4-6: Drought

Hazard Impacts	Probability	Potential Impact					Score:
		Infrastructure	Life	Economy	Environment	Average:	
Drought	3	1	2	2	3	2	6

Score = Probability x Average Potential Impact

Drought is defined as a water shortage with reference to a specified need for water in a conceptual supply and demand relationship. It is a complex phenomenon that is difficult to monitor and assess because it develops slowly and covers extensive areas, as opposed to other disasters that have rapid onsets and obvious destruction. Also unlike most disasters, the effects of drought can linger long after the drought has ended. It is an inherent, cyclical component of natural climatic variability and can occur at any place at any time. It is difficult to determine the onset, duration, intensity, and severity of a drought, all of which affect the consequences and mitigation techniques. High winds, low humidity, and extreme temperatures can all amplify the severity of the drought.

Types of Drought[1]:

- **Meteorological:** a reduction in rainfall from a normal precipitation pattern in regard to the amount, intensity, or timing of the event as well changes in the temperature, humidity, and wind patterns. The strict threshold differs for every nation; the United States defines meteorological drought as receiving less than 2.5mm of rainfall in 48 hours. Meteorological drought is the first drought stage detected.
- **Agricultural:** deficient moisture conditions that cause a lasting effect on crops and non-natural vegetation. It is dependent on rainfall, temperature, topography, evapotranspiration, permeability, and porosity of soils, precipitation effectiveness, and vegetative demand. Agricultural drought begins when the available soil moisture supports the actual evapotranspiration rate at only a fraction of the potential evapotranspiration rate.
- **Hydrological:** related to the effects of decreased precipitation on surface or subsurface water supply. It is the last stage of drought and is lagged behind meteorological and agricultural drought because water infiltrates down to the groundwater during the latter portion of the hydrological cycle. Subsurface water supply is the last drought component to return to normal when meteorological conditions and aquifer recharge return.
- **Socioeconomic:** what happens when the consequences of the drought start to affect the socioeconomic sector. It occurs when the demand for an economic good is greater than the available supply due to weather-related drought. Examples of such goods include water, hydroelectric power, food grains, meat, dairy, and much more. Socioeconomic drought affects the associated population both individually and collectively.
- **Ecological:** defined as "a prolonged and widespread deficit in naturally available water supplies — including changes in natural and managed hydrology — that create multiple stresses across ecosystems." More info on Ecological drought: https://snappartnership.net/teams/ecological-drought/.

The severity of a drought depends on the duration, intensity, and geographic extent of the water shortage as well as the demands on the area's water supply. The USDA rates droughts from D0–D4, depending on the severity of the drought, the amount of time it will take for vegetation to return to normal levels, and the possible effects of the drought on vegetation and water supply. See figure below.

1 http://drought.unl.edu/DroughtBasics/TypesofDrought.aspx

Drought differs from other natural hazards in multiple ways. First, drought is not as obvious as other hazards; it does not have the property destruction of a tornado or hurricane. Second, there is a lack of an exact and universally accepted definition of drought. Finally, the beginning and end of a drought is difficult to determine: though the surface water content may have recovered from a period of drought, the replenishment of groundwater levels is a longer process. In addition, droughts are often spread over a larger geographic area than other natural hazards. These things considered, the economic effects of a drought can be just as devastating as any other natural hazards.

Table 33: Drought Severity Classification

Category	Description	Possible Impacts
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures Coming out of drought: some lingering water deficits pastures or crops not fully recovered
D1	Moderate Drought	Some damage to crops, pastures Streams, reservoirs, or wells low, some water shortages developing or imminent Voluntary water-use restrictions requested
D2	Severe Drought	Crop or pasture losses likely Water shortages common Water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses Widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses Shortages of water in reservoirs, streams, and wells creating water emergencies

Source: http://droughtmonitor.unl.edu/AboutUSDM/DroughtClassification.aspx

Drought History

Vermont has a highly variable, unpredictable climate. Droughts, while low frequency hazards, are of serious concern to the population of Vermont. It is often difficult to recognize the onset of a drought during its preliminary stages, and this plus Vermont's variable climate can lead to the disregard for the seriousness of an oncoming drought. Even though the State usually has adequate rainfall, droughts occasionally occur. Several severe droughts have been recorded during the last century, while moderate and mild droughts are much more common. These localized deficiencies of water leave wells dry, cause damage to crops, and cause restrictions on water usages. Droughts cause the loss of potable water when wells run. Drought also makes conditions ripe for wildfires (see: Wildfire).

There were two declared statewide droughts in June and July 1995. These droughts were due to a lack in rainfall, which required officials to put restrictions on water usage. Lack of rain combined with some of the hottest temperatures led to the loss of crops in some areas. The drought persisted through the summer of 1995, and a third, more severe drought affected Southern Vermont in August of that year.

Since 2000, there have been two significant droughts in Vermont. In 2001-2002, Vermont was affected by a Severe Drought (D2), which peaked at over 14% of the State at the D2 level between November and December of 2001 and nearly 100% of the State in at least Moderate Drought (D1).

U.S. Drought Monitor – History of Drought in Vermont Percent Area in Drought (2000-2018)

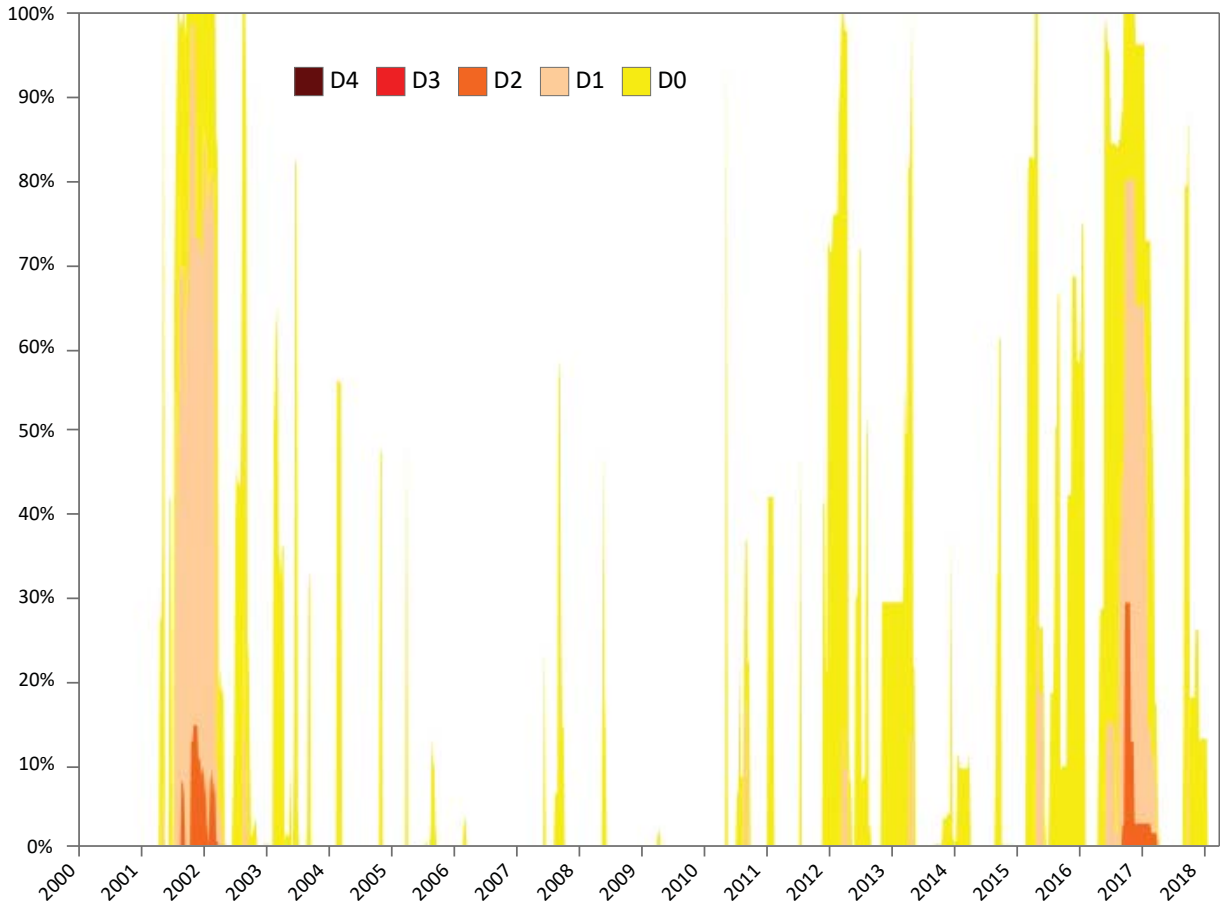

Figure 52: U.S. drought monitor – history of drought in Vermont percent area in drought (2000-2018)
Source: https://www.drought.gov/drought/states/vermont

In response to the 2001-2002 drought, the Vermont Agency of Natural Resources Drought Plan[2] was developed in consultation with VEM to guide its activities in response to droughts and extended periods of dry weather. The plan is a set of operating procedures that outline the responsibilities of various programs, lines of communication to be used, and the general sequence of actions to be followed based on the severity of the situation. Additionally, the plan provides a set of qualitative and quantitative Vermont-specific drought severity indices and recommended actions based on drought level. This drought section was updated and included in the 2013 State Emergency Operations Plan and will be modified again for inclusion in the 2018 State Emergency Management Plan.

In late summer/early autumn of 2007, ground water shortages were evident in several areas of Vermont. This was particularly apparent near shallow wells. The Drinking Water and Groundwater Protection Division in the DEC recently published a Groundwater Management Strategy to help insure adequate quantity and quality of groundwater, including during periods of drought[3]. The Office of the State Geologist develops groundwater resource maps for towns and conducts ongoing statewide assessments to help towns plan for adequate supply. The resources this program provides are intended for community planning purposes, so future water supplies can be sited. Communities with groundwater wells that have adequate yields in times of drought have a degree of protection, where low yield areas may be more vulnerable.

Portions of Vermont were in Severe Drought (D2) from October 2016 through April 2017, peaking at 29.15% of Vermont in October and November 2016 and 80% of the State was in at least Moderate Drought (D1).

2 http://drought.unl.edu/archive/plans/drought/state/VT_2005.pdf
3 http://dec.vermont.gov/sites/dec/files/dwgwp/DW/2018%20Groundwater%20Management%20Plan.pdf

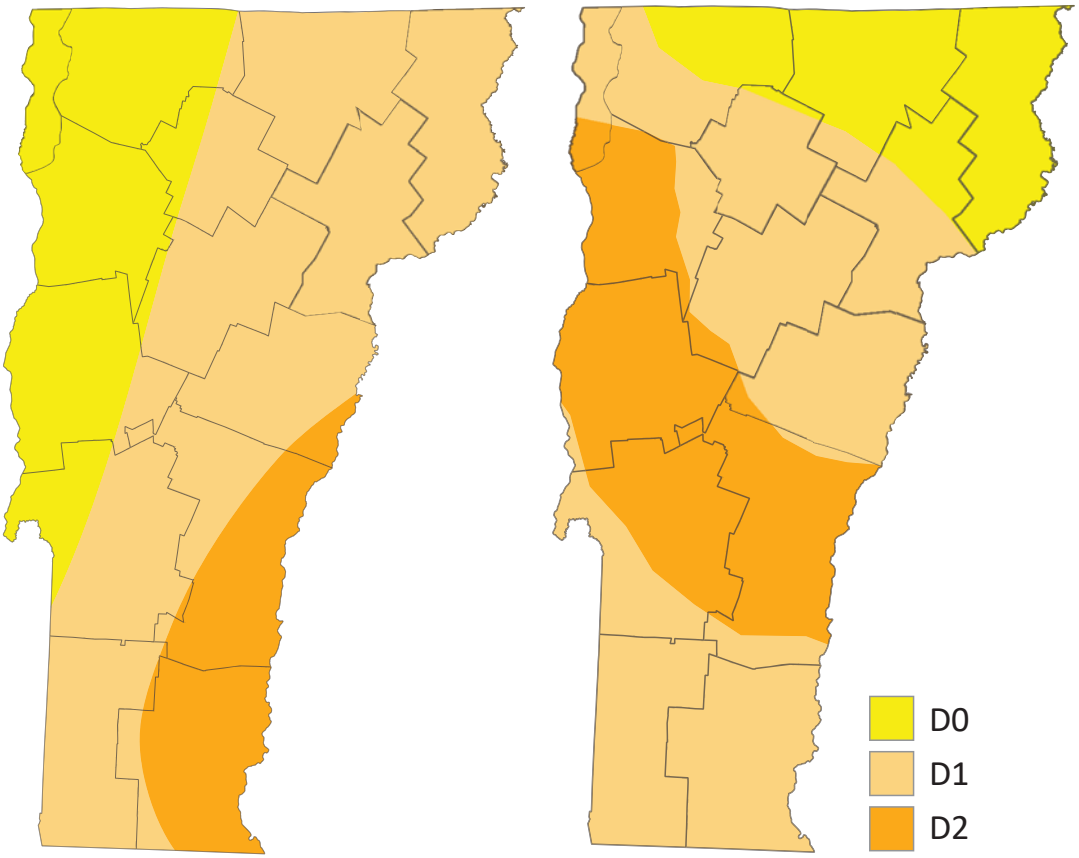

Figure 53: Map of abnormally dry (D0) to severe drought (D2) during significant drought periods in Vermont in late 2001 (left) and late 2016 (right)
Data Source: https://www.drought.gov/drought/states/vermont

Image of Lake Champlain's widening shoreline. *Photo Credit: Charlotte Scott*

Drought Trends & Vulnerability

Vermont is seeing an increase in average annual maximum and minimum temperature (see: Extreme Temperature), which is also contributing to an increased likelihood of drought. While Vermont's precipitation trend is an on upward trajectory, having seen increases in precipitation of 1.5 inches per decade[4] (see: Inundation & Fluvial Erosion), the precipitation and temperature extremes are expected to be more severe. This, paired with the occurrence of two D2 (Severe Drought) events in the 21st century, led the Steering Committee to consider the probability of a plausibly significant drought event to be "Likely", therefore receiving a Probability score of 3.

Structural impacts of drought are very uncommon, making the risk to state buildings, facilities, infrastructure or governmental functions low. The economic impact of a significant drought event is considered to be greater thank the risk to life or property. Though dollar losses from droughts are not estimated to date, certain losses could be investigated, such as the reduction in agricultural production during droughts, the construction of new community water supplies with better storage capability, the replacement of surface supplies and springs with drilled wells during the drought period, and drilled wells that have been deepened to capture additional yields when sustainable yield drops during the drought period.

Relative to other regions of the country, severe droughts are not frequent occurrences in Vermont. However, the USGS estimates that 97% of the rural population of the United States receives their drinking water through groundwater pumping, where access to municipal/village water is unavailable[5]. The Vermont State Climatologist and Vermont State Geologist have been working together to secure funding to map the State's groundwater resources to better understand statewide vulnerability to the hazard. The need for these data are expressed both in this Plan (see: Mitigation Strategy) and the 2018 Vermont Groundwater Management Plan. Though Vermont encompasses a small geographic area, the State has distinct regions that can experience significantly different weather patterns and react differently to the amount of precipitation they receive. According to the US Drought Monitor's archived data, the southeastern portion of the State is more vulnerable to prolonged periods of more significant drought, likely due to its lower elevation and landlocked location[6].

Drought Mitigation

The 2018 Vermont Groundwater Management Plan[7] identifies groundwater protection as a necessary precaution to minimize vulnerability to future fluctuations in groundwater levels due to both anticipated increased precipitation and prolonged drought periods. The plan goes further to note that while groundwater protection is an issue understood at the local, regional, state and federal levels, careful consideration of it only takes place during times when problems with groundwater levels may arise.

As noted above in Drought Trends & Vulnerability, the Vermont State Climatologist and State Geologist have been pursuing grants to secure funding for groundwater resource mapping. Knowing where the State's groundwater resources are located is considered critical information, necessary to understand the State's vulnerability and then to develop mitigation actions and strategies aimed at reducing drought vulnerability. Groundwater resource mapping, expansion of the number of monitoring wells across the State and a thorough analysis of water level monitoring data have been identified as mitigation actions under the 2018 State Hazard Mitigation Plan's "Promote Drought Resilience" strategy (see: Mitigation Strategy). Further, the 2018 Vermont

4 http://climatechange.vermont.gov/our-changing-climate/dashboard/more-annual-precipitation
5 https://water.usgs.gov/edu/droughtandgw.html
6 https://statesummaries.ncics.org/vt
7 http://dec.vermont.gov/sites/dec/files/dwgwp/DW/2018%20Groundwater%20Management%20Plan.pdf

Groundwater Management Plan identifies "exploring partnerships with FEMA to fund water data acquisition related to drought" as part of its long-term approach to increasing the State's understanding of and resilience to the hazard.

The Vermont Drought Task Force, made up of representatives from several state and federal agencies, is convened quarterly to discuss current drought conditions, share drought-related information, identify data gaps and needs and develop conservation guidance to all citizens, when applicable. The Task Force developed the Drinking Water Drought Reporter[8] online tool, which allows the Agency of Natural Resources to compile drought data and identify areas vulnerable to drought impacts.

Figure 54: ANR's Drinking Water Drought Reporter Map
Source: https://anrmaps.vermont.gov/websites/droughtreporter/

8 https://anrmaps.vermont.gov/websites/droughtreporter/