Introduction

Northwestern Nevada has experienced record-breaking precipitation during the winter of 2017. A series of atmospheric rivers have hit the area since January, leading to above-average snowpack and saturated soils. Precipitation measurements at Reno-Tahoe International Airport in January and February alone have totaled nearly 9 inches, more than the average annual total of 7.34 inches. These conditions have resulted in winter flooding in the Swan Lake area of Lemmon Valley, a closed basin with Swan Lake as its lowest point.

The State of Nevada requested Advance Measures Technical Assistance from the US Army Corps of Engineers (USACE) Sacramento District on February 28, 2017. The request specified that USACE should focus on assessing emergency protective measures for the current and potential flooding issues through the end of this spring's snowmelt period for the Swan Lake area of Lemmon Valley.

Objective

The goals of this technical assistance response were to provide recommendations for a hydrologic analysis and temporary flood-fight measures. The purposes of the hydrologic analysis are to estimate the magnitude of the snowmelt runoff that could flow into Swan Lake this spring and the potential maximum lake level. The purpose of the flood-fight recommendations is to develop a plan to reduce flood impacts to residents and critical infrastructure during this spring and summer.

Background

The Swan Lake Nature Study Area is located in the Eastern Lemmon Valley watershed, which is north of the city of Reno. The lake is formed at the lowest elevation of the valley (less than 4,920 ft NAVD88). There is no natural outlet for the lake, therefore the residents rely on summer-fall evaporation to reduce the water levels generated during winter-spring rain events and accumulated snow runoff. The topography of the area directly adjacent to the lake is largely level (less than 2% grade). Elevations increase more rapidly to the west and southeast of the lake. Four communities are located at the lake, on the north, northwest, east and southeastern shorelines. Additionally, a wastewater treatment plant is located in the southeast portion of the Swan Lake basin. A number of structures in these communities were constructed within the 100-year

floodplain (approx. 4,924 ft). The majority of these structures have either been elevated, or were constructed on elevated pads, however a number of older structures have foundations below 4,922 ft. A map of the watershed including the 100-year floodplain is included as Figure 1.

Due to a series of significant rain/snow events in January-February 2017 the water level in the lake has risen to 4,922 ft which has caused flooding in these lakeshore communities, displacing several residents, flooding septic and well-water systems, and forcing road closures. Additionally, the Peavine Range to the south, which drains into the Swan Lake basin, has received a greater than average amount of snowfall, which is anticipated to produce a record runoff amount during late spring and summer.

The nature of the area topography and location of the communities places some immediate constraints on short, intermediate, and long-term solutions to the flooding of Swan Lake. As previously noted, there is no natural outlet. Pumping water to nearby watersheds is not practical due to the distances and elevations involved, the neighboring systems being at or near capacity themselves, and water-quality concerns of moving water from Swan Lake out of the watershed. Water quality concerns also make increasing infiltration an undesirable measure because of the potential for groundwater contamination. The surficial lake deposit soils are generally sandy with low to moderate amounts of fines and zero plasticity.

Site Visit

On March 3, 2017, Sacramento District staff attended a site visit and meeting with Washoe County. The meeting date was set by the State of Nevada to ensure that they could coordinate schedules and collect background information. The site visit was a driving tour of the Lemmon Valley surrounding Swan Lake. USACE personnel included Brigid Briskin, Emergency Operations, Francis Weidenbener, Geotechnical Section, and Jesse Schlunegger, Hydraulic Analysis. Other attendees included representatives from the Nevada Department of Emergency Management and FEMA. The site visit included stops at four locations in the vicinity of Swan Lake.

1. The first location was at the intersection of Pompe Way and Albert Way, 39.6666N -119.8492W. In this location, three houses were flooded and several more threatened. The lakeside parcels are uninhabited with no structures present. Residents have attempted flood fighting with sand bags to varying degrees of success. It is noted that while the water has proceeded to surround several houses, it is relatively shallow, and houses as close as Coast Court, the first street inland from Pompe Way, are not currently threatened.

2. The second location was along Lemmon Drive at the northern tip of the lake, 39.6743N -119.8445W. Seven houses are flooded in this vicinity, with several others

threatened. Several homes in this community continue to maintain wells and septic systems, many of which have been flooded. The flooded houses in this area are those which have not been raised above the 100 year flood zone. Local flood fighting in this vicinity using sandbags was notable, however, it was observed that many of the sand bags were not placed correctly, i.e. stacked instead of overlapping, standing on end instead of laying, and overfull bags.

This location is at the north end of a berm that runs SSE towards the waste water treatment facility. This berm normally separates the lake from the communities to the north and east of the lake, however a number of low points, including at this location, allow flood waters in to threaten these communities. This is also the site of one of the closures of Lemmon Drive, as a low point in the roadway has been flooded to a depth of approximately 9 inches. The feasibility of using this natural berm as an aid in preventing flooding in these communities is discussed in the Topographic Assessment section below.

3. The third location was along Chickadee Drive to the northeast of the lake, 39.6711N -119.8289W, this site was investigated for practicability to be used as a detention area for lake water. This roughly triangular area is bounded by Chickadee Drive and Matterhorn Boulevard, and runs from Lemmon Drive northeast to Deodar Way. The area has an average slope of approximately 0.4% between Elevations 4924 and 4944. The feasibility of utilizing this region as a detention area is discussed in the Topographic Assessment section below.

4. The final site the team investigated was at the intersection of Lemmon Drive and Palace Drive, at the southeast end of the lake, just inland from the waste water treatment facility, 39.6465N -119.8312W. This location is at the southern end of the Lemmon Drive road closure, as well as the large berm that runs along the lake to the NNW, described in the paragraph on location 2 above. The team observed that the area between the berm and Lemmon Drive could potentially be isolated and used as another detention basin while also protecting the community to the east from rising lake water. This is further discussed in the Topographic Assessment section below.

Topographic Assessment

The purpose of the topographic assessment was to determine the potential to store water in open space adjacent to Swan Lake. The open space is northeast of Swan Lake between Matterhorn Blvd. and Chickadee Dr. Given the saturated soils in the valley, the team was interested in the storage volume that could be gained without excavation. The team obtained two-foot contours data from Washoe County of the area northeast of the lake, shown in Figure 2. As noted above in the Site Visit section, this area is fairly flat, with an average slope of about 0.4%. Elevation ranges from 4,924

and 4,944 ft NAVD88. There is one small depression, shown as a water body on the figure. The area of the depression alone would not provide significant storage.

The results of the topographic analysis are also shown in Figure 2. A two-tiered terrace was created to compute potential storage volume. Each tier would require a barrier such as k-rails on the low, "downstream" side and berms or barriers along the sides. Water would need to be pumped from the lake to the area. Area 1 requires approximately 3,000 ft of barrier along the 4,936 ft elevation curve, and 1,620 ft (total) of barrier along Chickadee Drive and Matterhorn Boulevard. This would provide approximately 100 acres of surface area and 165 acre-ft of storage capacity. Area 2 requires approximately 1,600 ft of barrier along the 4,932 ft elevation curve, and 2,100 ft (total) of barrier along Chickadee Drive and Matterhorn Boulevard. This would provide approximately 50 acres of surface area and 80 acre-ft of storage capacity.

Without excavation, the area northeast of Swan Lake could provide about 245 acre-ft of additional storage total. This storage volume would lower the level of Swan Lake by only a few inches. Construction of the storage areas in this area is not recommended as a means of lowering the lake.

If additional surface area is desired to increase evaporation, this area could be used to add 150 acres of surface area. The hydrologic modeling recommended below would aid in determining whether the additional evaporation would significantly impact the lake level.

The team also looked at the natural berm that runs along the northeastern side of the lake, described in the Site Visit section above. This berm is described geologically as Clay Dunes and should contain a slightly higher fines content than the lake and playa deposits that otherwise dominate the area geology. The berm has several low points at both ends and in the middle. This berm could be part of a long-term plan for flood risk management by extending the natural, existing feature. It could be used to create several small detention basins to alleviate high lake water levels. A plan would require some investigation and design and will not provide relief this water year.

Recommendation 1 – Hydrologic Analysis

The purposes of the recommended hydrologic analysis are to estimate the magnitude of the snowmelt runoff that could flow into Swan Lake this spring and the potential maximum lake level.

A rough estimate of lake level can be obtained by first computing the approximate total volume of basin's snowpack. Assuming that all of the snowmelt runoff reaches the lake and that there are no outflows gives a conservative estimate of maximum lake level. One way to estimate the volume is to use snow measurements from a similar basin

combined with the areal extent of snow in the watershed. The National Weather Service-Reno office provided the team with a measurement point in a similar watershed, included in the Appendix. The areal extents could be estimated with recent aerial photos or satellite imagery, or if those are not readily available, aerial imagery of past wet years could be used. Records of measured precipitation should be reviewed to decide whether significant additional precipitation can be expected in the watershed through the spring. If so, the estimated precipitation could be based on averages or estimates of wet years, taken from measurements at gages in or near the watershed. Then the total volume of water flowing into the lake can be compared to a storage-elevation curve to determine the increase in Swan Lake water surface elevation.

If there is interest in incorporating the effects of evaporation on Swan Lake levels, then a hydrologic model of the watershed could be built to simulate lake levels over time. The model should be built starting with information that is readily available, such as the HEC-1 model developed in 2007 by Quad Knopf for Washoe County. Inflows would be precipitation including snowpack and any wastewater flows that Swan Lake receives from outside the basin. Outflows would be evaporation and infiltration.

The estimate of maximum lake level should be compared to the height and alignment of proposed flood-fight measures to ensure that the level of protection implemented in the community is adequate.

Recommendation 2 – Flood Fight Measures

The purpose of the flood-fight recommendations is to develop a plan to reduce flood impacts to residents and critical infrastructure during this spring and summer. The recommendation is to establish a line of protection around existing communities and critical infrastructure. Recommended placement of flood fight materials are shown in Figure 3. The concept is to install temporary flood-fight barriers around the four residential areas closest to the lake. The recommendation does not include the wastewater treatment plant because it assumes that the flood-fight measures at the treatment plant implemented by Washoe County are adequate.

The line of protection needed is estimated to be about 4 miles. The alignment should be field verified to ensure that it is feasible and does not cut off any major streams or drainage paths. The lines tie in to high ground which was assumed to be 4,926 ft. This should be compared to the maximum lake level computed as described in the Hydrologic Analysis section above to ensure that the barriers extend to a high enough elevation. The alignment could be extended after the first installation if it becomes necessary given developing conditions. Additionally the height of the barriers used should be compared to the estimated maximum lake level to make sure the barrier is tall enough.

Once installed, pumps should be used to clear the water that has already inundated the residential properties. The pumps would also be needed to pump interior drainage, i.e. future runoff from upstream areas collecting behind the barriers. Known open culverts underneath the lines of protection should be equipped with positive closure so that backflow from the lake is prevented.

Two types of flood-fight barriers that could be used to implement this recommendation are k-rails and HESCO. K-rails, also known as Jersey barriers, are concrete barriers commonly used in transportation. Their typical height is 32 inches. Gaps in the k-rail alignment would need to be blocked with plastic sheeting, held in place with sandbags. Fill would be placed on the land side of the k-rails to prevent tipping. Advantages of using k-rail are that they may not require as much fill material, and they could be readily available from a Public Works department or the Department of Transportation. A disadvantage of using k-rail is that ground conditions that are not graded flat prior to installation could lead to barrier movement.

Another type of flood-fight barrier is HESCO. HESCO are connected gabion mesh boxes lined with fabric. HESCO can be purchased in 2 ft, 3 ft, or 4 ft heights. Advantages of using HESCO are that they can be deployed and installed quickly, the open bottom allows them to conform to non-level ground, and they can be stacked if necessary. A disadvantage of using HESCO is that it would need to be ordered and delivered which would take time, although delivery time could be as short as a few days.

Other flood fight technologies that may be considered are Muscle Wall, Portadam, and Rapid Deployment Flood Walls. Each have advantages and disadvantages that have not been assessed for the conditions at Swan Lake.

Recommendation 3 – Flood Fight Training

During the site visit, Washoe County officials expressed a need for their personnel to receive a flood-fight training refresher. USACE can provide flood-fight training as part of its normal preparedness operations. The training could benefit emergency management personnel, local workers who would be involved in a flood fight, or community residents. The State of Nevada should coordinate with the USACE Sacramento District to schedule flood fight training, if desired.

Conclusion

Based on the conditions observed during the March 3, 2017 site visit to Swan Lake, the USACE Sacramento District team recommended that a hydrologic analysis be conducted to estimate the maximum lake level during this spring snowmelt season. The team also recommended alignments for temporary flood-fight barriers. State resources

such as (but not limited to) the Nevada Department of Transportation and the National Guard should be engaged to install the selected flood barriers.

Figure 1

ANTELOPE VALLEY

COLD SPRINGS

WARM SPRINGS

W LEMMON VALLEY

Swan Lake

Silver Lake

COLD SPRINGS

E LEMMON VALLEY

SPANISH SPRINGS

LONG VALLEY

SUN VALLEY

Prosser Valley Ditch

Orr Ditch

Peavine Creek

TRUCKEE MEADOWS

Manzanita Lake

Truckee

Truckee River

Highland Ditch

Pioneer Ditch

Legend

- pub.WASHOE.NatFeat_HydroBasins
- Washoe_Water_bodies
- Elev_4924
- Monir Roads
- Major Roads

FLD_ZONE

- A
- AE
- AH
- AO

N W E S

4,900 2,450 0 4,900 Feet

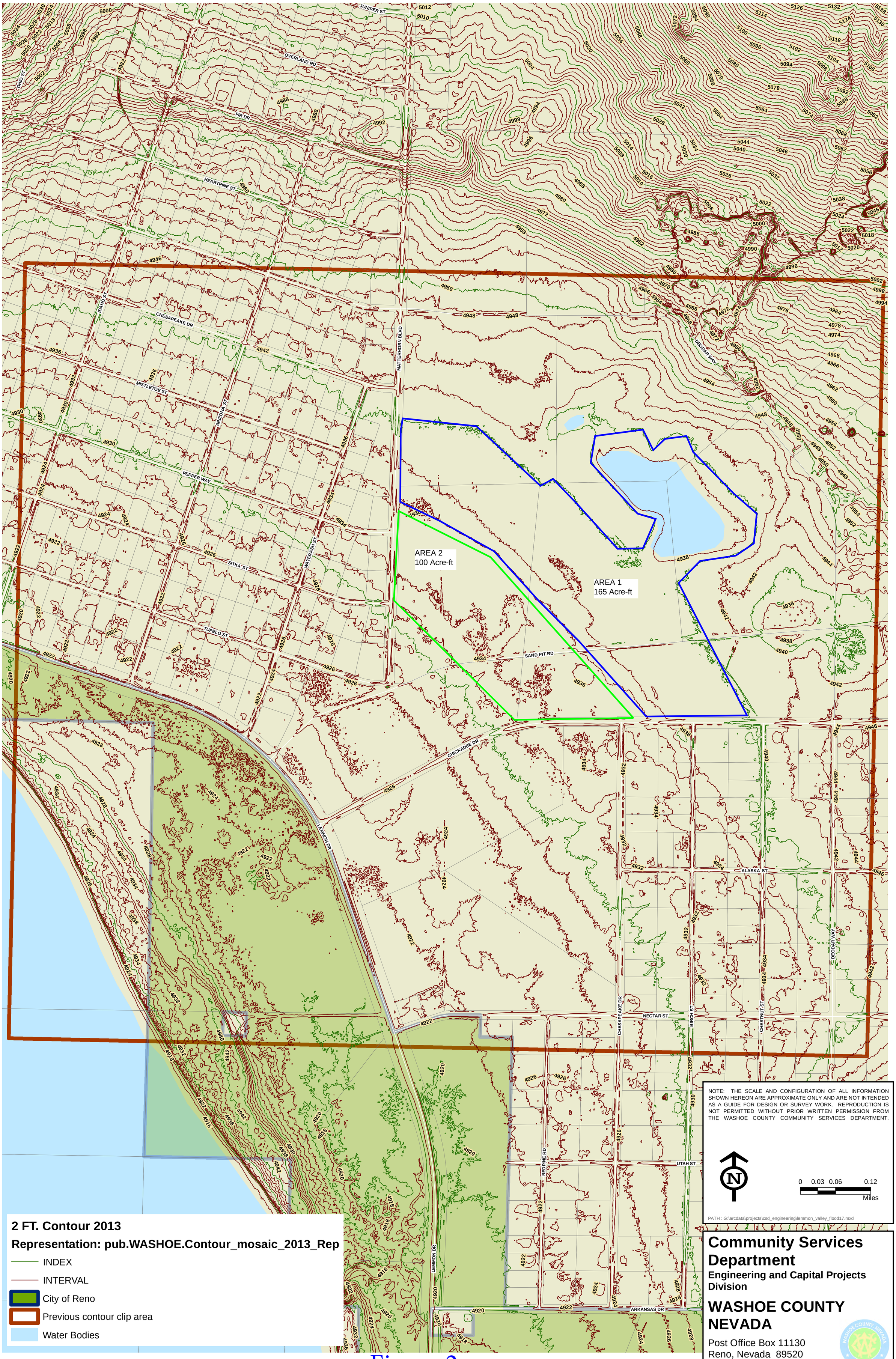
E. Lemmon Valley Hydro Basin
Area = 42.68 Sq. Mi.

Notes: The Scale and configuration of all Information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Community Services Department.

February, 2017

Washoe County Community Services Department
Engineering &
Capital Projects Division
Utility Division

P:\Joaquin Tabbada\MXD Files\Field Investigation MAP.mxd (2/23/2017)



SOURCE: Engineering and Capital Projects Division

Figure 2

DATE : 3/6/2017

SPK 2017 WINTER FLOODS
SWAN LAKE, NV

Figure 3

WASHOE CO

Reno Stead Airport

Lemmon Dr

Jean Way

Ramsey Way

Pompe Way

Chickadee Dr

Lemmon Valley - Golden Valley

Nectar St

Arkansas St

Swan Lake

North Valleys

Military Rd

Lear Blvd

Lemmon Valley Elementary School

Lemmon Dr

Lemmon Valley Waste Water Treatment Plant

0 0.5 1 Miles

Aerial Imagery: *NAIP 2015*

Legend

Proposed Temporary Barrier

Prepared by Jim Mars, CESPK - H&H Branch

MAR 2017

Appendix – National Weather Service Peavine Snowpack Analysis

Peavine Snowpack Analysis

Brian Brong - NWS Reno - March 3rd, 2017

Snow Data for Peavine

No direct snow measurements on Peavine

Closest site is Big Meadows approximately 10 miles to the south in the Mt Rose Wilderness at elevation of 8235 ft.

Site was installed in 1983 - 34 year climatology.

Close in elevation to Peavine Peak (8269 ft)

Should be a good approximation for conditions on Peavine.

Bottom line up front

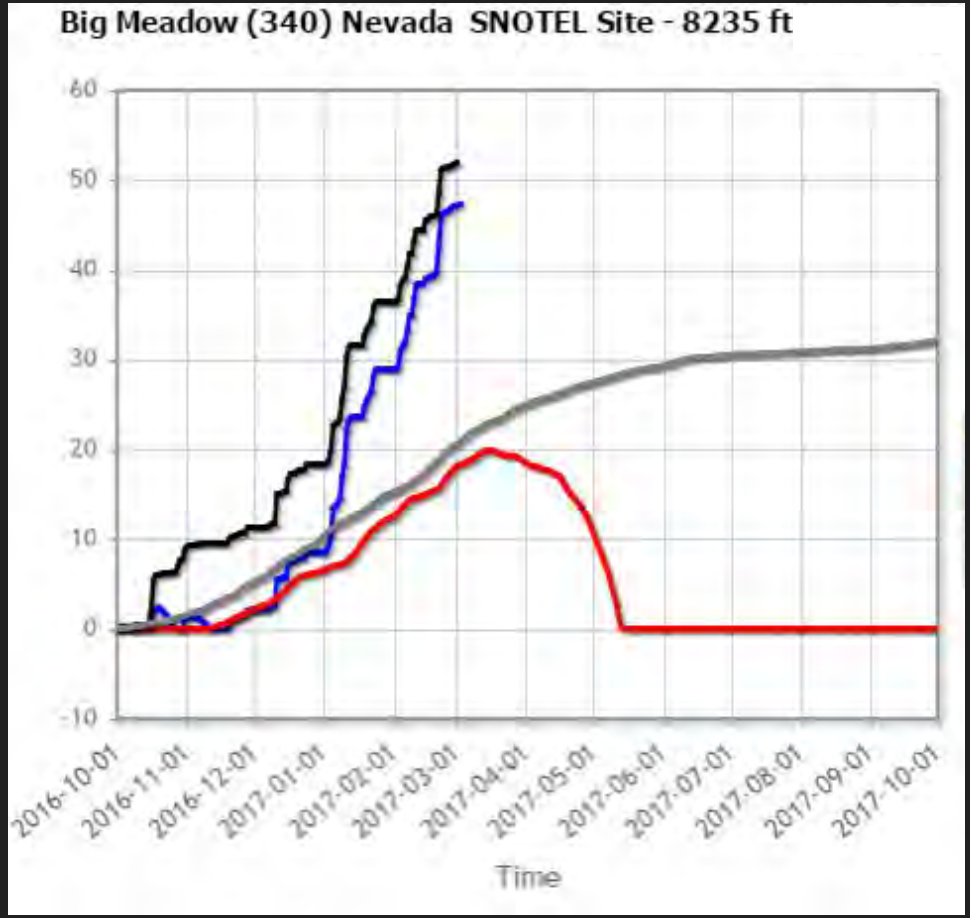
- ➔ As of March 3rd, 2017 - Up to 47 inches of water may be locked up in the snow on Peavine waiting to melt. More than double the average conditions.
- ➔ Typical snow melt season runs from mid March to mid May.
  However this has not been a typical winter - melt season could last until June.
- ➔ Difficult to predict how much water will directly flow into Swan Lake without accurate measurements in the watershed.
- ➔ Safe to expect much more water than usual, which could lead to additional flooding around Swan Lake.

Conditions on March 3rd

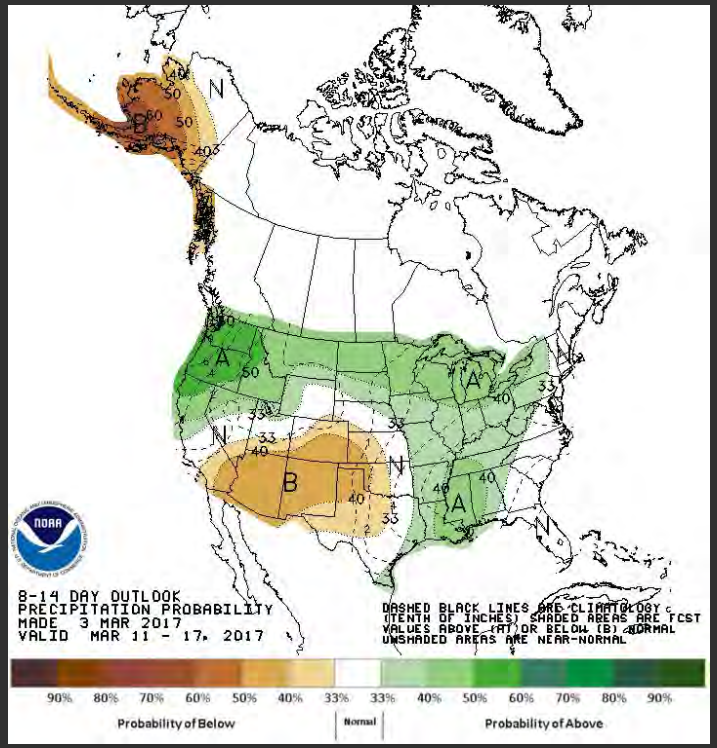
Black - Total precipitation Rain and Snow
Blue - Snow Water Equivalent, unmelted water lock up in the snowpack
Grey - Total precipitation Climatology
Red - Snow Water Equivalent Climatology
Vertical axis shows measurements in inches

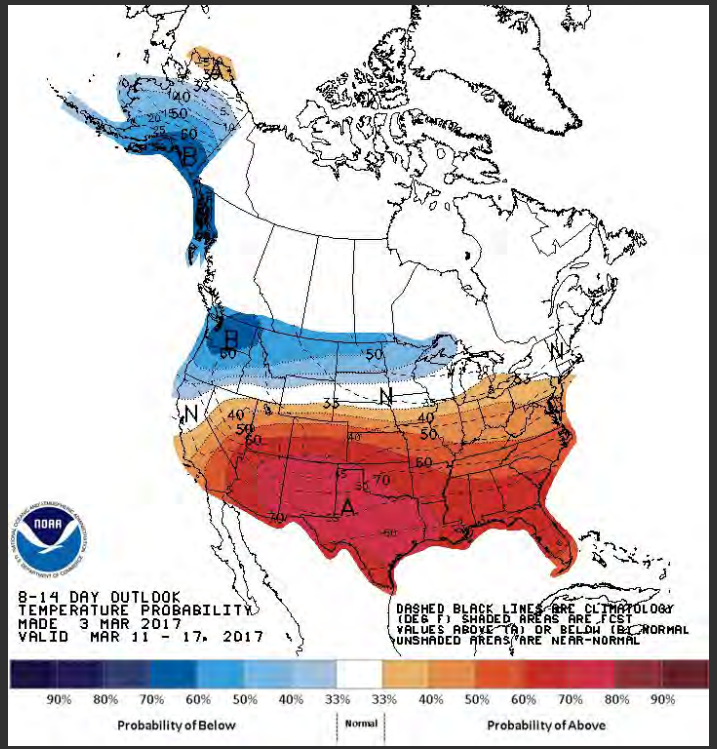
As of March 3rd, 2017…
Total Precipitation - 51.4” - 30” above average!
Snow Water Equiv. - 47.3” - 29” above average!

Red line also shows the average start to the melt season, roughly mid March ending in mid May.



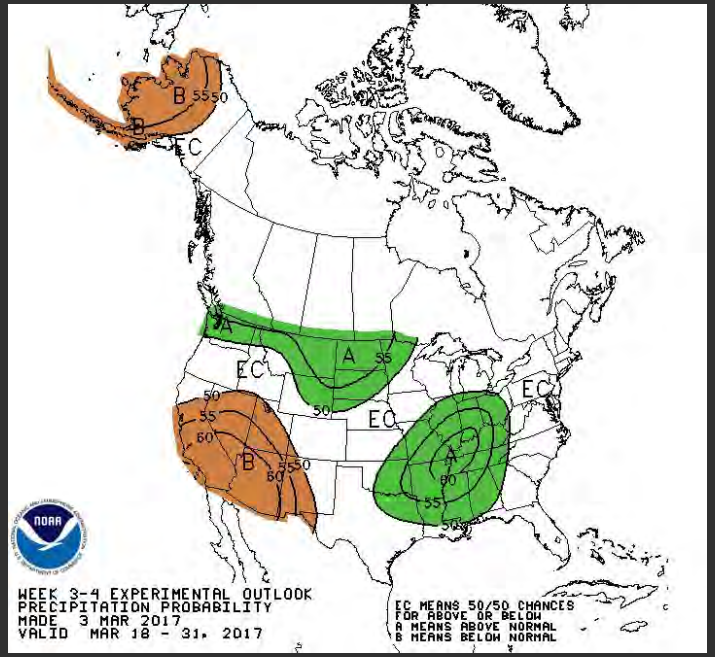
Looking Ahead - Big Picture Temp/Precip Outlook

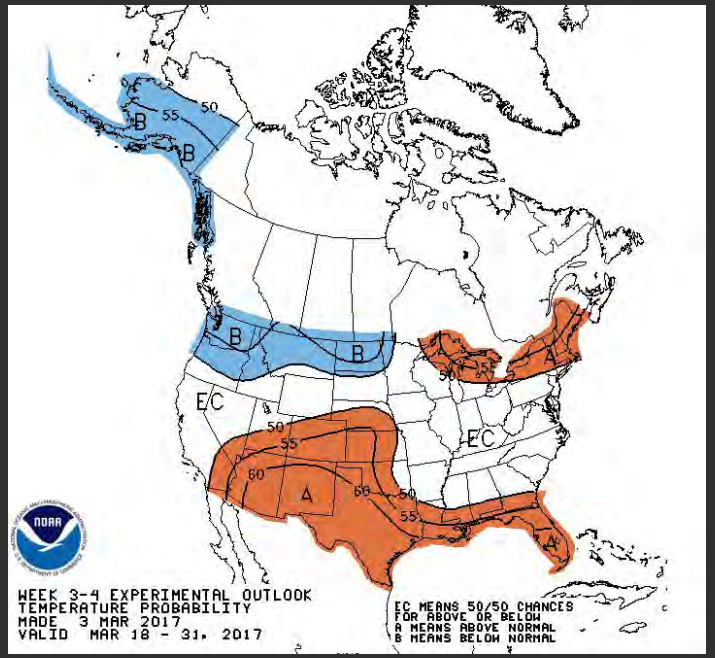




- March 11-17 - Warming temperatures may start melting below 6000 feet.
- We could see occasional storms expect a mix of rain and snow around Swan Lake.

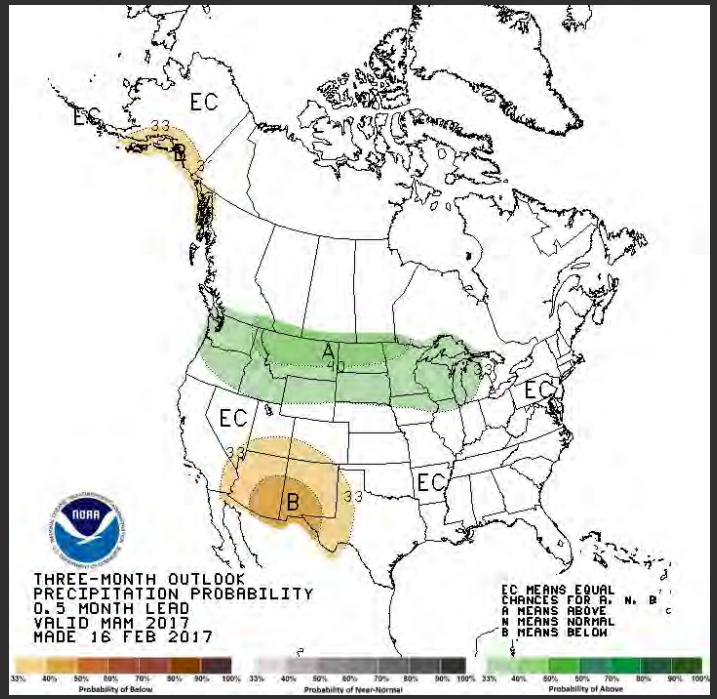
Week 3-4 Outlook - End of March

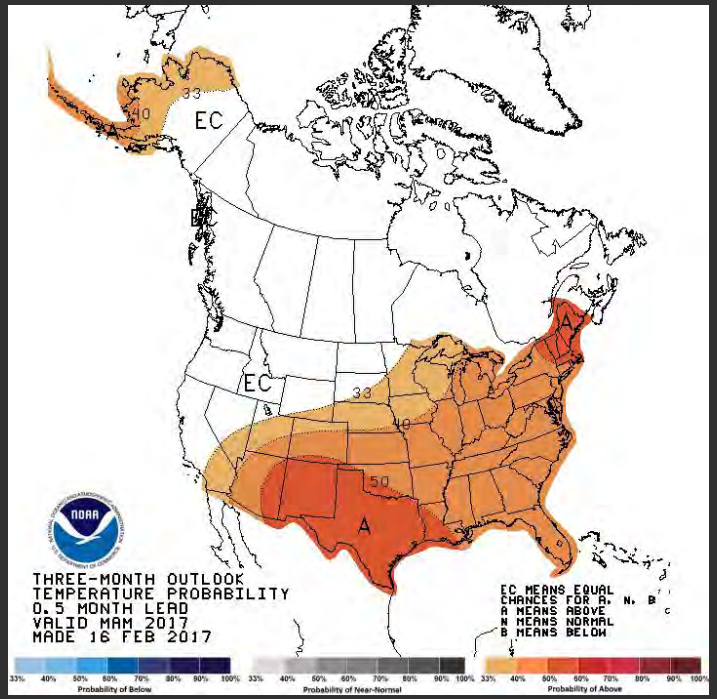




- March 18-31 - favoring below normal precipitation and normal temperatures, medium confidence.
- Could lead to increased snowmelt and river/creek flows in lower and middle elevations
- Week 3-4 outlooks have shown some useful skill this winter at predicting big-picture patterns. Not perfect but a place where progress is being made.

Spring 2017 Weather Outlooks - Anyone's Guess





- March-April-May - no favored outcome overall, equal chances of wet vs dry vs normal.
- Seasonal outlooks have shown limited skill in our region, so "no favored outcome" is the best guidance we can provide right now for months in advance.