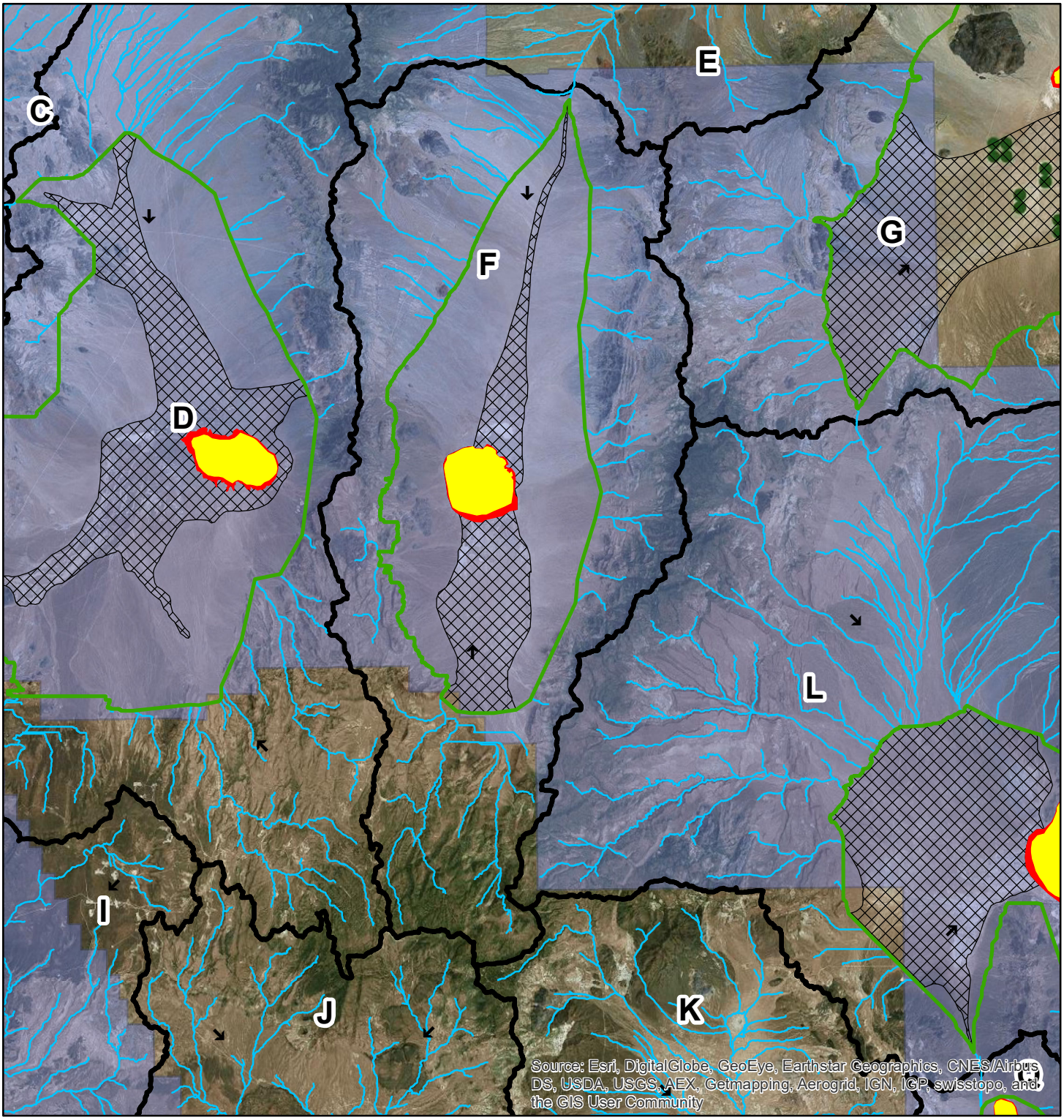
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

N

1:350,000

0 1.5 3 6 9 12 Miles

Figure 7.5: Flood Zone for Basin E with Aerial Image



Legend

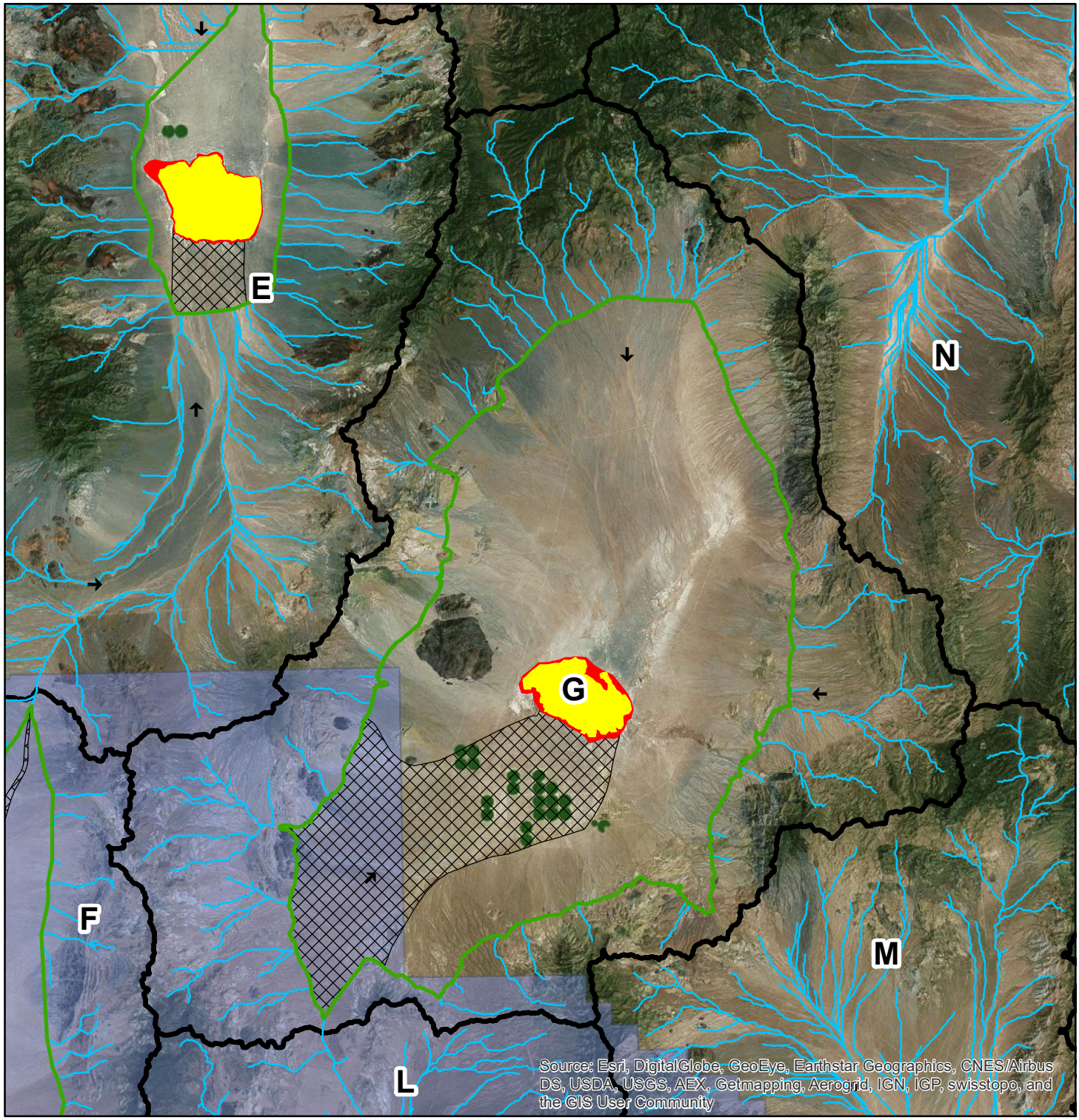
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

N

1:350,000

0 1.5 3 6 9 12 Miles

Figure 7.6: Flood Zone for Basin F with Aerial Image



Legend

- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

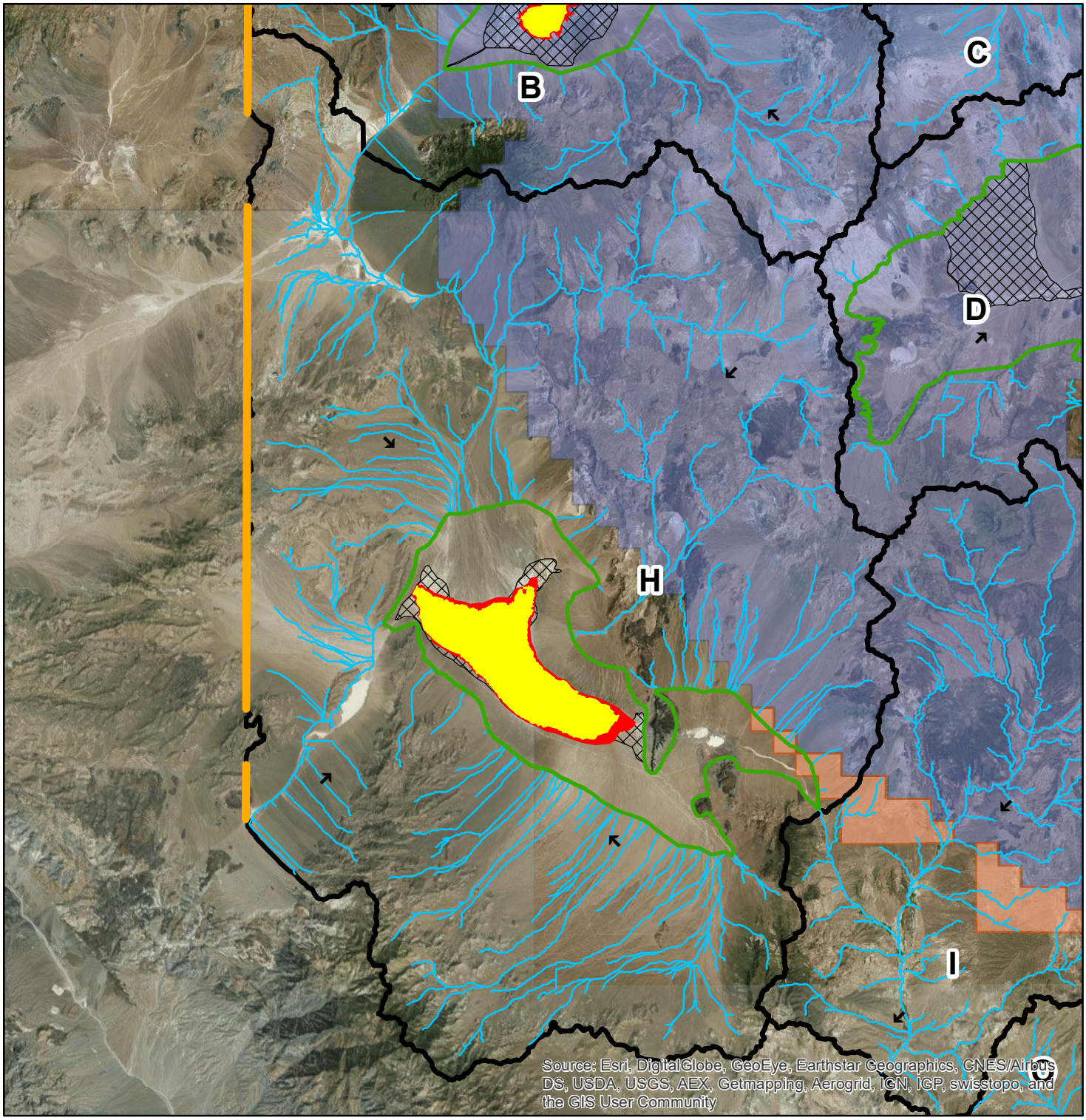
N

1:350,000

Miles

0 1 2 4 6 8

Figure 7.7: Flood Zone for Basin G with Aerial Image



Legend

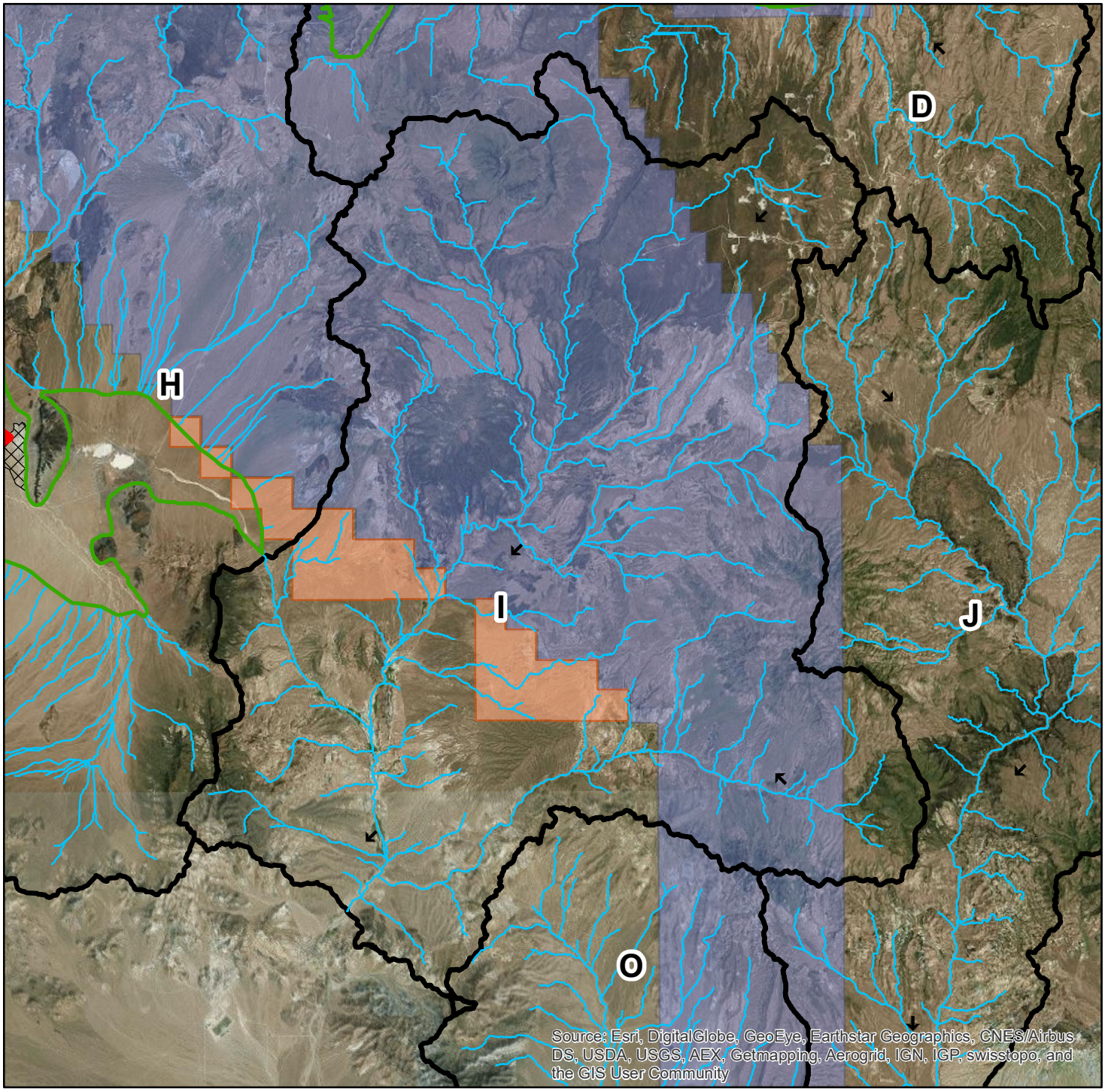
- Limits of DEM Data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

1:400,000

0 1.5 3 6 9 12 Miles

N

Figure 7.8: Concentrated Flows for Basin H



Legend

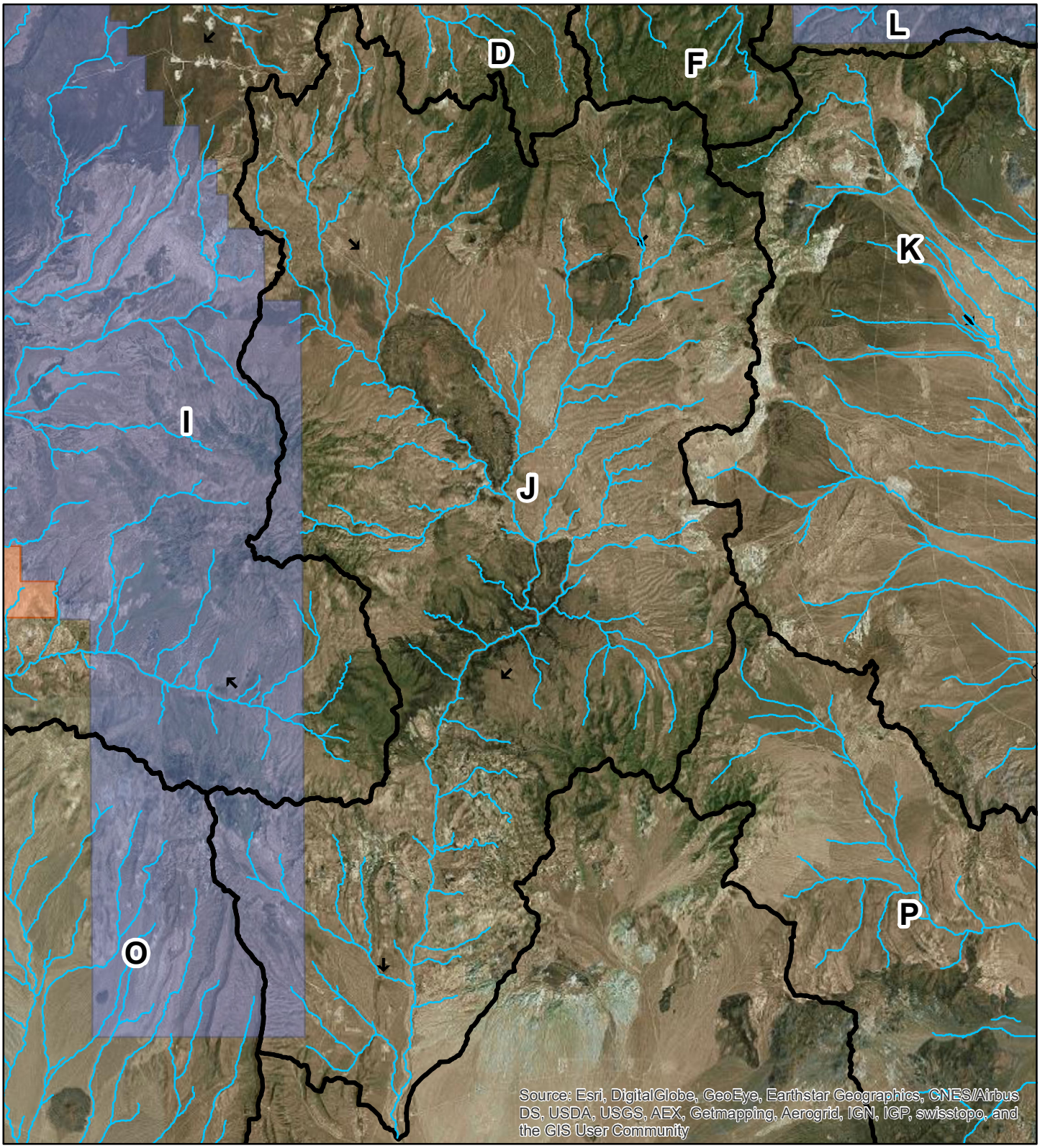
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

N

1:300,000

0 1 2 4 6 8 Miles

Figure 7.9: Flood Zone for Basin I with Aerial Image



Legend

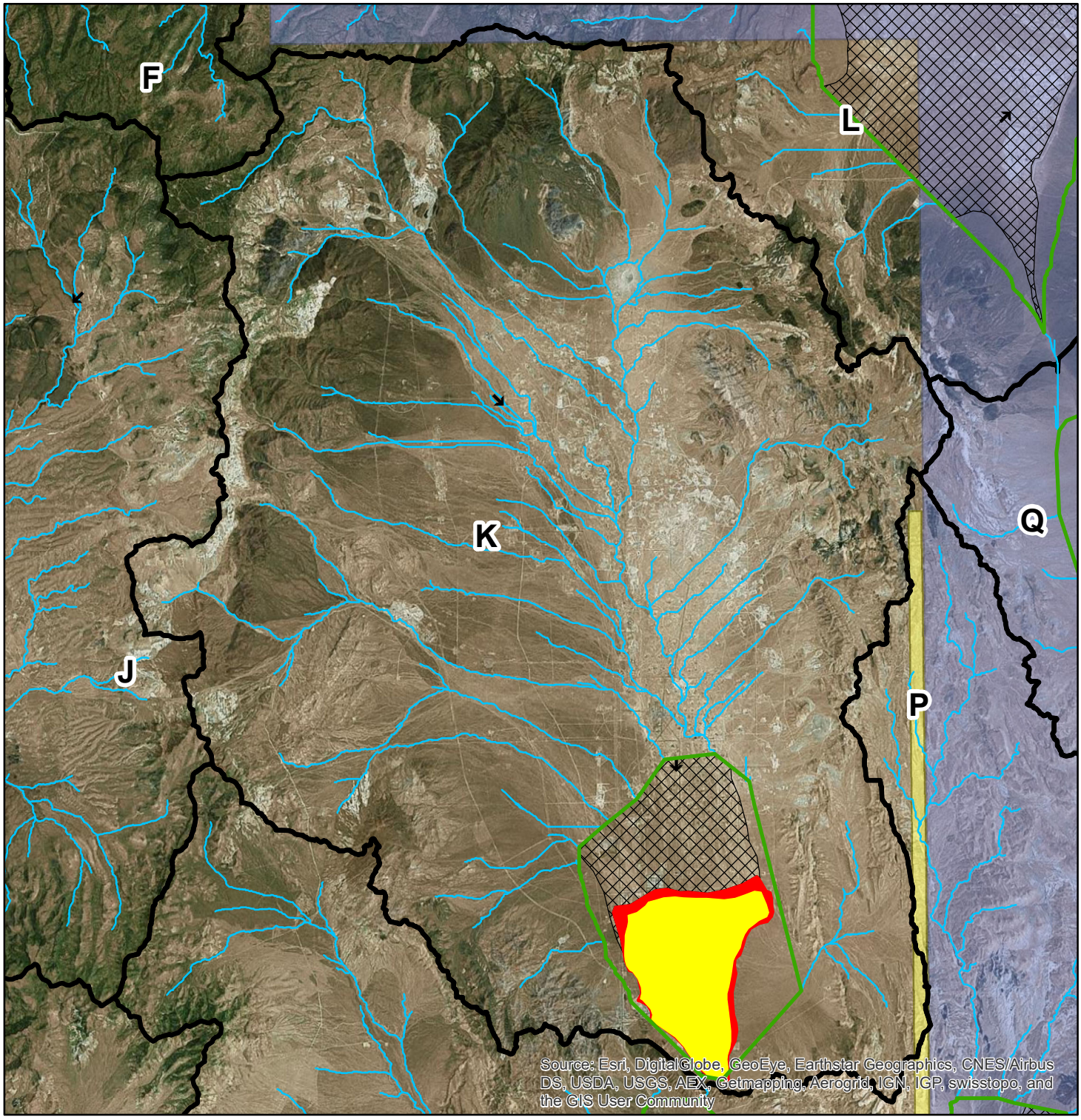
- Concentrated Flow Path
- Flow Direction
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

1:250,000

0 1 2 4 6 8 Miles

N

Figure 7.10: Flood Zone for Basin J with Aerial Image



Legend

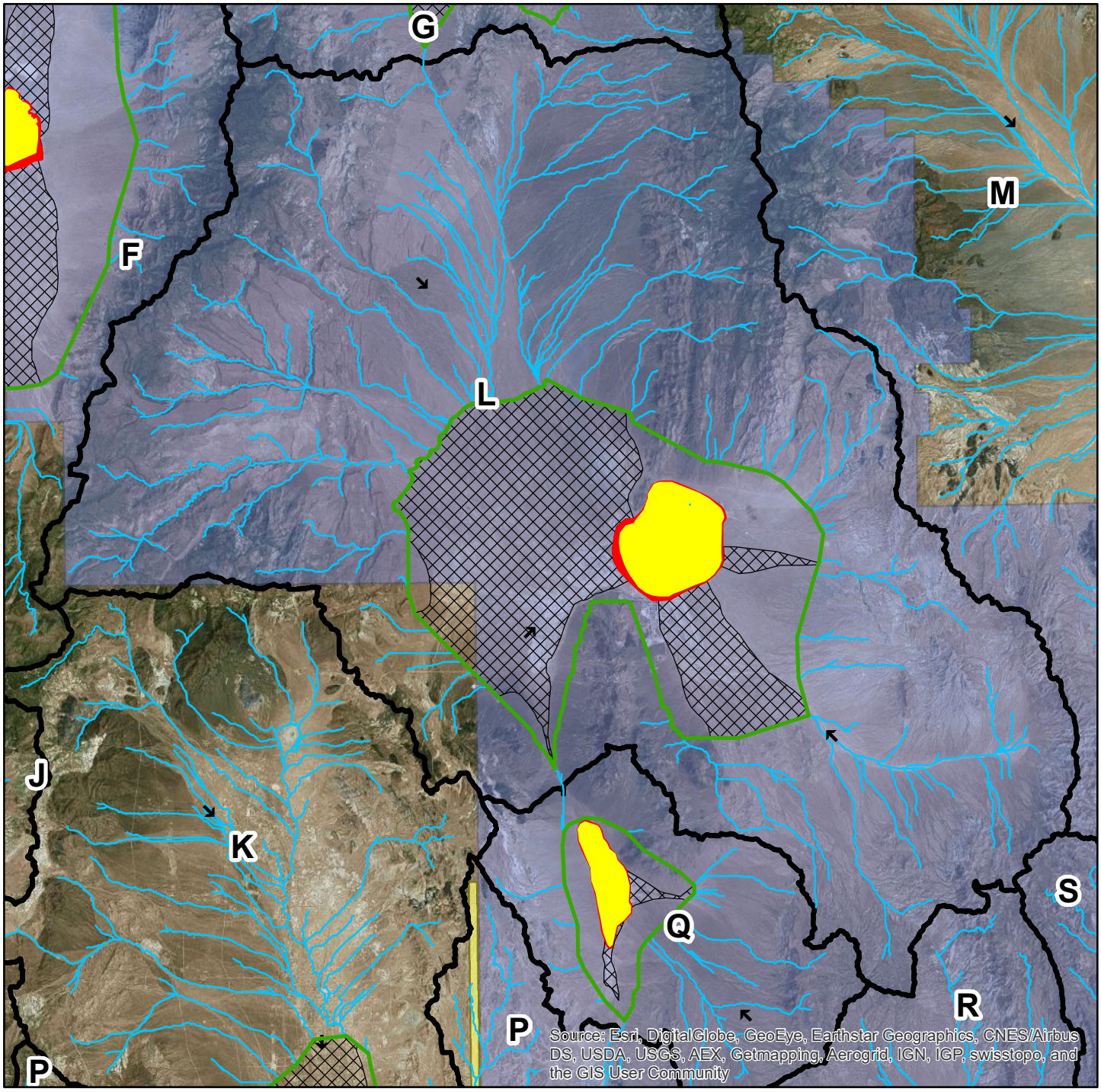
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 64 C/D and 65 D Expansion
- Existing NTTR Boundary

1:200,000

0 1 2 4 6 8 Miles

N

Figure 7.11: Flood Zone for Basin K with Aerial Image



Legend

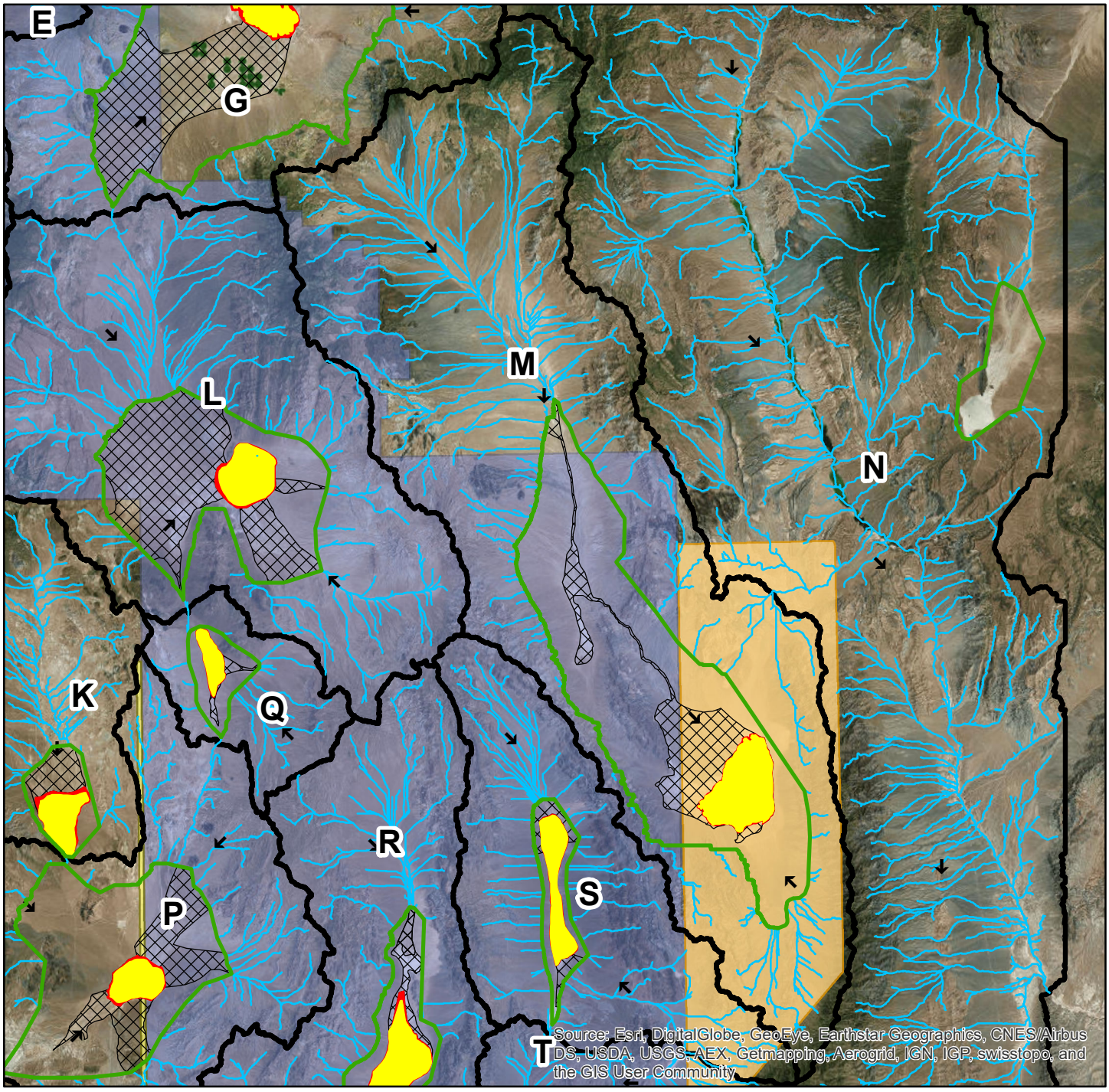
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64 C/D and 65D Expansion
- Existing NTTR Boundary

N

1:325,000

0 1 2 4 6 8 Miles

Figure 7.12: Flood Zone for Basin L with Aerial Image



Legend

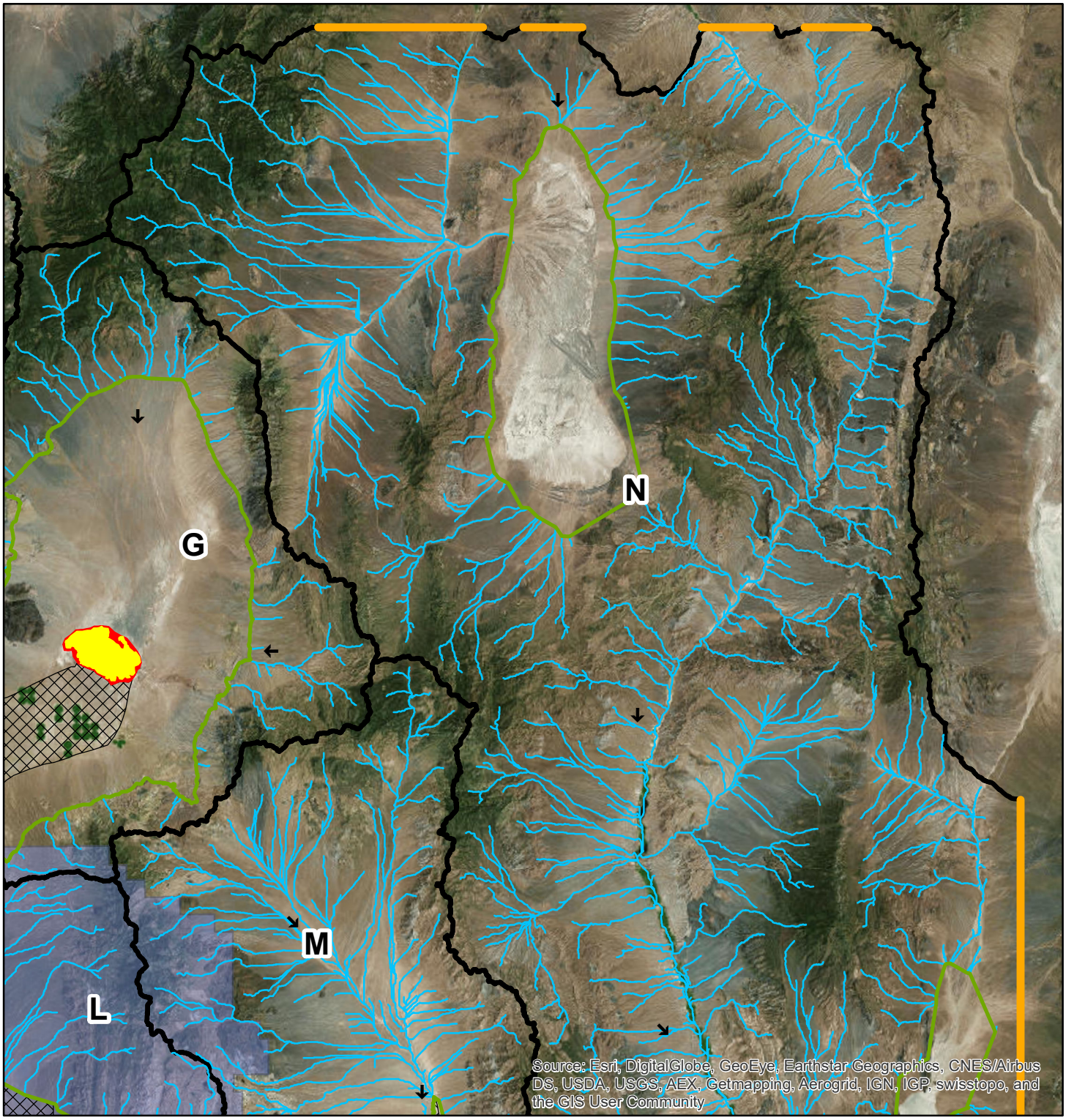
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:600,000

0 3 6 12 18 24 Miles

Figure 7.13: Flood Zone for Basin M with Aerial Image



Legend

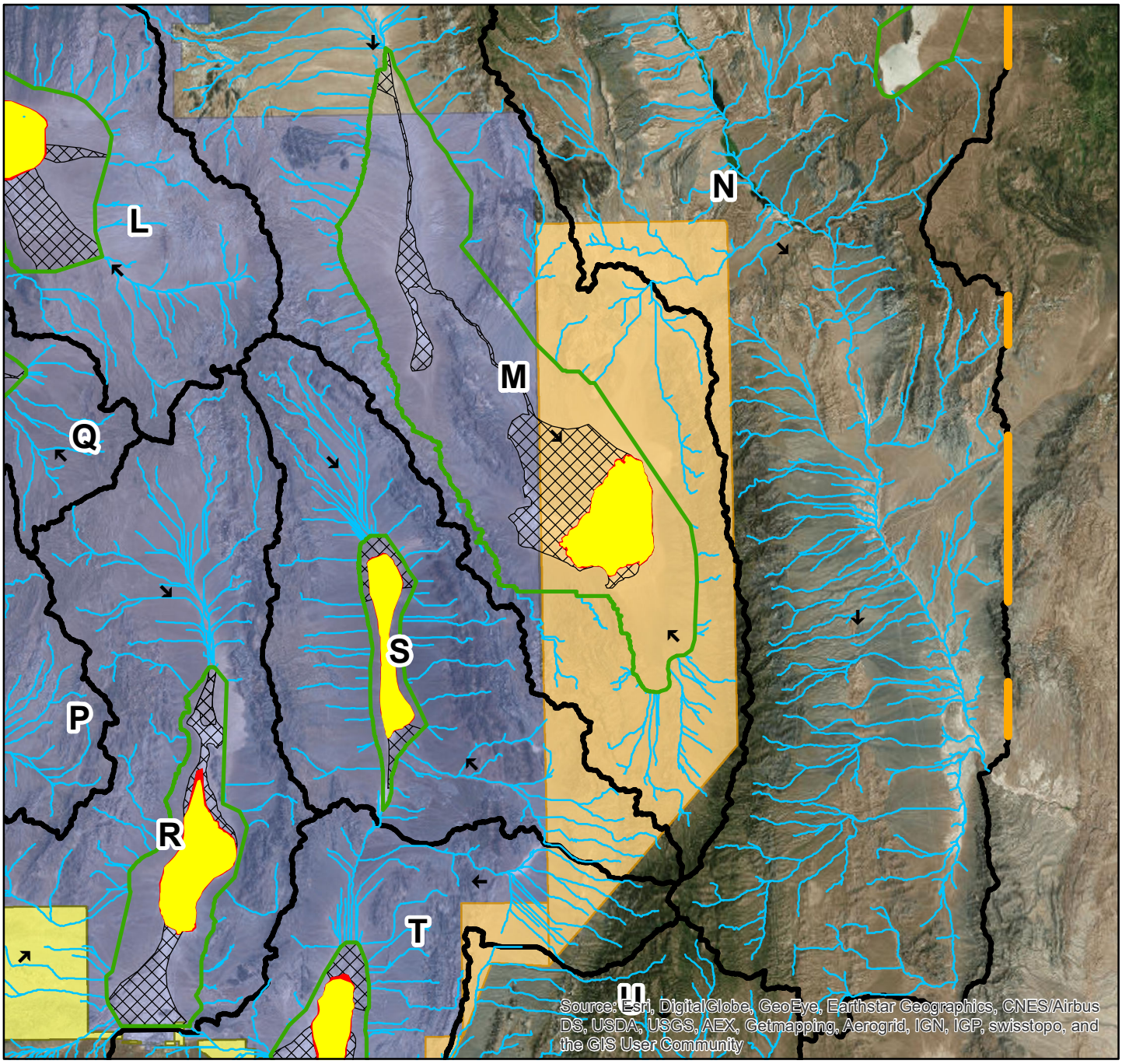
- Limits of DEM Data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Existing NTTR Boundary

1:500,000

0 2.5 5 10 15 20 Miles

N

Figure 7.14A: Flood Zone for Basin N with Aerial Image



Legend

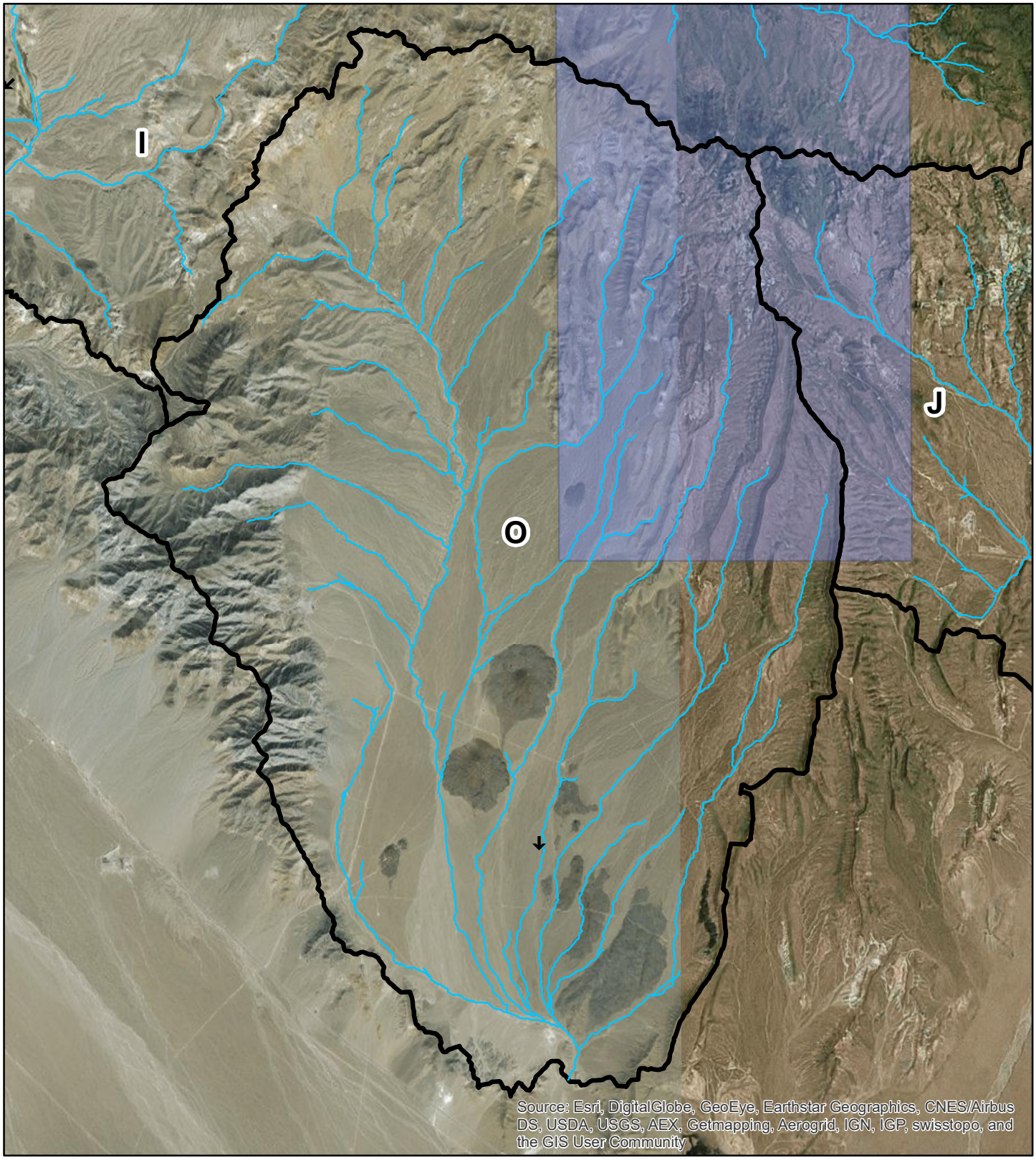
- Limits of DEM Data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:500,000

0 2.5 5 10 15 20 Miles

Figure 7.14B: Flood Zone for Basin N with Aerial Image



Legend

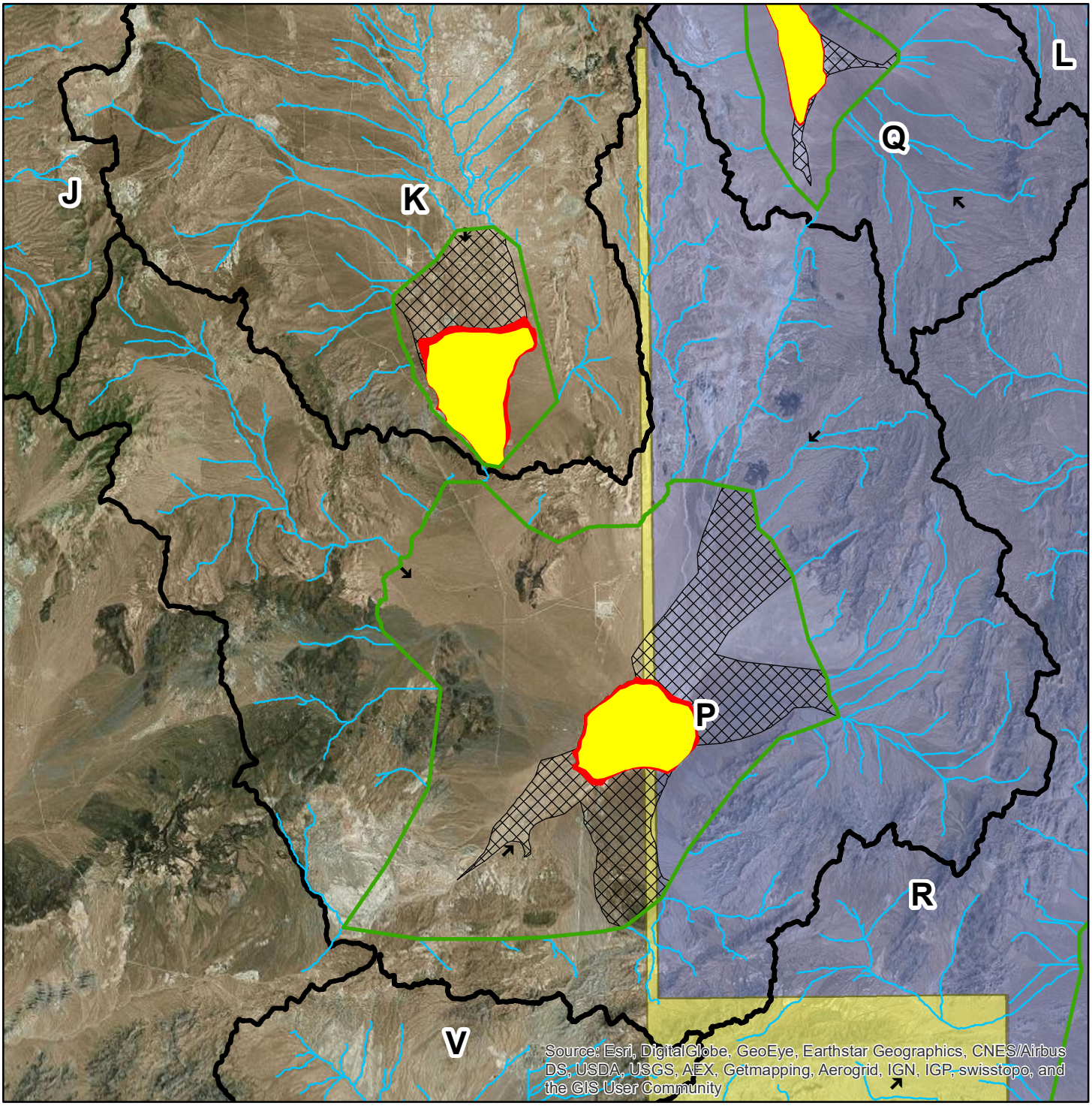
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Basin Boundary
- Existing NTTR Boundary

1:150,000

0 0.5 1 2 3 4 Miles

N

Figure 7.15: Flood Zone for Basin O with Aerial Image



Legend

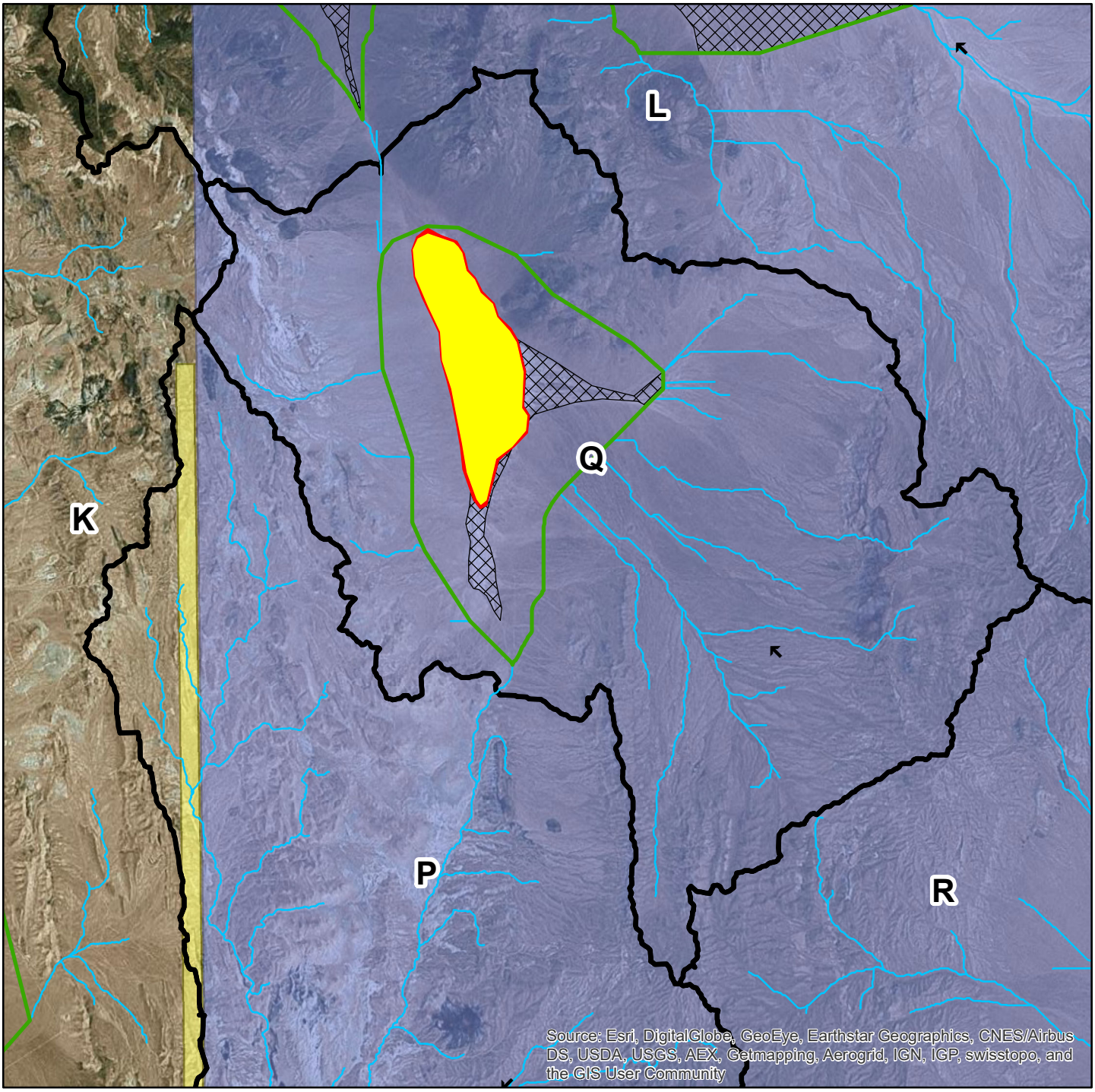
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Existing NTTR Boundary

N

1:275,000

0 1 2 4 6 8 Miles

Figure 7.16: Flood Zone for Basin P with Aerial Image



Legend

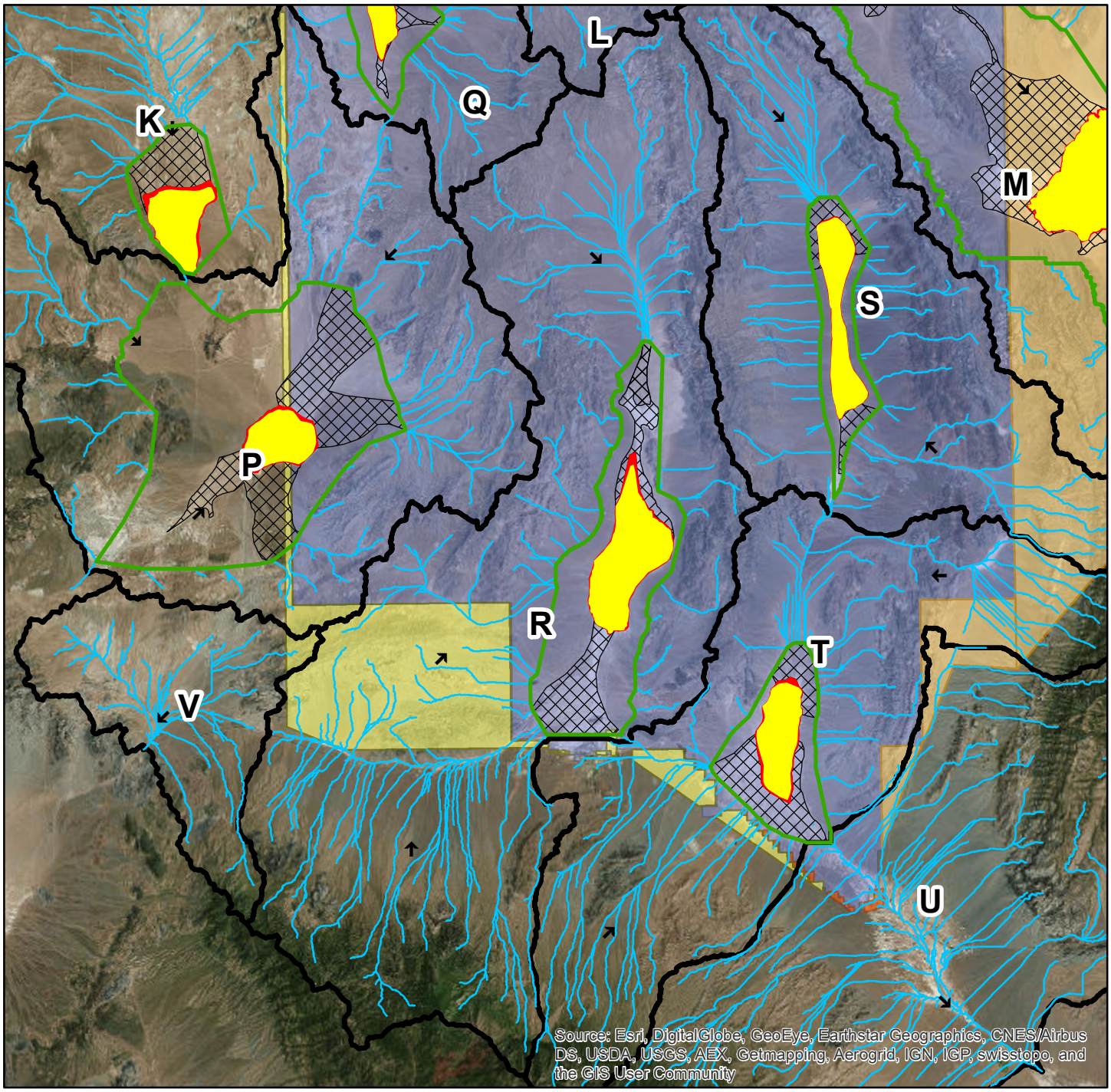
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Existing NTTR Boundary

N

1:150,000

0 0.5 1 2 3 4 Miles

Figure 7.17: Flood Zone for Basin Q with Aerial Image



Legend

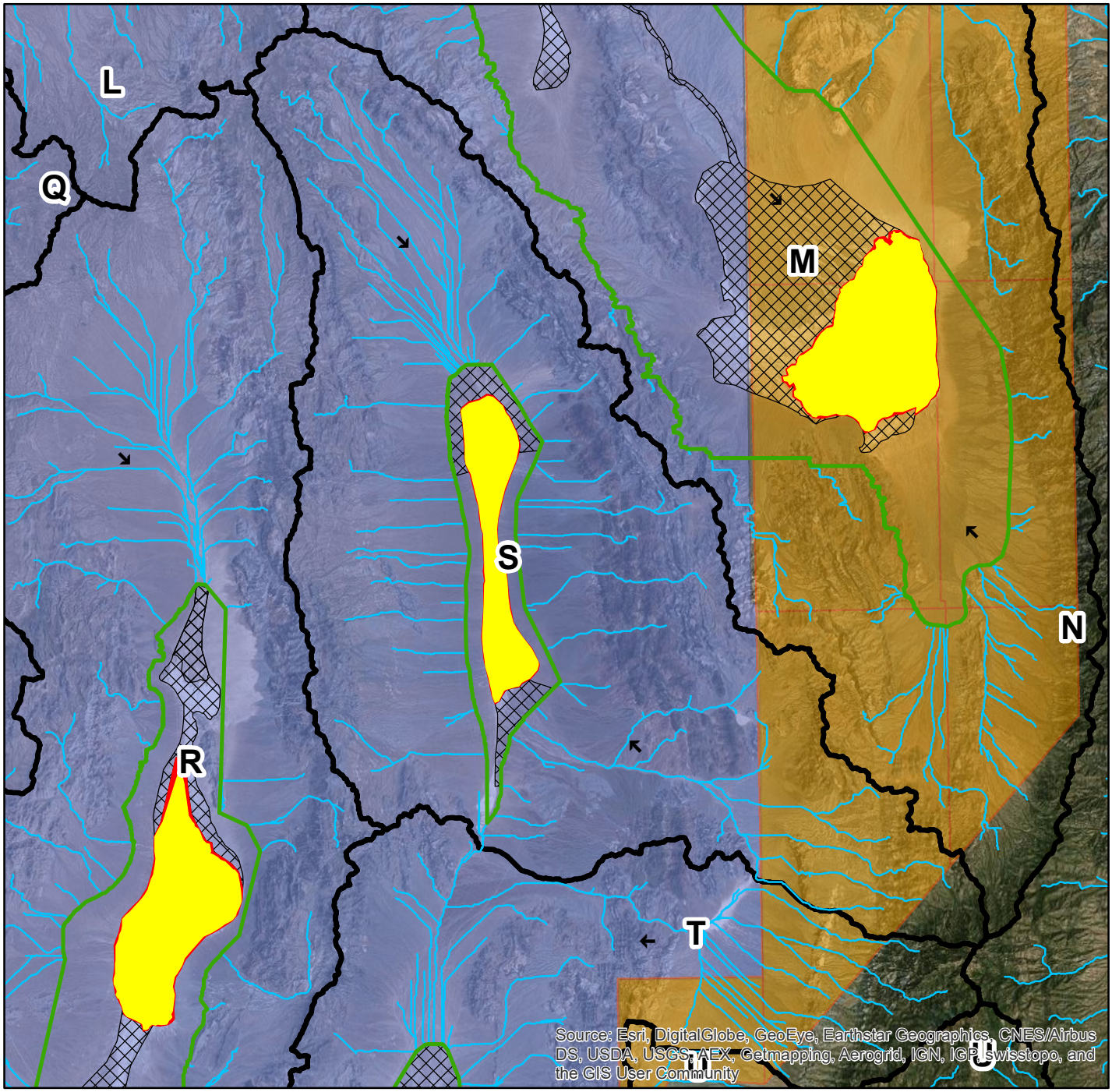
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:450,000

0 2.5 5 10 15 20 Miles

Figure 7.18: Flood Zone for Basin R with Aerial Image



Legend

- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

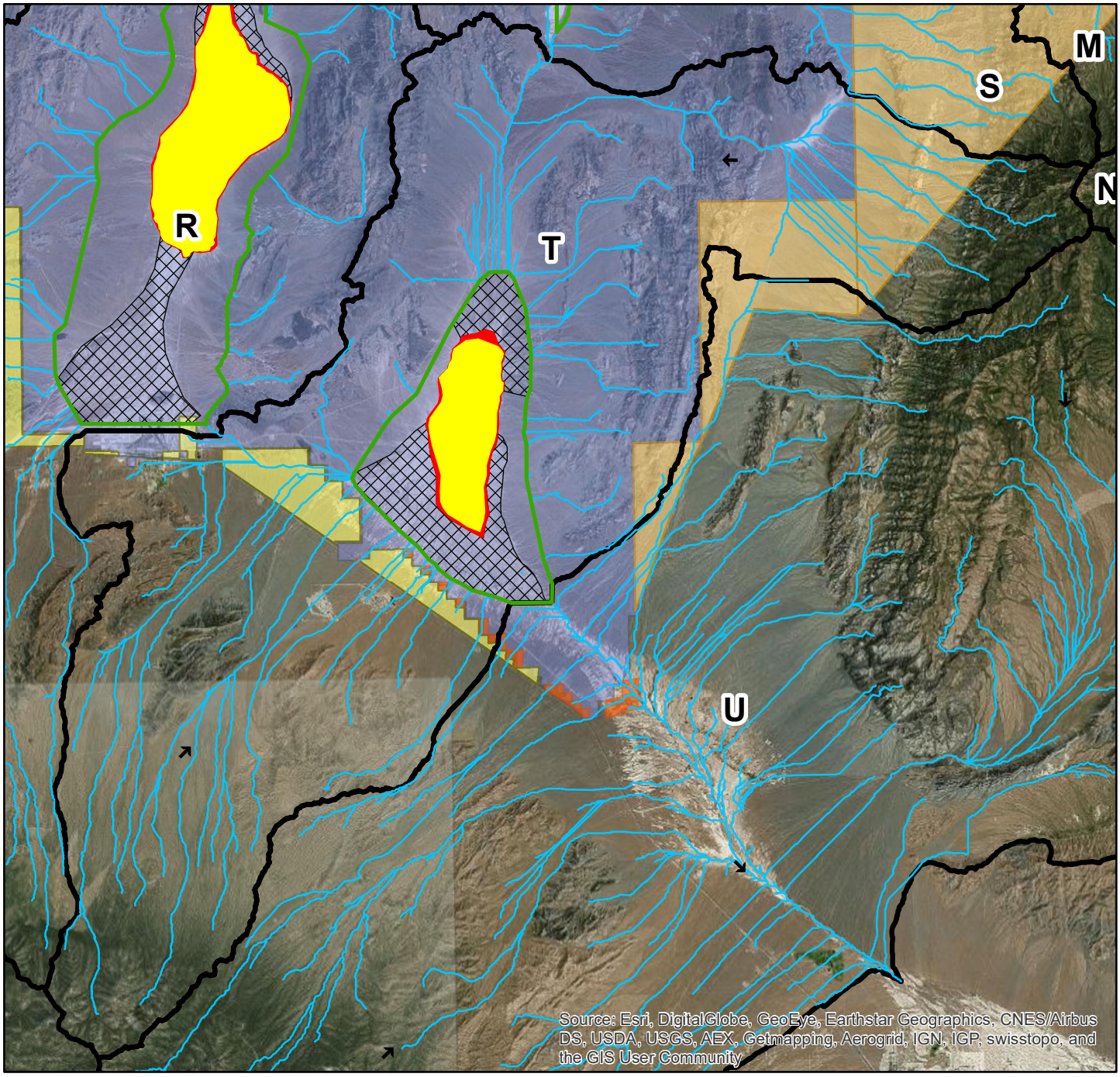
1:300,000

Miles

0 1.5 3 6 9 12

N

Figure 7.19: Flood Zone for Basin S with Aerial Image



Legend

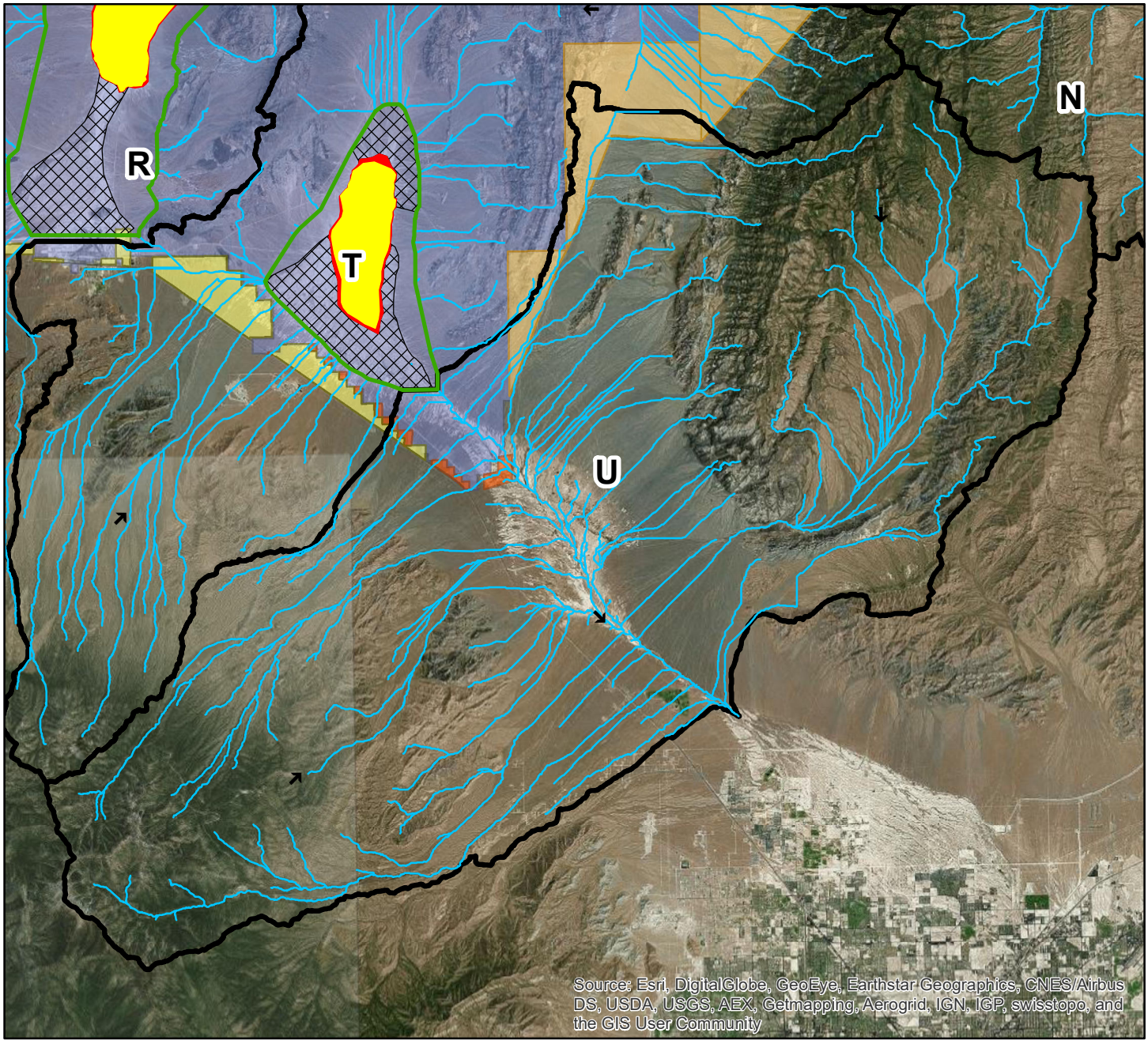
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:275,000

0 1 2 4 6 8 Miles

Figure 7.20: Flood Zone for Basin T with Aerial Image



Legend

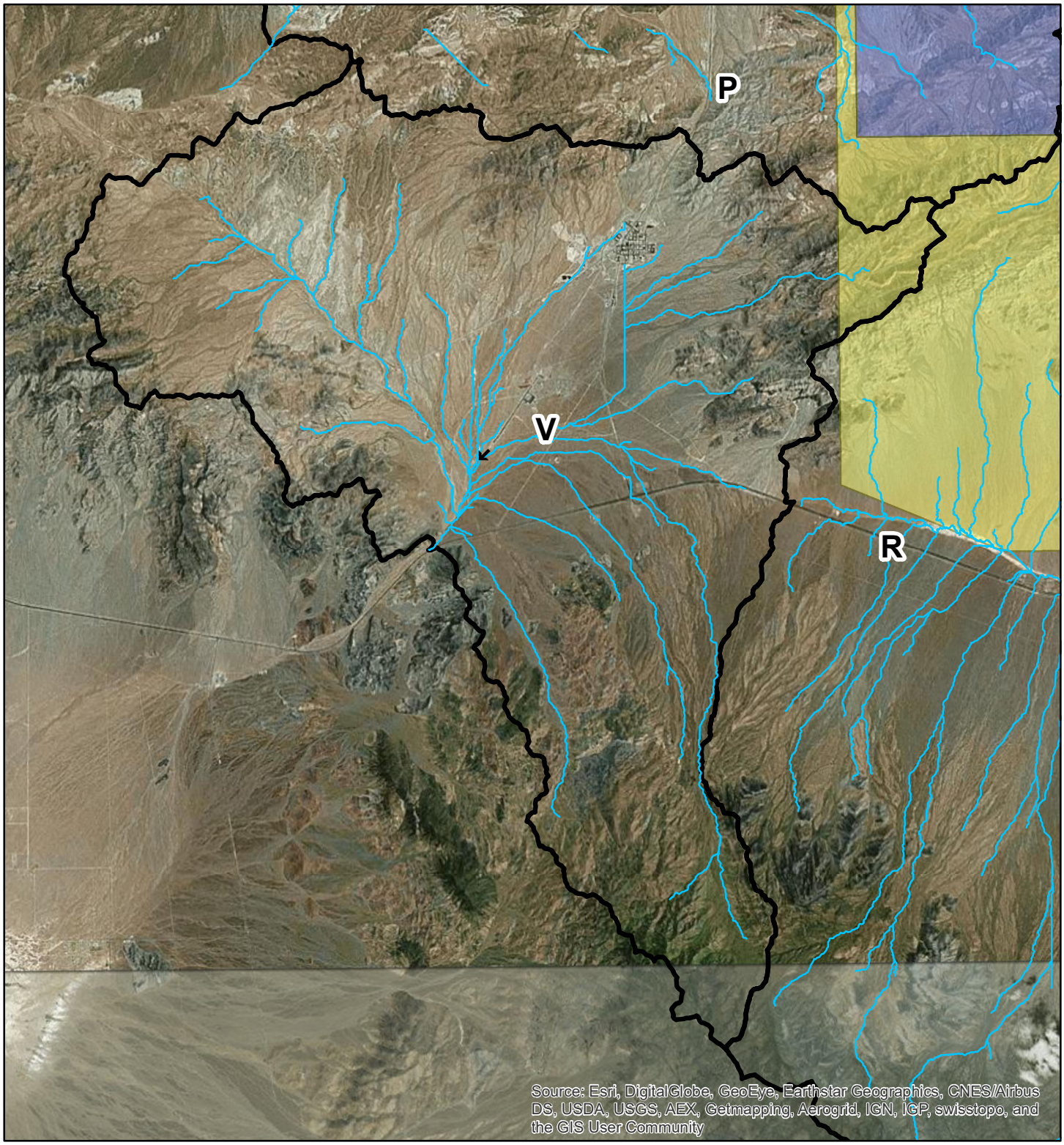
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:325,000

0 1 2 4 6 8 Miles

N

Figure 7.21: Flood Zone for Basin U with Aerial Image



Legend

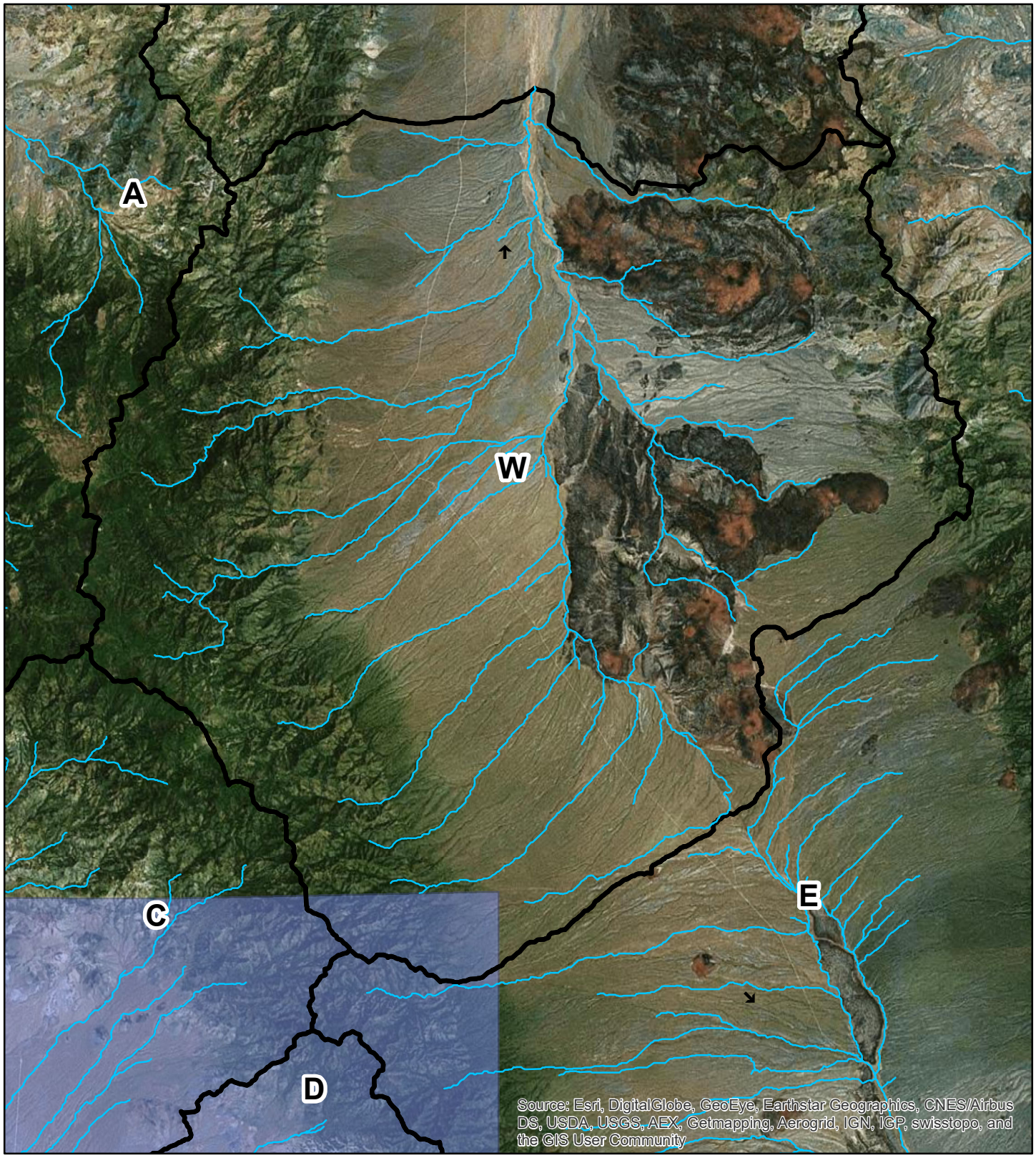
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Basin Boundary
- Alternative 3B 64C/D and 65D Expansion
- Existing NTTR Boundary

1:150,000

0 0.5 1 2 3 4 Miles

N

Figure 7.22: Flood Zone for Basin V with Aerial Image



Legend

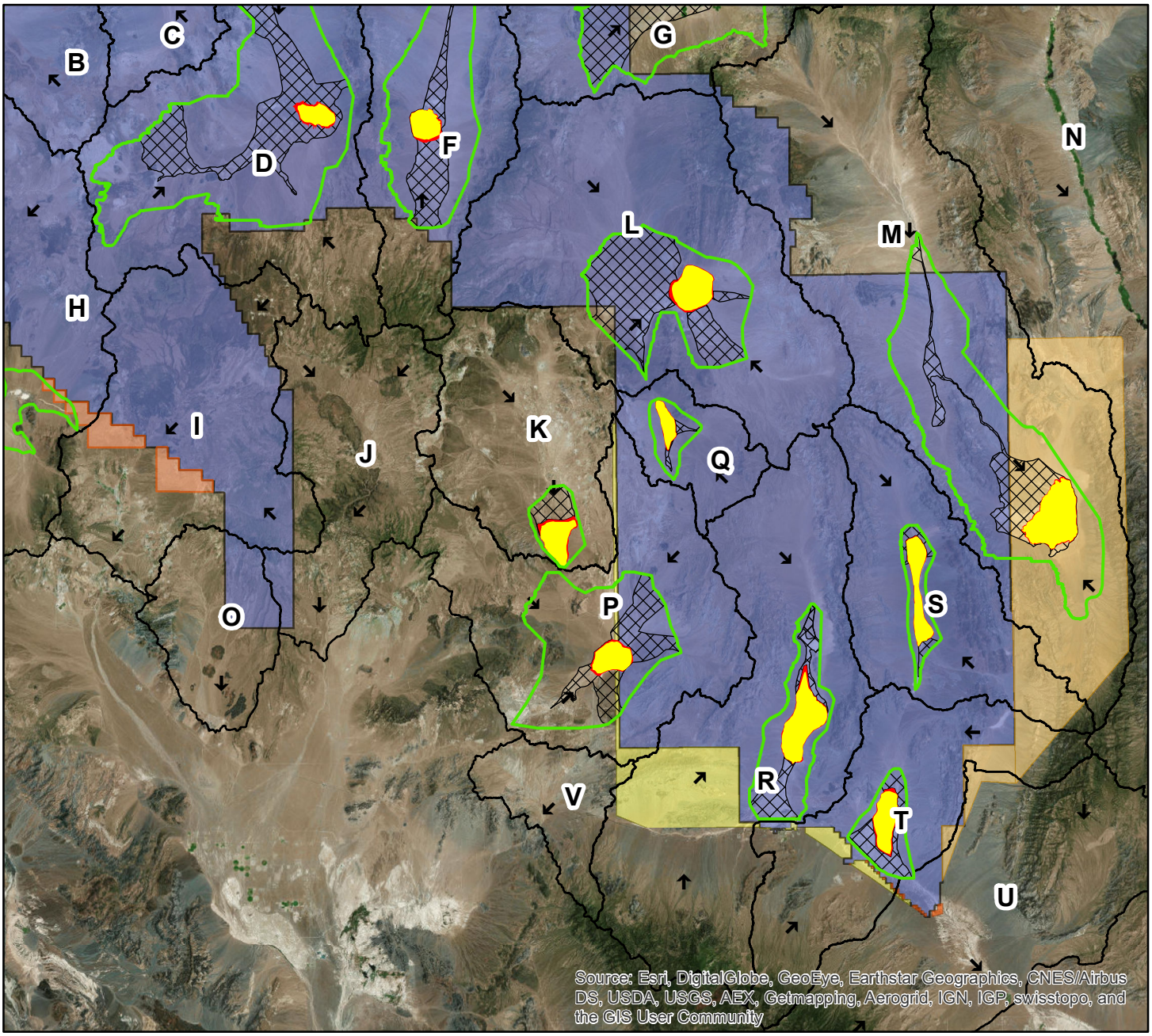
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Basin Boundary
- Existing NTTR Boundary

N

1:150,000

0 0.5 1 2 3 4 Miles

Figure 7.23: Flood Zone for Basin W with Aerial Image



Legend

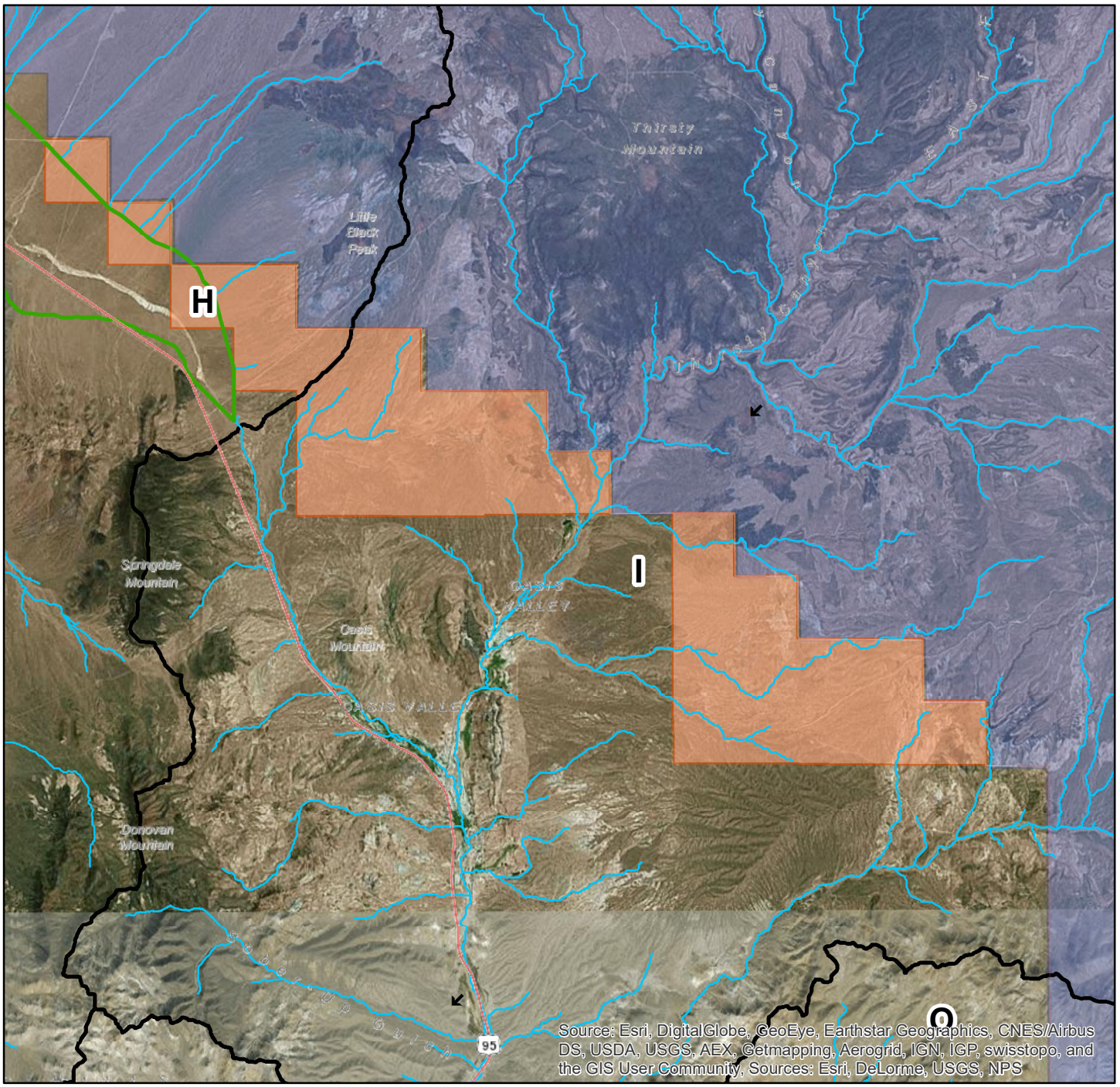
- Limits of DEM data
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- 100yrWSE
- 500yrWSE
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

N

1:850,000

0 3 6 12 18 24 Miles

Figure 8.0: Flood Zones for Expansion Areas with Aerial Image



Legend

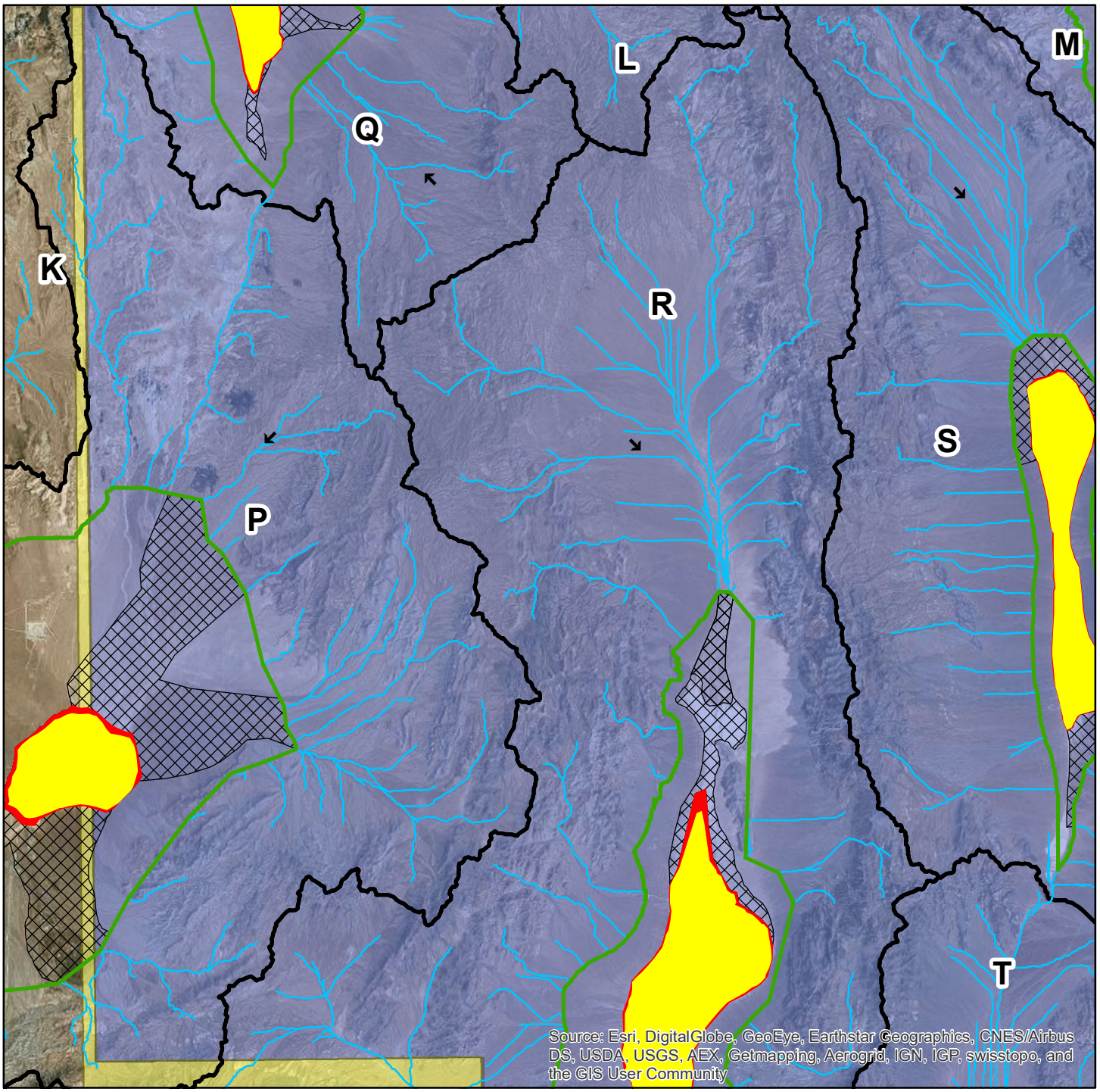
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3A Range 77 - EC South Expansion
- Existing NTTR Boundary

N

1:150,000

0 0.5 1 2 3 4 Miles

Figure 8.1: Flood Zone for Alternative 3A EC South with Aerial Image



Legend

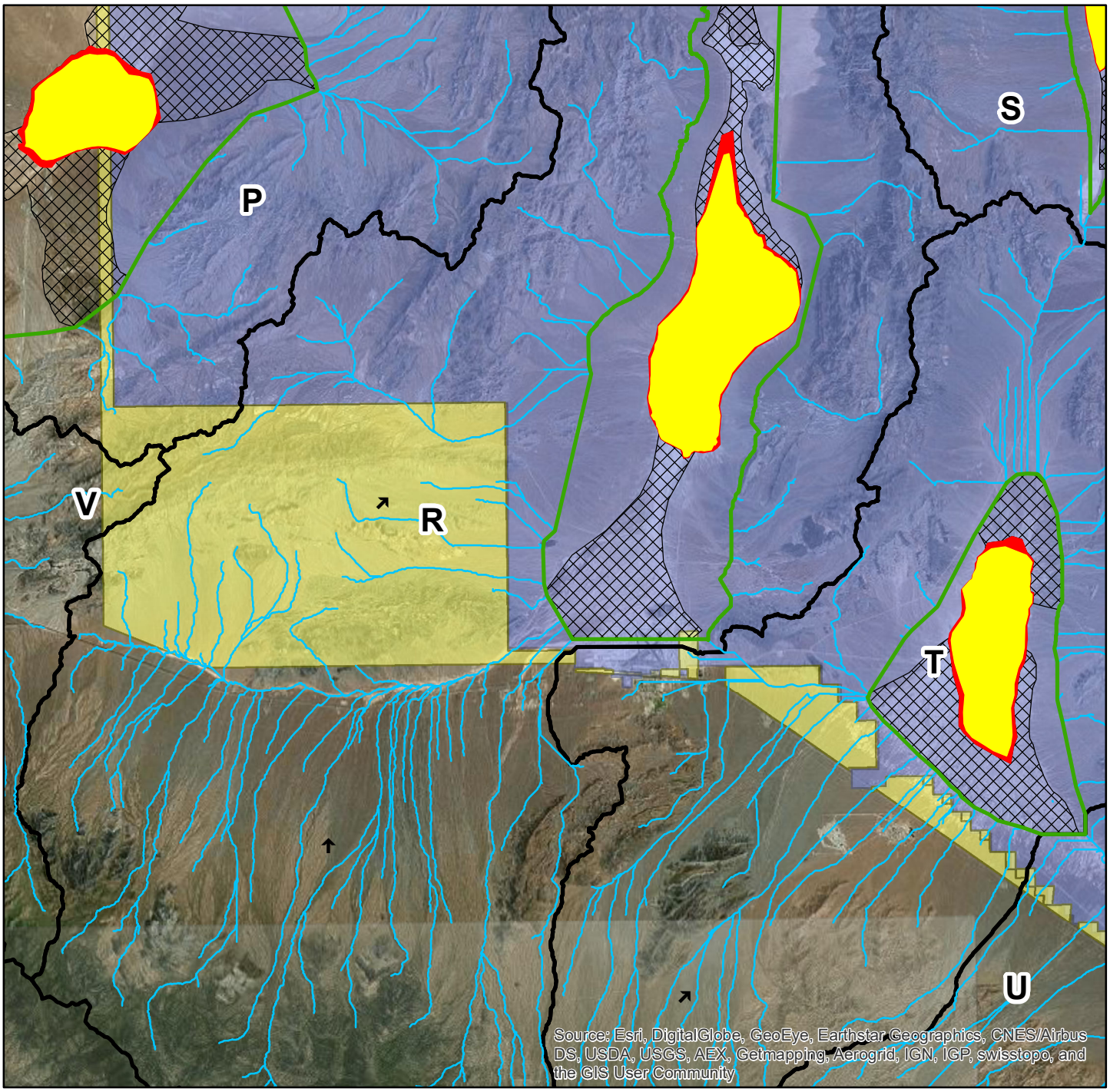
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Existing NTTR Boundary

N

1:250,000

0 1.5 3 6 9 12 Miles

Figure 8.2A: Flood Zone for Alternative 3B 64C/D and 65D with Aerial Image



Legend

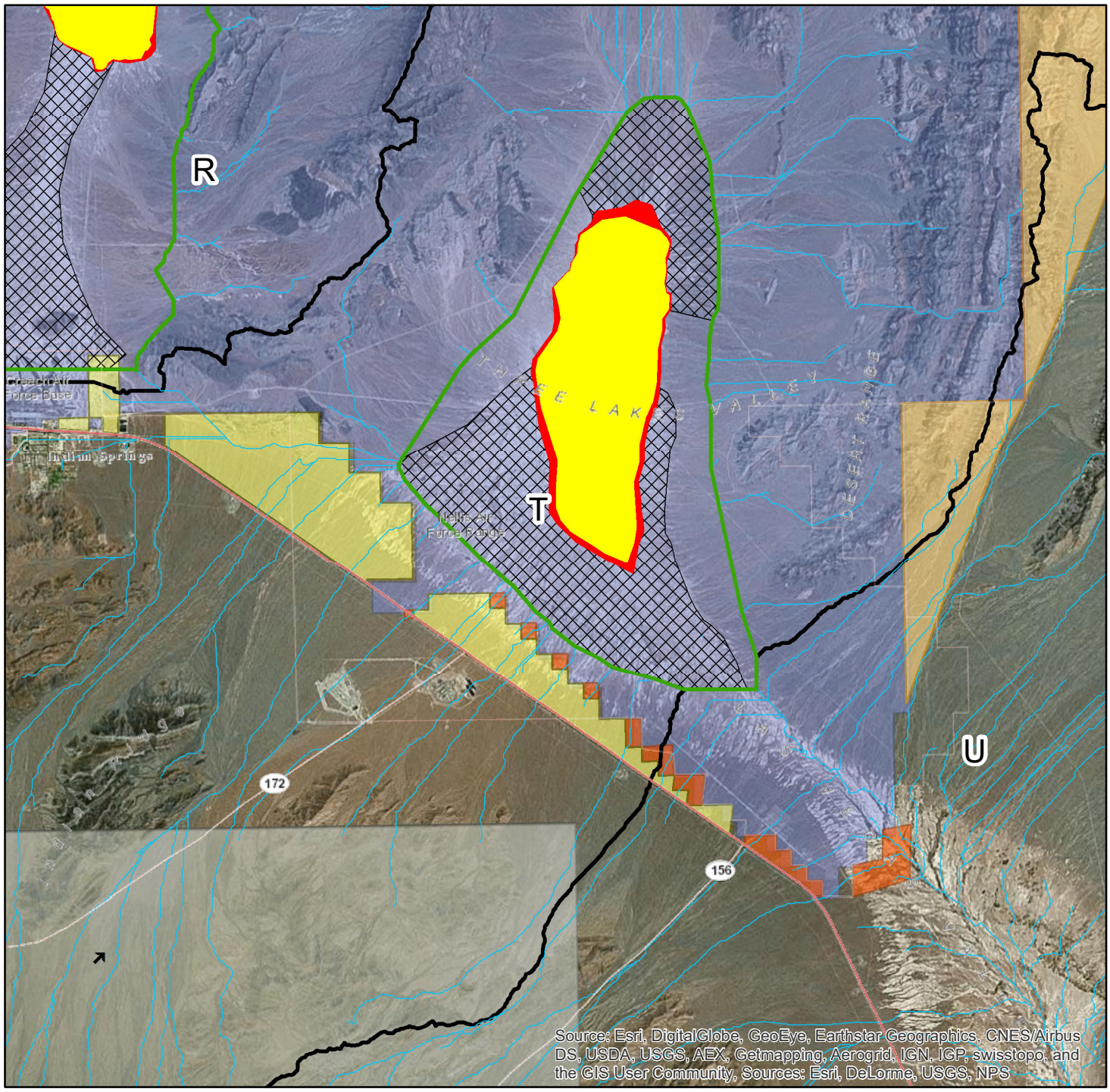
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Existing NTTR Boundary

N

1:250,000

0 1.5 3 6 9 12 Miles

Figure 8.2B: Flood Zone for Alternative 3B 64C/D and 65D with Aerial Image



Legend

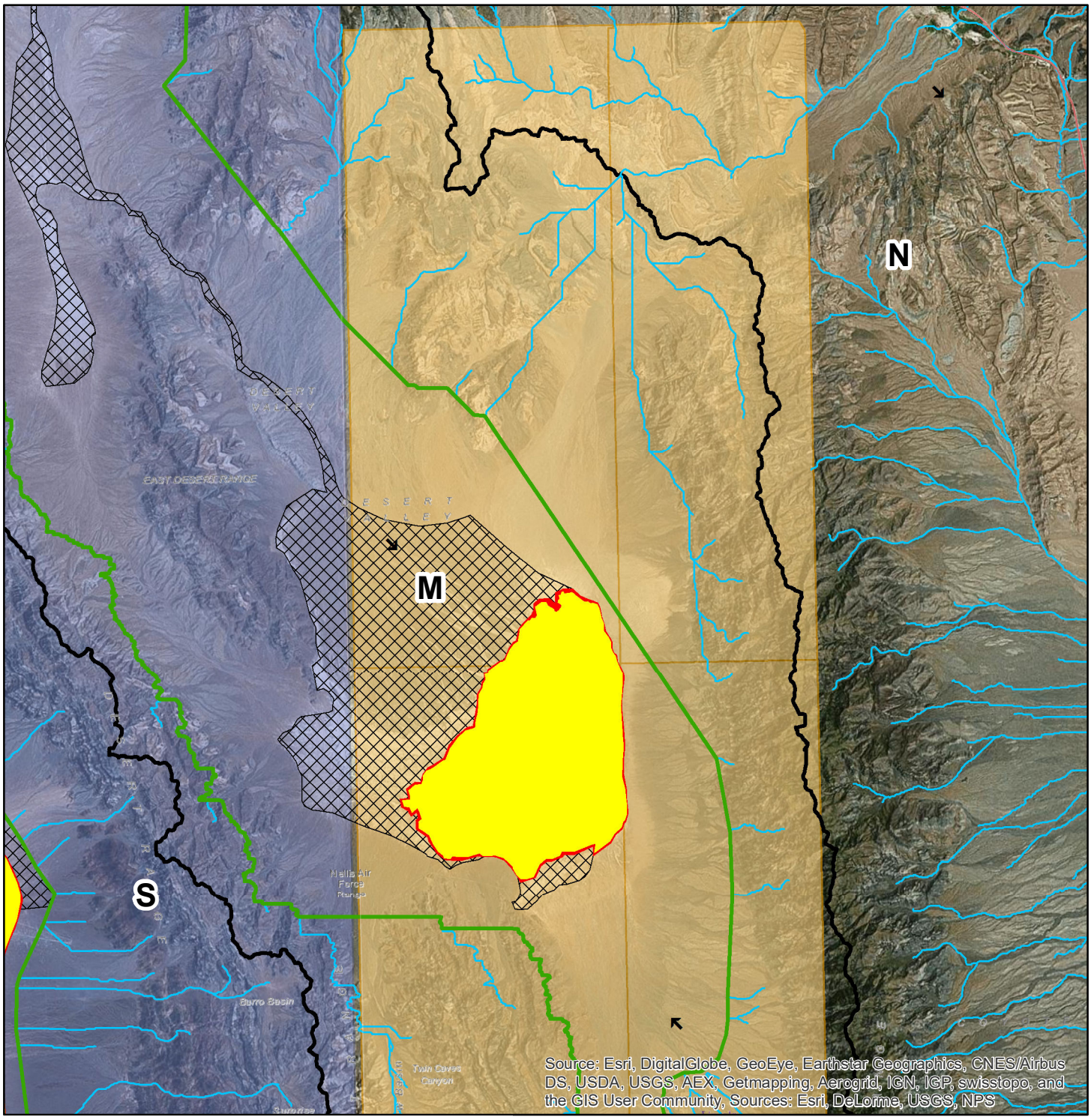
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3B 64C D and 65D Expansion
- Alternative 3B Administrative Incorporation
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:150,000

0 0.5 1 2 3 4 Miles

N

Figure 8.3: Flood Zone for Alternative 3B Administrative Incorporation with Aerial Image



Legend

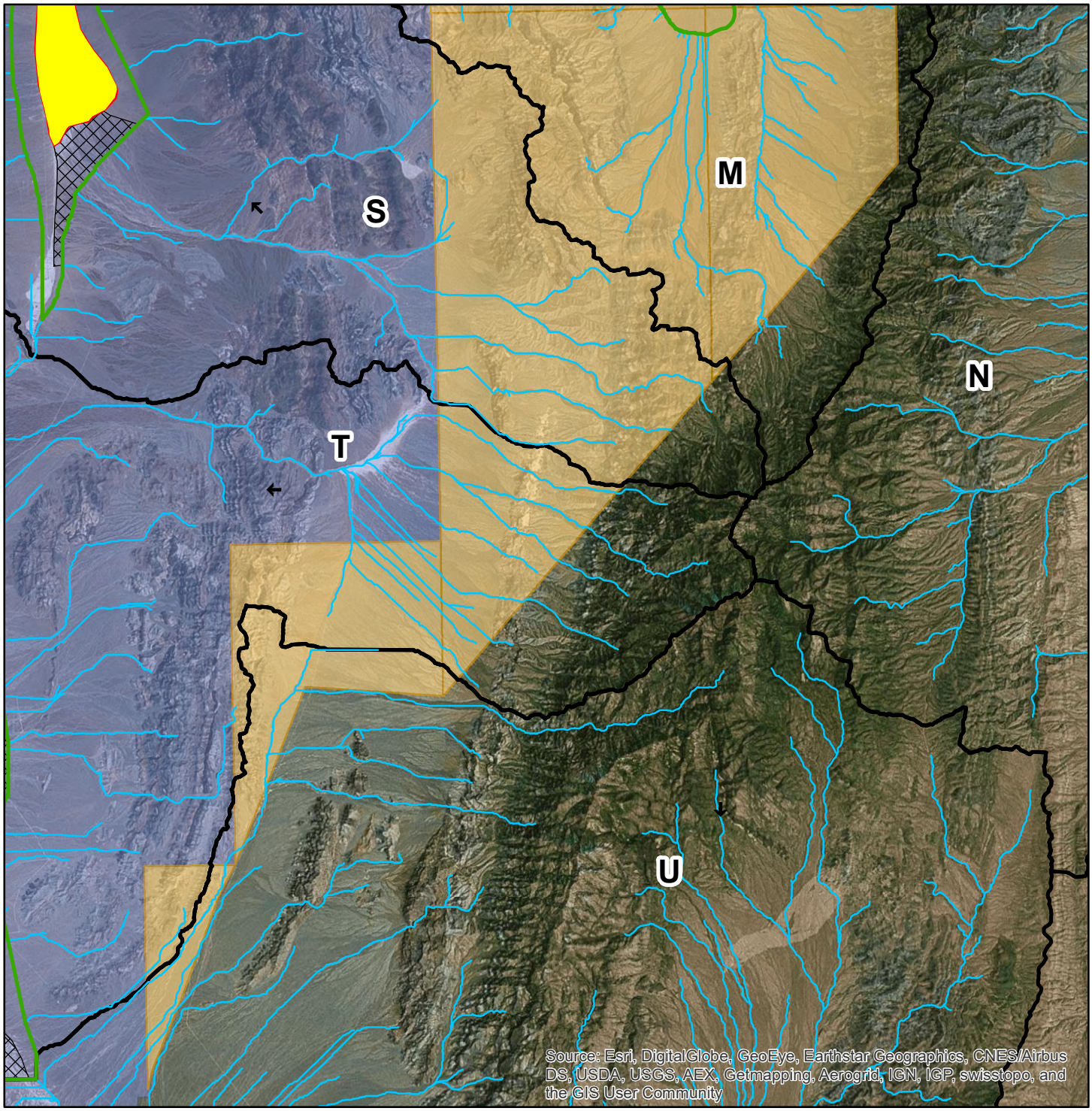
- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:200,000

0 1 2 4 6 8 Miles

N

Figure 8.4A: Flood Zone for Alternative 3C Alamo with Aerial Image



Legend

- Omitted GIS Generated Concentrated Flow Paths
- Flow Direction
- Concentrated Flow Path
- 100-year Playa Water Surface Elevation
- 500-year Playa Water Surface Elevation
- Alluvial Fan and Floodplain
- Basin Boundary
- Alternative 3C Alamo Expansion
- Existing NTTR Boundary

1:200,000

N

0 1 2 4 6 8 Miles

Figure 8.4B: Flood Zone for Alternative 3C Alamo with Aerial Image

APPENDIX C

HYDROLOGIC CALCULATIONS

RUNOFF VOLUME CALCULATIONS

- **TABLE C-1: PLAYA CALCULATIONS SUMMARY**
- **RUNOFF INTERPOLATION CALCULATIONS**
- **WATER SURFACE ELEVATION INTERPOLATION CALCULATIONS**

Table C-1: Playa Calculations Summary

Calculations to determine playa rainfall runoff depths for the 100 year 24 hour and 500 year 24 hour storm events.

Basin Name	Basin Area (sq mi.)	Basin Area (acres)	Playa average elevation (ft)	Playa area (acres)	Playa shore elevation (ft)	Playa shore elevation area (acres)	Playa volume capacity (ac-ft)	100yr 24hr runoff depth (in)*	500yr 24hr runoff depth (in)*	100yr 24hr Runoff volume (ac-ft)	500yr 24hr Runoff Volume (ac-ft)	100yr 24hr W.S.E. (ft)	500yr 24hr W.S.E. (ft)	100yr 24hr depth (ft)	500yr 24hr depth (ft)
A	1082	692480	5187	12888	5200	18562	204425	1.01	1.49	58284	85983	5190.7	5192.5	3.7	5.5
B	430	275200	4628	819	4660	6146	111440	1.03	1.56	23621	35776	4634.8	4638.3	6.8	10.3
C	386	247040	5331	1043	5360	3028	59030	1.10	1.62	22645	33350	5342.1	5347.4	11.1	16.4
D	675	432000	5060	2153	5070	13083	76180	1.36	2.06	48960	74160	5066.4	5069.7	6.4	9.7
E	574	367360	4848	4669	4860	8030	76194	1.25	1.85	38267	56635	4854.0	4856.9	6	8.9
F	361	231040	5318	2658	5340	8071	118019	1.67	2.47	32153	47556	5324.0	5326.9	6	8.9
G	700	448000	4731	1829	4760	10271	175450	1.55	2.25	57867	84000	4740.6	4744.9	9.6	13.9
H	981	627840	3944	1010	3960	21317	178616	1.44	2.21	75341	115627	3950.7	3954.4	6.7	10.4
I	448	286720	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
J	306	195840	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K	298	190720	3919	3753	3930	6281	55187	1.87	2.77	29721	44025	3924.9	3927.8	5.9	8.8
L	669	428160	4439	5413	4460	10377	165795	1.79	2.6	63867	92768	4447.1	4450.8	8.1	11.8
M	991	634240	3206	9502	3240	24419	576657	1.59	2.28	84037	120506	3211.0	3213.1	5	7.1
N	2919	1868160	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
O	154	98560	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P	458	293120	3079	3532	3100	7262	113337	1.4	2.09	34197	51052	3085.3	3088.5	6.3	9.5
Q	99	63360	4570	1786	4600	8161	149205	2.11	3.07	11141	16210	4572.2	4573.3	2.2	3.3
R	610	390400	3018	7677	3040	16823	269500	1.19	1.87	38715	60837	3021.2	3023.0	3.2	5
S	304	194560	3419	5573	3440	10126	164840	1.52	2.13	24644	34534	3422.1	3423.4	3.1	4.4
T	347	222080	3030	4370	3040	8182	62760	1.19	1.86	22023	34422	3033.5	3035.5	3.5	5.5
U	514	328960	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V	104	66560	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
W	157	100480	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

*Interpolated value from TR55 table 2-1 utilizing curve number (CN) value of 85
W.S.E. = water surface elevation
N/A = Not Applicable
Units: sq mi. = square mile, ft = feet, ac-ft = acre-feet, in = inches

Runoff Interpolation Calculations for Basin A

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.27	<---from NOAA Atlas 14 vol. 1
x_0	=	0.80	y_0	=	2.0	<--- lower limit
x_1	=	1.18	y_1	=	2.5	<--- upper limit

Solve for x:

x =	1.01	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.88	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.49	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin B

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.30	<---from NOAA Atlas 14 vol. 1
x_0	=	0.80	y_0	=	2.0	<--- lower limit
x_1	=	1.18	y_1	=	2.5	<--- upper limit

Solve for x:

x =	1.03	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.96	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.56	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin C

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.39	<---from NOAA Atlas 14 vol. 1
x_0	=	0.80	y_0	=	2.0	<--- lower limit
x_1	=	1.18	y_1	=	2.5	<--- upper limit

Solve for x:

x =	1.10	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.04	<---from NOAA Atlas 14 vol. 1
x_0	=	1.59	y_0	=	3.0	<--- lower limit
x_1	=	2.02	y_1	=	3.5	<--- upper limit

Solve for x:

x =	1.62	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin D

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.72	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.36	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.54	<---from NOAA Atlas 14 vol. 1
x_0	=	2.02	y_0	=	3.5	<--- lower limit
x_1	=	2.46	y_1	=	4.0	<--- upper limit

Solve for x:

x =	2.06	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin E

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.59	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.25	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.30	<---from NOAA Atlas 14 vol. 1
x_0	=	1.59	y_0	=	3.0	<--- lower limit
x_1	=	2.02	y_1	=	3.5	<--- upper limit

Solve for x:

x =	1.85	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin F

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.09	<---from NOAA Atlas 14 vol. 1
x_0	=	1.59	y_0	=	3.0	<--- lower limit
x_1	=	2.02	y_1	=	3.5	<--- upper limit

Solve for x:

x =	1.67	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	4.01	<---from NOAA Atlas 14 vol. 1
x_0	=	2.46	y_0	=	4.0	<--- lower limit
x_1	=	2.91	y_1	=	4.5	<--- upper limit

Solve for x:

x =	2.47	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin G

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.95	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.55	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.76	<---from NOAA Atlas 14 vol. 1
x_0	=	2.02	y_0	=	3.5	<--- lower limit
x_1	=	2.46	y_1	=	4.0	<--- upper limit

Solve for x:

x =	2.25	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin H

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.82	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.44	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.72	<---from NOAA Atlas 14 vol. 1
x_0	=	2.02	y_0	=	3.5	<--- lower limit
x_1	=	2.46	y_1	=	4.0	<--- upper limit

Solve for x:

x =	2.21	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin K

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.32	<---from NOAA Atlas 14 vol. 1
x_0	=	1.59	y_0	=	3.0	<--- lower limit
x_1	=	2.02	y_1	=	3.5	<--- upper limit

Solve for x:

x =	1.87	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	4.34	<---from NOAA Atlas 14 vol. 1
x_0	=	2.46	y_0	=	4.0	<--- lower limit
x_1	=	2.91	y_1	=	4.5	<--- upper limit

Solve for x:

x =	2.77	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin L

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.23	<---from NOAA Atlas 14 vol. 1
x_0	=	1.59	y_0	=	3.0	<--- lower limit
x_1	=	2.02	y_1	=	3.5	<--- upper limit

Solve for x:

x =	1.79	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	4.16	<---from NOAA Atlas 14 vol. 1
x_0	=	2.46	y_0	=	4.0	<--- lower limit
x_1	=	2.91	y_1	=	4.5	<--- upper limit

Solve for x:

x =	2.60	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin M

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.00	<---from NOAA Atlas 14 vol. 1
x_0	=	1.59	y_0	=	3.0	<--- lower limit
x_1	=	2.02	y_1	=	3.5	<--- upper limit

Solve for x:

x =	1.59	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.80	<---from NOAA Atlas 14 vol. 1
x_0	=	2.02	y_0	=	3.5	<--- lower limit
x_1	=	2.46	y_1	=	4.0	<--- upper limit

Solve for x:

x =	2.28	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin P

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.77	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.40	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.58	<---from NOAA Atlas 14 vol. 1
x_0	=	2.02	y_0	=	3.5	<--- lower limit
x_1	=	2.46	y_1	=	4.0	<--- upper limit

Solve for x:

x =	2.09	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin Q

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.60	<---from NOAA Atlas 14 vol. 1
x_0	=	2.02	y_0	=	3.5	<--- lower limit
x_1	=	2.46	y_1	=	4.0	<--- upper limit

Solve for x:

x =	2.11	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	4.67	<---from NOAA Atlas 14 vol. 1
x_0	=	2.91	y_0	=	4.5	<--- lower limit
x_1	=	3.37	y_1	=	5.0	<--- upper limit

Solve for x:

x =	3.07	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin R

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.51	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.19	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.32	<---from NOAA Atlas 14 vol. 1
x_0	=	1.59	y_0	=	3.0	<--- lower limit
x_1	=	2.02	y_1	=	3.5	<--- upper limit

Solve for x:

x =	1.87	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin S

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.91	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.52	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.63	<---from NOAA Atlas 14 vol. 1
x_0	=	2.02	y_0	=	3.5	<--- lower limit
x_1	=	2.46	y_1	=	4.0	<--- upper limit

Solve for x:

x =	2.13	<--- runoff depth for 500 year 24 hour

Runoff Interpolation Calculations for Basin T

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	2.51	<---from NOAA Atlas 14 vol. 1
x_0	=	1.18	y_0	=	2.5	<--- lower limit
x_1	=	1.59	y_1	=	3.0	<--- upper limit

Solve for x:

x =	1.19	<--- runoff depth for 100 year 24 hour

500 year 24 hour interpolated value from TR55 Table 2-1 utilizing Curve Number of 85

Inputs:

		runoff depth (in)			rainfall depth (in)	
x	=	unkown	y	=	3.31	<---from NOAA Atlas 14 vol. 1
x_0	=	1.59	y_0	=	3.0	<--- lower limit
x_1	=	2.02	y_1	=	3.5	<--- upper limit

Solve for x:

x =	1.86	<--- runoff depth for 500 year 24 hour

Water Surface Elevation Interpolation Calculations for Basin A

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1-y_0}{x_1-x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	58284	<--- runoff volume
x_0	=	5187	y_0	=	0	<--- lower limit
x_1	=	5200	y_1	=	204425	<--- upper limit

Solve for x:

x =	5190.7	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	85983	<--- runoff volume
x_0	=	5187	y_0	=	0	<--- lower limit
x_1	=	5200	y_1	=	204425	<--- upper limit

Solve for x:

x =	5192.5	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin B

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	23621	<--- runoff volume
x_0	=	4628	y_0	=	0	<--- lower limit
x_1	=	4660	y_1	=	111440	<--- upper limit

Solve for x:

x =	4634.8	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	35776	<--- runoff volume
x_0	=	4628	y_0	=	0	<--- lower limit
x_1	=	4660	y_1	=	111440	<--- upper limit

Solve for x:

x =	4638.3	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin C

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	22645	<--- runoff volume
x_0	=	5331	y_0	=	0	<--- lower limit
x_1	=	5360	y_1	=	59030	<--- upper limit

Solve for x:

x =	5342.1	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	33350	<--- runoff volume
x_0	=	5331	y_0	=	0	<--- lower limit
x_1	=	5360	y_1	=	59030	<--- upper limit

Solve for x:

x =	5347.4	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin D

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	48960	<--- runoff volume
x_0	=	5060	y_0	=	0	<--- lower limit
x_1	=	5070	y_1	=	76180	<--- upper limit

Solve for x:

x =	5066.4	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	74160	<--- runoff volume
x_0	=	5060	y_0	=	0	<--- lower limit
x_1	=	5070	y_1	=	76180	<--- upper limit

Solve for x:

x =	5069.7	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin E

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	38267	<--- runoff volume
x_0	=	4848	y_0	=	0	<--- lower limit
x_1	=	4860	y_1	=	76194	<--- upper limit

Solve for x:

x =	4854.0	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	56635	<--- runoff volume
x_0	=	4848	y_0	=	0	<--- lower limit
x_1	=	4860	y_1	=	76194	<--- upper limit

Solve for x:

x =	4856.9	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin F

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	32153	<--- runoff volume
x_0	=	5318	y_0	=	0	<--- lower limit
x_1	=	5340	y_1	=	118019	<--- upper limit

Solve for x:

x =	5324.0	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	47556	<--- runoff volume
x_0	=	5318	y_0	=	0	<--- lower limit
x_1	=	5340	y_1	=	118019	<--- upper limit

Solve for x:

x =	5326.9	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin G

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	57867	<--- runoff volume
x_0	=	4731	y_0	=	0	<--- lower limit
x_1	=	4760	y_1	=	175450	<--- upper limit

Solve for x:

x =	4740.6	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	84000	<--- runoff volume
x_0	=	4731	y_0	=	0	<--- lower limit
x_1	=	4760	y_1	=	175450	<--- upper limit

Solve for x:

x =	4744.9	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin H

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1-y_0}{x_1-x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	75341	<--- runoff volume
x_0	=	3944	y_0	=	0	<--- lower limit
x_1	=	3960	y_1	=	178616	<--- upper limit

Solve for x:

x =	3950.7	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	115627	<--- runoff volume
x_0	=	3944	y_0	=	0	<--- lower limit
x_1	=	3960	y_1	=	178616	<--- upper limit

Solve for x:

x =	3954.4	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin K

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	29721	<--- runoff volume
x_0	=	3919	y_0	=	0	<--- lower limit
x_1	=	3930	y_1	=	55187	<--- upper limit

Solve for x:

x =	3924.9	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	44025	<--- runoff volume
x_0	=	3919	y_0	=	0	<--- lower limit
x_1	=	3930	y_1	=	55187	<--- upper limit

Solve for x:

x =	3927.8	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin L

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	63867	<--- runoff volume
x_0	=	4439	y_0	=	0	<--- lower limit
x_1	=	4460	y_1	=	165795	<--- upper limit

Solve for x:

x =	4447.1	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	92768	<--- runoff volume
x_0	=	4439	y_0	=	0	<--- lower limit
x_1	=	4460	y_1	=	165795	<--- upper limit

Solve for x:

x =	4450.8	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin M

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	84037	<--- runoff volume
x_0	=	3206	y_0	=	0	<--- lower limit
x_1	=	3240	y_1	=	576657	<--- upper limit

Solve for x:

x =	3211.0	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	120506	<--- runoff volume
x_0	=	3206	y_0	=	0	<--- lower limit
x_1	=	3240	y_1	=	576657	<--- upper limit

Solve for x:

x =	3213.1	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin P

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1-y_0}{x_1-x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	34197	<--- runoff volume
x_0	=	3079	y_0	=	0	<--- lower limit
x_1	=	3100	y_1	=	113337	<--- upper limit

Solve for x:

x =	3085.3	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	51052	<--- runoff volume
x_0	=	3079	y_0	=	0	<--- lower limit
x_1	=	3100	y_1	=	113337	<--- upper limit

Solve for x:

x =	3088.5	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin Q

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	11141	<--- runoff volume
x_0	=	4570	y_0	=	0	<--- lower limit
x_1	=	4600	y_1	=	149205	<--- upper limit

Solve for x:

x =	4572.2	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	16210	<--- runoff volume
x_0	=	4570	y_0	=	0	<--- lower limit
x_1	=	4600	y_1	=	149205	<--- upper limit

Solve for x:

x =	4573.3	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin R

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	38715	<--- runoff volume
x_0	=	3018	y_0	=	0	<--- lower limit
x_1	=	3040	y_1	=	269500	<--- upper limit

Solve for x:

x =	3021.2	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	60837	<--- runoff volume
x_0	=	3018	y_0	=	0	<--- lower limit
x_1	=	3040	y_1	=	269500	<--- upper limit

Solve for x:

x =	3023.0	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin S

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1-y_0}{x_1-x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	24644	<--- runoff volume
x_0	=	3419	y_0	=	0	<--- lower limit
x_1	=	3440	y_1	=	164840	<--- upper limit

Solve for x:

x =	3422.1	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	34534	<--- runoff volume
x_0	=	3419	y_0	=	0	<--- lower limit
x_1	=	3440	y_1	=	164840	<--- upper limit

Solve for x:

x =	3423.4	<--- 500yr 24hr water surface elevation

Water Surface Elevation Interpolation Calculations for Basin T

Equation:

$$\frac{y-y_0}{x-x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

100 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	22023	<--- runoff volume
x_0	=	3030	y_0	=	0	<--- lower limit
x_1	=	3040	y_1	=	62760	<--- upper limit

Solve for x:

x =	3033.5	<--- 100yr 24hr water surface elevation

500 year 24 hour interpolated water surface elevation value

Inputs:

		elevations (ft)			volumes (ac-ft)	
x	=	unkown	y	=	34422	<--- runoff volume
x_0	=	3030	y_0	=	0	<--- lower limit
x_1	=	3040	y_1	=	62760	<--- upper limit

Solve for x:

x =	3035.5	<--- 500yr 24hr water surface elevation

FLOW RATE CALCULATIONS

- **TABLE C-2: HEC-1 RESULTS**
- **TABLE C-3: PRECIPITATION RATIO CALCULATIONS**
- **TABLE C-4: TLAG CALCULATIONS**
- **HEC-1 REPORTS**

Table C-2: HEC-1 results and Flow Rate Calculations for Proposed Expansion Areas

Flow rate calculations for Proposed Expansion Areas determined as ratios of expansion area within basin.

						Proposed Expansion Areas per Basin			
						Alternative 3A EC South Expansion	Alternative 3B 64 C/D & 65D Expansion	Alternative 3B Admin. Inc. Expansion	Alternative 3C Alamo Expansion
Basin Name	Q_{100} (cfs)	Q_{500} (cfs)	Basin Area (sq. mi.)	Q_{100} per sq. mi. (cfs/sq. mi.)	Q_{500} per sq. mi. (cfs/sq. mi.)	(sq. mi.)	(sq. mi.)	(sq. mi.)	(sq. mi.)
H	116077	179899	981	118	183	7			
I	92187	140504	448	206	314	21			
J	80249	119606	306	262	391				
M	118460	171617	991	120	173				257
N	276024	397313	2919	95	136				39
O	35508	56446	154	231	367				
P	67770	103483	458	148	226		11		
R	92367	146223	610	151	240		71		
S	65119	93070	304	214	306				28
T	65623	104018	347	189	300		8	0.55	30
U	109479	172035	514	213	335			1	8
V	42484	63896	104	409	614		3		
W	37089	55627	157	236	354				

	Flow Rate Calculations and Totals (cfs)							
	Alternative 3A EC South Expansion		Alternative 3B 64 C/D & 65D Expansion		Alternative 3B Administrative Inc. Expansion		Alternative 3C Alamo Expansion	
Basin Name	Q_{100}	Q_{500}	Q_{100}	Q_{500}	Q_{100}	Q_{500}	Q_{100}	Q_{500}
H	828	1284						
I	4321	6586						
J								
M							30721	44506
N							3688	5308
O								
P			1628	2485				
R			10751	17019				
S							5998	8572
T			1513	2398	104	165	5673	8993
U					213	335	1704	2678
V			1226	1843				
W								
totals:	5150	7870	15117	23746	317	500	47784	70057

Units: cfs = cubic feet per second, sq. mi. = square mile

Abbreviations: Q_{100} = 100 year 24 hour storm event, Q_{500} = 500 year 24 hour storm event

Table C-3: Precipitation Ratio Calculations

Precipitation Ratios utilized for HEC-1 calculations.

Basin Name	Geographic Location	100yr 24hr rainfall depth (in) [1]	500yr 24hr rainfall depth (in) [1]	Precipitation Ratio for 100yr 24hr storm event [2]
A	Ralston Valley/Stonecabin Valley	2.27	2.88	0.79
B	Stonewall Flat	2.30	2.96	0.78
C	Cactus Flat	2.39	3.04	0.79
D	Gold Flat	2.72	3.54	0.77
E	Reveille Valley/Railroad Valley	2.59	3.30	0.78
F	Kawich Valley	3.09	4.01	0.77
G	Sand Spring Valley	2.95	3.76	0.78
H	Sarcobatus Flat	2.82	3.72	0.76
I	Thirsty Canyon	3.13	4.13	0.76
J	Fortymile Canyon	3.64	4.82	0.76
K	Yucca Flat	3.32	4.34	0.76
L	Emigrant Valley	3.23	4.16	0.78
M	Tikaboo Valley/Desert Valley	3.00	3.80	0.79
N	Pahranagat Valley	3.10	3.94	0.79
O	Crater Flat	2.75	3.66	0.75
P	Frenchman Flat	2.77	3.58	0.77
Q	Papoose Lake	3.60	4.67	0.77
R	Indian Spring Valley	2.51	3.32	0.76
S	Three Lakes Valley (Northern)	2.91	3.63	0.80
T	Three Lakes Valley (Southern)	2.51	3.31	0.76
U	Yucca Forest	2.62	3.45	0.76
V	Mercury Valley	3.00	3.88	0.77
W	Reveille Valley	2.71	3.47	0.78

1 - Rainfall depths for 100yr-24hr and 500yr-24hr determined from NOAA Atlas 14 Vol. 1.

2 - Precipitation ratio calculated by dividing 100yr-24hr rainfall depth by 500yr-24hr rainfall depth.

Table C-4: T_{lag} Calculations

Tlag values utilized for HEC-1 calculations.

formula: $T_{lag} = 20K_n(LL_c/S^{0.5})^{0.33}$

where:

K_n = Manning's roughness factor for the basin channels

L = Length of longest watercourse (mi)

L_c = Length along longest watercourse measured upstream to a point opposite the centroid of the basin (mi)

S = Representative (average) slope of the longest watercourse (ft per mi)

Basin	K_n	L (mi)	Lc (mi)	upstream elevation (ft)	downstream elevation (ft)	S (ft/mi)	Tlag (hrs)
H	0.03	57	28	5240	4040	21	4.1
I	0.03	35	21	6300	3360	84	2.5
J	0.03	37	19	6440	3200	88	2.5
M	0.03	72	36	6400	4160	31	4.6
N	0.03	123	80	7700	2200	45	6.7
O	0.03	19	10	4320	2680	86	1.6
P	0.03	37	18	4980	3700	35	2.9
R	0.03	39	13	6175	3150	78	2.3
S	0.03	27	13	5725	3500	82	2.0
T	0.03	32	10	8200	3060	161	1.7
U	0.03	29	10	8000	2560	188	1.6
V	0.03	13	4	5600	3100	192	0.9
W	0.03	17	9	6800	5500	76	1.5

Note: Upstream and downstream elevations determined from USGS National Map base map provided within arcGIS.
K_n value selected per Table 604 of the CCRFCD Hydrologic Criteria and Drainage Design Manual

Units: mi = mile, ft = feet, hrs = hours

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   05AUG16  TIME  14:06:41   *
*                                       *
*****************************************
```

Basin H

```
***************************************
*                                     *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
 *** FREE ***
               1        ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
               2        ID     EXISTING CONDITION USING SCS METHODS
               3        ID     SCS TYPE II RAINFALL DISTRIBUTION
               4        ID     HYDROLOGIC MODEL FOR BASIN H
               5        ID     INPUT FILE = BASINH.DAT
               6        ID     INPUT FILE DATE = AUGUST 5, 2016
               7        ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
               8        ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
               9        IT       6       0       0     300
              10        IO       5       0       0
              11        IN       6       0       0
              12        JR    PREC    0.76     1.0
                        *
                        *

              13        KK       H
              14        PB    3.72
              15        PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
              16        PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
              17        PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
              18        PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
              19        PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
              20        PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
              21        PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
              22        PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
              23        PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
              24        PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
              25        PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
              26        PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
              27        PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
              28        PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
              29        PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
              30        PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
              31        PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
              32        PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
              33        PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
              34        PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
              35        PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
              36        PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
              37        PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
              38        PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
              39        PC 0.99890 1.00000
              40        KM   BASIN H
              41        BA     981
              42        LS       0    85.0
              43        UD     4.1
                        *
              44        ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
```

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

   13          H

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                                                  ****************************************
 *                                       *                                                  *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                  *    U.S. ARMY CORPS OF ENGINEERS      *
 *              JUN   1998               *                                                  *    HYDROLOGIC ENGINEERING CENTER     *
 *            VERSION 4.1                *                                                  *          609 SECOND STREET           *
 *                                       *                                                  *       DAVIS, CALIFORNIA 95616        *
 *  RUN DATE   05AUG16  TIME  14:06:41   *                                                  *           (916) 756-1104             *
 *                                       *                                                  *                                      *
 *****************************************                                                  ****************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN H
                              INPUT FILE = BASINH.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                        NMIN           6  MINUTES IN COMPUTATION INTERVAL
                       IDATE      1    0  STARTING DATE
                       ITIME        0000  STARTING TIME
                          NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                      NDDATE      2    0  ENDING DATE
                      NDTIME        0554  ENDING TIME
                      ICENT           19  CENTURY MARK

                   COMPUTATION INTERVAL     .10 HOURS
                        TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                       NPLAN           1  NUMBER OF PLANS

     JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                     .76      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                  FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                 TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN              RATIO 1  RATIO 2
                                                          .76     1.00

 HYDROGRAPH AT
+                    H    981.00     1   FLOW        116077.  179899.
                                         TIME          16.40    16.40


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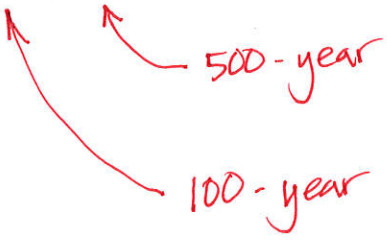

500-year

100-year

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1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             JUN  1998                 *
*           VERSION 4.1                 *
*                                       *
*  RUN DATE   05AUG16  TIME  14:06:57   *
*                                       *
*****************************************
```

Basin I

```
*************************************
*                                   *
*    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


```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
 *** FREE ***
               1        ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
               2        ID     EXISTING CONDITION USING SCS METHODS
               3        ID     SCS TYPE II RAINFALL DISTRIBUTION
               4        ID     HYDROLOGIC MODEL FOR BASIN I
               5        ID     INPUT FILE = BASINI.DAT
               6        ID     INPUT FILE DATE = AUGUST 5, 2016
               7        ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
               8        ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
               9        IT       6       0       0     300
              10        IO       5       0       0
              11        IN       6       0       0
              12        JR    PREC    0.76     1.0
                        *
                        *

              13        KK       I
              14        PB    4.13
              15        PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
              16        PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
              17        PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
              18        PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
              19        PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
              20        PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
              21        PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
              22        PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
              23        PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
              24        PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
              25        PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
              26        PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
              27        PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
              28        PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
              29        PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
              30        PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
              31        PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
              32        PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
              33        PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
              34        PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
              35        PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
              36        PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
              37        PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
              38        PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
              39        PC 0.99890 1.00000
              40        KM   BASIN I
              41        BA     448
              42        LS       0    85.0
              43        UD     2.5
                        *
              44        ZZ
```

1

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
```

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

   13          I

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                                                  ***************************************
 *                                       *                                                  *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                  *    U.S. ARMY CORPS OF ENGINEERS     *
 *              JUN   1998               *                                                  *    HYDROLOGIC ENGINEERING CENTER    *
 *           VERSION 4.1                 *                                                  *          609 SECOND STREET          *
 *                                       *                                                  *       DAVIS, CALIFORNIA 95616       *
 *  RUN DATE   05AUG16  TIME  14:06:57   *                                                  *           (916) 756-1104            *
 *                                       *                                                  *                                     *
 *****************************************                                                  ***************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN I
                              INPUT FILE = BASINI.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                        NMIN           6  MINUTES IN COMPUTATION INTERVAL
                       IDATE      1    0  STARTING DATE
                       ITIME        0000  STARTING TIME
                          NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                      NDDATE      2    0  ENDING DATE
                      NDTIME        0554  ENDING TIME
                      ICENT           19  CENTURY MARK

                   COMPUTATION INTERVAL     .10 HOURS
                        TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                       NPLAN           1  NUMBER OF PLANS

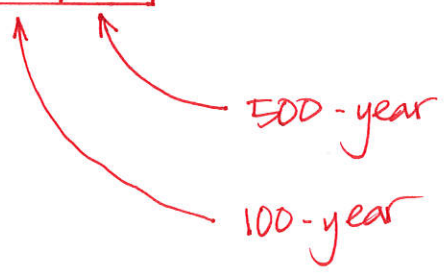
     JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                     .76      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                  FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                 TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .76     1.00

 HYDROGRAPH AT
+                    I    448.00     1   FLOW       92187.  140504.
                                          TIME        14.60    14.60


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



500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN   1998               *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   05AUG16  TIME  14:07:07   *
*                                       *
*****************************************
```

Basin J

```
***************************************
*                                     *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
 *** FREE ***
              1         ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
              2         ID     EXISTING CONDITION USING SCS METHODS
              3         ID     SCS TYPE II RAINFALL DISTRIBUTION
              4         ID     HYDROLOGIC MODEL FOR BASIN J
              5         ID     INPUT FILE = BASINJ.DAT
              6         ID     INPUT FILE DATE = AUGUST 5, 2016
              7         ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
              8         ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
              9         IT       6       0       0     300
             10         IO       5       0       0
             11         IN       6       0       0
             12         JR    PREC    0.76     1.0
                        *
                        *

             13         KK       J
             14         PB    4.82
             15         PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
             16         PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
             17         PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
             18         PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
             19         PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
             20         PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
             21         PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
             22         PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
             23         PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
             24         PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
             25         PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
             26         PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
             27         PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
             28         PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
             29         PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
             30         PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
             31         PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
             32         PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
             33         PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
             34         PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
             35         PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
             36         PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
             37         PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
             38         PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
             39         PC 0.99890 1.00000
             40         KM   BASIN J
             41         BA     306
             42         LS       0    85.0
             43         UD     2.5
                        *
             44         ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

INPUT
LINE (V) ROUTING (---->) DIVERSION OR PUMP FLOW

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

   13          J

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************                                                  ****************************************
 *                                      *                                                  *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                                  *    U.S. ARMY CORPS OF ENGINEERS      *
 *              JUN   1998              *                                                  *    HYDROLOGIC ENGINEERING CENTER     *
 *           VERSION 4.1                *                                                  *          609 SECOND STREET           *
 *                                      *                                                  *       DAVIS, CALIFORNIA 95616        *
 *  RUN DATE   05AUG16  TIME  14:07:07  *                                                  *           (916) 756-1104             *
 *                                      *                                                  *                                      *
 ****************************************                                                  ****************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN J
                              INPUT FILE = BASINJ.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                       NMIN           6  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      2    0  ENDING DATE
                     NDTIME        0554  ENDING TIME
                     ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL     .10 HOURS
                       TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                      NPLAN           1  NUMBER OF PLANS

     JR          MULTI-RATIO OPTION
                    RATIOS OF PRECIPITATION
                    .76      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .76     1.00

 HYDROGRAPH AT
+                    J    306.00     1   FLOW       80249.  119606.
                                         TIME        14.60    14.50


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

500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   05AUG16  TIME  14:07:30   *
*                                       *
*****************************************
```

Basin M

```
*************************************
*                                   *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
 *** FREE ***
              1         ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
              2         ID     EXISTING CONDITION USING SCS METHODS
              3         ID     SCS TYPE II RAINFALL DISTRIBUTION
              4         ID     HYDROLOGIC MODEL FOR BASIN M
              5         ID     INPUT FILE = BASINM.DAT
              6         ID     INPUT FILE DATE = AUGUST 5, 2016
              7         ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
              8         ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
              9         IT       6       0       0     300
             10         IO       5       0       0
             11         IN       6       0       0
             12         JR    PREC    0.79     1.0
                        *
                        *

             13         KK       M
             14         PB    3.80
             15         PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
             16         PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
             17         PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
             18         PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
             19         PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
             20         PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
             21         PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
             22         PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
             23         PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
             24         PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
             25         PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
             26         PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
             27         PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
             28         PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
             29         PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
             30         PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
             31         PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
             32         PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
             33         PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
             34         PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
             35         PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
             36         PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
             37         PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
             38         PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
             39         PC 0.99890 1.00000
             40         KM   BASIN M
             41         BA     991
             42         LS       0    85.0
             43         UD     4.6
                        *
             44         ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
```

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

   13          M

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************                                                  ****************************************
 *                                      *                                                  *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                                  *    U.S. ARMY CORPS OF ENGINEERS      *
 *              JUN   1998              *                                                  *    HYDROLOGIC ENGINEERING CENTER     *
 *           VERSION 4.1                *                                                  *          609 SECOND STREET           *
 *                                      *                                                  *       DAVIS, CALIFORNIA 95616        *
 *  RUN DATE   05AUG16  TIME  14:07:30  *                                                  *           (916) 756-1104             *
 *                                      *                                                  *                                      *
 ****************************************                                                  ****************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN M
                              INPUT FILE = BASINM.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                        NMIN           6  MINUTES IN COMPUTATION INTERVAL
                       IDATE      1    0  STARTING DATE
                       ITIME        0000  STARTING TIME
                          NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                      NDDATE      2    0  ENDING DATE
                      NDTIME        0554  ENDING TIME
                      ICENT           19  CENTURY MARK

                   COMPUTATION INTERVAL     .10 HOURS
                        TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                       NPLAN           1  NUMBER OF PLANS

     JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                     .79      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                  FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                 TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .79     1.00

 HYDROGRAPH AT
+                    M    991.00     1   FLOW      118460.  171617.
                                          TIME        17.00    16.90


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

500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             JUN  1998                 *
*           VERSION 4.1                 *
*                                       *
*  RUN DATE   05AUG16  TIME  14:07:41   *
*                                       *
*****************************************
```

Basin N

```
***************************************
*                                     *
*    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


```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
 *** FREE ***
               1        ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
               2        ID     EXISTING CONDITION USING SCS METHODS
               3        ID     SCS TYPE II RAINFALL DISTRIBUTION
               4        ID     HYDROLOGIC MODEL FOR BASIN N
               5        ID     INPUT FILE = BASINN.DAT
               6        ID     INPUT FILE DATE = AUGUST 5, 2016
               7        ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
               8        ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
               9        IT       6       0       0     300
              10        IO       5       0       0
              11        IN       6       0       0
              12        JR    PREC    0.79     1.0
                        *
                        *

              13        KK       N
              14        PB    3.94
              15        PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
              16        PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
              17        PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
              18        PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
              19        PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
              20        PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
              21        PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
              22        PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
              23        PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
              24        PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
              25        PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
              26        PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
              27        PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
              28        PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
              29        PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
              30        PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
              31        PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
              32        PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
              33        PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
              34        PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
              35        PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
              36        PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
              37        PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
              38        PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
              39        PC 0.99890 1.00000
              40        KM   BASIN N
              41        BA    2919
              42        LS       0    85.0
              43        UD     6.7
                        *
              44        ZZ
```

1

SCHEMATIC DIAGRAM OF STREAM NETWORK

INPUT
LINE (V) ROUTING (---->) DIVERSION OR PUMP FLOW

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

   13          N

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************                                                  ****************************************
 *                                      *                                                  *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                                  *    U.S. ARMY CORPS OF ENGINEERS      *
 *              JUN   1998              *                                                  *    HYDROLOGIC ENGINEERING CENTER     *
 *           VERSION 4.1                *                                                  *          609 SECOND STREET           *
 *                                      *                                                  *       DAVIS, CALIFORNIA 95616        *
 *  RUN DATE   05AUG16  TIME  14:07:41  *                                                  *           (916) 756-1104             *
 *                                      *                                                  *                                      *
 ****************************************                                                  ****************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN N
                              INPUT FILE = BASINN.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                       NMIN           6  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      2    0  ENDING DATE
                     NDTIME        0554  ENDING TIME
                     ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL     .10 HOURS
                       TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                      NPLAN           1  NUMBER OF PLANS

     JR          MULTI-RATIO OPTION
                    RATIOS OF PRECIPITATION
                    .79      1.00


     *** WARNING ***   UNIT HYDROGRAPH TRUNCATED FROM 337 TO 300 INTERVALS


     *** WARNING ***   UNIT HYDROGRAPH TRUNCATED FROM 337 TO 300 INTERVALS

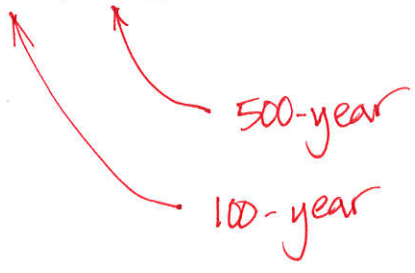

     *** WARNING ***   UNIT HYDROGRAPH TRUNCATED FROM 337 TO 300 INTERVALS
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN              RATIO 1  RATIO 2
                                                          .79     1.00

 HYDROGRAPH AT
+                    N   2919.00     1   FLOW        276024.  397313.
                                         TIME          19.30    19.30


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



500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             JUN  1998                 *
*           VERSION 4.1                 *
*                                       *
*  RUN DATE   05AUG16  TIME  14:07:56   *
*                                       *
*****************************************
```

Basin O

```
***************************************
*                                     *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
 *** FREE ***
               1        ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
               2        ID     EXISTING CONDITION USING SCS METHODS
               3        ID     SCS TYPE II RAINFALL DISTRIBUTION
               4        ID     HYDROLOGIC MODEL FOR BASIN O
               5        ID     INPUT FILE = BASINO.DAT
               6        ID     INPUT FILE DATE = AUGUST 5, 2016
               7        ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
               8        ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
               9        IT       6       0       0     300
              10        IO       5       0       0
              11        IN       6       0       0
              12        JR    PREC    0.75    1.0
                        *
                        *

              13        KK       O
              14        PB    3.66
              15        PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
              16        PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
              17        PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
              18        PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
              19        PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
              20        PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
              21        PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
              22        PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
              23        PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
              24        PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
              25        PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
              26        PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
              27        PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
              28        PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
              29        PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
              30        PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
              31        PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
              32        PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
              33        PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
              34        PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
              35        PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
              36        PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
              37        PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
              38        PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
              39        PC 0.99890 1.00000
              40        KM   BASIN O
              41        BA     154
              42        LS       0    85.0
              43        UD     1.6
                        *
              44        ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
```

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

   13          O

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************                                                  ****************************************
 *                                      *                                                  *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                                  *    U.S. ARMY CORPS OF ENGINEERS      *
 *              JUN   1998              *                                                  *    HYDROLOGIC ENGINEERING CENTER     *
 *           VERSION 4.1                *                                                  *          609 SECOND STREET           *
 *                                      *                                                  *       DAVIS, CALIFORNIA 95616        *
 *  RUN DATE   05AUG16  TIME  14:07:56  *                                                  *           (916) 756-1104             *
 *                                      *                                                  *                                      *
 ****************************************                                                  ****************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN O
                              INPUT FILE = BASINO.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                       NMIN           6  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      2    0  ENDING DATE
                     NDTIME        0554  ENDING TIME
                     ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL     .10 HOURS
                       TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                      NPLAN           1  NUMBER OF PLANS

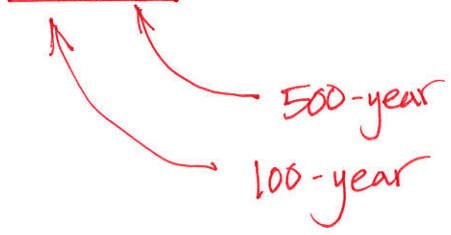
     JR          MULTI-RATIO OPTION
                    RATIOS OF PRECIPITATION
                    .75      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                      RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .75     1.00

 HYDROGRAPH AT
+                    O    154.00     1   FLOW       35508.   56446.
                                          TIME        13.60    13.60


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



500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   05AUG16  TIME  14:08:07   *
*                                       *
*****************************************
```

Basin P

```
*************************************
*                                   *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
 *** FREE ***
              1         ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
              2         ID     EXISTING CONDITION USING SCS METHODS
              3         ID     SCS TYPE II RAINFALL DISTRIBUTION
              4         ID     HYDROLOGIC MODEL FOR BASIN P
              5         ID     INPUT FILE = BASINP.DAT
              6         ID     INPUT FILE DATE = AUGUST 5, 2016
              7         ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
              8         ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
              9         IT       6       0       0     300
             10         IO       5       0       0
             11         IN       6       0       0
             12         JR    PREC    0.77     1.0
                        *
                        *

             13         KK       P
             14         PB    3.58
             15         PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
             16         PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
             17         PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
             18         PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
             19         PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
             20         PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
             21         PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
             22         PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
             23         PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
             24         PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
             25         PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
             26         PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
             27         PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
             28         PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
             29         PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
             30         PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
             31         PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
             32         PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
             33         PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
             34         PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
             35         PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
             36         PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
             37         PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
             38         PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
             39         PC 0.99890 1.00000
             40         KM   BASIN P
             41         BA     458
             42         LS       0    85.0
             43         UD     2.9
                        *
             44         ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE      (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
```

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

    13          P

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************                                                  ****************************************
 *                                      *                                                  *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                                  *   U.S. ARMY CORPS OF ENGINEERS       *
 *              JUN   1998              *                                                  *   HYDROLOGIC ENGINEERING CENTER      *
 *           VERSION 4.1                *                                                  *         609 SECOND STREET            *
 *                                      *                                                  *      DAVIS, CALIFORNIA 95616         *
 *  RUN DATE   05AUG16  TIME  14:08:07  *                                                  *          (916) 756-1104              *
 *                                      *                                                  *                                      *
 ****************************************                                                  ****************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN P
                              INPUT FILE = BASINP.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                       NMIN           6  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      2    0  ENDING DATE
                     NDTIME        0554  ENDING TIME
                     ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL     .10 HOURS
                       TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                      NPLAN           1  NUMBER OF PLANS

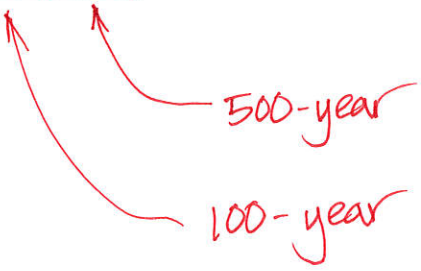
     JR          MULTI-RATIO OPTION
                    RATIOS OF PRECIPITATION
                    .77      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                      RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                       .77     1.00

 HYDROGRAPH AT
+                    P    458.00     1   FLOW       67770.  103483.
                                          TIME        15.10    15.00


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



500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   25AUG16  TIME  08:11:47   *
*                                       *
*****************************************
```

Basin R

```
*************************************
*                                   *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
*** FREE ***
               1        ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
               2        ID     EXISTING CONDITION USING SCS METHODS
               3        ID     SCS TYPE II RAINFALL DISTRIBUTION
               4        ID     HYDROLOGIC MODEL FOR BASIN R
               5        ID     INPUT FILE = BASINR.DAT
               6        ID     INPUT FILE DATE = AUGUST 5, 2016
               7        ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
               8        ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
               9        IT       6       0       0     300
              10        IO       5       0       0
              11        IN       6       0       0
              12        JR    PREC    0.76    1.0
                        *
                        *

              13        KK       R
              14        PB    3.32
              15        PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
              16        PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
              17        PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
              18        PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
              19        PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
              20        PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
              21        PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
              22        PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
              23        PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
              24        PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
              25        PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
              26        PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
              27        PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
              28        PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
              29        PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
              30        PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
              31        PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
              32        PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
              33        PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
              34        PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
              35        PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
              36        PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
              37        PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
              38        PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
              39        PC 0.99890 1.00000
              40        KM   BASIN R
              41        BA     610
              42        LS       0    85.0
              43        UD     2.3
                        *
              44        ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
```

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

   13          R

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                                                  ***************************************
 *                                       *                                                  *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                  *    U.S. ARMY CORPS OF ENGINEERS     *
 *              JUN   1998               *                                                  *    HYDROLOGIC ENGINEERING CENTER    *
 *           VERSION 4.1                 *                                                  *          609 SECOND STREET          *
 *                                       *                                                  *       DAVIS, CALIFORNIA 95616       *
 *  RUN DATE   25AUG16  TIME  08:11:47   *                                                  *           (916) 756-1104            *
 *                                       *                                                  *                                     *
 *****************************************                                                  ***************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN R
                              INPUT FILE = BASINR.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                       NMIN           6  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      2    0  ENDING DATE
                     NDTIME        0554  ENDING TIME
                     ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL     .10 HOURS
                       TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                      NPLAN           1  NUMBER OF PLANS

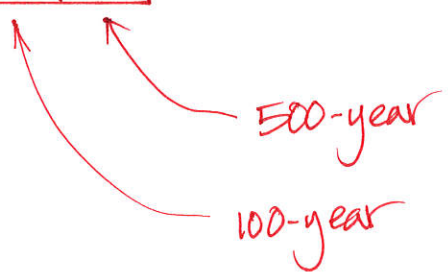
     JR          MULTI-RATIO OPTION
                    RATIOS OF PRECIPITATION
                    .76      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .76     1.00

 HYDROGRAPH AT
+                    R    610.00     1   FLOW       92367.  146223.
                                          TIME        14.40    14.40


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



500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   25AUG16  TIME  08:12:08   *
*                                       *
*****************************************
```

Basin S

```
*************************************
*                                   *
*   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


```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
*** FREE ***
             1          ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
             2          ID     EXISTING CONDITION USING SCS METHODS
             3          ID     SCS TYPE II RAINFALL DISTRIBUTION
             4          ID     HYDROLOGIC MODEL FOR BASIN S
             5          ID     INPUT FILE = BASINS.DAT
             6          ID     INPUT FILE DATE = AUGUST 5, 2016
             7          ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
             8          ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
             9          IT       6       0       0     300
            10          IO       5       0       0
            11          IN       6       0       0
            12          JR    PREC    0.80     1.0
                        *
                        *

            13          KK       S
            14          PB    3.63
            15          PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
            16          PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
            17          PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
            18          PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
            19          PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
            20          PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
            21          PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
            22          PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
            23          PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
            24          PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
            25          PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
            26          PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
            27          PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
            28          PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
            29          PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
            30          PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
            31          PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
            32          PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
            33          PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
            34          PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
            35          PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
            36          PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
            37          PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
            38          PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
            39          PC 0.99890 1.00000
            40          KM   BASIN S
            41          BA     304
            42          LS       0    85.0
            43          UD     2.0
                        *
            44          ZZ
```


SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
```

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

    13           S

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*               JUN  1998               *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   25AUG16  TIME  08:12:08   *
*                                       *
*****************************************

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

                        ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                        EXISTING CONDITION USING SCS METHODS
                        SCS TYPE II RAINFALL DISTRIBUTION
                        HYDROLOGIC MODEL FOR BASIN S
                        INPUT FILE = BASINS.DAT
                        INPUT FILE DATE = AUGUST 5, 2016
                        DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                        MODELED BY S&B CHRIST CONSULTING, LLC.

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

      IT          HYDROGRAPH TIME DATA
                       NMIN           6  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME         0000  STARTING TIME
                         NQ          300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      2    0  ENDING DATE
                     NDTIME         0554  ENDING TIME
                      ICENT           19  CENTURY MARK

                   COMPUTATION INTERVAL      .10 HOURS
                       TOTAL TIME BASE   29.90 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

      JP          MULTI-PLAN OPTION
                       NPLAN           1  NUMBER OF PLANS

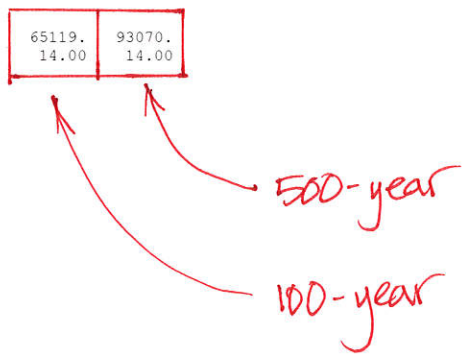
      JR          MULTI-RATIO OPTION
                      RATIOS OF PRECIPITATION
                      .80      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                          TIME TO PEAK IN HOURS

                                                                  RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION      AREA     PLAN                 RATIO 1  RATIO 2
                                                               .80      1.00

 HYDROGRAPH AT
+                     S     304.00      1    FLOW          65119.   93070.
                                             TIME          14.00    14.00


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



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1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   05AUG16  TIME  14:08:40   *
*                                       *
*****************************************
```

Basin T

```
*****************************************
*                                       *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
*** FREE ***
               1        ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
               2        ID     EXISTING CONDITION USING SCS METHODS
               3        ID     SCS TYPE II RAINFALL DISTRIBUTION
               4        ID     HYDROLOGIC MODEL FOR BASIN T
               5        ID     INPUT FILE = BASINT.DAT
               6        ID     INPUT FILE DATE = AUGUST 5, 2016
               7        ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
               8        ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
               9        IT       6       0       0     300
              10        IO       5       0       0
              11        IN       6       0       0
              12        JR    PREC    0.76     1.0
                        *
                        *

              13        KK       T
              14        PB    3.31
              15        PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
              16        PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
              17        PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
              18        PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
              19        PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
              20        PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
              21        PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
              22        PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
              23        PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
              24        PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
              25        PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
              26        PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
              27        PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
              28        PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
              29        PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
              30        PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
              31        PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
              32        PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
              33        PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
              34        PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
              35        PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
              36        PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
              37        PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
              38        PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
              39        PC 0.99890 1.00000
              40        KM   BASIN T
              41        BA     347
              42        LS       0    85.0
              43        UD     1.7
                        *
              44        ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
```

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

   13          T

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************                                    ************************************
 *                                      *                                    *                                  *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                    *   U.S. ARMY CORPS OF ENGINEERS   *
 *              JUN   1998              *                                    *   HYDROLOGIC ENGINEERING CENTER  *
 *           VERSION 4.1                *                                    *         609 SECOND STREET        *
 *                                      *                                    *      DAVIS, CALIFORNIA 95616     *
 *  RUN DATE   05AUG16  TIME  14:08:40  *                                    *          (916) 756-1104          *
 *                                      *                                    *                                  *
 ****************************************                                    ************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN T
                              INPUT FILE = BASINT.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                       NMIN           6  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1    0  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      2    0  ENDING DATE
                     NDTIME        0554  ENDING TIME
                     ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL     .10 HOURS
                       TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                      NPLAN           1  NUMBER OF PLANS

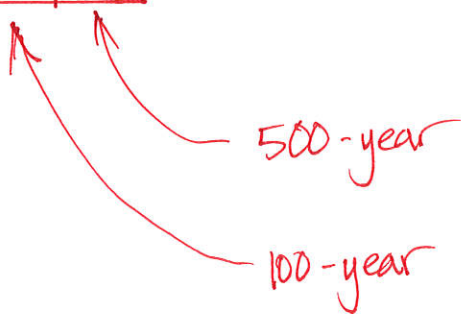
     JR          MULTI-RATIO OPTION
                    RATIOS OF PRECIPITATION
                    .76      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                        RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .76     1.00

 HYDROGRAPH AT
+                    T    347.00     1   FLOW        65623.  104018.
                                          TIME         13.70    13.70


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



500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   05AUG16  TIME  14:08:51   *
*                                       *
*****************************************
```

Basin U

```
*************************************
*                                   *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
*** FREE ***
             1          ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
             2          ID     EXISTING CONDITION USING SCS METHODS
             3          ID     SCS TYPE II RAINFALL DISTRIBUTION
             4          ID     HYDROLOGIC MODEL FOR BASIN U
             5          ID     INPUT FILE = BASINU.DAT
             6          ID     INPUT FILE DATE = AUGUST 5, 2016
             7          ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
             8          ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
             9          IT       6       0       0     300
            10          IO       5       0       0
            11          IN       6       0       0
            12          JR    PREC    0.76    1.0
                        *
                        *

            13          KK       U
            14          PB    3.45
            15          PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
            16          PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
            17          PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
            18          PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
            19          PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
            20          PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
            21          PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
            22          PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
            23          PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
            24          PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
            25          PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
            26          PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
            27          PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
            28          PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
            29          PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
            30          PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
            31          PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
            32          PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
            33          PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
            34          PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
            35          PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
            36          PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
            37          PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
            38          PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
            39          PC 0.99890 1.00000
            40          KM   BASIN U
            41          BA     514
            42          LS       0    85.0
            43          UD     1.6
                        *
            44          ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
```

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

   13          U

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                                                  ************************************
 *                                       *                                                  *                                  *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                  *    U.S. ARMY CORPS OF ENGINEERS  *
 *              JUN   1998               *                                                  *    HYDROLOGIC ENGINEERING CENTER *
 *           VERSION 4.1                 *                                                  *          609 SECOND STREET       *
 *                                       *                                                  *       DAVIS, CALIFORNIA 95616    *
 *  RUN DATE   05AUG16  TIME  14:08:51   *                                                  *          (916) 756-1104          *
 *                                       *                                                  *                                  *
 *****************************************                                                  ************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN U
                              INPUT FILE = BASINU.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                        NMIN           6  MINUTES IN COMPUTATION INTERVAL
                       IDATE      1    0  STARTING DATE
                       ITIME        0000  STARTING TIME
                          NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                      NDDATE      2    0  ENDING DATE
                      NDTIME        0554  ENDING TIME
                      ICENT           19  CENTURY MARK

                   COMPUTATION INTERVAL     .10 HOURS
                        TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                       NPLAN           1  NUMBER OF PLANS

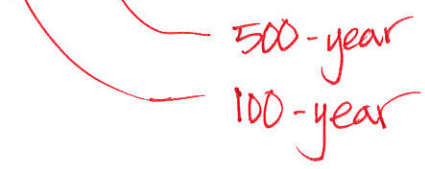
     JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                     .76      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .76     1.00

 HYDROGRAPH AT
+                    U    514.00     1   FLOW       109479.  172035.
                                          TIME         13.60    13.60


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



500-year

100-year

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   25AUG16  TIME  08:12:26   *
*                                       *
*****************************************
```

Basin V

```
***************************************
*                                     *
*   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 HEC-1 INPUT PAGE 1

```
          LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                        *DIAGRAM
 *** FREE ***
              1         ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
              2         ID     EXISTING CONDITION USING SCS METHODS
              3         ID     SCS TYPE II RAINFALL DISTRIBUTION
              4         ID     HYDROLOGIC MODEL FOR BASIN V
              5         ID     INPUT FILE = BASINV.DAT
              6         ID     INPUT FILE DATE = AUGUST 5, 2016
              7         ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
              8         ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
              9         IT       6       0       0     300
             10         IO       5       0       0
             11         IN       6       0       0
             12         JR    PREC    0.77     1.0
                        *
                        *

             13         KK       V
             14         PB    3.88
             15         PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
             16         PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
             17         PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
             18         PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
             19         PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
             20         PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
             21         PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
             22         PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
             23         PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
             24         PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
             25         PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
             26         PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
             27         PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
             28         PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
             29         PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
             30         PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
             31         PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
             32         PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
             33         PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
             34         PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
             35         PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
             36         PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
             37         PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
             38         PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
             39         PC 0.99890 1.00000
             40         KM   BASIN V
             41         BA     104
             42         LS       0    85.0
             43         UD     0.9
                        *
             44         ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
```

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

   13          V

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                                    ************************************
 *                                       *                                    *                                  *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                    *    U.S. ARMY CORPS OF ENGINEERS  *
 *              JUN   1998               *                                    *    HYDROLOGIC ENGINEERING CENTER *
 *           VERSION 4.1                 *                                    *          609 SECOND STREET       *
 *                                       *                                    *       DAVIS, CALIFORNIA 95616    *
 *  RUN DATE   25AUG16  TIME  08:12:26   *                                    *           (916) 756-1104         *
 *                                       *                                    *                                  *
 *****************************************                                    ************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN V
                              INPUT FILE = BASINV.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                        NMIN           6  MINUTES IN COMPUTATION INTERVAL
                       IDATE      1    0  STARTING DATE
                       ITIME        0000  STARTING TIME
                          NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                      NDDATE      2    0  ENDING DATE
                      NDTIME        0554  ENDING TIME
                      ICENT           19  CENTURY MARK

                   COMPUTATION INTERVAL     .10 HOURS
                        TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                       NPLAN           1  NUMBER OF PLANS

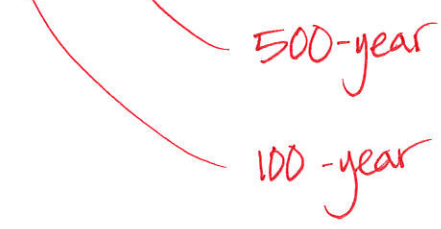
     JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                     .77      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .77     1.00

 HYDROGRAPH AT
+                    V    104.00     1   FLOW       42484.   63896.
                                          TIME        12.80    12.80


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



500-year

100-year

```
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*               JUN  1998              *
*            VERSION 4.1               *
*                                      *
*  RUN DATE   05AUG16  TIME  14:09:11  *
*                                      *
****************************************
```

Basin W

```
****************************************
*                                      *
*    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 HEC-1 INPUT PAGE 1

```
          LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

                        *DIAGRAM
*** FREE ***
               1        ID     ADAMS ECOLOGY NTTR HYDROLOGY STUDY
               2        ID     EXISTING CONDITION USING SCS METHODS
               3        ID     SCS TYPE II RAINFALL DISTRIBUTION
               4        ID     HYDROLOGIC MODEL FOR BASIN W
               5        ID     INPUT FILE = BASINW.DAT
               6        ID     INPUT FILE DATE = AUGUST 5, 2016
               7        ID     DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
               8        ID     MODELED BY S&B CHRIST CONSULTING, LLC.
                        *
                        *DIAGRAM
               9        IT       6       0       0     300
              10        IO       5       0       0
              11        IN       6       0       0
              12        JR    PREC    0.78     1.0
                        *
                        *

              13        KK       W
              14        PB    3.47
              15        PC 0.00000 0.00101 0.00202 0.00305 0.00408 0.00513 0.00618 0.00725 0.00832   0.009
              16        PC 0.01050 0.01161 0.01272 0.01385 0.01498 0.01613 0.01728 0.01845 0.01962   0.020
              17        PC 0.02200 0.02321 0.02442 0.02565 0.02688 0.02813 0.02938 0.03065 0.03192   0.033
              18        PC 0.03450 0.03581 0.03712 0.03845 0.03978 0.04113 0.04248 0.04385 0.04522   0.046
              19        PC 0.04800 0.04941 0.05084 0.05229 0.05376 0.05525 0.05676 0.05829 0.05984   0.061
              20        PC 0.06300 0.06461 0.06624 0.06789 0.06956 0.07125 0.07296 0.07469 0.07644   0.078
              21        PC 0.08000 0.08181 0.08364 0.08549 0.08736 0.08925 0.09116 0.09309 0.09504   0.097
              22        PC 0.09900 0.10101 0.10304 0.10509 0.10716 0.10925 0.11136 0.11349 0.11564   0.117
              23        PC 0.12000 0.12225 0.12460 0.12705 0.12960 0.13225 0.13500 0.13785 0.14080   0.143
              24        PC 0.14700 0.15020 0.15340 0.15660 0.15980 0.16300 0.16628 0.16972 0.17332   0.177
              25        PC 0.18100 0.18512 0.18948 0.19408 0.19892 0.20400 0.20940 0.21520 0.22140   0.228
              26        PC 0.23500 0.24268 0.25132 0.26092 0.27148 0.28300 0.30684 0.35436 0.43079   0.567
              27        PC 0.66300 0.68196 0.69864 0.71304 0.72516 0.72516 0.73500 0.74344 0.75136   0.758
              28        PC 0.76564 0.77200 0.77796 0.78364 0.78904 0.79416 0.79900 0.80360 0.80800   0.812
              29        PC 0.81620 0.82000 0.82367 0.82726 0.83079 0.83424 0.83763 0.84094 0.84419   0.847
              30        PC 0.85047 0.85350 0.85647 0.85936 0.86219 0.86494 0.86763 0.87024 0.87279   0.875
              31        PC 0.87767 0.88000 0.88229 0.88455 0.88679 0.88900 0.89119 0.89335 0.89549   0.897
              32        PC 0.89969 0.90175 0.90379 0.90580 0.90779 0.90975 0.91169 0.91360 0.91549   0.917
              33        PC 0.91919 0.92100 0.92279 0.92455 0.92629 0.92800 0.92969 0.93135 0.93299   0.934
              34        PC 0.93619 0.93775 0.93929 0.94080 0.94229 0.94375 0.94519 0.94660 0.94799   0.949
              35        PC 0.95069 0.95200 0.95330 0.95459 0.95588 0.95716 0.95844 0.95971 0.96098   0.962
              36        PC 0.96350 0.96475 0.96600 0.96724 0.96848 0.96971 0.97094 0.97216 0.97338   0.974
              37        PC 0.97580 0.97700 0.97820 0.97939 0.98058 0.98176 0.98294 0.98411 0.98528   0.986
              38        PC 0.98760 0.98875 0.98990 0.99104 0.99218 0.99331 0.99444 0.99556 0.99668   0.997
              39        PC 0.99890 1.00000
              40        KM   BASIN W
              41        BA     157
              42        LS       0    85.0
              43        UD     1.5
                        *
              44        ZZ
```

1 SCHEMATIC DIAGRAM OF STREAM NETWORK

```
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
```

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

   13          W

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                                                  ************************************
 *                                       *                                                  *                                  *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                  *   U.S. ARMY CORPS OF ENGINEERS   *
 *              JUN   1998               *                                                  *   HYDROLOGIC ENGINEERING CENTER  *
 *           VERSION 4.1                 *                                                  *         609 SECOND STREET        *
 *                                       *                                                  *      DAVIS, CALIFORNIA 95616     *
 *  RUN DATE   05AUG16  TIME  14:09:11   *                                                  *          (916) 756-1104          *
 *                                       *                                                  *                                  *
 *****************************************                                                  ************************************


                              ADAMS ECOLOGY NTTR HYDROLOGY STUDY
                              EXISTING CONDITION USING SCS METHODS
                              SCS TYPE II RAINFALL DISTRIBUTION
                              HYDROLOGIC MODEL FOR BASIN W
                              INPUT FILE = BASINW.DAT
                              INPUT FILE DATE = AUGUST 5, 2016
                              DESIGN STORMS = 100-YEAR, 24-HOUR STORM AND 500-YEAR, 24-HOUR STORM
                              MODELED BY S&B CHRIST CONSULTING, LLC.

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

     IT          HYDROGRAPH TIME DATA
                        NMIN           6  MINUTES IN COMPUTATION INTERVAL
                       IDATE      1    0  STARTING DATE
                       ITIME        0000  STARTING TIME
                          NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                      NDDATE      2    0  ENDING DATE
                      NDTIME        0554  ENDING TIME
                      ICENT           19  CENTURY MARK

                   COMPUTATION INTERVAL     .10 HOURS
                        TOTAL TIME BASE   29.90 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

     JP          MULTI-PLAN OPTION
                       NPLAN           1  NUMBER OF PLANS

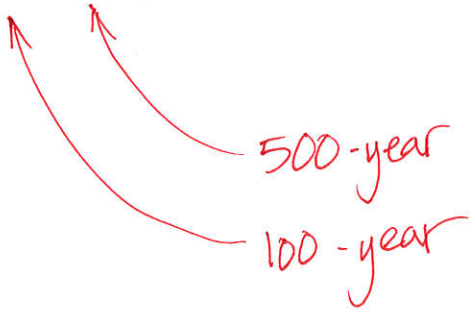
     JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                     .78      1.00
1

               PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2
                                                        .78     1.00

 HYDROGRAPH AT
+                    W    157.00     1   FLOW       37089.   55627.
                                          TIME        13.50    13.50


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



500-year

100-year

APPENDIX D

HYDRAULIC CALCULATIONS

- **TABLE D-1: HYDRAULIC CROSS SECTIONS RESULTS SUMMARY**
- **HYDRAFLOW EXPRESS HYDRAULIC SECTION CALCULATIONS**

Table D-1: Hydraulic Cross Sections Results Summary

100 year 24 hour Hydraulic Results			
Cross Section	Q_{100} (cfs)	Velocity (ft/s)	Depth (ft)
Cross Section I	92187	14.88	11.55
Cross Section R1	92367	9.23	7.24
Cross Section R2	92367	10.25	5.57

500 year 24 hour Hydraulic Results			
Cross Section	Q_{500} (cfs)	Velocity (ft/s)	Depth (ft)
Cross Section I	140504	16.70	13.92
Cross Section R1	146223	10.52	9.19
Cross Section R2	146223	11.77	7.15

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Nov 3 2016

Cross Section I 100yr

User-defined

Invert Elev (ft)	= 3988.00
Slope (%)	= 0.90
N-Value	= 0.035

Calculations

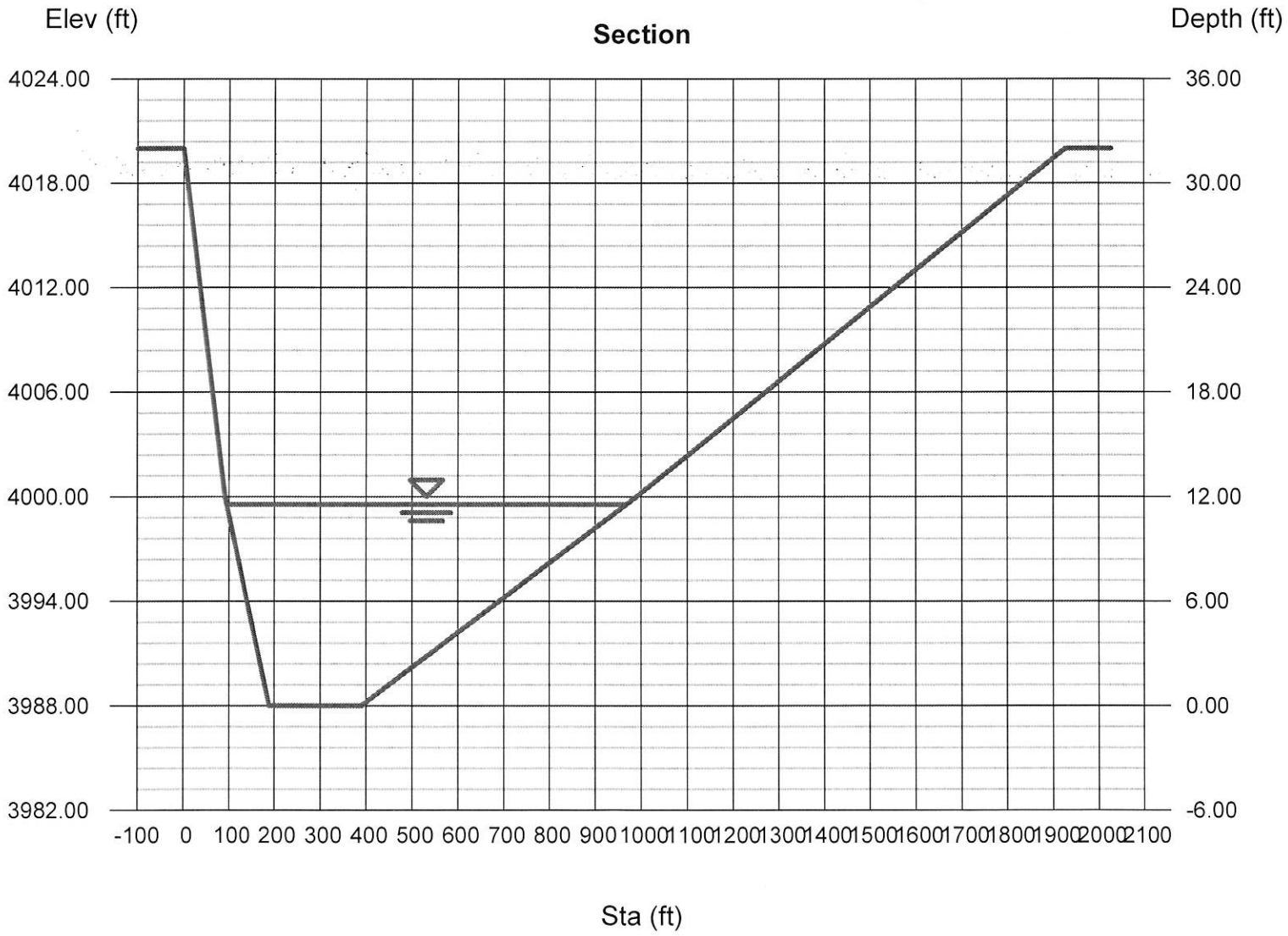
Compute by:	Known Q
Known Q (cfs)	= 92187.00

Highlighted

Depth (ft)	= 11.55
Q (cfs)	= 92,187
Area (sqft)	= 6195.39
Velocity (ft/s)	= 14.88
Wetted Perim (ft)	= 873.61
Crit Depth, Yc (ft)	= 11.47
Top Width (ft)	= 872.79
EGL (ft)	= 14.99

(Sta, El, n)-(Sta, El, n)...

(0.00, 4020.00)-(91.00, 4000.00, 0.035)-(189.00, 3988.00, 0.035)-(389.00, 3988.00, 0.035)-(990.00, 4000.00, 0.035)-(1927.00, 4020.00, 0.035)



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Nov 3 2016

Cross Section I 500yr

User-defined

Invert Elev (ft)	= 3988.00
Slope (%)	= 0.90
N-Value	= 0.035

Calculations

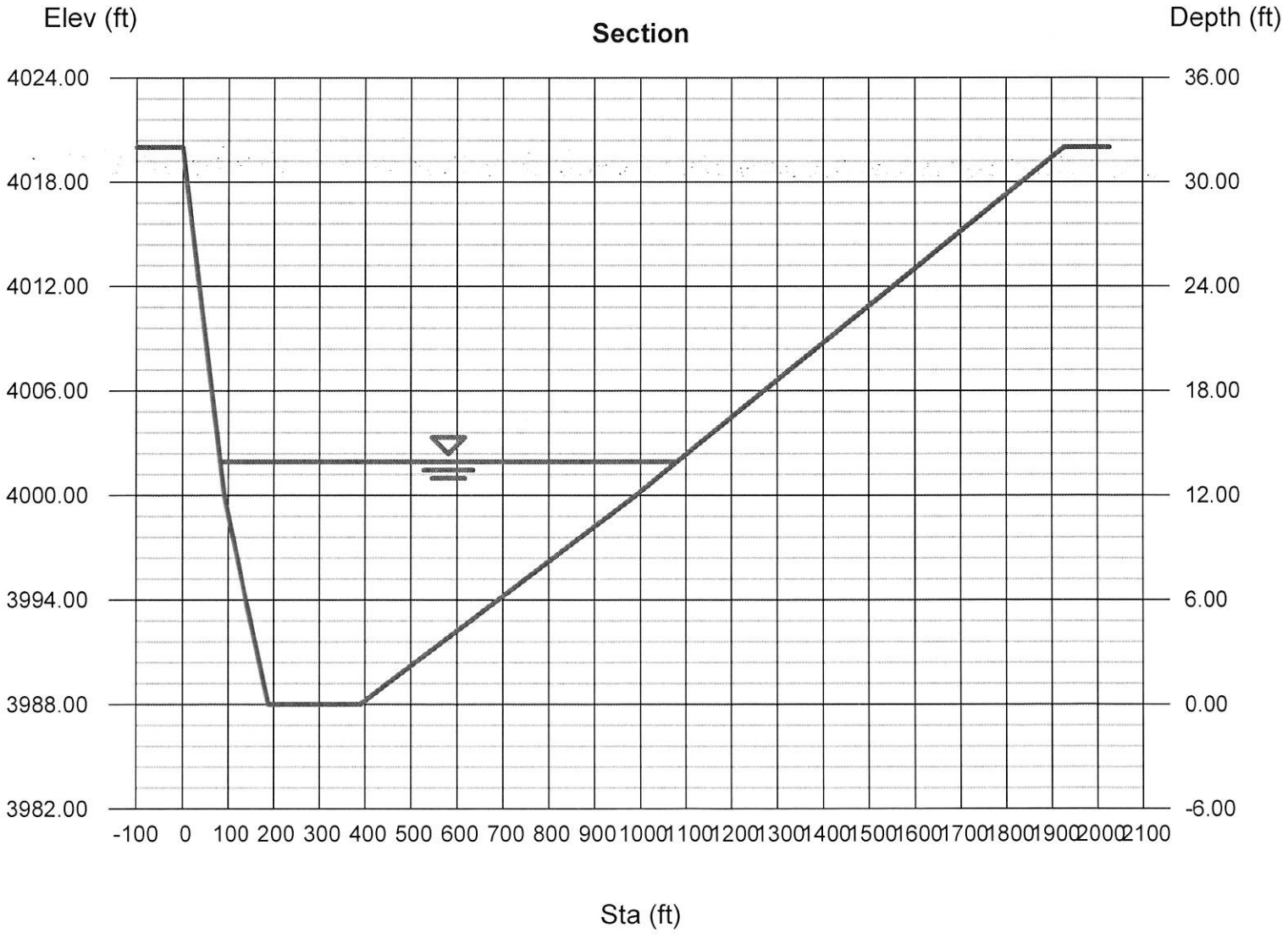
Compute by:	Known Q
Known Q (cfs)	= 140504.00

Highlighted

Depth (ft)	= 13.92
Q (cfs)	= 140,504
Area (sqft)	= 8414.99
Velocity (ft/s)	= 16.70
Wetted Perim (ft)	= 998.78
Crit Depth, Yc (ft)	= 14.02
Top Width (ft)	= 997.70
EGL (ft)	= 18.25

(Sta, El, n)-(Sta, El, n)...

(0.00, 4020.00)-(91.00, 4000.00, 0.035)-(189.00, 3988.00, 0.035)-(389.00, 3988.00, 0.035)-(990.00, 4000.00, 0.035)-(1927.00, 4020.00, 0.035)



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Nov 3 2016

Cross Section R1 100yr

User-defined

Invert Elev (ft)	= 3570.00
Slope (%)	= 0.50
N-Value	= 0.035

Calculations

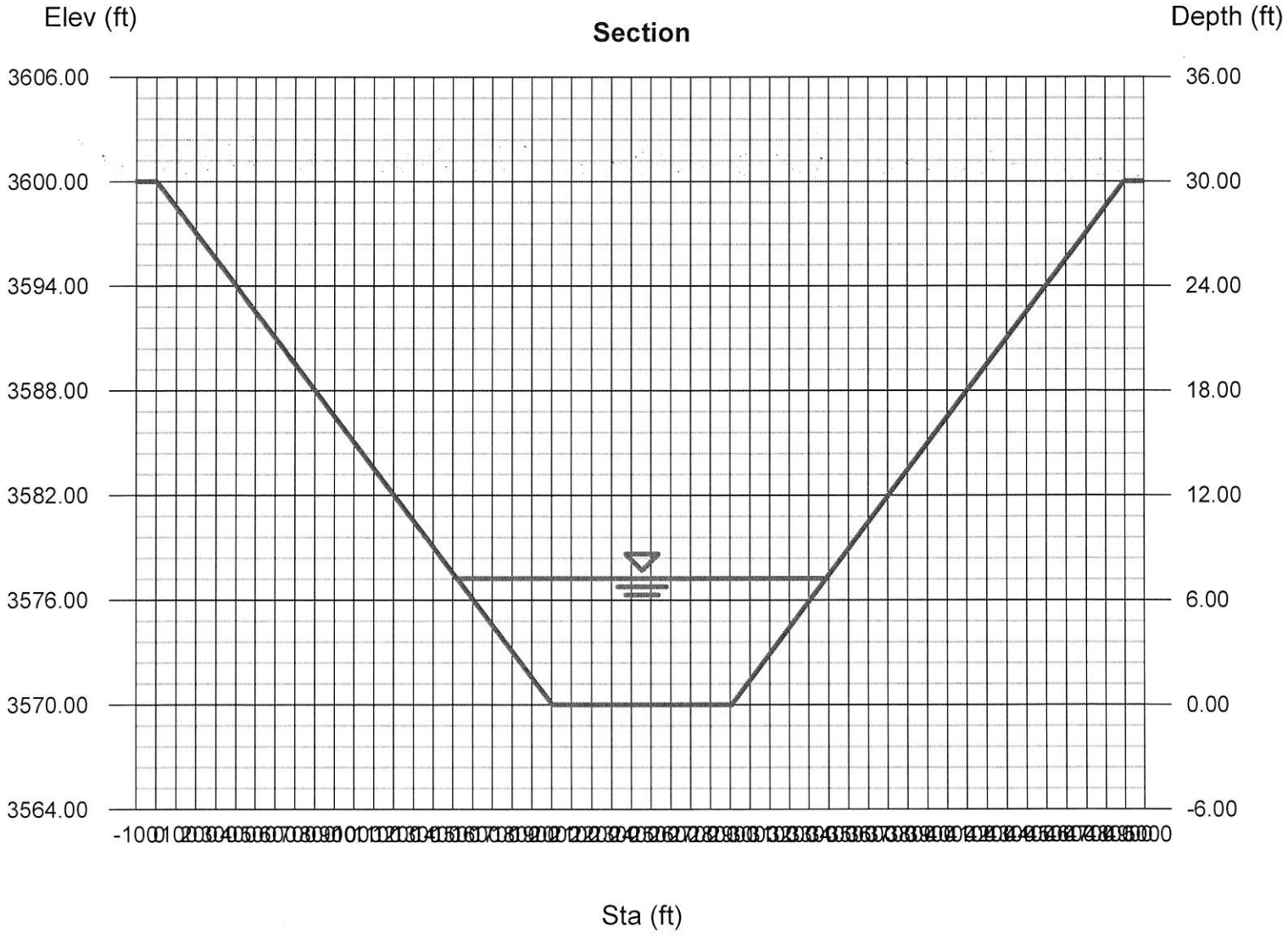
Compute by:	Known Q
Known Q (cfs)	= 92367.00

Highlighted

Depth (ft)	= 7.24
Q (cfs)	= 92,367
Area (sqft)	= 10012.49
Velocity (ft/s)	= 9.23
Wetted Perim (ft)	= 1864.99
Crit Depth, Yc (ft)	= 5.92
Top Width (ft)	= 1864.88
EGL (ft)	= 8.56

(Sta, El, n)-(Sta, El, n)...

(0.00, 3600.00)-(2005.00, 3570.00, 0.035)-(2906.00, 3570.00, 0.035)-(4895.00, 3600.00, 0.035)



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Nov 3 2016

Cross Section R1 500yr

User-defined

Invert Elev (ft)	= 3570.00
Slope (%)	= 0.50
N-Value	= 0.035

Calculations

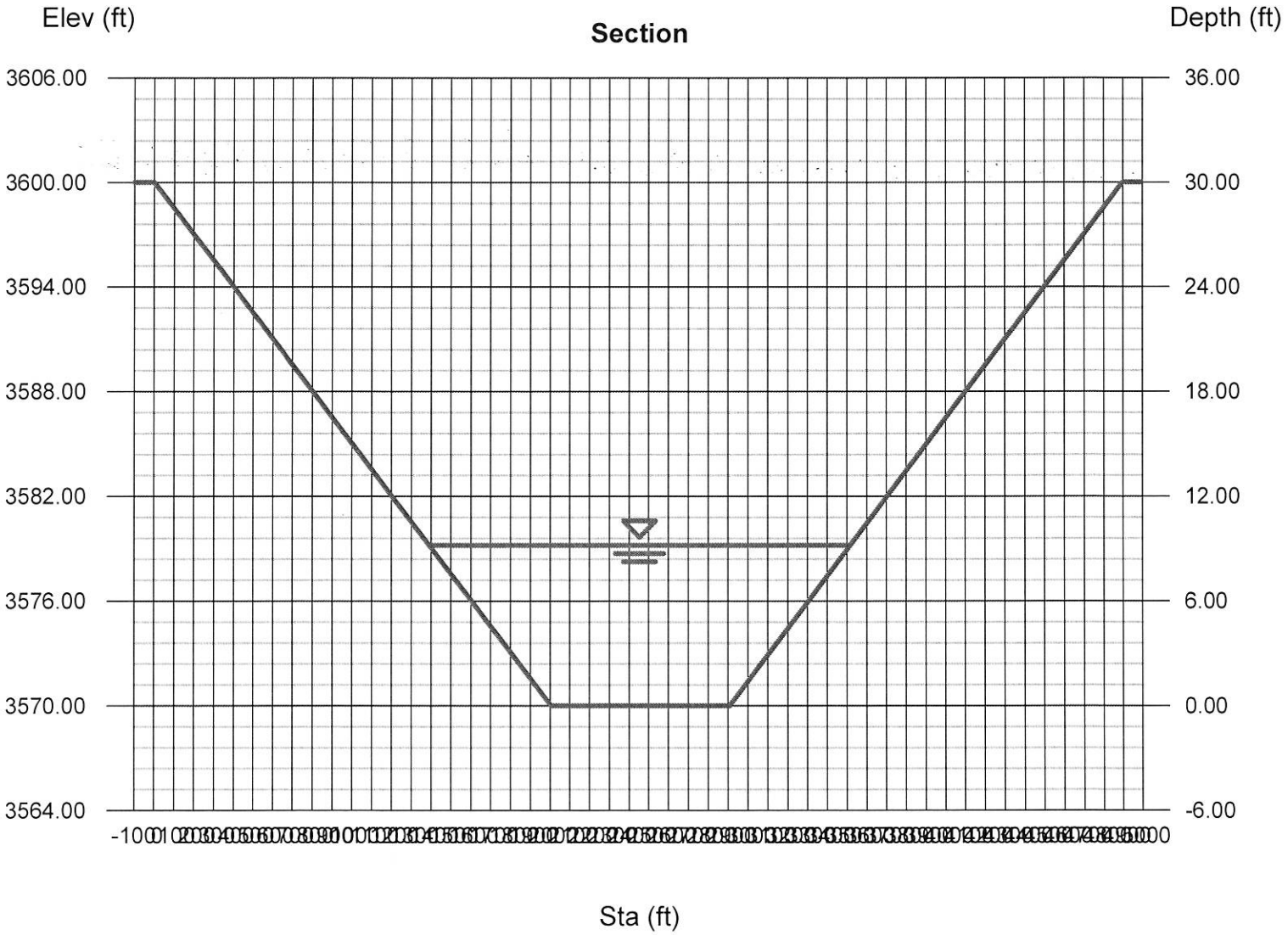
Compute by:	Known Q
Known Q (cfs)	= 146223.00

Highlighted

Depth (ft)	= 9.19
Q (cfs)	= 146,223
Area (sqft)	= 13902.54
Velocity (ft/s)	= 10.52
Wetted Perim (ft)	= 2124.66
Crit Depth, Yc (ft)	= 7.69
Top Width (ft)	= 2124.52
EGL (ft)	= 10.91

(Sta, El, n)-(Sta, El, n)...

(0.00, 3600.00)-(2005.00, 3570.00, 0.035)-(2906.00, 3570.00, 0.035)-(4895.00, 3600.00, 0.035)



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Nov 3 2016

Cross Section R2 100yr

User-defined

Invert Elev (ft)	= 3220.00
Slope (%)	= 0.80
N-Value	= 0.035

Calculations

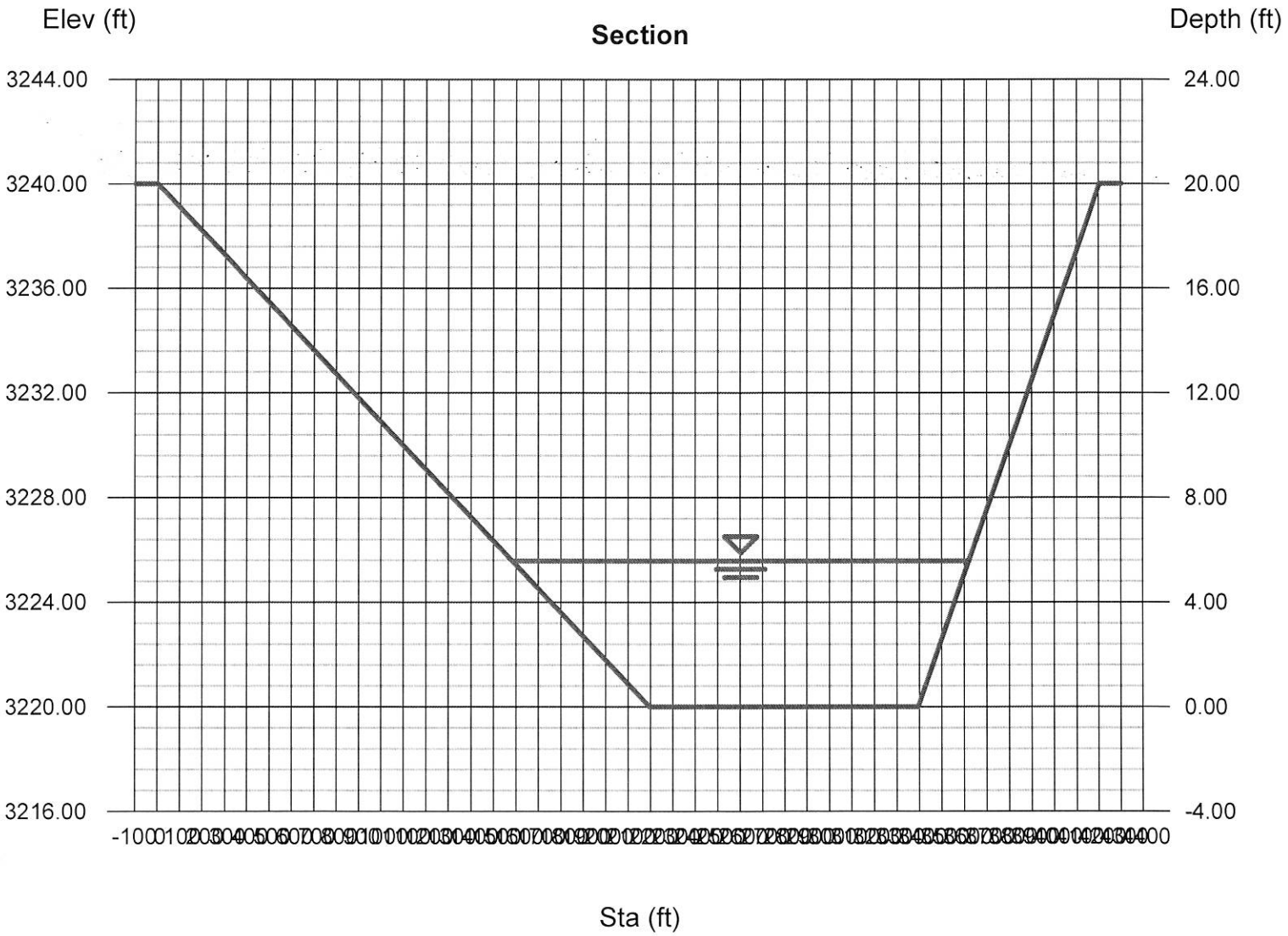
Compute by:	Known Q
Known Q (cfs)	= 92367.00

Highlighted

Depth (ft)	= 5.57
Q (cfs)	= 92,367
Area (sqft)	= 9014.11
Velocity (ft/s)	= 10.25
Wetted Perim (ft)	= 2036.72
Crit Depth, Yc (ft)	= 5.09
Top Width (ft)	= 2036.62
EGL (ft)	= 7.20

(Sta, El, n)-(Sta, El, n)...

(0.00, 3240.00)-(2196.00, 3220.00, 0.035)-(3396.00, 3220.00, 0.035)-(4204.00, 3240.00, 0.035)



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Nov 3 2016

Cross Section R2 500yr

User-defined

Invert Elev (ft)	= 3220.00
Slope (%)	= 0.80
N-Value	= 0.035

Calculations

Compute by:	Known Q
Known Q (cfs)	= 146223.00

Highlighted

Depth (ft)	= 7.15
Q (cfs)	= 146,223
Area (sqft)	= 12419.63
Velocity (ft/s)	= 11.77
Wetted Perim (ft)	= 2274.07
Crit Depth, Yc (ft)	= 6.68
Top Width (ft)	= 2273.95
EGL (ft)	= 9.31

(Sta, El, n)-(Sta, El, n)...

(0.00, 3240.00)-(2196.00, 3220.00, 0.035)-(3396.00, 3220.00, 0.035)-(4204.00, 3240.00, 0.035)

