Estimation of Available Water Capacity and Available Water Supply for Components and Map units for the Soil Survey of Yellowstone National Park

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This document is a subproject of the project "**Development of a Geo-spatial Estimate of Available Water Holding Capacity for Selected Areas in Yellowstone National Park and the Greater Yellowstone Area: Period of Work: Spring 2013, Henry F. Shovic, PhD", t**hrough an agreement with the Ann Rodman, Branch of Advanced Resource Technology, Yellowstone National Park and the Yellowstone Association.

Methods

Definitions and methods are from the NRCS Web Soil survey Descriptions of Interpretations: starting at http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

AWC is: Available water capacity (AWC) refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in centimeters of water per centimeter of soil for each soil layer or in/ft in older publications. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure, with corrections for salinity and rock fragments. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. It is not an estimate of the quantity of water actually available to plants at any given time.

AWS is: Available water supply (AWS) is the total volume of water (in centimeters) that should be available to plants when the soil, inclusive of rock fragments, is at field capacity. It is commonly estimated as the amount of water held between field capacity and the wilting point, with corrections for salinity, rock fragments, and rooting depth. In this project, AWS is estimated as a function of soil texture, rock fragments, soil depth, and organic matter. AWS is reported as a single value (in cm) of water for the specified depth of the soil. AWS is calculated as the AWC times the thickness of each soil horizon summed for all horizons to a specified depth. For the derivation of AWS, only the representative value for available water capacity is used.

The available water supply for each map unit component is computed as described above and then aggregated to a single value for the map unit by the process described below.

A map unit typically consists of one or more "components." A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated (e.g., available water supply), the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the process is to derive a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for the map units can be generated. Aggregation is needed because map units rather than components are delineated on the soil maps.

The composition of each component in a map unit is recorded as a percentage. A composition of 60 indicates that the component typically makes up approximately 60 percent of the map unit. For the available water supply, when a weighted average of all component values is computed, percent composition is the weighting factor. In this project, only the first three soil components are computed separately. The component "Dissimilar Soils" is proportioned into the three components, but not separately computed.

Available Water Holding Capacity (AWC) was estimated using an NRCS estimator for Montana (Table 1). This is located at: http://www.mt.nrcs.usda.gov/soils/mlra/guides/soilprop/availwater.html.

Additional Estimation Criteria:

- Solum depth was limited to 100 cm or the depth of the soil, whichever is less.
- Because of lacking lab data, horizons are assigned estimated organic matter proportion as follows:
    - A and AB horizons are 4%
    - B and BA horizons are 2.5%
    - All other horizons are 0%
    - Per the NRCS guide, 0.1 AWC (in/ft) is added for each % organic matter up to and including 4%.
    - Organic (histic) layers are given the highest potential AWC from Table 1 (2.2).
    - Rock fragments reduce AWC by proportion.
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Table 1. Guide for Estimating AWC (in/ft) for Soil Texture

		Soil Textural Class	Estimated Average Plant AWC (in/ft)[2]
		Sands	0.5
		Loamy sands	1.0
		Loamy fine sands	1.25
		Loamy very fine sands	1.25
		Fine sands	1.25
		Very fine sands	1.25
		Sandy loam	1.5
		Fine sandy loam	1.5
		Very fine sandy	2.0

		loam	
		Loam	2.0
		Silt loam	2.0
		Silt	2.0
		Clay loam	2.2
		Sandy clay loam	2.2
		Silty clay loam	2.2
		Sandy clay	2.0
		Silty clay	2.0
		Clay	2.0

The principal formulas used in estimation are:

AWC_calcinft= (([awc_inft]+([om_est]*0.1))*(1-[frag]/100))

AWC_cmcm= [AWC_calcinft]/12

AWS_cm= [awc_cmcm]*[hzth_100cm]

AWSComp1 = [AdjSoilCompOne%]*[SumOfAWS_cmFinal]/100

The above formula is repeated for each of three soil components in a map unit.

AWS_100MU: [AWSComp1]+[AWSComp2]+[AWSComp3]

Where:

AWC_calcinft = AWC estimated from awc_inft, om_est, and frag.

AWC_cmcm = AWC in ft/in converted to cm/cm.

AWS_cm = available water supply for a given horizon.

Frag = % rock or coarse fragments.

Om_est = the estimated organic matter (%)

Awc_inft = the estimated AWC from table 1, based on soil texture class.

SumOfAWS_cmFinal = the AWS summed for all horizons in a given soil component.

AdjSoilCompOne% = the adjusted component percentage adjusted for allocating dissimilar soils proportionally to the three component percentages.

AWSComp1 = the AWS for soil component 1, weighted by proportion of that component in a Map Unit.

AWS_100MU = Final weighted average AWS for a map unit.

The calculations are made in SQL queries in an ACCESS database. Horizon data for each soil family was extracted manually from the hard copy soil survey book (372 horizons for 87 soils and 2 miscellaneous areas) and from an existing table for map unit properties (80 map units). Results were exported to EXCEL spreadsheets. Variables used in the spreadsheets are defined there.

Quality control

Tables of component properties were cross-checked by queries for consistency and two random map units were chosen and manually calculated to verify formulas. Another model was used for the assignment of AWC, which produced lower, but consistent results. Twenty map units in the Map Unit Composition table were checked with the hardcopy book. No errors were found. Maps were made of AWS and checked for general consistency. Values were compared with others in the GYA and they appear to be in the same range.

Results

Results are given in cm of water for 100 cm of soil (or less if shallower). They are calculated for each soil component and for each map unit as a whole as a weighted average. The unweighted average for all YELL map unit delineations is 8.12 cm with a max of 17.11 and a min of 0.622 (Figure 1). The average for rhyolitic parent material is 7.40 with a max of 13.04 and a min of 1.10 (Figure 2). The average for other materials (primarily andesite) is 8.50 with a max of 17.11 and a min of 0.622 (Figure 3), somewhat higher than for rhyolites. This difference is lower than might be expected because this is an un-weighted average, but also because of the wide variation in rock fragments between soils which is relatively independent of rock type.

Soil Family (i.e. Component) by horizon is shown in the spreadsheet "YELLSoilSurvey_ComponentPropertiesByHorizon052113".

Soil component AWS for 100 cm is shown in the spreadsheet "YELLSoilSurvey_AWSSumByComponentFor100cm052113".

Map Unit AWS for 100 cm is shown in the spreadsheet "YELLSoilSurvey_AWSSumByMapUnitFor100cm052113".

A table suitable for joining to the soils feature class in ARCMAP is in "YELLMapUnitCharacteristicsAndAWSJoinTable052113". This includes map unit characteristics and AWS estimates by Map Unit from the spreadsheet "YELLSoilSurvey_AWSSumByMapUnitFor100cm052113".

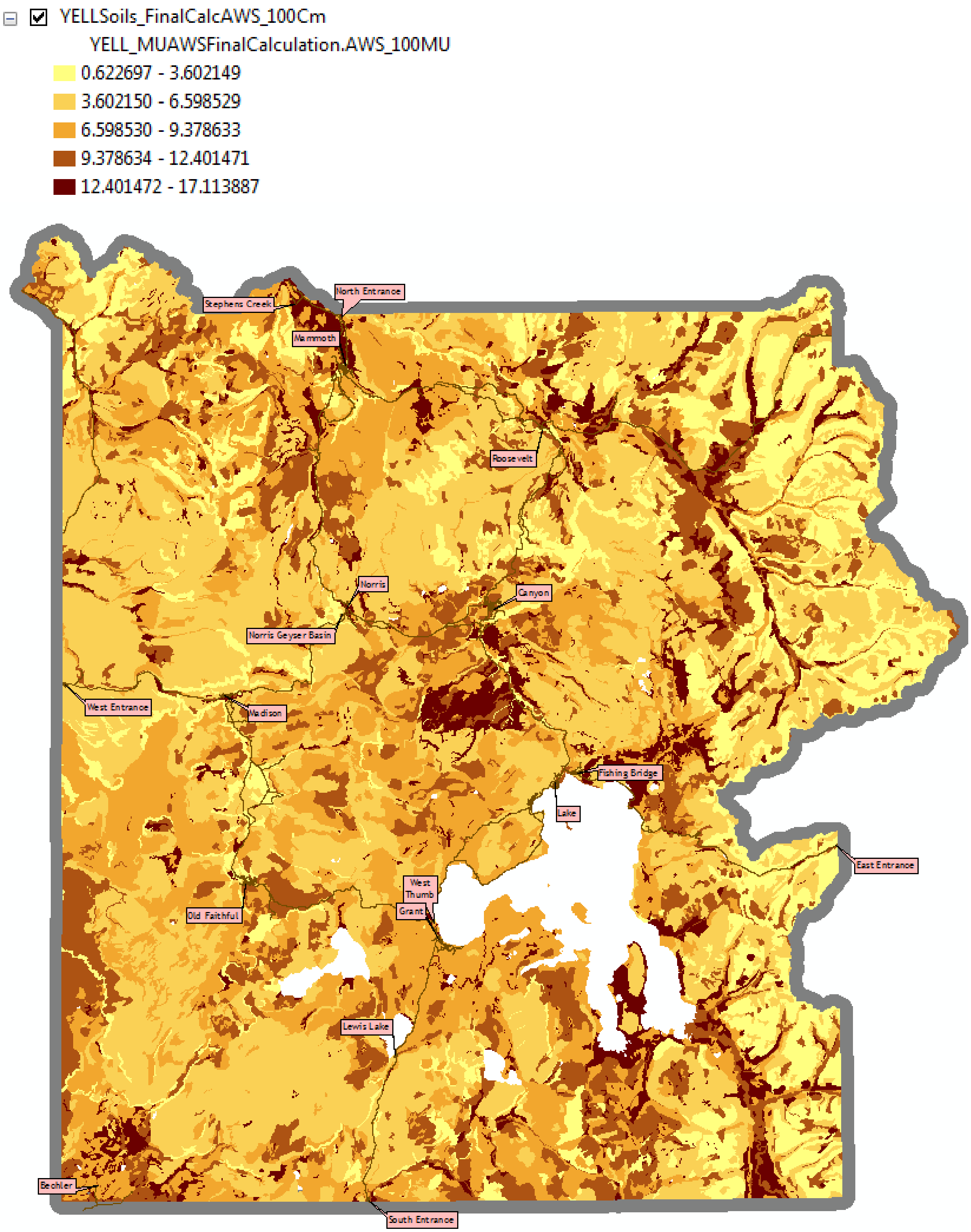

Figure 1. Yellowstone National Park Available Water Supply for 100 cm by Soil Map Unit.

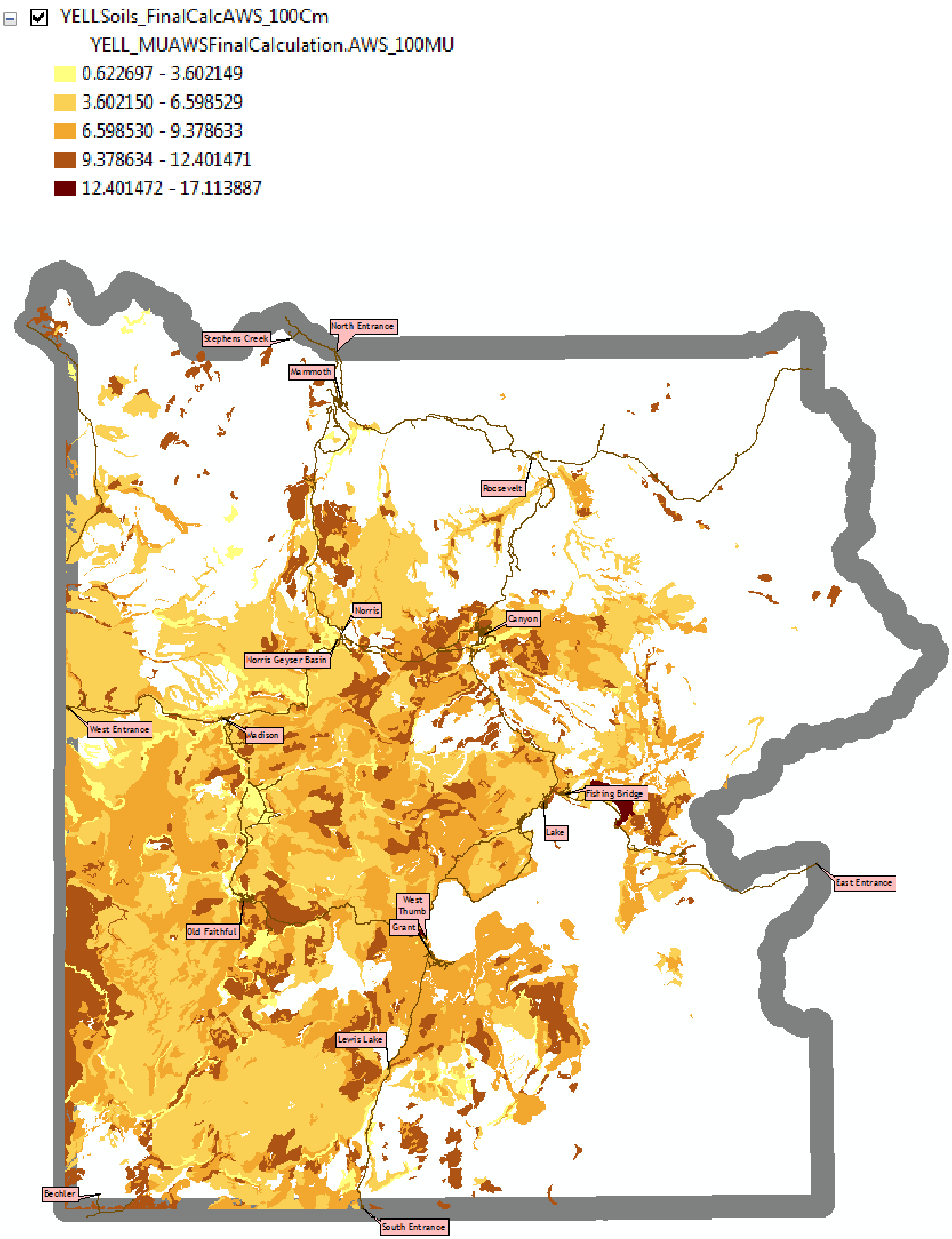

Figure 2. Yellowstone National Park Available Water Supply for 100 cm by Soil Map Unit for Rhyolitic Parent Materials.

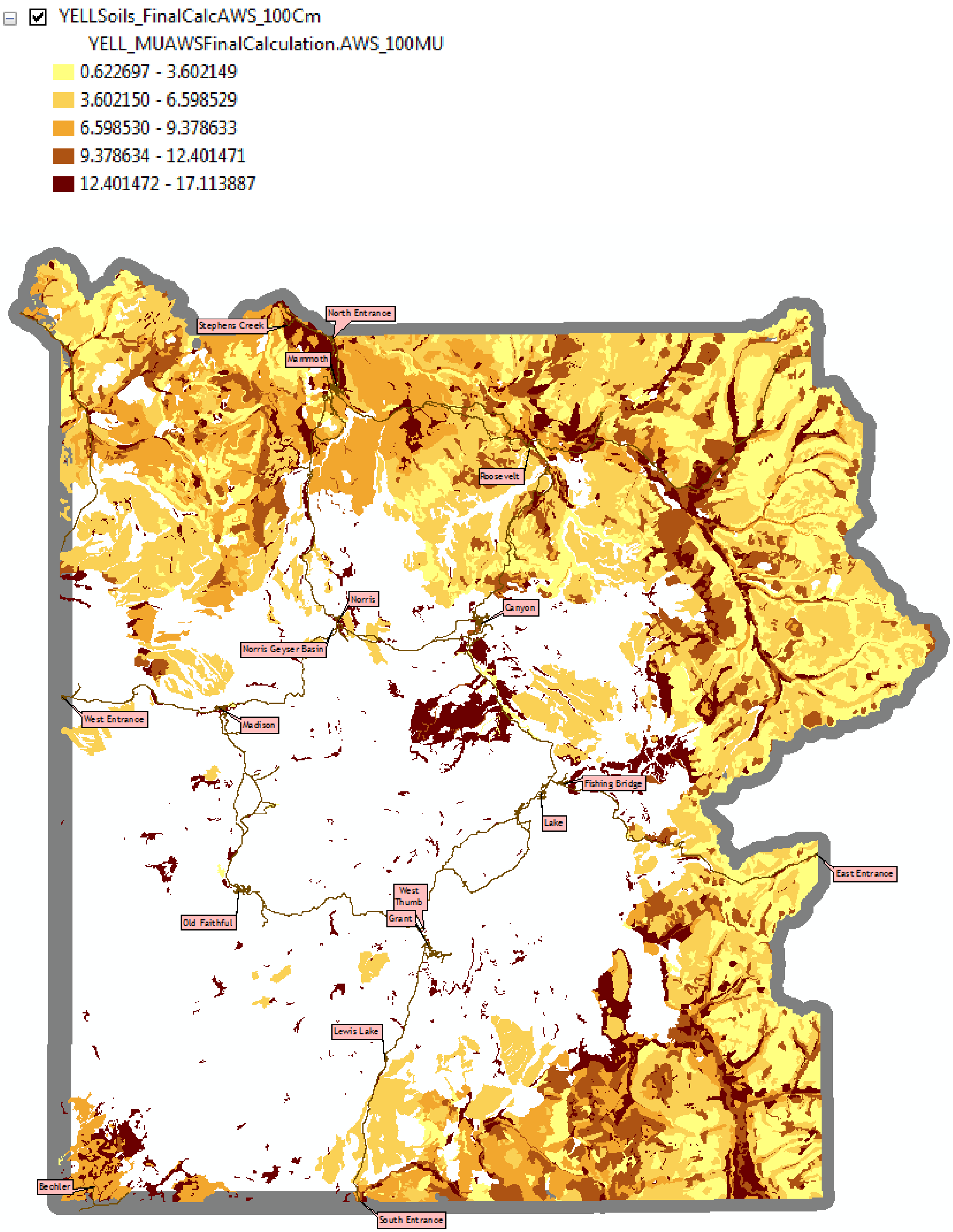

Figure 3. Yellowstone National Park Available Water Supply for 100 cm by Soil Map Unit for Non-Rhyolitic Parent Materials.