Ecological Monitoring Report Vernal Pools on the Hanford Site

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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1.0 Introduction

Shallow ephemeral wetlands (also known as vernal pools) in very small to rarely large depressions occur throughout the exposed, volcanic scablands on the Columbia Plateau. These pools are characterized by fresh water inundation for much of the winter and spring, followed by dramatic lowering of the water table at the approach of summer. On the Columbia Plateau, vernal pools are geographically limited but can be locally common (Rocchio and Crawford 2015b). In the state of Washington the Columbia Plateau Vernal Pool ecosystem is considered to be "Imperiled," that is with a high to moderate risk of extirpation (Rocchio and Crawford 2015a).

In 1997, during surveys conducted on the Hanford Site for the U. S. Department of Energy, Richland Operations Office (DOE-RL), The Nature Conservancy (TNC) located three previously undocumented clusters of approximately 20 vernal pools. The Hanford Site pools were located on the east end of Umtanum Ridge, in the central part of Gable Butte, and at the eastern end of Gable Mountain (TNC 1998). The fall and winter of 1996/1997 was unusually wet; 9.7 in. (25 cm) of precipitation fell from October 1996 through March 1997 compared with a normal (30-year average) precipitation of 4.85 in. (12.3 cm) (MSA 2018).

The fall and winter of 2016/2017 was also an unusually wet period with 6.86 in. (17.4 cm) of precipitation, which included 28 in. (71 cm) of snow falling between October and the end of February. During the late winter of 2017, the vernal pools documented in 1996/1997 were rediscovered and found to contain significant amounts of water. Section 3.0 documents the study of roughly 25 vernal pools found on Umtanum Ridge, Gable Butte, and Gable Mountain during 2017.

Upon completion of the 2017 vernal pool monitoring, it was proposed that vegetation monitoring occur at the vernal pools during both wet and dry years in order to better understand the ecological impact of intermitted flooding on plant species. The fall and winter of 2017/2018 were relatively dry with 4.12 in. (10.46 cm) of precipitation and 6.8 in. (17.27 cm) of snowfall, presenting an opportunity to monitor vegetation abundance and diversity within the vernal pools during a low precipitation year. These results are recorded in Section 4.0.

Vernal pool monitoring was not planned in 2019 after a relatively dry fall and winter of 2018/2019, but an unusually large amount of snowfall in late winter (32.1 in. [81.5 cm] from October to February and an additional 4.4 in. [11.2 cm] in March) presented an opportunity to check the vernal pools. The goal of this monitoring effort was to document the presence/absence of vernal pools following a late winter snowfall to better inform the timing and execution of future monitoring efforts. The results of this monitoring effort are recorded in Section 5.0.

1.1 Purpose and Need

Because vernal pools have not been regularly tracked or well-studied on the Hanford Site, and because they represent an imperiled ecosystem in Washington State, monitoring of these pools was initiated during the 2017 season. The purpose of this monitoring and the subsequent monitoring effort was to:

- Locate and map the vernal pools located on the central Hanford Site managed by the DOE-RL
- Provide a seasonal timeline for the pools

- Describe the vegetation present in the vernal pools as well as its distribution within the pools
- Document wildlife use of the pools through the use of trail cameras
- Look for evidence of the use of the pools as a breeding area for anurans
- Document pool use by aquatic crustaceans, insects, and/or other macroinvertebrates
- Identify occurrences of any federal or Washington State-listed species in the pools, including any endemic species or State-listed species of concern.

1.2 Background

The following section describes the Columbia Plateau Vernal Pool Ecological System in Washington State and its current conservation rankings and status within the state. In addition, the management status of this ecological system on the Hanford Site is discussed.

1.2.1 Columbia Plateau Vernal Pool Ecological System in Washington State

Vernal pools occur throughout the exposed volcanic scablands on the Columbia Plateau in Washington, Oregon, and northern Nevada. Washington occurrences are concentrated in the Channeled Scablands and glaciated areas in Adams, Douglas, Grant, Lincoln, southern Okanogan, and Spokane Counties (Rocchio and Crawford 2015b).

The Washington State Natural Heritage Program (WNHP) ranks ecological systems known to occur in Washington State. The 2016 Ecological Systems List ranks the Columbia Plateau Vernal Pool ecosystem as S2/S3, which indicates an imperiled ecosystem with a high to moderate risk of extirpation in Washington State (WNHP 2015a, 2016). The greatest threats to this ecosystem include: 1) livestock farming and ranching, and 2) transportation and service corridors, both of which do not occur on the Hanford Site. The primary threat facing the Hanford Site ecosystem is invasive non-native species.

1.2.2 Washington Wetlands Rating

Vernal pools are precipitation-based, seasonal wetlands. In eastern Washington, they are defined to include only scabrock and rainpool vernal wetlands (Ecology 2014). To be classified as a vernal pool, the wetland should be less than 4,000 ft^2 (372 m^2) and meet at least two of the following criteria found in Ecology (2014):

- *Its only source of water is rainfall or snowmelt from a small contributing basin and the basin has no groundwater input.* The wetland will typically lay in areas where the basalt has been exposed by the ice age floods and where basalts have small depressions that collect rainwater or snowmelt.

- *Wetland plants are typically present only in spring; the summer vegetation is typically upland annuals.* The water is present in the wetland for only short periods of time, usually less than 120 days. Wetland plants will be found only during the time of standing water or immediately afterwards.

- *The soils in the wetland are shallow (<30 cm or 1 ft deep) and are underlain by an impermeable layer such as basalt or clay.* You can determine the depth of the soil by digging a small hole with a tile spade. Determining if the impermeable layer is basalt should be easy (can't dig any farther), but identifying a clay layer is harder. You may have to take some of the soil between your fingers, add water, and feel if it is greasy and smooth (without grit).

- *Surface water is present for less than 120 days during the wet season*. Estimating the duration of surface water in a vernal pool wetland is difficult unless one visits the wetland several times and notes the time at which the wetland fills and the time it dries out.

Relatively undisturbed vernal pools are either a Category II or III wetlands, depending on their location in the landscape (Ecology 2014). Vernal pools that are located in a landscape with other wetlands, and that are relatively undisturbed during the early spring, are rated Category II; isolated, undisturbed vernal pools are Category III. Category II wetlands are considered difficult, if not impossible to replace, and provide high levels of some functions while Category III wetlands are generally less diverse or more isolated from other natural resources in the landscape. Hanford Site vernal pools fall into Category III.

The intent of rating categories is to provide a basis for developing standards for protecting and managing wetlands. Some decisions that can be made based on the rating include the width of buffers needed to protect the wetland from adjacent development and uses in and around the wetland. Washington State provides general guidance for protecting and managing Washington wetlands in *Wetlands in Washington State – Volume 2: Guidance for Protecting and Managing Wetlands* (Ecology 2005).

1.2.3 Hanford Site Management Guidance

The *Hanford Site Biological Resources Management Plan* (BRMP, DOE/RL 96-32) is identified by the Hanford Comprehensive Land-Use Plan (DOE/EIS-0222-SA-01) as the primary implementation control for managing and protecting natural resources on the Hanford Site. The DOE-RL places priority on monitoring those plant and animal species or habitats with specific regulatory protections or requirements that are rare and/or declining (e.g., federal or state listed endangered, threatened, or sensitive species), or are of significant interest to federal, state, or Tribal governments or the public. The BRMP (DOE/RL 96-32) ranks wildlife species and habitats (Levels 0 through 5), providing a graded approach to monitoring biological resources based on the level of concern for each resource.

Resources classified as Level 5 are the rarest and most sensitive habitats and species and are considered irreplaceable or at risk of extirpation or extinction. Per BRMP, the vernal pools on the Hanford Site are considered to be Level 5 resources. The primary management goal for Level 5 resources is preservation. There is no practical way to replace or restore a Level 5 habitat resource if it is lost; therefore, avoidance is the preferred mitigation for this habitat.

Regular inventory and monitoring is a critical component of DOE-RL's strategy to manage Level 5 resources effectively. Monitoring provides the information needed to determine population trends, distribution of species or habitat, and whether the habitat is declining. This information can then be used to determine if management actions are effective or if additional access restricted or other protective measures are required.

1.3 Scope of Document

This monitoring report:

- Describes the vernal pools on the Hanford Site and provides an overview of the historical monitoring that occurred in the mid-1990s
- Describes the methods used to monitor vernal pools on the Hanford Site during the fiscal year (FY) 2017 season
- Provides a review of the data collected in FY 2017 and the conclusions reached
- Describes the 2018 vegetation monitoring effort and the 2019 monitoring surveys
- Outlines future management actions and proposed monitoring to be taken in response to the results of the 2017, 2018, and 2019 studies.

2.0 Vernal Pools on the Hanford Site

The number, size, and extent of vernal pools on the Hanford Site appears to be closely linked to the amount and type of precipitation received in the fall and winter months. In 1996/1997, above average amounts of snow that lingered for a longer than average amount of time resulted in three well-defined clusters of vernal pools on the Hanford Site. The information below is based on the observations made in the spring of 1997 (TNC 1998).

2.1 General Description

The Hanford Site pools are located on the eastern end of Umtanum Ridge, in the central part of Gable Butte, and at the eastern end of Gable Mountain. Each cluster of pools is situated on top of an impermeable basalt layer that enables water to pond in shallow depressions during wetter winter seasons. The pools are sometimes characterized by a distinct zonation of species from the bottom of the pool, which might be barren throughout the growing season, to the upper pool edge, which is generally occupied by various annual plant species. Vernal pools show wide variations in their degree of development (i.e., some appear to be pools that fill intermittently and are invaded by sagebrush during extended dry periods).

2.2 Historical Monitoring at the Hanford Site (1996 and 1997)

The 1997 survey found that the vernal pools on the Hanford Site showed a wide variation with regard to a number of traits including: pool size, species composition, dominant species, degree of invasion by weedy (mostly non-native) species, and presence of rare plant species (TNC 1998). Pools averaged 60 by 60 ft (18 by 18 m) in size but ranged from 20 by 20 ft (6 by 6 m) to 150 by 100 ft (46 by 30 m). Dominant species were typically annuals. Some vernal pools had a high cover of moss and lichen species. In addition to their botanical resources, there was ample evidence of avian and other wildlife use of these vernal pools as they often provide water during dry times of the year.

The cluster of 10 to 11 vernal pools on the eastern end of Umtanum Ridge were of relatively high quality and appeared to be the most undisturbed (pristine) pools on the Hanford Site. Large and vigorous subpopulations of Suksdorf's monkeyflower (*Erythranthe suksdorfii,* formerly *Mimulus suksdorfii*) were found in almost all of these pools. Mousetail (*Myosurus calvicauli*) was located in one of the vernal pools. The pools were spread out over an area of about 100 by 3,500 ft (305 by 915 m).

The low, middle portion of Gable Butte supported a cluster of six or seven vernal pools. These pools supported healthy populations of several thousand *Erythranthe suksdorfii* and spreading pygmyleaf (*Loeflingia squarrosa* var *squarrosa*), plants. The area was far from current development; however, an old road did cross through the largest vernal pool.

The cluster of three pools on the eastern side of Gable Mountain was least pristine of the three sets of vernal pools. These weedy, intermittently-filled pools supported a population of several hundred *Erythranthe suksdorfii* plants. The aggressive weed, yellow starthistle (*Centaurea solstitialis*), posed a serious threat to native plants at these pools.

An alkaline spring and marshy area was found in a large shallow basin at the east end of Umtanum Ridge in the same area as the vernal pools. This previously unknown spring did not appear to have been significantly damaged by past grazing. It is perhaps the only spring of its kind on the Hanford Site. This spring supported a population of seep paintbrush (*Castlleja minor* var. *exilis*) and other alkali-tolerant plant species. There also were a number of weedy species present that could threaten the persistence of native plant species at the spring.

3.0 2017 Vernal Pool Monitoring

Late winter 2017 was unusually wet and snowy, and vernal pools were again noted at the east end of Umtanum Ridge. This section documents the monitoring done during the 2017 season, which focused on relocating pools that were documented in the 1997 survey, any additional pools that had been overlooked, and establishing a baseline for future studies of this unique ecological system.

3.1 Monitoring Methods

3.1.1 Locations and Descriptions of Vernal Pools on the Hanford Site

The first goal of the 2017 monitoring effort was to document the location of vernal pools on the Hanford Site.

- Locations documented in 1997 by TNC were revisited. All pools found were photographed and their location documented using a hand-held Global Positioning System (GPS). Larger pools were mapped by taking a series of GPS readings at the perimeter of the pool. A single GPS point was made for smaller pools (generally considered those with diameters roughly less than 10 yd [9 m]).

- In addition to pedestrian surveys, an overflight of the three known clusters of vernal pools and the surrounding area was taken on March 16, 2017, in order to acquire aerial photographs.

The aerial survey was conducted from a single engine fixed wing aircraft at an altitude of 1,000 to 3,500 ft (300 to 1,070 m). As shown in Figure 3-1, the flight took two passes east-west over the central portion of the Hanford Site above Gable Mountain, Gable Butte, and the eastern portion of Umtanum Ridge. In addition, the flight flew over another potential site of a vernal pool near the Laser Interferometer Gravitational-Wave Observatory (LIGO).

Vernal pools were located at all three previously documented locations (Umtanum Ridge, Gable Butte, and Gable Mountain). Figure 3-2 provides a general map showing the general locations of the vernal pool clusters on the Hanford Site. In all three areas, the underlying substrate was a rocky lithosol. Each location is discussed in more detail in the sections below.

Vernal pools identified during the step above were revisited on a roughly monthly basis to assess condition. Photographs of each pool were taken and the perimeters of larger pools were mapped using GPS to determine changes in pool size. In addition, one or more pools were photographed daily at mid-day using a trail camera; Hanford Site Security was notified of trail camera locations. Visits and daily photographs continued until the pools dried out and vegetation had become established.

3.1.2 Seasonal Timeline

Vernal pools identified in 2017 were revisited every few weeks to assess condition. Photographs of each pool were taken and the perimeters of larger pools were mapped using GPS to determine change in pool size. In addition, one or more pools were photographed daily at mid-day using a trail camera; Hanford Site Security was notified of trail camera locations. Visits and daily photographs continued until the pools dried out and vegetation had become established.

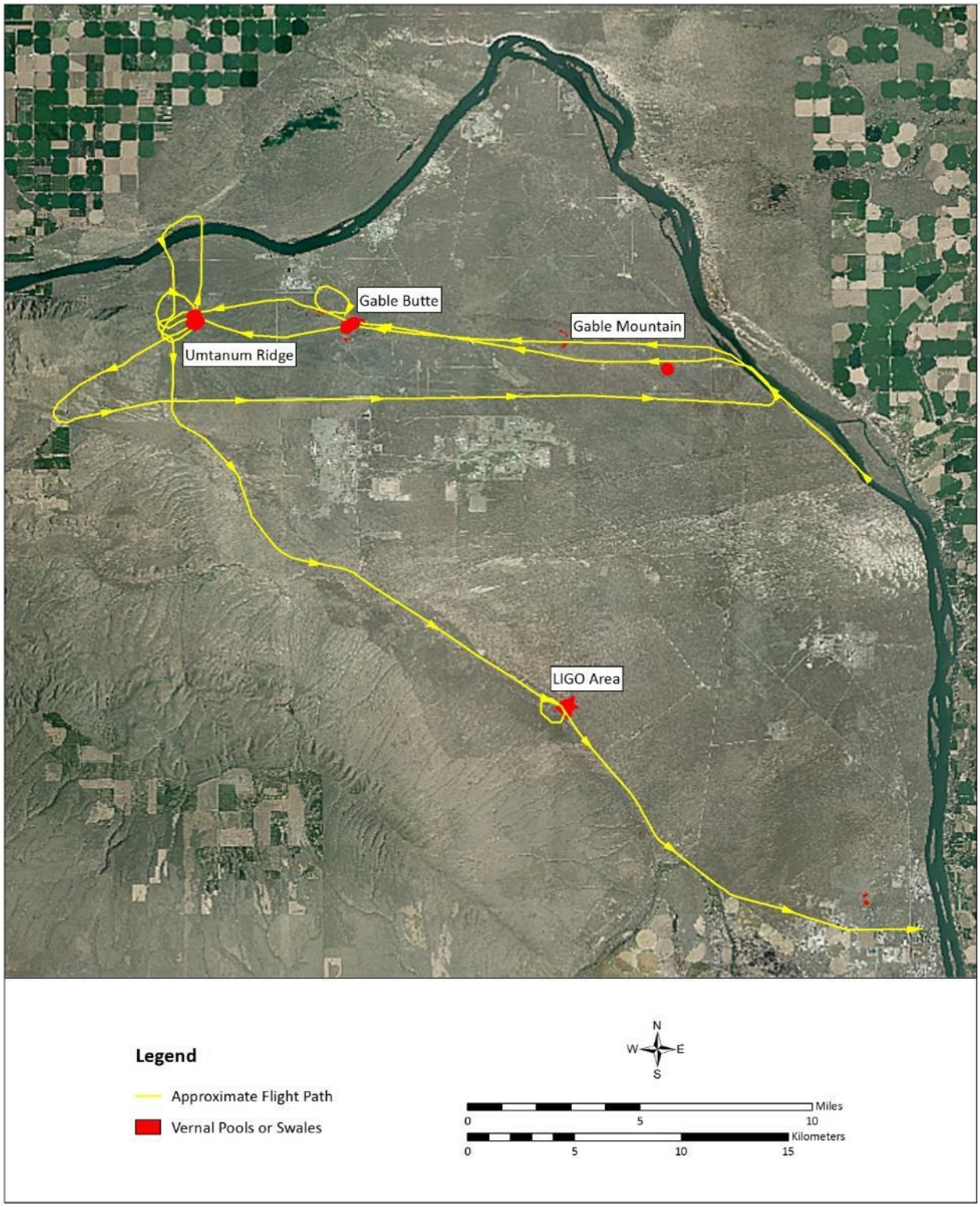

Figure 3-1. Path of the Aerial Survey of Vernal Pool Areas on the Hanford Site

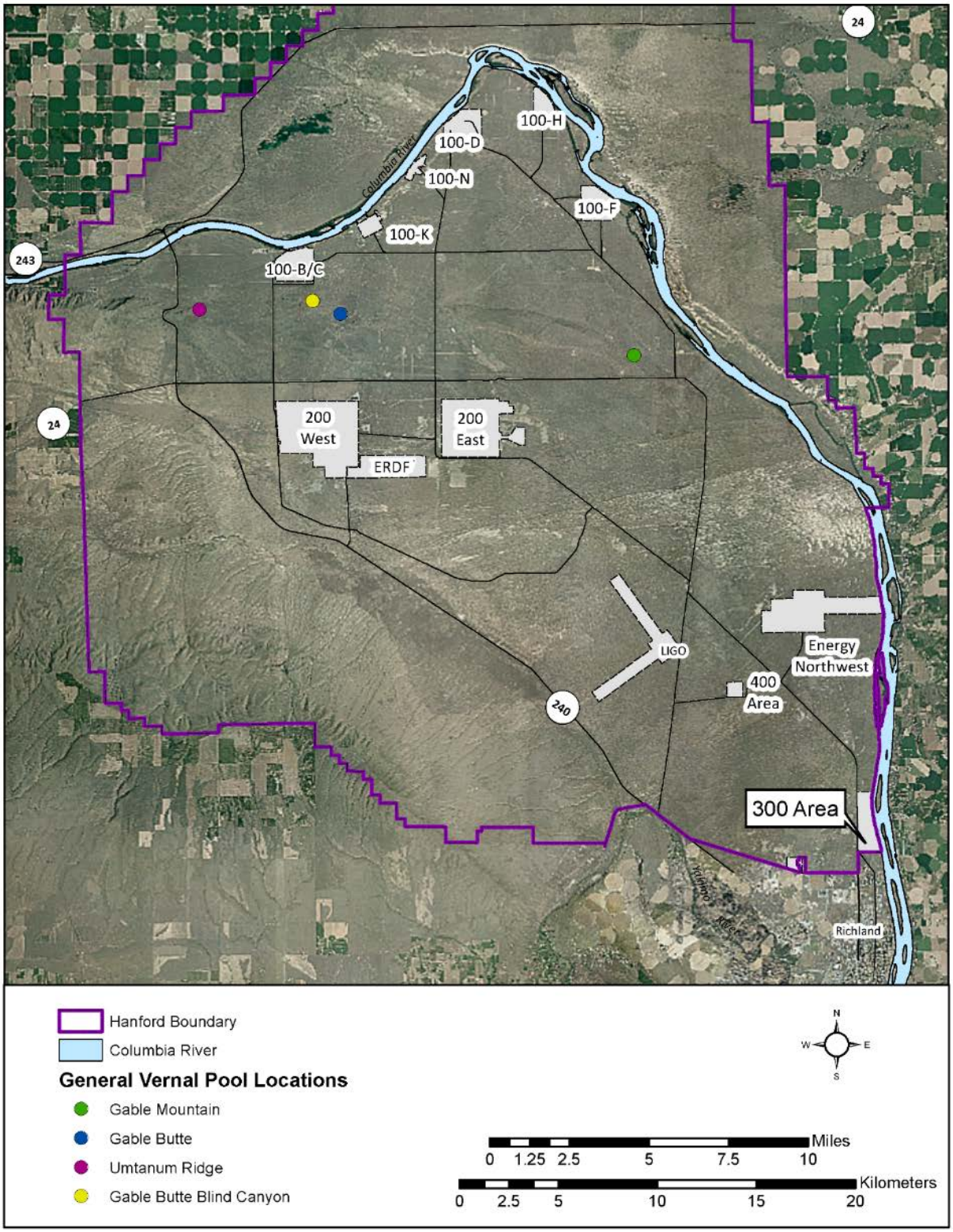

Figure 3-2. General Location of the Vernal Pool Areas on the Hanford Site

3.1.3 Vegetation Monitoring

Surveys of the vegetation present in the vernal pools occurred in mid-summer after all of the pools had dried out. These surveys documented the species present and noted obvious visual patterns in plant distribution within the pools. Previous researchers have noted zonal vegetation patterns of more or less concentric zones of different species groupings in vernal pools (Crowe et al. 1994).

Of particular interest was the presence or absence of species endemic to vernal pools. A list of core native taxa that are found almost exclusively in vernal pools in Washington State can be found in the paper by Bjork and Dunwiddie (2004).

In addition to endemic species, three State-listed species of conservation concern were found to inhabit some of the Hanford Site's vernal pools in 1997 (TNC 1998):

- Suksdorf's monkeyflower (*Erythranthe suksdorfii*) (formerly *Mimulus suksdorfii*)
- Mousetail (*Myosurus clavicaulis*)
- Spreading pygmyleaf (*Loeflingia squarrosa* var *squarrosa*).

Any species of conservation concern encountered in Washington State (WNHP 2017) was documented for submission to the Washington Natural Heritage Program Rare plant database.

Populations of non-native invasive weeds in or around the pools were also noted as these species pose the greatest threat to vernal pool ecosystems on the Hanford Site.

In addition to documenting the vascular plants present, any area with a noticeable amount of cryptogamic species (e.g., mosses and lichens) was documented.

3.1.4 Wildlife Usage

Wildlife and wildlife signs were noted during visits to the vernal pools throughout the 2017 season. In addition to this incidental data, trail cameras were set up at some pools to capture wildlife present at the pool throughout the day. Specific sampling efforts focused on the presence or absence of breeding anurans; macroinvertebrates were also sampled throughout the season in the pools that still contained water.

3.1.4.1 Trail Cameras

Trail cameras were used at four different pools during the March/April timeframe in order to document the use of the pools during the period in which they serve as a local water source. Hanford Site Security was notified of trail camera locations.

3.1.4.2 Anuran Surveys

Two species of native anurans, the Woodhouse's toad (*Anaxyrus woodhousii*) and the Great Basin spadefoot toad (*Spea intermontana*), inhabit the Hanford Site. These anurans are known to breed in the ephemeral pools and sloughs adjacent to the Columbia River; however, there are no data indicating whether they also use the vernal pools for this purpose. Visual surveys were used to locate breeding habitats and identify which anurans were present.

3.1.4.3 Macroinvertebrate Sampling

The goal of the macroinvertebrate sampling was to determine whether or not the vernal pools support an active population of macroinvertebrates, not to prepare a definitive list of taxa or to quantify the

number of macroinvertebrates in a given pool. A second goal was to look specifically for the presence or absence of fairy shrimp.

Samples were collected from March through May as long as pools were still filled. A D-frame mesh net was used to collect the sample from the pool by walking in or around the pool and forcing pool water through the net. All macroinvertebrates collected with the net were dumped into a wide plastic tub for observation and categorized according to type.

3.2 Umtanum Ridge Vernal Pools

A cluster of roughly 10 vernal pools and a likely spring are clustered together at the eastern end of Umtanum Ridge. As shown in Figure 3-3, pools 1 and 2 are located fairly close to the ridgeline while the remaining pools are further south. Pools in this cluster are designated in this report as Umtanum (U) followed by a number from 1 to 10.

One area, marked as a possible spring on the map below, remained wet well into the summer and appears to have a more continuous source of water than the surrounding pools, which are dependent on precipitation for fill. The TNC also noted an alkaline spring and marshy area in the same area as the vernal pools on Umtanum (TNC 1998).

The first two pools in the Umtanum Ridge cluster, Pools U-1 and U-2, were incidentally observed on February 28, 2017, while doing other ecological monitoring work (Figure 3-4). Due to the unusually wet fall and winter in 2016/2017, a return visit was made to this area on March 13 to check for additional pools and document their location and size. Subsequent visits were made on March 30, April 6, May 8 and 12, June 5, and July 18. The following discussion summarizes the observations of the Umtanum Ridge pools that were made throughout the 2017 season.

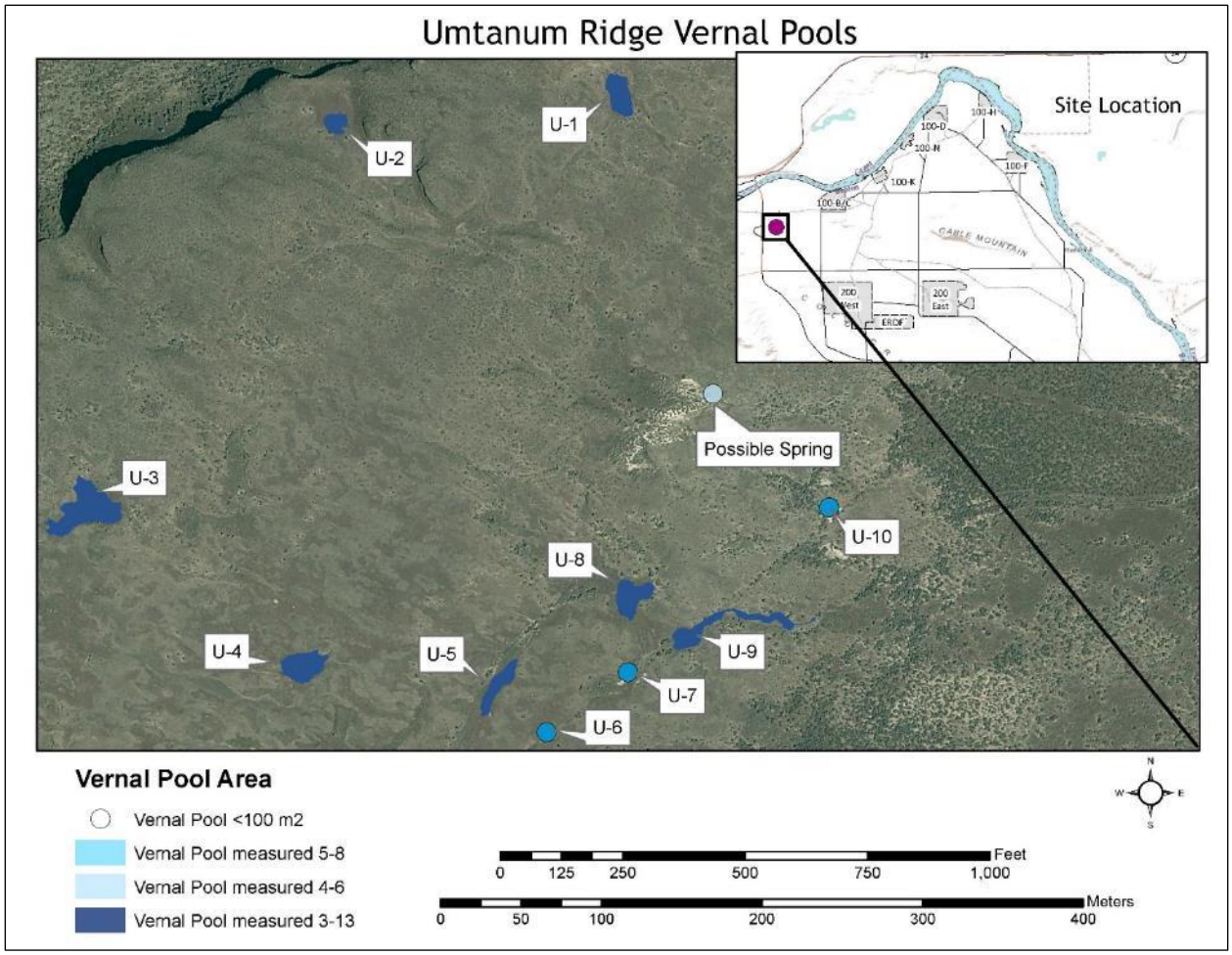

Figure 3-3. Cluster of Vernal Pools on Umtanum Ridge

3.2.1 Umtanum Ridge - February 28, 2017

The first two pools in the Umtanum Ridge cluster, Pools U-1 and U-2, were incidentally observed on February 28, 2017 (Figure 3-4). A big sagebrush (*Artemisia tridentata*) shrub was rooted in the middle of pool U-1 and Sandberg bluegrass (*Poa secunda*) appeared to be growing under the water in the shallowest part of the pool. Elk and mule deer tracks and scat were found in and around both pools. Both U-1 and U-2 were located close to the crest of the ridge in an area with very shallow lithosolic soils (Figure 3-5).

Figure 3-4. First Vernal Pools Observed on Umtanum Ridge (February 28, 2017)

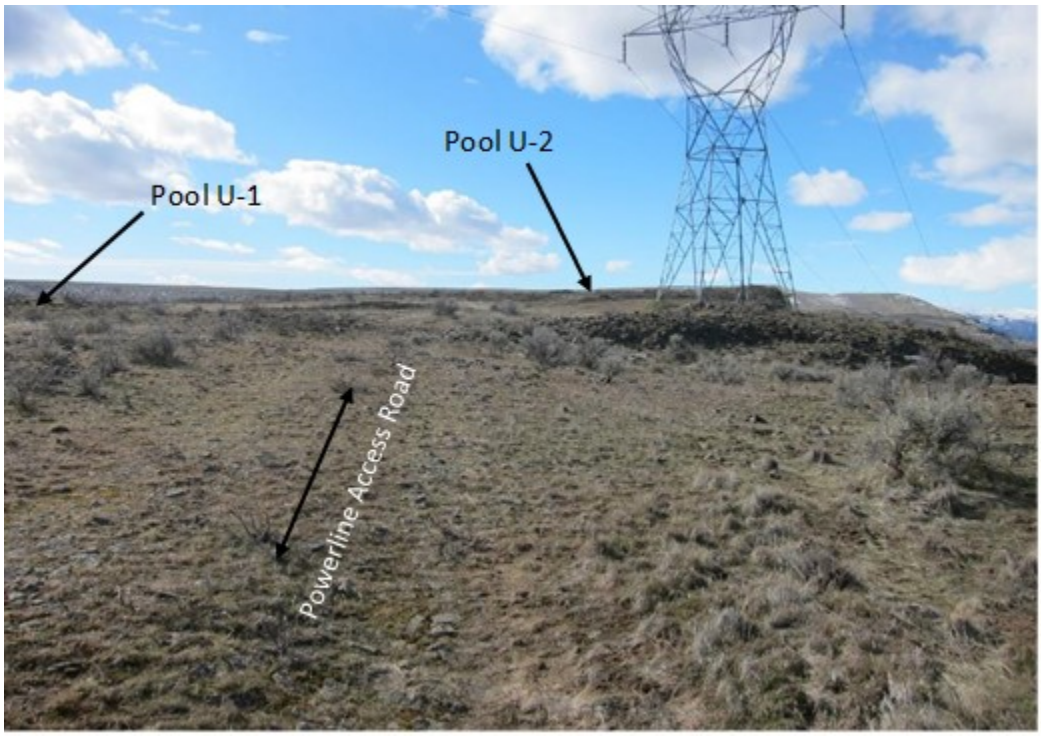

Figure 3-5. Location and Area Surrounding Pools U-1 and U-2

The primary vegetative cover in the area surrounding the two vernal pools consisted of stiff sagebrush (*Artemisia rigida*) where soils were shallow and big sagebrush where soils were deeper. Sandberg bluegrass was the most prevalent native grass. A healthy cryptogamic crust, consisting of lichens and mosses, was very noticeable and widespread between basalt fragments. Desert parsley (*Lomatium canbyi*) was in bloom and common between the rocks.

3.2.2 Umtanum Ridge - March 13, 2017

A pedestrian survey to look for additional pools that might occur on Umtanum Ridge was completed on March 13, 2017 (Figure 3-6). Eight more pools were found on Umtanum Ridge to the south of pools U-1 and U-2. The location of all 10 pools was documented and pool perimeters recorded using Global Positioning System (GPS) coordinates. Table 3-1 documents the size of the 10 identified Umtanum pools on March 13. All of the pools were larger on this date than on any subsequent observation dates, and it was noted that U-1 and U-2 appeared to have dried out a bit since February 28, 2017. Figures 3-7 and 3-8 provide a look at the 10 pools identified on Umtanum Ridge on March 13, 2017. In general, the pools toward the southeastern portion of the area seemed to be quite small and scattered as the elevation started to decline. Many of these unnumbered puddle-like pools were close to the presumed alkaline spring location.

Figure 3-6. Lithosol Surrounding Pools U-1 and U-2

Table 3-1. Sizes of the Vernal Pools on Umtanum Ridge.

Location	Date Measured	Area (m^2)	Area (acres)
U-1	3-13	323.9	0.080
U-2	3-13	155.1	0.038
U-3	3-13	831.0	0.205
U-4	3-13	406.6	0.100
U-5	3-13	280.4	0.069
U-6	3-13	Very small	Very small
U-7	3-13	Very small	Very small
U-8	3-13	359.5	0.089
U-9	3-13	485.2	0.120
U-10	3-13	Very small	Very small

Figure 3-7. Individual Pools Identified on Umtanum Ridge on March 13, 2017

Figure 3-8. Individual Pools Identified on Umtanum Ridge on March 13, 2017

All of the pools were located in lithosolic areas with shallow soils underlain by basalt. Sandberg bluegrass inhabited many of the gaps between rocks where the soil was deep enough, and the cryptogamic crust was quite healthy in the area. Elk and mule deer signs covered the areas surrounding the pools.

3.2.3 Umtanum Ridge - March 16, 2017

On March 16, 2017, photographs taken during the aerial flight showed most of the larger pools that had been documented during the pedestrian survey several days previously. In addition, a pool further west

on the ridge near State Route 24 was detected; this pool was noted but not studied further in 2017. Selected aerial photographs of the pools on Umtanum Ridge are shown In Figure 3-9.

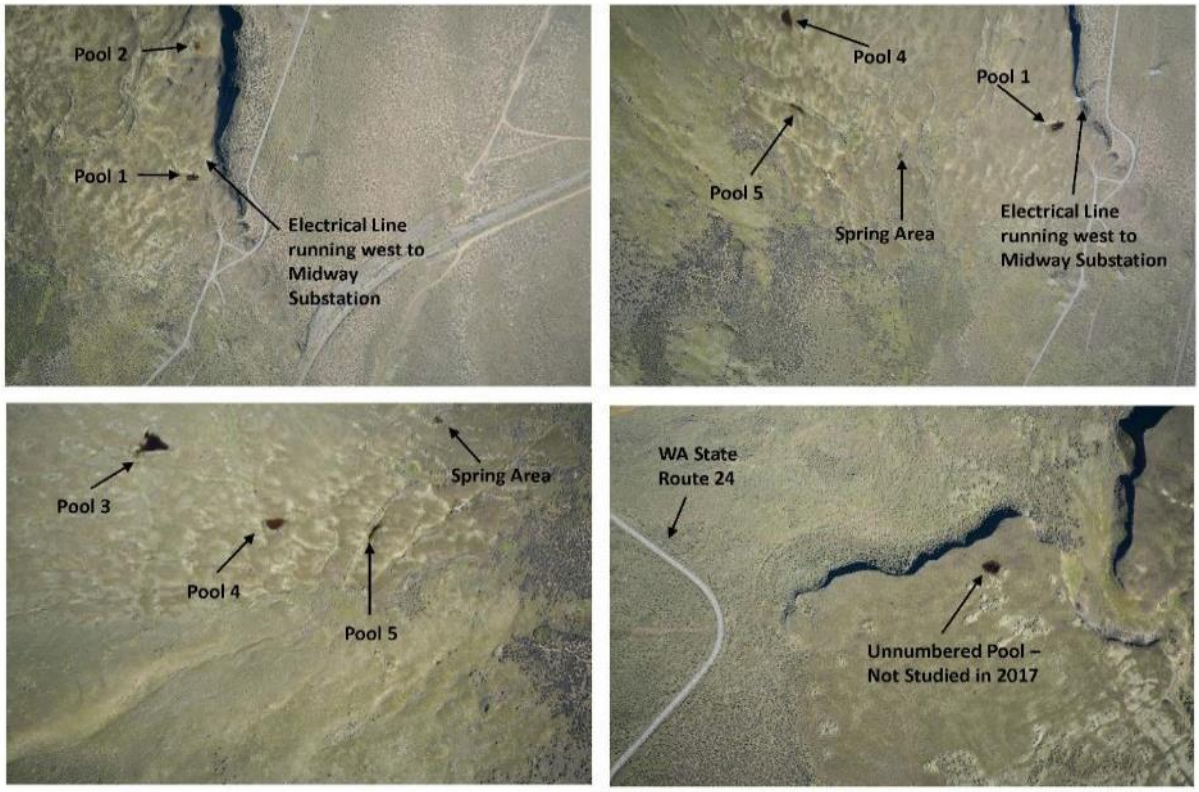

Figure 3-9. Aerial Photographs of Vernal Pools on Umtanum Ridge (March 16, 2017)

3.2.4 Umtanum Ridge – March 30, 2017

Pools U-1 and U-2 were visited on March 30, 2017, primarily to check on their condition and to pick up the trail camera that was placed on the rock ridge above pool U-2. The camera was used to look at daily fluctuations in water and wildlife usage. Both pools had dried up by this date and the trail camera was moved to pool U-3.

Figure 3-10 shows pool U-1 on March 30. Cheatgrass (*Bromus tectorum*) and Sandberg bluegrass were the most common plants growing along the edge of the former pool area and the deep hoof prints from deer and elk in the muddy soil were common. The middle of the old pool area had little vegetation and consisted primarily of last year's dead grasses tamped down. Deep tire tracks indicated recent off-road travel through the pool.

The photo of U-2 in Figure 3-10 shows the bright green area of cheatgrass and Sandberg bluegrass that surrounded the outer area of the pool. Pool U-2 was dry by March 18, as seen by the photographs taken daily by the trail camera (Figure 3-11). Unfortunately, the trail camera was discovered and knocked down by an elk later that day. The camera also captured a coyote using the pool in mid-March.

Figure 3-10. Umtanum Pools U-1 and U-2 on March 30, 2017

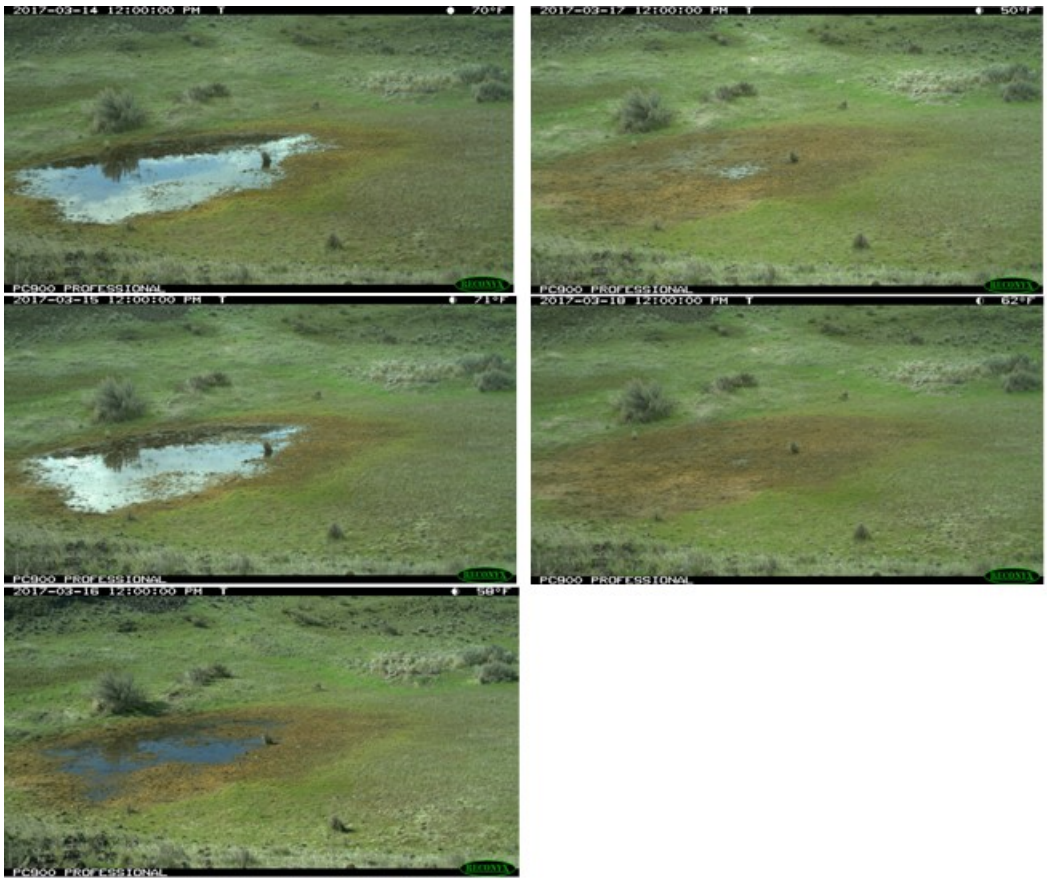

Figure 3-11. Daily Sequence of Pool U-2 Taken from March 14 through March 18, 2017

3.2.5 Umtanum Ridge – April 6, 2017

All of the pools previously identified on Umtanum Ridge were visited on April 6, 2017. With the exceptions of pools U-3 and U-4, all pools had dried out by this time. In addition, standing water and small puddles were found in the area suspected of being an alkaline spring.

Pool U-1 had been dried out on the previous visit (March 30). A week later, the dead, matted grasses in the center of the pool had broken down further and some vegetation was poking through. Sandberg bluegrass was the most prevalent species present both in the center of the pool and in the area to the outside that did not have the matted grass cover. Cheatgrass and spring whitlowgrass (*Draba verna*) were also quite common. The big sagebrush shrub in the middle of the pool seemed to be growing despite the inundation of water surrounding it earlier in the season. Mule deer and elk tracks were found throughout the pool area along with coyote scat. Figure 3-12 shows pool U-1 along with close ups of the surface vegetation.

Figure 3-12. Pool U-1 with Initial Vegetation Growth (April 6, 2017)

Pool U-2 had dried out by mid-March, and most noticeable growth in the center of this pool was the moss that covered much of the open ground and Sandberg bluegrass. Rabbit (*Sylviligagus nuttalli)* scat was also wide spread within the former pool area.

Pool U-3, one of only two pools that still contained water, had an area of 309.5 m^2 (0.076 ac) on April 6, 2017. This area was only 37% of the pool's size a month earlier (March 13). Pool U-4 also held water that covered an area of 154.2 m^2 (0.038 ac), an area 38% of its size on March 13. A great many elk and mule deer track were seen surrounding both pools. Pool 4 also supported a large population of mosquito larvae and water striders. Figure 3-13 shows pools U-3 and U-4 on April 6, 2017. Figure 3-14 shows the shrinkage of these two pool between March and April.

Figure 3-13. Umtanum Pools U-3 and U-4 on April 6, 2017

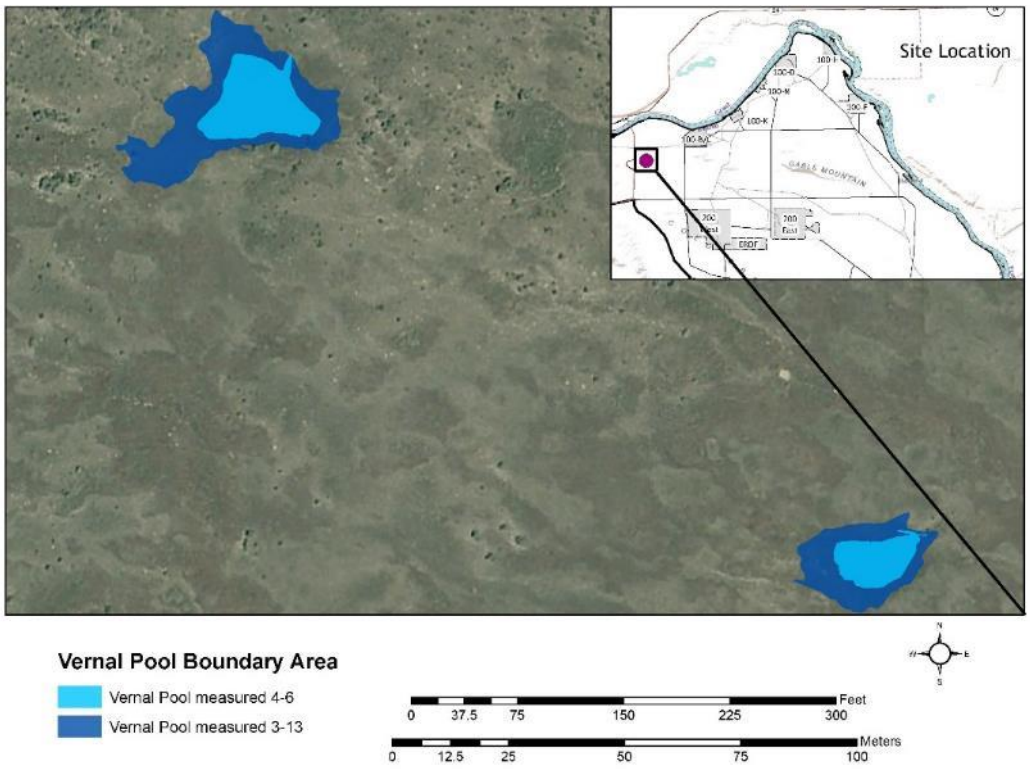

Figure 3-14. Shrinkage of Pools U-3 and U-4 Between March 13 and April 6, 2017

The remaining pools on Umtanum Ridge had all dried since the previous survey on March 13, but many remained fairly muddy and a large number of wildlife tracks, chiefly mule deer and elk, were seen in all pools (Figure 3-15). Former pool areas were identifiable due to the lack of vegetation growth compared to the adjacent area that had not been underwater earlier in the year. Sandberg bluegrass and cheatgrass were the most common species seen growing within the former pools.

Pool U-9, a long, thin pool at a low point in the topography, seemed to be slightly wetter than the other dried out pools. One species that appeared to be especially prevalent in these areas was broad-leaved

pepperweed (*Lepidium latifolium*), which is a Class B weed in Washington State. This species is a rhizomatous perennial that may sprout quickly once the water in the pools are gone. In the area where the pepperweed was found, an orange-colored fungal or algal-type growth covered the surface. Figure 3-15 shows the pepperweed and orange growth in the former pool U-9.

Figure 3-15. Recently Dried Pools on Umtanum Ridge (April 6, 2017)

Although most of the previously identified pools on Umtanum Ridge had dried out in March, a new area with a significant number of small pools containing standing water were found within the vicinity of the vernal pools. After walking the area, the conclusion drawn was that this area was the site of an alkaline spring that feeds the surrounding area. (The location of this spring is shown above in Figure 3-3.) From a distance, this area is prominent due to the presence of large swards of giant wild rye (*Leymus cinereus*). As with the vernal pools in the area, there was much evidence of repeated use by wildlife. Figure 3-16 shows the alkaline spring area on April 6.

Figure 3-16. Probable Alkaline Spring on Umtanum Ridge (April 6, 2017)

3.2.6 Umtanum Ridge – May 8, 2017

All of the vernal pools in the Umtanum cluster were visited in early May. All of the pools, including pools U-3 and U-4, had dried out by then and vegetation was starting to grow within the perimeters of the former pools. In the area surrounding the pools the cheat grass had begun to senesce and was turning red. Elk and mule deer tracks were observed surrounding every pool site.

At pool U-1, vegetation was poking through the matted, dead grass layer that had been underwater earlier in the season. The most prominent species included cheatgrass, lowland cudweed (*Gnaphalium palustre*), spring whitlow grass (in seed), and tumblemustard (*Sisymbrium altissimum*). Photos taken at pool U-1 on this date are shown in Figure 3-17.

Figure 3-17. Pool U-1 with Vegetation from Center of the Pool (May 8, 2017)

Pool U-2 is shown in Figure 3-18 along with two prominent plant species, bracted verbena (*Verbena bracteata*) and obscure suncup (*Neoholmgrenia andina*), that had germinated within the former pool.

Figure 3-18. Pool U-2 and Plants Colonizing the Dried Pool Area (May 8, 2017)

Pool U-3 was the largest pool on Umtanum Ridge, and was surrounded by a fringe of cheatgrass. Small annual plants (e.g., cheatgrass, obscure suncup, lowland cudweed, and Russian thistle [*Salsola tragus*]) were beginning to colonize the pool area. Suksdorf's monkeyflower (*Erythranthe suksdorfii*), a State-sensitive species, was also found in this pool. Figure 3-19 shows pool U-3 and the monkeyflower.

Figure 3-19. Pool U-3 and Suksdorf's Monkeyflower with Lowland Cudweed (May 8, 2017)

Pool U-4 had dried out prior to the visit on May 8, 2017, however, a trail camera placed at the pool on March 23, 2017 showed that the pool still had a significant amount of water in it as late as April 14 when it was knocked over and dragged from the area by an elk. Figure 3-20 shows the sequence of daily pictures of the pool from March 24 through April 13. Note that the pool seems to temporarily refill after a few rainy days, such as the period from April 11 to April 13 when the section of the pool pictured in the foreground disappears then reappears.

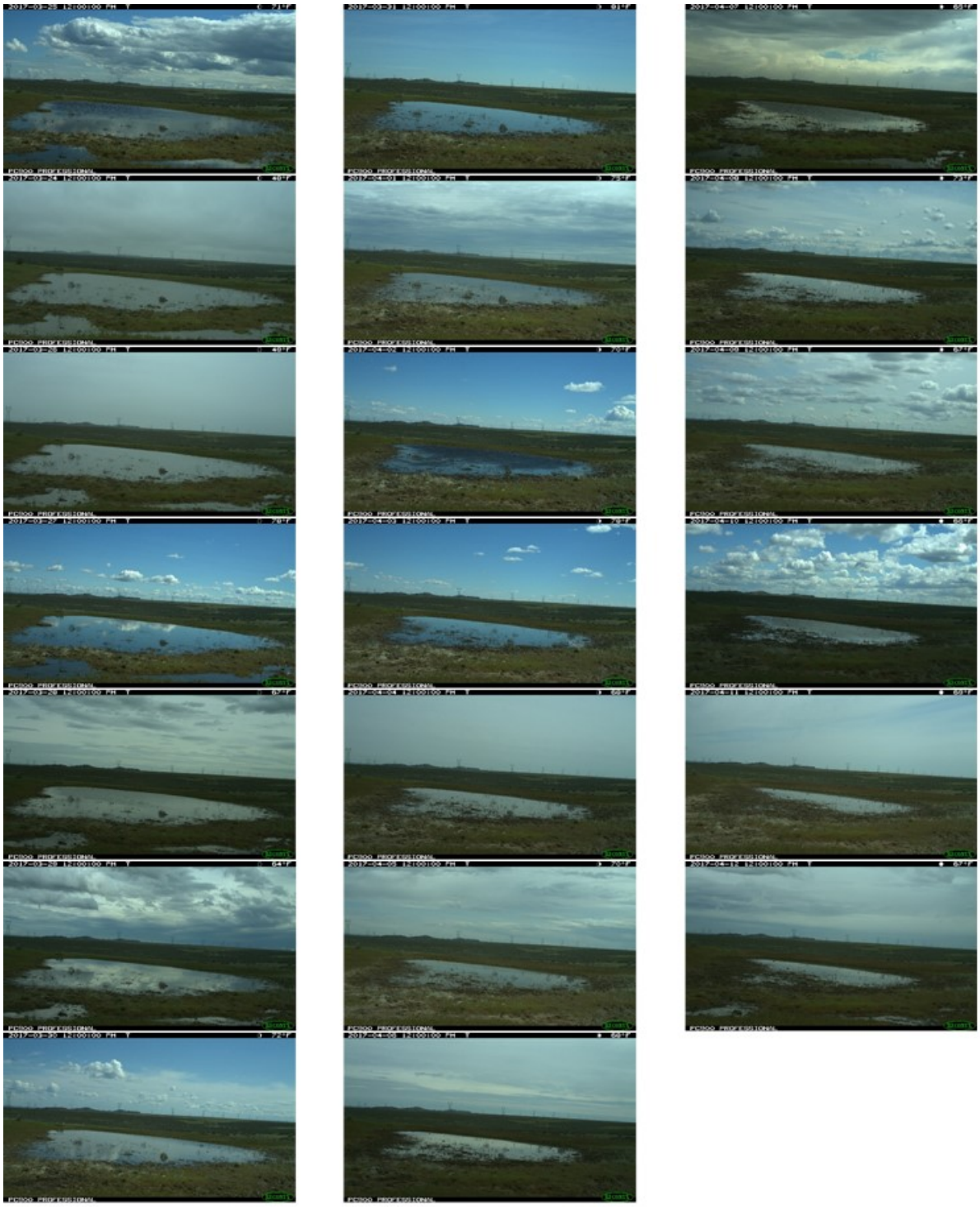

Figure 3-20. Daily Pictures of Pool U-4 Showing Fluctuations of Water Coverage (March – April 2017)

Figure 3-21 shows pool U-4 on May 8, 2017; the location of the trail camera at the pool was at the point where staff are standing in this picture. A few of the elk pictures taken by the trail camera are also shown in this figure. Coyotes were also detected by the trail camera.

Figure 3-21. Pool U-4 on May 8, 2017, and Elk Pictures from the Trail Camera

The smaller pools to the east and northeast of pool U-4 dried out weeks before pools U-3 and U-4. Obvious salt residue was found around these pools. Cheatgrass was the most common grass in these pools, and tumblemustard and broad-leaved pepperweed were common weedy species found in many of the pools. Figure 3-22 shows the status of pools U-5 through U-9 on May 8, 2017.

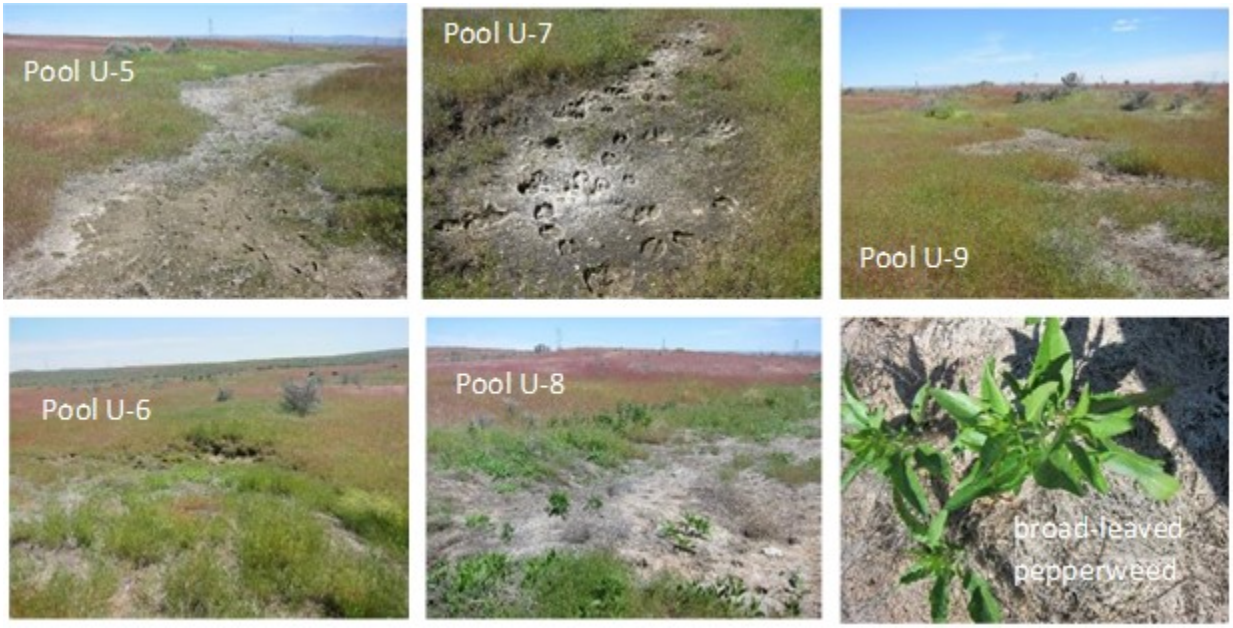

Figure 3-22. Smaller Umtanum Ridge Pools on May 8, 2017

The only standing water remaining at the Umtanum Ridge site on May 8, 2017 was in the area of the undocumented spring. Heavy elk and deer use was evident in this area, and leaf-cutter bees (*Osmia* sp.) were very active during the visit. The most notable vegetation in this area were large clumps of giant

wildrye. In marshy areas and next to the pools of standing water, the most common species were cheatgrass, tumblemustard, Russian thistle, jagged chickweed (*Holosteum umbellatum*), and pink microsteris (*Microsteris gracilis*). The only perennial noted within the pools was Sandberg bluegrass. A few macro-invertebrates were found in the remaining pools (chiefly water boatmen, diving beetle larvae, and mosquito larvae). Figure 3-23 shows the alkaline spring on May 8.

Figure 3-23. Alkaline Spring on Umtanum Ridge (May 8, 2017)

3.2.7 Umtanum Ridge – May 12 and June 8, 2017

As part of a review of plant community element occurrences on the Hanford Site, a number of the vernal pools on Umtanum Ridge were visited in early May and early June. On May 12, 2017, the spring area and surrounding small pools as well as pools U-10, U-9, U-3, and U-2 were visited.

The pools around the spring could be seen from a distance due to the healthy stand of giant wildrye (*Leymus cinereus*) associated with the area. The small pools in this area were all outlined with a ring of cheatgrass, which was very noticeable as the grass was turning purple. In some pools giant wildrye, a perennial grass, was growing despite earlier inundation with water. Figure 3-24 depicts some of the small unnumbered pools around the spring area.

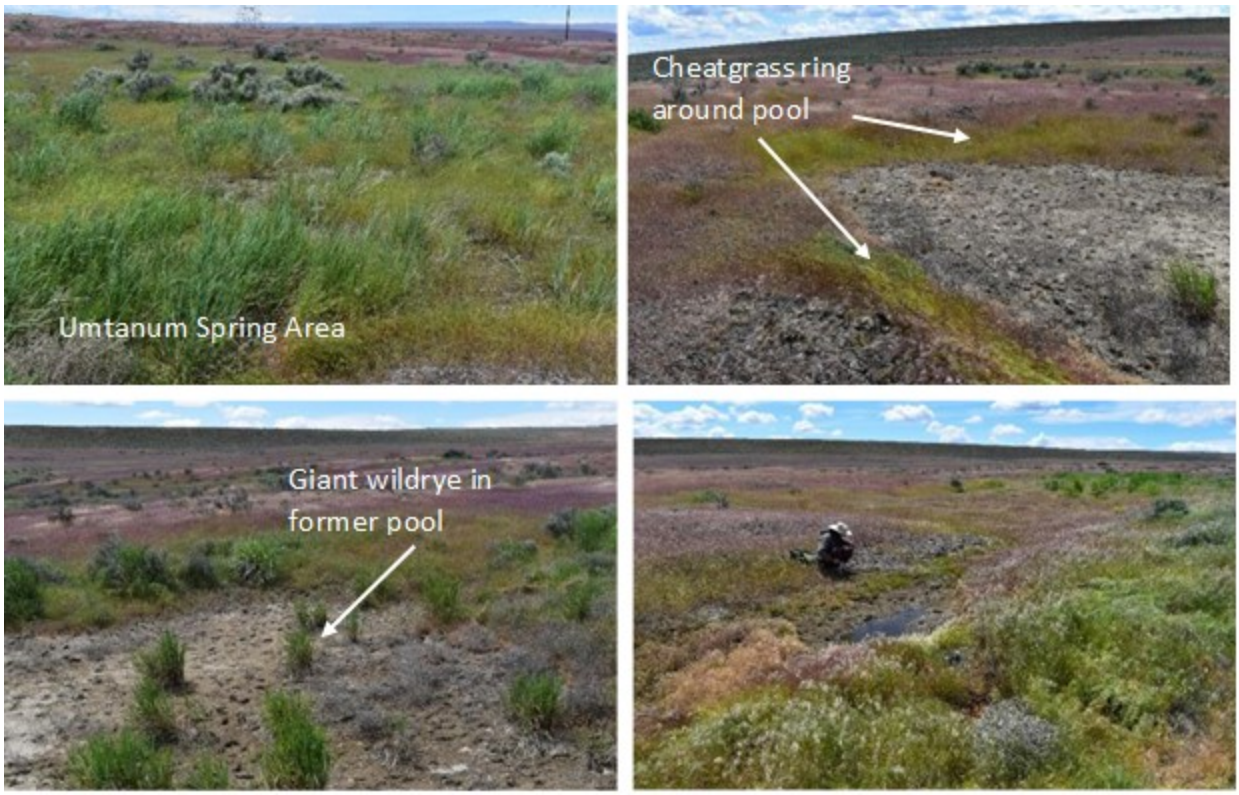

Figure 3-24. Small Pools Surrounding the Spring Area on Umtanum Ridge (May 12, 2017)

Pools U-9 and U-10, two previously numbered pools in the vicinity of the spring area, were also bordered by cheatgrass. Although the pools had dried out, soils were somewhat moist in areas within the former pool. Vegetation starting to colonize these pools included liverworts, toad rush, Suksdorf's monkeyflower, matted cryptantha (*Cryptantha circumscissa*), and some small annual grasses (*Vulpia* sp.). In pool U-9, the perennial weed broadleaf pepperweed had colonized a portion of the pool area. Pools U-9 and U-10 are shown in Figure 3-25.

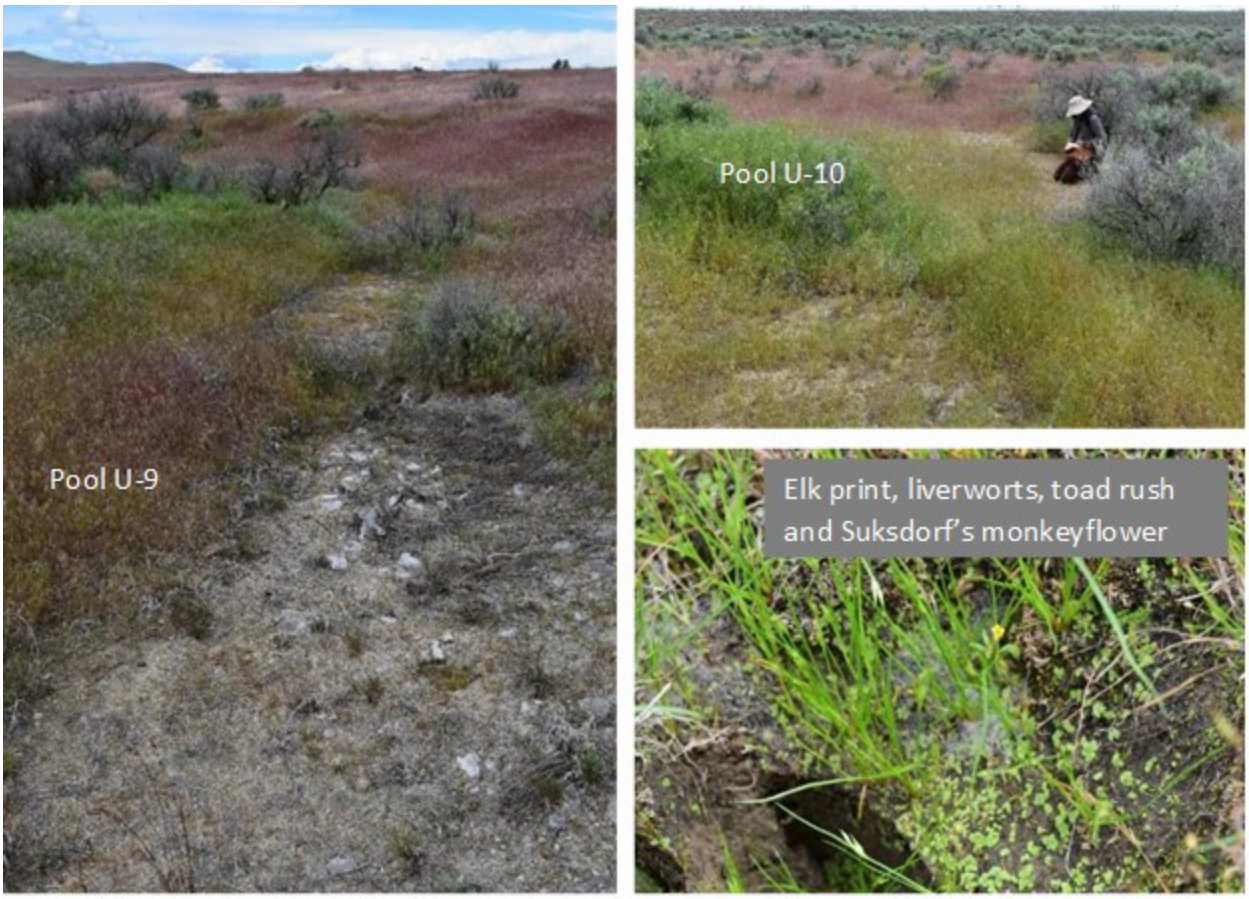

Figure 3-25. Pools U-9 and U-10 on Umtanum Ridge (May 12, 2017)

Pool U-3 had been one of the last pools on Umtanum Ridge to dry out and vegetation was still scarce in the center of the pool. Cheatgrass ringed the pool. Pool U-3 is shown in Figure 3-26.

Figure 3-26. Pool U-3 on Umtanum Ridge (May 12, 2017)

Pool U-2 was the first pool to dry out on Umtanum Ridge (mid-March), which may account for the sagebrush recruits growing in the wetted area. This pool also had a lot of moss growing in addition to white plectritis (*Plectritis macrocarps*), obscure suncup, bracted verbena, Suksdorf's monkeyflower, and Russian thistle. Figure 3-27 shows pool U-2 in early May.

Figure 3-27. Pool U-2 on Umtanum Ridge (May 12, 2017)

On June 5, 2017, field biologists returned and visited pool U-1, U-8, and U-9, as well as the small pools near the spring area. Again, the primary purpose for the visit was to review the area for plant community element occurrences; however, incidental data were collected and are documented here.

As shown in Figure 3-28, pool U-1 had been dried since late-March and the thatched grass had broken down in the intervening period. The vegetation in the pool included the perennial forb bracted verbena, as well as many small annuals including obscure suncup, lowland knapweed, and Russian thistle.

At the alkaline spring, the cheat grass surrounding the small pools was dried and brown in contrast to the plants growing in the pool areas. Many of the pool areas had a white alkaline layer covering the soil. Common species included purple-stemmed monkeyflower, lowland cudweed, toad rush, cheatgrass, and liverworts. Some views of the spring area are shown in Figure 3-29.

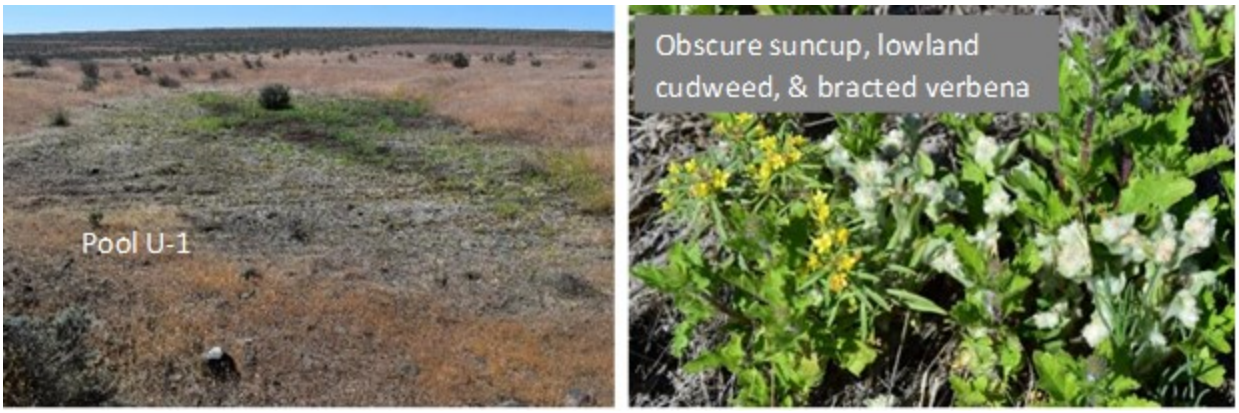

Figure 3-28. Pool U-1 on Umtanum Ridge (June 5, 2017)

Figure 3-29. Spring Area on Umtanum Ridge (June 5, 2017)

Pools U-8 and U-9 still had moist soils and supported a number of characteristic species including lowland cudweed, white pigweed (*Amaranthus alba*), toad rush, liverworts, and cheatgrass. Figure 3-30 shows pools U-8 and U-9 in early June.

Figure 3-30. Umtanum Ridge Pools U-8 and U-9 (June 5, 2017)

3.2.8 Umtanum Ridge – July 18, 2017

A final visit to the Umtanum Ridge pools in mid-July was made to assess the vegetation and conditions in the former pool areas. Most pools, although not damp to the touch, appeared to contain more moisture than the surrounding area; darker soils were seen in the center of the pool. The only

exception to this trend was pool U-7, which was very dry. Bee and butterfly activity was noted throughout the area.

All pools were visually examined for evidence of zonation in the vegetation layer. Only pool U-1 showed a clear outer and inner zonation, but pool U-9 showed distinct differences between the "stream-like" sections (referred to as inner in Table 3-2) and the wider more "pool-like" sections (referred to as outer in Table 3-2) of the pool. The species present in each pool area are listed in Table 3-2.

Table 3-2. Umtanum Ridge, Vegetation Survey - July 18, 2017.

Species	Common Name	U-1	U-2	U-3	U-4	U-5	U-6	U-7	U-8	U-9
SHRUBS										
Artemisia tridentata	big sagebrush	O	X							
GRASSES AND RUSHES										
Bromus tectorum	cheatgrass	O		X	X	X			X	O, I
Poa secunda	Sandberg bluegrass	O	X		X	X				I
Psuedoregnaria spicata	bluebunch wheatgrass	O	X							
Juncus bufonius	toad rush	O, I	X	X		X	X		X	
FORBS										
Amaranthus albus	white pigweed								X	O, I
Conyza canadensis	horsetail	O	X			X				I
Draba verna	spring whitlow grass	O	X							
Erigeron pumilus	shaggy fleabane	O								
Erodium cicutarium	storksbill	O				X				
Lactuca serriola	prickly lettuce			X		X	X		X	I
Lepidium latifolium	broad-leaved pepperweed				X					O, I
Neoholmgrenia andina	obscure suncup	O		X	X					
Gnaphalium palustre	lowland cudweed	O, I	X	X	X	X	X		X	O
Salsola tragus	Russian thistle	O, I	X	X		X	X	X	X	O, I
Sisymbrium altissimum	Jim Hill tumblemustard			X	X	X	X		X	O
Tragopogon dubius	salsify	O				X				I
Verbena bracteata	carpet verbena	O, I	X	X	X	X			X	O

I = Inner
O = Outer
X = Present with No Zonation

Shown in Figure 3-31, pool U-1 had an inner and outer vegetation zone. The plants on the outside contained a few perennials including sagebrush, bluebunch wheatgrass, and shaggy fleabane, characteristic of the vegetation adjacent to the pool. Although this outer area was covered by water early in the season, this pool was fairly shallow and the edges dried quickly, which may account for the

presence of these species. The species toward the center of the pool were generally only found in the pools on Umtanum Ridge. The most dominant species in pool U-1 were lowland cudweed, carpet verbena, and Russian thistle.

Figure 3-31. Umtanum Pool U-1 (July 18, 2017)

Pool U-2 had no obvious zonation in the vegetation. This pool was dry early in the season (by mid-March), which may account for the few big sagebrush recruits found in the formerly inundated area. The most dominant plants were lowland cudweed, carpet verbena, horsetail (*Conyza canadensis*), and toad rush. Figure 3-32 depicts pool U-2 and the vegetation within the pool on July 18, 2017.

Figure 3-32. Umtanum Pool U-2 (July 18, 2017)

Pools U-3 and U-4 contained water as late as mid-April. The vegetation in pool U-3 was dominated by carpet vervain; and pool U-4 was dominated by lowland cudweed and broad-leaved pepperweed (in the areas with moister soil). Figure 3-33 shows pools U3 and U-4 on July 18.

Figure 3-33. Umtanum Pools U-3 and U-4 (July 18, 2017)

The remaining pools (U-5, U-6, U-7, U-8, and U-9) on Umtanum Ridge had all dried out prior to the end of March, and many of the pools had a white, clay-like upper crust on the former pool areas. Pool U-5 was dominated by lowland cudweed, and pool U-6 had an uncolonized bare area in the center and a high number of Russian thistle plants. Pool U-7 was very dry and the only vegetation present was Russian thistle. Pool U-8 had a number of patches of cheat grass surrounded by bare soil within the former pool perimeter; lowland cudweed dominated other areas within this pool. Pool U-9 had a wider pond-like area and a longer stream-like section. The pond-like area was dominated by broad-leaved pepperweed. Figure 3-34 contains pictures of pools U-5, U-6, U-8, and U-9 taken on July 18; pool U-7 was not photographed on that date.

Figure 3-34. Umtanum Pools U-5, U-6, U-8 and U-9 (July 18, 2017)

3.3 Gable Butte Vernal Pools

Vernal pools on Gable Butte are found in two distinct areas. The largest set, a cluster of 10 or more pools found in the saddle to the west of the railroad cut, is the subject of this section. The pools in this area of Gable Butte were the largest seen on the Hanford site in 2017. The second area on Gable Butte is further to the west and contains the blind canyon pool.

3.3.1 Gable Butte Saddle Area

3.3.1.1 Gable Butte Saddle – March 6, 2017

After finding vernal pools on Umtanum Ridge in late February, other known pool locations, including the pools on Gable Butte, were visited. On March 6 2017, a preliminary survey to locate pools was performed. GPS data were collected for the perimeters of the three largest pools (GB-1, GB-2, and GB-4). Other smaller pools were noted as discrete points. Figure 3-35 shows the locations of the pools in the Gable Butte saddle area; the pool boundaries measured on March 6 are shown, as well as subsequent outlines measured in early April. Table 3-3 shows the sizes of pools GB-1, GB-2, and GB-4 in early March.

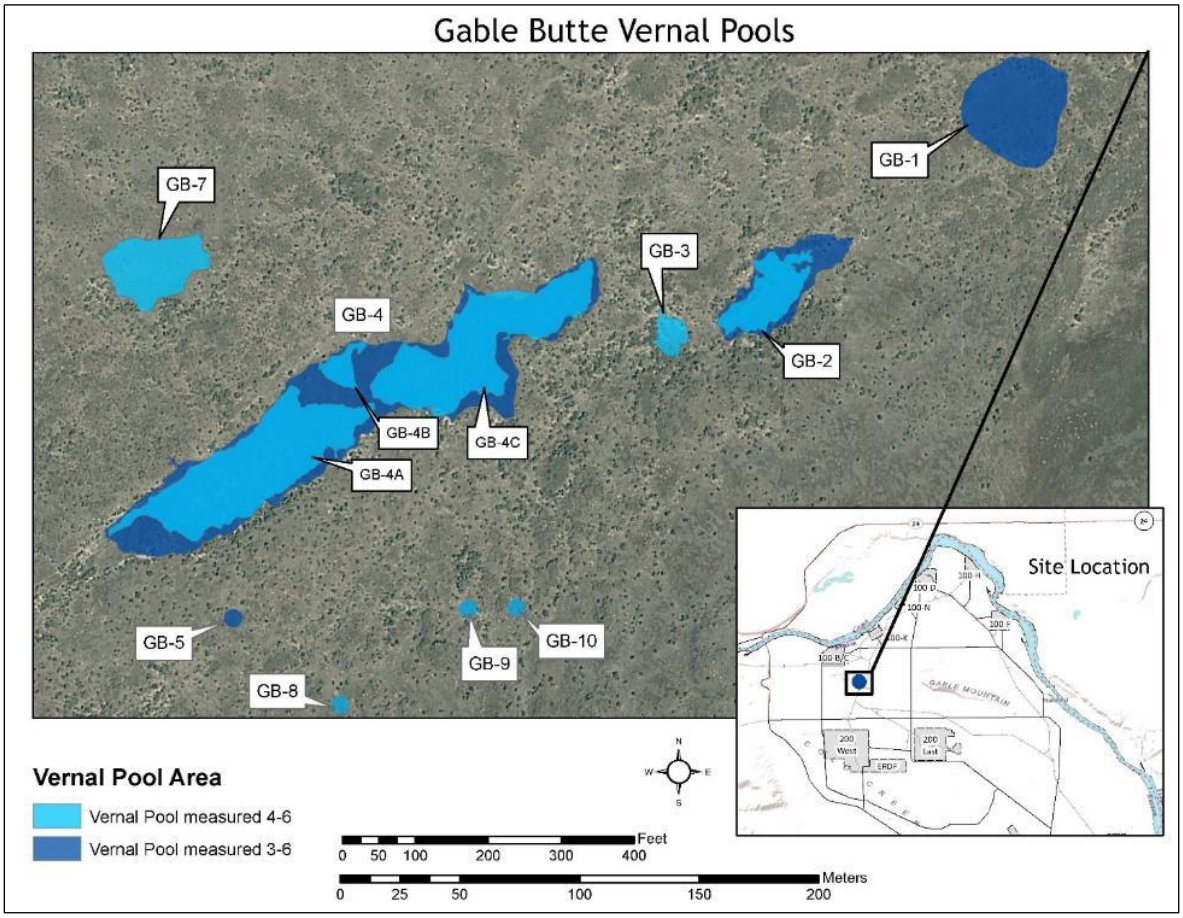

Figure 3-35. Cluster of Vernal Pools in the Saddle on Gable Butte (March 6 and April 6, 2017)

Table 3-3. Gable Butte Vernal Pool Sizes (March 6, 2017).

Gable Butte	Date	Pool Area (m^2)	Pool Area (acres)
GB-1	3-6	1542.18	0.381
GB-2	3-6	1202.34	0.297
GB-4	3-6	7014.71	1.733

The first pool (labeled GB-1) seen was also the furthest pool to the northeast in the Gable Butte group. Elk and mule deer tracks were observed surrounding the pool. The surrounding area was quite rocky. Lichens, mosses, and blooming small spring annuals, notably spring whitlow grass, dominated the vegetation on the surrounding lithosol. Figure 3-36 shows pool GM-1 on March 6.

Figure 3-36. Gable Butte Pool GB-1 on March 6, 2017

Gable Butte pools GB-2 and the adjacent, much smaller pool GB-3 were located to the southwest of GB-1. Pools GB-2 and GB-3 are shown in Figure 3-37.

Figure 3-37. Gable Butte Pools GB-2 and GB-3 on March 6, 2017

GB-4 was by far the largest vernal pool seen on the Hanford Site in 2017. The pool stretched down the saddle area along a Northeast-Southwest axis, and sometimes gave the appearance of a series of connected pools. Water depth appeared to vary quite a lot from point to point. During the measurement of pool GB-4, another pool was seen slightly to the northwest; this pool was not photographed on March 6. Several views of pool GB-4 on March 6 are found in Figure 3-38.

Figure 3-38. Gable Butte Pools GB-2 and GB-3 on March 6, 2017

A number of smaller pool were seen to the south of pool GB-4 but only one of the largest (labeled GB-5) was photographed on March 6. Pool GB-5 was estimated as roughly 25 m^2 (0.006 ac). The area where these small pools were located has an exceptionally rocky layer with limited soils built up in pockets. Some of the deepest soils were found surrounding small pool locations where the mud was deep. Bunches of native Sandberg bluegrass was prevalent in the lithosol and could be seen under the surface of the water in the pools. Elk and mule deer tracks were seen throughout the area. Figure 3-39 shows pool GB-5 and the surrounding area.

Figure 3-39. Gable Butte Pool GB-5 and Surrounding Area on March 6, 2017

3.3.1.2 Gable Butte Saddle – March 16, 2017

Figure 3-40 provides aerial photographs of the vernal pools on the Gable Butte Saddle taken March 16. The aerial pictures captured images of the pools seen on the Gable Butte Saddle on March 6, as well as several pools that had not been identified on that visit.

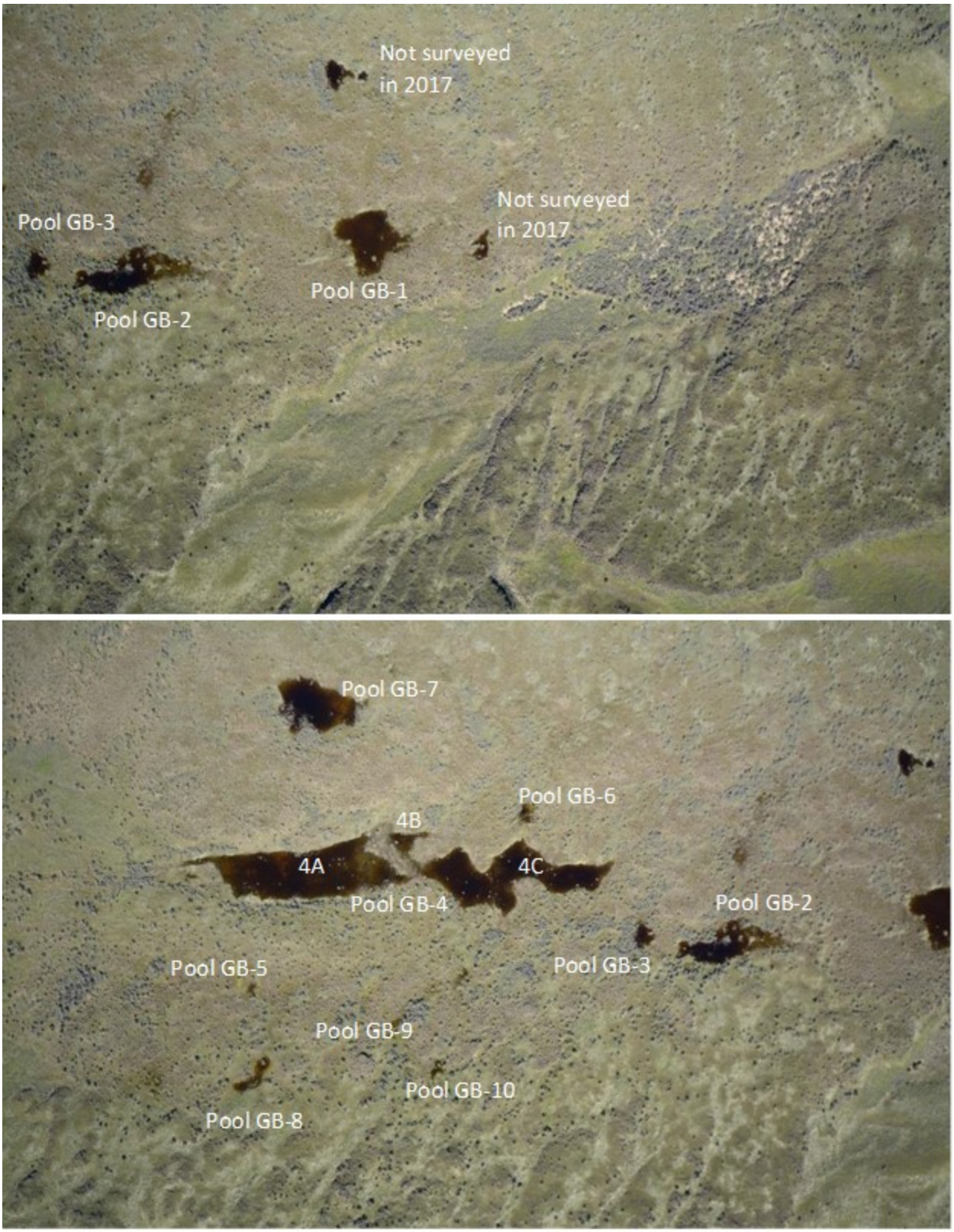

Figure 3-40. Aerial Photos of the Vernal Pools in the Gable Butte Saddle (March 16, 2017)

3.3.1.3 Gable Butte Saddle – April 6, 2017

The Gable Butte vernal pools visited in early March were revisited on April 6; in addition, another pool west of the large pool 4 that had been seen on the aerial photographs was visited and designated as pool GB-7. Many of the smaller pools south of pool GB-4 were dried out. Pools GB-1, GB-2, and GB-4 were reduced in size on this visit (Table 3-4). In particular, pool GB-4 had been segmented into 3 smaller pools. The rocky area around all of the pools was dominated by Sandberg bluegrass and cheatgrass. Spring whitlowgrass was still the most common forb found. The cryptogamic crust in the recently dried pools was especially healthy.

Table 3-4. Gable Butte Saddle Vernal Pool Sizes (April 6, 2017).

Gable Butte	Date	Pool Area (m^2)	Pool Area (acres)
GB-2	4-6	699.38	0.173
GB-3	4-6	182.04	0.045
GB-4A	4-6	2312.82	0.572
GB-4B	4-6	181.93	0.045
GB-4C	4-6	2521.14	0.623
GB-7	4-6	938.98	0.232

Pool GB-1 covered almost a third of an acre in early March but had dried out considerably by early April; the remaining pool was quite shallow. This pool was not remeasured due to the deep and muddy pool margins, which made it extremely difficult to walk around. The mosses in the dried-out potion of the pool were quite robust. Pool GB-2 also had dried out and covered about 58% of the area measured on March 6. Pool GB-3 had not been measured previously and covered less than 1/20 of an acre on April 6. Pools GB-1, GB-2, and GB-3 are shown in Figure 3-41.

Figure 3-41. Gable Butte Pools GB-1, GB-2, and GB-3 on April 6, 2017

GB-4 is by far the largest pool on the Hanford Site. On April 6 this pool was found to have split into three separate pools, which were subsequently labeled as GB-4A, GB-4B, and GB-4C from southwest to northeast, respectively. In total, these pools covered an area just shy of 5,058 m^2 (1.25 ac), which represents almost 72% of the size of the pool on March 6. Figure 3-42 depicts pool GB-4 in early April.

When staff arrived at pool GB-4A, four Bufflehead Ducks (*Bucephala albeola*) were actively feeding in the pool; the ducks stayed in one of the three sub-pools the entire visit. A Greater Yellowlegs (*Tringa melanoleuca*) was also moving along the edge of pool GB-4A and seemed hesitant to leave the area, suggesting a nest nearby. As usual at most of the pools, elk and mule deer tracks were quite evident around and in the pools. A D-net was used to sample macro-invertebrates in all three sub-pools. Similar species were found in all of the pools and consisted of many mosquito larvae, water boatmen, and water striders.

The vegetation immediately around pool GB-4 included cheatgrass, Sandberg bluegrass, and spring whitlowgrass. A small mustard (*Descurainia* sp.) was also occasionally found close to the pool edge. Further away, big-seeded desert parsley (*Lomatium macrocarpum*) and yellow bells (*Frittilaria pudica*) were common along with widely scattered big sagebrush shrubs.

Just upslope to the north of pool GB-4, a new pool (GB-7) was visited for the first time. Identified during the aerial flight, this pool covered about 930 m^2 (0.23 ac); it had been observed that the edges had dried out causing the pool to have begun shrinking by this date. Pool GB-7 is shown in Figure 3-43 below.

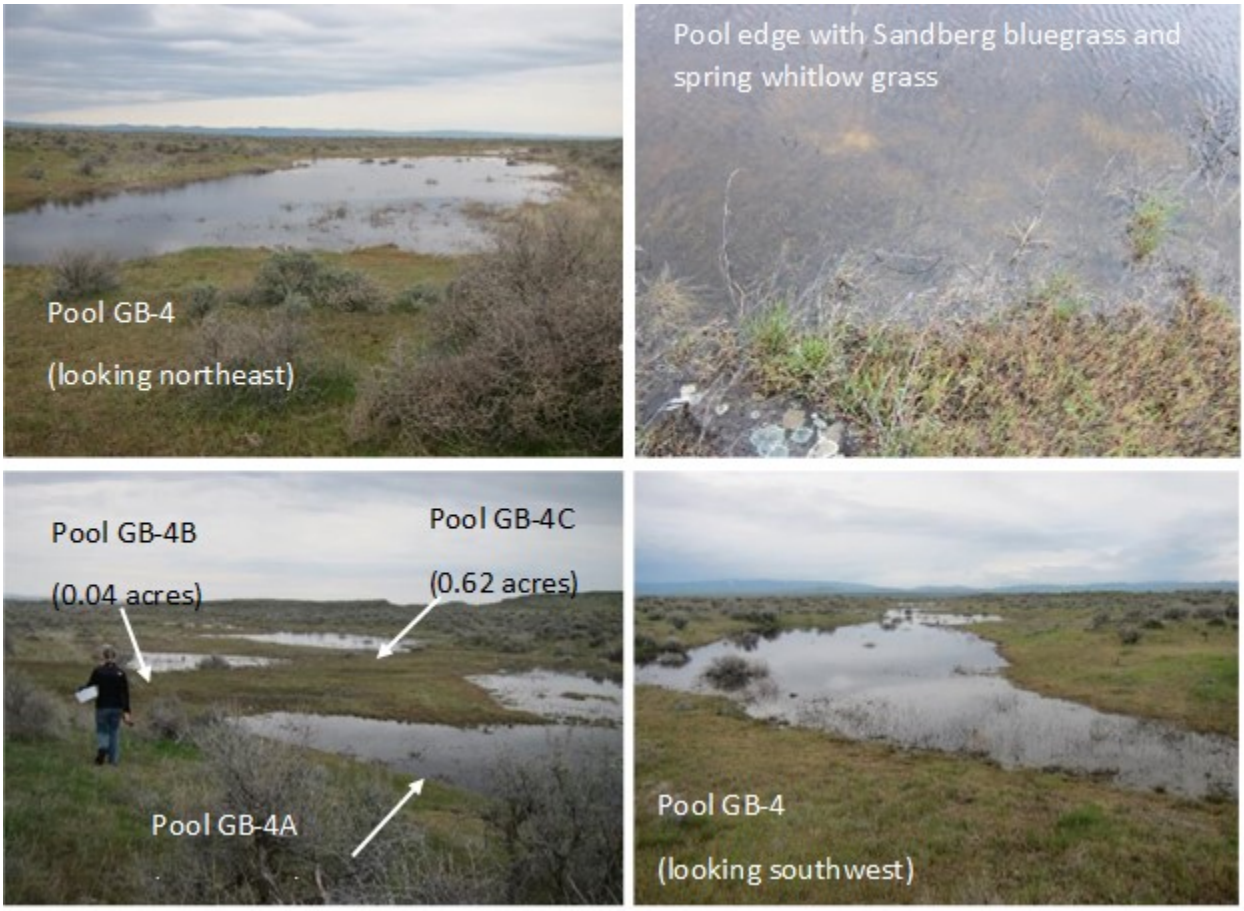

Figure 3-42. Gable Butte Pool GB-4 on April 6, 2017

Figure 3-43. Gable Butte Pool GB-7 on April 6, 2017

All of the other pools previously identified in early March had dried up by April 6. Typical dried pools on Gable Butte are shown in Figure 3-44.

Figure 3-44. Dried Out Gable Butte Pools Located South of GB-4 (April 6, 2017)

3.3.1.4 Gable Butte Saddle – April 28, 2017

With the advent of warmer days during April, the pools on Gable Butte had been dried out or significantly reduced in size. Pools GB-2, GB-3, GB-4, and GB-7 still had water in them, although the

original pool GB-4 now consisted of three very distinct pools. Pool GB-1, which was fairly large but shallow, had dried up.

The area within pool GB-1 that was slightly higher and dried out first was covered with a thick stand of cheatgrass. The Sandberg bluegrass that was underwater appeared to be the first plant to begin actively growing once the water receded. The soil in the pool was still moist enough to support a healthy cryptogamic crust. Elk and mule deer tracks crisscrossed the original pool area. Figure 3-45 shows pool GB-1 on April 28.

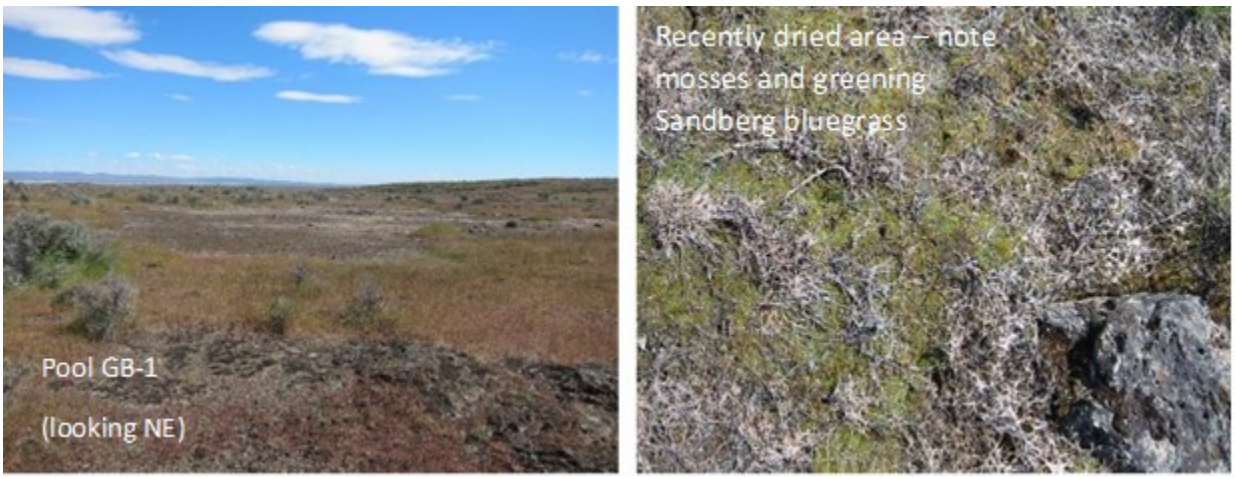

Figure 3-45. Gable Butte Pool GB-1 on April 28, 2017

Both pools GB-2 and GB-3 still contained water but the pool areas had shrunk significantly since April 6. There were still a number of elk, mule deer, and coyote tracks and scat around these pools. In addition to cheatgrass and Sandberg bluegrass, some flixweed (*Descurainia sophia*) had become established in the area that had recently dried. Figure 3-46 shows pools GB-2 and GB-3 in late April.

Figure 3-46. Gable Butte Pools GB-2 and GB-3 on April 28, 2017

Gable Butte pool GB-4 still was the largest pool on the Hanford Site; however, as noted in early April, this pool had separated into three sub-pools (labeled GB-4A, GB-4B, and GB-4C south to north) as it dried out. The breaks between the sub-pools expanded during the 3 weeks between the April sampling dates. In late April, Mallards (*Anas platyrhynchos*) were using the pool throughout the visit and a number of yellow swallowtail (*Papilo rufulus*) butterflies were observed. The sub-pools comprising pool GB-4 are shown in Figure 3-47.

Sampling for aquatic macro-invertebrates, using a D-net, was performed in the three sub-pools of pool GB-4 on April 28. Because other vernal pools in the scablands of eastern Washington support populations of fairy shrimp (Crustacean Order Anostraca), one of the specific goals for this sampling was to do a careful screen for their presence on Gable Butte. Although no fairy shrimp were found, macro-invertebrates collected included all sizes of water boatmen, red and white wrigglers (midge larvae), all stages of mosquito larvae and mosquito adults, and adult and larval diving beetles (Figure 3-48).

In addition to the invertebrates sampled, many Great Basin spadefoot toad (*Scaphiopus intermontana*) tadpoles were observed. The tadpoles were at different stages of development, which is not surprising given the very short metamorphosis time for this species (Figure 3-48).

Figure 3-47. Gable Butte Sub-Pools of GB-4 on April 28, 2017

Figure 3-48. Organisms found in Gable Butte Pool GB-4 on April 28, 2017

Pool GB-7 lies to the west of pool GB-4 in an area that is notable for the rocky rise from the saddle of the butte. The area where the pool is located appears to be a bit drier than the saddle area and supported some large pricklypear cacti (*Opuntia polyacantha*) plants. This pool had also grown much smaller since the visit 3 weeks before. Like the other pools on Gable Butte, there were many elk, mule deer, and coyote tracks surrounding the pool. Vegetation was still scarce in the dried-out area with Sandberg bluegrass, cheatgrass, and flixweed being the most commonly found species. A pair of Least Sandpipers (*Calidris minutilla)* appeared to be nesting in the weeds on the edge of pool GB-7. Figure 3-49 provides some pictures of this pool in late April.

Figure 3-49. Gable Butte Pool GB-7 on April 28, 2017

3.3.1.5 Gable Butte Saddle – July 31, 2017

The final visit to the Gable Butte pools on July 31 was made to assess the vegetation and conditions in the former pool areas. The pools on Gable Butte all had high rock cover and little soil, which was very dry by the end of July. All pools were visually examined for evidence of zonation in the vegetation layer. The species present in each pool area are listed in Table 3-5.

Table 3-5. Gable Butte, Vegetation Survey - July 31, 2017. (2 Pages)

Species	Common Name	GB-1	GB-2	GB 3	GB-4A	GB-4B	GB-4C	GB-5	GB-6	GB-7	GB-8	GB-9
SHRUBS												
Artemisia tridentata	big sagebrush							X				
GRASSES and RUSHES												
Bromus tectorum	cheatgrass	X	X	X			X	X	X	X	X	X
Distichlis stricta	alkali saltgrass						X					
Poa secunda	Sandberg bluegrass	X	X	X	X	X		X	X	X	X	X
Polypogon monospeliensis	rabbitfoot grass				x	X	X					

Table 3-5. Gable Butte, Vegetation Survey - July 31, 2017. (2 Pages)

Species	Common Name	GB-1	GB-2	GB 3	GB-4A	GB-4B	GB-4C	GB-5	GB-6	GB-7	GB-8	GB-9
Juncus bufonius	toad rush	X	X	X	X	X		X	X	X	X	X
FORBS												
Achillea millefolium	yarrow		X							X		
Amaranthus albus	white pigweed	X			X	X	X	X		X	X	X
Amsinckia lycopsoides	fiddleneck tarweed							X				
Centaurea repens	Russian knapweed								X			
Chenopodium leptophyllum	slimleaf goosefoot	X		X	X	X	X			X		
Cleome lutea	yellow beplant								X			
Conyza canadensis	horsetail	X	X	X				X			X	X
Draba verna	spring whitlow grass							X			X	
Epilobium brachycarpum	tall willowherb							X				
Erigeron pumilus	shaggy fleabane	X	X			X		X		X	X	X
Erodium cicutarium	storksbill					X						
Gnaphalium palustre	lowland knapweed	X	X	X		X		X	X	X	X	X
Heliotropium curassavicum	salt heliotrope		X	X	X	X	X		X	X		
Kochia scoparia	kochia								X	X		
Lactuca serriola	prickly lettuce	X	X	X		X	X			X		X
Lepidium perfoliatum	clasping pepperweed		X	X		X	X		X			
Neoholmgrenia andina	obscure suncup	X	X									
Plantago patagonica	woolly plantain							X				X
Salsola tragus	Russian thistle	X	X	X	X	X	X	X		X	X	X
Sisymbrium altissimum	Jim Hill tumble mustard	X	X	X	X	X	X	X		X	X	X
Spharalcea munroana	Munro's globemallow	X		X		X	X	X		X		X
Tragopogon dubius	salsify	X		X				X				
Verbena bracteata	carpet verbena		X	X	X		X			X		

Gable Butte pool GB-1 is very rocky throughout with a noticeable cryptogamic crust growing between the rocks; in fact, moss is a dominant vegetation cover in pool GB-1. No zonation was apparent in this pool, which is shown in Figure 3-50.

Figure 3-50. Gable Butte Pool GB-1 and Some Representative Vegetation (July 31, 2017)

Some zonation was seen in pool GB-2, and the cryptogamic crust (both lichens and mosses) was quite noticeable. No zonation was noted in the smaller adjacent pool GB-3. Pools GB-2 and GB-3 are shown in Figure 3-51.

Figure 3-51. Gable Butte Pools GB-2 and GB-3 (July 31, 2017)

Pool GB-4 had broken down into three smaller pools by early April; each of the sub-pools were considered separately during the July 31 survey.

- Pool GB-4A was the southernmost (and largest) pool. This pool had large areas covered with a dark gravel substrate. The gravel appeared to support a healthy cryptogamic crust. During the survey, three Nighthhawks circled the pool overhead. No zonation was noted in pool GB-4A.

- Pool GB-4B was the middle (and smallest) pool. No zonation was noted in this pool.

- Pool GB-4C was the northernmost pool. Some zonation, based on soil color, was noted in this pool. Soil in the center of the pool appeared darker and has increased vegetation compatred to the outer sections of the pool. Vegetation in these areas was dominated by narrowleaf goosefoot (*Chenopodium leptophyllum*). Some cryptogamic crust was noted, especially mosses. Overall, this pool had less vegetation cover than the other two sub-pools. Fresh coyote scat was found in pool GB-4C.

Pool GB-6 was a small pool located just to the north of pool GB-4C that had dried sometime in March. The pool was covered with a whitish layer on the soil and supported the showy yellow beeplant (*Cleome lutea*), which was being visited by a number of bees during the July 31 site visit.

Figure 3-52 provides pictures of each of the GB-4 sub-pools and pool GB-6, Figure 3-53 shows some of the common vegetative species found in late July.

Figure 3-52. Gable Butte Pools GB-4A, GB-4B, GB-4C, and GB-6 (July 31, 2017)

Figure 3-53. Some of the Plants Seen at Gable Butte Pools GB-4, and GB-6 (July 31, 2017)

Gable Butte pool GB-5 contained dark soils among the rocks. The cryptogamic crust in this pool seemed to cover a greater proportion of the soil than in other pools; mosses and lichens were quite noticeable. A sagebrush shrub in the pool seemed to have weathered the seasonal inundations (Figure 3-54).

Figure 3-54. Gable Butte Pool GB-5 (July 31, 2017)

Pool GB-7 appeared to have patches of vegetation, which may be due to rock cover or lack of soil. Cryptogamic crust cover was patchy as well. When crust was present, mosses were prevalent. Pool GB-7 was one of the last pools to dry out. Figure 3-55 shows pool GB-7 in late July.

Figure 3-55. Gable Butte Pool GB-7 (July 31, 2017)

Pools GB-8 and GB-9 were both small pools located to the south of pool GB-4. Both of these pools had dried by the end of March. There is little soil at either pool location. Figure 3-56 shows pools GB-8 and GB-9 on July 31.

Figure 3-56. Gable Butte Pools GB-8 and GB-9 (July 31, 2017)

3.3.2 Gable Butte Blind Canyon Pool

The blind canyon pool on Gable Butte was identified during the aerial flight on March 16 and was first visited on March 30, 2017. This pool is located in a small area bordered by steep basalt formations on both sides and by a ridge with a steep drop off at the northeast edge. Although this pool is on Gable Butte, it is separated from the larger cluster of pools to the east. Later in the season, a second pool near the ridge was located to the east of the blind canyon pool; however, the second pool was not monitored in 2017. Figure 3-57 is an aerial photograph of the area where these two pools occured.

3.3.2.1 Gable Butte Blind Canyon Pool – March 30, 2017

The blind canyon pool covered an area of 465.9 m^2 (0.115 acre) on March 30. As shown in the aerial photo above and in the map in Figure 3-58, this pool's area was limited by the steep canyon sides. Animal signs around the pool on March 30 included many mule deer and elk prints, as well as scat. The vegetation around and sometimes underwater at the edge of the pool included cheatgrass, spring whitlowgrass, and cranesbill (*Erodium cicutarium*). The area had a very rocky base and a nice cryptogamic crust. Last year's Russian thistle was found around and on the pool; in some areas, the tumbleweed pile was several feet deep. Figure 3-59 shows the blind canyon pool on March 30.

Figure 3-57. Aerial Photograph of the Blind Canyon Pool on Gable Butte (March 16, 2017)

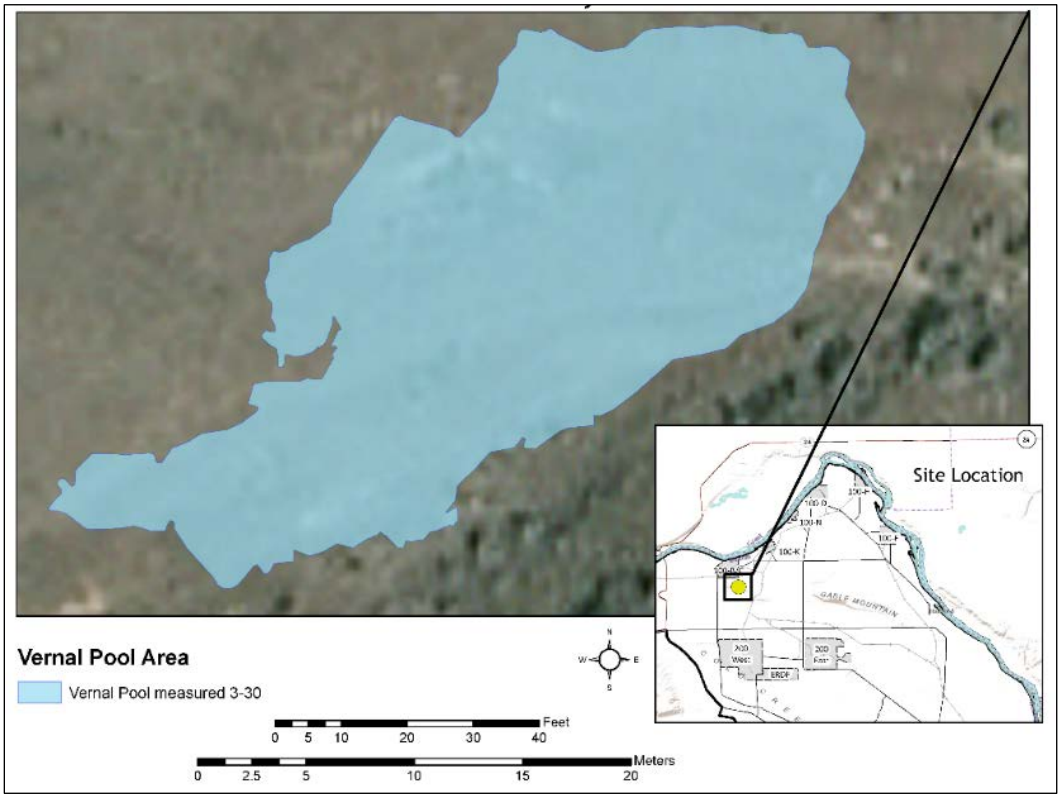

Figure 3-58. Map of Gable Butte Blind Canyon

Figure 3-59. Gable Butte Blind Canyon Pool (March 30, 2017)

3.3.2.2 Gable Butte Blind Canyon Pool - April 6, 2017

The area covered by the blind canyon pool on April 6 appeared to be the same as it had been the week before. A trail camera was installed next to a clump of giant wildrye at the entrance to the small canyon. Sandberg bluegrass, bluebunch wheatgrass, and prairie star (*Lithophragma parviflorum*) were common on the cliffs above the pool. Figure 3-60 depicts this vernal pool on April 6.

Figure 3-60. Gable Butte Blind Canyon Pool (April 6, 2017)

3.3.2.3 Gable Butte Blind Canyon Pool – April 28, 2017

The blind canyon pool was slightly smaller on the April 28 visit than it had been 3 weeks earlier; it appeared to have shrunk roughly 1 ft (30.5 cm) around the entire perimeter. The water remaining in the pool was a deep golden-brown color and had a large amount of decaying vegetation in it that may account for the distinct odor emanating from the pool. In the area that had recently dried, the vegetation moving in included cheatgrass, spring whitlowgrass, flixweed (*Descuriana sophia*), and salsify (*Tragopogon dubius*). The perennial Sandberg bluegrass also seemed to begin to turn green once the water receded. Figure 3-61 provides a look at the blind canyon pool in late April.

The steeper area around the pool was dominated by big sagebrush, bluebunch wheatgrass, and Sandberg bluegrass. Forbs, including long-leaved phlox (*Phlox longifolia*), white cupseed (*Plectritis macrosera*), big-seed desert parsley (*Lomatium macrocarpum*), and cushion fleabane (*Erigeron poliospermus*), were in bloom in this area.

Figure 3-61. Gable Butte Blind Canyon Pool (April 28, 2017)

Macro-invertebrates collected in the pool using a D-net included red and white wrigglers (midge larvae), many water boatmen, mosquito larvae, and diving beetles. Figure 3-62 shows some of the macro-invertebrates sampled.

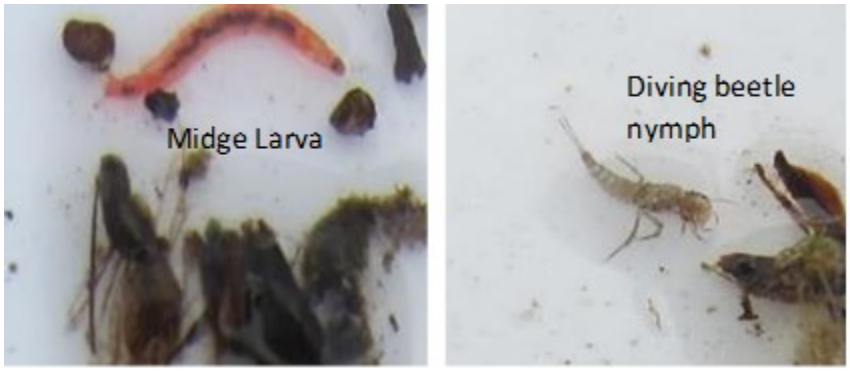

Figure 3-62. Macro-Invertebrates from Gable Butte Blind Canyon Pool (April 28, 2017)

The trail camera that was placed on the previous visit was retrieved on April 28. Pictures taken each day at noon did not show noticeable daily changes in the pool size, but use of the pool by wildlife was common (Figure 3-63). Pictures of elk, mule deer, and a pair of mallards were taken until the camera was knocked over by an elk on April 27.

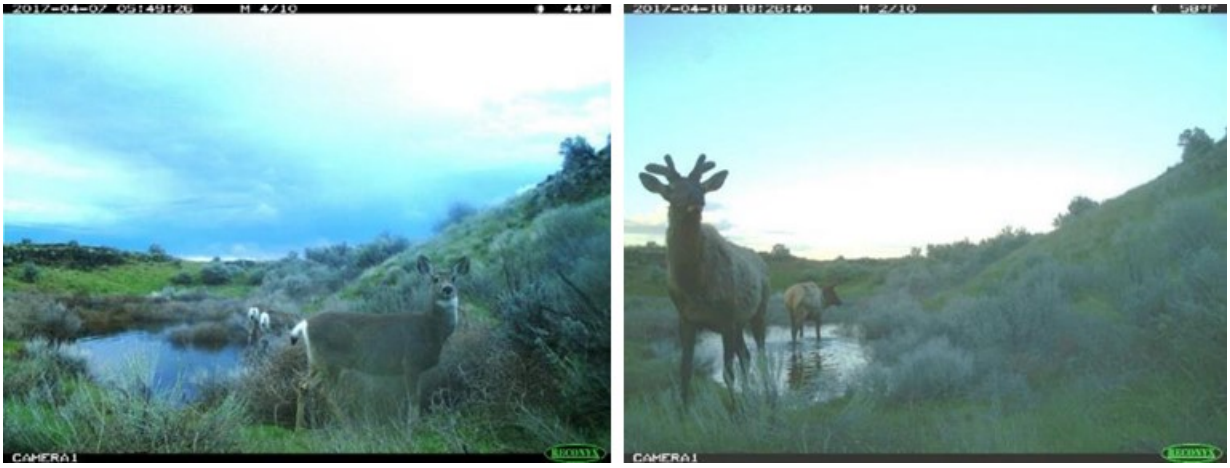

Figure 3-63. Mule Deer and Elk Captured on Trail Camera at Blind Canyon Vernal Pool (April 2017)

3.3.2.4 Gable Butte Blind Canyon Pool - May 8, 2017

As shown in Figure 3-64, the blind canyon pool had lost some water but was still being used heavily by wildlife. Water in the pool was quite odiferous and surrounding mud contained numerous elk and mule deer hoof prints as well as coyote prints and scat. Little vegetation was seen in the area where the water had receded; however, the wildrye on the edge of the pool had grown substantially.

Figure 3-64. Gable Butte Blind Canyon (May 8, 2017)

3.3.2.5 Gable Butte Blind Canyon Pool – August 17,2017

The blind canyon pool had dried by the final visit on August 17. The pool had heavy rock cover and a lighter grey soil was observed in the center of the pool. Soil moisture was very dry. Fresh coyote scat was observed within and around the pool boundary. High bee and butterfly activity was noted. Figure 3-65 shows the blind canyon pool on August 17.

Figure 3-65. Gable Butte Blind Canyon Pool (August 17, 2017)

The vegetation present in the blind canyon pool on August 17 is shown in Table 3-6. This pool had some zonation present. Toad rush, horseweed, annual rabbitsfoot grass, and lowland cudweed were generally found on the outer edge of the pool while the other species listed in the table were more common in the center. Figure 3-66 shows some of the species seen during the monitoring.

Table 3-6. Gable Butte Blind Canyon, Vegetation Survey (August 17, 2017).

Species	Common Name
GRASSES AND RUSHES	
Polypogon monospeliensis	annual rabbitsfoot grass
Juncus bufonius	toad rush
FORBS	
Amaranthus albus	white pigweed
Cleome lutea	yellow beeplant
Conyza canadensis	horsetail
Epilobium brachycarpum	tall willowherb
Gnaphalium palustre	lowland cudweed
Heliotropium curassavicum	salt heliotrope
Plantago patagonica	woolly plantain
Salsola tragus	Russian thistle
Verbena bracteata	carpet verbena

Figure 3-66. Vegetation in Gable Butte Blind Canyon Pool (August 17, 2017)

3.4 Gable Mountain Vernal Pools

The Nature Conservancy descriptions of the pools found in the mid-1990s included a cluster of pools on the southeast lower elevations of Gable Mountain. This area was revisited in 2017 and the three pools were located and mapped as shown in Figure 3-67. This area is quite rocky and the surrounding vegetation was dominated by cheatgrass and Sandberg bluegrass. The cryptogamic crust was very well developed on the lithosols around the pools.

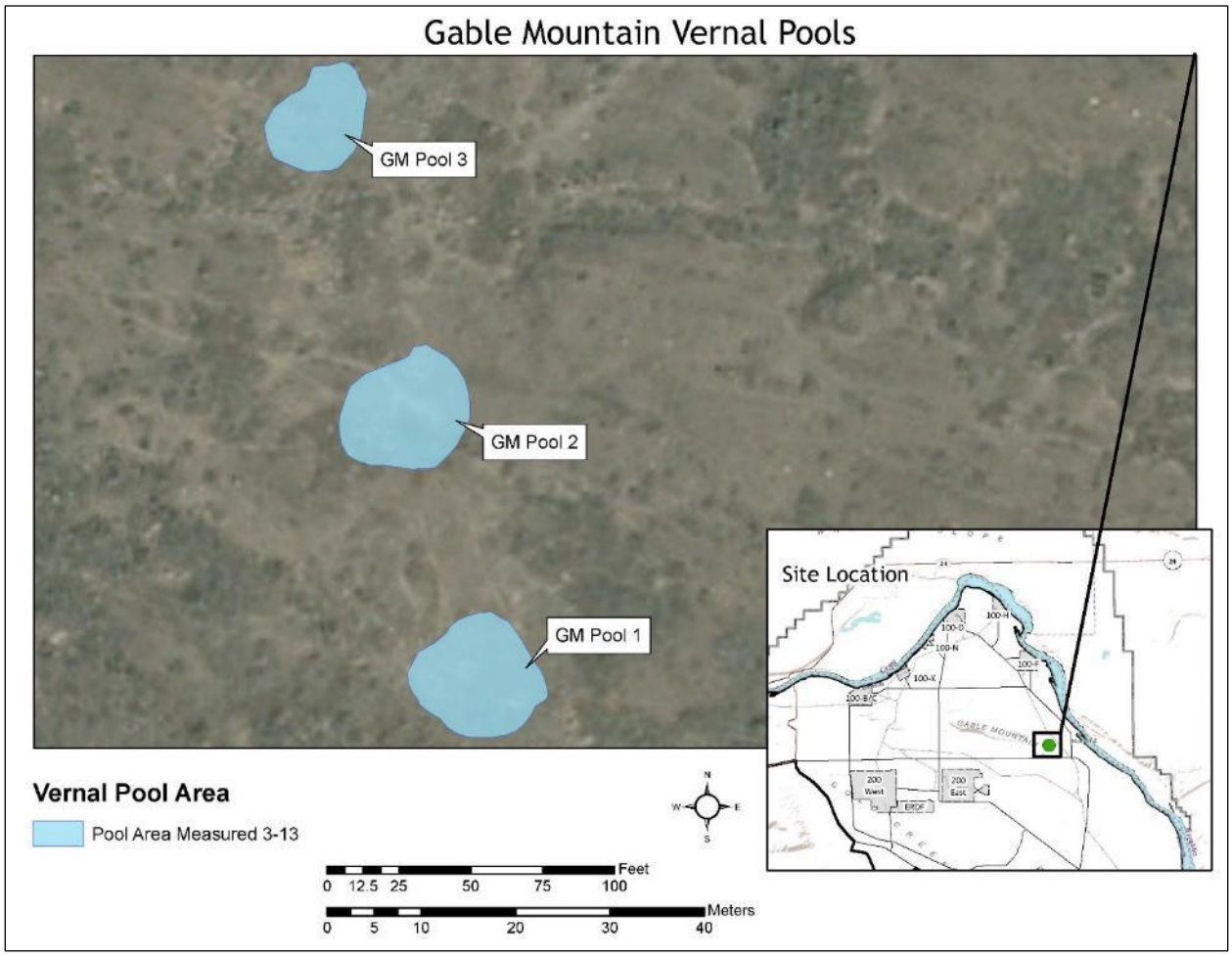

Figure 3-67. Vernal Pools on Gable Mountain (March 13, 2017)

The initially measured area of the Gable Mountain pools (designated as GM-X) is shown in Table 3-7.

Table 3-7. Size of Vernal Pools on Gable Mountain on March 13, 2017.

Pool Number	Date Measured	Pool Area (m^2)	Pool Area (acres)
GM1	3-13	137.60	0.034
GM2	3-13	137.36	0.034
GM3	3-13	90.41	0.022

3.4.1 Gable Mountain Pools – March 13, 2017

The first visit to vernal pools on Gable Mountain occurred on March 13. All three pools were spherical in shape and were similar in area (Table 3-7). The Gable Mountain pools were surrounded by quite rocky lithosols. The primary vegetation at the borders of the pools consisted of cheatgrass, Sandberg bluegrass, and spring whitlowgrass. Figure 3-68 shows these three pools and the surrounding area on March 13.

Figure 3-68. Vernal Pools on Gable Mountain (March 13, 2017)

3.4.2 Gable Mountain Pools – March 16, 2017

The aerial survey pools on March 16 flew just to the north of the Gable Mountain pools allowing pools GM-2 and GM-3 to be photographed; pool GM-1 was not photographed. No additional pools were detected.

3.4.3 Gable Mountain Pools – March 30, 2017

The Gable Mountain pools were revisited on March 30; at that time all pools still contained water and had active populations of macro-invertebrates. The area surrounding the pools consisted primarily of cheatgrass, spring whitlowgrass, Sandberg bluegrass, needle-and-thread grass (*Hesperostipa comata*), Russian thistle, and Jim Hill tumblemustard. Some of the first three species listed were also visible underwater at the edge of the pool. Mosses and lichens were quite vigorous around the pool and sometimes extended into the pool. Pool GM-1 covered an area 89% of the size measured on March 13, the area of pool GM-2 had dropped to roughly 69% of its former size, and GM-3 had shrunk to 75% of the earlier size. Figure 3-69 depicts all three pools on March 30, 2017.

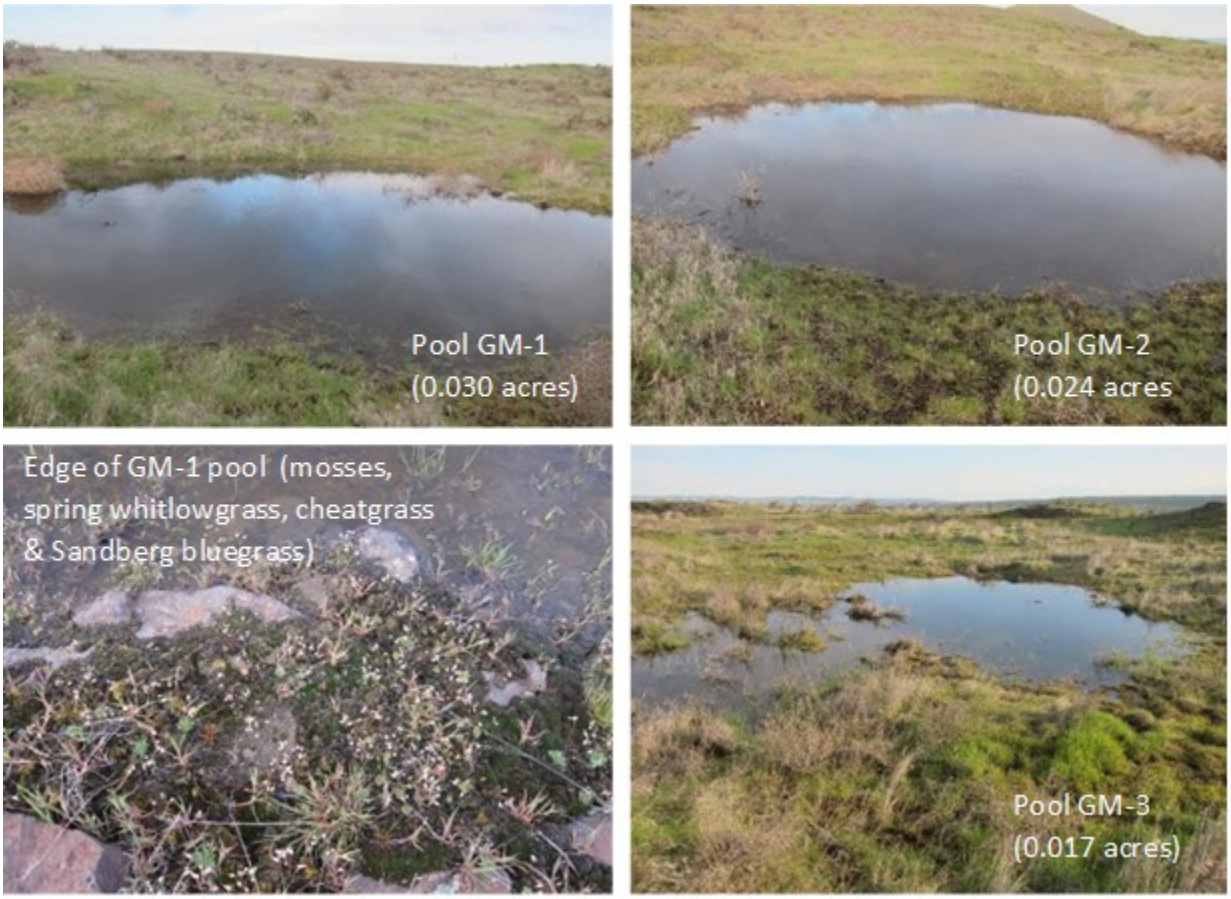

Figure 3-69. Vernal Pools on Gable Mountain (March 30, 2017)

Animal signs around and in the pool included elk tracks and scat, mule deer tracks and scat, and coyote scat. Meadowlarks were seen and heard around the pools throughout the survey. Figure 3-70 shows animal signs and a close-up of the lithosol surrounding the Gable Mountain pools.

Figure 3-70. Lithosol and Animal Signs Around Gable Mountain Pools (March 30, 2017)

Macro-invertebrates were observed in a white plastic tub after collection by sweeping a D-net through the water and loose debris material on the bottom of the pools. Water boatmen, midge larvae, and mosquito larvae were common along with small flies. Diving beetle larvae were also seen. Figure 3-71 shows the method used to sample the pools and a few of the invertebrates found.

Figure 3-71. Sampling Gable Mountain Pools for Macro-Invertebrates (March 30, 2017)

3.4.4 Gable Mountain Pools – May 8, 2017

Of the three pools on Gable Mountain, only GM-1 had any water remaining in it on May 8. This pool covered roughly 47% of the initial area measure in early March. Figure 3-72 captures the progression of the dry out of Gable Mountain pools from March 13 through May 8, 2017.

On May 8, all of the pools on Gable Mountain had signs of heavy use by elk and mule deer. A trail camera that had been set up near pool GM-1 on March 30 provided a number of pictures despite having been knocked over on April 1 (Figure 3-73). Gable Mountain pool GM-1 had a pair of mallards on it when the survey began. Killdeers were also active in the immediate area and may have been nesting nearby.

Pool GB-1 was almost 60% smaller than it was on March 30, but the water remaining in the pool was teeming with many invertebrates including diving beetles, water boatmen, mosquito larvae, and red and white wrigglers. Figure 3-74 shows pool GM-1 on May 8 along with some of the macro-invertebrates found in that pool.

Gable Mountain pools GM-2 and GM-3 were both dried out on May 8, although GM-2 still had mud in the center of the former pool. Small annuals, including purslane speedwell (*Veronica peregrina*), jagged

chickweed (*Holosteum umbellatum*), obscure suncup, lowland cudweed, and Russian thistle, as well as liverworts were beginning to colonize the pools. Figure 3-75 shows pool GM-2 and GM-3.

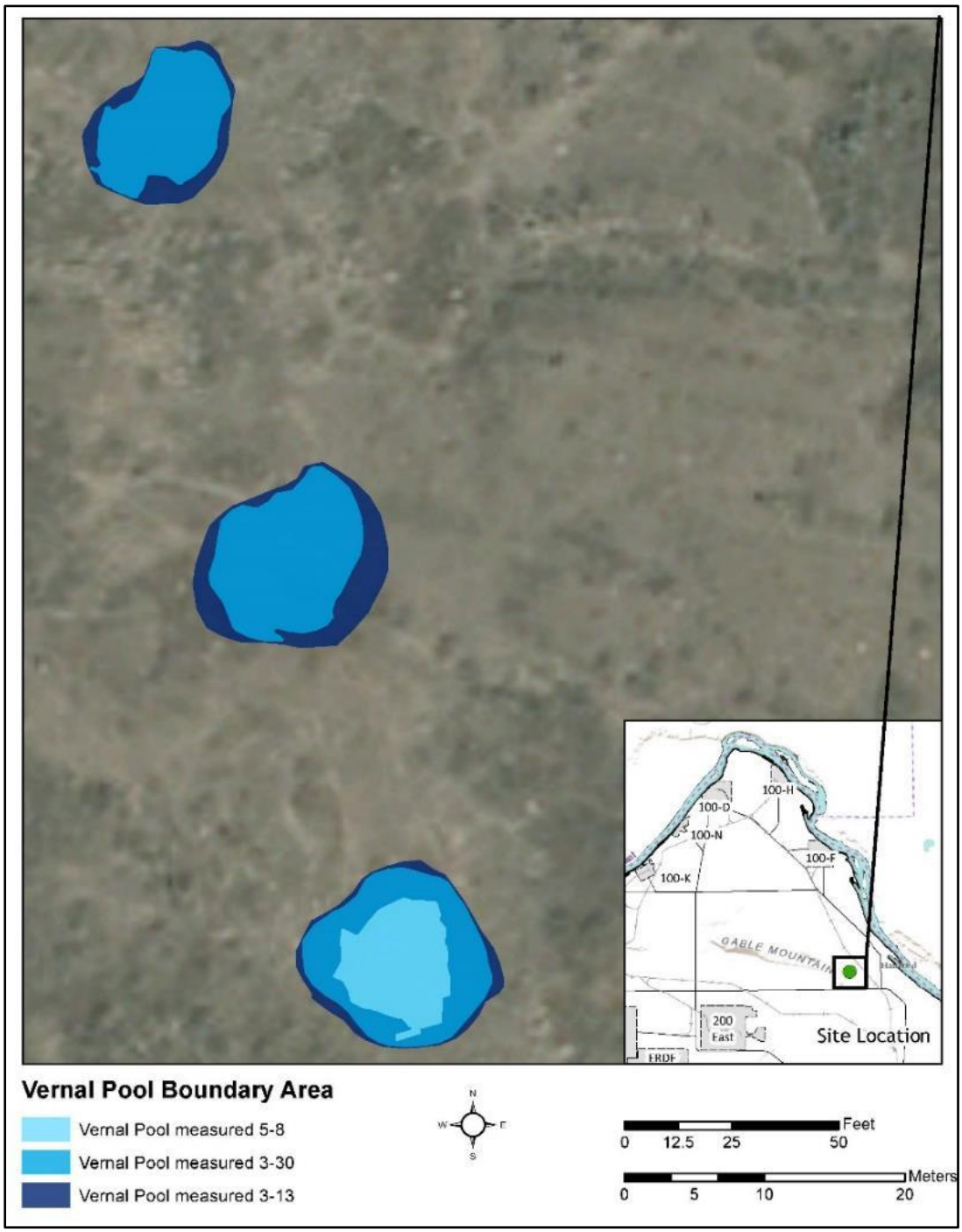

Figure 3-72. Progression of Gable Mountain Pools Dry Out in Spring 2017

Figure 3-73. Mule Deer and Elk Use of Gable Mountain Vernal Pools

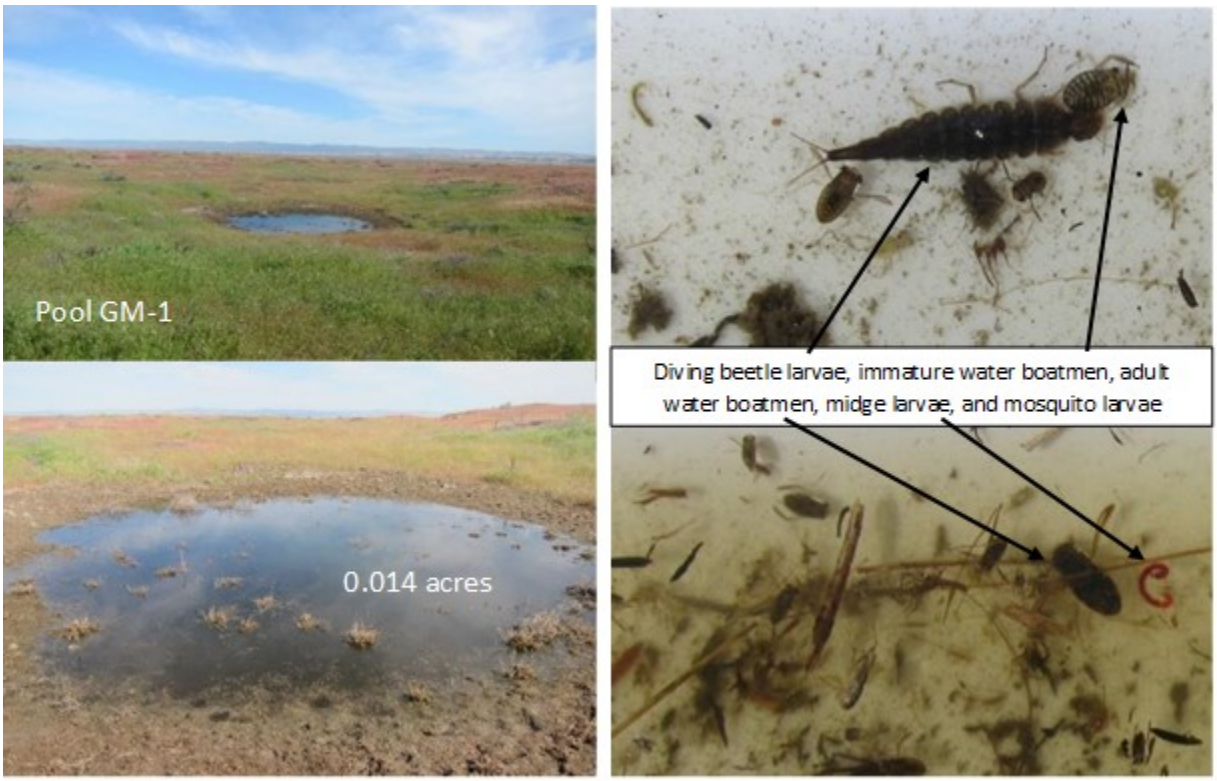

Figure 3-74. Pool GM-1 and Aquatic Invertebrates on May 8, 2017

Figure 3-75. Gable Mountain Pools GM-2 and GM-3 (May 8, 2017)

3.4.5 Gable Mountain Pools – June 5, 2017

By early June all of the Gable Mountain pools were dried out and the former pool areas supported a growing herb layer. The greening pools were quite visible from a distance since they stood out from the browning vegetation surrounding them. The most prominent plant species colonizing the pools were lowland cudweed, cheatgrass, Sandberg bluegrass, toad rush, Russian thistle, thyme-leaved spurge (*Euphorbia serpyllifolia*), and tumblemustard. Suksdorf's monkeyflower, a Washington State sensitive species, was also present in the pools. Figure 3-76 depicts the three Gable Mountain pools and some of the vegetation colonizing them.

Figure 3-76. Gable Mountain Pools GM-1, GM-2, and GM-3 (June 8, 2017)

3.4.6 Gable Mountain Pools – July 24, 2017

The final visit to the Gable Mountain pools occurred on July 24, 2017. The soil in all three pools was light in color and very dry. Both pools GM-1 and GM-2 appeared to have some zonation, with the centers of the pools having sparse vegetation with lowland cudweed and toad rush as the most prevalent species. Table 3-8 provides a list of the species present in late July at all three pools. Coyote activity was noticeable throughout the area, most noticeably around GM-1 and GM-2, which both had burrows on the perimeter of the former pool. Bee and butterfly activity was noted during the survey, especially near pool GM-1 and GM-3. Figure 3-77 shows all three pools as they appeared in late July.

Table 3-8. Gable Mountain Vegetation Survey - July 18, 2017.

Species	Common Name	GM-1	GM-2	GM-3
GRASSES AND RUSHES				
Bromus tectorum	cheatgrass	X		X
Poa secunda	Sandberg bluegrass	X	X	X
Polypogon monspeliensis	annual rabbitfoot grass	X		
Juncus bufonius	toad rush	X	X	X
FORBS				
Amaranthus albus	white pigweed	X	X	X
Ambrosia acnthicarpa	bur ragweed	X	X	
Amsinckia lycopsoides	fiddleneck tarweed			X
Conyza canadensis	horsetail			X
Erigeron pumilus	shaggy fleabane			X
Euphorbia serpyllifolia	thymeleaf spurge		X	
Gnaphalium palustre	lowland cudweed	X	X	X
Lactuca serriola	prickly lettuce		X	
Salsola tragus	Russian thistle	X	X	X
Sisymbrium altissimum	Jim Hill tumblemustard		X	X
Sphaeralcea munroana	Munro globemallow			X
Verbena bracteata	carpet verbena	X	X	

X = Present

Figure 3-77. Gable Mountain Pools on July 24, 2017

3.5 Summary and Conclusions

Vernal pools on the Hanford Site exhibited a wide range of characteristics ranging from their size and persistence to the species present. This section provides an overall summary of the observations made

and data collected for the Hanford Site's vernal pools in 2017, as well as the trends noted and conclusions reached.

3.5.1 Location and Sizes

In 1997, approximately 20 vernal pools were documented by the TNC in three separate clusters: the eastern end of Umtanum Ridge, the saddle area just west of the railroad cut on Gable Butte, and at the southeast toe of Gable Mountain (TNC 1998). In 2017, pools were documented in all three of these locations. An additional pool situated along the northern ridge in a blind canyon was recorded further west on Gable Butte (Figure 3-9). The aerial flight over the northern portion of the Hanford Site allowed the identification of several pools not seen during the ground survey including the pool in the blind canyon and a second pool just to the east of that pool (Figure 3-9).

All of the pools were located in rocky areas with exposed basalt and very shallow soils. The underlying impermeable basalt layer allows water to pool in lower lying areas following fall-winter rainfall and snowmelt. The size of the pools vary based on the size of the local depressions and the amount of precipitation received. In 2017, pools ranged in area from 7,015 m^2 (1.73 ac) to puddle-sized; the median size of the pools large enough to measure (larger than roughly 10 m^2 [0.002 ac]) was 360 m^2 (0.09 ac). Many of the pools appeared as though they were filled with water most years; however, that has not been documented to date.

The vegetation surrounding the vernal pool locations is typical of local lithosolic communities. Big sagebrush (*Artemisia tridentata*), stiff sagebrush (*Artemisia rigida*), and buckwheats (*Eriogonum* spp.) were the most common shrubs surrounding the pools; Sandberg bluegrass (*Poa secunda*) and bluebunch wheatgrass (*Psuedoregnaria spicata*) were the most commonly represented bunchgrasses in the understory.

3.5.2 Seasonal Timelines

The presence and duration of vernal pools on the Hanford Site appears to vary drastically from year to year. The sections below discuss the relationship between yearly patterns in snowfall and total precipitation and the presence of vernal pools in the spring as well as the season patterns of pool dry out seen in 2017.

3.5.2.1 Yearly Patterns

Timelines for the vernal pools are highly dependent on the weather patterns for that particular season. Because the water in the pools comes from precipitation, rainfall and snow cover during the previous fall and winter may determine if the vernal pools are seen at all, as well as how short the period of inundation is at each site.

As a comparison with other years, the period from September 2016 to February 2017 ranks as the third "wettest season" since the fall/winter of 1995/1996. Table 3-9 provides an overview of the September through February precipitation during those years (MSA 2018). Note that the wettest fall-winter periods prior to 2016/2017 occurred in the back-to-back seasons of 1995/1996 and 1996/1997. The Nature Conservancy identification and study of the vernal pools on the Hanford Site was in 1997 (TNC 1998).

Snowfall during the winter months may also be tied to the formation of vernal pools, since thaw may release a significant amount of water in a relatively short time frame. In the fall-winter of 2016/2017, 28.0 in. (71.0 cm) of snow fell. This snowfall amount was tied in the fall-winter season of 1995/1996 and exceeded only two times in the past 22 years: 40.5 in. (103 cm) in 1996/1997 and 28.4 in. (72.1 cm) in

2003/2004. Table 3-9 contains the snowfall recorded for the September through March period at the Hanford Meteorological Station; the normal snowfall (the 30-year average from 1981 through 2010) is 15.3 in. (38.9 cm) per year (MSA 2018).

Table 3-9. September through February Precipitation and September through March Snowfall at the Hanford Meteorological Station.

Year	Precipitation (inches)[1]	Snowfall (inches)
1995-96	***7.66***	***28.0***
1996-97	***9.22***	***40.5***
1997-98	***4.95***	8.1
1998-99	3.70	0.9
1999-2000	2.35	9.3
2000-01	3.59	14.4
2001-02	4.06	10.7
2002-03	***5.55***	1.3
2003-04	***5.46***	***28.4***
2004-05	2.63	12.2
2005-06	***5.44***	2.9
2006-07	4.33	8.1
2007-08	4.27	***26.5***
2008-09	3.75	***19.0***
2009-10	3.91	4.8
2010-11	***5.09***	***17.1***
2011-12	2.80	13.5
2012-13	3.54	6.0
2013-14	2.72	14.2
2014-15	3.33	1.4
2015-16	***4.72***	14.1
2016-17	***6.92***	***28.0***
Average (1946-2017)	4.3	14.2
Normal (30-year average from 1981-2010)	4.6	15.3

NOTE: Bolded and italicized data in shaded boxes were above normal.

3.5.2.2 2017 Vernal Pool Seasonality

Vernal pools were revisited periodically during 2017 until the pools dried out and vegetation had become established. The following patterns of pool dry out were seen for each of the pool locations:

- On Umtanum Ridge pools were beginning to dry out by mid-March and trail cameras captured the dry out of pool U-2, which appeared to be empty on March 18. By early April only the two largest pools on Umtanum (pools U-3 and U-4) still contained any water. Pool U-3 had shrunk by 63% and pool U-4 by 62% between March 13 and April 6. Exact dryout dates for these pools is not known but trail camera photographs show that pool U-4 still contained water on April 14.

- The pools located on the saddle of Gable Butte all contained water on March 6, but all of the smaller pools had dried out by the April 4. The five largest pools (GB-1, GB-2, GB-3, GB-4, and GB-7) still contained water in early April, although the largest pool (GB-4) had broken into three smaller pools.

By the end of April (April 28, 2017), all of these pools, with the exception of pool GB-1, had not yet dried out. All pools were dry by the final visit on July 31.

- The vernal pool located in the blind canyon on Gable Butte still had water in it on May 8 but had dried before the final visit on August 17.

- The Gable Mountain pools all held water through the end of March; but only pool GM-1 contained any water on May 8. By June 5, pool GM-1 had also dried out.

Overall, in 2017 the smaller vernal pools lasted only a few weeks and were dry by mid-March. The larger pools however still contained water well into the spring. Although the exact dates of dry out are unknown, it is clear that at least five or six pools were still present in mid-May.

3.5.3 Vegetation

Surveys of the vegetation present in the vernal pools occurred in mid-summer after all of the pools had dried out.

3.5.3.1 Species Found in the Vernal Pools

As listed in Table 3-10, a total of 47 species of vascular plants were observed in the vernal pool basins in 2017. Overall, approximately 62% of the species found in the pools were native while the rest were introduced. About 72% of the species in the pools were annuals.

The wetland status of the species observed is also noted in Table 3-10. The wetland status assigned was based on the *National Wetland Plant List* for the arid west (Lichvar et al. 2016). The indicator codes used in Table 3-10 are explained in the chart below.

Indicator Code	Indicator Status	Designation	Comment
OBL	Obligate Wetland	Hydrophyte	Almost always occur in wetlands
FACW	Facultative Wetland	Hydrophyte	Usually occur in wetlands, but may occur in non-wetlands
FAC	Facultative	Hydrophyte	Occur in wetlands and non-wetlands
FACU	Facultative Upland	Nonhydrophyte	Usually occur in non-wetlands, but may occur in wetlands
UPL	Obligate Upland	Nonhydrophyte	Almost never occur in wetlands

As is typical of seasonal wetlands, many of the plants found in the vernal pool basins after they dried up are nonhydrophytes; 43% are strictly upland species while an additional 30% are facultative upland plants. Of the remaining species, only *Erythranthe floribunda* is considered an obligate wetland species. Four species (*Gnaphalium palustre, Grindelia hitsuta, Juncus bufonius,* and *Polypogon monspeliensis*) are generally found in wetlands and the remaining seven species are facultative species, occurring in both wetland and non-wetlands.

Table 3-10. Vegetation Present in the Vernal Pool Basins after Dry-Out. (2 Pages)

Scientific Name	Common Name	Native or Introduced	Special Status	Wetland Status	Vernal Pool Locations		
					U Ridge	Gable Butte	Gable Mtn.
Achillea millefolium	yarrow	native		FACU		X	
Amaranthus albus	white pigweed	introduced		FACU	X	X	X
Ambrosia acanthicarpa	bur ragweed	native		UPL			X
Amsinckia lycopsoides	fiddleneck tarweed	native		UPL			X
Artemisia tridentata (recruits)	big sagebrush	native		UPL	X		
Bromus tectorum	cheat grass	introduced		UPL	X	X	X
Chaenactis douglasii	hoary false yarrow	native		UPL	X		
Chenopodium leptophyllum	slimleaf goosefoot	native		FACU		X	X
Convolvulus arvensis	field bindweed	introduced	WA - Class C weed	UPL			X
Conyza canadensis	horseweed	native		FACU	X	X	X
Cryptantha circumscissa	matted cryptantha	native		UPL	X	X	
Descurainia sophia	flixweed	introduced		UPL		X	
Distichlis spicata	alkali saltgrass	native		FAC		X	
Draba verna	spring whitlowgrass	introduced		UPL	X	X	X
Epilobium brachycarpum	tall willowherb	native		UPL		X	
Erigeron pumilus	shaggy fleabane	native		UPL	X	X	X
Erodium cicutarium	storksbill	introduced		UPL	X	X	
Erythranthe floribunda	purplestem monkeyflower	native		OBL	X	X	X
Erythanthre suksdorfii	Suksdorf's monkeyflower	native	WA - Sensitive	FACU	X	X	X
Euphorbia serpyllifolia	thymeleaf spurge	native		UPL		X	X
Gnaphalium palustre	lowland cudweed	native		FACW	X	X	X
Grindelia hirsutula	hairy gumweed	native		FACW			X
Heliotriopium curassavicum	salt heliotrope	native		FACU		X	
Holosteum umbellatum	jagged chickweed	introduced		UPL	X	X	
Hornungia procumbens	ovalpurse	introduced		FAC	X	X	X
Juncus bufonius	toad rush	native		FACW	X	X	X
Kochia scoparia	summer cypress	introduced	WA - Class B weed	FAC	X	X	

Table 3-10. Vegetation Present in the Vernal Pool Basins after Dry-Out. (2 Pages)

Scientific Name	Common Name	Native or Introduced	Special Status	Wetland Status	Vernal Pool Locations		
					U Ridge	Gable Butte	Gable Mtn.
Lactuca serriola	prickly lettuce	introduced		FACU	X	X	X
Lepidium latifolium	broadleaf pepperweed	introduced	WA - Class B weed	FAC	X	X	X
Lepidium perfoliatum	clasping pepperweed	introduced		FACU		X	
Leymus cinereus	giant ryegrass	native		FAC	X	X	X
Microsteris gracilis	pink microsteris	native		FACU	X		X
Neoholmgrenia andina	obscure suncup	native		UPL	X	X	X
Peritoma lutea	yellow bee-plant	native		FACU		X	
Plantago patagonica	woolly plantain	native		UPL		X	
Plectritis macrocera	white cupseed	native		FACU	X		
Poa secunda	Sandberg bluegrass	native		FACU	X	X	X
Polypogon monspeliensis	rabbitsfoot grass	introduced		FACW		X	X
Psuedoregneria spicata	bluebunch wheatgrass	native		UPL	X		
Rhaponticum repens	Russian knapweed	introduced	WA - Class B weed	UPL		X	
Salsola tragus	Russian thistle	introduced		FACU	X	X	X
Sisymbrium altissimum	Jim Hill tumble mustard	introduced		FACU	X	X	X
Sphaeralcea munroana	Munro's globemallow	native		UPL		X	X
Tragopogon dubius	salsify	introduced		UPL	X	X	
Verbena bracteata	carpet verbena	native		FAC	X	X	X
Veronica peregrina	purslane speedwell	native		FAC			X
Vulpia spp.	vulpia	introduced		N/A	X	X	X

As noted in Table 3-10, there were differences among the vegetation at the three pool locations; however, 18 species were found in all three pool locations. Figures 3-78 and 3-79 show the native species that were present at all three vernal pool locations, and Figure 3-80 shows some of the more distinctive introduced species found in all three locations.

Conyza canadensis
horseweed

Erigeron pumilis
shaggy fleabane

Erythranthe floribunda
purple-stemmed monkeyflower

Erythranthe suksdorfii
Suksdorf's monkeyflower

Gnaphalium palustre
lowland cudweed

Juncus bufonius
toad rush

Figure 3-78. Native Plants Found in Vernal Pools at All Three Locations

Leymus cinereus
giant wildrye

Neoholmgrenia andina
obscure suncup

Poa secunda
Sandberg bluegrass

Verbena bracteata
bracted verbena

Figure 3-79. Native Plants Found in Vernal Pools at All Three Locations

Amaranthus albus
white pigweed

Draba verna
spring whitlow grass

Hornugia procumbens
ovalpurse

Lepidium latifolium
broad-leaved pepperweed

Polypogon monspielensis
annual rabbitfoot grass

Sisymbrium altissimum
Jim Hill tumblemustard

Figure 3-80. Distinctive Introduced Plants Found in Vernal Pools at all Three Locations

3.5.3.2 Vegetation Patterns in the Dried Vernal Pool Basins

In addition to documenting the species present, obvious visual patterns in plant distribution within the pools were noted in the late summer vegetation surveys. Previous researchers have noted zonal vegetation patterns of more or less concentric zones of different species groupings in vernal pools

(Crowe et al. 1994); however, these concentric zones were not found in the majority of vernal pool basins on the Hanford Site in 2017.

Although distinct zones were not commonly observed in the majority of Hanford Site pools in 2017, individual species often did have areas within the dried pool basins where they did tend to be found more frequently. Distribution notes for each of the species observed in the Hanford pools in 2017 can be found in Table 3-11.

In addition to 2017 observation for the Hanford Site pools, notes from a study done by Bjork and Dunwiddie (2004) are included for comparison in Table 3-11. During their 1997 and 1998 studies of the vernal pools in eastern Washington, Bjork and Dunwiddie looked at the floristics of 342 vernal pools located in Spokane, Adams, Lincoln, Grant, and Okanogan Counties. All of these pools are located in areas that receive marginally more annual precipitation than the Hanford Site (ranging from an average of 9 in. [23 cm] at Coulee City in the west to 18 in. [36 cm] in Spokane) and 1997 was an unusually wet year[1].

Table 3-11. Species Distributions within Vernal Pools on the Hanford Site. (4 Pages)

Scientific Name	Common Name	Distribution Notes from Current Study	Species Notes from Bjork & Dunwiddie Study (2004)[a]
Achillea millefolium	yarrow	On margins – Gable Mountain pools only	Common on margins, occasional on basins; local form flood tolerant
Amaranthus albus	white pigweed	in pool basin, germinated after desiccation – all locations	Occasional summer annual on pool basins, germinating post desiccation
Ambrosia acanthicarpa	bur ragweed	On margins – Gable Mountain	(*Ambrosia* sp.) a single occurrence on margins of an alkaline pool; non-core
Amsinckia lycopsoides	fiddleneck tarweed	On margins – Gable Mountain	Common at margins, growing at higher densities on pool margins than surrounding grasslands (
Artemisia tridentata (recruits)	big sagebrush	Middle of early drying shallow pools - Umtanum Ridge	Common around pools; flood intolerant; germinates occasionally in pools post-desiccation but is later killed in high water
Bromus tectorum	cheat grass	Common in margins and areas of the pools that dried earlier in the season – all locations	Uncommon on margins; apparently flood intolerant
Chaenactis douglasii	hoary false yarrow	Uncommon – found on basin that dried out by end of March on Umtanum Ridge	NOT listed in Bjork and Dunwiddie 2004.
Chenopodium leptophyllum	slimleaf goosefoot	On margins and basin -Gable Butte and Gable Mountain	(*Chenopodium alba* complex) Occasional on margins; non-core
Convolvulus arvensis	field bindweed	On margin – uncommon on Gable Mountain	Locally common on basins and margins

[1] In 1998, nearly all pools were fully desiccated by the middle of April. Water levels in 1997 were extremely high; most pools began to dry at the end of May, though very large pools retained standing water through June (Bjork and Dunwiddie 2004).

Table 3-11. Species Distributions within Vernal Pools on the Hanford Site. (4 Pages)

Scientific Name	Common Name	Distribution Notes from Current Study	Species Notes from Bjork & Dunwiddie Study (2004)[a]
Conyza canadensis	horseweed	On margins and in basin – all locations	Common on margins and basin, germinating post-desiccation
Cryptantha circumscissa	matted cryptantha	In basin – common to sandier basin areas on Gable Butte and Umtanum Ridge	NOT listed in Bjork and Dunwiddie 2004.
Descurainia sophia	flixweed	On margins - Gable Butte	Occasional on margins, mostly where disturbed; non-core
Distichlis spicata	alkali saltgrass	On margin – Gable Butte	Common on basins and margins of alkaline/salty pools
Draba verna	spring whitlowgrass	On margin, sometimes underwater at edges of pools – all locations	Occasional on margins; flood intolerant; very common beyond high water mark on both lithosol and deeper soils surrounding vernal pools
Epilobium brachycarpum	tall willowherb	On margins - Gable Butte	Very common on margins
Erigeron pumilus	shaggy fleabane	In early desiccated pools – all locations	Rare on margins; flood intolerant; noncore
Erodium cicutarium	storksbill	On margins – Umtanum and Gable Butte	NOT listed in Bjork and Dunwiddie 2004.
Erythranthe floribunda	purplestem monkeyflower	On margins and in basins – all locations	(*Mimulus floribundus*) Occasional on margins, grows extremely robustly around alkaline/salty pools
Erythanthre suksdorfii	Suksdorf's monkeyflower	On margins and in basins – all locations	(*Mimulus suksdorfii*) Rare on margins
Euphorbia serpyllifolia	thymeleaf spurge	In basin – Gable Butte and Gable Mountain	(*Chamaesyce serpyllifolia*) Common on pool basin, germinating post-desiccation
Gnaphalium palustre	lowland cudweed	Common - on margins and in basins – all locations	Very common on basins, occasional on margins
Grindelia hirsutula	gumweed	Uncommon , on margins -Gable Mountain	(listed as *G. columbiana* and *G. nana*) Common in central and west sub-regions, on basins and margins, equally common in pools and surrounding grasslands
Heliotriopium curassavicum	salt heliotrope	Where found, formed large mats within pool – Gable Butte	NOT listed in Bjork and Dunwiddie 2004.
Holosteum umbellatum	jagged chickweed	On margins – Gable Butte and Umtanum Ridge	Rare on margins, locally very common in surrounding grasslands, non-core
Hornungia procumbens	ovalpurse	In basin – all locations	NOT listed in Bjork and Dunwiddie 2004.
Juncus bufonius	toad rush	In basin – all locations	Very common
Kochia scoparia	summer cypress	On margins – Gable Butte and Umtanum Ridge	NOT listed in Bjork and Dunwiddie 2004.

Table 3-11. Species Distributions within Vernal Pools on the Hanford Site. (4 Pages)

Scientific Name	Common Name	Distribution Notes from Current Study	Species Notes from Bjork & Dunwiddie Study (2004)[a]
Lactuca serriola	prickly lettuce	On margins – all locations	Common on margins and basins, mostly germinating post desiccation; highly drought tolerant, flowering well into autumn
Lepidium latifolium	broadleaf pepperweed	On margins and in basin with deeper soils – all locations	Occasional on margins, most common where alkaline/salty (
Lepidium perfoliatum	clasping pepperweed	Common on margins and in basin – Gable Butte	(*Lepidium* spp.?) Rare on margins, non-core
Leymus cinereus	giant ryegrass	On margins, occasionally in basin in pools that desiccated earlier in season –all locations	Very common margins
Microsteris gracilis	pink microsteris	On margins – Gable Mountain and Umtanum Ridge	Very common on margins, especially in east sub-region; sometimes forming dense populations of tall robust plants having relatively large, fragrant flowers
Neoholmgrenia andina	obscure suncup	Common in basins and on margins – all locations	(*Camissonia andina*) Occasional on basins and margins
Peritoma lutea	yellow bee-plant	On margins and in basin – common on Gable Butte	NOT listed in Bjork and Dunwiddie 2004.
Plantago patagonica	woolly plantain	In basin – Gable Butte	Very common, mostly on margins
Plectritis macrocera	white cupseed	On margins – Umtanum Ridge	Occasional on margins
Poa secunda	Sandberg bluegrass	On margins (underwater early in season) and occasionally in basin of shallower pools – all locations	NOT listed in Bjork and Dunwiddie 2004.
Polypogon monspeliensis	Annual rabbitsfoot grass	On margins – Gable Butte	Common on margins and basins of alkaline/salty margins
Psuedoregneria spicata	bluebunch wheatgrass	On margins – shallow early drying pools – Umtanum Ridge	Flood intolerant, occasional along pool margins, non-core
Rhaponticum repens	Russian knapweed	Uncommon – Gable Butte	NOT listed in Bjork and Dunwiddie 2004.
Salsola tragus	Russian thistle	Common – germinated after desiccation in basin and on margins – all locations	NOT listed in Bjork and Dunwiddie 2004.
Sisymbrium altissimum	Jim Hill tumble-mustard	On margins - all locations	Common on margins, particularly where disturbed; flood intolerant; germinating post-desiccation; very common in surrounding grassland, non-core
Sphaeralcea munroana	Munro's globemallow	Uncommon – on margins – Gable Butte and Gable Mountain	NOT listed in Bjork and Dunwiddie 2004.

Table 3-11. Species Distributions within Vernal Pools on the Hanford Site. (4 Pages)

Scientific Name	Common Name	Distribution Notes from Current Study	Species Notes from Bjork & Dunwiddie Study (2004)[a]
Tragopogon dubius	salsify	On margins – Umtanum Ridge and Gable Butte	Occasional on margins; non-core
Verbena bracteata	carpet verbena	Very common, more common on margins, but sometimes in basin –all locations	Rare on margins or basins; germinating post-desiccation; flood intolerant, non-core
Veronica peregrina	purslane speedwell	Uncommon – Gable Mountain	Very common, mostly on basins
Vulpia spp.	vulpia	Small annual grass; on margins - all locations	(*Vulpia octoflora*) Rare on margins, non-core

[a] In some cases, scientific names for species have changed since Bjorn and Dunwiddie (2004) completed their study. In those cases, the species listed in their work has been included in parentheses for clarity.

3.5.3.3 Special Status Species

One species, *Erythranthe suksdorfii* (Suksdorf's monkeyflower) found in the vernal pools in all three Hanford locations is listed as a Washington State Sensitive species (WNHP 2017). Suksdorf's monkeyflower is a small plant, which is generally only 1 to 4 in. (3 to 10 cm) tall. Most of the plants seen in the vernal pool basins were at the larger end of that range and seemed to be quite robust.

At the state level, this species is ranked as an S3, meaning that it is considered to be vulnerable – at a moderate risk of extirpation in the state. Suksdorf's monkeyflower is also rare in Montana and Wyoming (Camp and Gamon 2011), although on a global scale it ranks as a G4 –secure and at a fairly low risk of extinction or elimination, but with possible cause for some concern.

Two additional State-listed species were observed in the vernal pools by the TNC in 1997: mousetail (*Myosurus clavicaulis*) and spreading pygmyleaf (*Loeflingia squarrosa* var *squarrosa*). Mousetail was observed in a pool on Umtanum Ridge while spreading pygmyleaf was observed on Gable Butte. Unfortunately, neither species was observed in the 2017 vernal pool surveys.

3.5.3.4 Weedy Species

As noted above, 38% of the species documented in the vernal pools were non-native species, many of which are somewhat weedy or invasive in habit. Many of the native annual species found are also considered to be weeds. Overall, almost half of the species noted in the vernal pools are listed as invasive in *Weeds of the West* (Whitson et al. 2012). In the absence of other pressures on the vernal pools at the Hanford Site (e.g., heavy grazing and agricultural use), these species may pose the greatest threat to Hanford Site vernal pool ecosystems. Previous studies have noted flixweed (*Descurainia sophia*), knapweed species (*Centaura*), and Jim Hill tumble-mustard (*Sisymbrium altissimum*) as particularly invasive in vernal pools (Bjork and Dunwiddie 2004). Native species, such toad rush (*Juncus bufonius*), also appears to increase with greater disturbance in the pools (Brown 2001).

Among the non-natives found in the pools, four species are listed as noxious weeds by Washington State (Washington State Noxious Weed Control Board 2017).

- *Kochia scoparia* (kochia), *Lepidium latifolium* (broad-leaved pepperweed), and *Rhaponticum repens* (Russian knapweed) are categorized as Class B noxious weeds, which are nonnative species whose distribution is limited to portions of Washington State. The goal with Class B weeds is to prevent them from spreading into new areas, and to contain or reduce their population in already infested areas. None of these weeds are designated for control in Benton County because these species are already abundant; however, these species are controlled on the Hanford Site.

- *Convolvulus arvensis* (field bindweed) is a Class C noxious weed. Class C weeds are widespread in Washington State and are of special interest to the agricultural industry.

In the mid-1990s, during the TNC survey, a heavy infestation of the aggressive weed *Centaurea solstitialis* (yellow starthistle) was noted in the vernal pools on Gable Mountain (TNC 1998). This species appears to have been controlled and was not seen during the 2017 surveys.

3.5.3.5 Biological Soil Crusts

As the vernal pools began to dry out, the coverage of the basin area by nonvascular plants became apparent in a number of the pools. A variety of mosses and liverworts were observed, although no attempt was made to quantify the coverage or the species composition of these species in the biological soil crust in the 2017 study. Figure 3-81 depicts two areas within recently dried vernal pools where mosses and liverworts were especially prevalent.

Figure 3-81. Mosses and Liverworts Growing in Recently Dried Vernal Pool Basin

3.5.4 Wildlife Use

Wildlife and wildlife signs were noted during visits to the vernal pools throughout the season. In addition to this incidental data, trail cameras were set up at some pools to capture wildlife present at the pool throughout the day. Specific sampling efforts focused on the presence or absence of breeding anurans; macroinvertebrates were also sampled in April and May in the pools that still contained water.

3.5.4.1 Large Mammal Use

Evidence of the use of vernal pools by the larger mammals on the Hanford Site was found in every vernal pool studied during spring 2017. The trail cameras placed at selected vernal pools also recorded

the use of pools at all three locations by mule deer, elk, and coyotes (Figure 3-82). The trail cameras usually operated for a few days at a time because curious elk generally knocked them down.

Figure 3-82. Trail Camera Photos of Elk on Umtanum Ridge and Mule Deer at Gable Mountain Pools

(The pictures above have been lightened for better viewing.)

Footprints made by Rocky Mountain elk (*Cervus elaphus nelsoni*), mule deer (*Odocoileus hermionus*), and coyote (*Canis latrans*) were sometimes so numerous that the basin of the vernal pools and the surrounding area were pockmarked by the numerous indentations. The microhabitat afforded by these footprints were often the sites for the germination of the annuals colonizing the pools after dry out. Figure 3-83 shows a pool crisscrossed with numerous track and an elk hoof print colonized with germinating annual plant species.

Figure 3-83. Elk and Deer Prints in a Pool on Umtanum Ridge (left) and Germination of Annual Plants within an Elk Print (right).

Scat left by elk, mule deer, coyote, and Nuttall's cottontail rabbit (*Sylvilagus nuttallii*) was also common in and adjacent to the pools (Figure 3-84). Other signs of wildlife use include elk antler sheds and coyote dig sites (Figure 3-85).

Figure 3-84. Typical Scat Found In or Adjacent to the Vernal Pools

Figure 3-85. Signs of Vernal pool Use by Large Mammals

3.5.4.2 Avian Use

A review of avian uses of vernal pools in California documented over 65 taxa that were found in or adjacent to pools. The diversity of bird species found was attributed to the distinct habitat features of the pools such as water surface areas, water depth, inundation period, soil moisture gradient, vegetation zones and condition, invertebrate biota compositions of and proximity to wetland complexes, tradition, and disturbance. Zones within the vernal pools that vary throughout the season as the pools fill and dry out contain an array of micro- and macro-habitats from open water to mudflats and dry pool beds (Silveira 1998).

Although there were no formal surveys of bird use at the Hanford Site vernal pools in 2017, incidental observations included sightings of waterfowl, wading birds, and sagebrush dwelling passerines at the pools.

- Waterfowl observed included four Bufflehead ducks (*Bucephela albeola*) seen in the large pool (GB-4) on the saddle of Gable Butte on April 6, a pair of Mallards (*Anas platyrhynchos*) captured by a trail camera in the vernal pool in the Gable Butte Blind Canyon on April 13 (Figure 3-86), and another Mallard pair seen in large pool on Gable Butte (pool GB-4) on April 28. Both the Mallards and the

Buffleheads were on the surface of the pools feeding when observed, and all of the birds remained feeding through the site visits. Silveira (1998) noted that the shallow vernal pools resulted in optimal foraging depths for a number of waterfowl species, including Mallards, which prefers water depths of less than 10 in. (25.4 cm). This was consistent with the depths of the two pools in which they were observed in 2017. The diversity of aquatic invertebrates in the pools was credited with providing high protein foods for dabbling ducks.

- Shorebirds seen included a Greater Yellowlegs (*Tringa melanoleuca*) feeding along the margin of the GB-4 pool on April 6 and Least Sandpipers (*Calidris minutilla*) feeding in the mud along the margins of the GB-7 pool on April 28 (Figure 3-86). Greater Yellowlegs (aquatic gleaners) generally prefer areas with a water depth of less than 6 in. (15.2 cm), while sandpipers are aquatic gleaners that generally feed along shorelines and in mudflats (Silveira 1998).

- An empty Horned Lark (*Eremophila alpestris*) nest was on May 8 in the basin of pool U-2 on Umtanum Ridge; this pool had dried out in mid-March (Figure 3-86). Silveira (1998) noted that Horned Larks were generally observed using the dry pool beds.

- A Western Meadowlark (*Sturnella neglecta*) was captured by a trail camera at the pool U-4 on Umtanum on April 4 (Figure 3-86). Silveira (1998) observed Meadowlarks feeding on the mudflats and dried vernal pool beds in his study. It is interesting to note that Horned Larks and Western Meadowlarks were two of three most commonly observed passerines in a study of avian use of vernal pools on the Santa Rosa plateau as well (Baker et al. 1992).

Three Common Nighthawks (*Chordeiles minor*) were observed circling over the vernal pools on the saddle of Gable Mountain during the visit in mid-July. Although no direct interaction with the dried vernal pools was seen during the visit, it is interesting to note that Silveira (1998) comments on Nighthawks nesting in dry vernal pool beds in his review.

Because vernal pools often are found at a distance from more permanent water sources and some pools may not fill each year, waterfowl and shorebirds are considered to be an important dispersal agent for propagules among vernal pool groups. This dispersal may have important consequences for populations and species diversity of vernal pool plants and invertebrates (Silveira 1998; Baker et al. 1992).

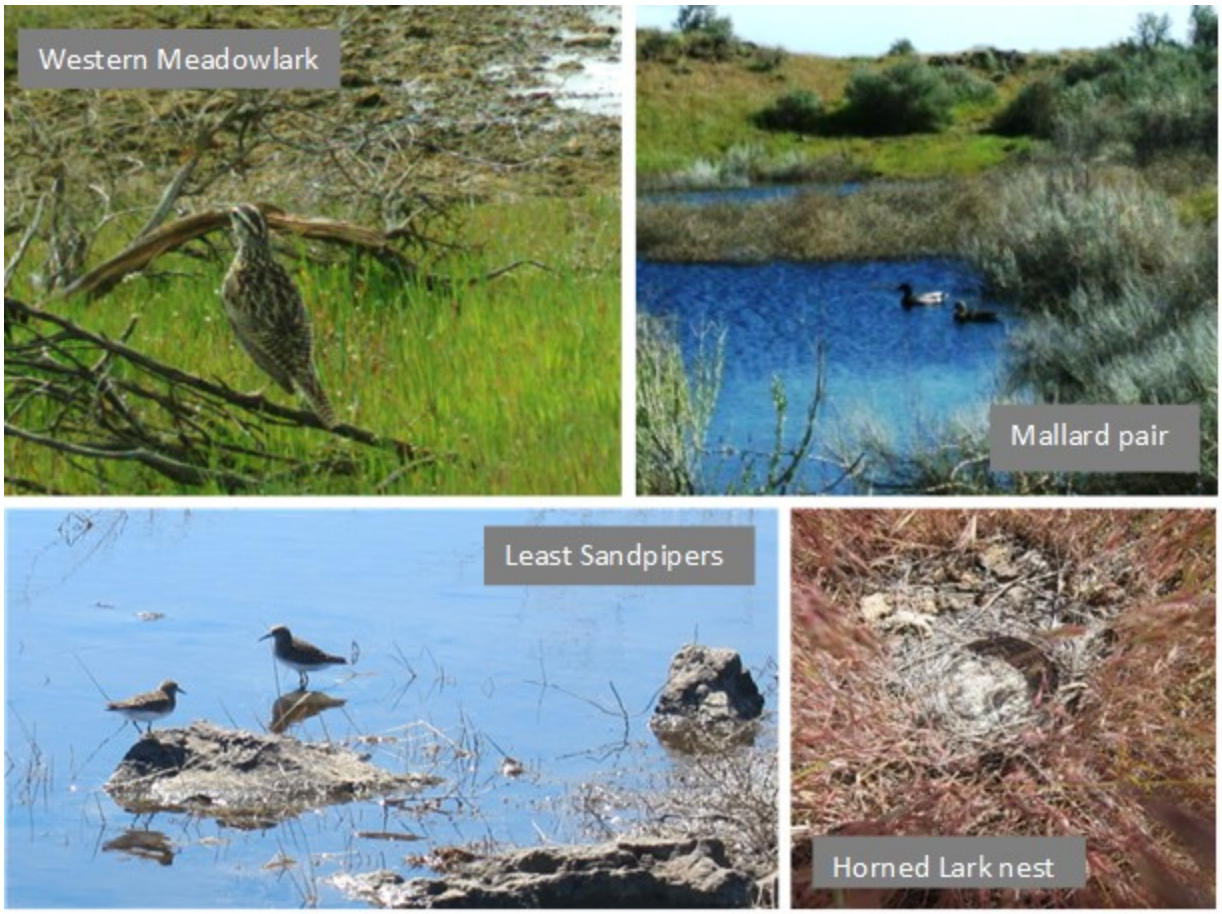

Figure 3-86. Avian Use of the Vernal Pools

3.5.4.3 Anurans

Great Basin spadefoot toads (*Spea intermontana*) occur primarily in shrub-steppe habitats and are known to breed in the ephemeral pools and sloughs adjacent to the Columbia River on the Hanford Site. In late March in the Columbia Basin, spadefoots start breeding using a variety of aquatic habitats including slow flowing springs, seasonal pools, irrigation ditches and ponds. They are typically "explosive breeders" with all breeding completed in a period of a few days. However, at some sites, males can call for weeks or even months.

Breeding duration at each site varies with conditions such as water temperature and hydroperiod. Eggs hatch typically in 2 to 3 days, but development can take longer if water temperatures are cooler. Tadpole development typically takes 1 to 2 months but can accelerate with high temperatures if pool drying threatens to strand developing larvae (WDFW 2017).

In late April 2017, a large number of spadefoot toad larvae were seen in the largest vernal pool (GB-4) on Gable Butte. Although the duration of this vernal pool in 2017 is not certain, significant water was still present when the tadpoles were observed. Figure 3-87 shows one of the largest tadpoles observed.

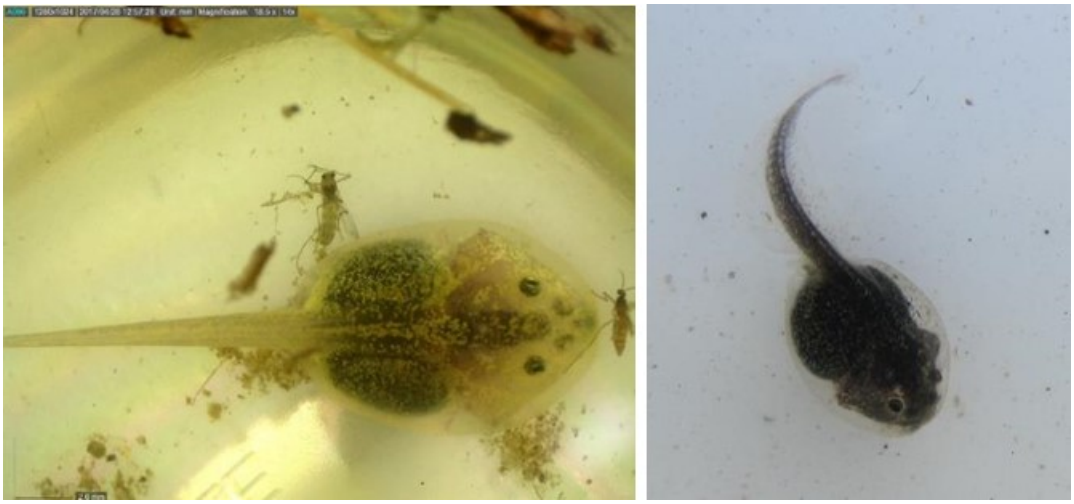

Figure 3-87. Great Basin Spadefoot Toad Tadpoles in Vernal Pool on Gable Butte (April 28, 2017)

A study done on the duration of vernal pool duration and metamorphosis of the western spadefoot toad (*Spea hammondii*) in California concluded that pools need to persist 5 weeks after breeding to support successful metamorphosis (Morey 1996). The key conclusions of this work were that:

- The size and somatic condition of the adult toads are positively correlated with pool duration.
- The risk of mortality sharply increases in pools that dry sooner than about 35 days after breeding.

3.5.4.4 Macroinvertebrates

The goals for sampling within active vernal pools were first to determine whether or not the pools supported an active population of macroinvertebrates, and second to look specifically for the presence or absence of fairy shrimp. Fairy shrimp are of particular interest because these crustaceans can survive prolonged periods (sometimes decades) of heat and desiccation by forming a cyst in a late stage of embryonic development, allowing them to persist through the sometimes lengthy dry periods in the vernal pool environment. Because the cyst contains a well-developed embryo, fairy shrimp can quickly develop into mature adults when conditions are right, reproducing before the vernal pool dries out. In addition, not all the dormant cysts appear to hatch in a single season. Three species of fairy shrimp known from the vernal pools of California[2] (conservancy fairy shrimp [*Branchinecta conservatio*], longhorn fairy shrimp [*Branchinecta longiantenna*], and vernal pool fairy shrimp [*Branchinecta lynchi*]) are currently listed as Endangered (conservancy and longhorn fairy shrimp) or 'Threatened' (vernal pool fairy shrimp) under the *Endangered Species Act* (70 FR 46924).

A D-frame mesh net was used to collect samples from the pool by walking in or around the pool and forcing pool water from all pool depths through the net. All of the material collected in the net was dumped into a white plastic tub for observation and a general assessment of the types of organisms collected. A few of the pools at each location were surveyed during routine visits to the pools.

Macroinvertebrates were collected in all of the pools assessed, and the basic organisms observed appeared to be common to all of the pools. As the season progressed the size of the populations

[2] Vernal pool fairy shrimp have also been documented in vernal pools in southern Oregon.

increased dramatically, and a net was not needed to ascertain the presence of the many aquatic insects inhabiting the pools. Because the initial goal of the monitoring was to ascertain whether free-swimming macroinvertebrate populations could be found in the pools on the Hanford Site, no attempt was made to identify these organisms below the family classification level. The major types of macoinvertebrates found during 2017 consisted of the following:

- **Water boatmen** (Family Corixidae, Order Hemiptera - true bugs) were the first insect seen in the late winter. They increased in numbers as the season progressed and persisted throughout the time the pools were full.

- **Mosquitoes** (Family Culicidae, Order Diptera - flies) were found with increasing regularity as the season progressed. All stages of the mosquito lifecycle were observed.

- **Midges** (Family Chironomidae, Order Diptera - flies) are sometimes known as "Blind Mosquitoes" because they resemble mosquitoes; however, male midges tend to have feathery antennae, something not seen on mosquitoes. Larvae are worm-like and are sometime called "blood worms."

- **Predaceous diving beetle** (Family Dytiscidae, Order Coleoptera - beetles) first became noticeable later in the season. Both the larvae, commonly known as water tigers, and adults were seen in the pools.

- **Water Striders** (Family Gerridae, Order Hemiptera – true bugs) were not seen as commonly as the insects above, but could be seen skating across the surface of the pools, particularly the larger pool on Gable Butte.

Figure 3-88 shows some of the insects seen during the sampling.

A smaller net was used to look for fairy shrimp (Order Anostraca); however, despite a focused search throughout the later part of the season, none were seen in any of the pools in 2017.

A previous study of free-swimming invertebrate communities in eastern Washington vernal pools found eight species of crustaceans (four species of copepods [Copepoda], and one species each of seed shrimps [Ostracoda], water fleas [Cladocera], clam shrimps [Conchostrac] and fairy shrimps [Anostraca]) and seven species of swimming insects (two species of mosquitos [Culicidae], four species of diving beetles [Dytiscidae], and one species of water strider [Gerridae]). In addition, rotifers (Rotifera) and water mites (Acarina) were collected (Kulp and Rabe 1984). The vernal pools surveyed were in areas with much higher rainfall than the Hanford Site; activity traps and a Wilding sampler were used to collect samples, which may account for the greater number of taxa seen.

Figure 3-88. Macroinvertebrates found in Hanford Vernal Pools

4.0 2018 Vernal Pool Monitoring

The fall and winter of 2017/2018 was relatively dry compared to the previous year, presenting an opportunity to check the vernal pools for inundation and to evaluate vegetation in a drier year. Precipitation from October 2017 to the end of February 2018 totaled 4.12 in. (10.46 cm), 2.74 in. (6.96 cm) less than the previous winter. During the same time period, snowfall totaled 6.8 in. (17.27 cm), 21.2 in. (53.85 cm) less than the previous winter (MSA 2019).

Two visits were made to select vernal pools in 2018. The first visit occurred in March and had the goal of establishing presence/absence of vernal pools, and the second visit occurred in May or June and had the goal of collecting data on vernal pool vegetation diversity and abundance. These data will be used to inform future monitoring efforts and to establish baseline data for vegetative composition in vernal pools in relatively low precipitation years.

4.1 Monitoring Methods

The 2018 vernal pool monitoring occurred in two parts, consisting of a presence/absence survey and of a vegetation survey. The presence/absence survey occurred on March 5, 2018, almost exactly 1 year after the previous year's monitoring efforts. The goal of this survey was to see if any of the pools contained water and to assess their condition. The majority of the vernal pools on Gable Mountain, Gable Butte, Gable Butte Blind Canyon, and Umtanum Ridge were visited. The largest pools that held water later into the year in 2017 were prioritized during this monitoring effort, as it was hypothesized that these pools would be the most likely to contain water during a low-precipitation year. Upon visiting the pools, information recorded included notable plant species, animal sign, moss and biotic crust cover, soil moisture, and presence/absence of water.

Vegetation monitoring occurred on May 23 and June 5, 2018. The goal of vegetation monitoring was to assess the vernal pool vegetation in a year when little to no water collected in the pools. In order to assess canopy cover and frequency of occurrence, a transect line was established across the center point of the pool and measurements were taken every 3.28 ft (1 m) using a plot frame and the methods described in *Steppe Vegetation of Washington* (Daubenmire 1970). Canopy cover is defined in Daubenmire (1970) as "the percentage of ground surface included in the vertical projection of a polygon drawn around the extremities of undisturbed foliage of a plant." The total vegetative cover can exceed 100% with this method due to species overlapping when plot measurements are taken in densely vegetated areas. The name and relative amount of ground cover for each rooted species within the confines of the plot frame is documented for each plot-frame measurement and these data are extrapolated to represent coverage for the entire site (Figure 4-1). Frequency of occurrence was represented as the percentage of times a species was observed within the given number of plot frames measured. For example, if a species was represented in 10 out of 25 plot frames, its frequency would be 10/25 x 100 = 40%. The relative magnitude of a frequency rating in comparison to a canopy coverage rating provides an index of species distribution and its influence within a vegetation community. Species that were observed within the vernal pool but were not counted in a plot frame were recorded as occurrences and are denoted as an "X" in the tables. Areas of bare ground and biological crust were also recorded, and rocks were excluded from the assessment.

In addition to presence/absence surveys and vegetation surveys, signs of animal usage were anecdotally recorded at each vernal pool site visited. Signs of animal usage included animal scat, game trails, prints, digs, and sightings.

Figure 4-1. Staff Performing Vegetation Monitoring During 2018 Monitoring

4.2 Umtanum Ridge Vernal Pools – 2018

The first pool in the Umtanum Ridge cluster, pool U-1, and the Umtanum Ridge spring were both visited as part of the initial presence/absence survey on March 5, 2018. Pool U-1 contained no water and had visible tire tracks running through the section of the pool near an access road (Figure 4-2). Pool U-1 contained a notable number of small seedlings as well as sagebrush recruits and bunchgrasses. The greatest density of seedlings at pool U-1 were observed growing within indentations made from deer and elk hoof prints. Observations of seedlings growing within animal prints matched observations of this same occurrence from previous monitoring efforts in 2017. Notably, the perennial bluebunch wheatgrass (*Pseudoregnaria spicata*) was found growing in an area of the pool that had been under water the year before.

The Umtanum Ridge spring was visited as it was hypothesized that it may contain water even in years of low precipitation. The spring contained no water and the soils were covered with a white alkaline crust in many of the areas that had contained water the year prior (Figure 4-3). Two species observed in this area were facultative wetland species: cocklebur (*Xanthium strumarium*) and cottonbatting plant (*Pseudognaphalium stramineum*).

Signs of animal use were found in all pools, the majority of which were elk and mule deer hoof prints. The remaining vernal pools seen on the eastern edge of Umtanum Ridge during 2017 efforts were not visited on March 5, 2018, as none of the larger and most persistent pools seen on the Hanford Site on that date contained water.

Figure 4-2. Umtanum Ridge Pool U-1 and Seedlings Growing in Elk Hoof Prints at U-1

Figure 4-3. The Umtanum Ridge Spring in March 2019

The Umtanum Ridge pools were visited again on June 5, 2018, in order to assess vegetative composition. Vegetation data was collected at Pool U-1, U-2, and U-4. Transects at each pool varied in length: U-1 was 13 m (42.6 ft), U-2 was 7 m (23 ft), and U-4 was 18 m (55.1 ft). Pool U-1 had 17 species recorded within the pool boundaries, 10 of which were native species (Table 4-1). Canopy cover totaled 47.2%, with 14.4% native cover and 32.8% non-native cover. Cheatgrass (*Bromus tectorum*) had the highest cover at 26.4% cover, while Sandberg bluegrass was the native species with the highest cover at 4.9% cover. This was the only vernal pool where Blackfoot River evening primrose (*Camissonia andina*) was found; it occurred in 47.8% of plot frames. A large, mature sagebrush is located in the middle of pool U-1 and is surrounded by multiple sagebrush recruits of different size cohorts.

Pool U-2 contained 14 species within the pool boundaries, made up of 8 native species and 6 non-native species (Figure 4-4). Canopy cover totaled 46.3% with 22.4% native cover and 23.9% non-native cover (Table 4-2). Cheatgrass had the highest species cover at 14.6%, and Sandberg bluegrass had the highest native species cover at 8.3% followed by sixweeks fescue (*Vulpia octoflora*) with 7.9% cover. Cheatgrass and spring whitlowgrass (*Draba verna*) had the highest frequency of occurrence with 100% and 91.7% occurrence in plot frames, respectively. A large amount of big sagebrush (*Artemisia tridentata*) recruits were seen within the pool boundaries compared to the areas surrounding the pool. Bluebunch wheatgrass (*Pseudoroegnaria spicata*) was found along the boundary of the pool, which was unusual compared to the other vernal pools but was a relatively common grass in the area. Pool U-2 had the second highest coverage of biotic crust and the second highest native plant cover compared to the other vernal pools measured in 2018.

Pool U-4 contained 13 species within the pool boundaries, made up of 6 native species and 7 non-native species (Figure 4-4). Canopy cover totaled 38.2%, made up of 4.9% native cover and 33.3% non-native cover (Table 4-3). Cheatgrass had the highest species cover at 21.9% and sixweeks fescue had the highest native species cover at 1.9%. Cheatgrass and spring whitlowgrass had the highest frequency of occurrence at 100% and 77.8% occurrence in plot frames, respectively. Pool U-4 had the second lower native cover measured of all the pools monitored in 2018. Broadleaved pepperweed (*Lepidium latifolium*), a Class B noxious weed in Washington State, was detected in this pool and recommendations will be made for its treatment and removal.

At all of the Umtanum Ridge pools measured in 2018, cheatgrass was the most common species with an average cover of 21.0%. Native cover averaged 13.9%, higher than the Gable Mountain and Gable Butte pools but lower than the Blind Canyon pool. Biotic crust averaged 21.1%, a few percent above the average crust cover of 18.4%. The Umtanum Ridge pools averaged 14.6 species per pool with an average of 8 native species and 7.6 non-native species.

Figure 4-4. The Umtanum Ridge Vernal Pools Monitored in 2018 for Vegetative Composition

Table 4-1. Percent Canopy Cover and Frequency of Occurrence at Umtanum Pool 1 in 2018. (2 Pages)

Species	% Cover	% Frequency
Artemisia tridentata (big sagebrush)	1.7	8.7
Bromus tectorum (cheatgrass) [a]	26.4	100
Camissonia andina (Blackfoot River evening primrose)	2.8	47.8
Conyza canadensis (Canadian horseweed)	X	X
Draba verna (spring whitlowgrass) [a]	4	73.9
Epilobium brachycarpum (tall annual willowherb)	0.5	21.7
Erigeron pumilis (shaggy fleabane)	1.3	8.7
Erodium cicutarium (redstem storksbill) [a]	0.2	8.7
Holosteum umbellatum (jagged chickweed) [a]	1.7	47.8
Lactuca serriola (prickly lettuce) [a]	0.1	4.3
Poa bulbosa (bulbous bluegrass)	X	X
Poa secunda (Sandberg bluegrass)	4.9	13.0

Table 4-1. Percent Canopy Cover and Frequency of Occurrence at Umtanum Pool 1 in 2018. (2 Pages)

Species	% Cover	% Frequency
Pseudoroegneria spicata (bluebunch wheatgrass)	X	X
Salsola tragus (Russian thistle) [a]	0.3	13.0
Sisymbrium altissimum (Jim Hill's tumblemustard) [a]	0.1	4.3
Verbena bracteata (bracted vervain)	1.5	17.4
Vulpia octoflora (sixweeks fescue)	1.7	26.1
Crust	12.1	82.6
Bare ground	6.3	78.3
Total Canopy Cover	**47.2**	
Total Native % Cover	14.4	
Total Invasive % Cover	32.8	

[a] Invasive species
X - present in pool, not detected on transect

Table 4-2. Percent Canopy Cover and Frequency of Occurrence at Umtanum Pool 2 in 2018. (2 Pages)

Species	% Cover	% Frequency
Artemisia tridentata (big sagebrush)	X	X
Bromus tectorum (cheatgrass) [a]	14.6	100
Conyza canadensis (Canadian horseweed)	X	X
Draba verna (spring whitlowgrass) [a]	8.3	91.7
Epilobium brachycarpum (tall annual willowherb)	6	75
Erigeron pumilis (shaggy fleabane)	0.2	8.3
Holosteum umbellatum (jagged chickweed) [a]	0.6	25.0
Lactuca serriola (prickly lettuce) [a]	X	X
Poa secunda (Sandberg bluegrass)	8.3	83.3
Pseudoroegneria spicata (bluebunch wheatgrass)	X	X
Salsola tragus (Russian thistle) [a]	0.4	16.7
Tragopogon dubius (yellow salsify) [a]	X	X
Verbena bracteata (bracted vervain)	X	X
Vulpia octoflora (sixweeks fescue)	7.9	41.7
Crust	34.8	91.7
Bare ground	2.5	58.3
Total Canopy Cover	**46.3**	
Total Native % Cover	22.4	
Total Invasive % Cover	23.9	

[a] Invasive species
X - present in pool, not detected on transect

Table 4-3. Percent Canopy Cover and Frequency of Occurrence at Umtanum Pool 4 in 2018.

Species	% Cover	% Frequency
Bromus tectorum (cheatgrass) [a]	21.9	100
Descuriania sophia (flixweed) [a]	0.1	5.6
Draba verna (spring whitlowgrass) [a]	6.8	77.8
Epilobium brachycarpum (tall annual willowherb)	0.4	16.7
Erigeron pumilis (shaggy fleabane)	X	X
Holosteum umbellatum (jagged chickweed) [a]	0.7	27.8
Lepidium latifolium (broadleaved pepperweed) [a]	1.9	22.2
Microsteris gracilis (slender phlox)	1.5	33.3
Poa secunda (Sandberg bluegrass)	X	X
Salsola tragus (Russian thistle) [a]	0.6	22.2
Sisymbrium altissimum (Jim Hill's tumblemustard) [a]	1.3	22.2
Verbena bracteata (bracted vervain)	1.1	16.7
Vulpia octoflora (sixweeks fescue)	1.9	22.2
Crust	16.5	
Bare ground	55.6	
Total Canopy Cover	**38.2**	
Total Native % Cover	4.9	
Total Invasive % Cover	33.3	

[a] Invasive species

X - present in pool, not detected on transect

4.3 Gable Butte Vernal Pools – 2018

Vernal pools in both the Gable Butte Saddle area and the Gable Butte Blind Canyon were visited and assessed in 2018 for presence/absence and vegetative composition.

4.3.1 Gable Butte Saddle Area

Gable Butte Pools GB-1, GB-2, GB-3, GB-4, and GB-7 were visited during presence/absence monitoring on March 5, 2018. Additionally, a pool basin to the west of GB-1 was located based on aerial photographs and was visited on March 5, 2018 (Figure 4-5). None of the six pools were found to contain water. Common plants growing within the pools in March included Jim Hill's tumble mustard (*Sisymbrium altissimum*), spring whitlow grass (*Draba verna*), tall annual willowherb (*Epilobium brachycarpum*), shaggy fleabane (*Erigeron pumilis*), and cheatgrass (*Bromus tectorum*). Sandberg bluegrass (*Poa secunda*) and common yarrow (*Achillea millefolium*) were often found in the margins of pools. Shaggy fleabane (*Erigeron pumilis*) appeared to be more prevalent than the previous summer at

most pools. Notably, GB-4 contained a population of desiccated desert saltgrass (*Distichlis spicata*), which typically grows in alkaline soils. Pool GB-7, located on a lithosol with little soil buildup, appeared to have moister soil than any of the other Gable Butte pools and had a high amount of mosses growing among the rocks over the entire basin area. Figure 4-6 shows the Gable Butte pools in March.

Hoof prints; scat from mule deer, elk, rabbit, and coyote; and game trails were seen across the Gable Butte Vernal Pool area. Small annual seedlings were found in great abundance within indentations made from elk and deer tracks, matching the trend seen at the Umtanum Ridge pools.

The new pool west of GB-1, referred to as GB-11, had a large number of Russian thistle (*Salsola tragus*) plants and other weed seedlings. Common plants in this pool included cheatgrass and shaggy fleabane, with common yarrow prevalent in the margins. Big sagebrush (*Artemisia tridentata*) seedlings were detected in the new pool along with elk and mule deer prints, and coyote and rabbit scat.

Figure 4-5. A Map Showing the Vernal Pool West of GB-1 First Monitored in 2018, and the Pool's Appearance in March 2018

Figure 4-6. The Gable Butte Vernal Pools in March 2018

The Gable Butte Pools were visited again on May 23, 2019, to assess vegetative composition. Vegetation data were collected at Pools GB-1, GB-4A, and GB-7. Transects at each pool varied in length: Pool GB-1 was 26 m (85.3 ft), GB-4A was 26 m (85.3 ft), and GB-7 was 23 m (75.5 ft).

Pool GB-1 contained 17 species within the pool boundaries, made up of 8 native and 9 non-native species (Table 4-4). Canopy cover totaled 40.5%, made up of 8.7% native and 31.8% non-native species. Cheatgrass was the dominant non-native species with a coverage of 19.4%, followed by spring whitlowgrass (*Draba verna*) with a coverage of 8.1%. The dominant native species was shaggy fleabane with 3.8% cover and occurring in 53.8% of plot frames. Prickly lettuce (*Lactuca serriola*), yellow salsify (*Tragopogon dubius*), Munro's globemallow (*Sphaeralcea munroana*), and Canadian horseweed (*Conyza canadensis*) were observed primarily in the pools margins.

Pool GB-4A contained 23 species within the pool boundaries, made up of 11 native species and 12 non-native species (Table 4-5). Canopy cover totaled 39.6%, made up of 5.4% native cover and 34.2% non-native cover. Cheatgrass made up a large proportion of the total cover with 24.1% cover and occurrence in 100% of plot frames. The dominant native species at this pool was salt heliotrope (*Heliotropium curassavicum*) with 3.7% cover and occurrence in 30.8% of plot frames. This is the only vernal pool on the Hanford Site where desert saltgrass was observed. This may be because GB-4A holds water longer than most of the other Hanford Site pools. This species has been found at vernal pools outside of the Hanford Site. Pool GB-4A has the highest diversity of plants of the pools monitored in 2018.

Pool GB-7 contained 15 species within the pool boundaries, made up of 8 native and 7 non-native species (Table 4-6). Canopy cover totaled 34.0%, made up of 10.1% native and 23.9% non-native cover.

Cheatgrass cover was lower at this pool compared to the other Gable Butte pools, totaling 6.8% cover. Jim Hill's tumblemustard was the dominant non-native species with 8.7% cover, and sixweeks fescue was the dominant native species with 4.1% cover.

At all of the Gable Butte pools measured in 2018, cheatgrass was the most common species with an average cover of 16.8%. Native cover averaged 8.1%, lower than the Umtanum Ridge and Blind Canyon pools but slightly higher than the Gable Mountain pools. Biotic crust averaged 19.6%, a few percent above the average crust cover of 18.4% and fairly similar to the Umtanum Ridge pools (21.1%). The Gable Butte pools averaged 18.3 species per pool with an average of 9 native species and 9.3 non-native species. Figure 4-7 shows the Gable Butte pools in May 2018.

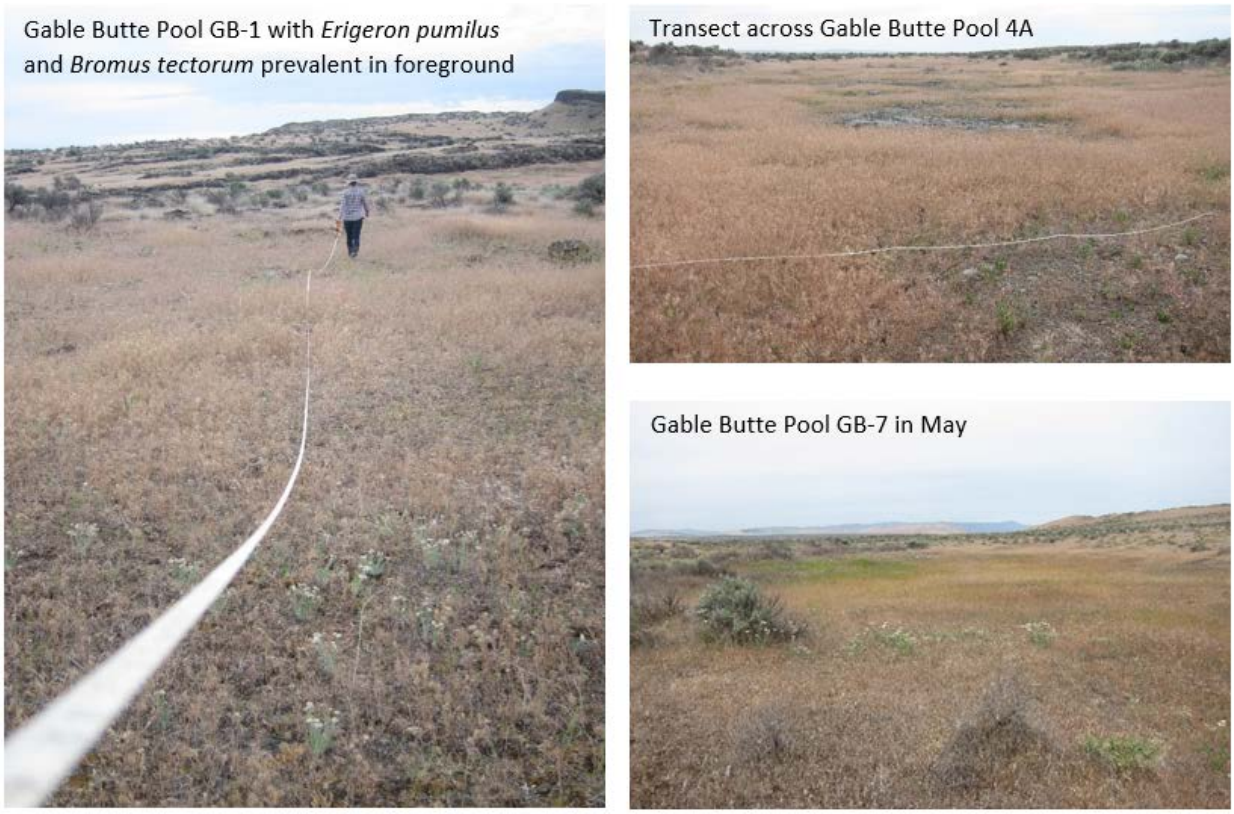

Figure 4-7. The Gable Butte Pools in May 2019

Table 4-4. Percent Canopy Cover and Frequency of Occurrence at Gable Butte Pool 1 in 2018. (2 Pages)

Species	% Cover	% Frequency
Bromus tectorum (cheatgrass) [a]	19.4	100
Conyza canadensis (Canadian horseweed)	X	X
Descuriania sophia (flixweed) [a]	0.6	3.8
Draba verna (spring whitlowgrass) [a]	8.1	92.3
Epilobium brachycarpum (tall annual willowherb)	1.4	38.5

Erigeron pumilis (shaggy fleabane)	3.8	53.8
Erodium cicutarium (redstem storksbill) [a]	0.7	7.7
Holosteum umbellatum (jagged chickweed) [a]	1.1	42.3
Lactuca serriola (prickly lettuce) [a]	X	X
Microsteris gracilis (slender phlox)	1.0	38.5
Poa secunda (Sandberg bluegrass)	0.2	7.7
Salsola tragus (Russian thistle) [a]	0.6	23.1
Sisymbrium altissimum (Jim Hill's tumblemustard) [a]	1.3	15.4
Sphaeralcea munroana (Munro's globemallow)	X	X
Tragopogon dubius (yellow salsify) [a]	X	X
Verbena bracteata (bracted vervain)	0.8	11.5
Vulpia octoflora (sixweeks fescue)	1.5	7.7
Crust	22.4	84.6
Bare ground	4.5	88.5
Total Canopy Cover	**40.5**	
Total Native % Cover	8.7	
Total Non-Native % Cover	31.8	

[a] Invasive species
X - present in pool, not detected on transect

Table 4-5. Percent Canopy Cover and Frequency of Occurrence at Gable Butte Pool 4A in 2018 (2 Pages)

Species	% Cover	% Frequency
Achillea millefolium (common yarrow)	0.1	3.8
Ambrosia acanthicarpa (flatspine bur ragweed)	X	X
Bromus tectorum (cheatgrass) [a]	24.1	100
Chenopodium leptophyllum (slimleaf goosefoot)	X	X
Conyza canadensis (Canadian horseweed)	X	X
Descuriania sophia (flixweed) [a]	0.3	11.5
Distichlis spicata (desert saltgrass)	0.1	3.8
Draba verna (spring whitlowgrass) [a]	0.4	15.4
Elymus elymoides (bottlebrush squirreltail)	X	X
Erodium cicutarium (redstem storksbill) [a]	0.1	3.8
Heliotropium curassavicum (salt heliotrope)	3.7	30.8
Holosteum umbellatum (jagged chickweed) [a]	0.2	7.7
Kochia scoparia (kochia) [a]	0.2	7.7
Lactuca serriola (prickly lettuce) [a]	1.6	46.2
Lepidium perfoliatum (clasping pepperweed) [a]	1.9	38.5
Peritoma lutea (yellow spiderflower)	X	X

Poa secunda (Sandberg bluegrass)	X	X
Polypogon monspeliensis (rabbitsfoot grass) [a]	0.9	15.4
Salsola tragus (Russian thistle) [a]	2.0	61.5
Sisymbrium altissimum (Jim Hill's tumblemustard) [a]	2.5	42.3
Sphaeralcea munroana (Munro's globemallow)	X	X
Tragopogon dubius (yellow salsify) [a]	X	X
Verbena bracteata (bracted vervain)	1.5	42.3
Crust	15.1	73.0
Bare ground	15.5	100.0
Total Canopy Cover	**39.6**	
Total Native % Cover	5.4	
Total Non-Native % Cover	34.2	

[a] Invasive species
X - present in pool, not detected on transect

Table 4-6. Percent Canopy Cover and Frequency of Occurrence at Gable Butte Pool 7 in 2018. (2 Pages)

Species	% Cover	% Frequency
Bromus tectorum (cheatgrass) [a]	6.8	82.6
Descuriania sophia (flixweed) [a]	0.4	17.4
Draba verna (spring whitlowgrass) [a]	4.1	78.3
Epilobium brachycarpum (tall annual willowherb)	1.5	60.9
Erigeron pumilis (shaggy fleabane)	0.2	8.7
Heliotropium curassavicum (salt heliotrope)	0.8	8.7
Holosteum umbellatum (jagged chickweed) [a]	2.1	60.9
Lactuca serriola (prickly lettuce) [a]	1.7	26.1
Microsteris gracilis (slender phlox)	1.8	30.4
Poa secunda (Sandberg bluegrass)	0.7	4.3
Poa species (annual bluegrass)	0.8	8.7
Salsola tragus (Russian thistle) [a]	0.1	4.3
Sisymbrium altissimum (Jim Hill's tumblemustard) [a]	8.7	91.3
Verbena bracteata (bracted vervain)	0.2	8.7
Vulpia octoflora (sixweeks fescue)	4.1	56.5
Crust	21.4	69.6
Bare ground	11.4	82.6
Total Canopy Cover	**34.0**	
Total Native % Cover	10.1	
Total Non-Native % Cover	23.9	

[a] Invasive species
X - present in pool, not detected on transect

4.3.2 Gable Butte Blind Canyon

One vernal pool at the Gable Butte Blind Canyon was detected in 2017 monitoring (BC-1) but aerial photographs suggested another pool was present east of the monitored pool. This previously unmonitored pool was visited on March 5, 2018, and though it was dry it had similar characteristics to the other dry vernal pools and most likely contains water during high precipitation years. This pool is referred to as BC-2 (Figure 4-8). The BC-1 pool was visited on March 5, 2018, and found to be very dry (Figure 4-9). This pool lacked the annuals found in other vernal pool basins. The soil in this pool appeared to be sandier than the other Gable Butte pools. Given the topography surrounding this vernal pool, it serves as a catch basin for Russian thistle (*Salsola tragus*), many of which were found within the pool boundaries.

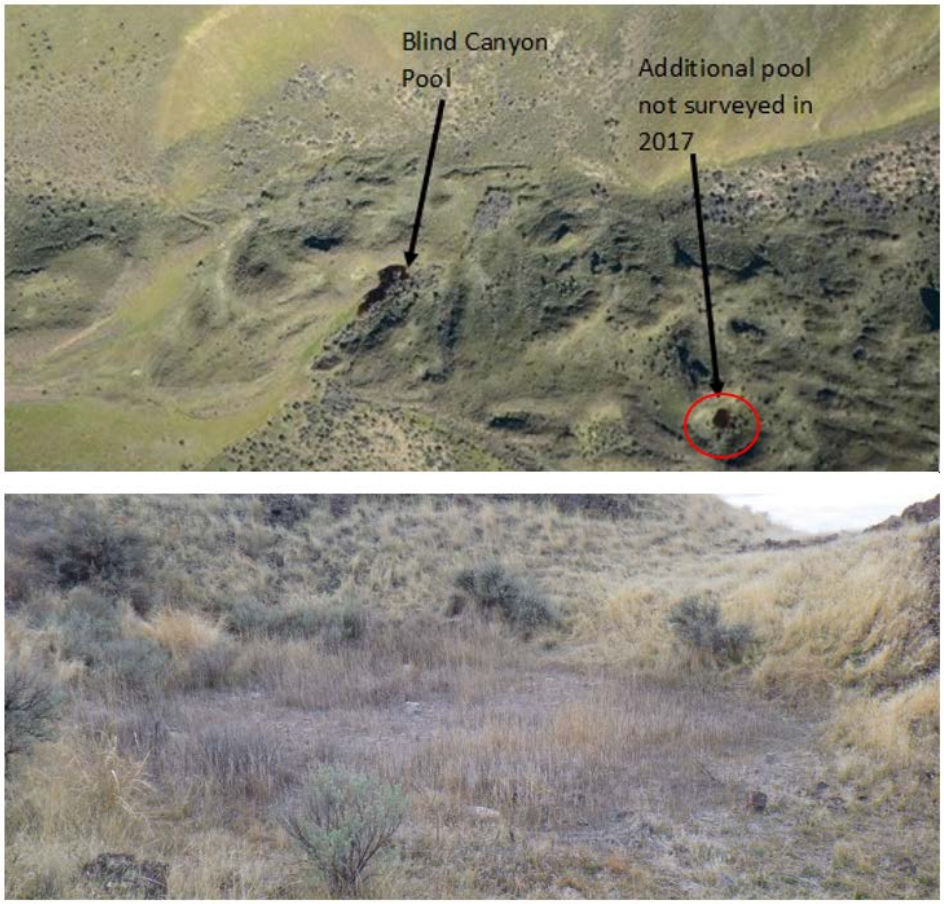

Figure 4-8. The Blind Canyon Vernal Pool, BC-2, From 2018 Monitoring

Figure 4-9. The Blind Canyon Vernal Pool, BC-1, From 2018 Monitoring

Pool BC-1 was revisited on May 23, 2018, to assess vegetative composition (Table 4-7). Daubenmire plots were taken every 6.56 ft (2 m) due to the length of this pool and the transect spanned 111.5 ft (34 m). This pool had areas with significant bare ground as well as very rocky areas (not included in estimation of bare ground). In addition, the Russian thistle that had built up in the pool made taking plot measurements difficult in certain areas. Dead Russian thistle were not counted in plot measurements.

Total plant cover measured 47.9% with 27.2% native cover and 20.7% non-native cover. This pool had the highest native cover of all the vernal pools measured in 2018. Thirteen total species were identified within the pool basin and eight of those species were native. The dominant species within pool BC-1 was salt heliotrope (*Heliotropium curassavicum*), a native species characteristic of disturbed areas and vernal pools on Hanford. This is the only pool where cheatgrass was not the dominant species; cheatgrass had a cover of 8.8%. The dominant non-native species was Jim Hill's tumblemustard (*Sisymbrium altissimum*) with 10.9% cover. Other notable species measured at this site included yellow spiderflower (*Peritoma lutea*, 3.8% cover) and lowland cudweed (*Gnaphalium palustre*, 5.4% cover).

Biotic crust at this site had a coverage of 1.5%, which is significantly lower than the other three clusters of pools that average 24% coverage. Native plant cover was the highest at Pool BC-1 at 27.2% compared to an average of 9.8% at the other pools.

Table 4-7. Percent Canopy Cover and Frequency of Occurrence at Gable Butte Blind Canyon Pool 1 in 2018.

Species	% Cover	% Frequency
Achillea millefolium (common yarrow)	X	X
Artemisia tridenata (big sagebrush)	0.1	5.9
Bromus tectorum (cheatgrass) [a]	8.8	88.2
Chenopodium album (lambsquarters) [a]	X	X
Erigeron pumilis (shaggy fleabane)	X	X
Epilobium brachycarpum (tall annual willowherb)	0.3	11.8
Gnaphalium palustre (lowland cudweed)	5.4	70.6
Heliotropium curassavicum (salt heliotrope)	17.6	64.7
Lactuca serriola (prickly lettuce) [a]	0.9	35.3
Peritoma lutea (yellow spiderflower)	3.8	35.3
Poa secunda (Sandberg bluegrass)	X	X
Salsola tragus (Russian thistle) [a]	0.4	17.6
Sisymbrium altissimum (Jim Hill's tumblemustard) [a]	10.6	58.8
Crust	1.5	35.3
Bare ground	26.3	82.4
Total Canopy Cover	**47.9**	
Total Native % Cover	27.2	
Total Non-Native % Cover	20.7	

[a] Invasive species
X - present in pool, not detected on transect

4.4 Gable Mountain Vernal Pools – 2018

The three vernal pools located east of Gable Mountain were visited on March 5, 2018. All three pools were dry. Pool GM-1 was noted to have very little vegetation apart from cheatgrass (*Bromus tectorum*). Pool GM-2 appeared to have moister soil and there were areas covered with moss. Pool GM-3 had no water and the southern end of the pool had a healthy biotic crust between the rocks.

Coyote digs were found in pools GM-1 and GM-2. Elk, deer, and coyote tracks were common throughout the three pools and an obvious game trail led from GM-1 to GM-2.

The Gable Mountain pools were revisited on May 23, 2018, and all three were assessed for vegetative composition. The transect at Pool GM-1 was 13 m (42.6 ft), and the transects at GM-2 and GM-3 were 7 m (23.0 ft). Pool GM-1 had coverage measuring 43.5%, made up of only 1.2% native cover and 42.3% non-native cover (Table 4-8). Nine species were detected at GM-1 with three of those being native and six non-native. The most abundant species was cheatgrass with 28.8% cover. The most abundant native species was bracted vervain (*Verbena bracteata*) with 1.2% cover. This pool had the highest amount of biotic crust cover with 60% coverage.

Pool GM-2 had greater species diversity than GM-1 (Table 4-9). Fourteen species were identified at this site, eight of which were native and six were non-native. Pool GM-2 had coverage measuring 45.8%, made up of 16.1% native and 29.7% invasive cover. The most abundant species at this site was cheatgrass with 12.5% cover, and the most abundant native species was sixweeks fescue (*Vulpia octoflora*) with 8.6% cover. This pool had less biotic crust than GM-1, measuring 17.1% cover.

Pool GM-3 had 14 species detected, with 7 native and 7 non-native species (Table 4-10). Canopy cover totaled 53.1% with 5.0% native cover and 48.1% non-native cover. The most abundant species at this site was cheatgrass with 38.2% cover and the most abundant native species were toad rush (*Juncus bufonius*) and sixweeks fescue, both with 2.1% cover. Pool GM-3 also had less biotic crust than GM-1, measuring 16.8% cover.

When analyzed as a group, the Gable Mountain vernal pools had the lowest native species cover (7.4% cover), number of native species (6), and total species detected (12.3 species per pool) of all the vernal pool clusters. They also had the highest biotic crust coverage (31.3%); however, this is due to the extremely high coverage at pools GM-1; GM-2 and GM-3 had relatively average biotic crust cover. Average cheatgrass cover was higher at the Gable Mountain pools (26.5%) than at the other pool clusters measured in 2018. Figure 4-10 shows each of the Gable Mountain pools and the coyote dig and biotic crust found at Pool GM-1.

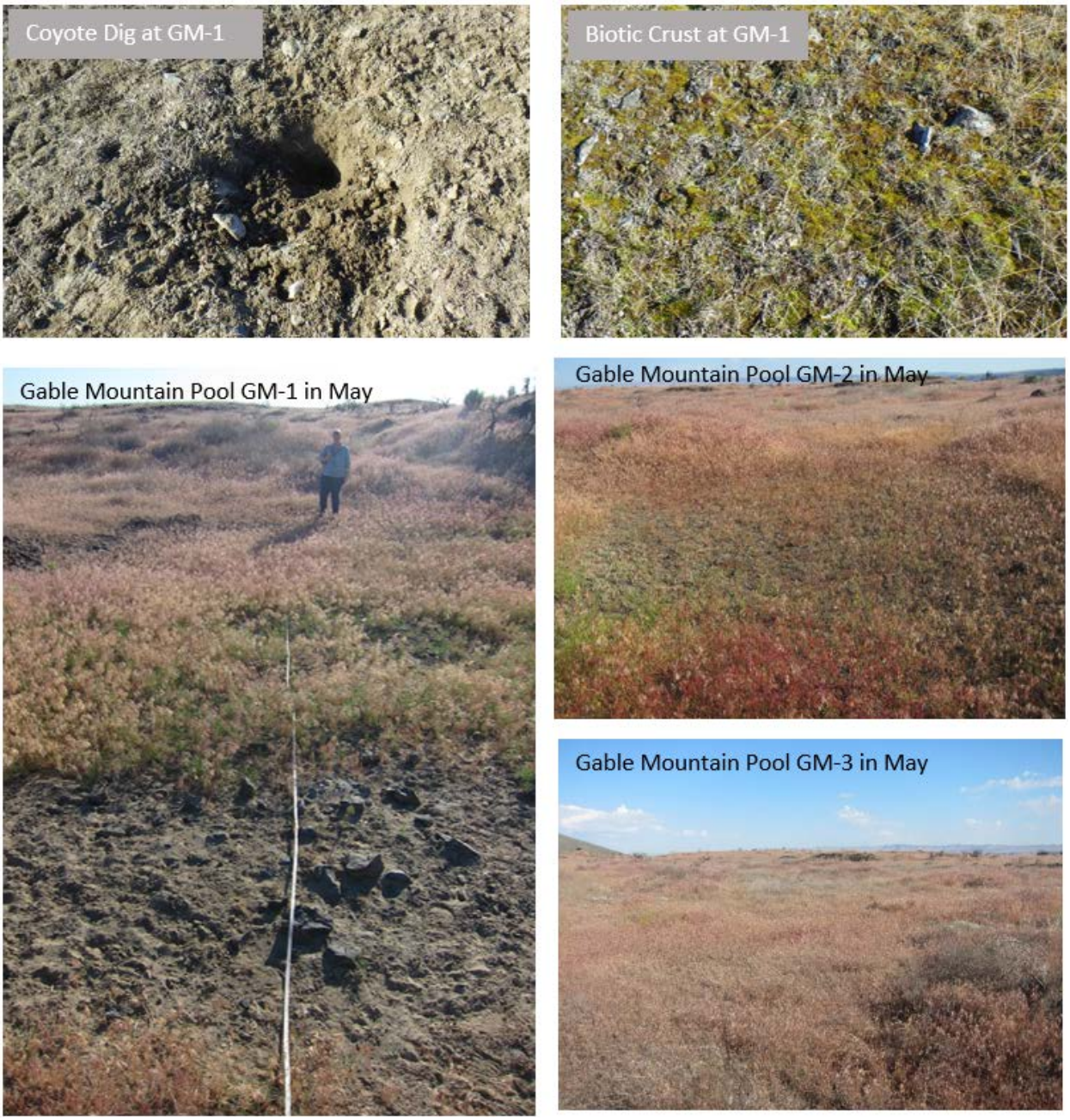

Figure 4-10. The Gable Mountain Pools in May 2018

Table 4-8. Percent Canopy Cover and Frequency of Occurrence at Gable Mountain Pool 1 in 2018. (2 Pages)

Species	% Cover	% Frequency
Bromus tectorum (cheatgrass) [a]	28.8	92.3
Draba verna (spring whitlow grass) [a]	0.4	15.4

Lactuca serriola (prickly lettuce) [a]	X	X
Poa secunda (Sandberg bluegrass)	X	X
Polypogon monspeliensis (rabbitsfoot grass) [a]	8.3	69.2
Salsola tragus(Russian thistle) [a]	4.8	76.9
Sisymbrium altissimum (Jim Hill's tumblemustard)	X	X
Tragopogon dubius (yellow salsify) [a]	X	X
Verbena bracteata (bracted vervain)	1.2	7.7
Crust	60.0	100.0
Bare ground	4.0	15.4
Total Canopy Cover	**43.5**	
Total Native % Cover	1.2	
Total Non-Native % Cover	42.3	

[a] Invasive species
X - present in pool, not detected on transect

Table 4-9. Percent Canopy Cover and Frequency of Occurrence at Gable Mountain Pool 2 in 2018.

Species	% Cover	% Frequency
Achillea millefolium (common yarrow)	X	X
Bromus tectorum (cheatgrass) [a]	12.5	85.7
Draba verna (spring whitlowgrass) [a]	11.1	85.7
Epilobium brachycarpum (tall annual willowherb)	0.4	14.3
Euphorbia serpyllifolia (thyme-leafed spurge)	X	X
Gnaphalium palustre (lowland cudweed)	2.5	28.6
Holosteum umbellatum (jagged chickweed) [a]	1.1	42.9
Juncus bufonius (toad rush)	4.6	42.9
Lactuca serriola (prickly lettuce)	X	X
Poa bulbosa (bulbous bluegrass) [a]	X	X
Poa secunda (Sandberg bluegrass)	X	X
Salsola tragus (Russian thistle) [a]	2.9	42.9
Sisymbrium altissimum (Jim Hill's tumblemustard) [a]	2.1	85.7
Vulpia octoflora (sixweeks fescue)	8.6	57.1
Crust	17.1	71.4
Bare ground	31.8	100.0
Total Canopy Cover	**45.8**	
Total Native % Cover	16.1	
Total Non-Native % Cover	29.7	

[a] Invasive species
X - present in pool, not detected on transect

Table 4-10. Percent Canopy Cover and Frequency of Occurrence at Gable Mountain Pool 3 in 2018.

Species	% Cover	% Frequency
Bromus tectorum (cheatgrass) [a]	38.2	100
Descuriania sophia (flixweed) [a]	X	X
Draba verna (spring whitlowgrass) [a]	7.1	71.4
Erigeron filifolius (threadleaf fleabane)	X	X
Epilobium brachycarpum (tall annual willowherb)	X	X
Euphorbia serpyllifolia (thyme-leafed spurge)	X	X
Holosteum umbellatum (jagged chickweed) [a]	1.4	57.1
Juncus bufonius (toad rush)	2.1	14.3
Lactuca serriola (prickly lettuce) [a]	X	X
Poa secunda (Sandberg bluegrass)	0.4	14.3
Sisymbrium altissimum (Jim Hill's tumblemustard) [a]	1.4	57.1
Sphaeralcea munroana (Munro's globemallow)	0.4	14.3
Tragopogon dubius (yellow salsify) [a]	X	X
Vulpia octoflora (sixweeks fescue)	2.1	14.3
Crust	16.8	57.4
Bare ground	8.9	85.7
Total Canopy Cover	**53.1**	
Total Native % Cover	5.0	
Total Non-Native % Cover	48.1	

[a] Invasive species
X - present in pool, not detected on transect

4.5 Summary and Conclusions

The dry winter of 2018 contrasted the unusually wet winter of 2017, presenting an opportunity to check the vernal pools for inundation and to evaluate vegetative composition on a year with below average rain and snowfall. All of the pools visited were dry, though some had soil that appeared moister than others.

It is difficult to determine if a cluster of pools are healthier or more pristine than the others, as each cluster varies in its attributes significantly (Table 4-11). The highest biotic crust cover occurred at the Gable Mountain pools, yet those pools also had the highest non-native plant cover. The Gable Butte pools had the highest number of native species but relatively low native cover. The pool that could be considered the most pristine based on these data would be the Gable Butte Blind Canyon pool, which had the highest native cover and the lowest non-native cover. Interestingly, at this pool biotic crust cover was nearly non-existent. The Umtanum Ridge pools, described as the most pristine pools at the Hanford Site during the 1997 vernal pool surveys, had relatively average vegetative composition when compared to the other vernal pools in 2018. The presence of the Washington State sensitive species

Suksdorf's monkeyflower (*Erythanthre suksdorfii*) at the Umtanum Ridge pools may have contributed to the Nature Conservancy describing them as pristine – this plant was not found in 2018 surveys.

Table 4-11. Vernal Pool Summary Statistics from 2018 Vegetation Monitoring.

	GM	GB BC	GB	U	
Vegetation Composition	*Average Per Pool*				*Average - All Pools*
Number of Species	12.3	13	18.3	14.6	14.6
Number of Native Species	6.0	8.0	9.0	8.0	7.8
Native Cover	7.4%	27.2%	8.1%	13.9%	14.1%
Non-Native Cover	40.0%	20.7%	30.0%	30.0%	30.2%
Biotic Crust Cover	31.3%	1.5%	19.6%	21.1%	18.4%

GM = Gable Mountain
GB BC = Gable Butte Blind Canyon
GB = Gable Butte
U = Umtanum Ridge

Though vegetative composition was not analyzed in 2017, plant species were recorded throughout 2017 monitoring and plant species lists were developed during the July and August 2017 visits. In the modified version of Table 4-12 below, the obligate (OBL) and facultative (FACW) wetland species found in vernal pools in 2017 are listed (Table 4-12). It is apparent that less facultative and obligate wetland species were found in the vernal pools during 2018 monitoring, and those that were found were not as widespread as the year prior. Purplestem monkey flower (*Erythranthe floribunda*), the only obligate wetland species detected in 2017 was not found in 2018. Interestingly, GM-2, which had soil that appeared moister than the other pools, contained both lowland cudweed (*Gnaphalium palustre*) and toad rush (*Juncus bufonius*). Three other plants not considered facultative or obligate wetland species were not found in 2018 surveys: white pigweed (*Amaranthus albus*), Suksdorf's monkeyflower, and obscure suncup (*Neoholmgrenia andina*). Suksdorf's monkeyflower is a Washington State sensitive species and tracking its occurrence through both wet and dry years will help increase understanding of the plant's germination and habitat requirements.

Table 4-12. Wetland Vegetation Found in Vernal Pools in 2017 and 2018.

Scientific Name	Common Name	Wetland Status	2017 Vernal Pool Locations			2018 Vernal Pool Locations		
			U	GB	GM	U	GB	GM
Erythranthe floribunda	purplestem monkeyflower	OBL	X	X	X			
Gnaphalium palustre	lowland cudweed	FACW	X	X	X		X	X
Grindelia hirsutula	hairy gumweed	FACW			X			
Juncus bufonius	toad rush	FACW	X	X	X			X
Polypogon monspeliensis	rabbitsfoot grass	FACW		X	X		X	X
Xanthium strumarium	rough cocklebur	FACW				X		

U = Umtanum Ridge
GB = Gable Butte
GM = Gable Mountain

Vegetation in the majority of the vernal pools was dominated by cheatgrass (*Bromus tectorum*) with an average cover of 18.3% at all pools. Native species composed 53.4% of all species found at vernal pools. When comparing 2018 plant composition to 2017 species lists, it is important to consider that less pools were monitored in 2018. As listed in Table 4-13, a total of 38 species of vascular plants were observed in the vernal pool basins in 2018 compared to 47 observed in 2017. Approximately 61% of the species found in the pools were native while the rest were introduced, closely matching the percent of native species from 2017 (62%). A shift occurred from wetland to upland species from 2017 to 2018. In 2017, 73% of plants found in the vernal pools were strictly upland or facultative upland species, in 2018 that percentage rose to 79%.

Table 4-13. Vegetation Present in the Vernal Pool Basins in 2018. (2 Pages)

Scientific Name	Common Name	Native or Introduced	Special Status	Wetland Status	Vernal Pool Locations		
					U Ridge	Gable Butte	Gable Mtn.
Achillea millefolium	yarrow	native		FACU		X	X
Ambrosia acanthicarpa	flatspine bur ragweed	native		UPL		X	
Artemisia tridentata	big sagebrush	native		UPL	X		
Bromus tectorum	cheatgrass	introduced		UPL	X	X	X
Camissonia andina	Blackfoot River evening primrose	native		UPL	X		
Chenopodium album	lambsquarters	introduced		FACU		X	
Chenopodium leptophyllum	slimleaf goosefoot	native		FACU		X	
Conyza canadensis	horseweed	native		FACU	X	X	
Descurainia sophia	flixweed	introduced		UPL	X	X	X
Distichlis spicata	alkali saltgrass	native		FAC		X	
Draba verna	spring whitlowgrass	introduced		UPL	X	X	X
Elymus elymoides	bottlebrush squirreltail	native		FACU		X	
Epilobium brachycarpum	tall willowherb	native		UPL	X	X	X
Erigeron filifolius	threadleaf fleabane	native		UPL			X
Erigeron pumilus	shaggy fleabane	native		UPL	X	X	
Erodium cicutarium	redstem storksbill	introduced		UPL	X	X	
Euphorbia serpyllifolia	thymeleaf spurge	native		UPL			X
Gnaphalium palustre	lowland cudweed	native		FACW		X	X
Heliotriopium curassavicum	salt heliotrope	native		FACU		X	
Holosteum umbellatum	jagged chickweed	introduced		UPL	X	X	X

Table 4-13. Vegetation Present in the Vernal Pool Basins in 2018. (2 Pages)

Scientific Name	Common Name	Native or Introduced	Special Status	Wetland Status	Vernal Pool Locations		
					U Ridge	Gable Butte	Gable Mtn.
Juncus bufonius	toad rush	native		FACW			X
Kochia scoparia	summer cypress	introduced	WA - Class B weed	FAC		X	
Lactuca serriola	prickly lettuce	introduced		FACU	X	X	X
Lepidium latifolium	broadleaf pepperweed	introduced	WA - Class B weed	FAC	X		
Lepidium perfoliatum	clasping pepperweed	introduced		FACU		X	
Microsteris gracilis	pink microsteris	native		FACU	X	X	
Peritoma lutea	yellow spiderflower	native		FACU		X	
Poa bulbosa	bulbous bluegrass	introduced		FACU	X		X
Poa secunda	Sandberg bluegrass	native		FACU		X	X
Poa species	bluegrass species	N/A		N/A		X	
Polypogon monspeliensis	rabbitsfoot grass	introduced		FACW		X	X
Psuedoregneria spicata	bluebunch wheatgrass	native		UPL	X		
Salsola tragus	Russian thistle	introduced		FACU	X	X	X
Sisymbrium altissimum	Jim Hill tumble mustard	introduced		FACU	X	X	X
Sphaeralcea munroana	Munro's globemallow	native		UPL		X	X
Tragopogon dubius	salsify	introduced		UPL	X	X	X
Verbena bracteata	bracked verbena	native		FAC	X	X	X
Vulpia octoflora	sixweeks fescue	native		UPL	X	X	X

Vegetation monitoring after a wet winter in 2017 and a dry winter in 2018 revealed different vegetative communities. Species cover and frequency of occurrence cannot be compared as these data were not collected in 2017, but the differences in these preliminary data suggest that changes occur between relatively wet and dry years. Repeating vegetative composition surveys at vernal pools during a relatively wet year is essential to have a thorough understanding of how vegetative composition changes based on winter precipitation and snowfall.

5.0 2019 Vernal Pool Monitoring

The fall and winter of 2018/2019 was fairly mild until February 2019 when the Hanford Site saw large amounts of snowfall comparable to the snowfall experienced before the 2017 vernal pool monitoring season. Precipitation between October and the end of February totaled 5.15 in. (13.1 cm), more than the winter of 2017/2018 and less than the winter of 2016/2017 (Table 5-1). In addition to the 32.1 in. (81.5 cm) of snowfall received from October 2018 to February 2019, 4.4 in. (11.2 cm) of snow fell in March 2019.

Table 5-1. Precipitation and Snowfall from October to the end of February at the Hanford Site.

Winter	Precipitation (inches)	Snowfall (inches)
2016/2017	6.86	28
2017/2018	4.12	6.8
2018/2019	5.15	32.1

This unusually large amount of snowfall presented an opportunity to monitor vernal pools for presence/absence. Additionally, monitoring during a year with higher snowfall and lower precipitation than the 2016/2017 season may indicate if precipitation or snowfall have a greater effect on vernal pool water levels.

5.1 Monitoring Methods

Vernal pool monitoring in the 2019 season was relatively simple with the goal of assessing vernal pool presence/absence. If water was detected in a vernal pool, the pool was mapped with a handheld GPS in order for the boundary to be compared to boundaries from 2017 monitoring. If multiple pools held water, a vegetation survey would be planned for the late spring of that year in order to compare vegetative composition in a dry year to a wet year. Too few pools were found holding water for an extensive vegetation survey and the decision was made to postpone the survey until a year where more pools contained water.

5.2 Umtanum Ridge Vernal Pools – 2019

Umtanum Ridge Pools U-1 and U-2 were visited on April 19, 2019. Neither pool held water, as seen in Figure 5-1. Both pools appeared to have relatively heavy vegetative cover. Pool U-1 contained significant coverage from cheatgrass (*Bromus tectorum*), Sandberg bluegrass (*Poa secunda*), shaggy fleabane (*Erigeron pumilis*), and big sagebrush (*Artemisia tridentata)*. Big sagebrush recruits appeared to be 1 to 2 years old, and the number of sagebrush recruits and shaggy fleabane individuals appeared to have increased significantly from the previous 2 years. The vegetative boundaries of U-2 were difficult to distinguish from the surrounding areas. Soil at both pools appeared to hold more moisture than soil in the surrounding areas but was not muddy, as other pools had appeared soon after drying out. Because neither Pool U-1 nor U-2 held water, the other Umtanum Ridge pools were not visited.

Figure 5-1. The Umtanum Ridge Pools in 2019

5.3 Gable Butte Vernal Pools – 2019

Pools in both the Gable Butte Saddle area and Blind Canyon were visited in 2019 in order to determine presence/absence of water and to map the boundaries.

5.3.1 Gable Butte Saddle Area

Six vernal pools in the Gable Butte Saddle area were visited on April 19, 2019, including Pools GB-1, GB-2, GB-3, GB-4, GB-6, and GB-7. Water was present in pools GB-4 and GB-7 while the other pools were dry (Figure 5-2). The dried Gable Butte pools appeared to have held water at some point in the spring based on the lack of vegetation present within the pool boundaries, the soil moisture, and the deeply indented elk and deer prints found throughout the pools.

Pool GB-4 had split into multiple pools, similar to what was observed in 2017 monitoring, and there were clearly delineated dry and wet areas within the GB-4 boundaries. Four distinct water-holding pools had formed within the boundaries of GB-4 (Figure 5-3). Three of the water-holding pools were located in the GB-4C area and one was located in the GB-4A area. The pool in the GB-4A area was the largest. The map shown in Figure 5-4 shows the vernal pools measured in 2019 compared to the boundaries of the pools measured in 2017. The pools formed in 2019 were significantly smaller than those formed in 2017. Two mallards (*Anas platyrhynchos*) were observed swimming in Pool GB-4. Pool

GB-7 also contained water and the boundary of this pool was significantly smaller than that measured in 2017. Dead vegetation surrounded the pool, as shown in Figure 5-5.

Figure 5-2. The Gable Butte Pools with No Water in April 2019

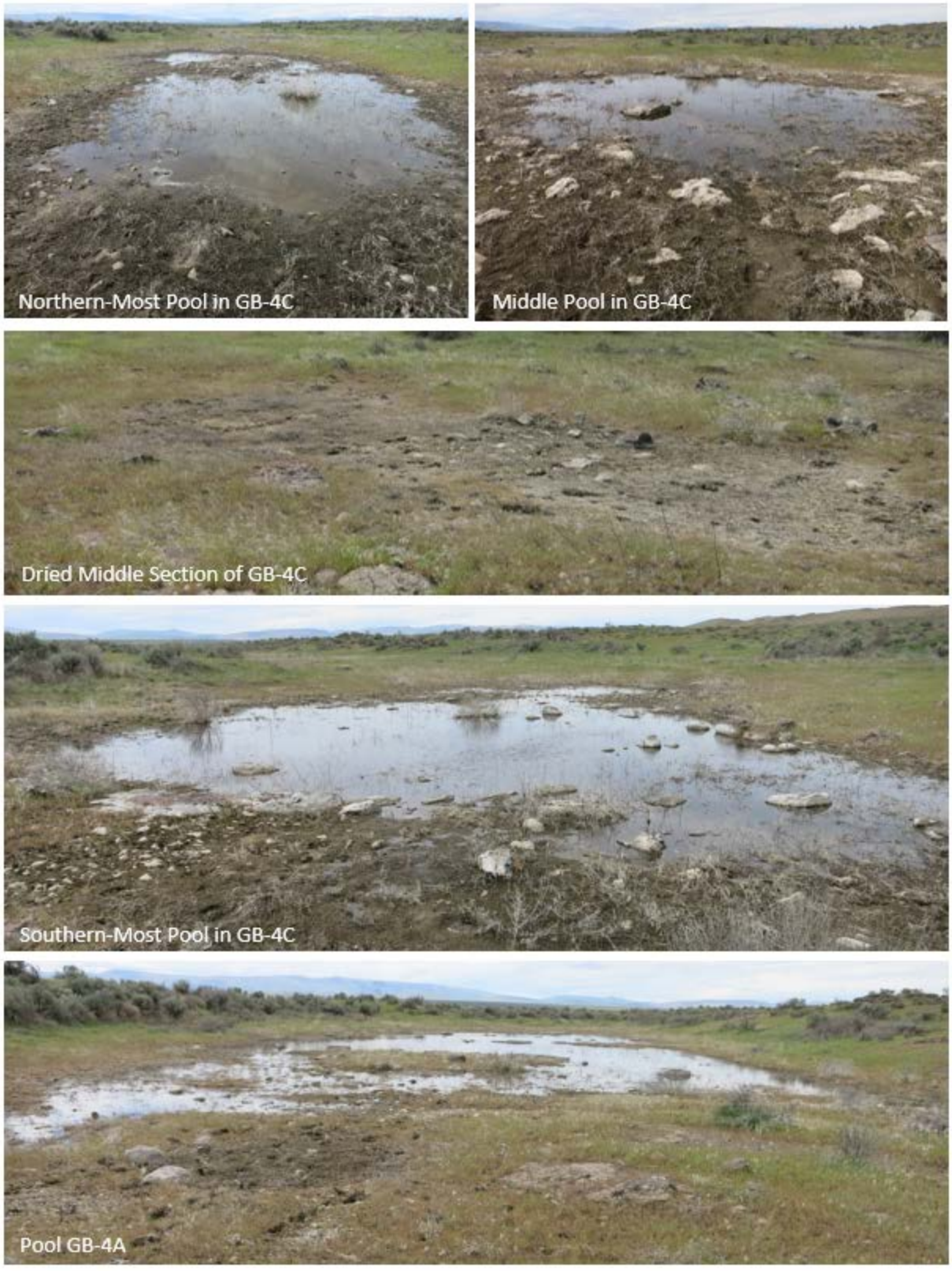

Figure 5-3. Water-Holding Areas of GB-4 in April 2019

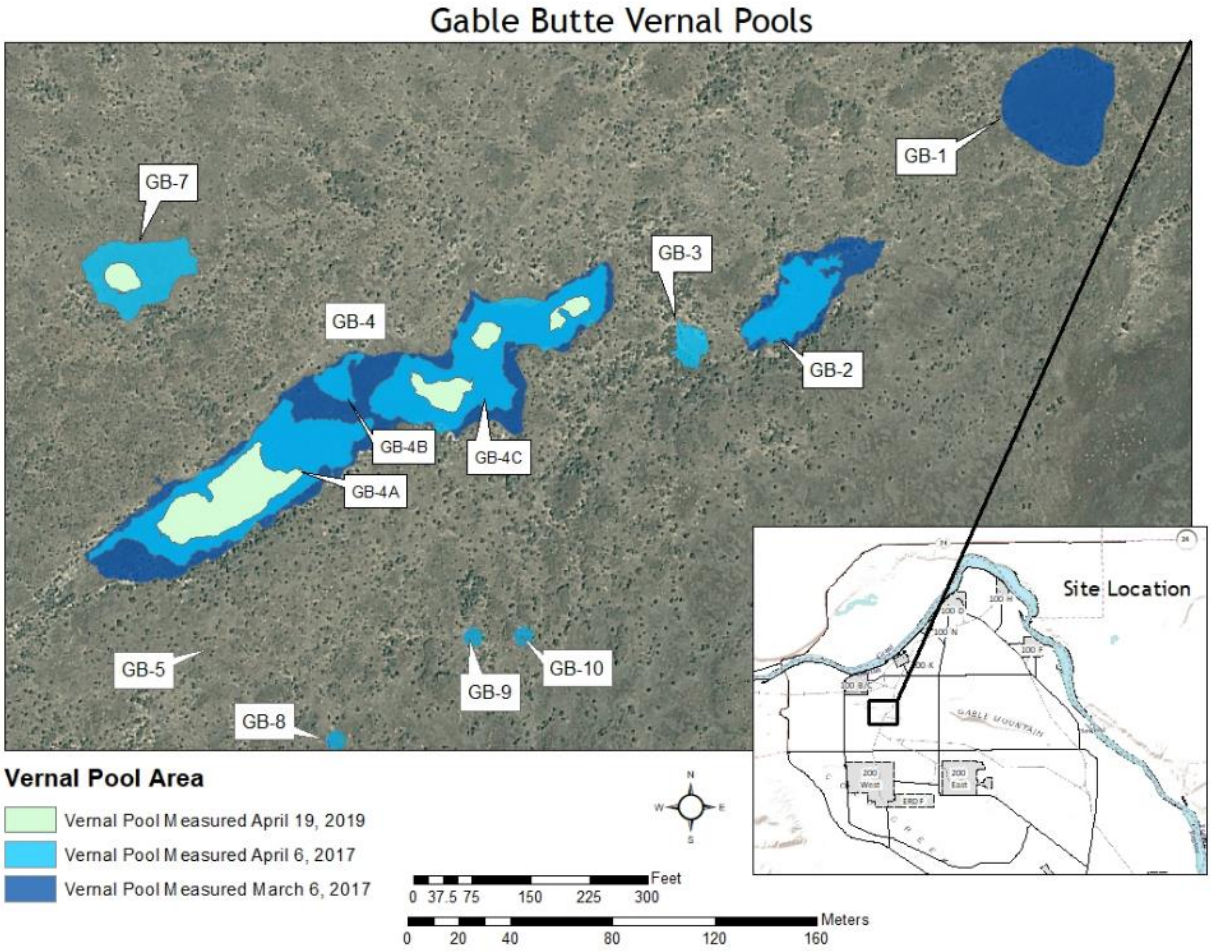

Figure 5-4. The Gable Butte Pool Boundaries in 2019 Compared to 2017 Boundaries

Figure 5-5. Gable Butte Pool 7 in 2019, Showing Dead Vegetation Surrounding Pool

5.3.2 Gable Butte Blind Canyon

Gable Butte Blind Canyon Pool 1 was visited on April 19, 2019. No water was present in the pool and the soil appeared to be dry, as shown in Figure 5-6.

Figure 5-6. Gable Butte Blind Canyon Pool 1 in April 2019

5.4 Gable Mountain Vernal Pools – 2019

Gable Mountain Vernal Pools GM-1, GM-2, and GM-3 were visited the morning of April 18, 2019. GM-1 contained water and the soil around the boundary was muddy with considerable animal tracks. The water within the pool was murky and brown. Cheatgrass was the clear dominant species in the margins of the pool. Desiccated Sandberg bluegrass bunches were also present in the margins. Pool GM-2 was present and filled with water. Similarly to pool GM-1, the soil surrounding GM-2 was muddy and marked with animal tracks. This suggests both GM-1 and GM-2 may have contained more water earlier in the season. Pool GM-3 had no water. The inner pool area was dominated by cheatgrass. The soil of GM-3 was moist but not muddy, suggesting if the pool had held water that year it was either very little or not recent. Figure 5-7 shows the boundaries of the Gable Mountain pools measured in 2019 compared to 2017 boundaries. Similar to the Umtanum Ridge pools, GM-1 and GM-2 were both significantly smaller than what was found in 2017. Figure 5-8 shows the Gable Mountain Vernal Pools in 2019.

Previous monitoring of these pools in 2017 found all three pools having water on March 30; only Pool GM-1 contained water during the next monitoring effort on May 8, 2017.

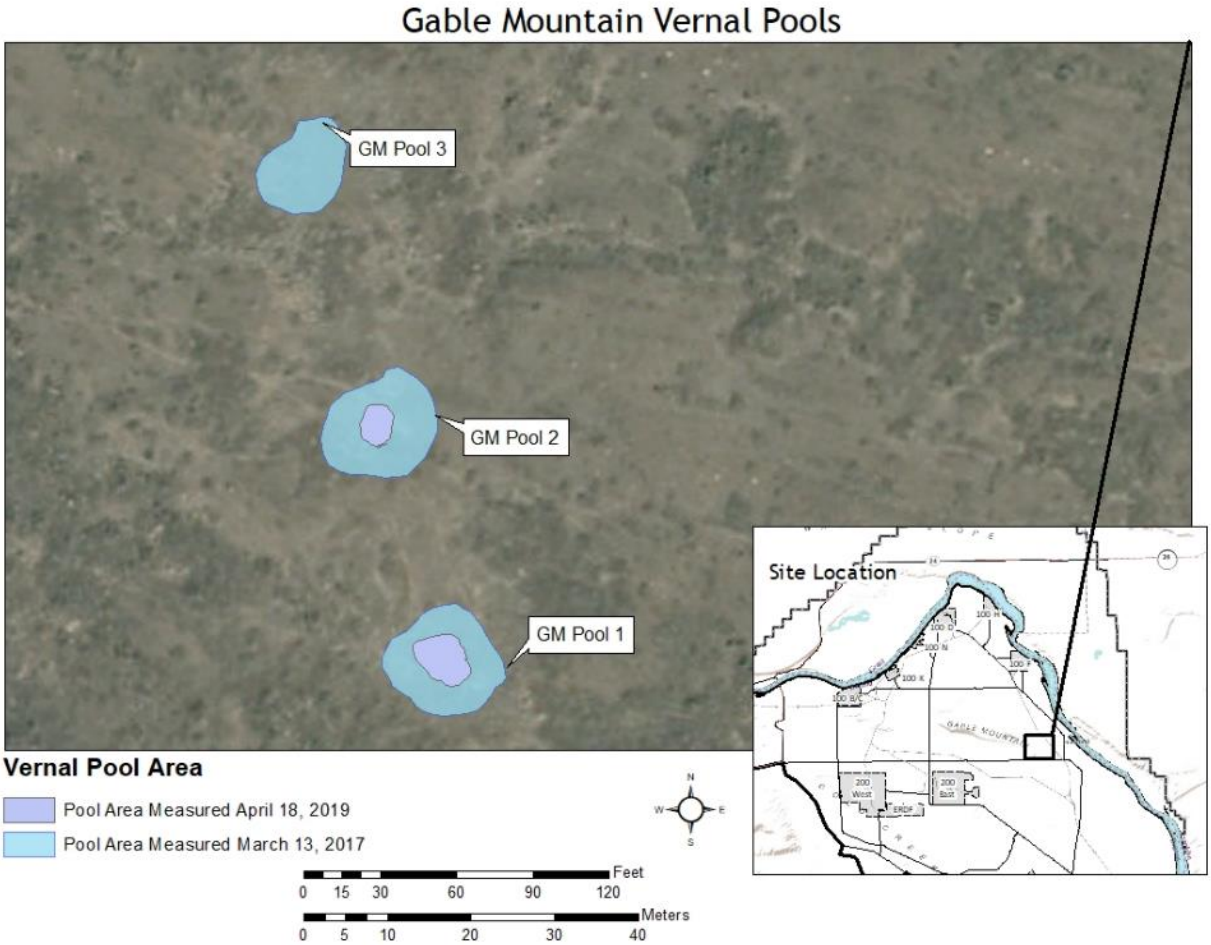

Figure 5-7. Boundaries of the Gable Mountain Pools in 2019 Compared to 2017 Boundaries

Figure 5-8. The Gable Mountain Pools in April 2019

5.5 Summary and Conclusions

Though snowfall in 2019 was significantly higher than in the 2016/2017 season, vernal pools were not as numerous or robust in 2019 as they were in 2017. Gable Butte and Gable Mountain pools were the only pools monitored that contained water, suggesting these pools are more likely to contain water in lower precipitation and snowfall years. Because they held water in a year when not all pools were inundated, pools GB-4, GB-7, GM-1, and GM-2 may host different cohorts of plants than the drier pools. Interestingly, vegetative composition surveys in 2018 found facultative wetland plants at GM-2, GM-3, and GB-4. Gable Butte pool BC-1 was the only pool where facultative wetland plants were found in 2018 and that did not contain water in 2019.

The small size and limited occurrence of the vernal pools after heavy snowfall suggests a few possible scenarios. It is possible that winter precipitation plays a greater role in determining vernal pool water levels than snowfall, and 2018/2019 precipitation was not enough to fill pools to 2017 levels. Vernal pool progression may also be associated with daily temperatures and the speed of snowmelt. It is also possible that monitoring in mid-April was too late in the season to detect all of the vernal pools that had filled that year. For example, 2017 monitoring found the Gable Mountain pools were all present on March 30, but only GM-1 was present on May 8. Future monitoring with the goal of determining presence/absence of vernal pools should aim to visit the pools as soon as snowmelt occurs, ideally early March. Monitoring the vernal pools in early March 2019 was not possible, as it snowed the first week of March 2019 and there was significant snow on the ground through the first half of the month.

6.0 Management Actions and Proposed Future Monitoring

The results of the vernal pool monitoring effort on the Hanford Site initiated the following management actions:

1) All pool locations will be used to update the Hanford Site map of Level 5 resources, which is generally published in BRMP (DOE 2017). The next revision of BRMP will present an opportunity to include these data in the map of Level 5 resources.

2) The locations of populations of noxious weeds (Washington State Noxious Weed Control Board 2017) found in or encroaching upon the vernal pools, will be referred to Mission Support Alliance's Biological Controls group for control of those plants. This management action is continuous as pool vegetation continuous to be assessed.

3) The vernal pools will be evaluated as potential plant community element occurrences. Proper documentation will be submitted to the Washington Natural Heritage Program (WNHP) if the criteria for an element occurrence are met. Current evaluation suggests the vegetative communities of the Hanford Site vernal pools do not match the vegetative communities that the WNHP assign to vernal pools in the state. Continuing discussions with the WNHP are necessary to potentially include Hanford Site vernal pools as plant community element occurrences.

Based on the 2017 monitoring, a number of monitoring tasks were recommended. The tasks are described below, along with any progress made on the item since 2017 monitoring.

1) While the vernal pool areas are fairly well defined in the field, these pools probably do not fill with water every year. Even if they do contain water, the size of the vernal pools likely varies significantly from year to year. In order to better understand the vernal pools on the Hanford Site, an annual survey should be done in the mid-February to March timeframe (after any surface snow has melted). This survey should include GIS mapping of the perimeters of any pools present.

   ➔ Annual surveys were performed in 2018 and 2019 to assess vernal pool presence. Vernal pools were found in 2019 surveys and their perimeters were mapped. Data are included in this report. Future annual surveys will help increase the understanding of the conditions required for vernal pools on the Hanford Site.

2) Vegetation monitoring should be for a series of years, including both wet and dry years, so that the ecological impact of the intermittent flooding in the species coverage and diversity can be better understood. Transects that traverse the center of the pool would be useful to further delineate any zonation that may be occurring in the pools.

   ➔ Vegetation monitoring was performed in 2018, which was a relatively dry year where the pools did not fill with water. Transects traversed the center of the pools and these data can be used in future studies analyzing delineation. Further monitoring of pool vegetation during years when the pools fill with water is needed.

3) Rare plant monitoring should occur in years when the vernal pools are present because the three State-listed species previously identified (Suksdorf's monkeyflower, mousetail, and spreading pygmyleaf) as residing in the pools are small annual plants that may not be present in the drier years. Periodic monitoring may allow a better understanding of the conditions needed for germination and survival of these rare species.

   ➔ Vegetation monitoring in 2018 did not detect any State-listed species, suggesting they may be less likely to germinate during dry years. Additional monitoring is needed to confirm this.

4) More complete and specific monitoring of the pools for macroinvertebrates should be done when pools are present. The 2017 monitoring was done simply to assess whether or not the pools supported these organisms, and because the 2017 survey indicated that indeed a large diverse population is present, a more focused survey should be done. Survey methods should be chosen to make sure all potential macroinvertebrate taxa are likely to be found and a more detailed identification of the organisms present should be made (i.e., to genus level or below if practical). Sampling for fairy shrimp needs to begin earlier in the season since these organisms generally are found in cool-water pools and some vernal pool species require temperatures of 50 °F (10 °C) or less to hatch (USFWS 2007).

5) The largest pool on Gable Butte supported numerous spadefoot toad tadpoles in 2017. Although the tadpoles were noted, it is not known if they were able to complete full metamorphosis before the pool dried out. A more focused study of the timing for egg laying and tadpole development, as well as pool conditions, would add much to the understanding of this species on the Hanford Site. In addition, call surveys for Woodhouse's toads (*Anaxyrus woodhousii*), a Washington State Monitor species restricted to shrub-steppe habitat in the Columbia Plateau Ecoregion (WDFW 2015), should be done to see if they also use the vernal pools for egg laying.

6) The information on bird use of the pools was collected, incidentally, in 2017. Focused bird surveys of the pools would provide additional information about their importance to a range of birds from waterfowl and shorebirds to upland species during the spring nesting season. These birds may be quite important in the spread of vegetation and macroinvertebrates within and among the pools on site.

7) A more focused study of the use of the pools by mammals is also recommended. Trail cameras were useful but were limited by the ease with which elk, in particular, knocked them over and rendered them useless. Small mammal use of the pools was not specifically studied or observed in 2017; more focus on the identification of tracks and scat found in the mud within the pool area or live traps may provide additional data.

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