Index to State of America’s Water Infrastructure
Rethinking Water 2022.

• The Resource
  • Climate
  • Groundwater
  • Water quality

• Infrastructure
  • Dams
  • Conveyance – Pipes and Sewer Systems
  • Water and Wastewater Treatment systems

• Affordability, Financing/Investment
Climate

- Drought
- Extreme Precipitation
- Streamflow
- Floods
- Sea Level Rise
Increasing Water Stress is a challenge for cities, energy, industries and agriculture across the country.

Our index accounts for climate variability.
Drought

Since 2000

Steep increase projected in Southwestern US Drought as indicated in soil moisture in future climate change scenarios


https://droughtmonitor.unl.edu/
Trends (red increasing, blue decreasing) in daily rainfall > 95th percentile of rain on rainy days

Statistically significant trends in both maps are in red and blue

See also https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing
Streamflow


USGS | National Water Dashboard

Trends in annual 7-day low streamflow based on different periods of record


Low Flow trends are regional – due to climate and regulation of flows
Floods

Number of water-related billion-dollar disaster events each year in the United States and the associated costs (in 2017 dollars, adjusted for inflation)

NOAA NCEI, 2018: Billion-Dollar Weather and Climate Disasters [web page]. NOAA National Centers for Environmental Information, Asheville, NC.

https://nca2018.globalchange.gov/chapter/3/

Increasing flood losses amplify concerns with projected flood risk changes (past 100 year event becomes much more frequent over much of USA)

Projected change in flood frequency. Median return period (years) in future (2071–2100) for discharge corresponding to a 100-year flood in the past (1971–2000), using CMIP6 models with (SSP5-RCP8.5) scenarios

**Inequitable patterns of US flood risk in the Anthropocene**

*Where flood risk is projected to rise fastest in the US*

A new analysis projects changes in flood risk between 2020 and 2050 by zooming in on every neighborhood across the U.S. The map shows county-level data on the average annual loss due to flood damage.

Percentage rise, 2020-2050

Flood damage measured in 2020 U.S. dollars.

Map: The Conversation/CC-BY-ND • Source: Wing, et al. 2022
Sea Level Rise

Return Periods of nuisance coastal flooding, affecting transportation, houses, wastewater and water treatment and electricity distribution systems.

Coastal areas have major cities and smaller underserved populations. Sea Level rise threatens their infrastructure and existence.

Nuisance flooding is one measure of potential impacts to date

Sea Level Rise projections suggest increasing future impacts


Measured groundwater level changes from ~1950 to 2007 in the High Plains aquifer – note the high spatial variability within aquifer.

Drought accelerates depletion, but growing demands increasingly tap groundwater as surface reservoir construction is expensive and difficult from a regulatory perspective.

Columbia Water Center White Paper: Assessment of trends in groundwater levels across the United States
Groundwater Quality

Inorganic contaminants are prevalent in many of the nation’s aquifers putting individual well owners and community well owner’s at risk, if the water is not treated.

USGS National Groundwater Quality Survey
Health-based violations of the Safe Drinking Water Act and racial, ethnic and language vulnerability vary by county. Darker colors indicate more numerous violations and greater vulnerability.

Violations data are from June 2016 through May 2019, and vulnerability measures are from the 2016 CDC Social Vulnerability Index. (Graphic courtesy of the NRDC via Ensia. First published in the Watered Down Justice Report, Sep. 2019 R 19-09-A.)
EPA Reported Drinking Water Quality Violations from Community Water Systems (CWS)
Event Reporting Frequency may not be perfect

Hot spots of health-based violations, 1982–2015 based on total number of violations per CWS

Total violations per water system, by housing density category and income group.

Tier 1 violations of national primary drinking-water regulations for nitrate and for pathogens.


Water Quality 3

Map of the percent of active county community water systems listed as Safe Drinking Water Act (SDWA) Serious Violators.

Map of the percent of county Clean Water Act (CWA) permittees listed as Clean Water Act Significant Noncompliers.

https://doi.org/10.1038/s41467-021-23898-z
Water Quality 3 -PFAS

PFAS, a man made chemical has emerged as a significant, pervasive and persistent health risk: rainwater concentrations exceed USEPA health advisory levels, and it is now found in many of the nation’s water supply systems.

Dozens of California communities have seen recent rates of childhood lead poisoning exceed those of Flint, Mich.

Thousands of U.S. Areas Afflicted with Lead Poisoning beyond Flint’s
The Michigan city doesn't even rank among the most dangerous lead hotspots in America

4 million Americans could be drinking toxic water and would never know
RANGER, TEXAS — THE LEADERS OF THIS FORMER OIL BOOMTOWN NEVER GAVE 2-YEAR-OLD ADAM WALTON A CHANCE TO AVOID THE POISON.

At least 33 US cities used water testing 'cheats' over lead concerns (Guardian)
Water departments to change lead-testing methods after investigation

Lead Poisoning Afflicts Neighborhoods across California
Dozens of California communities have seen recent rates of childhood lead poisoning exceed those of Flint, Mich.

“Between January 1, 2018 and December 31, 2020, there were 12,892 violations of the Lead and Copper Rule by 7,595 community water systems in the United States. These systems served 27,521,741 people”. - NRDC

“Between January 1, 2018 and December 31, 2020, there were violations of the Lead and Copper Rule by community water systems in the United States. These systems served people”. - NRDC
Streams and rivers continue to face non-point source pollution with little improvement in dissolved oxygen – a critical endpoint for healthy ecosystems.

A desirable level of dissolved $O_2$ is 8 mg/l. Less than 4 mg/l can be critical. Warmer water cannot hold as much oxygen.

Nationally averaged statistics of dissolved oxygen in US waters using all available data from USGS and USEPA. The improvement in Dissolved Oxygen in the 1970s after the passage of the Clean Water Act has not held up!

Columbia Water Center Analyses done by Yueli Liang & Leigh Ramsey.

Trends in Dissolved Oxygen post 1983 by state. Note red is a positive trend indicating an improvement in dissolved oxygen and green is negative indicating a deterioration.
Infrastructure

• **Dams and Levees**
• **Conveyance – Pipes and Sewers**
• **Water and Wastewater treatment**
  • Wastewater treatment and Reuse
Dams

Risk Assessment of Non-Federal Dams across the United States
(follow this link to an interactive tableau of dam status)

State of Water Supply Dams across the US

State of Flood Control Dams across the US

Nearly 2/3rds of dams are rated poor, unsatisfactory or unrated
92000+ dams total
>80000 non-federal dams
Failure consequences largely unknown

Based on data from National Inventory of Dams
Dams Taller than 50 ft and rated High Hazard

Unsatisfactory 251
Poor 1701
Fair 3842
Not Rated 2136
Not Available 2588

5794 + 4724 = 10518

Satisfactory 4350
(43% of those rated/known in this category)
(29% of all dams in this category)
Dams Taller than 50 ft and rated Significant Hazard

Unsatisfactory 115
Poor  1362
Fair 2289
Not Rated 3224
Not Known 1149
3766+ 4373 = 8139

Satisfactory 2182
(37% of those rated/known in this category)
(21% of all dams in this category)

18657 Total High and significant hazard ratings with poor, fair unsatisfactory or not rated
74% of dams in these 2 categories of concern!!
Levees

Age and condition of levees, or safety information is not publicly available

Of interest re hydrologic alteration by levees:

Conveyance – Pipes and Sewer Systems

These account for ~70% of the cost of urban water and wastewater systems, and are expensive to maintain. Failing main pipes are a frequent cause for boil water notices for drinking water.

Busted sewers can be a significant and persistent pollution source.

A shift to more decentralized treatment systems could be beneficial.
Aging Infrastructure and deferred maintenance are the primary contributors to pipe failure. Climate, soil and seismic conditions are also important factors.

PipeID is a database of pipe types, materials and condition for a number of utilities hosted by Virginia Tech.

Average Age of Pipe Infrastructure by Region - Waterfm.com
Conveyance – Pipes and Sewer Systems 3

Water Main Break Rates In the USA and Canada: A Comprehensive Study – Utah State University
The condition of centralized water infrastructure in the US. Conditions are based on state-level infrastructure report cards from assessments conducted in 2015 or later. The labelled conditions correspond to the following grades: “good” is a B or above, “adequate” is a B- or C+, “mediocre” is a C, “fair” is a C-, and “poor” is a D+ or below. No states received a rating higher than a B- in any water infrastructure category. Repair and replacement needs are highest in the Northeast and South regions.

State Infrastructure Rankings | ASCE's 2021 Infrastructure Report Card
Domestic wastewater reuse regulations by state as of 2012.

Rainwater and stormwater reuse regulations by state as of 2016.

Greywater reuse regulations by state as of 2016.
Septic Systems can be effective for low density areas. Climate, soil, and lack of maintenance can lead to high failure rates, pollution and health risks.
Revealed: millions of Americans can’t afford water as bills rise 80% in a decade
– Guardian, 2020

Guardian graphic | Source: Guardian Investigation, Roger Colton.
The Economic Benefits of Investing in Water Infrastructure

The Value of Water Campaign

Federal Investment in Water Utility Infrastructure

Annual Federal Investment Per Capita

<table>
<thead>
<tr>
<th>Recipient</th>
<th>Per Capita Federal Investment</th>
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<td>IT Infrastructure (Federal Departments)</td>
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<td>Water Infrastructure</td>
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A burgeoning crisis? A nationwide assessment of the geography of water affordability in the United States

How should water affordability be measured in the United States? A critical review

Measuring water affordability and the financial capability of utilities

Water and wastewater bills have been rising at nearly twice the rate of inflation since 2000, as utilities spend to patch or restore failing infrastructure, leading to concerns of affordability for lower income (often minority) populations.
Many utilities fail to cover annual costs (Operation & Maintenance), leading to deferred maintenance and failure

Challenges:
• Low water rates
• Declining per capita use
• Future capital needs

Strained finances:
• Wisconsin
• Minnesota
• Kentucky
• North Carolina
• Oklahoma
• Georgia
Univ of N. Carolina Environmental Center has extensive Dashboards that allow an exploration of metrics for the states in the map on the left.