



Vermont Groundwater Monitoring Network: A real-time tool for assessing climatic drought

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*June 6, 2017 Lyndonville, VT
June 7, 2017 Manchester, VT*

U.S. Department of the Interior
U.S. Geological Survey

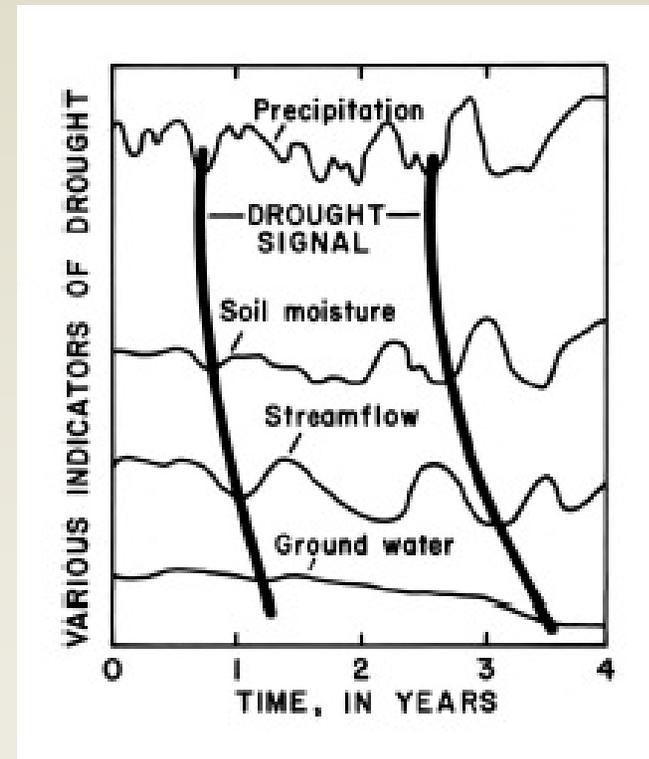
Outline of talk

1. Drought and Hydrologic Science.
2. USGS-VTDEC monitoring network.
3. Building resiliency.

What is Drought?

A drought is a period of drier-than-normal conditions that results in water-related problems.

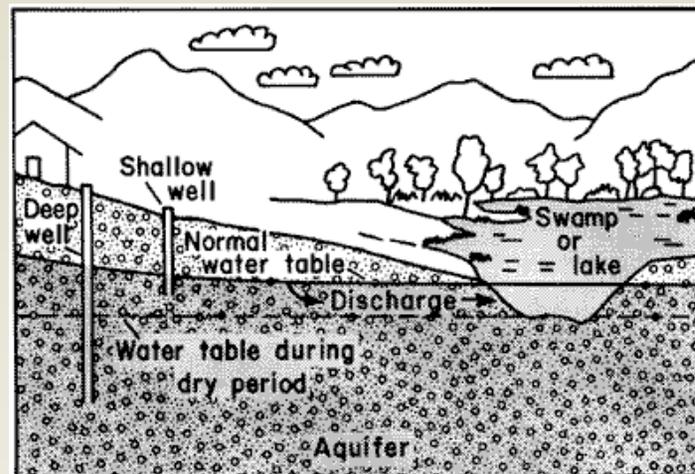
- **Meteorological drought**
 - lack of precipitation
- **Agricultural drought**
 - lack of soil moisture
- **Hydrologic drought**
 - reduced streamflow or groundwater levels



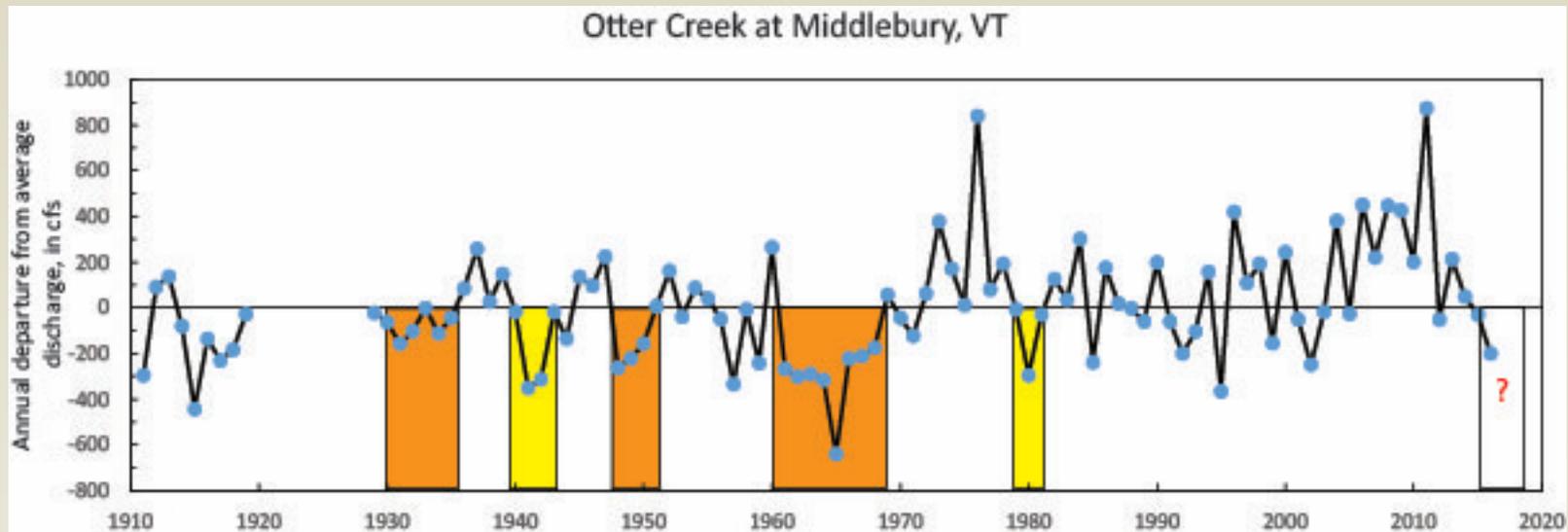
Importance of Hydrologic Science

Hydrologic Science helps cope with drought in two ways.

- **Drought planning**
 - Natural phenomena that will happen again
 - Key to coping with supply drought
- **Drought mitigation**
 - Informed management decisions once the drought begins.
 - Current status and recent trend



Hydrologic Drought in Vermont



1930-36: Severe drought throughout VT. Moderate in northern VT.

1939-43: Moderate drought throughout VT.

1947-51: Severe drought through northern VT.

1960-69: Severe drought throughout VT.

1979-80: Moderate drought throughout VT.

U.S. Geological Survey Water Supply Paper 2375, 591 p., *National Water Summary 1988-89, Hydrologic Events and Floods and Droughts.*

USGS-VTDEC GW Monitoring Network

Development of real time groundwater information shows great potential.

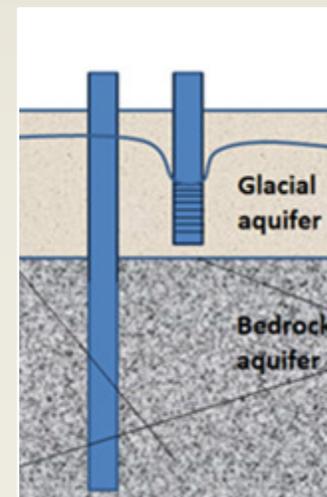
- **13 Observation Wells**
 - 10 periodic (monthly)
 - 3 real-time (hourly)
- **Long-term record**
 - 1960's to present
- **Glacial Aquifer**
 - constructed in overburden



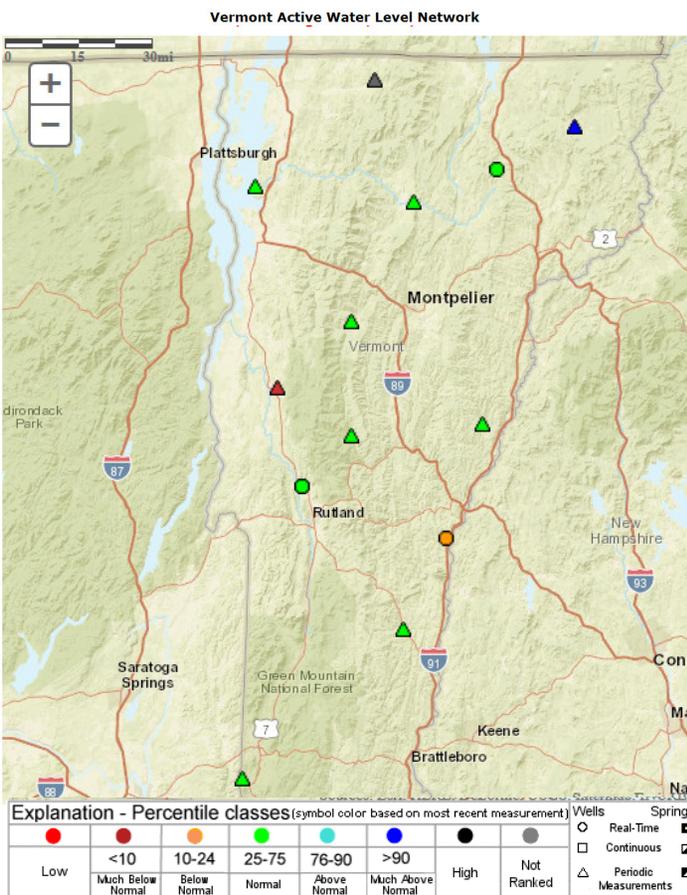
VT-RJW 1 Rochester



VT-HLW 54 Hartland



Groundwater Monitoring Network



Counties	Well Count	Real-Time	Continuous	Periodic
Addison County	1	-	-	1
Bennington County	1	-	-	1
Chittenden County	1	-	-	1
Essex County	1	-	-	1
Franklin County	1	-	-	1
Lamoille County	1	-	-	1
Orange County	1	-	-	1
Orleans County	1	1	-	-
Rutland County	1	1	-	-
Washington County	1	-	-	1
Windsor County	3	1	-	2
Number of active VT wells:	13	3		10

Map Index	Site ID	Site Name	Most Recent Measurement	Date	Well Depth	Local Aquifer
▲ 1	424810073160401	VT-PQW 1	12.79 BLS	4/26/2017	17.8	Stratified Deposits, Undifferentiated
▲ 2	431551072350601	VT-CKW 1	3.70 BLS	4/26/2017	22.0	Stratified Deposits, Undifferentiated
● 3	433240072242901	VT-HLW 54	8.60 BLS	5/24/2017	51.0	Stratified Deposits, Undifferentiated
● 4	434217073010601	VT-PFW 8	35.48 BLS	5/24/2017	42.0	Stratified Deposits, Undifferentiated
▲ 5	435129072483301	VT-RJW 1	9.58 BLS	4/28/2017	73.0	Stratified Deposits, Undifferentiated
▲ 6	435343072151801	VT-WOW 1	1.92 BLS	4/28/2017	54.0	Stratified Deposits, Undifferentiated
▲ 7	440016073070901	VT-MGW 11	7.93 BLS	4/28/2017		
▲ 8	441215072483101	VT-WAW 2	5.75 BLS	4/28/2017	45.5	Stratified Deposits, Undifferentiated
▲ 9	443405072323501	VT-MPW 1	17.21 BLS	4/28/2017	50.0	Stratified Deposits, Undifferentiated
▲ 10	443646073124901	VT-MJW 3	29.94 BLS	4/28/2017	40.0	Stratified Deposits, Undifferentiated
▲ 11	443952072114001	VT-GLW 1	14.39 BLS	5/24/2017	82.0	Stratified Deposits, Undifferentiated
▲ 12	444731071514701	VT-BIW 1	1.52 BLS	4/27/2017	35.0	Stratified Deposits, Undifferentiated
▲ 13	445603072422902	VT-BKW 1.1	14.55 BLS	4/28/2017	48	Outwash

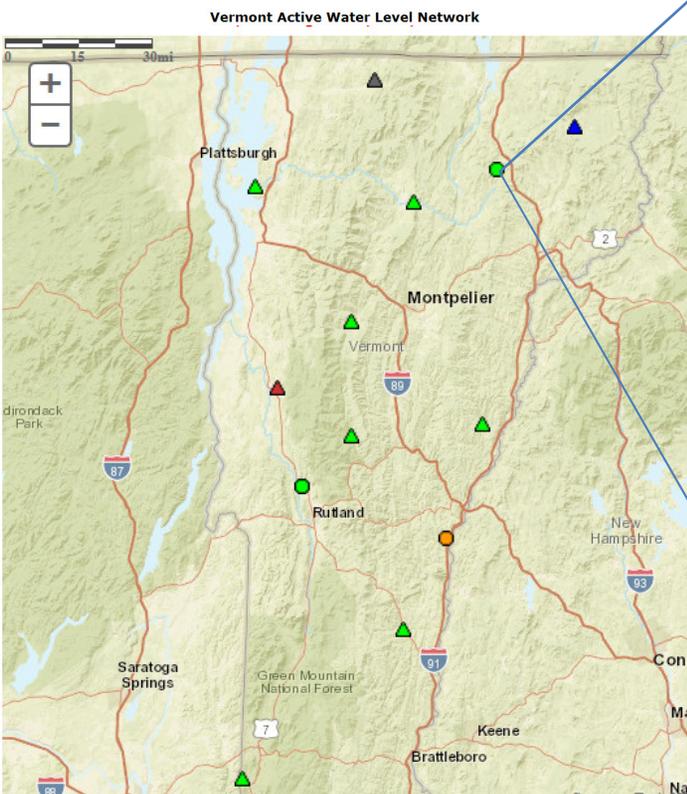


<https://groundwaterwatch.usgs.gov/USGSGWNNetworks.asp>

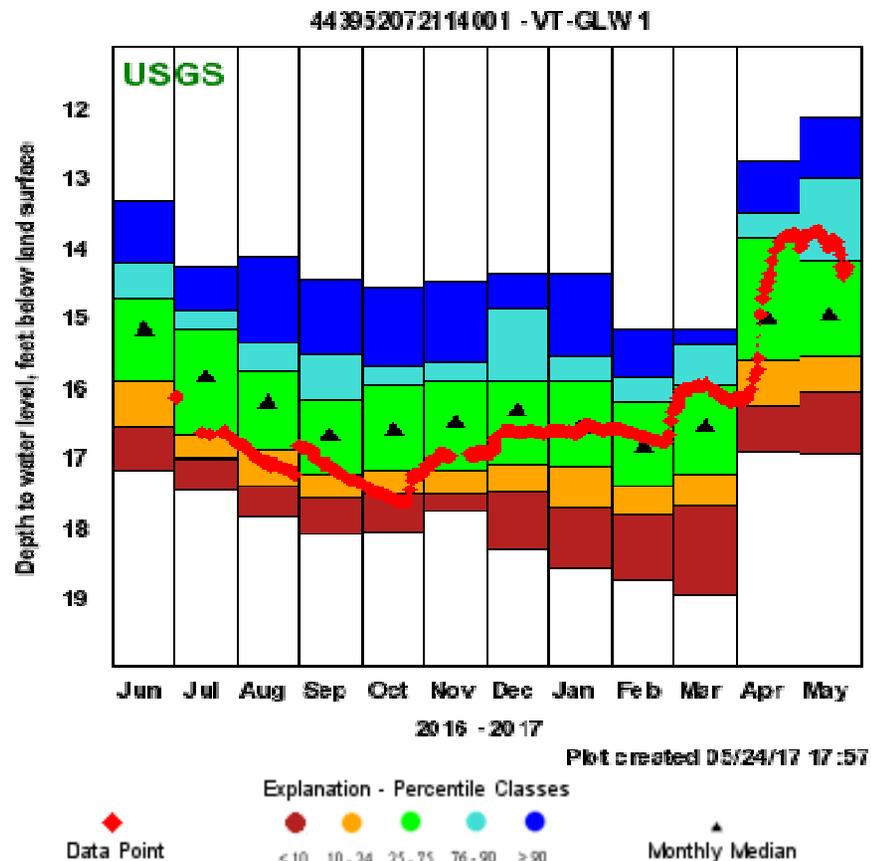
Groundwater Monitoring Network



In cooperation with...
VERMONT
 DEPARTMENT OF ENVIRONMENTAL CONSERVATION

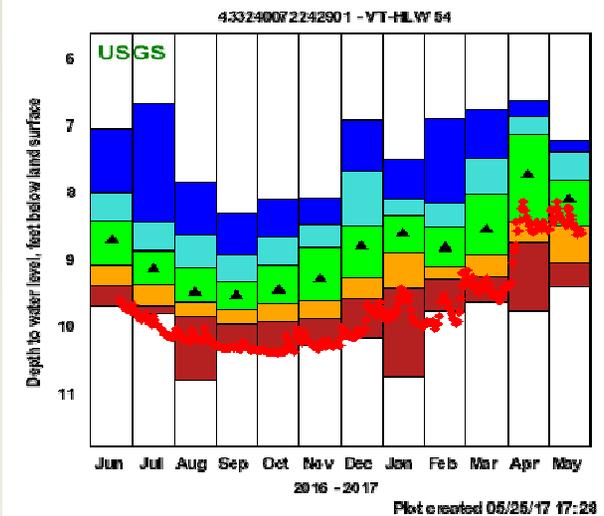
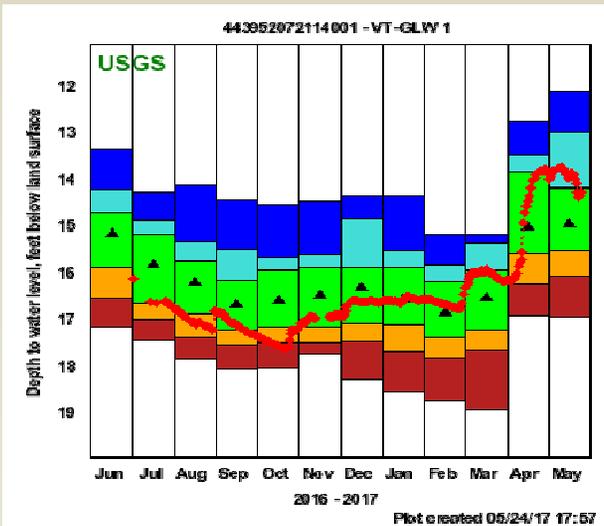


Explanation - Percentile classes (symbol color based on most recent measurement)						Wells		Springs	
●	●	●	●	●	●	○	○	□	□
Low	<10 Much Below Normal	10-24 Below Normal	25-75 Normal	76-90 Above Normal	>90 Much Above Normal	High	Not Ranked	Real-Time	Continuous
								Periodic Measurements	



<https://groundwaterwatch.usgs.gov/USGSGWNNetworks.asp>

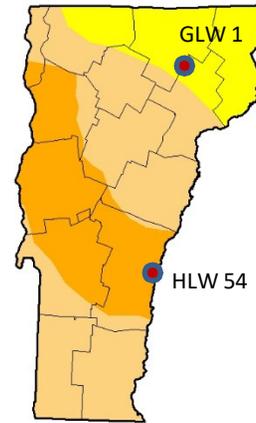
Hydrologic Drought



Explanation - Percentile Classes

◆ Data Point ● <10 ● 10-24 ● 25-75 ● 76-90 ● >90 ▲ Monthly Median

U.S. Drought Monitor Vermont



October 25, 2016
(Released Thursday, Oct. 27, 2016)
Valid 8 a.m. EDT

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	90.01	29.15	0.00	0.00
Last Week 10/15/2016	0.00	100.00	90.01	29.15	0.00	0.00
3 Months Ago 7/26/2016	15.40	84.60	14.77	0.00	0.00	0.00
Start of Calendar Year 12/29/2015	31.53	68.37	0.00	0.00	0.00	0.00
Start of Water Year 9/7/2015	11.92	88.08	43.99	0.00	0.00	0.00
One Year Ago 10/27/2015	90.48	9.52	0.00	0.00	0.00	0.00

Intensity

D0 Abnormally Dry D3 Extreme Drought
D1 Moderate Drought D4 Exceptional Drought
D2 Severe Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Sinner
Western Regional Climate Center



<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor Vermont



May 23, 2017
(Released Thursday, May 25, 2017)
Valid 8 a.m. EDT

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	100.00	0.00	0.00	0.00	0.00	0.00
Last Week 05-16-2017	100.00	0.00	0.00	0.00	0.00	0.00
3 Months Ago 02-23-2017	27.30	72.70	95.23	2.58	0.00	0.00
Start of Calendar Year 01-03-2017	3.71	96.29	54.92	2.58	0.00	0.00
Start of Water Year 09-27-2016	11.92	88.08	43.99	0.00	0.00	0.00
One Year Ago 05-24-2016	72.67	27.33	0.00	0.00	0.00	0.00

Intensity

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Author:
Brad Rippey
U.S. Department of Agriculture



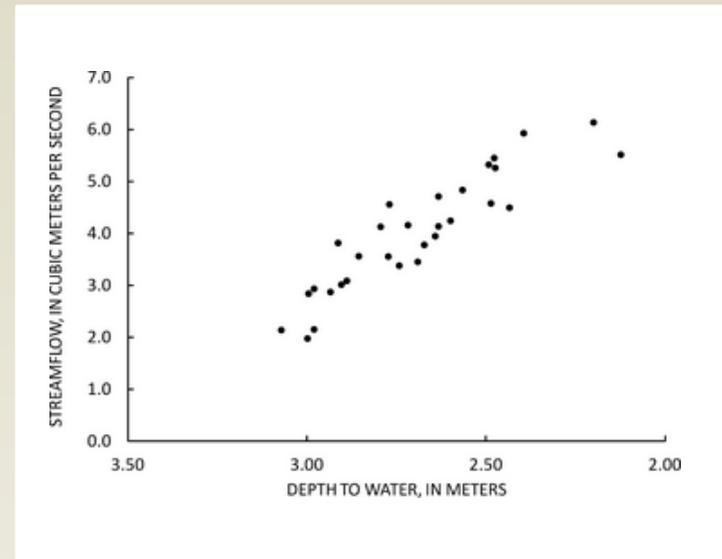
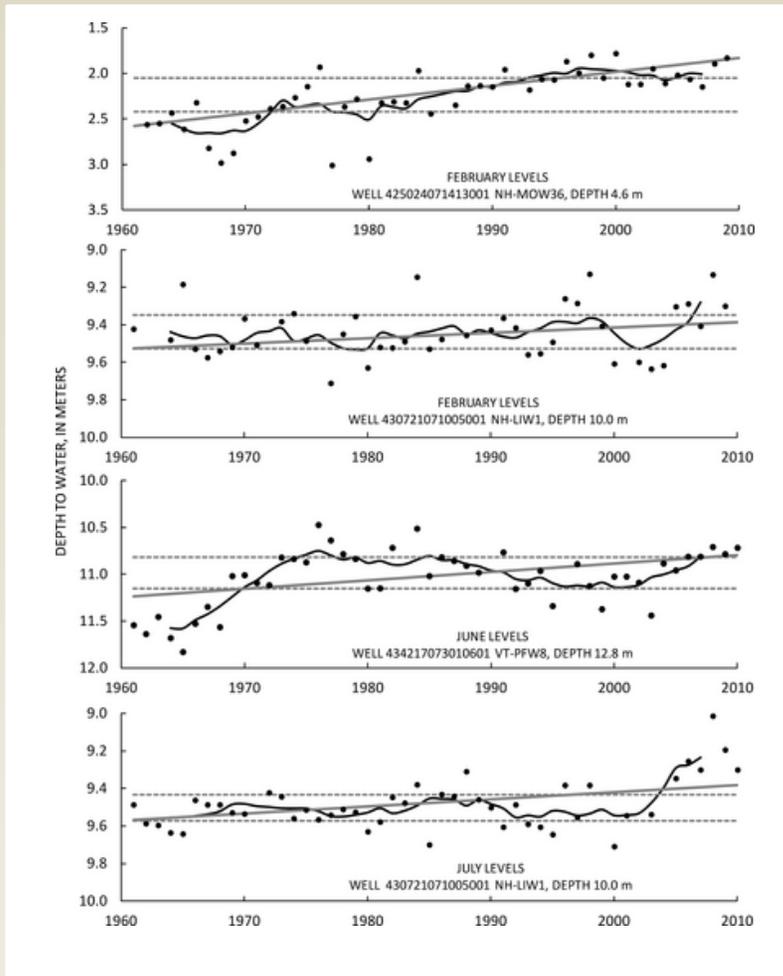
<http://droughtmonitor.unl.edu/>

Building Resiliency

Hydrologic monitoring is foundation for making informed decisions

- **Real-time monitoring network**
 - Current conditions in context to historical values
- **Hydrologic research**
 - Science to support the understanding of groundwater resources
- **Hydrologic response models**
 - Evaluating the response of climate and land use on hydrology

Historical Groundwater Trends in Northern New England and Relations with Streamflow and Climatic Variables



“Hydrologic response” models

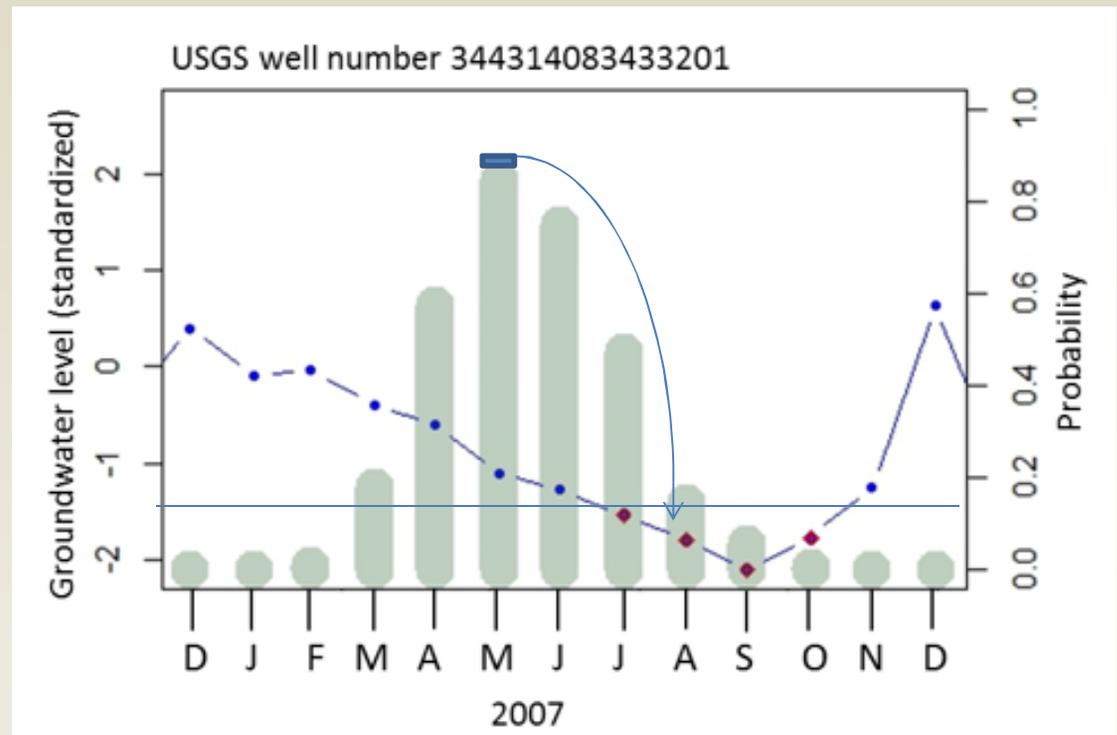
- 1. Probability models** – Likelihood of drought “90 days from now”
 - Logistic regression models that predict future conditions at wells (based on current and past conditions).
- 2. HyDroDSS** – Hydrologic drought decision support system
 - Analysis of hydrologic variables that may indicate the risk for streamflows to be below user-defined flow targets at a designated site of interest.
- 3. SYE** – Sustainable-yield estimator
 - SYE estimates streamflow adjusted for current water user from a database of permitted groundwater and surface-water withdrawal and discharge volumes.
- 4. SWB** – Soil-water balance model
 - SWB estimates potential recharge at a daily time step using precipitation, air temperature, land-use, hydrologic soil group, flow direction , soil-water capacity.
- 5. PRMS** – Precipitation runoff modeling system
 - PRMS is a physical process based modeling system that evaluates the response of climate and land use on streamflow and general watershed hydrology.
- 6. Coupled groundwater models(GSFLOW)** – MODFLOW & PRMS

Statistical groundwater level prediction

3-month forecast model

Blue line: monthly GW level
(red points are below threshold level)

Green bars: probability that the GW level will be at or below the threshold level three months later



Dudley, R.W., Hodgkins, G.A., and Dickinson, J.E., 2017, Forecasting the probability of future groundwater levels declining below specified low thresholds in the conterminous U.S.: *Journal of the American Water Resources Association* (JAWRA), <in review>

HyDroDSS: Hydrologic Drought Decision Support System

Developed with Rhode Island WRB:

Input data

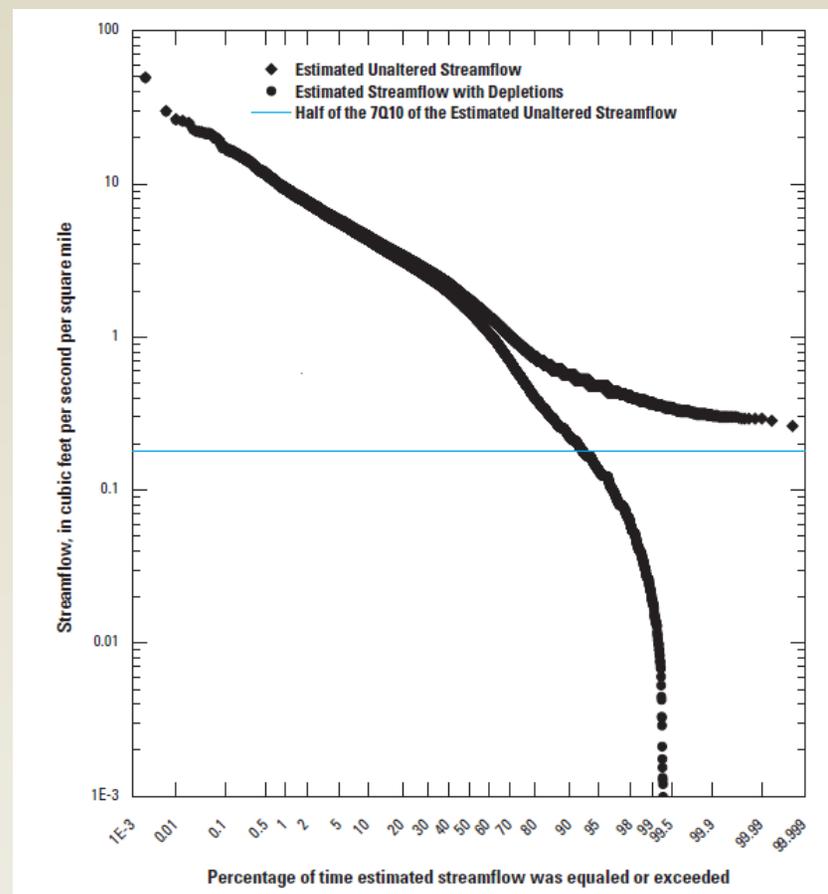
- USGS streamflow and groundwater data
- Monthly precipitation from NWS
- Permitted withdrawals

Output data

- Estimates of daily mean flow

Report:

Granato, G.E., 2014, Hydrologic Drought Decision Support System (HyDroDSS): U.S. Geological Survey Open-File Report 2014-1003, 91 p., with CD-ROM,



<https://webdmamrl.er.usgs.gov/g1/ggranato/Software/HyDroDSS.html>

Sustainable Yield Estimator

Statewide model, with MA DEP:

Input data

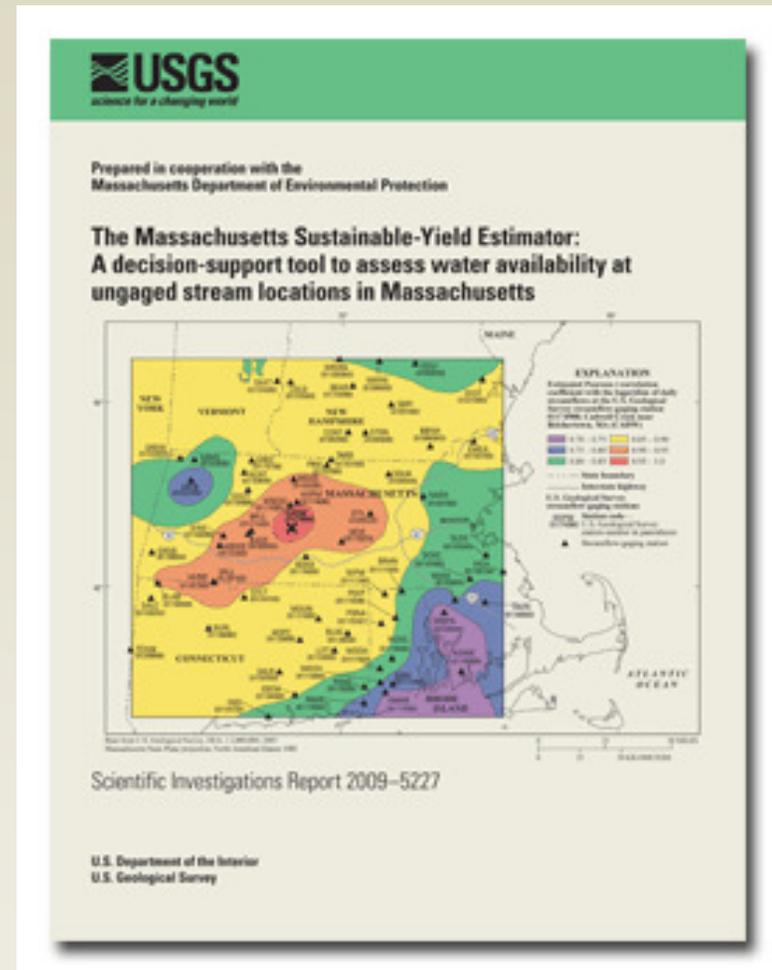
- Flow-duration at gaged sites used to estimate flow at ungaged.
- Permitted withdrawals and discharges

Output data (integrated with StreamStats)

- Streamflow values at ungaged locations adjusted for withdrawals and discharges

Report:

Archfield, S.A., Vogel, R.M., Steeves, P.A., Brandt, S.L., Weiskel, P.K., and Garabedian, S.P., 2010, The Massachusetts Sustainable-Yield Estimator: A decision-support tool to assess water availability at ungaged stream locations in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2009–5227, 41 p. plus CD-ROM.



New Hampshire PRMS Model

Statewide model, with NH DES Coastal Program and NH HHS BRACE program:

GCMs as input data – updated regularly

- precipitation and temp and wind, etc.

Output data (in GRANIT system GIS)

- recharge, soil moisture, snowpack, streamflow, etc.

PILOT report:

Bjerklie, D.M. et al, 2015, **Simulating hydrologic response to climate change scenarios in four selected watersheds of New Hampshire**: U.S. Geological Survey Scientific Investigations Report 2015–5047, 53 p., <http://dx.doi.org/10.3133/sir20155047>.

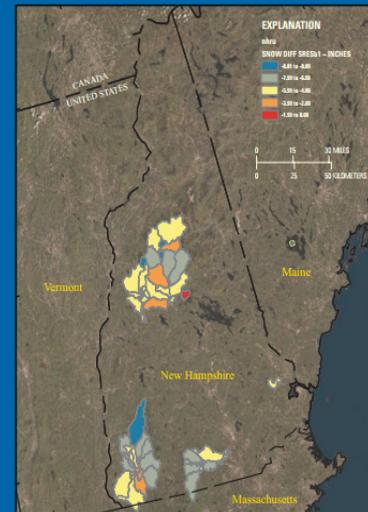
STATEWIDE report:

Bjerklie, D.M. and Luke Sturtevant, 2017, **Simulated Hydrologic Response to Climate Change During the 21st Century in New Hampshire**, Scientific Investigations Report 2017–XXX (in review)



Prepared in cooperation with the
New Hampshire Department of Health and Human Services

Simulating Hydrologic Response to Climate Change Scenarios in Four Selected Watersheds of New Hampshire



Scientific Investigations Report 2015–5047



<http://pubs.er.usgs.gov/publication/sir20155047>

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