Climate Impacts On Our Lakes

Explore Lakes Webinar Series

NH Lakes - January 5, 2022

Presented by:
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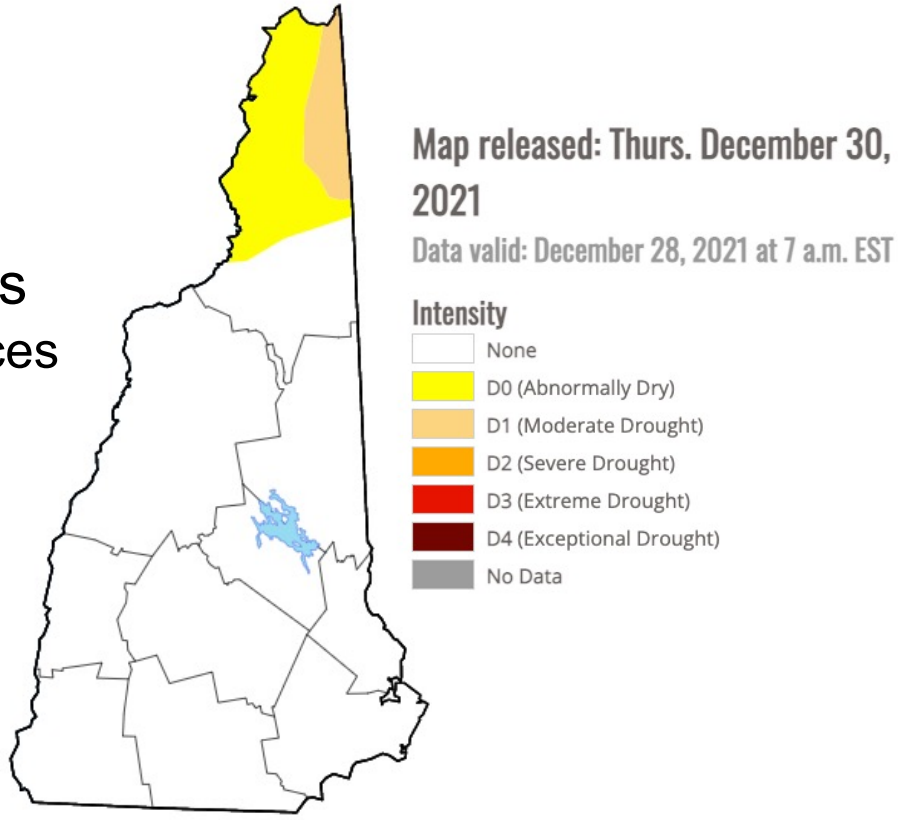
Hydrogeologist
EDGEWATERNH.COM

EDGEWATER STRATEGIES
CLEAR SOLUTIONS

Discussion Outline

- Part 1: Climate
  - Low-Water **Drought**
  - High-Water Heavy Precipitation
- Part 2: Wells + Lake Water Levels
  - Types of **Wells** / Groundwater Sources
  - Water Level Fluctuations
  - **Lake Level** Fluctuations
- Part 3: **Impacts of Climate**
  - Wells
  - Lakes
  - Shorelines
  - What should we expect next?



Part 1:Climate – Low and High Precipitation

Climate driven low-water conditions

Impact of drought - July 2020

History of drought in NH

How drought is determined.

Drought Occurence

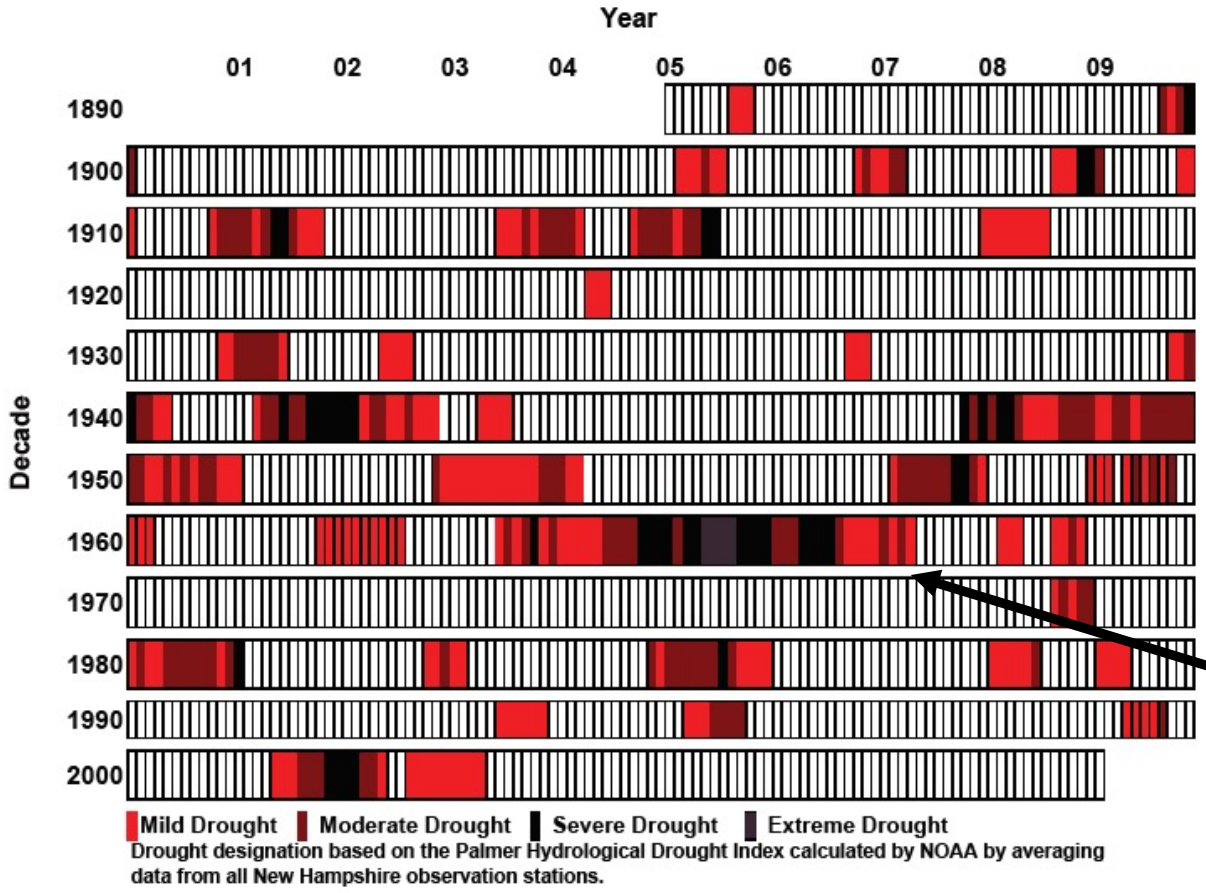


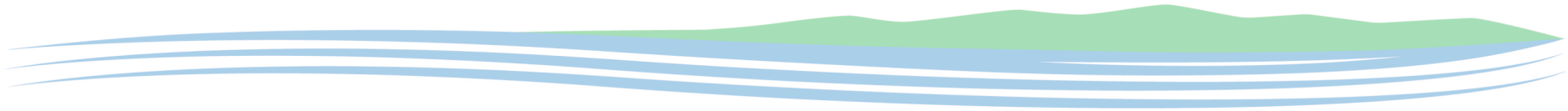
Figure Description: Three months or more of drought based on the Palmer Hydrological Drought Index 1985 2008. Source: NOAA

Although NH is water-rich, we are susceptible to drought.

- Smaller watersheds
- Little aquifer storage
- Surface waters for recreation, not just water supply.

1963-1967 – 4 Year Drought

Description	Possible Impacts
Abnormally Dry	Going into drought: short-term dryness slows growth of crops/pastures. Coming out of drought: some lingering water deficits; crops/pastures not fully recovered.
Moderate Drought	Some damage to crops/pastures; streams, reservoirs, or wells are low with some water shortages developing or imminent; voluntary water-use restrictions requested.
Severe Drought	Crop/pasture losses are likely; water shortages are common and water restrictions are imposed.
Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions.
Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies.



U.S. Drought Monitor

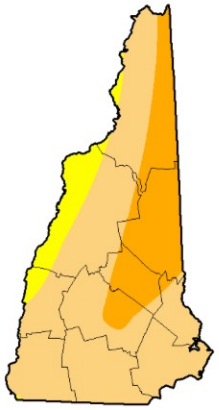
New Hampshire

Maximum Drought Extent

Intensity and Impacts

- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)
- No Data

http://droughtmonitor.unl.edu/



September 10, 2002

(Released Thursday, Sep. 12, 2002)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	91.16	25.61	0.00	0.00
Last Week 9/3/2002	0.00	100.00	63.95	0.15	0.00	0.00
3 Months Ago 6/11/2002	62.11	37.89	0.00	0.00	0.00	0.00
Start of Calendar Year 1/1/2002	0.00	100.00	100.00	91.97	0.00	0.00
Start of Water Year 9/25/2001	0.00	100.00	89.69	23.55	0.00	0.00
One Year Ago 9/11/2001	0.00	100.00	91.42	29.99	0.00	0.00

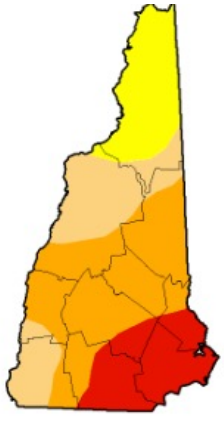
September 21, 2010

(Released Thursday, Sep. 23, 2010)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	44.12	55.88	11.41	0.00	0.00	0.00
Last Week 9/14/2010	44.12	55.88	3.18	0.00	0.00	0.00
3 Months Ago 6/22/2010	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year 12/29/2009	100.00	0.00	0.00	0.00	0.00	0.00
Start of Water Year 9/29/2009	100.00	0.00	0.00	0.00	0.00	0.00
One Year Ago 9/22/2009	100.00	0.00	0.00	0.00	0.00	0.00



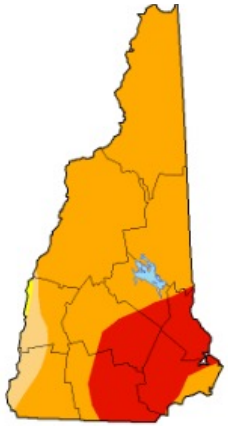
October 18, 2016

(Released Thursday, Oct. 20, 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	82.31	59.35	19.27	0.00
Last Week 10/11/2016	0.00	100.00	62.44	40.49	19.27	0.00
3 Months Ago 7/19/2016	21.54	78.46	41.60	17.18	0.00	0.00
Start of Calendar Year 12/29/2015	50.84	49.16	14.88	0.00	0.00	0.00
Start of Water Year 9/27/2016	15.33	84.67	62.44	40.49	19.27	0.00
One Year Ago 10/20/2015	76.38	23.62	14.88	0.00	0.00	0.00



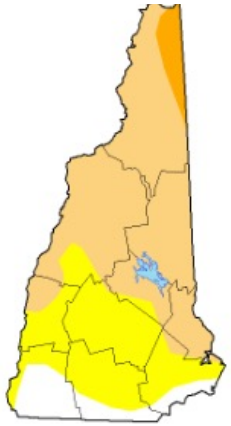
October 6, 2020

(Released Thursday, Oct. 8, 2020)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	99.66	95.06	21.99	0.00
Last Week 10-01-2020	0.00	100.00	100.00	95.06	10.59	0.00
3 Months Ago 07-09-2020	0.04	99.96	56.44	0.00	0.00	0.00
Start of Calendar Year 01-02-2020	100.00	0.00	0.00	0.00	0.00	0.00
Start of Water Year 10-01-2020	0.00	100.00	100.00	95.06	10.59	0.00
One Year Ago 10-10-2019	52.70	47.29	0.00	0.00	0.00	0.00



June 29, 2021

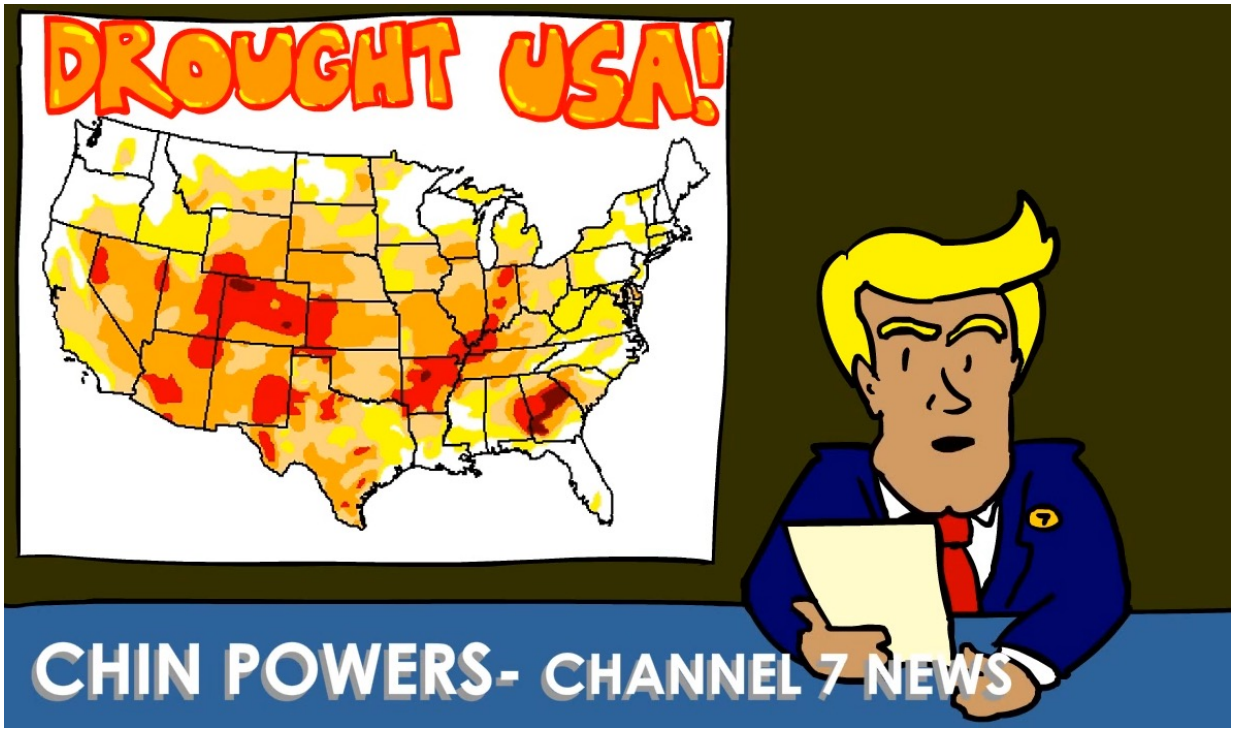
(Released Thursday, Jul. 1, 2021)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	9.75	90.25	58.47	3.93	0.00	0.00
Last Week 06-22-2021	9.75	90.25	58.47	0.00	0.00	0.00
3 Months Ago 03-30-2021	27.78	72.22	14.93	0.00	0.00	0.00
Start of Calendar Year 12-29-2020	51.63	48.37	12.20	0.00	0.00	0.00
Start of Water Year 09-29-2020	0.00	100.00	100.00	95.06	10.59	0.00
One Year Ago 06-30-2020	1.45	98.55	56.41	0.00	0.00	0.00

How is drought determined?



This is worth a watch!

youtube.com/watch?v=i7F6QwRqyVI

Drought Tracking and Designation in NH

NH DES Drought Management Team

- Drinking Water Groundwater
- Dams
- Streamflow
- Geological Survey
  - Streamflow
  - Lake levels
  - Sol Moisture
  - Snowpack
  - Water Use
  - Groundwater levels
  - Emergency well approvals
  - Residential well replacements
  - Bulk water deliveries
  - Water use restrictions
  - Staff/public/media observations
  - State: Climate / Agriculture / Forest Fires / Fisheries

US Drought Monitor

- Palmer Drought Severity Index
- CPC Solid Moisture Model
- USGS Weekly Streamflows
- Standardized precipitation index
- Other climatological inputs (ex. Keech-Bryam Drought Index for fire)

State Drought Management Team

NH Department of Homeland Security and Emergency Management
NH Dept. of Agriculture, Markets and Food
NH Dept. of Safety, Division of Fire Safety
NH Department of Resources and Economic Development
NH Office of Energy and Planning
NH Fish and Game
NH Department of Health and Human Services
NH Department of Environmental Services
NH Water Well Board
Public Utilities Commission - Water & Gas Division
Public Utilities Commission - Electric Division
NH State Climatologist
UNH Cooperative Ext.
US Army Corps of Engineers
United States Geologic Survey
USDA NASS - New England Field Office

USDA - Farm Service Agency
NH Water Works Association
NH Business and Industry Association
NH Farm Bureau
Public Service of New Hampshire
Granite State Hydropower Association
NH Health Officers Association
Association of Regional Planning Commissions
NH Rivers Management Advisory Committee
NH Lakes Management Advisory Committee
Ski NH
Manchester Water Works
City of Portsmouth
Local Government Center
Granite State Rural Water

Legal Mechanisms to Address Drought

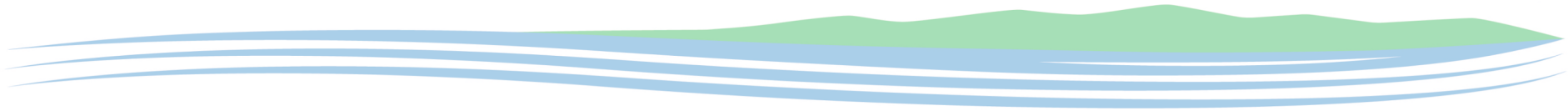
- Large groundwater withdrawal permits – reduce withdrawals based on phase of drought
- Emergency authority to approve new large groundwater withdrawals
- Municipal authority to restrict or ban residential lawn watering during drought (applies to public **and** *residential wells*)
- Authority to require dam owners to release water
- Authority to require a public water system to extend service to address a nearby emergency

Other:

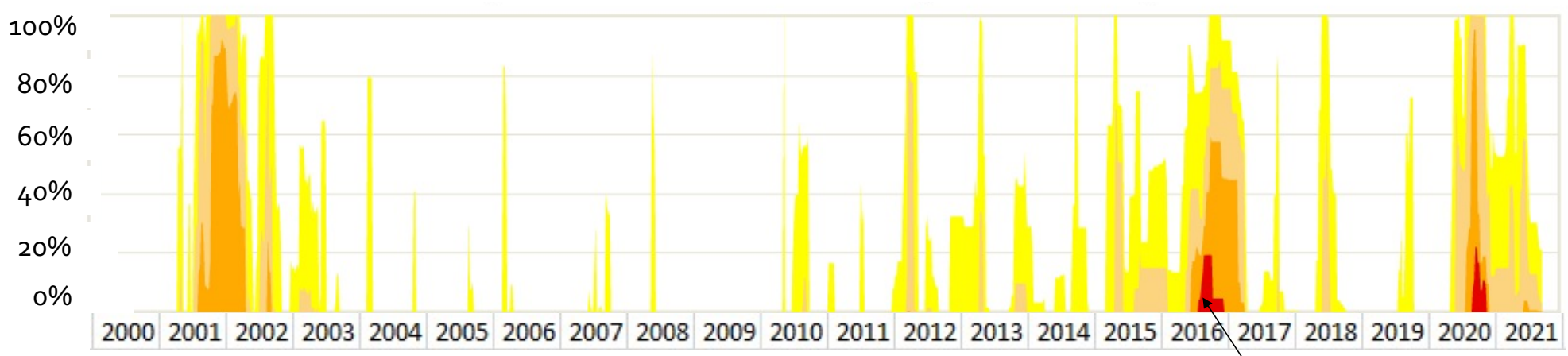
Bulk Water haulers have registrations to pull from surface waters.

DO NOT mix surface waters and groundwater – *fill dug well from pond*.

FEMA / Dept. of Agriculture provides Drought Disaster Declarations

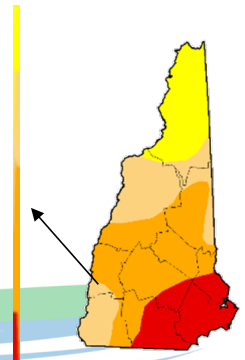


Occurrence of Drought: Percent of NH in Drought from 2000-2020



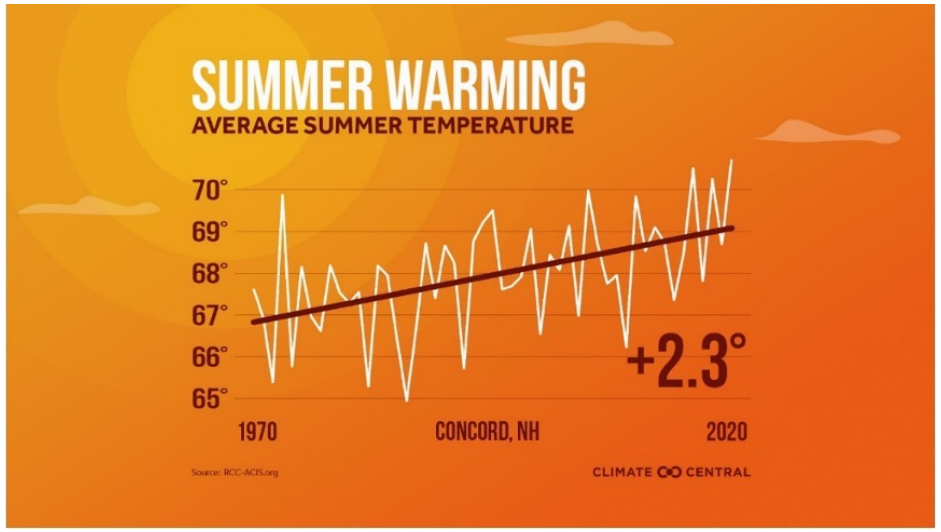
Intensity and Impacts

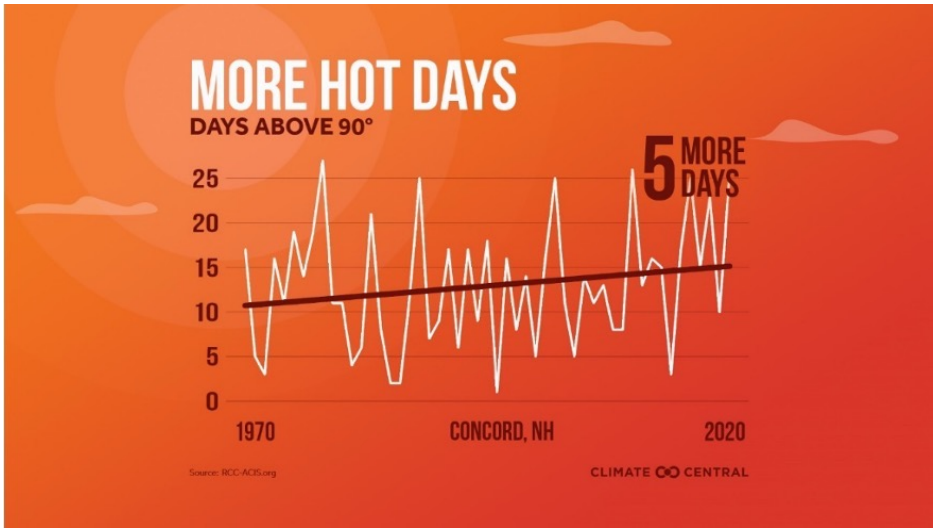
- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)
- No Data



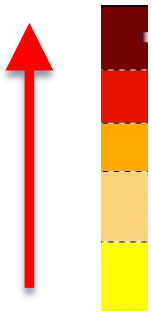
https://droughtmonitor.unl.edu/

Climate Impacts on Drought





Drought Intensity



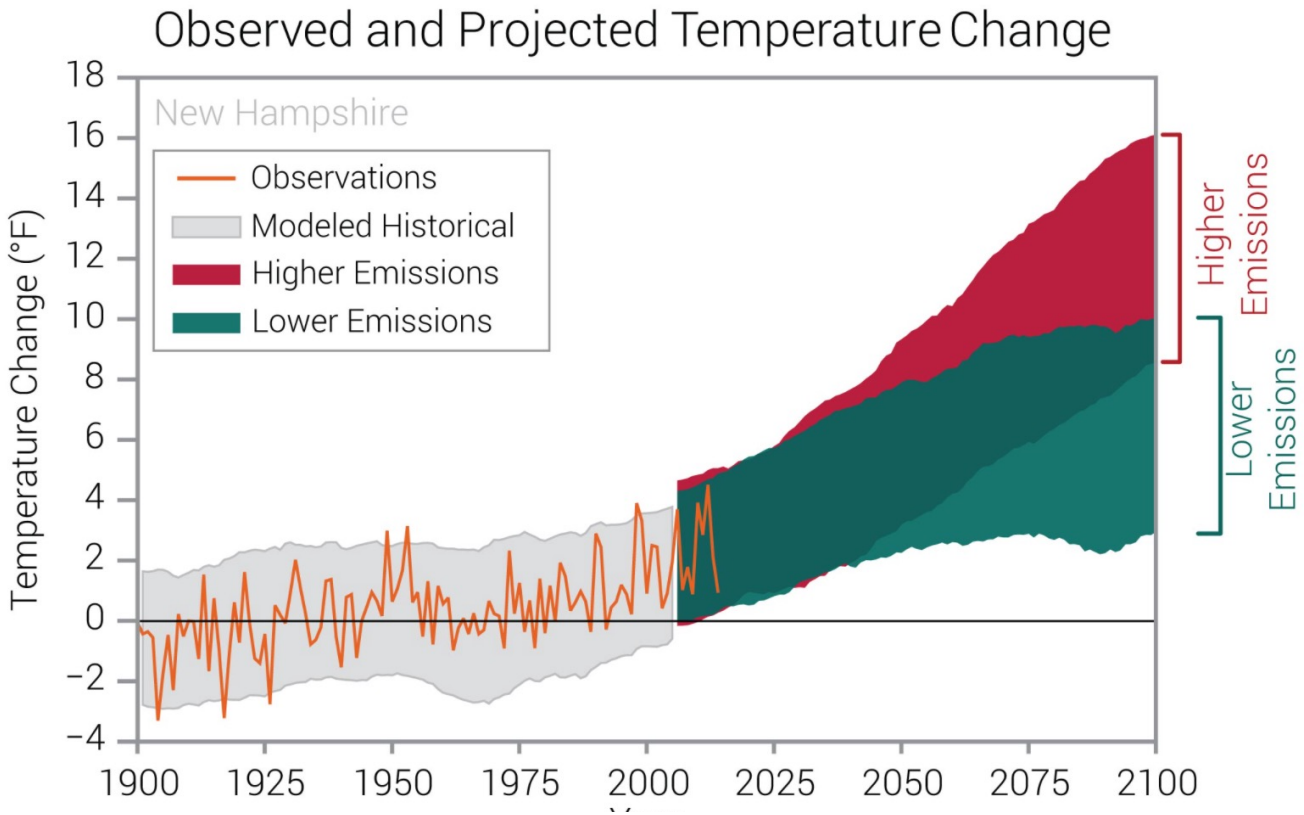
Greater the chances for

Flash Drought

NEW CONCEPT/TERMINOLOGY!

Flash Drought = 2 Category change over 2 weeks that persists for 2 weeks

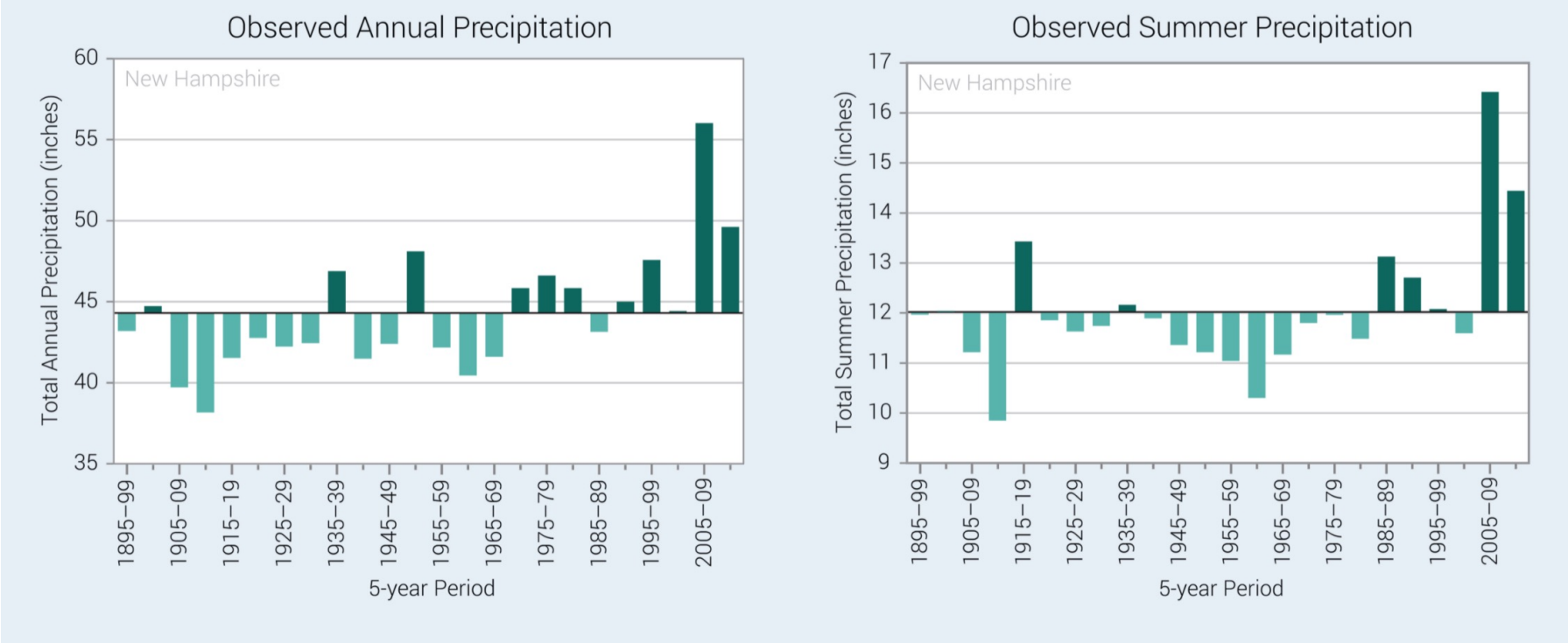
We are getting warmer…



https://statesummaries.ncics.org/chapter/nh/. NOAA, 2017

Is the average annual precipitation increasing?

Average annual precipitation in NH = 44.5 inches



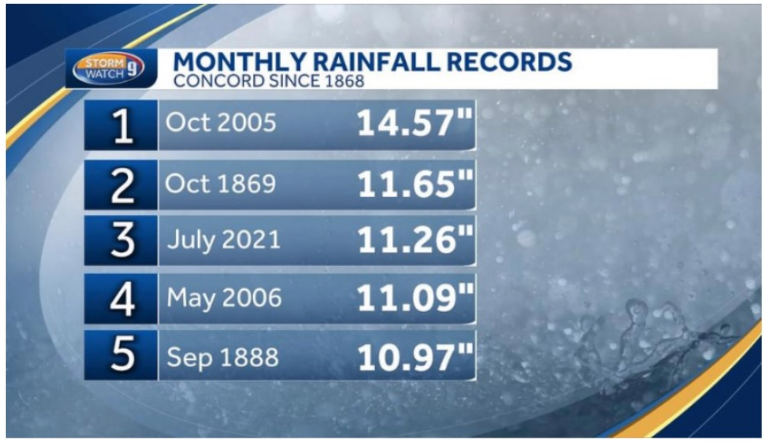
https://statesummaries.ncics.org/chapter/nh/. NOAA, 2017

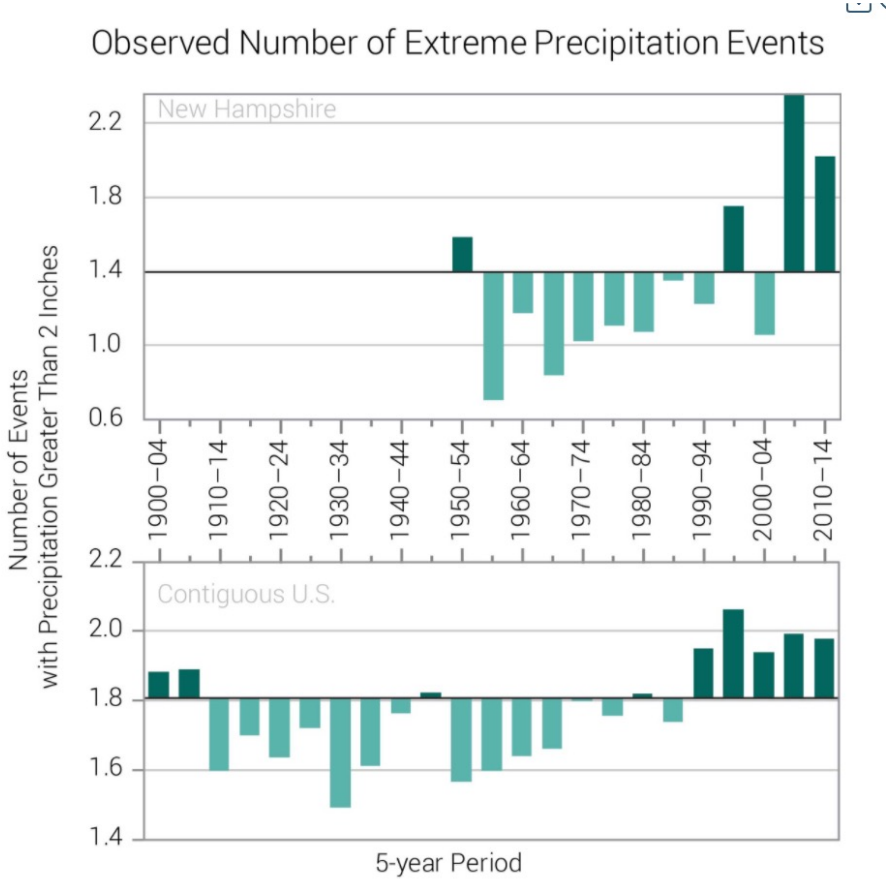
Climate driven high-water conditions

Impact of heavy rains – July 2021

WMUR Weather Updates
6h · **July 28, 2021**

This record wettest July in Concord is now the 3rd wettest month since records have been kept(they go back to 1868). A good shot to get to second by later tomorrow evening.





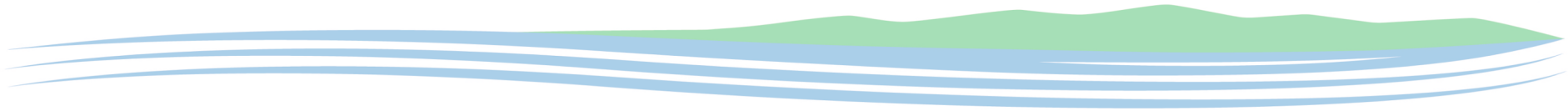
Normal July Precipitation is ~ 3.5”

Long lasting rain is better than short heavy rains.

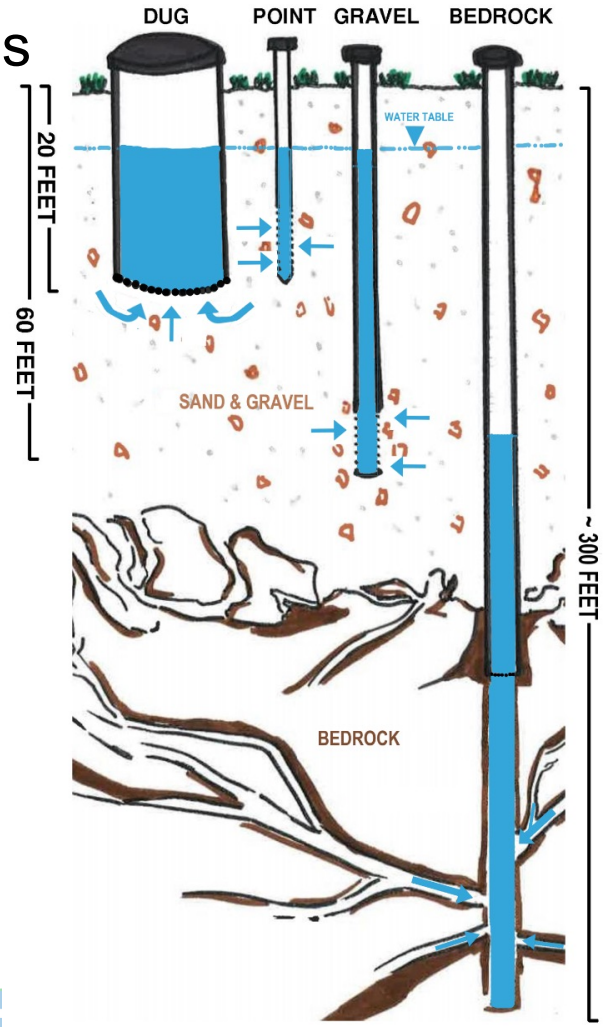
https://statesummaries.ncics.org/chapter/nh/. NOAA, 2017

Part 2: Wells/Groundwater Flow + Lake Water Levels

- Types of wells and how water flows into them
- How drought effects groundwater levels
- Monitoring lake water levels and streamflow
- How drought/heavy rains impact surface waters
  Influence of dams on lake levels

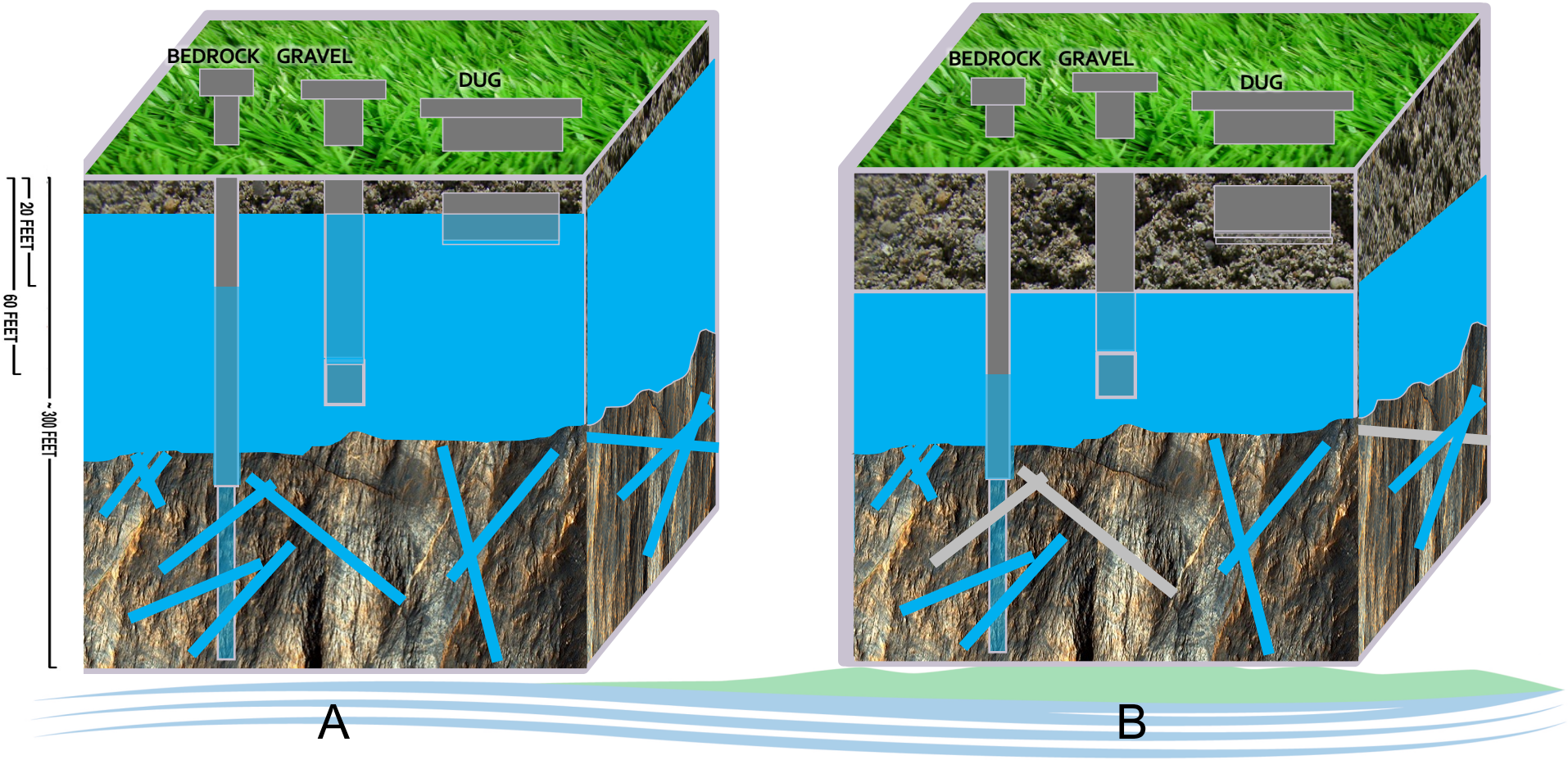


Groundwater Flow to Wells



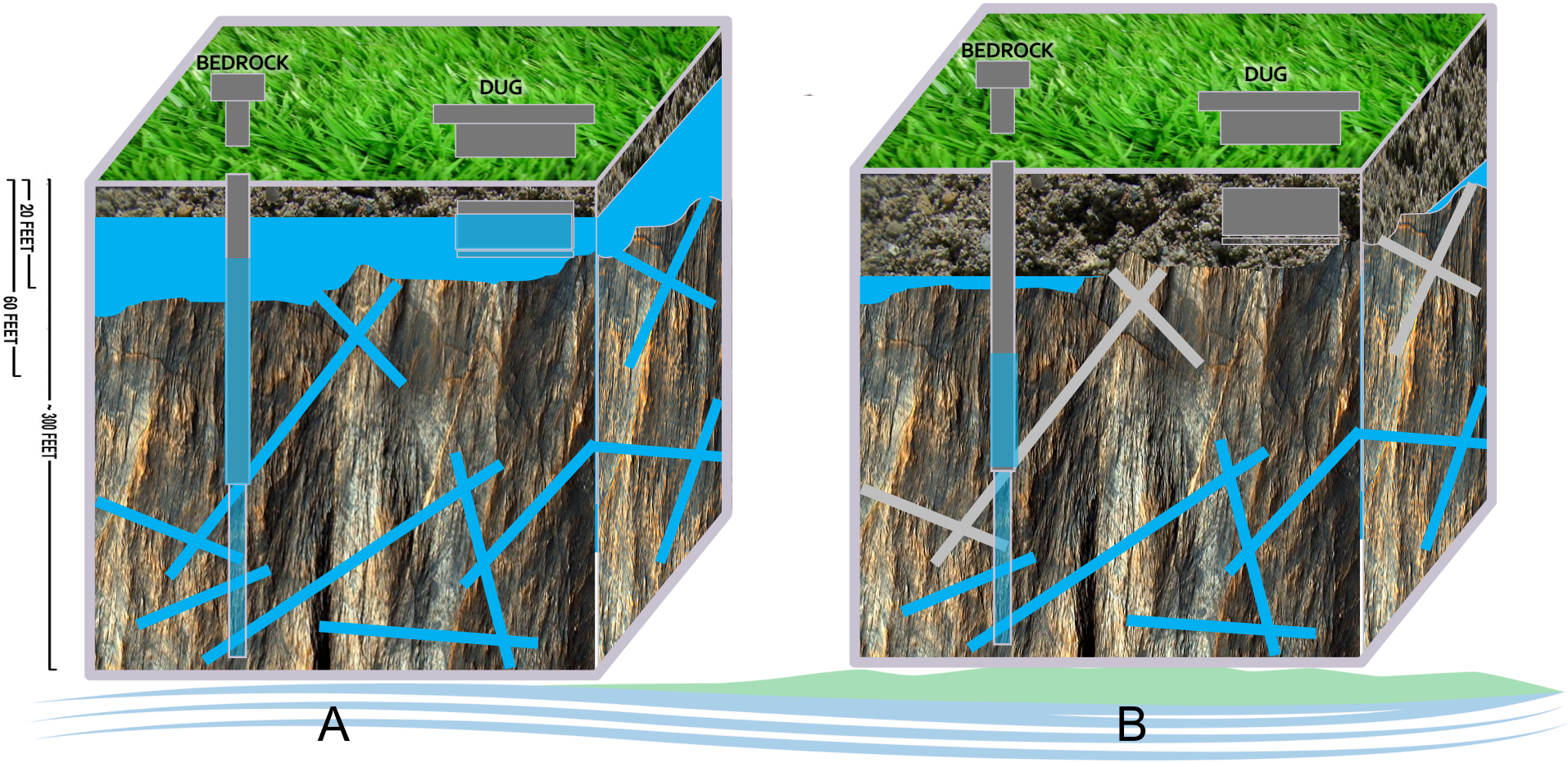
What happens when groundwater levels drop?

Materials overly bedrock

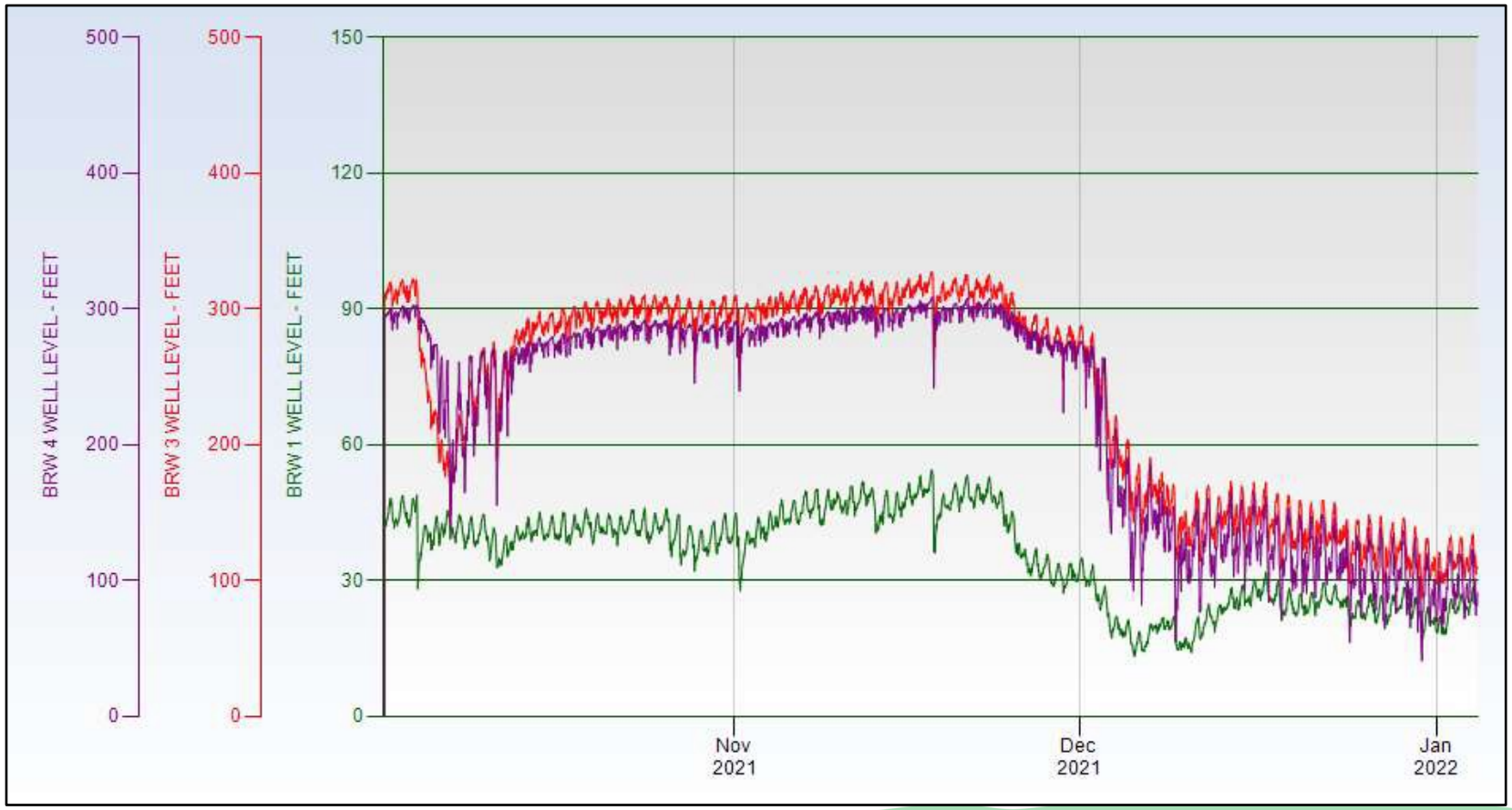


What happens when groundwater levels drop?

Materials do not overly bedrock



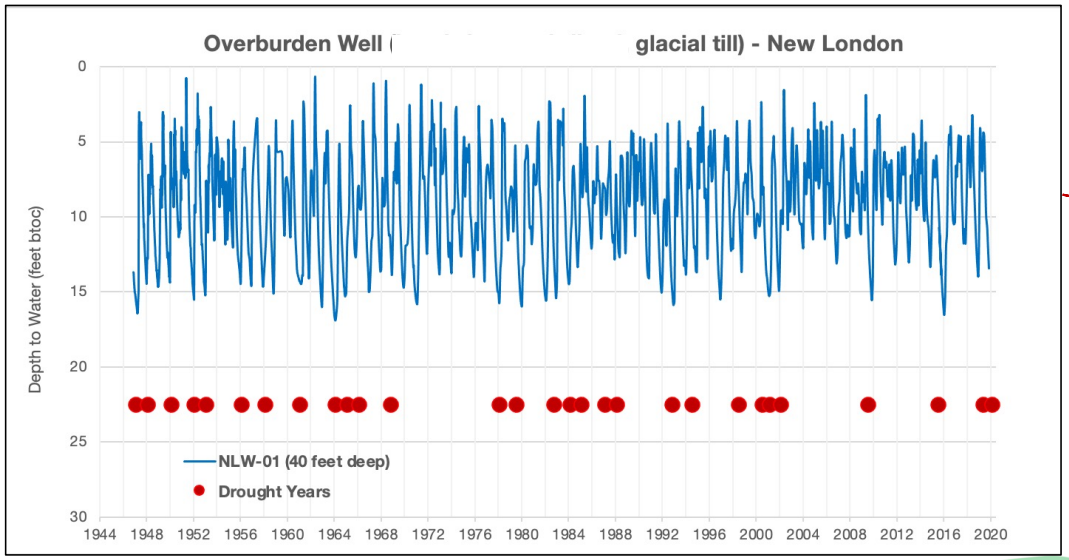
Example of groundwater level fluctuations over time

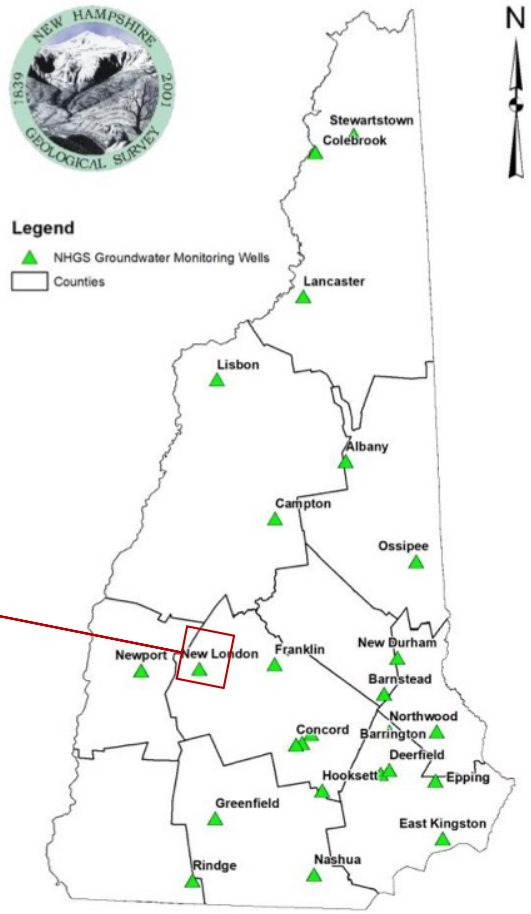


NH Geological Survey

Monthly Water Level Data

Ambient (non-pumping)
19 Overburden (Gravel) Wells
11 Bedrock Wells (9 with data back to 2009)





September 2020

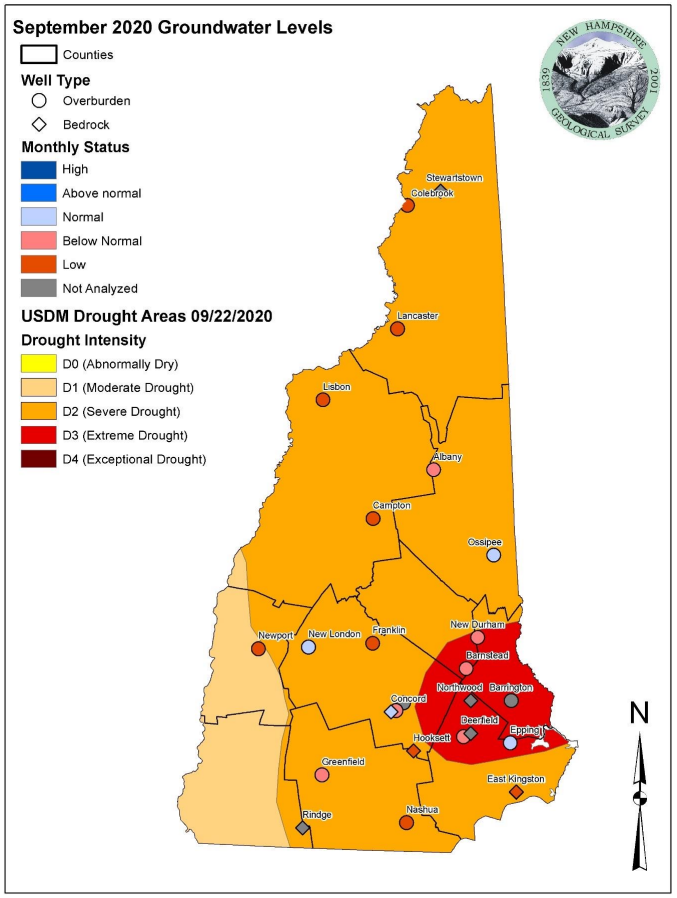
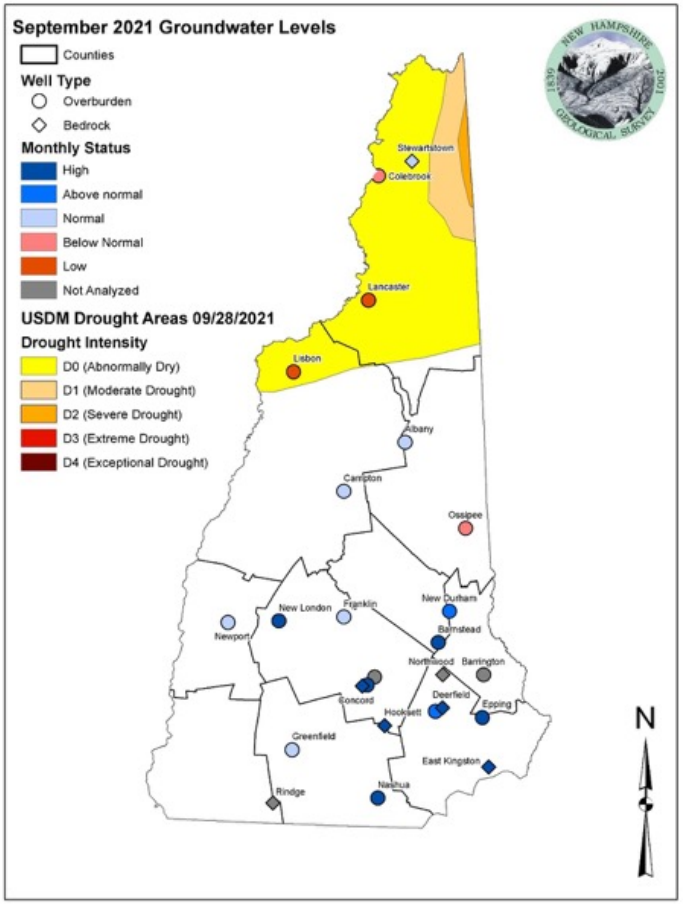


Table 1. Summary of groundwater levels sorted by region (dark blue – high, blue – above normal, light blue – normal, pink – below normal, red – low.

Well	Town	Well type	Screen/ open Interval (ft)	Depth to Water (ft)	Monthly Average (ft)	Current Status	Departure from Avg. (ft)	Change since last month (ft)
ADW-14	Albany	Overburden	77.5-79.5	7.66	6.9	Low	-0.76	-0.37
ADW-15	Albany	Overburden	16-18	9.45	8.78	Below norm	-0.67	-0.3
BAW-10	Barnstead	Overburden	23-25	3.34	3.36	Below norm	0.02	-0.2
BBW-53	Barrington	Overburden	21-23	5.76	-	Not Analyzed	-	-0.09
CBW-34	Campton	Overburden	21-23	14.74	13.7	Low	-1.04	-0.29
CTW-73	Colebrook	Overburden	105-107	8.4	7.86	Low	-0.54	-1.3
CVW-02.1	Concord	Overburden	59.8-61.8	40.9	-	Not Analyzed	-	-0.23
CVW-04	Concord	Overburden	25-27	19.17	18.26	Below norm	-0.91	-0.3
DDW-46	Deerfield	Overburden	59.8-61.8	39.65	39.12	Below norm	-0.53	-0.19
EPW-90	Epping	Overburden	39.45-40.7	29.38	28.88	Normal	-0.5	-0.54
FKW-01	Franklin	Overburden	45.5-47.5	14.2	12.72	Low	-1.48	-0.67
GSW-75	Greenfield	Overburden	35.8-37.8	62.36	61.22	Below norm	-1.14	-0.6
LCW-01	Lancaster	Overburden	28-30	3.56	2.3	Low	-1.26	-0.13
LLW-19	Lisbon	Overburden	49.8-52.3	15.38	14.54	Low	-0.84	-0.23
NAW-218	Nashua	Overburden	66-68	30.7	28.84	Low	-1.86	-1.8
NFW-53	New Durham	Overburden	28-30	20.6	19.78	Below norm	-0.82	-0.25
NLW-01	New London	Overburden	40-42	13.44	12.31	Normal	-1.13	-1.11
NPW-03	Newport	Overburden	40.5-42.5	8.57	7.25	Low	-1.32	-0.25
NPW-06	Newport	Overburden	58-60	8.77	7.35	Low	-1.42	-0.22
OXW-38	Ossipee	Overburden	0-22.55	36.15	35.77	Normal	-0.38	-0.24
CVWB-01	Concord	Bedrock	470-480	27.18	25.64	Normal	-1.54	-0.54
CVWB-02	Concord	Bedrock	0-315	25.23	22.61	Normal	-2.62	-1.91
DDWB-01	Deerfield	Bedrock	0-300	18.94	-	Not Analyzed	-	-0.68
EAWB-01	East Kingston	Bedrock	463-473	26.31	24.52	Low	-1.79	-0.81
EAWB-02	East Kingston	Bedrock	0-323	27	24.48	Low	-2.52	-1.05
HTW-05	Hooksett	Bedrock	0-102.7	50.64	49.29	Low	-1.35	-0.44
NWWB-01	Northwood	Bedrock	0-130	7.91	-	Not Analyzed	-	-0.36
RGWB-01	Rindge	Bedrock	391-401	16.2	-	Not Analyzed	-	-0.8
RGWB-02	Rindge	Bedrock	0-285	18.92	-	Not Analyzed	-	-0.81
SOWB-01	Stewartstown	Bedrock	443-453	18.45	-	Not Analyzed	-	-1.2
SOWB-02	Stewartstown	Bedrock	0-303	27	-	Not Analyzed	-	-1.3

September 2021



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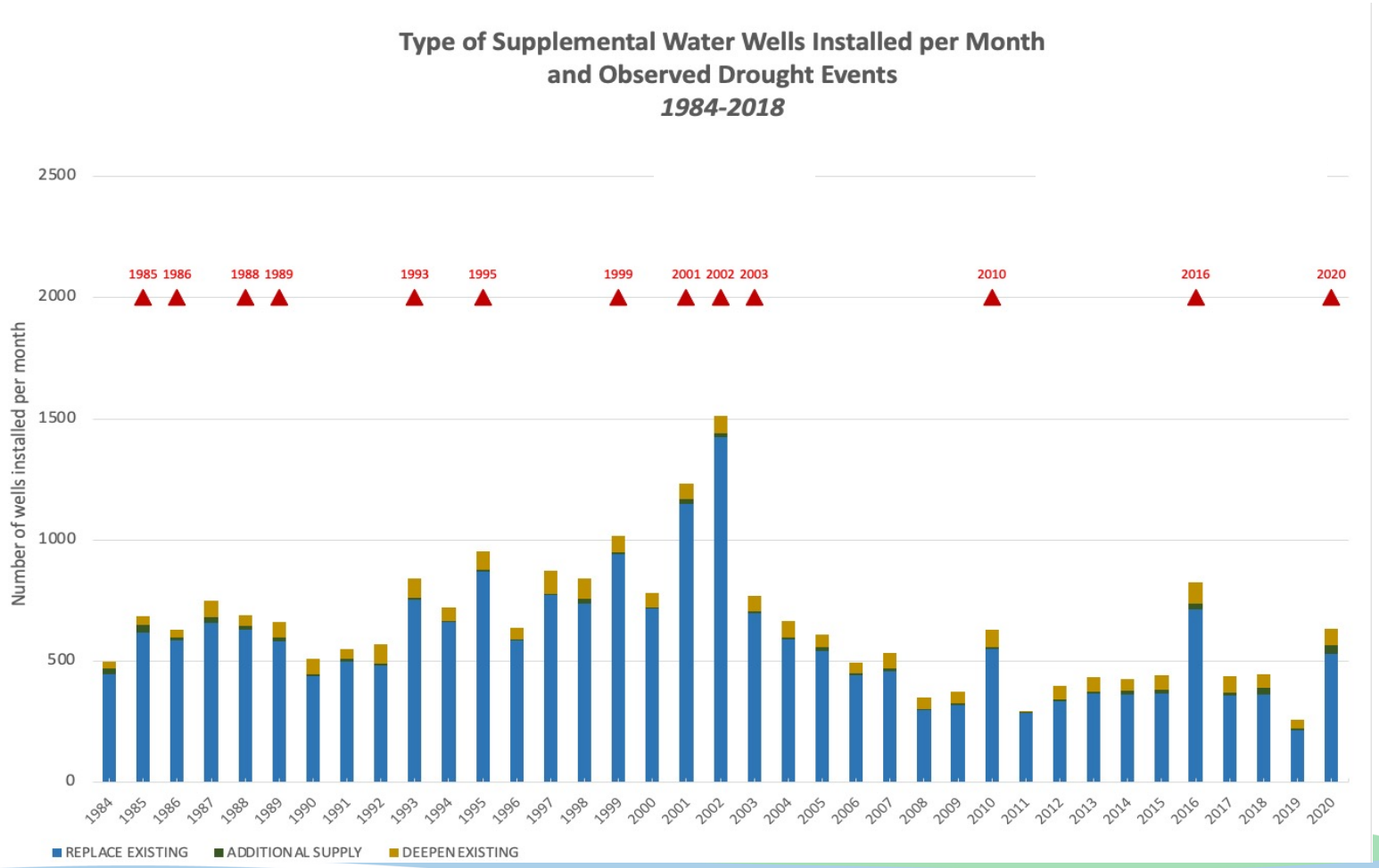
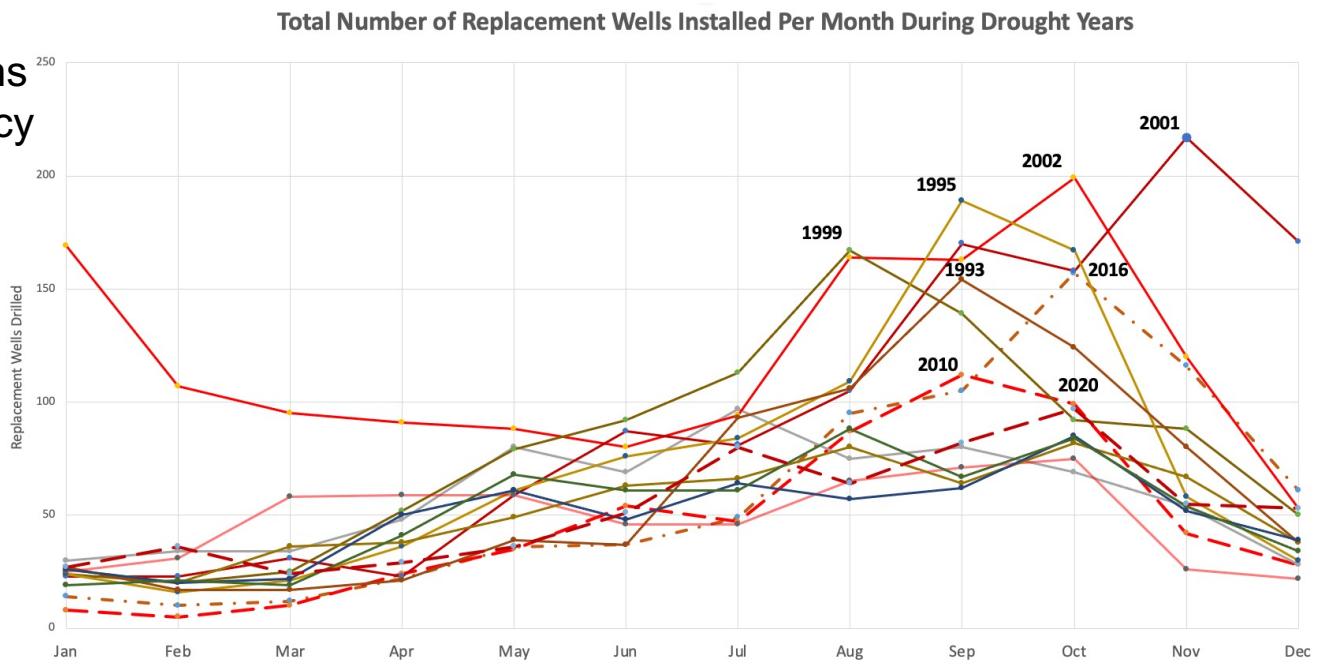
ADW-15	Albany	Overburden	16-18	9.1	8.79	Normal	-0.31	-0.25
BAW-10	Barnstead	Overburden	23-25	0.81	3.25	High	2.44	-0.2
BBW-53	Barrington	Overburden	21-23	3.71		Not Analyzed	-	-0.25
CBW-34	Campton	Overburden	21-23	13.51	13.69	Normal	0.18	-0.61
CTW-73	Colebrook	Overburden	105-107	8.25	7.88	Below norm	-0.37	0.05
CVW-02.1	Concord	Overburden	59.8-61.8	41.07		Not Analyzed	-	0.3
CVW-04	Concord	Overburden	25-27	16.42	18.23	High	1.81	0.15
DDW-46	Deerfield	Overburden	59.8-61.8	38.68	39.1	Above norm	0.42	0.03
EPW-90	Epping	Overburden	39.45-40.7	27.45	28.79	High	1.34	0.11
FKW-01	Franklin	Overburden	45.5-47.5	12.92	12.72	Normal	-0.2	-0.07
GSW-75	Greenfield	Overburden	35.8-37.8	61.19	61.21	Normal	0.02	0.61
LCW-01	Lancaster	Overburden	28-30	3.22	2.31	Low	-0.91	-0.37
LLW-19	Lisbon	Overburden	49.8-52.3	15.21	14.57	Low	-0.64	-0.11
NAW-218	Nashua	Overburden	66-68	26.44	28.8	High	2.36	0.18
NFW-53	New Durham	Overburden	28-30	19.22	19.76	Above norm	0.54	-0.1
NLW-01	New London	Overburden	40-42	8.09	12.27	High	4.18	-0.96
NPW-03	Newport	Overburden	40.5-42.5	7.17	7.25	Normal	0.08	-0.41
NPW-06	Newport	Overburden	58-60	7.75	7.37	Normal	-0.38	-0.42
OXW-38	Ossipee	Overburden	0-22.55	36.47	35.79	Below norm	-0.68	-0.09
CVWB-01	Concord	Bedrock	470-480	20.16	25.21	High	5.05	0.67
CVWB-02	Concord	Bedrock	0-315	15.76	22.08	High	6.32	-0.07
DDWB-01	Deerfield	Bedrock	0-300	17.03	18.31	High	1.28	-0.03
EAWB-01	East Kingston	Bedrock	463-473	22.5	24.36	High	1.86	-0.08
EAWB-02	East Kingston	Bedrock	0-323	21.87	24.28	High	2.41	-0.1
HTW-05	Hooksett	Bedrock	0-102.7	47.17	49.25	High	2.08	-0.18
NWWB-01	Northwood	Bedrock	0-130	5.04		Not Analyzed	-	0.55
RGWB-01	Rindge	Bedrock	391-401	13.86		Not Analyzed	-	0.58
RGWB-02	Rindge	Bedrock	0-285	16.57		Not Analyzed	-	0.58
SOWB-01	Stewartstown	Bedrock	443-453	18.95		Not Analyzed	-	-1.15
SOWB-02	Stewartstown	Bedrock	0-303	26.36	25.22	Normal	-1.14	-0.06

More Well Installations and Replacement Wells in Drought Years



Are we gaining resiliency to droughts?

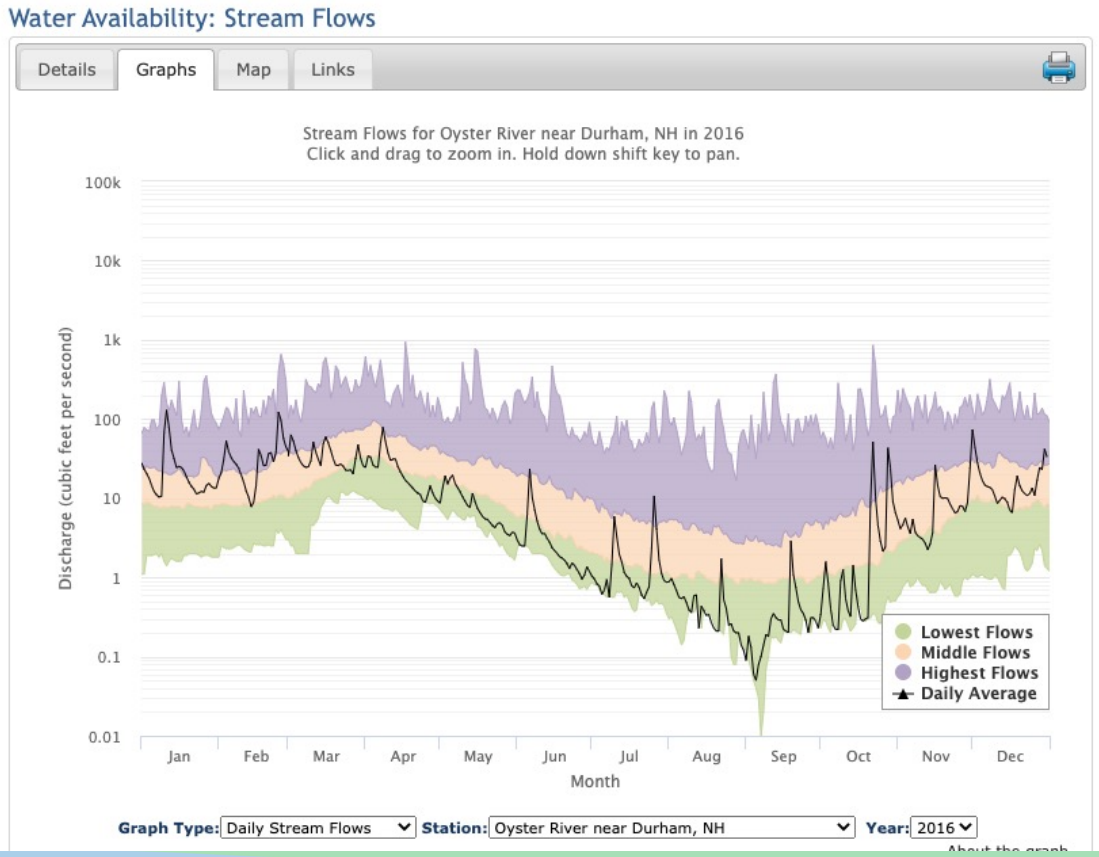
- Well Replacement
- Groundwater Recharge
- Water Conservation Regulations
- Diversified Sources/Redundancy
- PWS Interconnections
- Pump Deepening



But, droughts will happen.
Water levels will drop
There will be more water users

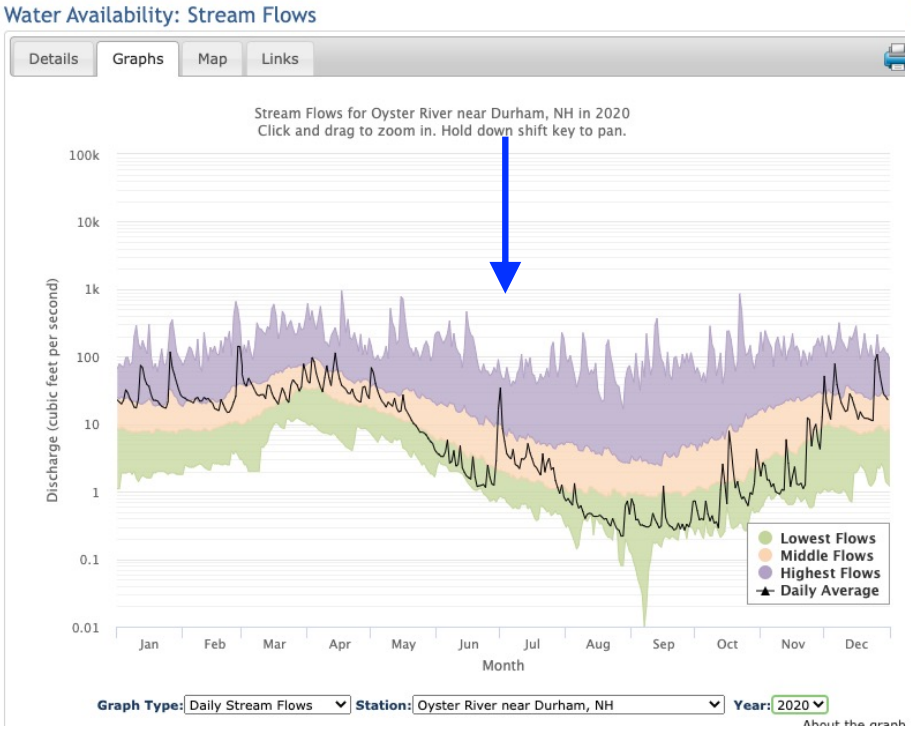
Surface Water Fluctuations – Streams

2016 Data

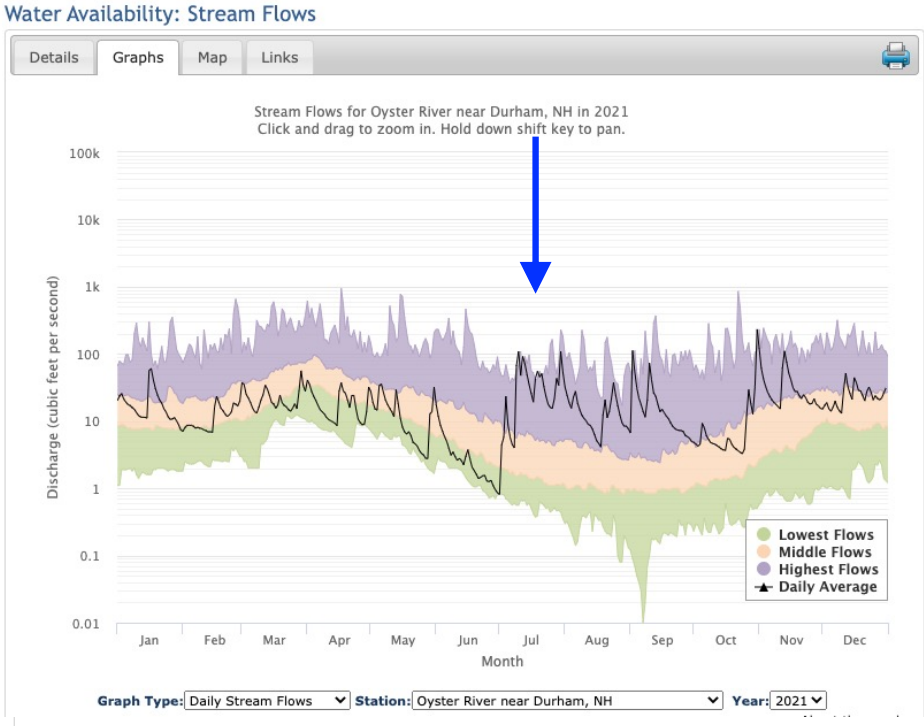


2020 - 2021 Data

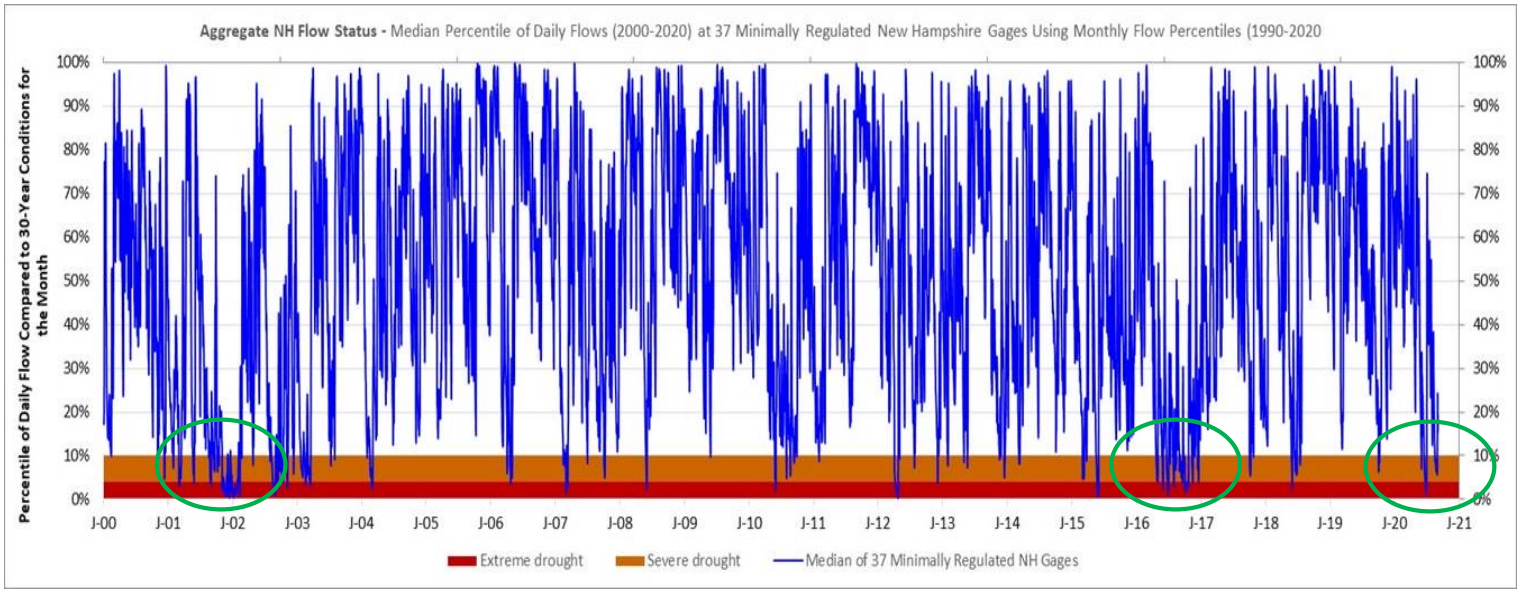
Single rain event



vs. sustained rain events

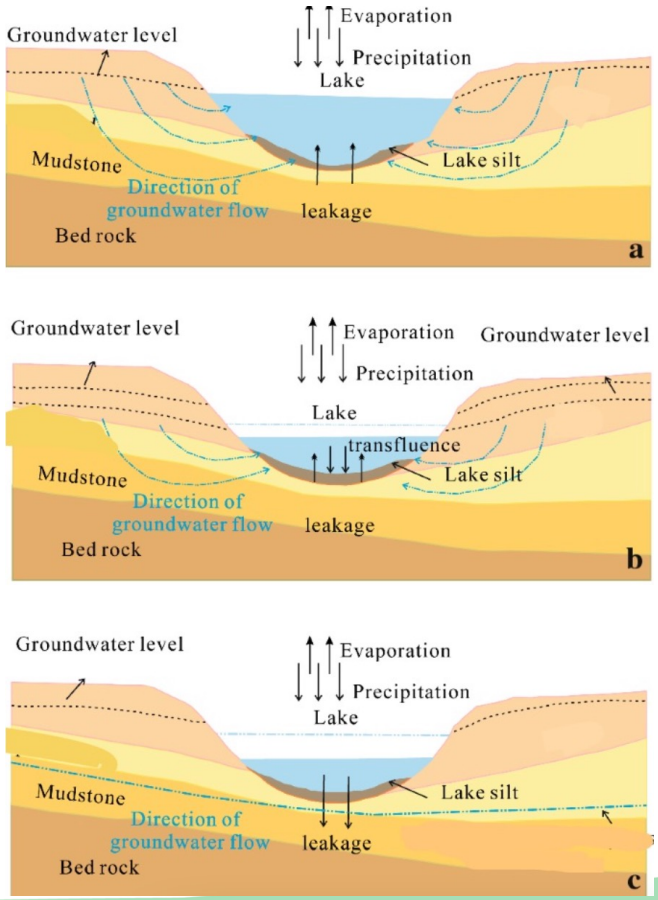


Drought - Stream Conditions:

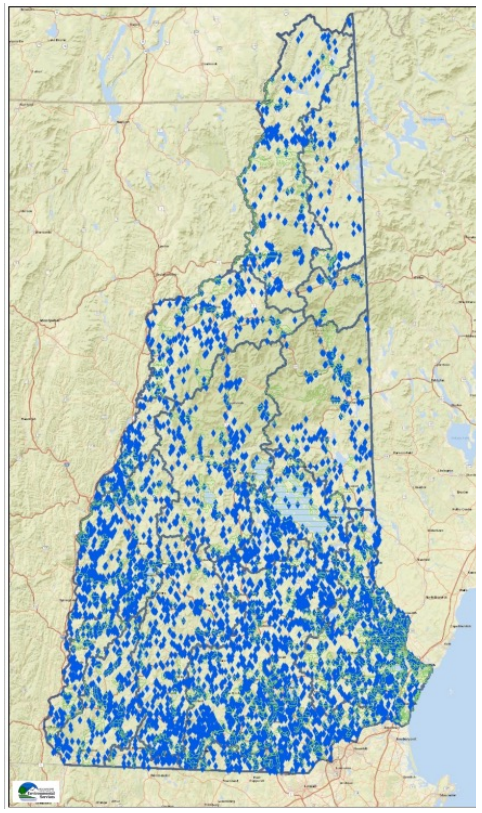


Surface Water Fluctuations – Lakes

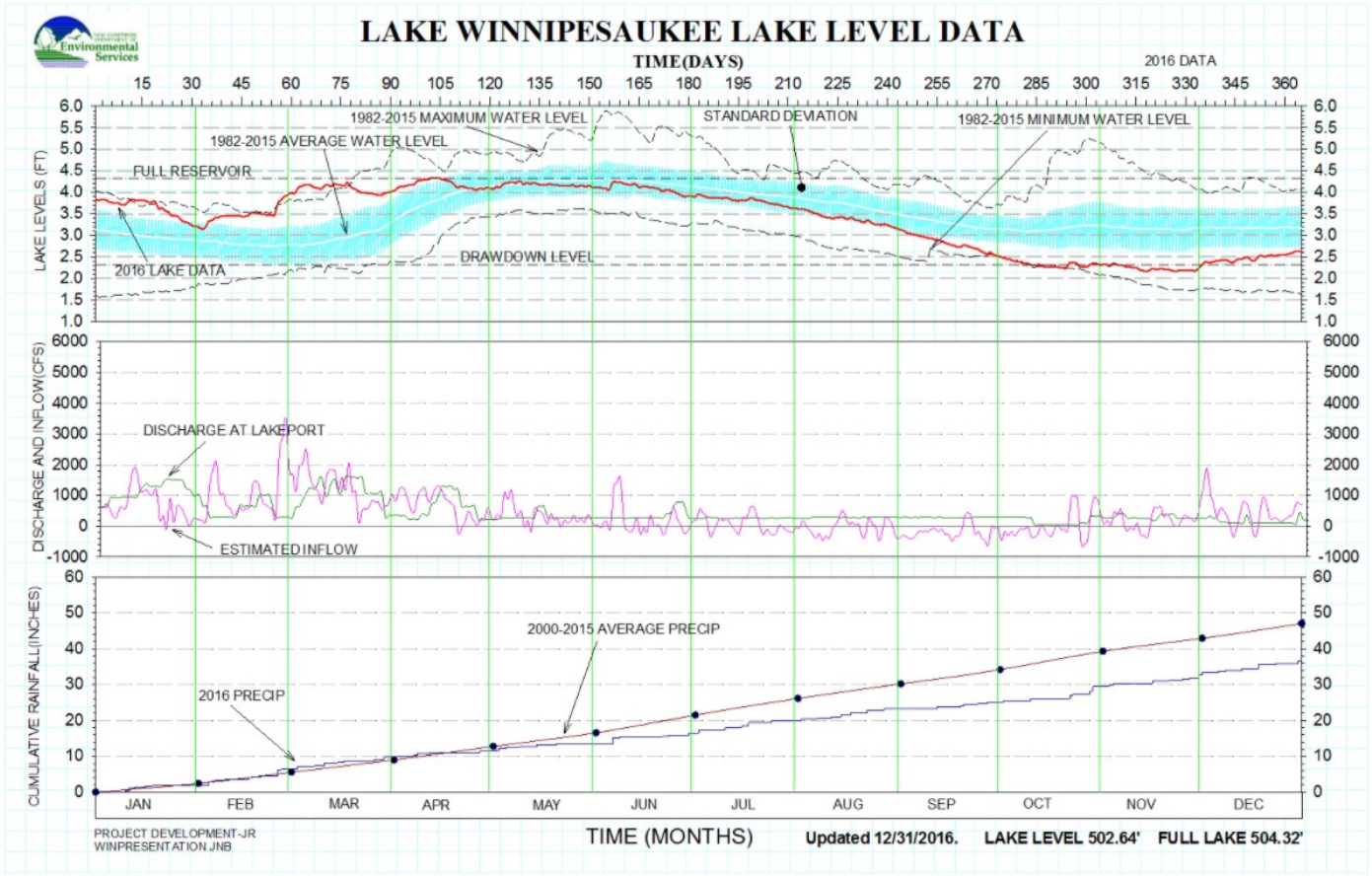
Inflows vs Outflows
Gaining vs Loosing
Many are Dam Controlled



Dams in NH

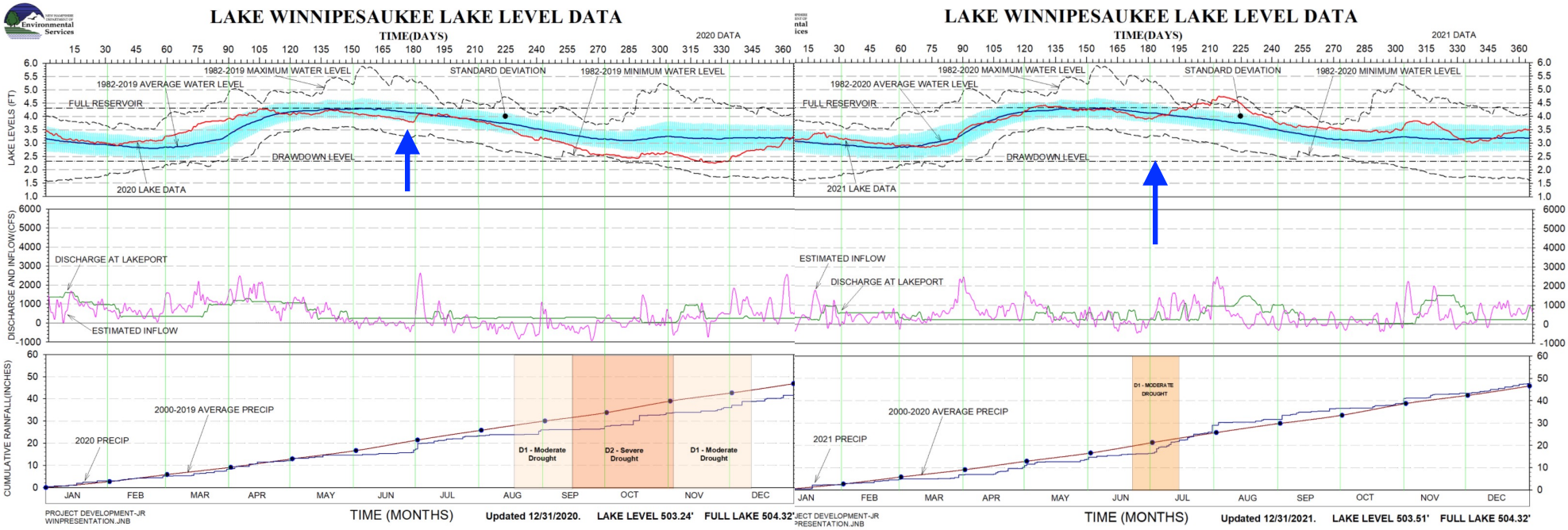


2016 Data


LAKE WINNIPESAUKEE LAKE LEVEL DATA
TIME(DAYS)
2016 DATA
1982-2015 MAXIMUM WATER LEVEL
STANDARD DEVIATION
1982-2015 MINIMUM WATER LEVEL
1982-2015 AVERAGE WATER LEVEL
FULL RESERVOIR
2016 LAKE DATA
DRAWDOWN LEVEL
LAKE LEVELS (FT)
DISCHARGE AT LAKEPORT
ESTIMATED INFLOW
DISCHARGE AND INFLOW(CFS)
2000-2015 AVERAGE PRECIP
2016 PRECIP
CUMULATIVE RAINFALL(INCHES)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
TIME (MONTHS)
PROJECT DEVELOPMENT-JR
WINPRESENTATION.JNB
Updated 12/31/2016. LAKE LEVEL 502.64' FULL LAKE 504.32'

2020 - 2021 Data

Single rain event vs. sustained rain events



Part 3: Impacts of Climate Thru Photographs

- Wells
- Lakes
- Shorelines

Wells will go dry.

Replacements / Deepening / Interconnections will be needed

Larger swings in surface water levels over short time period

Shoreline erosion
Impacts to vegetation
Different run-off patterns
Warmer lake temperatures
Aquatic species impacts
More/widespread algal blooms

Limited access to boat ramps/lifts
Boat speed limits enforces

Dock / Shoreline Structure Damage Will Occur

Ice Damage

Fluctuating temperatures and drifting ice in early/late winter

“January Thaw”

Later ice-in earlier ice-out

Impact of Extreme Events

Hurricane Isaias August 2020

Isaias Brings Wind, Rain And Tornado Risks Up Through The Northeast Into Canada

npr By Bill Chappell, Rachel Treisman
Published August 4, 2020 at 9:26 AM EDT

Impact of Extreme Events

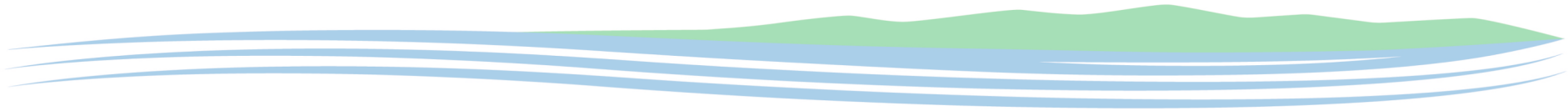
Shoreline erosion and damage to trees/vegetation

What have we learned? What should we expect in the future?

- More frequent (flash?) droughts
- Warming air temperatures, more hotter days
- Higher precipitation –more frequent ”Extreme” events

- Groundwater levels fluctuations in different types of wells
- Lake levels fluctuate based on precipitation – and Dams

- Wells going dry – more water conservation measures/interconnections
- Greater fluctuations in lake levels (shorter timelines)
- Changes in water quality (warmer, longer residence time, blooms)
- Erosion to shorelines – damage to structures – impacts to recreation



EDGEWATER STRATEGIES
CLEAR SOLUTIONS

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Shoreland/Wetland Permitting
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Public Water Management

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