Project Report

Blue Hill, Brooksville, and Surry Climate Vulnerability Assessment

Blue Hill, Maine

Submitted to:
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Submitted by:
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Table of Contents

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Executive Summary

GEI Consultants, Inc. (GEI) and the Gulf of Maine Research Institute (GMRI) prepared seven memos (attached herein as Appendices) summarizing the vulnerability of heat, drought and drinking water, power outages, ocean acidification, plant hardiness, tick-borne diseases, and the working waterfront as they pertain to a changing climate. The climate vulnerabilities summarized in these seven memos were specific to the Blue Hill, Brooksville, and Surry region, sometimes referred to as the Blue Hill Peninsula. Climate vulnerability related to coastal flooding has been summarized for each Town as separate reports as part of this comprehensive project.

This executive summary provides context around the importance of a regional approach to understanding climate-related risks and actions, describes how this work aligns with the "Maine Won't Wait" Climate Action Plan, and summarizes key findings and recommendations from within the attached memos.

Each of these memos is included in an Appendix of this document.

E.S.1. The Importance of a Regional Approach

The Towns of Blue Hill, Brooksville, and Surry had the outstanding foresight to combine resources for conducting a comprehensive climate vulnerability assessment. This cooperative partnership included a Project Manager (Allen Kratz), a diverse group of volunteer oversight committee members who each brought a helpful and unique perspective, shared project funding sources, and collective administration efforts. This type of regional initiative is important in smaller, rural communities in Maine, which often lack staff capacity to respond to grant applications and manage projects. This project sets an excellent precedence for what groups of small communities are able to accomplish in Maine.

Given the interconnected nature of climate challenges across Maine, a regional approach is helpful for effective adaptation planning. For example, one town's evacuation route may require driving through a neighboring town with a road that is at-risk of flooding. Adaptation in this scenario would require collaboration between the two communities. Another example could be the siting and creation of a drinking water source that could benefit multiple communities. In other words, climate challenges defy municipal boundaries, and cooperative partnerships allow for synergistic solutions.

E.S.2. Alignment with "Maine Won't Wait" Climate Action Plan

The recommendations and findings from these vulnerability assessments align closely with some of the strategic goals and priorities outlined in the 2024 update of the "Maine Won't Wait" Climate Action Plan, such as:

1. **Strengthening Resilience to Climate Impacts**: An emphasis on diversifying fisheries, bolstering infrastructure, and improving water resource management corresponds with the plan's focus on enhancing community resilience and disaster preparedness.

2. **Protecting Natural and Working Lands and Waters**: Efforts to conserve fisheries, manage ocean acidification, and monitor saltwater intrusion support the plan's goal to safeguard Maine's marine and freshwater ecosystems while promoting sustainable practices.
3. **Building Healthy and Resilient Communities**: Recommendations on public health education for tick-borne diseases, increasing capacity for emergency response, and ensuring clean drinking water mirror the plan's focus on creating equitable resilience solutions.
4. **Creating Jobs and Economic Prosperity**: Diversifying fisheries and promoting aquaculture innovations align with strategies to adapt heritage industries and grow new economic sectors tied to climate resilience.

E.S.3. Findings and Recommendations

We have summarized the key findings and recommendations from the attached climate vulnerability assessments below.

Ocean Acidification

- **Findings**: The Gulf of Maine is particularly vulnerable to ocean acidification due to its low pH and temperature. Shellfish, such as soft clams and oysters, are relatively vulnerable, while American lobster is relatively resilient but faces other climate-related threats.
- **Recommendations**:
  - Reduce local nutrient loading via stormwater and wastewater management.
  - Explore phytoremediation strategies like kelp aquaculture.
  - Diversify fisheries to reduce economic reliance on acidification-sensitive species.

Plant Hardiness

- **Findings**: Maine's plant hardiness zones have shifted from 5b-6a to 6a-6b due to winter warming (+5°F over the past century). Longer growing seasons offer new crop opportunities but increase pest risks and the likelihood of frost damage.
- **Recommendations**:
  - Adopt longer-season and frost-resistant crops.
  - Promote inter-cropping and emergency response measures for frost events.
  - Educate gardeners and growers on adaptive planting strategies.

Tick-Borne Diseases

- **Findings**: Warmer winters and increased humidity have expanded deer tick populations, raising Lyme disease incidence in the three towns. Vulnerable groups include the elderly, outdoor workers, and children.

- **Recommendations**:
  - Provide community training on tick prevention and symptom recognition.
  - Encourage use of insect repellents and protective clothing.
  - Increase accessibility to early diagnosis and treatment services.

Working Waterfronts

- **Findings**: Sea level rise, increased flooding, and warming waters threaten Maine's working waterfront economy, including fishing and aquaculture. The Gulf of Maine is warming 3.5 times faster than the global average, altering species distributions.
- **Recommendations**:
  - Upgrade infrastructure to reduce risk of coastal flooding.
  - Diversify fisheries to capitalize on emerging species (e.g., squid, blue crab).
  - Identify funding for infrastructure resilience projects.

Power Outages

- **Findings**: Maine's aging electric grid is increasingly vulnerable to weather-related outages, which disrupt essential services and pose health risks, especially for older populations.
- **Recommendations**:
  - Upgrade infrastructure to improve resilience.
  - Establish emergency backup power systems for critical facilities.

Extreme Heat

- **Findings**: Rising temperatures and more frequent extreme heat days pose health risks, particularly to older adults in the towns, where air conditioning is less prevalent than the national average.
- **Recommendations**:
  - Install cooling systems in priority buildings like schools and care facilities.
  - Establish public cooling centers and communication plans for extreme heat events.
  - Promote heat pump installations through public assistance programs.

Clean Drinking Water and Drought

- **Findings**: Drinking water is primarily sourced from bedrock wells. Challenges include saltwater intrusion, arsenic contamination, and vulnerability to drought due to limited aquifer recharge.
- **Recommendations**:
  - Encourage testing of private wells for contaminants and salinity.
  - Improve public awareness about groundwater recharge protection.

- Establish public drinking water source with backup generator.

E.S.4. Conclusion

The vulnerability assessments highlight the urgency of addressing climate risks in rural Maine while showcasing opportunities for proactive adaptation. Their alignment with the “Maine Won’t Wait” framework underscores the need for collaborative, well-resourced, and forward-thinking strategies to secure Maine’s environmental, economic, and community health for future generations.

Appendix A Working Waterfront Vulnerability Assessment

Memo

To: Mr. Allen Kratz

From: Gayle Bowness, Stephanie Sun

Date: October 28, 2024

Re: Working Waterfront Vulnerability Assessment
Climate Vulnerability Assessment
Towns of Blue Hill, Brooksville, and Surry, Maine

The Gulf of Maine Research Institute. has reviewed the vulnerability of working waterfronts for the Towns of Blue Hill, Brooksville, and Surry, Maine (the "Towns") and has summarized the findings in this memo.

This memo provides background on working waterfronts in Maine, identifies future risks to working waterfront infrastructure and economy, and provides recommendations for adapting to the climate-driven impacts to the working waterfront in the Towns.

This memo is part of a larger vulnerability study funded with a Community Action Grant through the Governor's Office of Policy Innovation and the Future (GOPIF) Community Resilience Partnership with additional support from the Town of Brooksville.

Background:
Working waterfronts have been the lifeblood of many coastal communities in Maine, supporting industries such as fishing, aquaculture, tourism, and boat building, to name a few. These activities not only contribute to the state's economy but also play a vital role in preserving the cultural heritage of Maine's coastal communities. The vitality of Maine's working waterfront economy depends upon safe and climate-resilient working waterfront infrastructure, access to the water, healthy ecosystems, and a robust working waterfront workforce. As a result of climate change, working waterfront infrastructure may be at risk of increased flooding or damage due to sea level rise, resulting in the potential loss of working waterfront access or rising maintenance or repair costs (Carey, 2021). Currently, Maine is already facing a backlog of infrastructure projects for working waterfront protection and enhancement, with aging and vulnerable infrastructure representing both a burden to the state as well as an opportunity to increase the day-to-day capacity and resilience of Maine's blue economy and the resilience of coastal communities that rely upon access to the water (MCC, 2020). Finally, changes in marine conditions create both challenges and opportunities for those who rely on a healthy ecosystem in the Gulf of Maine.

NOAA's ENOW (Economics: National Ocean Watch) framework integrates various datasets, including information on industries, employment, wages, and demographics related to coastal and ocean-dependent activities. It offers a platform to analyze and understand the economic contributions of these sectors to the economy at a county, state, and national level. The sectors covered in the ENOW framework are shared below:

Living Resources (LR): Involves activities related to fishing, aquaculture, and other industries directly reliant on marine life for their economic output.
Marine Construction (MC): Includes infrastructure development along coastlines, such as building ports, coastal protection structures, and other construction projects related to coastal areas.
Tourism and Recreation (TR): Encompasses leisure activities, tourism, and hospitality industries that thrive in coastal and marine environments, including activities like beach vacations, cruises, and water sports.
Ship and Boat Building (SBB): Ship and boat building specifically involves the construction of vessels, ranging from small boats to large ships, for various purposes like commercial shipping, recreational boating, and military applications.
Maritime Transportation (MT): Includes shipping, ports, and other maritime-related activities integral to transporting goods and people across oceans and along coastlines.
Offshore Mineral Extraction (OME): Involves activities related to offshore oil and gas exploration, mining, and extraction of minerals and energy resources from the ocean floor.

In 2019, the Total Ocean Economy[1] in Hancock County represented 15.5% of the county's total GDP, comprised 84 establishments, and employed just over 6,000 people, including those who are self-employed (NOAA ENOW). In Hancock County, employment in the ocean economy generated $145.5 million in wages and over $300 million in GDP. Employment and GDP data for Hancock County across ocean economy sectors are shared in the table below:

Ocean Economy Sector	Percent of Total Ocean Economy	Number of people employed	Wages ($)	GDP ($)
Living Resources (*Includes commercial fishing, seafood processing, aquaculture)*	20.2%	1,999	24.9 million	68.4 million
Marine Construction *(including beach nourishment and harbor*	0.4%	34	874,000	1.4 million
Ship and Boat Building	5.7%	410	18.2 million	19.2 million
Marine Transportation	0.9%	68	2.2 million	3 million
Tourism and Recreation (*including marinas, boat dealers and charters, recreational fishing, eating, and drinking establishments)*	71.9%	3,593	98.6 million	243.6 million

Table 1: Economic Snapshot of Ocean Economy Sectors in Hancock County, ME. Data Source: NOAA ENOW

[1] Defined in NOAA's ENOW framework as all ocean economic activities within a geography

Business Reliance on Waterfront Access and Infrastructure:
The working waterfront economy encompasses a range of activities that rely on access to water. Understanding the distinction between water-dependent and water-enhanced uses is crucial in preparing for climate impacts on working waterfronts. Maine's fishing industry heavily relies on direct access to the water for activities such as lobstering, commercial fishing, and aquaculture. These activities are intrinsically tied to the water and its resources. Similarly, ports, docks, and harbors are essential for marine transportation and the functioning of the maritime industry.

Some sectors benefit from proximity to the water, even though they do not inherently require direct waterfront access for their operations. While not directly dependent on waterfront access, businesses like waterfront restaurants and hotels can be categorized as "waterfront enhanced," deriving advantages from their proximity to water while providing additional services that attract visitors to waterfront communities. In Brooksville, Blue Hill, and Surry, restaurants, and hotels are a part of a local and regional economy that extends beyond the working waterfront -- to ensure a balanced perspective on the working waterfront economy in the Towns and avoid skewing significance towards restaurants and hotels, this memo incorporates figures and data that exclude these establishments.

The ENOW framework, along with information from the Maine Coast Fishermen's Association and Tidal Bay Consulting, can help identify North American Industry Classification System (NAICS) codes, which categorize businesses for statistical purposes. By analyzing these codes, stakeholders can gather data on working waterfront businesses, including their types, employee counts, and revenue. The NAIC codes used in this memo can be found in Appendix A.

Trends and Projections in the Gulf of Maine:
Sea Level Rise: Sea level rise and coastal flooding stand to impact the LR, MT, MC, SSB, and TT sectors of the working waterfront economy, depending on individual operations' reliance upon potentially vulnerable working waterfront assets. Maine's coastline has experienced an average sea-level rise of approximately one foot over the last century (MCCSTS, 2020). Based on IPCC and NOAA sea level rise projection data, the Maine Climate Council recommends that coastal municipalities plan to manage 1.5 feet of sea level rise by 2050 and 4 feet by 2100. These trends put coastal infrastructure at increasing risk, affecting the harbors, piers, and processing facilities that are foundational to the working waterfront, as well as beaches and waterfront access points that underpin the parts of the coastal tourist economy. For example, dry beach areas in Maine are expected to decrease by 43% under 1.6 feet of sea level rise, resulting in a potential loss of $136 million in tourism spending across the state. Additionally, up to 21,000 jobs in coastal communities are expected to be at risk due to coastal flooding between the years 2020-2050 (MCCSTS, 2020)

Note that the potential impacts of sea level rise on mudflats and implications for intertidal habitat and the shellfish industry in Maine have not been well-studied but is an ongoing area of research (MCC STS. 2024).

Ocean Temperature Changes

The Maine Climate Impact Dashboard publishes vital insights into long-term marine temperature records across the Gulf of Maine in five locations. The closest location to the Blue Hill Peninsula is on Mount Desert Island, which has historically maintained an annual average sea surface temperature of around 46°F. However, over the last decade, conditions have notably shifted, consistently hovering around 49°F. The Gulf of Maine Research Institute also offers comprehensive updates on seasonal and annual warming trends spanning the entire Gulf of Maine region. This data demonstrates a warming trend in the Gulf of Maine that is nearly 3.5 times faster than the global average. For the first four months of 2023, the average monthly sea surface temperature was in the top three warmest over all years on record, and February, March, and April set new records for the highest monthly average sea surface temperature in the Gulf of Maine. 2021 stands out as the warmest year on record for the region, signaling sustained and concerning warming trends that have wide-ranging implications for species, food web dynamics, and broader ecosystem characteristics (Gulf of Maine Research Institute, *Annual Warming Update 2024*).

The Maine Climate Impact Dashboard also offers localized climate projections derived from recent globally coordinated climate model experiments. These projections outline anticipated changes in the average annual ocean temperatures across three distinct emissions scenarios: low, medium, and high. Across all scenarios, the Gulf of Maine is expected to undergo continued warming until mid-century. Projections suggest that by this point, sea surface temperatures will likely range between 52.5°F and 54.5°F, dependent on the emissions pathway chosen.

In the lower emissions scenario, sea surface temperatures are projected to stabilize by mid-century, showing minimal increase thereafter. Conversely, the medium emissions scenario predicts a potential temperature rise to around 55°F by the end of the century, approximately 3°F higher than current levels. Under the higher emissions scenario, temperatures could reach 61°F by the century's end, indicating a persistent warming trend beyond that timeframe.

Harmful Algal Blooms:

Climate change is driving significant shifts in ocean conditions that are contributing to the growing frequency and intensity of harmful algal blooms (HABs). Warming water temperatures increased nutrient runoff from agriculture and urban areas, and alterations in ocean circulation patterns all play a role in promoting the formation and expansion of HABs. Warmer temperatures can accelerate algal growth, while higher levels of nutrients, especially nitrogen and phosphorus, serve as fertilizers for these blooms. These nutrients often come from land-based sources, such as agricultural runoff, wastewater discharge, and urban stormwater, which are exacerbated by more frequent and intense rainfall events linked to climate change.

Additionally, changes in ocean circulation and stratification can influence the vertical mixing of water, allowing nutrient-rich deeper waters to remain closer to the surface, further fueling algal growth. The expansion of HABs poses serious threats to marine ecosystems by depleting oxygen levels and creating hypoxic "dead zones," which harm fish and other marine life. These blooms also produce toxins that can accumulate in shellfish and other marine organisms, leading to health risks for humans and potentially disrupting coastal economies dependent on fishing and aquaculture.

Ocean Acidification:
Please refer to the Ocean Acidification Vulnerability Assessment Memo:

Altered Ecosystem Characteristics:
Changing marine temperatures in the Gulf of Maine are already reshaping its subarctic ecosystem, ushering in more temperate conditions that allow new species to thrive while endangering others. These changes create challenges and opportunities that will have impacts on wild harvest fishermen and fisheries managers (MCCSTS, 2020).

Warming waters also result in vertical stratification that hampers nutrient mixing and creates low oxygen conditions that are detrimental to marine life. The documented reductions in key species such as herring, cod, and *Calanus finmarchicus* (which are pivotal in aquatic food webs) highlight these shifting dynamics. About half of the region's commercial fish and shellfish, including American lobster, also exhibit high climate levels sensitivity and face potential negative impacts from future warming. Conversely, species like longfin squid, silver hake, black sea bass, and blue crab are seen in increasing numbers in the Gulf of Maine and could potentially become new commercially valuable fisheries (MCCSTS, 2020). However, forecasting climate change impacts on fisheries, especially by 2050, is challenging due to uncertainty in emissions scenarios and as well as an insufficient understanding of species and ecosystem responses.

Finally, changes in precipitation, notably the timing and intensity of spring runoff, significantly impact coastal salinity conditions. This relationship remains an active and intricate area of research, influencing coastal circulation that governs nutrient supply, phytoplankton distribution in estuaries, and the spread of scallop, mussel, and lobster larvae along the coast (MCCSTS, 2020).

Working Waterfront Economies in Brooksville, Blue Hill, and Surry
Caveats and areas for further study:
Predicting the precise impact of climate change on specific fisheries is challenging. Uncertainty in assessing impact stems from factors such as the emissions pathways society will pursue, limited understanding of how climate affects individual species and their ecosystem interactions, and unknown thresholds or tipping points within global and regional systems. Furthermore, the rate at which species can adapt to changing conditions remains uncertain.

To understand climate vulnerability on working waterfront-dependent and enhanced businesses, research also needs to be conducted on an establishment-by-establishment basis to understand the ways in which ocean economy businesses and their operations (e.g., supply chains) are reliant upon working waterfront access and infrastructure. Additionally, the cultural value of working waterfronts as a driver of Maine's coastal tourism economy and the implications of climate change upon the tourism economy (e.g., reduction of beach area) may also warrant further study. Finally, it is important to recognize how the waterfront economy is interconnected. For example, while the ship and boat building sector is not reliant upon a healthy marine ecosystem, demand for boat sales is driven by industries that are reliant upon a healthy ecosystem, such as commercial fishing or recreational boating. Please note that this memo does not consider cascading impacts across industries and sectors.

Blue Hill

Working waterfront assets vulnerable to flood inundation under various sea level rise and coastal flood scenarios include Webber's Cove Boatyard, The Blue Hill Town Wharf, and the South Blue Hill Wharf (see Flood Risk Memo). It's crucial to note that other private waterfront access points supporting working waterfront establishments are not covered in the Flood Risk Memo.

In Blue Hill, forty-seven local businesses contribute to the working waterfront economy, with thirty-five being restaurants in the TR Sector. Excluding restaurants and hotels, twelve businesses form the working waterfront economy in Blue Hill, employing 47 individuals with an estimated location sales value close to $13 million (refer to Table 2).

Ocean Economy Sector	NAICS code	Number of Establishments	Location Sales	Number of employees	Reliance on waterfront access	Reliance on healthy marine ecosystems
Living Resources	Shellfish Fishing	1	$1,182,000	2	High	High
Living Resources	Finfish Fishing	2	$2,364,000	4	High	High
Ship and Boat Building	Boat Building	3	$661,000	7	Moderate	None
Tourism and Recreation	Boat Dealers	6	$8,717,000	34	Moderate	None

Table 2: Snapshot of working waterfront businesses in Blue Hill.

While the LR sector in Blue Hill isn't entirely captured in NAICS employment data since many fishermen are self-employed, Maine Department of Marine Resources data indicate that commercial fishermen landed nearly 900,000 pounds of seafood, amounting to $3,000,000 in value in Blue Hill in 2022. Although total landings values rose from 2002 to 2016, 2022 data reflects the lowest landings since 2011. However, establishing direct causal links between climate impacts and landing data remains challenging at this stage.

Historically, Blue Hill's commercial landings have been dominated by lobster, representing the majority of species landed in pounds and 84% of the total landed value. A potential decline in American Lobster abundance in Maine could heighten the sensitivity of Blue Hill's lobster-centric fishing economy to altered ecosystems due to climate change.

Maine's lobster harvest in 2022 declined by 26% from its peak in 2016, driven by climate-related factors such as warming waters and changes in zooplankton populations, which affect lobster reproduction and planktonic food availability (MCC STS 2024). While lobsters are relatively resistant to ocean acidification compared to other shellfish, these climate impacts, combined with challenges like over-reliance on the fishery, sea level rise, storm damage, interactions with North Atlantic right whales, and offshore wind development, pose serious threats to the industry. Multidecadal models further predict a continued downward trend in lobster abundance, with one model projecting a 40% decrease in population by 2050 due to thermal effects and predator changes, while another suggests a northward shift in lobster distribution under future climate scenarios (MCC STS 2024).

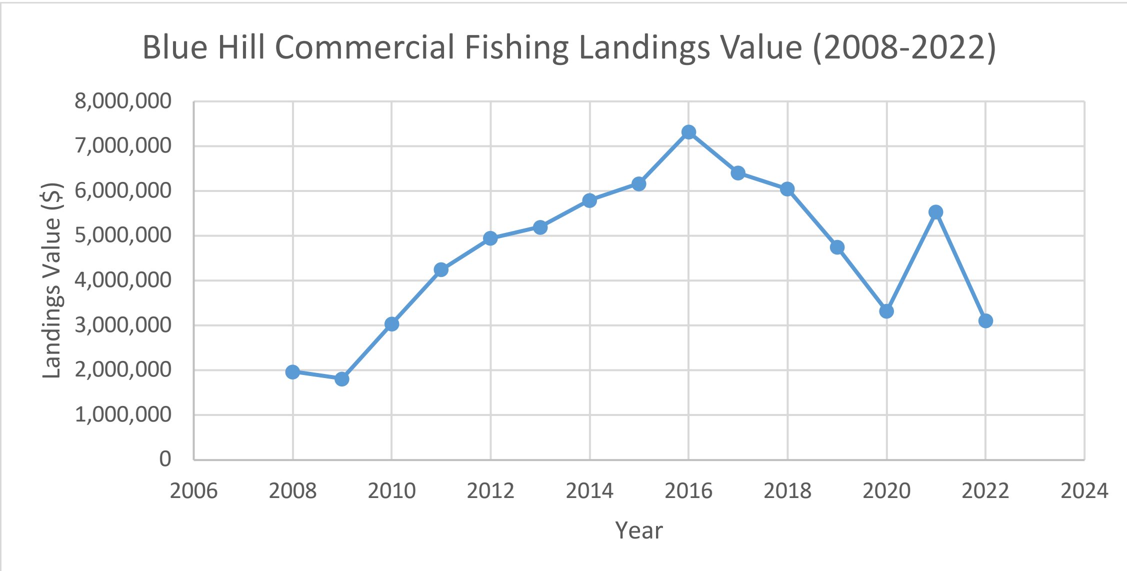

Figure 1: Commercial landings by value for the Blue Hill from 2008-2022. Source: Department of Marine Resources Landings Portal

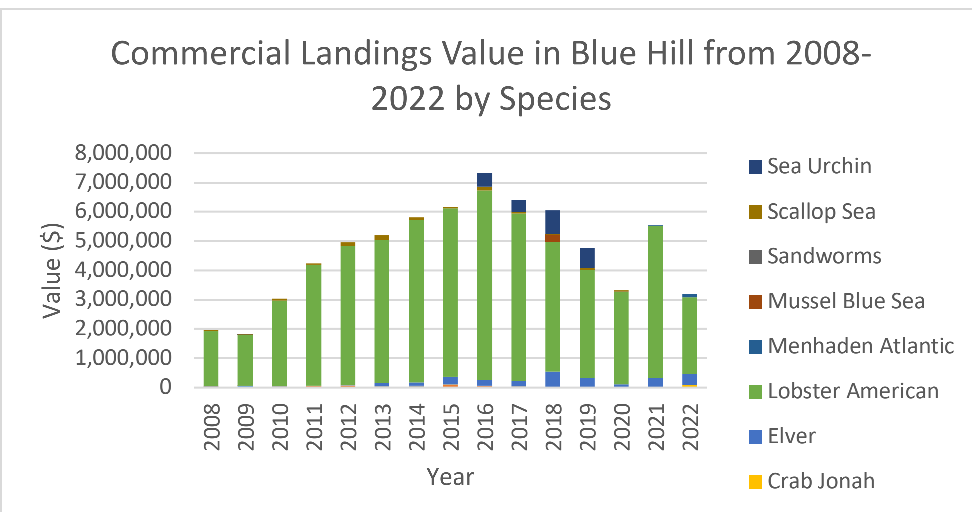

Figure 2: Commercial landings value by species for Blue Hill from 2008-2022. Source: Department of Marine Resources Landings Portal

Brooksville:

Working waterfront assets susceptible to flood inundation include several key locations in Brooksville: the Brooksville Town Landing boat ramp and parking lot, Goose Falls boat ramp, Bridge Road boat ramp, South Wharf Road boat ramp, Bucks Harbor Yacht Club, Bucks Harbor marina parking, Bagaduce boat launch, and the Seal Cove Boatyard (see Flood Risk Memo). It's important to acknowledge that other private waterfront access points supporting working waterfront establishments are not encompassed in the Flood Risk Memo.

Within Brooksville, seven businesses contribute to the working waterfront economy, all situated in the Tourism and Recreation sector. Excluding restaurants, the remaining four businesses comprise boat dealers specializing in marine equipment and supplies alongside one marina. Collectively, these businesses employ 13 individuals and generate an estimated location sales volume of close to $3,500,000 (refer to Table 3). While boat dealers might not always require waterfront access, having such access can be beneficial, though these needs must also be balanced alongside risks from coastal hazards. Conversely, a marina heavily relies on waterfront access for its operations and will need to be aware of potential inundation impacts.

Ocean Economy Sector	NAICS Code	Number of establishments	Location Sales	Number of Employees	Reliance on waterfront access	Reliance on healthy marine ecosystems
Tourism and Recreation	Boat Dealers	3	$3,375,000	12	Moderate	None
Tourism and Recreation	Marinas	1	$113,000	1	High	None

Table 3: Snapshot of working waterfront businesses in Brooksville.

Since many commercial fishermen are self-employed, the LR sector is only partially captured under NAICS employment data. Data from the Maine Department of Marine Resources indicate that commercial fishermen landed over 93,000 pounds of seafood, amounting to just over $105,000 in value in Brooksville in 2022. Over the past eight years, landing values in Brooksville have been in decline, now lower than those in 2008. Brooksville's landings primarily consist of soft clam and Atlantic crab. Lobster has represented less than one-third of commercial landings value in Brooksville since 2016 and hasn't been landed in Brooksville since 2020 (DMR landings data). The LR sector's reliance on soft clam and Atlantic crab species makes it particularly sensitive to the impacts of ocean acidification (see Ocean Acidification memo).

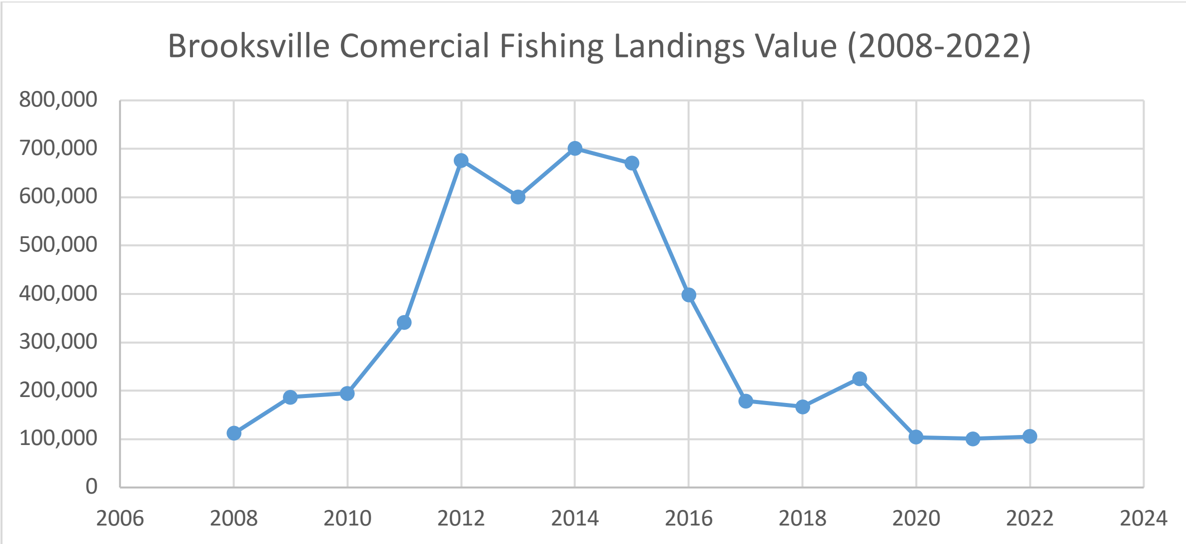

Figure 3: Commercial landings value for Brooksville from 2008-2022. Source: Department of Marine Resources Landings Portal

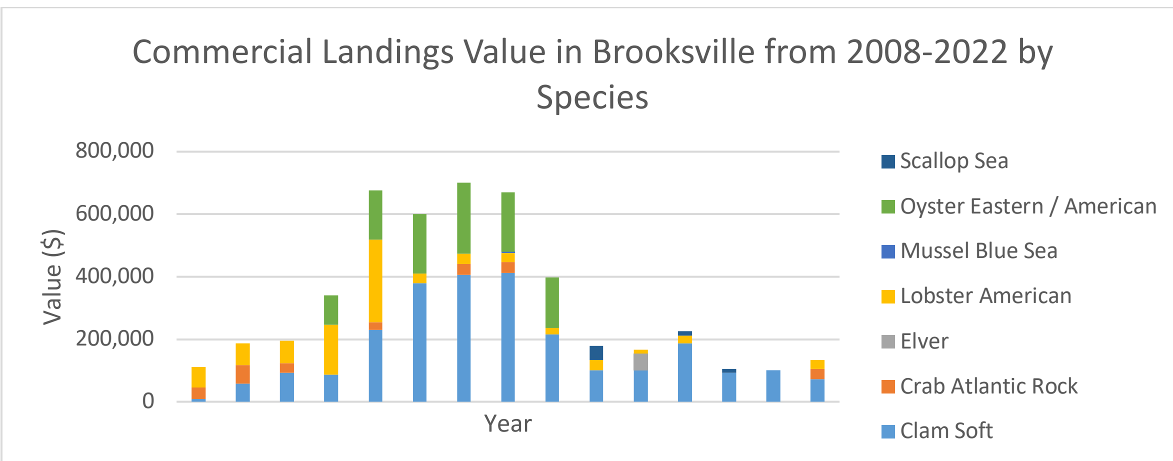

Figure 4: Commercial landings value by species for Brooksville from 2008-2022. Source: Department of Marine Resources Landings Portal

Surry:

Surry's Town Wharf was the only working waterfront asset that was identified as being vulnerable to flood inundation under different flood scenarios (see Flood Risk Memo). Importantly, working waterfront establishments may rely upon other private waterfront access points that are not covered in the Flood Risk Memo.

Within Surry, we found five businesses contributing to the working waterfront economy across the Tourism and Recreation (TR) and Ship and Boat Building (SBB) sectors. Excluding restaurants, the remaining four businesses comprise boat dealers and boat builders, collectively employing 24 individuals and generating an estimated location sales volume surpassing $2,600,000 (refer to Table 4). While both business types may benefit from access to the water, neither depends on it and thus has reduced vulnerability to coastal hazard risk. At the same time, these businesses may start to see increased demand for services such as boat repair following extreme weather events or may see other changes in demand for commercial vessels as climate, regulatory, and financial changes drive other shifts within the commercial fishing industry.

Ocean Economy Sector	NAICS Code	Number of establishments	Location Sales	Number of Employees	Reliance on waterfront access	Reliance on healthy marine ecosystems
Tourism and Recreation	Boat Dealers	2	$845,000	5	Moderate	None
Ship and Boat Building	Boat Building	2	$1,789,000	19	Moderate	None

Table 4: Snapshot of working waterfront businesses in Brooksville.

While the Living Resources (LR) sector might not be entirely captured in NAICS employment data due to many self-employed fishermen, Maine Department of Marine Resources data reveal that commercial fishermen landed 6,629 pounds of seafood, totaling just over $500,000 in value in Surry in 2022. Unlike Blue Hill and Brooksville, Surry historically exhibited low reliance on American lobster. Since 2011, the primary species fished in Surry has been elver, significantly boosting its commercial fishing landings value due to its high price per pound (Waller et al., 2023).

Elver, a type of eel, spawn in the ocean and migrate to freshwater to mature. Maine's elver fishery harvests these small eels returning to freshwater from their ocean spawning areas, employing restricted harvest methods like hand dip or fyke nets and eel traps (Maine Department of Marine Resources). However, there's substantial uncertainty surrounding elver's abundance, life stage status, and habitat requirements (Atlantic States Marine Fisheries Commission), making it challenging to predict their responses to changing ocean and upstream freshwater conditions. Nevertheless, existing research suggests that increasing ocean temperatures might influence elver run timing, although the effects of warming on elver recruitment are yet to be fully understood (Jessop, B.M., 2021).

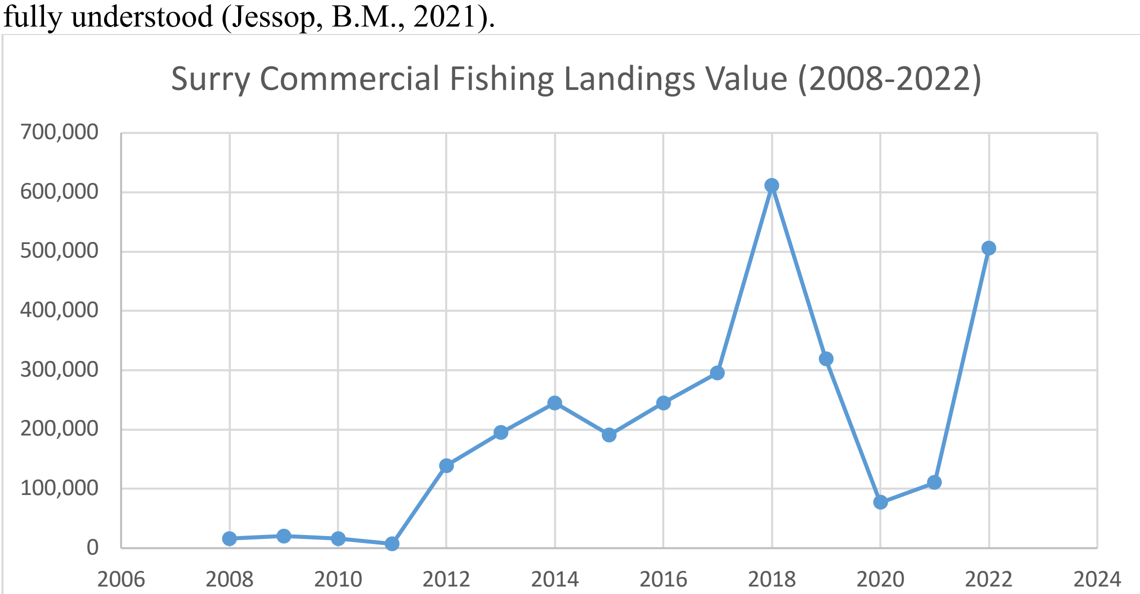

Figure 5: Commercial landings value in Surry from 2008-2022. Source: Department of Marine Resources Landings Portal

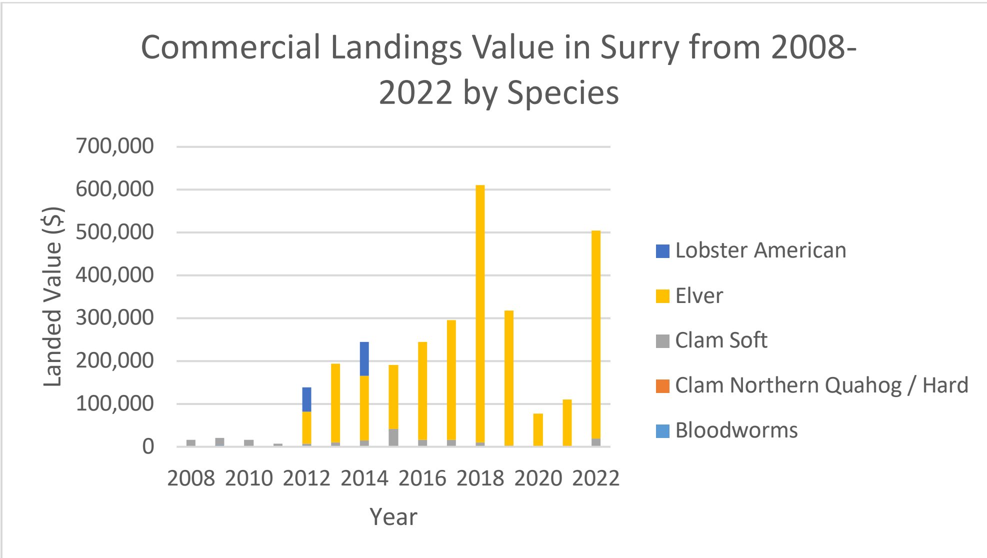

Figure 6: Commercial landings value by species in Surry from 2008-2022. Source: Department of Marine Resources Landings Portal

Recommendations:

- Determine which ocean economy businesses are dependent upon which waterfront access points, including private, single-user, or walk-in working waterfront access points.
- Conduct utility-level vulnerability assessments to understand how coastal flooding and storm surge may impact working waterfront infrastructure and operations.
- Identify funding mechanisms for working waterfront infrastructure upgrades or adaptation.
- Work with working waterfront businesses and employees to understand how climate change is impacting operations and identify potential adaptation actions.
- Promote a business development and regulatory environment that encourages the diversification of the living resources sector to take advantage of species shifts.

References:

Carey, M. T. (2021). The critical nature of Maine's working waterfront and access to the shore. *The Island Institute*.

Gulf of Maine Research Institute. *Gulf of Maine Warming Updates.* Retrieved October 2024, from https://gmri.org/projects/gulf-of-maine-warming-updates/

Jessop, B. M. (2021). Increasing coastal and continental shelf water temperatures influence the start of the glass eel fishery and recruitment abundance for American eels in Atlantic coastal Nova Scotia. *Marine and Coastal Fisheries*, *13*(5), 509-517.

Maine Climate Council (2020), *Maine Won't Wait: A Four Year Climate Action Plan.* https://www.maine.gov/climateplan/sites/maine.gov.climateplan/files/inline-files/MaineWontWait_December2020_printable_12.1.20.pdf

Maine Climate Council Scientific and Technical Subcommittee (2024). *Scientific Assessment of Climate Change and Its Effects in Maine*. https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/STS_2024_digital.pdf

Pershing, A. and V. Stamieszkin. (2020). The North Atlantic Ecosystem, from Plankton to Whales. Annual Review of Marine Science 12. pp. 339-359 https://www.annualreviews.org/doi/full/10.1146/annurev-marine-010419-010752

Appendix A:

List of NAICS codes queried for this analysis from the ENOW Ocean Economy Framework:

Sector	Industry	NAICS	NAICS Industry (2012 NAICS)
Living Resources	Fish Hatcheries and Aquaculture	112511	Finfish Farming and Fish Hatcheries
		112512	Shellfish Farming
		112519	Other Aquaculture
	Fishing	114111	Finfish Fishing
		114112	Shellfish Fishing
		114119	Other Marine Fishing
	Seafood Processing	311710	Seafood Product Preparation and Packaging
	Seafood Markets	445220	Fish and Seafood Markets
Marine Construction	Marine Related Construction	237990	Other Heavy and Civil Engineering Construction
Marine Transportation	Deep Sea Freight	483111	Deep Sea Freight Transportation
		483113	Coastal and Great Lakes Freight Transportation
	Marine Passenger Transportation	483112	Deep Sea Passenger Transportation
		483114	Coastal and Great Lakes Passenger Transportation
	Marine Transportation Services	488310	Port and Harbor Operations
		488320	Marine Cargo Handling
		488330	Navigational Services to Shipping
		488390	Other Support Activities for Water Transportation
	Search and Navigation Equipment	334511	Search, Detection, Navigation, Guidance, Aeronautical and Nautical System and Instrument Manufacturing
	Warehousing	493110	General Warehousing and Storage
		493120	Refrigerated Warehousing and Storage
		493130	Farm Product Warehousing and Storage
Ship and Boat Building	Boat Building and Repair	336612	Boat Building and Repair
	Ship Building and Repair	336611	Ship Building and Repair

Sector	Industry	NAICS	NAICS Industry (2012 NAICS)
Offshore Mineral Resources	Limestone, Sand and Gravel	212321	Construction Sand and Gravel Mining
		212322	Industrial Sand Mining
	Oil and Gas Exploration and Production	211111	Crude Petroleum and Natural Gas Extraction
		211112	Natural Gas Liquid Extraction
		213111	Drilling Oil and Gas Wells
		213112	Support Activities for Oil and Gas Operations
		541360	Geophysical Exploration and Mapping Services
Tourism and Recreation	Boat Dealers	441222	Boat Dealers
	Eating and Drinking Places	722511	Full Service Restaurants
		722513	Limited Service Eating Places
		722514	Cafeterias
		722515	Snack and Nonalcoholic Beverage Bars
	Hotels and Lodging	721110	Hotels (except Casino Hotels) and Motels
		721191	Bed and Breakfast Inns
	Marinas	713930	Marinas
	Recreational Vehicle Parks and Campsites	721211	RV Parks and Recreational Camps
	Scenic Water Tours	487210	Scenic and Sightseeing Transportation, Water
	Sporting Goods	339920	Sporting and Athletic Goods Manufacturing
	Amusement and Recreation Services	487990	Scenic and Sightseeing Transportation, Other
		611620	Sports and Recreation Instruction
		532292	Recreation Goods Rental
		713990	Amusement and Recreation Services Not Elsewhere Classified
	Zoos and Aquaria	712130	Zoo and Botanical Gardens
		712190	Nature Parks and Other Similar Institutions

Appendix B Ocean Acidification Vulnerability Assessment

Gulf of Maine Research Institute

Memo

To: Mr. Allen Kratz

From: Gayle Bowness, Stephanie Sun

Date: October 25 2024

Re: Ocean Acidification Vulnerability Assessment
Climate Vulnerability Assessment
Towns of Blue Hill, Brooksville, and Surry, Maine

The Gulf of Maine Research Institute. has reviewed background, trends, and projections of ocean acidification for the Towns of Blue Hill, Brooksville, and Surry, Maine (the "Towns") and we have summarized the findings in this memo.

This memo is part of a larger vulnerability study funded with a Community Action Grant through the Governor's Office of Policy Innovation and the Future (GOPIF) Community Resilience Partnership with additional support from the Town of Brooksville. This work is based on our proposal dated August 4th, 2023.

Background: The world's oceans play a crucial role as natural "carbon sinks," absorbing over a quarter of the CO2 emissions produced by humanity since the Industrial Era began (MCC STS. 2020). This service, while invaluable, carries a significant downside: the uptick in CO2 levels leads to ocean acidification, particularly affecting marine life like corals and shellfish, hindering their shell growth. Relative to other waters on the East Coast of the United States, the deeper waters in the Gulf of Maine face a heightened vulnerability to ocean acidification, due to a relatively low pH and temperature that renders them less capable of buffering against pH changes (Wang et al., 2013).

It's crucial to distinguish between ocean acidification and its counterpart, coastal acidification. Both coastal and ocean acidification involve an escalation of carbon dioxide levels in the water. Ocean acidification is mainly caused by CO2 absorption from the atmosphere into the ocean. Coastal acidification on the other hand has additional, localized drivers -- primarily nutrient influx from nearby rivers which can stimulate biological activity, causing fluctuations in CO2 concentration within marine waters. The resulting instability from these fluctuations can significantly impact marine organisms (MCC STS. 2020). Moreover, the surplus of nutrients in coastal acidification can trigger eutrophication, where the decomposition of large phytoplankton populations releases CO2, lowers pH, and depletes oxygen, creating inhospitable environmental conditions for marine life.

Figure 1: Drivers of coastal acidification. Source: Kelly et al., 2011)

Trends: Global average surface ocean pH has experienced a decline from 8.2 to 8.1 (a 30% reduction) since the late 19th century. However, in the Gulf of Maine, scientists have only been collecting pH measurements for less than 2 decades, making it challenging to analyze long-term localized trends (MCC STS. 2020).

Under the Representative Concentration Pathway (RCP) 8.5, which represents the most extreme emissions scenario, the Gulf of Maine is projected to experience ocean acidification levels that fall below the critical threshold for shellfish health for much of the year by 2050 (MCC STS. 2024). However, it is important to recognize that pH levels can vary significantly in coastal areas. Forecasts for the Gulf of Maine suggest that the aragonite saturation state (a key indicator of ocean acidification) will decline across the entire region, with the effects being more severe near the coast, in deeper waters, and in areas affected by frequent and intense freshwater input, such as from river flooding. Further research also suggests that while ocean acidification may worsen over time, this process may be partially mitigated by the rate of warming in the Gulf of Maine (MCC STS. 2024).

Species Vulnerability

A number of marine species have been identified since 2020 as being vulnerable to ocean acidification (MCC STS. 2024). Changes in acidity can significantly inhibit the ability of shellfish to “build” their shells, especially in the early life stages when shellfish are most vulnerable. While lobster appears to be relatively resistant to ocean acidification impacts as compared to other commercially viable shellfish species, they have also been shown to be more susceptible to pathogens higher acidity conditions, particularly where water temperatures are lower (MCC STS. 2024). Given that the **interaction** of changing conditions have been shown to most affect American lobster, particular attention should be paid to emerging research on the compound impact of changing ocean conditions on lobster species, rather than focusing just on ocean acidification alone.

Implications for the Blue Hill Peninsula: Ocean acidification alone may not have a significant impact on commercial fisheries in Blue Hill. Although a majority of landed value in Blue Hill was from American Lobster (see Figure 2), the species appears to be more resistant to ocean acidification effects as compared to other commercially valuable shellfish (MCC STS. 2024). On the other hand, Brooksville’s commercial fishing industry appears to have a higher reliance upon commercially valuable shellfish species such as Soft Clams and Eastern Oysters (see Figure 4), which have a higher sensitivity to low pH environments, particularly during early life stages (NOAA Fisheries, Siedlecki. S. A, et al., 2021).

Elvers also represent a significant portion of landed value in Brooksville and Surry and a small portion of landed value in Blue Hill. Although no studies have been conducted on the impacts of ocean acidification on the species in Maine, research conducted in Nova Scotia on the effect of acidification on the survival of American Eel suggested that the eel can tolerate low pH conditions fairly well (Reynolds, C., 2011).

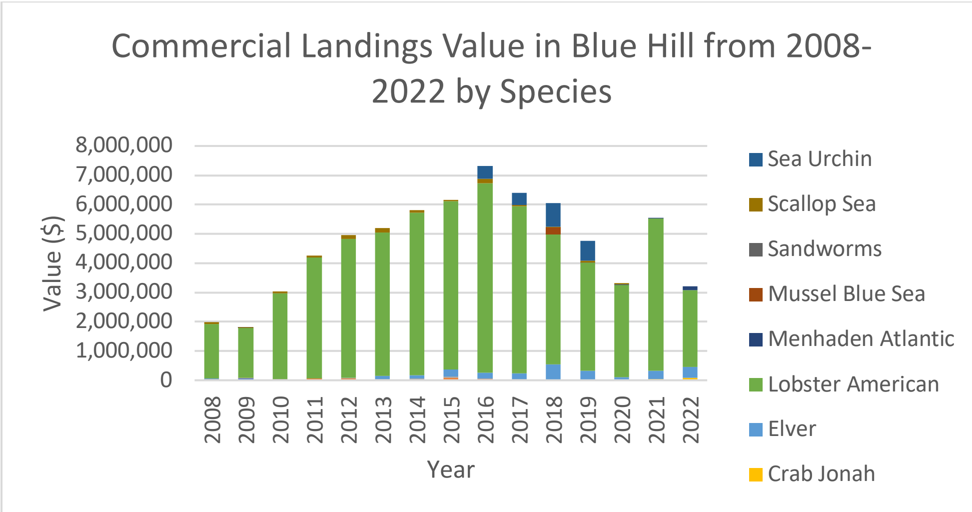

Figure 2: Commercial Landings Value in Blue Hill from 2008-2022 by Species. Data Source: Maine DMR Landings Portal

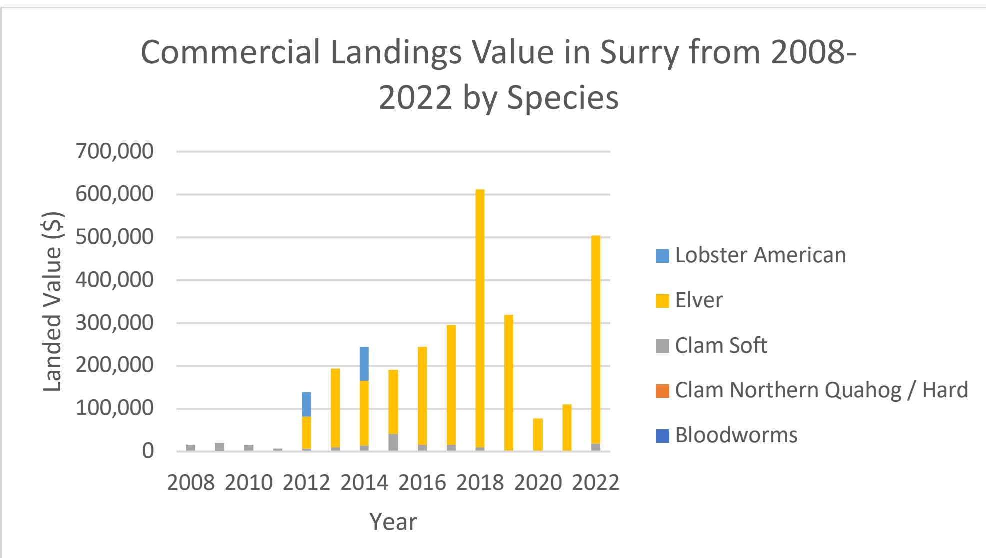

Figure 3 Commercial Landings Value in Surry from 2008 to 2022 by Species. Data Source: Maine DMR Landings Portal

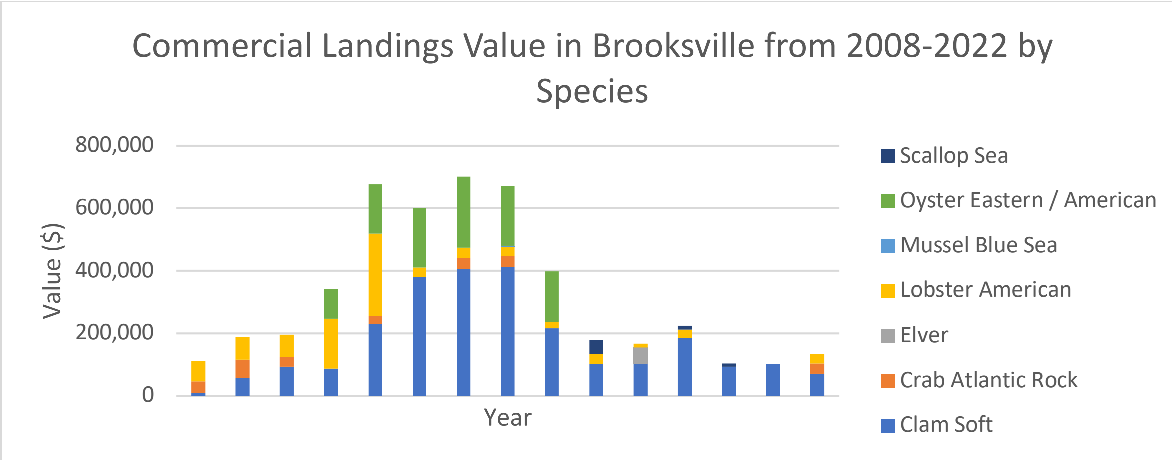

Figure 4: Commercial Landings Value in Brooksville from 2008 to 2022 by species. Data Source: Maine DMR Landings Portal

Recommendations: GMRI has reviewed ocean acidification trends and their potential impacts in the Towns of Blue Hill, Brooksville, and Surry. From our review, we have developed the following recommendations for consideration:

- Ensure coastal adaptation strategies that address warming, acidification, sea level rise, and working waterfront economy are developed in consideration of one another.
- Manage local nutrient loading by developing additional best management practices for stormwater and wastewater systems.
- Stay up to data on emerging research on the interaction between ocean acidification and other changes in marine conditions and how they may affect target species or ecosystem function
- Diversify fishing enterprises to reduce risk.
- Develop plans for remediating coastal vegetated habitats such as salt marshes, seagrass beds, and kelp forests.
- Introduce phytoremediation through kelp aquaculture (in particular sugar kelp) to raise oxygen concentration and absorb nutrient waste.

References:

Maine Climate Council Scientific and Technical Subcommittee (2020). *Scientific Assessment of Climate Change and Its Effects in Maine*.https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/GOPIF_STS_REPORT_092320.pdf

Maine Climate Council Scientific and Technical Subcommittee (2024). *Scientific Assessment of Climate Change and Its Effects in Maine*. https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/STS_2024_digital.pdf

NOAA Fisheries, *Northeast Fish and Shellfish Climate Vulnerability Assessment,* Updated 2024. https://www.fisheries.noaa.gov/national/climate/climate-vulnerability-assessments

Reynolds, C. (2011). The effect of acidification on the survival of American eel.

Siedlecki, S. A., Salisbury, J., Gledhill, D. K., Bastidas, C., Meseck, S., McGarry, K., ... & Morrison, R. (2021). Projecting ocean acidification impacts for the Gulf of Maine to 2050: New tools and expectations. *Elem Sci Anth*, *9*(1), 00062.

Wang, Z. A., Lawson, G. L., Pilskaln, C. H., & Maas, A. E. (2017). Seasonal controls of aragonite saturation states in the Gulf of Maine. *Journal of Geophysical Research: Oceans*, *122*(1), 372-389.

Appendix C Plant Hardiness Vulnerability Assessment

Memo

To: Mr. Allen Kratz

From: Gayle Bowness, Stephanie Sun

Date: October 25 2024

Re: Plant Hardiness Vulnerability Assessment
Climate Vulnerability Assessment
Towns of Blue Hill, Brooksville, and Surry, Maine

The Gulf of Maine Research Institute. has reviewed the vulnerability of plant hardiness for the Towns of Blue Hill, Brooksville, and Surry, Maine (the "Towns") and we have summarized the findings in this memo.

This memo provides background on Plant Hardiness in Maine, identifies future outlooks on plant hardiness, and provides recommendations for managing changes in plant hardiness as a result of climate change.

This memo is part of a larger vulnerability study funded with a Community Action Grant through the Governor's Office of Policy Innovation and the Future (GOPIF) Community Resilience Partnership with additional support from the Town of Brooksville. This work is based on our proposal dated August 4th, 2023.

Background:
Winter cold hardiness plays a pivotal role in determining where plants can thrive, making it one of the most critical climatic factors for successful plant growth (MCC STS. 2020). Cold hardiness refers to the lowest temperatures that a fully dormant plant can endure, and certain plants naturally possess a higher degree of cold hardiness than others. Understanding plant hardiness zones is an important part of agricultural planning, particularly in a changing climate where frequent temperature extremes or warming may make growing traditional crops more difficult, even as the same shifts create opportunities to grow new ones (USDA Forest Service). Plant hardiness zones can also be a useful tool in selecting native plants that are well suited to local social and climactic conditions and that can support local ecosystems and biodiversity (USDA). Maine encompasses Plant Hardiness Zones 3-6, with each zone based on the 30-year average of the coldest temperature recorded each winter. Zone 3, for instance, is 10 degrees Fahrenheit colder than Zone 4, and this range demarcates the suitability of different plant species (USDA Forest Service). Currently, the towns of Blue Hill, Brooksville, and Surry are in Plant Hardiness Zone 6a and 6b, with an average annual extreme minimum temperature of –10 to 0 degrees Fahrenheit.

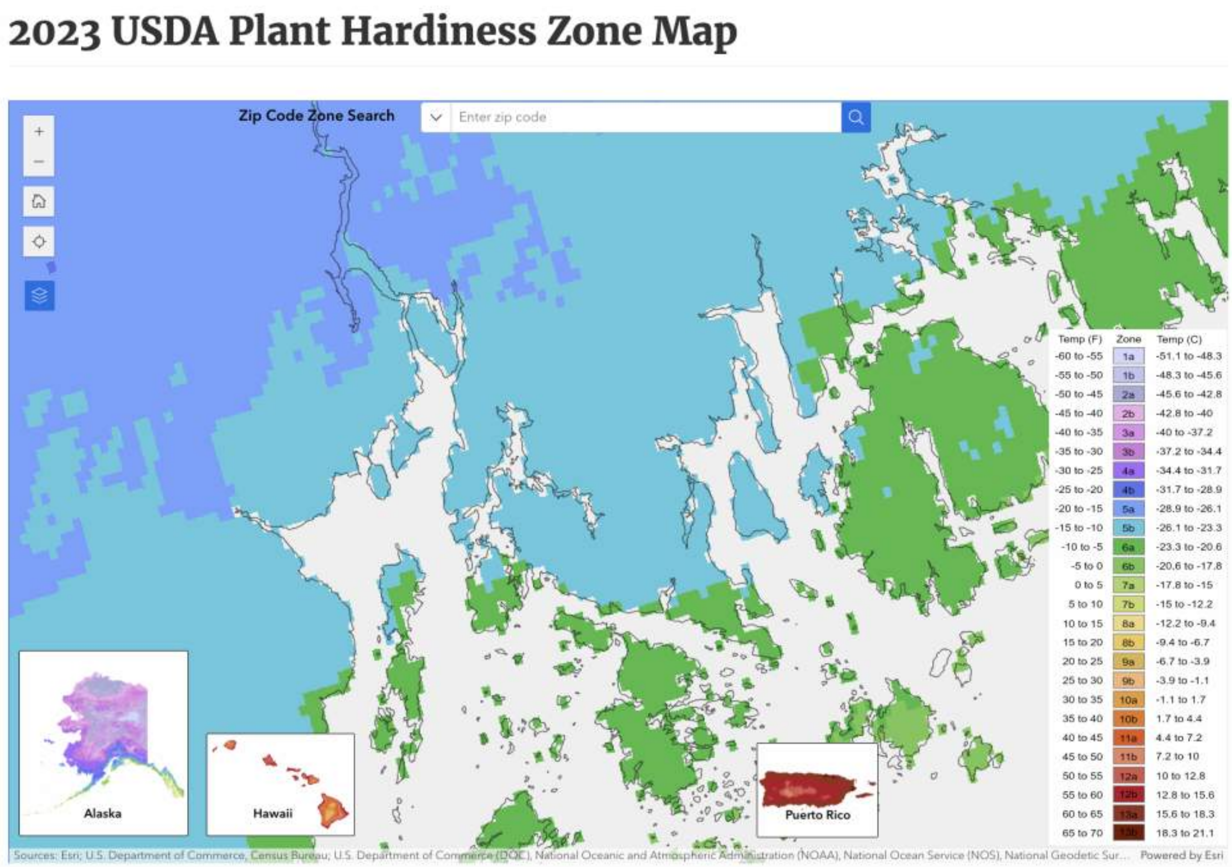

Figure 1: USDA plant hardiness zones for the State of Maine. Source: USDA (2023)

History and Trends:
Maine's agricultural industry generates $3.6 billion annually and provides 27,000 jobs, but producers are increasingly concerned about poor crop and cover crop germination, labor shortages, and the growing financial burden of climate-induced changes (MCC STS, 2024). Climate change is generating significant shifts in Maine's agricultural landscape. Winter, in particular, is the fastest warming season, having increased by 5°F compared to a century ago (MCC STS, 2024). Additionally, there has been a two-week increase in the average growing season since 1950, with Maine's warm season lengthening in the late summer and early fall (MCC STS, 2024). In November 2023, the USDA shifted its plant hardiness zones—where Blue Hill, Brooksville, and Surry used to be in zones 5b-6a, they are now in zones 6a-6b. These changes may have far-reaching effects with the potential to reduce crop yields, decrease the quality of harvests, and increase the need for irrigation.

Projections/ Future Outlook:
Plant hardiness zones that farmers and gardeners rely upon may continue to shift northward, allowing Mainers to grow crops that would only be able to flourish in warmer climates (Maine Climate and Agriculture Network, 2017). The USDA's 2023 updated plant hardiness zones further indicate that average annual minimum temperatures could increase by 20 5°F between 2005 and 2085 under the highest emissions scenario, with Northern Maine average temperatures resembling those of current conditions in Connecticut (MCC STS 2024).

While warmer temperatures and longer growing seasons may present unique opportunities for growing in Maine, they also may allow new pests or diseases to become established and increase the frequency and intensity of stress to crops, livestock, and agricultural workers (MCC STS 2024). Winter temperatures, which might increase more rapidly than growing season temperatures in Maine, may impact an array of perennial crops, with warm periods during winter days potentially causing these plants to de-acclimate and lose their winter hardiness thus increasing the likelihood of winter injury or winterkill. For example, variable late winter and early spring temperatures have led to premature crop development before the last spring freeze date, for example, warm winter temperatures followed by spring frosts affected Maine's apple, blueberry, and peach crops in 2012 and 2016 (Maine Climate and Agriculture Network, 2017). Several crops also benefit from the insulation provided by snowpacks; where snowpacks may decrease due to warming, winterkill may be more likely. Winter warming and warming during the growing season may also shift the timing of development events (such as flowering) for tree fruit. Finally, high winter temperatures may allow pests that do not overwinter to persist year-round, while projected increases in heat waves, and the potential for drought and other extreme weather events may further dampen opportunities for greater crop productivity (MCC STS 2024).

Recommendations:

GMRI has reviewed plant hardiness trends in Maine and the impacts of climate on plant hardiness in the Towns of Blue Hill, Brooksville, and Surry. From our review, we have developed the following recommendations for consideration:

- Choose longer-season crops or varieties
- Growers should be flexible with earlier to later planting dates for current crop selections
- Experiment with double cropping, inter-cropping, and the greater use of cover crops
- Considering spring frost risk in selecting planting dates, sites, and crop variety
- Minimize frost risk where possible (e.g. mulch, row covers)
- Enhance emergency response capacity (e.g., freeze forecast, heaters, frost protectants)
- Diversify farm enterprises to minimize risk
- Garden centers may wish to change plant selection and inventory to meet changing hardiness zones, and can play a large role in customer education and outreach

References:

Maine Climate and Agriculture Network, *Maine Farm Climate Adaptation Summary.* 2017. Accessed November 15, 2023. https://umaine. edu/climate-ag/farm-response-changing-weather/

Maine Climate Council Scientific and Technical Subcommittee (2020). *Scientific Assessment of Climate Change and Its Effects in Maine*.https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/GOPIF_STS_REPORT_092320.pdf

Maine Climate Council Scientific and Technical Subcommittee (2024). *Scientific Assessment of Climate Change and Its Effects in Maine*. https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/STS_2024_digital.pdf

USDA *2023 USDA Plant Hardiness Zone Map*. Accessed October 2024. https://planthardiness.ars.usda.gov/

USDA Forest Service, *Assessing Potential Climate Change Pressures across the Conterminous Unites States: Mapping Plnt Hardiness Zones, Heat Zones, Growing Degree Days, and Cumulative Drought Severity throughout this Century*. 2018. https://www.fs.usda.gov/nrs/pubs/rmap/rmap_nrs9.pdf

Appendix D Tick Borne Disease Vulnerability Assessment

Memo

To: Mr. Allen Kratz

From: Gayle Bowness, Stephanie Sun

Date: October 25, 2024

Re: Tick Borne Disease Vulnerability Assessment
Climate Vulnerability Assessment
Towns of Blue Hill, Brooksville, and Surry, Maine

The Gulf of Maine Research Institute. has reviewed the vulnerability of tick-borne diseases for the Towns of Blue Hill, Brooksville, and Surry, Maine (the "Towns") and we have summarized the findings in this memo.

This memo provides a history of tick-borne diseases in Maine, identifies future risks of tick-borne diseases, and provides recommendations for minimizing the risk of contracting tick-borne diseases as a result of climate change.

This memo is part of a larger vulnerability study funded with a Community Action Grant through the Governor's Office of Policy Innovation and the Future (GOPIF) Community Resilience Partnership with additional support from the Town of Brooksville. This work is based on our proposal dated August 4th, 2023.

History of Tick-Borne Diseases in Maine:
Maine has seen a notable increase in the population of deer ticks, a primary vector for Lyme disease. Lyme disease incidence in Maine has consistently been in the top five among U.S. states and has been increasing over time as the range of deer ticks has expanded in Maine (MCC STS. 2024).
Since 2001, Maine has witnessed a steady uptick in the incidence of tick-borne diseases, with Lyme disease being the most prevalent. The surge in these diseases presents a substantial public health challenge for the state. Figure 1 outlines the trends in the number of confirmed and probably Lyme, Anaplasmosis, and Babesiosis cases. Notably, Maine experienced a record-breaking number of Lyme disease cases, with the highest three-year average incidence recorded between 2015 and 2017, surpassing the entire United States (MCC STS. 2020). In 2017 alone, the state reported an unprecedented number of Lyme disease cases. Over the period from 2015 to 2017, Maine boasted the highest three-year average incidence of Lyme disease in the entire United States. Recent years have seen a disproportionate rise in the incidence rate of Lyme disease among the elderly population (65+) and youth aged 5-14 (Maine Tracking Program).

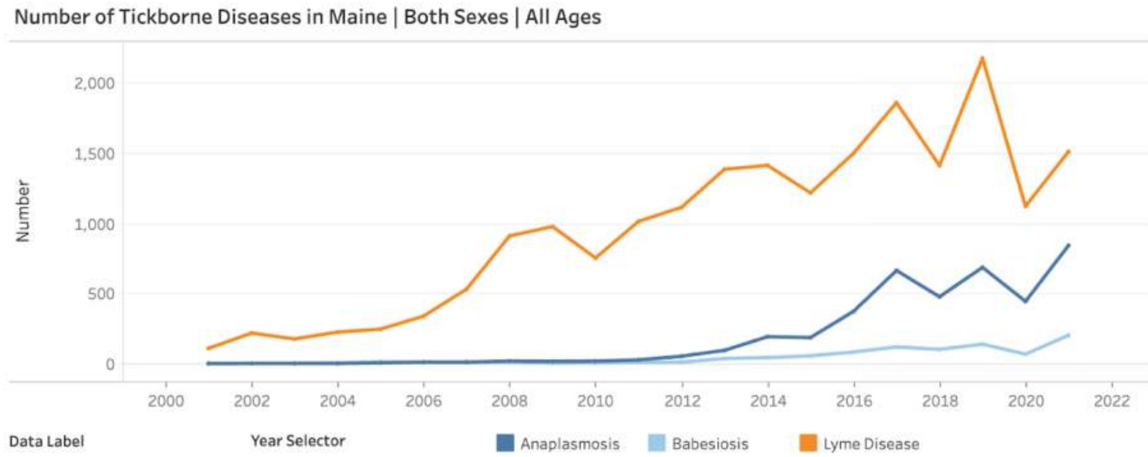

Figure 1: Changes in the number of tickborne diseases recorded in Maine over the last 20 years. Source: The Maine Environmental Public Health Tracking Program.

Based on the latest available data from 2023, Hancock County is one of the hotspots for tickborne diseases within the state. The Lyme disease incidence rate in this county is notably high, standing at 406.6 cases per 100,000 individuals, compared to 13.4 cases per 100,000 people in 2001 (Maine Tracking Program). The incidence rates for Anaplasmosis and Babesiosis are lower than that of Lyme disease, though Hancock County still has the second and third highest rates of these two diseases in the State (Maine Tracking Program).

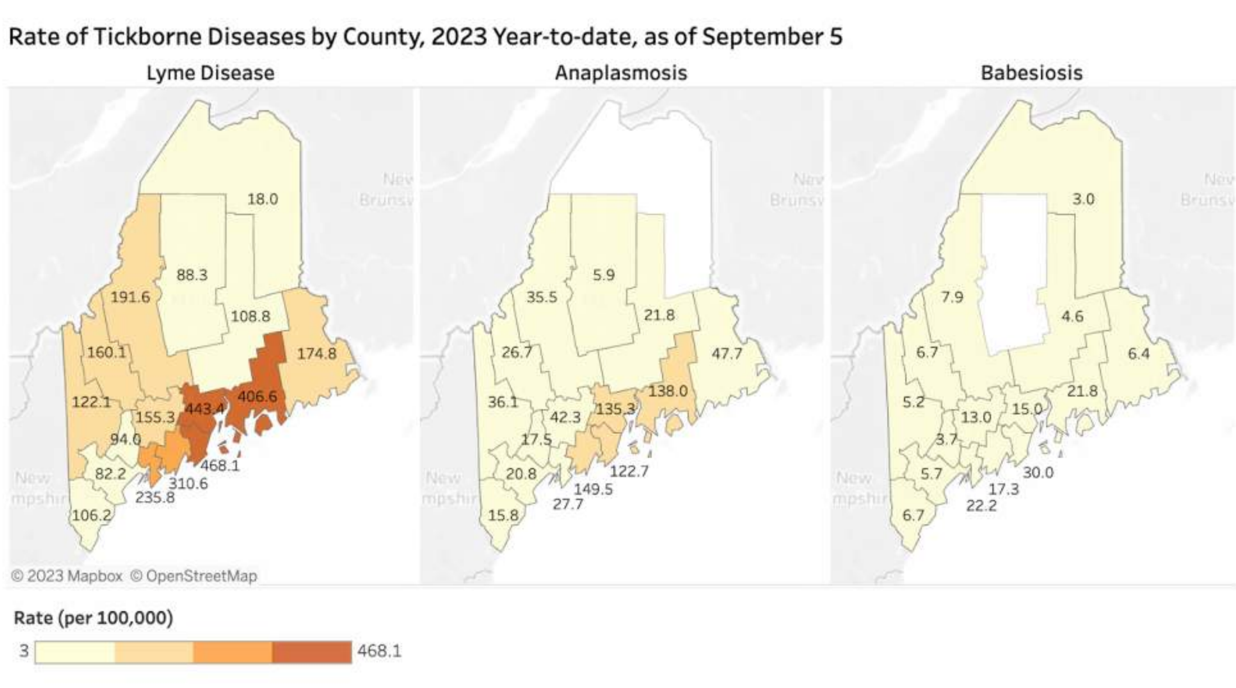

Figure 2: Rate of Tickborne diseases in Maine, summarized by county and disease type. Source: Maine Tracking Program.

Blue Hill:

In Blue Hill, the incidence rate for Lyme disease per 100,000 people has increased from 37.2 in 2010 to 302.3 in 2020, with the incidence rate peaking at 566.9 per 100,000 people in 2019. Based on the average incidence rate of 545.3 cases per year between 2016 and 2020, Blue Hill has the 19th highest incidence rate for towns in the state of Maine.

Brooksville:
The incidence rate of Lyme disease for Brooksville between 2016 and 2020 was 433.9, and it has the 22nd highest incidence rate in the State. Lyme disease incidence rates remained at zero for much of 2010-2018, the rate of Lyme disease peaked at 642 per 100,000 people in 2019.

Surry:
As compared to Blue Hill and Brooksville, Surry has a relatively lower incidence rate (42nd in the state of Maine) of Lyme disease with 322.9 cases per 100,000 people reported between 2016 and 2019. Like Brooksville, Lyme disease incidence rates were 0 between 2010 and 2018 and spiked to 400.3 per 100,000 people in 2019.

Effects of Tick-borne diseases:
Many individuals who contract tick-borne diseases struggle to get early diagnosis and intervention. This is because the symptoms of Lyme disease, Babesiosis, and Anaplasmosis such as fever, fatigue, and headaches, mimic those of the common flu, meaning patients often do not seek treatment at the onset of their symptoms (Johns Hopkins Medicine Lyme Disease Research Center). Left untreated, Lyme disease can affect the joints, heart, and nervous system, while Babesiosis is particularly life-threatening to those who are immunocompromised (UMaine Cooperative Extension Tick Lab). Advanced age is as a risk factor for disease severity for tick-borne disease, and, Anaplasmosis has been shown to occur more frequently in older adults (Dema et al., 2005), and hospitalization for tick-borne diseases are longer for adults over the age of 60 (Krause, et al, 2003). Children are also more at risk of contracting tick-borne diseases in the Northeast United States during the spring and summer months because they spend more time outdoors in grassy or wooded areas, including within their immediate home environment e.g gardens and lawns (Klein et al., 1996). Additionally, those who are employed in outdoor industries (e.g. forestry, construction) have a higher exposure to ticks and are more likely to contract tick-borne illness than those who work in indoor environments.

Blue Hill, Brooksville, and Surry are home to populations that experience higher risks associated with contracting tick-borne disease and well as poorer health outcomes if they do contract tick-borne diseases. The percentage of residents over the age of 65 in each of these communities is higher than the state of Maine, and the state of Maine has the highest percentage of residents over the age of 65 in the country (U.S. Census Bureau, 2020).

Jurisdiction	Persons Under 5	Persons Over 65
Blue Hill	1.9%	23.9%
Brooksville	3.0%	42.3%
Surry	4.7%	30.9%
Hancock County	4.3%	25.1%
Maine	4.4%	21.7%

Table 1: Vulnerable population demographics. Source: 2021 American Community Survey (census.gov)

Future Outlook:
Projections from the Maine Climate Council indicate that, with ongoing trends of increasing relative humidity and warmer winter temperatures, the occurrence of tick-borne diseases could potentially evolve into a chronic issue, particularly in Southern Maine, where deer tick populations have stabilized. Deer tick populations are increasing in Northern Maine and are reflected in high and increasing rates of Lyme Disease in the state (MCC STS. 2024). While it remains uncertain whether the rate of tickborne diseases will continue to increase, the Maine Climate Council predicts that the Lone Star Tick (Amblyomma americanum), a vector for ehrlichiosis, which is currently uncommon in the state, may become established in Southern and Coastal Maine (MCC STS. 2024).

Broadly, a warming climate will support tick survival, but survival will be limited to where there is suitable habitat for ticks and hosts, such as deciduous and mixed forests. For example, overwintering ticks can survive cold and varying winter conditions so long as there is adequate insulation from snow and leaf litter. Where there is less ground insulation, temperature swings could lead to a decrease in the overwinter survival of certain tick species (MCC STS. 2024). Finally, tick abundance is attributable not only to climatological variables but also to white-tailed deer density, with current models predicting increases in tick abundance only in areas where there is already a presence of white-tailed deer (MCC STS. 2024).

Recommendations:
GMRI has reviewed tick-borne disease trends and the risk of Lyme, Babesiosis and Anaplasmosis to residents in the Towns of Blue Hill, Brooksville, and Surry. From our review, we have developed the following recommendations for consideration:

- Provide training for schools, caregivers, and workplaces that includes information on the risks of exposure and infection of tickborne diseases, and how to identify them
- Encourage employers and workers to report workplace illness and injury (including tick bites) promptly
- Provide outdoor industry workers and outdoor recreators with access to EPA-registered insect repellents
- Develop best management practices for trail, yard and forest maintenance, working with residents and land trusts as appropriate
- Encourage residents to wear protective clothing and check for ticks following long periods spent outside in wooded areas, bushes, and tall grass
- Promote the availability and affordability of healthcare to address the early detection and treatment of tick-borne illnesses

References:

Demma, L. J., Holman, R. C., McQuiston, J. H., Krebs, J. W., & Swerdlow, D. L. (2005). Epidemiology of human ehrlichiosis and anaplasmosis in the United States, 2001–2002. *The American journal of tropical medicine and hygiene*, *73*(2), 400-409.

Johns Hopkins Medicine Lyme Disease Research Center. *Disease Information*. Retrieved November 15, 2023 https://www.hopkinslyme.org/

Klein, J. D., Eppes, S. C., & Hunt, P. (1996). Environmental and life-style risk factors for Lyme disease in children. *Clinical pediatrics*, *35*(7), 359-363.

Krause PJ, McKay K, Gadbaw J, Christianson D, Closter L, Lepore T, Telford SR 3rd, Sikand V, Ryan R, Persing D, Radolf JD, Spielman A. Tick-Borne Infection Study Group. Increasing health burden of human babesiosis at endemic sites. American Journal of Tropical Medicine and Hygiene. 2003;68:431–436

Maine Center for Disease Control and Prevention. *Lyme Disease*. Retrieved October 30, 2023, from https://www.maine.gov/dhhs/mecdc/infectious-disease/epi/vector-borne/lyme/index.shtml#about

Maine Environmental Public Health Tracking Program. (2023). *Tickborne Diseases.* https://data.mainepublichealth.gov/tracking/tickborne

Maine Climate Council Scientific and Technical Subcommittee (2020). *Scientific Assessment of Climate Change and Its Effects in Maine* https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/GOPIF_STS_REPORT_092320.pdf

Maine Climate Council Scientific and Technical Subcommittee (2024). *Scientific Assessment of Climate Change and Its Effects in Maine. https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/STS_2024_digital.pdf*

Appendix E Heat Risk Vulnerability Assessment

Memo

To: Mr. Allen Kratz

From: Alex Gray (GEI), Leila Pike, P.E. (GEI)

cc: Gayle Bowness (GMRI), Stephanie Sun (GMRI)

Date: December 3, 2024

Re: Heat Risk Vulnerability Assessment
Climate Vulnerability Assessment
Towns of Blue Hill, Brooksville, and Surry, Maine
GEI Project No. 2303435

GEI Consultants, Inc. has reviewed heat risk for the Towns of Blue Hill, Brooksville, and Surry, Hancock County, Maine (the "Towns") and we have summarized the findings in this memo. This analysis evaluated the impact of elevated air temperatures on humans. This memo provides a history of temperature change in Maine, projections of temperature increase, a summary of health risks of extreme heat, and recommendations around increasing resiliency to heat.

This memo is part of a larger vulnerability study funding with a Community Action Grant through the Governor's Office of Policy Innovation and the Future (GOPIF) Community Resilience Partnership with additional funding support from the Town of Brooksville. This work is based on our proposal dated August 4, 2023.

Temperature Change in Maine

Historical data suggests that air temperature in Maine is increasing. Between 1895 and 2019, the statewide annual air temperature, based on mean daily temperature observations, has increased by 3.2 degrees F. The lower overnight air temperatures in Maine have been increasing at a greater rate than the daily highs and, in general, coastal areas have warmed more than inland areas in Maine. Increasing overnight temperatures could lead towards more prolonged high temperatures, limiting the ability for relief from the heat. This data was based on the National Oceanic and Atmospheric Administration (NOAA) U.S. Climate Divisional Database and summarized by the Maine Climate Council (MCC) Scientific and Technical Subcommittee (MCC, 2020).

Similar to projections for sea level rise, climate models show a range of potential annual air temperature increases, which depend on future amounts of greenhouse-gas emissions. Temperature projections for Maine indicate an additional annual temperature increase of 2.0 to 4.0 degrees F by 2050 and up to 10.0 degrees F by the end of the century.

In addition to a mean daily temperature increase, the number of "extreme heat days" are projected to increase two- to four-times by the 2050s (MCC, 2020). The MCC Scientific and Technical Subcommittee defines "extreme heat days" as "days where the heat index (a combination of temperature and relative humidity that approximates the 'felt' temperature) exceeds 95.0 degrees F." For Bangor, Maine, the number of extreme heat days would likely increase from 3.0 to 10.5 from approximately the year 2000 to 2050 (Fig. 1).

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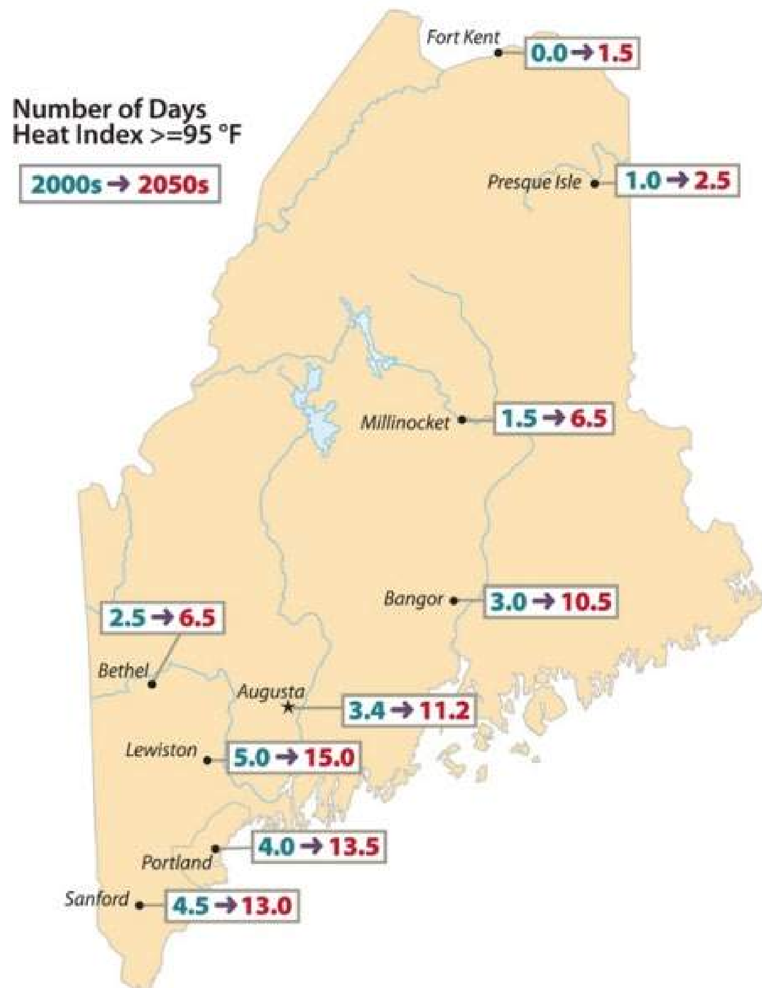

Fig. 1. Change in Number of Extreme Heat Days (MCC, 2020)

Health Risk of Heat Exposure

Extreme heat poses a health risk to humans. The MCC (2020) report indicates that extreme heat is associated with a number of negative health outcomes, including heatstroke, exacerbation of existing respiratory and diabetes-related conditions, and deleterious effects on pregnant persons and their babies (MCC, 2020). The most vulnerable groups to heat-related illnesses include older adults, children, people of low socioeconomic status, people with chronic diseases, people with disabilities, people experiencing homelessness, and people who work outdoors (Louis, 2022).

The Towns of Blue Hill, Brooksville, and Surry are home to a relatively older demographic compared to the state as a whole. The percentage of residents in the Towns over the age of 65 is higher than the state average, and the state of Maine has the highest percentage of residents over the age of 65 in the country (U.S. Census Bureau, 2021). Table 1 provides a summary of the vulnerable population demographics for the three Towns, Hancock County, and the State of Maine.

Table 1. Heat Vulnerable Population Demographics

Jurisdiction	Persons Under 5	Persons 65+	Persons in Poverty
Blue Hill	1.9%	23.9%	9.7%
Brooksville	3.0%	42.3%	4.9%
Surry	4.7%	30.9%	7.8%
Hancock County	4.3%	25.1%	10.3%
Maine	4.4%	21.7%	11.5%

Source: U.S. Census Bureau (2021)

While the occurrence of extreme heat days in Maine is projected to increase, it is still relatively uncommon in Maine compared to elsewhere in the country. However, residents in Maine would likely be especially vulnerable to extreme heat due to Maine's older demographic, the lower likelihood of residents being acclimated to extreme heat due to the typically cooler climate experienced in the state, and the reduced prevalence of air conditioning in homes (MCC, 2020). As of 2019, approximately 41.5% of adults in Hancock County lived in homes with air conditioning, compared to 59.8% of adults for the state of Maine (Maine CDC, 2023). These numbers are notably lower than the percentage of households across the United States with access to air conditioning, which was estimated to be 90% in 2015 (U.S. EIA, 2018).

The vulnerability of Mainers to extreme heat was documented in a 2017 study of emergency department visits and deaths among residents within Maine, New Hampshire, and Rhode Island (Wellenius, et al., 2017). This study found that there was a 10% increase in emergency department visits and deaths for all causes (not just heat-related visits or deaths) on days of extreme heat (95 degrees F or higher) compared to days with a heat index of 75.0 degrees F. This increase was higher in Maine than the other states included in the study.

Recommendations

GEI has reviewed the temperature trends and risks of extreme heat related to residents in the Towns of Blue Hill, Brooksville, and Surry. From our review, we have developed the following recommendations for consideration:

- Identify priority buildings for air conditioning installation, such as schools and long-term care facilities that do not currently have air conditioning.
- Take an inventory of impacts. For example, consider town-wide questionnaires to identify homes without air conditioning and hear from residents about their experience with extreme heat.
- Establish local community cooling centers and a threshold heat index or extreme heat duration when the cooling centers would become available to the public. Likewise, establish local community warming centers and threshold cold index when the warming center would become available to the public.
- Develop a communication strategy to deploy leading up to anticipated extreme temperature days to communicate temperature warnings and safety guidance.

- Encourage residents to check on family, friends, and neighbors who may not have access to air conditioning.
- Advertise public assistance programs for heat pump installation and weatherization, such as the Maine Housing Heat Pump Program and the Weatherization Program. Weatherization and heat pump installation will also benefit users in the cold winter months.
- Increase public recreational water access and amenities to encourage public use (e.g., restrooms, picnic tables, parking, etc.).

Limitations

This memo presents the initial findings of heat risk for the Towns of Blue Hill, Brooksville, and Surry, Maine based on readily available online information and published references. Reuse of this report for any purpose, in part or in whole, is at the sole risk of the user.

References

Louis, J. T (2022). "Maine CDC Extreme Temperature Community Resilience Guidebook." A capstone submitted in fulfillment of the requirements for the degree: Master of Public Health, University of Southern Maine, in collaboration with Maine Center for Disease Control and Prevention Environmental and Occupational Health Program, April.

Maine Center for Disease Control and Prevention (CDC) (2022). Heat-related Illnesses. Accessed November 2023 from the Maine Tracking Network: https://data.mainepublichealth.gov/tracking/heat.

Maine Climate Council (MCC) (2020). Scientific Assessment of Climate Change and Its Effects in Maine, August.

U.S. Census Bureau (2021). American Community Survey. Accessed September 25, 2023, from: https://data.census.gov/.

U.S. Energy Information Administration (EIA) (2018). Residential Energy Consumption Survey. Accessed November 2023 from: https://www.eia.gov/consumption/residential/data/2015/hc/php/hc7.7.php.

Wellenius, G. A., Eliot, M. N., Bush, K. F., Holt, D., Lincoln, R. A., Smith, A. E., & Gold, J. (2017). Heat-related morbidity and mortality in New England: Evidence for local policy. Environmental research, 156, 845-853.

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Appendix F Power Outage Vulnerability Assessment

Memo

To: Mr. Allen Kratz

From: Leila Pike, P.E. (GEI), Alison Brady (GEI)

cc: Gayle Bowness (GMRI), Stephanie Sun (GMRI)

Date: December 3, 2024

Re: Power Outage Vulnerability Assessment
Climate Vulnerability Assessment
Towns of Blue Hill, Brooksville, and Surry, Maine
GEI Project No. 2303435

GEI Consultants, Inc. has reviewed the potential vulnerability of power outages for the Towns of Blue Hill, Brooksville, and Surry, Hancock County, Maine (the "Towns") and we have summarized the findings in this draft memo.

This memo provides a history of power outages in Maine, identifies future risk of power outages, and provides recommendations for minimizing damages due to power outages as a result of climate change.

This memo is part of a larger vulnerability study funded with a Community Action Grant through the Governor's Office of Policy Innovation and the Future (GOPIF) Community Resilience Partnership with additional funding support from the Town of Brooksville. This work is based on our proposal dated August 4, 2023. Comments received on this memo by the Oversight Committee will be incorporated into the final vulnerability assessment.

Maine's Electric Grid

The three major components of the electric grid are generation, transmission, and distribution. Damage to any of these components can cause outages, though most major power outages and disturbances that threaten power to tens of thousands of customers are ones that disrupt high-voltage transmission, which is the infrastructure that carries electricity over long distances. Much of the country's transmission and distribution (T&D) infrastructure is aging and struggling with reliability (ASCE, 2021).

The Maine Public Utilities Commission (PUC) regulates the transmission and distribution of local electric utilities within Maine, such as Central Maine Power (CMP) and Versant Power (Maine OPA, 2017). Interstate transmission is regulated by the Federal Energy Regulatory Commission (FERC) (ASCE, 2021). CMP and Versant Power deliver electricity throughout the majority of Maine, while smaller municipal and co-op utility services make up the rest. Versant Power, owned by ENMAX Corporation, is the regulated electric transmission and distribution utility that services Hancock County (Maine OPA, 2017).

History of Power Outages Due to Weather in Maine

Data suggests that the frequency of weather-related power outages is increasing, both in Maine and across the country. Table 1 provides a summary of major power outages in Maine (affecting at least 50,000 people for at least one hour) due to weather from 2000 to 2023 that were reported to the Department of Energy by utility companies, as well as the cumulative duration of these outages. These power outage events are also displayed graphically in Fig. 1. Further detail on these outages is provided in Attachment 1 (U.S. DOE, 2023).

Table 1. Major Power Outages Due to Weather Reported in Maine 2000-2023 (U.S. DOE, 2023)

Year	# Outages	Total Duration of Outages
2023	3	14:47:00
2022	7	19:35:00
2021	5	8:21:00
2020	12	20:17:00
2019	3	18:15:00
2018	7	23:59:00
2017	3	6:53:00
2016	5	2:35:00
2015	1	10:30:00
2014	4	17:06:00
2013	1	20:12:00
2012	1	10:49:00
2011	0	0:00:00
2010	2	3:30:00
2009	1	11:08:00
2008	3	4:42:00
2007	2	3:54:00
2006	1	3:18:00
2005	0	0:00:00
2004	0	0:00:00
2003	0	0:00:00
2002	0	0:00:00
2001	0	0:00:00
2000	0	0:00:00

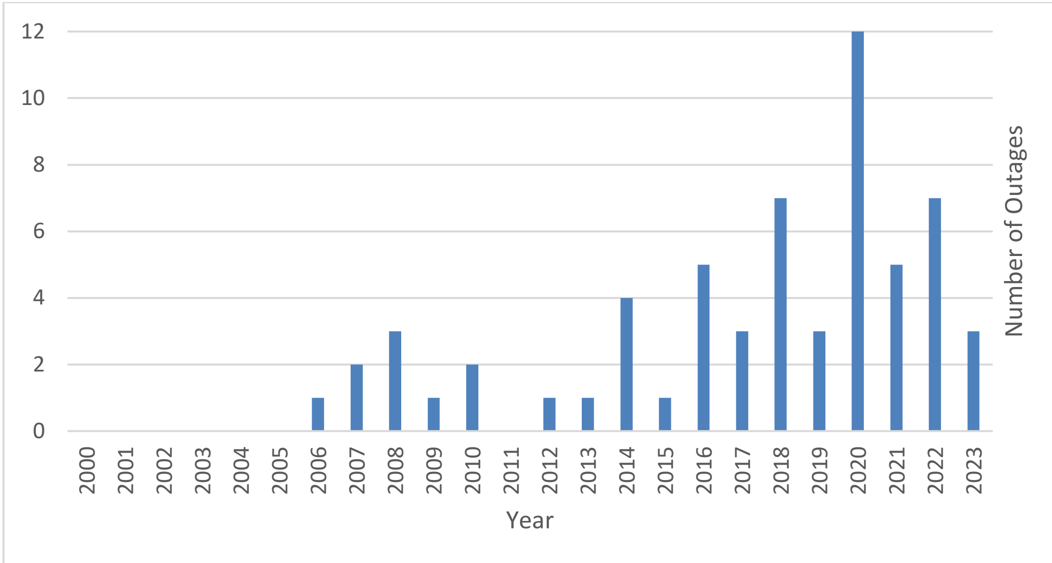

Fig. 1. Major Power Outages due to Weather Reported in Maine 2000-2023 (U.S. DOE, 2023)

These data for Maine across the period from 2000 to 2023 suggest that the frequency of major power outages due to weather events in Maine has been generally increasing since 2000. This aligns with a similar trend reported country-wide (Fig. 2). A significant increase was experienced in 2021 when the number of weather-related power outages in the country was 88% higher than the annual average between 2000 and 2021 (Climate Central, 2022).

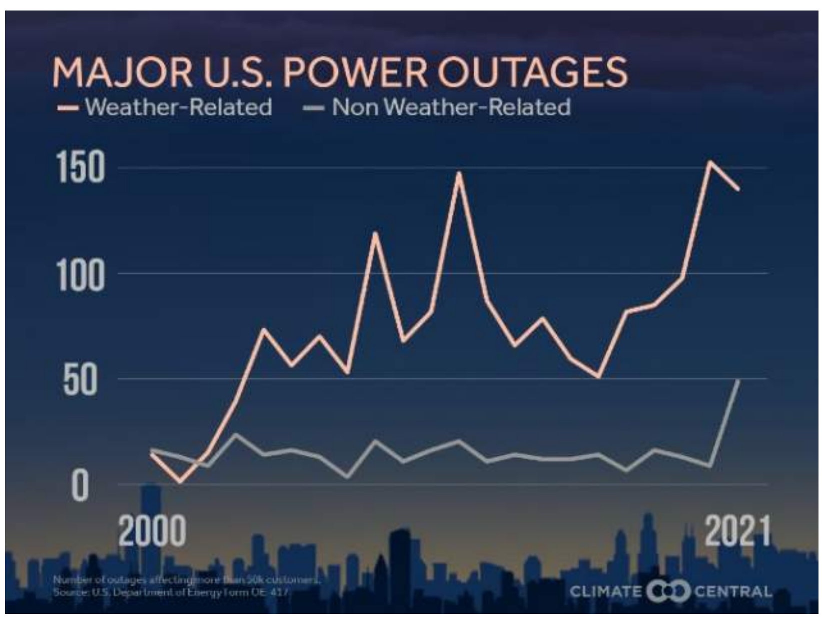

Fig. 2. Major U.S. Power Outages (Climate Central, 2022)

In addition to contributing to power outages, major weather events can be costly to municipalities and states. Between 1980 and 2023, there were approximately sixteen weather events in Maine that caused at least one billion dollars' worth of damage. Details of these major weather events are provided in Attachment 2.

Effects of Power Outages

A 2022 report (Climate Central, 2022) highlighted that power outages can have numerous adverse effects, including:

- Disruption to communications, water supply, and transportations.
- Closure of retail businesses, grocery stores, gas stations, and other services.
- Food spoilage and water contamination.
- Inability to use medical devices.

Co-occurring factors, such as displacement, extreme temperatures, and air pollution, as well as vulnerability factors such as age and socioeconomic status can exacerbate the effects of power outages on individuals. More information on co-occurring and vulnerability factors is provided in Fig. 3.

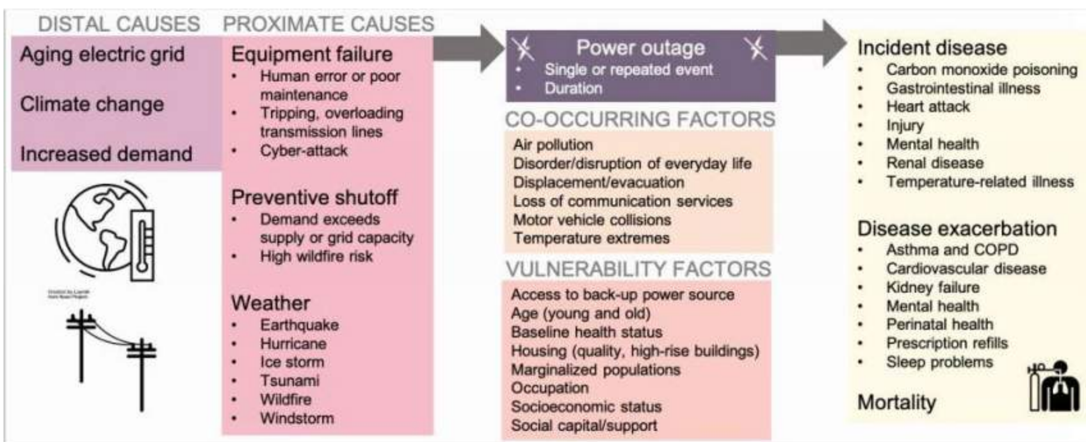

Fig. 3. Links Between Power Outages and Adverse Health Effects (Casey et al., 2020)

An example of co-occurring and vulnerability factors particular to Maine include temperature extremes and age of residents. For Maine, most of the major power outages since 2000, summarized in Attachment 1, occurred during the winter months, likely during periods of cold temperatures. If homes are not equipped with back-up power or generators, this may mean that access to drinking water supplied by private wells and heat that is dependent on electricity could be compromised.

The percentage of residents in Blue Hill, Brooksville, and Surry over the age of 65 is higher than the state average, and the state of Maine has the highest percentage of residents over the age of 65 in the country (U.S. Census Bureau, 2021). Table 2 provides a summary of the vulnerable population demographics for the three Towns, Hancock County, and the State of Maine. People within these populations would be more likely to experience adverse effects from power outages.

Table 2. Vulnerable Population Demographics

Jurisdiction	Persons Under 5	Persons Over 65	Persons in Poverty
Blue Hill	1.9%	23.9%	9.7%
Brooksville	3.0%	42.3%	4.9%
Surry	4.7%	30.9%	7.8%
Hancock County	4.3%	25.1%	10.3%
Maine	4.4%	21.7%	11.5%

Source: U.S. Census Bureau (2021)

The Future Risk of Power Outages

Historical trends and future predictions suggest that we will likely see an increase in extreme weather events that often lead to power outages, such as hurricanes, winter storms, flooding, and heat waves (Climate Central, 2022). An increase in frequency and intensity of coastal storm events and rising sea levels pose an increasing risk to the country's electric grid since many of the 8,625 power plants in the U.S. were built near shorelines to have access to cooling water and have yet to be adapted to withstand more frequent and intense climate-related events. This risk of inundated power pants was experienced during Hurricane Irene and Hurricane Sandy, when 44 and 69 power plants were in flooded areas within the country, respectively (U.S. DOE, 2013).

The Federal Emergency Management Agency (FEMA) uses the National Risk Index (NRI) to evaluate the relative risk to natural hazards that communities face compared to other communities throughout the country (FEMA, 2023). The three types of hazards with the highest risk values for Hancock County are hurricanes, coastal flooding, and ice storms (FEMA, 2023). The Community Report for Hancock County is provided in Attachment 3.

Recommendations

Measures can be taken to increase the resiliency of utility infrastructure and reduce the likelihood of weather-related power outages, which are the main cause of power outages (FEMA, 2021). An article written by Craig Zamuda (U.S. Department of Energy) and Anne Ressler (ICF International) in The Electricity Journal (Zamuda and Ressler, 2020) highlights federal funding programs that would support community investment in electricity resilience to extreme weather and outlines adaptation methods. A table of the federal funding programs is provided in Attachment 4. Suggested electric utility adaptation methods include:

1. Elevate substations and system control rooms.

2. Build floodwalls for power stations and infrastructure that cannot be elevated.

3. Replace wooden poles with metal, concrete, or composite poles that better resist high winds or wildfire.

4. Install guy wires or other structural supports to stabilize vulnerable poles.

5. Upgrade transmission and distribution lines with materials that can better resist high winds, debris, and wildfires.

6. Burry power lines in locations vulnerable to high winds; and,
7. Perform routine maintenance, such as vegetation management, to minimize impacts from, for example, fallen trees.

Additionally, microgrids could be used to provide power to smaller regions in the event of power outages to the central grid. Microgrids could be powered by alternative sources than the central grid, such as renewable energy or even batteries (Zamuda and Ressler, 2020). Microgrids could be used to power emergency facilities, such as the police department, fire department, or reginal heating or cooling centers.

Limitations

This memo presents the initial findings of power outage vulnerability for the Towns of Blue Hill, Brooksville, and Surry, Maine based on readily available online information and published references. Reuse of this report for any purposes, in part of in whole, is at the sole risk of the user.

References

ASCE (2021). Energy. ASCE 2021 Infrastructure Report Card. Retrieved from 2021 Report Card for America's Infrastructure: https://infrastructurereportcard.org/cat-item/energy-infrastructure/.

Casey, J., Fukurai, M., Hernandez, D., Balsari, S., & Kiang, M. (2020). Power outages and community health: a narrative review. Curr Environ Health Rep, 371-383, December.

Climate Central (2022). Surging Power Outages and Climate Change. Retrieved October 25, 2023, from: https://www.climatecentral.org/climate-matters/surging-weather-related-power-outages.

Do, V., McBrien, H., Flores, N. M., Northrop, A. J., Schlegelmilch, J., Kiang, M. V., & Casey, J. A. (2023Spatiotemporal distribution of power outages with climate events and social vulnerability in the USA. Nature Communications, 14 (2470), April.

FEMA (2023). National Risk Index for Natural Hazards. August. Retrieved from: https://www.fema.gov/flood-maps/products-tools/national-risk-index.

FEMA (2021). FEMA Data Digest: Power Outage. Accessed October 2023 from: https://community.fema.gov/PreparednessConnect/s/article/FEMA-Data-Digest-Power-Outage.

Maine Office of the Public Advocate (ME OPA) (2017). Electricity. Retrieved from: https://www.maine.gov/meopa/electricity/electricity-guides.

NOAA National Centers for Environmental Information (NCEI) (2023). U.S. Billion-Dollar Weather and Climate Disasters.

U.S. Census Bureau (2021). American Community Survey. Accessed September 25, 2023, from: https://www.census.gov.

U.S. Department of Energy (DOE) (2023). Electric Disturbance Events (OE-417) Annual Summaries. Retrieved from: https://www.oe.netl.doe.gov/OE417_annual_summary.aspx.

U.S. Department of Energy (DOE) (2013). Comparing the Impacts of Northeast Hurricanes on Energy Infrastructure, April.

U.S. Energy Information Administration (U.S. EIA) (2022). Electricity Explained: How electricity is delivered to consumers. August. Retrieved October 25, 2023, from: https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php.

Zamuda, C. and Ressler, A. (2020). Federal adaptation and mitigation programs supporting Community investment in electricity resilience to extreme weather. The Electricity Journal.

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Attachments:

Attachment 1. Major Power Outages due to Weather in Maine
Attachment 2. Winter and Climate Billion Dollar Disasters to affect Maine from 1980 to 2023
Attachment 3. National Risk Index Community Report for Hancock County, Maine
Attachment 4. Federal Funding Programs for Electricity Resilience Investments

Attachment 1

Major Power Outages Due to Weather in Maine

Date & Time Event Began	Date & Time of Resotoration	Duration of Outage	Area Affected	Event Type	Demand Loss (MW)	Number of Customers Affected
1/23/23 7:05 AM	1/24/23 5:17 PM	10:12:00	Connecticut: Rhode Island: Massachusetts: Vermont: New Hampshire: Maine:	Severe Weather	Unknown	41,000
3/14/23 8:00 AM	3/16/23 8:20 AM	0:20:00	Connecticut: Massachusetts: Vermont: Rhode Island: New Hampshire: Maine:	Severe Weather	Unknown	83,000
5/1/23 5:16 AM	5/1/23 9:31 AM	4:15:00	Connecticut: Massachusetts: Rhode Island: Maine: New Hampshire: Vermont:	Severe Weather	Unknown	54,000
1/29/22 8:45 AM	1/30/22 1:00 AM	16:15:00	Connecticut: Massachusetts: New Hampshire: Rhode Island: Vermont: Maine:	Severe Weather	120	12,000
2/18/22 7:10 AM	2/18/22 4:25 PM	9:15:00	Connecticut: Maine: Massachusetts: New Hampshire: Vermont: Rhode Island:	Severe Weather	7	7,047
4/19/22 8:41 AM	4/19/22 12:10 PM	3:29:00	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	67,754
10/14/22 1:15 PM	10/14/22 5:45 PM	4:30:00	Connecticut: Massachusetts: Maine: Rhode Island: New Hampshire: Vermont:	Sever Weather	Unknown	76,388
11/30/22 6:45 PM	12/2/22 4:00 AM	9:15:00	Maine: Massachusetts: Connecticut: Rhode Island: Vermont: New Hampshire:	Severe Weather	113	113,000
12/16/22 11:30 PM	12/18/22 11:21 PM	23:51:00	Massachusetts: Vermont: New Hampshire: Maine:	Severe Weather	Unknown	36,600
12/23/22 5:20 AM	Unknown	Unknown	Connecticut: Rhode Island: Massachusetts: Vermont: New Hampshire: Maine:	Severe Weather	Unknown	500,000
3/1/21 10:45 PM	3/2/21 6:35 PM	19:50:00	Connecticut: Massachusetts: New Hampshire: Maine: Rhode Island: Vermont:	Severe Weather	Unknown	69260
3/29/21 11:06 AM	Unknown	Unknown	Connecticut: Massachusetts: Maine: Vermont: Rhode Island: New Hampshire:	Severe Weather	Unknown	70,000
6/30/21 6:50 PM	Unknown	Unknown	Connecticut: Massachusetts: Rhode Island: Vermont: New Hampshire: Maine:	Severe Weather	Unknown	53103
8/22/21 12:11 PM	8/23/21 4:30 PM	4:19:00	Connecticut: Massachusetts: Maine: Rhode Island: Vermont:	Severe Weather	Unknown	28,134
10/27/21 2:25 AM	10/29/21 8:37 AM	6:12:00	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	169000

Date & Time Event Began	Date & Time of Resotoration	Duration of Outage	Area Affected	Event Type	Demand Loss (MW)	Number of Customers Affected
2/7/20 4:25 PM	2/8/20 12:00 PM	19:35:00	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	123,359
3/24/20 2:55 AM	3/24/20 6:50 AM	3:55:00	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	51026
4/9/20 7:40 PM	4/11/20 10:00 PM	2:20:00	Maine:	Severe Weather	Unknown	340,000
4/13/20 1:05 PM	4/14/20 4:00 PM	2:55:00	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	68476
8/4/20 3:15 PM	8/7/20 10:27 AM	19:12:00	Connecticut: Massachusetts: New Hampshire: Maine: Rhode Island: Vermont:	Severe Weather	2000	1,188,247
8/27/20 5:11 PM	8/28/20 10:00 AM	16:49:00	Connecticut: Massachusetts: New Hampshire: Maine: Rhode Island: Vermont:	Severe Weather	100	60687
9/30/20 5:55 AM	9/30/20 11:30 PM	17:35:00	Connecticut: Maine: Rhode Island: Massachusetts: New Hampshire: Vermont:	Severe Weather	Unknown	155,000
10/7/20 6:50 PM	10/9/20 3:00 PM	20:10:00	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	186,600
11/15/20 11:05 PM	11/16/20 5:00 AM	5:55:00	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	62,408
11/30/20 4:24 PM	12/1/20 2:25 PM	22:01:00	Massachusetts: Maine: Connecticut: Rhode Island: Vermont: New Hampshire:	Severe Weather	Unknown	116,000
12/5/20 4:40 PM	Unknown	Unknown	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	271,231
12/25/20 7:55 AM	12/25/20 4:45 PM	8:50:00	Connecticut: Maine: New Hampshire: Massachusetts: Rhode Island: Vermont:	Severe Weather	Unknown	19,000

Date & Time Event Began	Date & Time of Resotoration	Duration of Outage	Area Affected	Event Type	Demand Loss (MW)	Number of Customers Affected
2/25/19 1:35 PM	2/26/19 2:50 AM	13:15:00	Connecticut, Massachusetts, New Hampshire, Maine, Vermont, Rhode Island	Severe Weather	Unknown	72,332
10/17/19 12:45 AM	10/19/19 9:30 AM	8:45:00	Connecticut: Rhode Island: Massachusetts: Vermont: New Hampshire: Maine:	Severe Weather	Unknown	101,683
11/1/19 1:15 AM	11/2/19 9:30 PM	20:15:00	Connecticut: Maine: Massachusetts: Rhode Island: New Hampshire: Vermont:	Severe Weather	Unknown	80,066
3/7/18 7:37 PM	3/10/18 4:35 PM	20:58:00	Connecticut: Massachusetts: Maine: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	102,000
4/5/18 12:50 AM	4/5/18 4:00 PM	15:10:00	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	65,932
5/5/18 4:30 AM	5/5/18 3:30 PM	11:00:00	Vermont: New Hampshire: Maine:	Severe Weather	Unknown	31900
6/18/18 6:20 PM	6/19/18 12:15 AM	5:55:00	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	112,927
10/16/18 4:15 AM	10/16/18 5:11 PM	12:56:00	Connecticut: Rhode Island: Massachusetts: Vermont: New Hampshire: Maine:	Severe Weather	Unknown	18,000
11/3/18 5:20 PM	11/4/18 2:30 PM	21:10:00	Connecticut: Massachusetts: New Hampshire: Vermont: Maine: Rhode Island:	Severe Weather	Unknown	62,000
11/27/18 8:00 AM	11/28/18 4:50 PM	8:50:00	Maine: New Hampshire: Vermont:	Severe Weather	Unknown	32,000
3/2/17 12:20 PM	3/2/17 11:45 PM	11:25:00	Connecticut: Maine: Massachusetts: New Hampshire: Rhode Island: Vermont:	Severe Weather	Unknown	54,316
3/14/17 12:32 PM	Unknown	Unknown	Connecticut: Massachusetts: Rhode Island: New Hampshire: Maine: Vermont:	Severe Weather	Unknown	69,647
10/29/17 11:40 PM	11/1/17 6:08 PM	18:28:00	Connecticut: Massachusetts: New Hampshire: Maine: Rhode Island: Vermont:	Severe Weather	Unknown	310,453

Date & Time Event Began	Date & Time of Resotoration	Duration of Outage	Area Affected	Event Type	Demand Loss (MW)	Number of Customers Affected
1/10/16 8:46 PM	1/11/16 5:25 AM	8:39:00	Maine: Connecticut: Massachusetts: Vermont: New Hampshire: Rhode Island:	Weather	Unknown	59,859
2/25/16 1:44 AM	2/25/16 2:45 PM	13:01:00	Connecticut: Maine: Massachusetts: Rhode Island: Vermont:	Weather	Unknown	114,190
7/22/16 11:50 PM	7/23/16 9:10 AM	9:20:00	Massachusetts: Connecticut: Rhode Island: New Hampshire: Vermont: Maine	Severe Weather	Unknown	57,058
9/11/16 12:05 PM	9/11/16 3:10 PM	3:05:00	Connecticut: Massachusetts: New Hampshire: Rhode Island: Vermont: Maine:	Severe Weather	Unknown	57,960
12/30/16 2:30 AM	12/30/16 7:00 PM	16:30:00	Maine:	Weather or Natural Disaster	Unknown	85,263
6/23/15 6:30 PM	6/24/15 5:00 AM	10:30:00	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	Severe Weather	Unknown	62,442
7/3/14 10:55 PM	7/4/14 1:50 AM	2:55:00	Vermont, New Hampshire, Maine, Rhode Island, Massachusetts, Connecticut	Severe Weather - Thunderstorms	Unknown	64,000
10/22/14 10:46 PM	10/22/14 10:47 PM	0:01:00	New Hampshire, Maine, Massachusetts, Rhode Island, Connecticut, Vermont	Severe Weather	Unknown	66,650
11/2/14 1:46 PM	Unknown	Unknown	Massachusetts, Maine, Vermont, New Hampshire, Rhode Island, Connecticut	Severe Weather - Winter Storm	Unknown	63,719
11/26/14 5:50 PM	11/28/14 7:00 AM	13:10:00	New Hampshire, Massachusetts, Maine, Rhode Island, Connecticut, Vermont	Severe Weather - Winter Storm	Unknown	79,530
12/23/13 3:20 PM	12/25/13 11:32 AM	20:12:00	Central Maine Maine	Severe Weather - Ice/Snow	Unknown	52,500
8/29/25 7:15 PM	9/1/25 6:04 AM	10:49:00	Southeast and Seacoast Maine	Severe Weather - Hurricane Sandy	Unknown	50,000
2/25/10 11:53 PM	3/1/10 4:10 PM	16:17:00	Southern Maine and New Hampshire	Winter Storm	510	509,606
11/8/10 6:47 AM	11/8/10 6:00 PM	11:13:00	Maine	Snow and High Winds	N/A	60,863
2/23/09 2:38 AM	2/24/09 1:46 PM	11:08:00	Southern Central and Western Maine	Ice/Snow Storm	N/A	131,000
2/13/08 6:43 PM	2/14/08 12:00 PM	17:17:00	State of Maine	Ice Storm	50	50,462
7/24/08 7:23 AM	7/24/08 5:41 PM	10:18:00	Bangor Hydro System, northern Maine	Electric System Separation/Severe Lightning Storms	180	110,000
12/12/08 8:45 AM	12/14/08 9:52 AM	1:07:00	Southern and Central Maine	Ice Storm	N/A	169,757
4/5/07 9:20 PM	4/6/07 1:10 PM	15:50:00	Southern and Coastal Maine	Heavy Snow Storm	-	117,142
4/16/07 10:14 AM	4/18/07 10:18 PM	12:04:00	Southern and Coastal Maine	Heavy Snow Storm	-	127,545
1/18/06 3:16 PM	1/18/06 6:34 PM	3:18:00	Southern and Central Maine	Severe Storm	75	63,000

Source: Department of Energy (DOE) (2023)

Attachment 2

Winter and Climate Billion Dollar Disasters to Affect Maine From 1980 to 2023

Weather and Climate Billion-Dollar Disasters to affect Maine from 1980-2023 (CPI-Adjusted)

Name	Disaster	Begin Date	End Date	Total CPI-Adjusted Cost (Billions of Dollars)	Deaths	Summary
Midwest/Southeast/Northeast Winter Storm, Cold Wave (January 1982)	Winter Storm	1/8/1982	1/16/1982	$2.2	85	Winter storm and cold wave affect numerous states (AL, AR, CT, DE, FL, GA, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, NC, ND, NH, NJ, NY, OH, OK, PA, RI, SC, TN, TX, VA, VT, WI, WV) across the Midwest, Southeast and Northeast.
Hurricane Gloria (September 1985)	Tropical Cyclone	9/26/1985	9/28/1985	$2.4	11	Category 2 hurricane makes several landfalls along the eastern seaboard, affecting states from North Carolina to Maine.
Winter Storm, Cold Wave (December 1989)	Winter Storm	12/21/1989	12/26/1989	$1.7	100	Winter storm and deep cold impacts the Northeast, South and Southeast. The states impacted include AL, AR, CT, FL, GA, IL, IN, KY, LA, ME, MO, MS, NC, NH, NY, OH, OK, PA, SC, TN, TX, VA, VT and WV.
Hurricane Bob (August 1991)	Tropical Cyclone	8/18/1991	8/20/1991	$3.4	18	Category 2 hurricane brushes the Outer Banks of North Carolina before making landfall in Rhode Island. Its impacts were felt from North Carolina to Long Island and into New England.
East Coast Blizzard and Severe Weather (March 1993)	Winter Storm	3/11/1993	3/14/1993	$11.9	270	The "Storm of the Century" impacts the entire Eastern seaboard from Florida to Maine. This historic storm dumped 2-4 feet of snow and caused hurricane force winds across many Eastern and Northeastern states. This caused power outages to over 10 million households. Additional impacts included numerous tornadoes across Florida causing substantial damage. This was the most destructive and costly winter storm to affect the United States (since 1980), until it was surpassed by the February 2021 winter storm and cold wave.
Winter Storm, Cold Wave (January 1994)	Winter Storm	1/17/1994	1/20/1994	$2.2	70	Winter storm affects the Southeast and Northeast regions. The states impacted include CT, DE, IL, IN, KY, MA, MD, ME, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, VT and WV.
New England Flooding (October 1996)	Flooding	10/19/1996	10/22/1996	$1.3	1	The flooding damaged homes, businesses, vehicles and other infrastructure. Factories and mills in Lawrence, Haverhill and Lowell, Massachusetts were severely impacted. A total of 81 bridges needed to be rebuilt after to flood on area lakes and rivers. Communities such as Ocean Park, Old Orchard Beach and Westbrook were severely flooded. Communitites in southern Maine were aslo significantly damaged by floodwaters destroying homes, businesses and washing out raods, bridges and dams.
Northeast Ice Storm (January 1998)	Winter Storm	1/5/1998	1/9/1998	$2.7	16	Intense ice storm hits Maine, New Hampshire, Vermont, and New York, with extensive forestry losses
Central and Eastern Winter Storm (January 1999)	Winter Storm	1/1/1999	1/4/1999	$1.9	25	South, Southeast, Midwest, Northeast affected by damaging winter storm
Central and Eastern Winter Storm (Mid-January 1999)	Winter Storm	1/13/1999	1/16/1999	$1.6	0	Winter storm affecting the Central and Eastern states including IL, IN, OH, MI, WV, VA, MD, PA, NJ, NY, MA, CT, VT, NH and ME.
East/South Severe Weather and Flooding (April 2007)	Severe Storm	4/13/2007	4/17/2007	$3.7	9	Flooding, hail, tornadoes, and severe thunderstorms across numerous states (CT, DE, GA, LA, ME, MD, MA, MS, NH, NJ, NY, NC, PA, RI, SC, TX, VT, VA) in mid-April, including 3 "killer" tornadoes.

Central and Eastern Winter storm, Cold Wave (February 2015)	Winter Storm	2/14/2015	2/20/2015	$3.9	30	A large winter storm and associated cold wave impacted many central, eastern and northeastern states (CT, DE, GA, IL, KY, MA, MD, ME, MI, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA). The city of Boston was particularly impacted as feet of snow continued to accumulate causing load-stress on buildings and clogging transportation corridors. Total, direct losses in Massachusetts alone exceed $1.0 ($1.3) billion for this event, with considerable damage in many other states.
West/Northeast/Southeast Drought (2016)	Drought	1/1/2016	12/31/2016	$4.5	0	California's 5-year drought persisted during 2016 while new areas of extreme drought developed in states across the Northeast and Southeast. The long-term impacts of the drought in California have damaged forests where 100+ million trees have perished and are a public safety hazard. The agricultural impacts were reduced in California as water prices and crop fallowing declined. However, agricultural impacts developed in Northeast and Southeast due to stressed water supplies.
Central and Eastern Winter Storm (January 2018)	Winter Storm	1/3/2018	1/5/2018	$1.3	22	A Nor'easter caused damage across many Northeastern states including MA, NJ, NY, CT, ME, NH, PA, MD, RI, SC, TN, VA, NC and GA.
Central and Eastern Winter Storm and Cold Wave (December 2022)	Winter Storm	12/21/2022	12/26/2022	$8.7	87	Historic winter storm and powerful arctic front caused significant impact across much of the nation, bringing heavy rains, snow, ice and high winds that sent temperatures plummeting. More than 200 million people were under a winter weather advisory or warning and more than a million customers, from Texas to Maine, were left without power. Buffalo, New York was paralyzed by near hurricane force winds and continuous snow squalls, which contributed to dozens of fatalities in the region. Additional impacts were widespread frozen water pipes that led to extensive water damage in many homes, businesses and to other critical infrastructure.
Northeastern Winter Storm / Cold Wave (February 2023)	Winter Storm	2/2/2023	2/5/2023	$1.8	1	A strong winter storm produced snow, high winds and bitter cold across numerous Northeastern states. High winds caused widespread power outages in Massachusetts while Mount Washington, New Hampshire observed a wind chill temperature of -108 degrees Fahrenheit. This was one of the coldest wind chill temperatures ever recorded in the United States.

Source: NOAA National Centers for Environmental Information (NCEI) (2023)

Attachment 3

National Risk Index Community Report for Hancock County, Maine

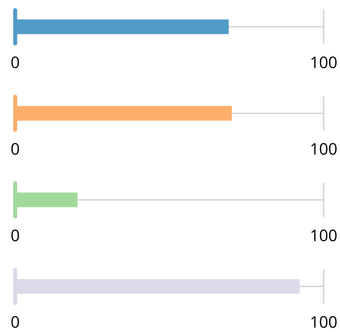
National Risk Index

October 24, 2023

Hancock County, Maine

Summary

Risk Index is **Relatively Low**	Score **69.1**	
Expected Annual Loss is **Relatively Low**	Score **70.1**	
Social Vulnerability is **Relatively Low**	Score **20.4**	
Community Resilience is **Very High**	Score **92.5**	

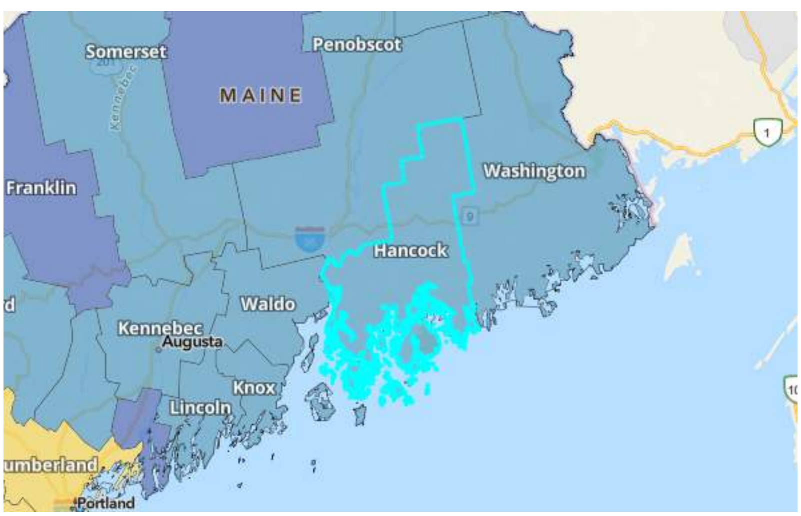


While reviewing this report, keep in mind that low risk is driven by lower loss due to natural hazards, lower social vulnerability, and higher community resilience.

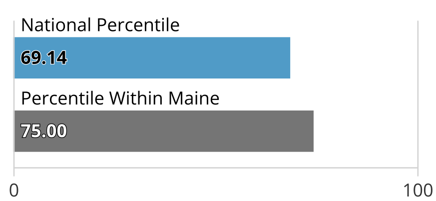
For more information about the National Risk Index, its data, and how to interpret the information it provides, please review the **About the National Risk Index** and **How to Take Action** sections at the end of this report. Or, visit the National Risk Index website at hazards.fema.gov/nri/learn-more to access supporting documentation and links.

Risk Index

The Risk Index rating is **Relatively Low** for **Hancock County, ME** when compared to the rest of the U.S.



Score	69.14



69% of U.S. counties have a lower Risk Index

75% of counties in Maine have a lower Risk Index

Risk Index Legend

Very High | Relatively High | Relatively Moderate | Relatively Low | Very Low

No Rating | Not Applicable | Insufficient Data

Hazard Type Risk Index

Hazard type Risk Index scores are calculated using data for only a single hazard type, and reflect a community's Expected Annual Loss value, community risk factors, and the adjustment factor used to calculate the risk value.

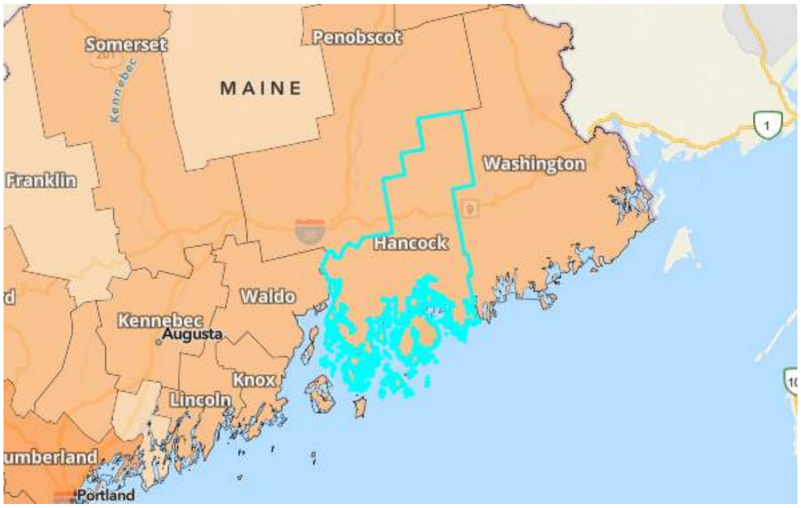
Hazard Type	Risk Index Rating	Risk Index Score	National Percentile
Avalanche	Not Applicable	--	
Coastal Flooding	Relatively Moderate	83.9	0 100
Cold Wave	Relatively Low	42.2	0 100
Drought	Relatively Low	78.5	0 100
Earthquake	Very Low	59.2	0 100
Hail	Very Low	28.7	0 100
Heat Wave	No Expected Annual Losses	0	0 100
Hurricane	Relatively Low	83.1	0 100
Ice Storm	Relatively High	94.9	0 100
Landslide	Relatively Moderate	79.9	0 100
Lightning	Relatively Moderate	79.5	0 100
Riverine Flooding	Relatively Low	36.4	0 100
Strong Wind	Relatively Low	21.2	0 100
Tornado	Very Low	19.4	0 100
Tsunami	Insufficient Data	--	
Volcanic Activity	Not Applicable	--	
Wildfire	Very Low	13.9	0 100
Winter Weather	Relatively Moderate	55.6	0 100

Risk Factor Breakdown

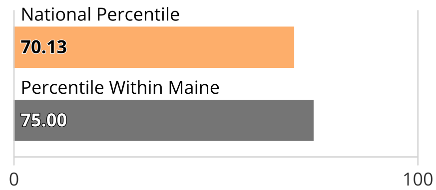
Hazard Type	EAL Value	Social Vulnerability	Community Resilience	CRF	Risk Value	Risk Index Score
Hurricane	$6,598,402	Relatively Low	Very High	1.04	$6,788,123	84.3
Coastal Flooding	$2,094,550	Relatively Low	Very High	1.04	$2,166,053	81.7
Ice Storm	$1,103,381	Relatively Low	Very High	1.04	$1,179,806	94.6
Lightning	$272,887	Relatively Low	Very High	1.04	$290,295	77.6
Earthquake	$226,918	Relatively Low	Very High	1.04	$242,617	58.5
Drought	$213,907	Relatively Low	Very High	1.04	$230,632	77.4
Riverine Flooding	$202,057	Relatively Low	Very High	1.04	$211,659	34.1
Tornado	$149,914	Relatively Low	Very High	1.04	$160,853	16.3
Landslide	$122,400	Relatively Low	Very High	1.04	$128,673	82.9
Strong Wind	$84,225	Relatively Low	Very High	1.04	$89,885	17.5
Winter Weather	$59,688	Relatively Low	Very High	1.04	$63,158	51.2
Hail	$30,221	Relatively Low	Very High	1.04	$31,998	24.8
Cold Wave	$24,969	Relatively Low	Very High	1.04	$26,423	40
Wildfire	$4,260	Relatively Low	Very High	1.04	$4,586	13
Heat Wave	$0	Relatively Low	Very High	1.04	$0	0
Avalanche	--	Relatively Low	Very High	1.04	--	--
Tsunami	--	Relatively Low	Very High	1.04	--	--
Volcanic Activity	--	Relatively Low	Very High	1.04	--	--

Expected Annual Loss

In **Hancock County, ME**, expected loss each year due to natural hazards is **Relatively Low** when compared to the rest of the U.S.



Score	**70.13**



70% of U.S. counties have a lower Expected Annual Loss

75% of counties in Maine have a lower Expected Annual Loss

Expected Annual Loss Legend

Very High · Relatively High · Relatively Moderate · Relatively Low · Very Low

No Expected Annual Losses · Not Applicable · Insufficient Data

Composite Expected Annual Loss	**$11,187,777.77**
Composite Expected Annual Loss Rate National Percentile	**56.7**

Building EAL	**$10,071,157.11**	Population EAL	**0.07** fatalities
Building EAL Rate	**$1 per $1.35K of building value**	Population EAL Rate	**1 per 800.17K people**
Agriculture EAL	**$312,881.93**	Population Equivalence EAL	**$803,738.74**
Agriculture EAL Rate	**$1 per $67.35 of agriculture value**		

Expected Annual Loss for Hazard Types

Expected Annual Loss scores for hazard types are calculated using data for only a single hazard type, and reflect a community's relative expected annual loss for only that hazard type.

15 of 18 hazard types contribute to the expected annual loss for **Hancock County, ME**.

Hazard Type	Expected Annual Loss Rating	EAL Value	Score
Hurricane	Relatively Low	$6,598,402	83.1
Coastal Flooding	Relatively Moderate	$2,094,550	83.9
Ice Storm	Relatively High	$1,103,381	94.9
Lightning	Relatively Moderate	$272,887	79.5
Earthquake	Very Low	$226,918	59.2

Hazard Type	Expected Annual Loss Rating	EAL Value	Score
Drought	Relatively Low	$213,907	78.5
Riverine Flooding	Relatively Low	$202,057	36.4
Tornado	Very Low	$149,914	19.4
Landslide	Relatively Moderate	$122,400	79.9
Strong Wind	Relatively Low	$84,225	21.2
Winter Weather	Relatively Moderate	$59,688	55.6
Hail	Very Low	$30,221	28.7
Cold Wave	Relatively Low	$24,969	42.2
Wildfire	Very Low	$4,260	13.9
Heat Wave	No Expected Annual Losses	$0	0.0
Avalanche	Not Applicable	--	--
Tsunami	Insufficient Data	--	--
Volcanic Activity	Not Applicable	--	--

Expected Annual Loss Values

Hazard Type	Total	Building Value	Population Equivalence	Population	Agriculture Value
Avalanche	--	--	--	--	--
Coastal Flooding	$2,094,550	$2,082,667	$11,883	0.00	n/a
Cold Wave	$24,969	$119	$22,503	0.00	$2,347
Drought	$213,907	n/a	n/a	n/a	$213,907
Earthquake	$226,918	$198,572	$28,346	0.00	n/a
Hail	$30,221	$18,552	$3,313	0.00	$8,356
Heat Wave	$0	$0	$0	0.00	$0
Hurricane	$6,598,402	$6,428,337	$82,397	0.01	$87,668
Ice Storm	$1,103,381	$1,071,344	$32,037	0.00	n/a
Landslide	$122,400	$105,000	$17,400	0.00	n/a
Lightning	$272,887	$1,037	$271,850	0.02	n/a
Riverine Flooding	$202,057	$103,687	$97,906	0.01	$464
Strong Wind	$84,225	$11,313	$72,825	0.01	$87
Tornado	$149,914	$45,252	$104,620	0.01	$42
Tsunami	n/a	n/a	n/a	n/a	n/a
Volcanic Activity	--	--	--	--	--
Wildfire	$4,260	$3,965	$294	0.00	$1
Winter Weather	$59,688	$1,313	$58,366	0.01	$9

Exposure Values

Hazard Type	Total	Building Value	Population Equivalence	Population	Agriculture Value
Avalanche	--	--	--	--	--
Coastal Flooding	$10,982,027,361	$341,286,668	$10,640,740,693	917.31	n/a
Cold Wave	$634,347,297,875	$12,995,090,407	$621,331,204,300	53,563.03	$21,003,168
Drought	$8,706,089	n/a	n/a	n/a	$8,706,089
Earthquake	$657,092,877,000	$13,548,077,000	$643,544,800,000	55,478.00	n/a
Hail	$656,696,577,791	$13,548,305,243	$643,127,200,000	55,442.00	$21,072,548
Heat Wave	$0	$0	$0	0.00	$0
Hurricane	$656,696,577,791	$13,548,305,243	$643,127,200,000	55,442.00	$21,072,548
Ice Storm	$654,864,088,743	$13,484,686,064	$641,379,402,679	55,291.33	n/a
Landslide	$244,834,001,035	$5,015,555,709	$239,818,445,327	20,674.00	n/a
Lightning	$656,675,505,243	$13,548,305,243	$643,127,200,000	55,442.00	n/a
Riverine Flooding	$14,049,528,756	$363,615,002	$13,685,794,655	1,179.81	$119,098
Strong Wind	$656,696,577,791	$13,548,305,243	$643,127,200,000	55,442.00	$21,072,548
Tornado	$656,696,577,791	$13,548,305,243	$643,127,200,000	55,442.00	$21,072,548
Tsunami	n/a	n/a	n/a	n/a	n/a
Volcanic Activity	--	--	--	--	--
Wildfire	$41,607,819,338	$777,091,535	$40,829,845,479	3,519.81	$882,324
Winter Weather	$656,696,577,791	$13,548,305,243	$643,127,200,000	55,442.00	$21,072,548

Annualized Frequency Values

Hazard Type	Annualized Frequency	Events on Record	Period of Record
Avalanche	--	--	--
Coastal Flooding	10.6 events per year	n/a	Various (see documentation)
Cold Wave	0.1 events per year	1	2005-2021 (16 years)
Drought	3.6 events per year	105	2000-2021 (22 years)
Earthquake	0.080% chance per year	n/a	2021 dataset
Hail	0.5 events per year	14	1986-2021 (34 years)
Heat Wave	0 events per year	0	2005-2021 (16 years)
Hurricane	0.1 events per year	23	East 1851-2021 (171 years) / West 1949-2021 (73 years)
Ice Storm	1.3 events per year	65	1946-2014 (67 years)
Landslide	0 events per year	0	2010-2021 (12 years)
Lightning	5.2 events per year	89	1991-2012 (22 years)
Riverine Flooding	1 event per year	24	1996-2019 (24 years)

Hazard Type	Annualized Frequency	Events on Record	Period of Record
Strong Wind	0.8 events per year	22	1986-2021 (34 years)
Tornado	0 events per year	0	1950-2021 (72 years)
Tsunami	n/a	n/a	1800-2021 (222 years)
Volcanic Activity	--	--	--
Wildfire	0.002% chance per year	n/a	2021 dataset
Winter Weather	6.8 events per year	85	2005-2021 (16 years)

Historic Loss Ratios

Hazard Type	Overall Rating
Avalanche	--
Coastal Flooding	Relatively Low
Cold Wave	Very Low
Drought	Relatively High
Earthquake	Relatively Low
Hail	Relatively Low
Heat Wave	No Rating
Hurricane	Relatively High
Ice Storm	Relatively Moderate
Landslide	Relatively Low
Lightning	Very High
Riverine Flooding	Very Low
Strong Wind	Very Low
Tornado	Relatively Low
Tsunami	Insufficient Data
Volcanic Activity	--
Wildfire	Very Low
Winter Weather	Very Low

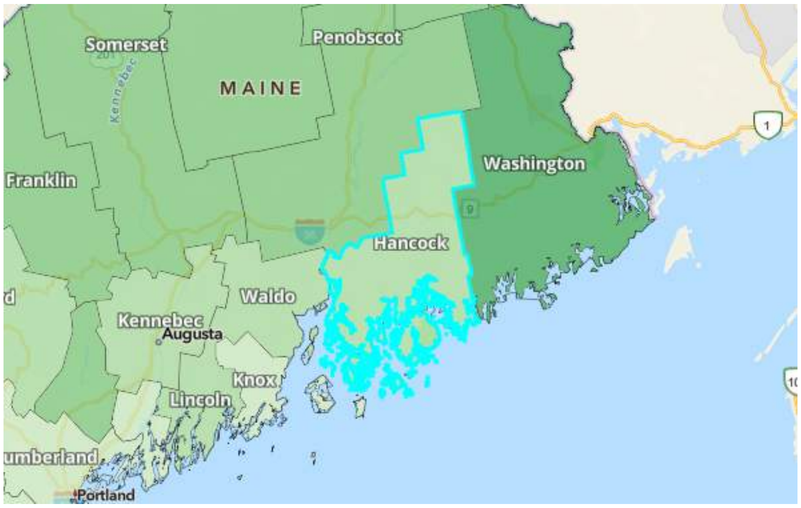
Expected Annual Loss Rate

Hazard Type	Building EAL Rate (per building value)	Population EAL Rate (per population)	Agriculture EAL Rate (per agriculture value)
Avalanche	--	--	--
Coastal Flooding	$1 per $6.51K	1 per 54.12M	--
Cold Wave	$1 per $114.01M	1 per 28.58M	$1 per $8.98K
Drought	--	--	$1 per $98.51

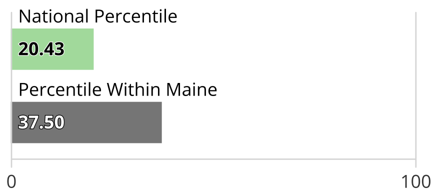
Hazard Type	Building EAL Rate (per building value)	Population EAL Rate (per population)	Agriculture EAL Rate (per agriculture value)
Earthquake	$1 per $68.23K	1 per 22.69M	--
Hail	$1 per $730.28K	1 per 194.14M	$1 per $2.52K
Heat Wave	--	--	--
Hurricane	$1 per $2.11K	1 per 7.81M	$1 per $240.37
Ice Storm	$1 per $12.65K	1 per 20.07M	--
Landslide	$1 per $129.03K	1 per 36.96M	--
Lightning	$1 per $13.06M	1 per 2.37M	--
Riverine Flooding	$1 per $130.67K	1 per 6.57M	$1 per $45.40K
Strong Wind	$1 per $1.20M	1 per 8.83M	$1 per $241.94K
Tornado	$1 per $299.40K	1 per 6.15M	$1 per $497.13K
Tsunami	--	--	--
Volcanic Activity	--	--	--
Wildfire	$1 per $3.42M	1 per 2.19B	$1 per $21.43M
Winter Weather	$1 per $10.32M	1 per 11.02M	$1 per $2.25M

Social Vulnerability

Social groups in **Hancock County, ME** have a **Relatively Low** susceptibility to the adverse impacts of natural hazards when compared to the rest of the U.S.



Score	20.43



20% of U.S. counties have a lower Social Vulnerability

38% of counties in Maine have a lower Social Vulnerability

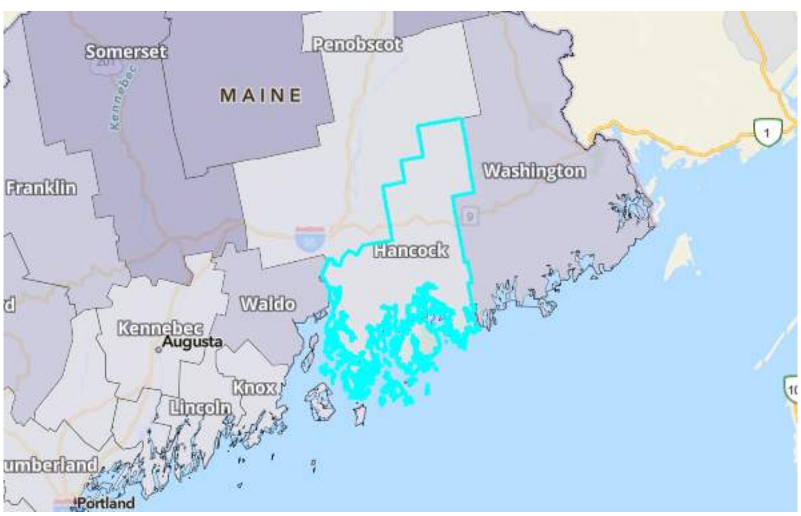
Social Vulnerability Legend

Very High · Relatively High · Relatively Moderate · Relatively Low · Very Low

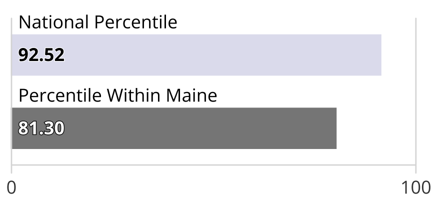
Data Unavailable

Community Resilience

Communities in **Hancock County, ME** have a **Very High** ability to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions when compared to the rest of the U.S.



Score	92.52



8% of U.S. counties have a higher Community Resilience

19% of counties in Maine have a higher Community Resilience

Community Resilience Legend

Very High · Relatively High · Relatively Moderate · Relatively Low · Very Low

Data Unavailable

About the National Risk Index

The National Risk Index is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards: Avalanche, Coastal Flooding, Cold Wave, Drought, Earthquake, Hail, Heat Wave, Hurricane, Ice Storm, Landslide, Lightning, Riverine Flooding, Strong Wind, Tornado, Tsunami, Volcanic Activity, Wildfire, and Winter Weather.

The National Risk Index leverages available source data for Expected Annual Loss due to these 18 hazard types, Social Vulnerability, and Community Resilience to develop a baseline relative risk measurement for each United States county and Census tract. These measurements are calculated using average past conditions, but they cannot be used to predict future outcomes for a community. The National Risk Index is intended to fill gaps in available data and analyses to better inform federal, state, local, tribal, and territorial decision makers as they develop risk reduction strategies.

Explore the National Risk Index Map at **hazards.fema.gov/nri/map**.

Visit the National Risk Index website at **hazards.fema.gov/nri/learn-more** to access supporting documentation and links.

Calculating the Risk Index

Risk Index scores are calculated using an equation that combines scores for Expected Annual Loss due to natural hazards, Social Vulnerability and Community Resilience:

Risk Index = Expected Annual Loss × Social Vulnerability ÷ Community Resilience

Risk Index scores are presented as a composite score for all 18 hazard types, as well as individual scores for each hazard type.

For more information, visit **hazards.fema.gov/nri/determining-risk**.

Calculating Expected Annual Loss

Expected Annual Loss scores are calculated using an equation that combines values for exposure, annualized frequency, and historic loss ratios for 18 hazard types:

Expected Annual Loss = **Exposure** × **Annualized Frequency** × **Historic Loss Ratio**

Expected Annual Loss scores are presented as a composite score for all 18 hazard types, as well as individual scores for each hazard type.

For more information, visit **hazards.fema.gov/nri/expected-annual-loss**.

Calculating Social Vulnerability

Social Vulnerability is measured using the Social Vulnerability Index (SVI) published by the Centers for Disease Control and Prevention (CDC).

For more information, visit **hazards.fema.gov/nri/social-vulnerability**.

Calculating Community Resilience

Community Resilience is measured at the County level using the Baseline Resilience Indicators for Communities (HVRI BRIC) published by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI).

For more information, visit **hazards.fema.gov/nri/community-resilience**.

How to Take Action

There are many ways to reduce natural hazard risk through mitigation. Communities with high National Risk Index scores can take action to reduce risk by decreasing Expected Annual Loss due to natural hazards, decreasing Social Vulnerability, and increasing Community Resilience.

For information about how to take action and reduce your risk, visit **hazards.fema.gov/nri/take-action**.

Disclaimer

The National Risk Index (the Risk Index or the Index) and its associated data are meant for planning purposes only. This tool was created for broad nationwide comparisons and is not a substitute for localized risk assessment analysis. Nationwide datasets used as inputs for the National Risk Index are, in many cases, not as accurate as available local data. Users with access to local data for each National Risk Index risk factor should consider substituting the Risk Index data with local data to recalculate a more accurate risk index. If you decide to download the National Risk Index data and substitute it with local data, you assume responsibility for the accuracy of the data and any resulting data index. Please visit the **Contact Us** page if you would like to discuss this process further.

The methodology used by the National Risk Index has been reviewed by subject matter experts in the fields of natural hazard risk research, risk analysis, mitigation planning, and emergency management. The processing methods used to create the National Risk Index have produced results similar to those from other natural hazard risk analyses conducted on a smaller scale. The breadth and combination of geographic information systems (GIS) and data processing techniques leveraged by the National Risk Index enable it to incorporate multiple hazard types and risk factors, manage its nationwide scope, and capture what might have been missed using other methods.

The National Risk Index does not consider the intricate economic and physical interdependencies that exist across geographic regions. Keep in mind that hazard impacts in surrounding counties or Census tracts can cause indirect losses in your community regardless of your community's risk profile.

Nationwide data available for some risk factors are rudimentary at this time. The National Risk Index will be continuously updated as new data become available and improved methodologies are identified.

The National Risk Index Contact Us page is available at **hazards.fema.gov/nri/contact-us**.

Attachment 4

Federal Funding Programs for Electricity Resilience Investments

Table 1
Example of Key Federal Programs Supporting Electricity Resilience Investments.

Federal Program	Funding Mechanism/Cost share	Dependent upon Disaster Declaration	EligibilityApplicant/ Recipients[1]	Example of Eligible Response Measures
FEMA Pre-Disaster Mitigation	Annual Appropriation/75 % fed/ 25 % non-fed	No	State, Tribal, Territorial/Local Government	Damaged and undamaged infrastructure/Hazard mitigation planning
FEMA Building Resilient Infrastructure and Communities	6% of annual amount spent on disaster response:75% fed/ 25% non-fed	Yes	State, Tribal, Territorial/Local Government	Damaged and undamaged infrastructure/Hazard mitigation planning/Technical Assistance
FEMA Hazard Mitigation Grant	Supplemental Appropriation/75 % fed/ 25 % non-fed	Yes	State, Tribal, Territorial/Local Government	Damaged and undamaged infrastructure/Hazard mitigation planning
FEMA Public Assistance	Supplemental Appropriation/75 % fed/ 25 % non-fed	Yes	State, Tribal, Territorial/Local Government & private non-profits	Damaged infrastructure, including energy assets
HUD CDBG-Disaster Recovery	Supplemental Appropriation/No cost share	Yes	State, Tribal, Territorial/Local Government & private non-profits	Damaged and undamaged infrastructure Low income community focus
HUD CDBG-Mitigation	Supplemental Appropriation/No cost share	Yes	Same as above but with private owned utility waiver provision	Damaged and undamaged infrastructure/Hazard mitigation planning Low income community focus
Public Transportation Emergency Relief Program	Annual and Supplemental Appropriations	Yes	Public transit operators	Damages related to public transportation systems
Economic Adjustment Assistance Program	Annual and Supplemental Appropriations	No	State and local governments and non-profit organizations in communities in distress	Electricity infrastructure investment to increase community's resiliency to natural disasters
Disaster Loan Assistance, Small Business Act, Section 7B	Low interest loans	Yes	Private individuals, non-profits, and small businesses	Protect against property damage or economic losses by electricity improvements.
State Energy Program, Energy Policy and Conservation Act	No cos share	No	States and Territories	Advance energy initiatives for energy security, resilience, and emergency preparedness
Weatherization Assistance Program, Energy Conservation and Production Act	No cost share	No	States	Support for energy assessments of homes' efficiency, and efficiency improvements (e.g. installing insulation, improved HVAC systems, and more efficient lighting and appliances)
National Coastal Zone Management Program and Enhancement Program, Coastal Zone Management Act of 1972	No cost share	No	States	Planning and data collecting for infrastructure siting, and providing technical assistance and training
Rural Electricity Service Electric Program, Rural Electrification Act of 1936	No cost share	No	Wholesale and retail providers of rural electricity	Generation, transmission and distribution infrastructure

Source: Zamuda and Ressler (2020)

Appendix G Clean Drinking Water and Drought Vulnerability Assessment

Memo

To: Mr. Allen Kratz

From: Leila Pike, P.E. (GEI), Alison Brady (GEI), Lissa Robinson, P.E. (GEI)

cc: Gayle Bowness (GMRI), Stephanie Sun (GMRI)

Date: December 3, 2024

Re: Clean Drinking Water and Drought Vulnerability Assessment
Climate Vulnerability Assessment
Towns of Blue Hill, Brooksville, and Surry, Maine
GEI Project No. 2303435

GEI Consultants, Inc. has reviewed existing data on the sources and vulnerability of clean drinking water for the Towns of Blue Hill, Brooksville, and Surry, Hancock County, Maine (the "Towns") and we have summarized the findings in this memo.

This memo is part of a larger vulnerability study funded with a Community Action Grant through the Governor's Office of Policy Innovation and the Future (GOPIF) Community Resilience Partnership with additional funding support from the Town of Brooksville. This work is based on our proposal dated August 4, 2023.

Drinking Water Sources

Drinking water for the Towns of Blue Hill, Brooksville, and Surry is primarily sourced from drilled bedrock wells (Maine DHHS, 2023). Bedrock wells supply both private and public drinking water systems. Records at the State of Maine Drinking Water Program indicated no surface water (i.e., lakes or ponds) or surficial (i.e., dug wells in soil) public drinking water sources in the three towns although it is possible there may be private systems served by these types of sources.

State and federal records indicated a total of 25 public water systems in the 3 towns serving a population of 4,174 people (Maine DHHS, 2023). Attachment 1 includes a list of public water systems by town that are comprised mainly of schools and childcare facilities, medical offices, and restaurants. These water systems are classified as public because they serve more than 25 individuals; however, they are not necessarily available as a water source for the public outside of the facilities that they serve. Attachment 2 presents the population per system. It is likely that these public water systems supplement the private systems for a large percentage of the populations since, for example, students attending schools with public water systems return home to private water supply systems. Records indicated no town-wide, municipal, or quasi-municipal public water supply systems in these three towns thereby suggesting that the overarching majority of residents in the towns rely on private ground water wells for their source of drinking water. The exception would be residents who live, for example, in facilities that are served by public water systems.

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Portland, ME 04101
207.797.8901

The state of Maine identifies public water systems as follows:

> *"A public water system is defined as any publicly or privately-owned system of pipes or other constructed conveyances, structures and facilities through which water is obtained for or sold, furnished or distributed to the public for human consumption, if such system has at least 15 service connections or serves at least 25 individuals daily at least 60 days out of the year or bottles water for sale." (Maine DHHS, 2022).*

Hydrogeologic Setting

Drinking water wells are typically located in either bedrock or surficial material (i.e., soil) such as sand and gravel (Fig. 1). Since the wells in the three towns are primarily constructed in bedrock, viability as drinking water source depends on several key factors: the bedrock must be fractured, sufficiently saturated, and able to be recharged by precipitation that falls on the ground and infiltrates through overlying sediments. The highest yielding bedrock wells are typically located in areas with fractured bedrock that is overlain by sand and gravel, and sandy glacial till, some of the more highly transmissive surficial materials. In contrast, clay soils and impervious land cover (i.e., paved parking lots) may allow some recharge but these land cover types significantly limit the recharge capacity of bedrock aquifers.

Sand and gravel aquifers were formed as water melted from the glaciers and wells constructed in these surficial materials are typically a high-yielding material. However, these aquifers are found in limited areas around the state and so most residential wells in Maine are drilled into fractured bedrock (MGS, 2012).

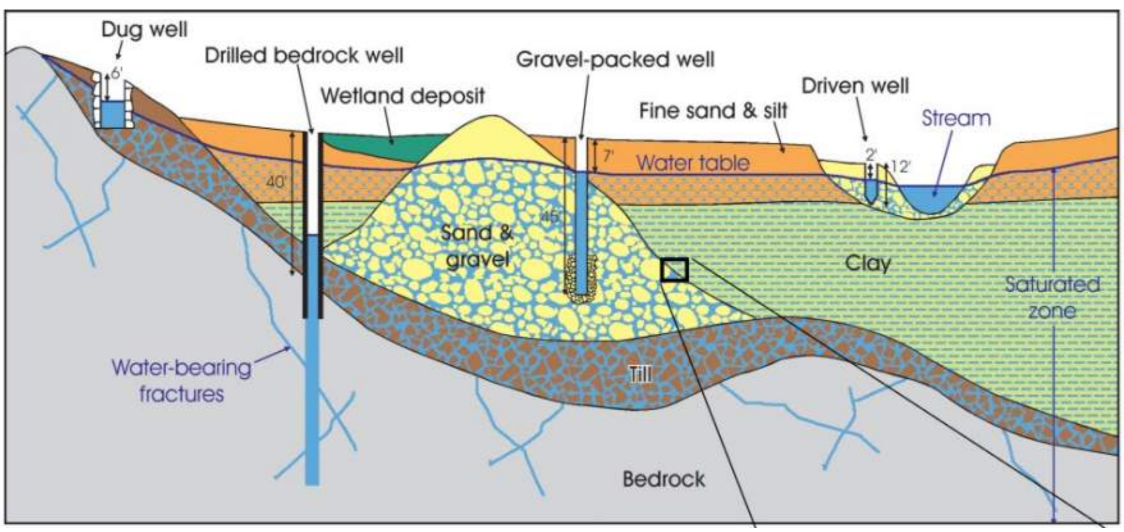


Fig. 1 Diagram of well types and aquifers (MGS, 2012)

The Maine Geological Survey (MGS) recognized the value of sand and gravel deposits for their high water quality and quantity potential and initiated an extensive program to map Significant Sand and Gravel Aquifers in the state, including Blue Hill and Surry. Surficial deposits with the potential to yield more than 10 gallons per minute from surficial materials are delineated on Significant Sand and Gravel Aquifer Maps.

Sand and Gravel Aquifer maps indicated limited areas of sand and gravel deposits in the Towns of Blue Hill and Surry. The available MGS Significant Sand and Gravel Aquifer Maps that include the Towns of Blue Hill and Surry are provided in Attachment 3. The Town of Brooksville was not included in this mapping effort.

In addition to sand and gravel aquifer mapping, lineament maps are also a useful indicator of bedrock ground water availability (MGS, 2023b). The occurrence of permeable, high-yield zones in bedrock is related to geologic structures such as faults and joints that often exist as linear features. These linear features can be mapped by geologists with photolineament analysis using airborne methods such as Side Looking Airborne Radar (SLAR) imagery and by using stereo photographs and a desk-top stereoscope.

Lineament data for the three towns was available on the map titled "Lineaments, High-Yield Bedrock Wells, and Potential Bedrock Recharge Areas in the Bangor 2 Degree Sheet" (MGS, 1986). This map is included in Attachment 3 and shows linear features (length and orientation) that were mapped at a scale of 1:250,000 from Side Looking Airborne Radar (SLAR) imagery. The maps also show the location of high-yield bedrock wells (i.e., wells with estimated yield of more than 10 gallons per minute) and shaded areas depicting locations of potential bedrock recharge.

The Maine Geologic Survey (MGS) has served as an important steward for geologic and water resource mapping. MGS has many publications and maps available for online viewing and downloading. Bedrock and surficial geology maps are also a good source of information about geologic settings and their associated water bearing characteristics. Furthermore, the "Ground Water Handbook for the State of Maine" (Caswell, 1987) is a handbook written in a non-technical style that discusses the principles of ground water hydrology, available hydrogeologic data, and specific problems and case studies.

While high-yield bedrock wells are generally considered to be of value to homeowners, it is important to note that significant pumping of wells near the ocean have the potential to incur saltwater intrusion, a topic covered in the section below. Similarly, wells located near septic systems have the potential for contamination from nitrate-nitrogen, bacteria, and viruses if there is insufficient distance between a well and septic system.

Drinking Water Quality

With strong reliance on ground water as a drinking water source, it is not only important for there to be sufficient quantity of water but also that the water is potable and safe to drink. With time, standards and guidelines have been put in place to protect drinking water quality and safeguard human health.

In 1974, federal legislation passed the Safe Drinking Water Act, which led to the definition of federal drinking water standards for inorganic parameters in public water supplies, effective 1977. Under this legislation, the federal Environmental Protection Agency (EPA) established two levels (primary and secondary) of drinking water standards. EPA National Primary Drinking Water Regulations (primary standards) are the highest level of a contaminant that is allowed in public drinking water. EPA has determined that concentrations exceeding the primary standard present a health risk. The EPA primary standards are legally enforceable standards that apply to public water systems.

The EPA National Secondary Drinking Water Regulations (secondary standards) are non-enforceable guidelines. Secondary standards regulate contaminants that may cause cosmetic effects (such as skin or tooth discoloration), aesthetic effects (taste, odor, or color) or technical effects (such as damage to water equipment or reduced effectiveness of treatment for other contaminants).

In Maine, the Center for Disease Control and Prevention developed drinking water guidelines called Maximum Exposure Guidelines (MEGs) for certain parameters to assist individuals in making decisions regarding the suitability for human consumption of drinking water contaminated with chemicals. According to the Maine CDC, MEGs represent the most recent recommendations for concentrations of chemical contaminants in drinking water below which there is minimal risk of a deleterious health effect resulting from long-term ingestion of water. Maine MEGs are non-enforceable standards.

Public water systems in Maine are required to routinely monitor their water quality and the Maine Department of Health and Human Services (DHHS) Drinking Water Program (DWP) is responsible for ensuring public water systems comply with federal and state regulations on drinking water (ASCE, 2020). Private, non-public water system wells, typically used for residential homes, are not regulated under the federal Safe Drinking Water Act or state law and homeowners are responsible for maintaining their own water quality (MCC, 2020).

Wells can be contaminated through naturally occurring contaminants (e.g., arsenic, uranium, radon, sea water) or through human-related activities, such as onsite wastewater disposal (i.e., septic systems, and/or the storage, transport, and/or spilling of hazardous material (e.g., pesticides or oil spills). Water quality testing helps to understand the potential constituents present in ground water and it is important to test wells on a regular basis. It is also important to understand the land use within the wells recharge zone and to ensure sufficient distance between potential contaminant (i.e., septic systems, petroleum, and hazardous materials etc.) and sensitive receptor (i.e., drinking water well). Fig. 2 depicts how surface contamination could compromise water quality in a sand and gravel aquifer.

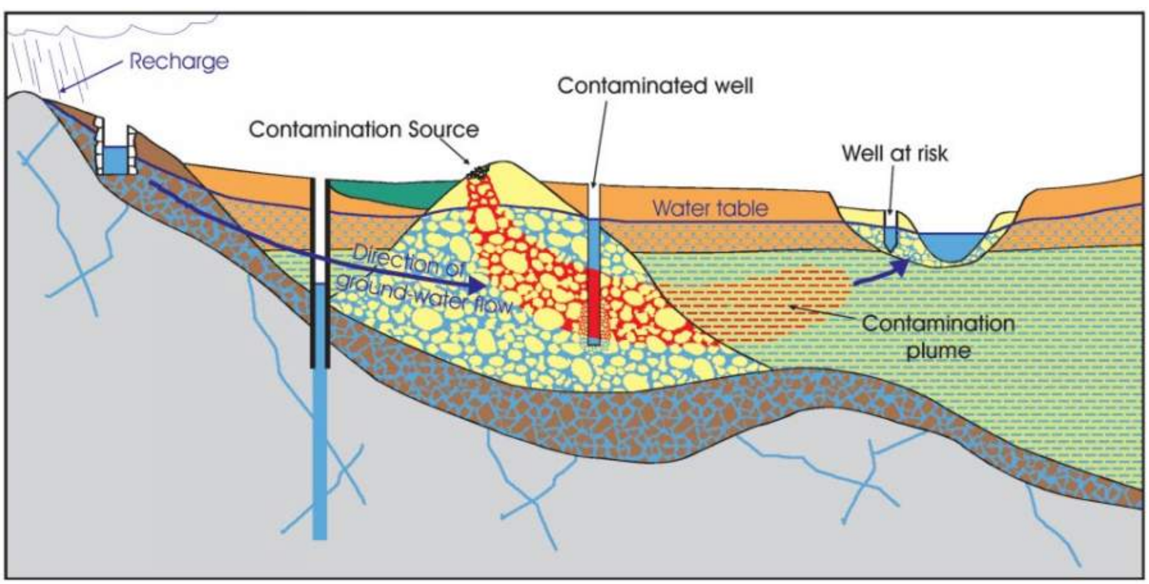


Fig. 2 Example of a contamination plume (MGS, 2005)

While public water systems must comply with routine water quality testing requirements, private well owners are not required to have their well water tested. Private well owners may test water quality on a voluntarily basis through the State of Maine Health and Environmental Testing Laboratory (HETL) or other private testing labs. The Maine CDC Maine Tracking Network has provided a summary of water quality results for wells tested for contamination through the Maine HETL from 1999 – 2013. The dataset included results for 175 wells in Blue Hill, 99 wells in Brooksville, and 176 wells in Surry. The results indicated that in many instances, private well water exceeds the thresholds for contamination, particularly for arsenic where the threshold was exceeded by 41.1% of the tested private wells in Blue Hill, 17.2% of the tested private wells in Brooksville, and 45.5% of the tested private wells in Surry. These results, along with the results for other contaminants tested, are summarized in Attachment 4.

We have provided reference information from the Maine DHHS on well testing for private wells, testing for arsenic, and guidance for well owners with elevated arsenic levels. These materials are in Attachment 5.

Saltwater Intrusion

Saltwater intrusion poses a significant risk to residents of coastal Maine due to its presence and persistence and once contaminated, due to the difficulty to return to potable water quality. This threat is of particular concern for coastal communities in which aquifers provide the sole source of drinking water such as the case for Blue Hill, Brooksville, and Surry. Changing patterns in precipitation, sea level rise, and increased pressure on desire to live on the coast have the potential to worsen the threat of saltwater intrusion on drinking water wells.

The potential for saltwater intrusion is a function of ground water elevation and total well depth relative to the tidal elevations. A relationship known as the Ghyben-Herzberg Ratio estimates the static or non-flowing thickness of the freshwater lens over seawater (MGS, 1986). Typically used in island and peninsula settings, this relationship is based on the difference in density between seawater and freshwater. The Ghyben–Herzberg ratio states that, for every foot of fresh water in an unconfined aquifer above sea level, there will be forty feet of fresh water in the aquifer below sea level. The Ghyben-Herzberg Ratio is written as:

$$(h_{salt} + h_{fresh}) \times 1.000 = (h_{salt}) \times 1.025$$

This equation can be simplified to:

$$h_{salt} = 40\ h_{fresh}$$

where:

h_{salt} = thickness of the freshwater lens below Mean Sea Level.

h_{fresh} = the height of the water table above Mean Sea Level.

1.000 = density of freshwater

1.025 = density of seawater

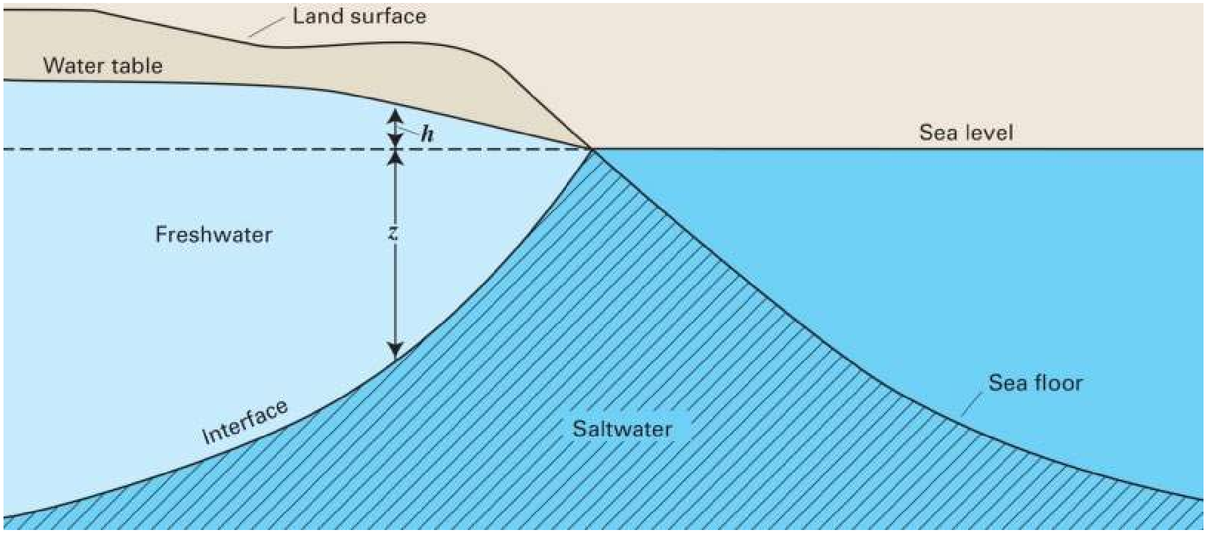


Fig. 3 Ghyben-Herzberg Ratio (SMPDC, 2023)

It is important to perform water quality testing at private wells, especially those located close to the shore (i.e., within 600 feet). As conditions change in time, regular water quality testing can help guide homeowner decisions regarding well pumping rates, well proximity to septic systems, fertilizer and road salt application, and a host of other potential natural and man-made threats to drinking water quality. If continued degradation in water quality is observed, the homeowner may need to consider well relocation (i.e., away from potential contamination sources).

Drought Conditions

Maine is typically characterized by a diverse climate that is not usually associated with drought. However, drought is a normal recurring feature in all climatic regions. Maine experienced its most damaging drought to date during the period from 1999 to 2002 (NOAA, 2023). In the 9 months leading up to April 2002, approximately 17,000 private wells in Maine ran dry. More recently, Maine experienced significant droughts in 2016 and during the period from 2020 to 2022. Hancock County, Maine experienced drought conditions during the summer of 2022 (NOAA, 2023). Attachment 6 contains a graph showing historic drought conditions from 2001 to 2023.

NOAA and the U.S. Drought Monitor use a 5-category system to classify drought: abnormally dry, moderate drought, severe drought, extreme drought, and exceptional drought.

Drought conditions have the potential to significantly lower ground water levels in wells and it is possible for some shallow wells to run dry under drought conditions. Lower ground water levels also have the potential to increase the threat of saltwater intrusion in wells located close to the coast.

Drinking Water and Climate Change

Drinking water supplied by wells in the Towns of Blue Hill, Brooksville, and Surry is threatened by climate change due to issues related to both water quantity and water quality based on impacts from, for example, saltwater intrusion from sea level rise and reduced groundwater recharge due to changing patterns in precipitation.

Sea level rise will likely lead to an increased risk of saltwater intrusion due to the inward movement of the salt/freshwater lens from higher sea water levels. Overtopping and inundation of uplands during coastal storm events also have the potential to threaten well casings located in close proximity to the coast where poor seals on well casings could allow saltwater to enter the well and contaminate drinking water supplies.

The results of our flood vulnerability analysis for the Towns of Blue Hill, Brooksville, and Surry suggested that approximately 13 wells in Blue Hill, 16 wells in Brooksville, and 8 wells in Surry are at risk of coastal flood inundation due to 100-yr coastal storm surge and sea level rise between now and 2070 (GEI, 2023).

Sea level rise may also reduce the quantity of freshwater available, and lead to increased chance of saltwater intrusion, due to the advancement of the saltwater interface landward, which would likely reduce the thickness of the freshwater lens (Fig. 4). Deep wells closer to the shoreline and have an increased risk of experiencing saltwater intrusion. Table 1 provides a summary of the number of wells at various depths for the Towns of Blue Hill, Brooksville, and Surry.

Fig. 4 Sea level rise and saltwater intrusion of well water (Carver and Shaffner, 2017)

Table 1. Number of Wells by Town (MGS, 2023)

Well Depth Range (ft)	Number of Wells by Town		
	Blue Hill	Brooksville	Surry
0.0-50.0	0	3	0
50.1-100.0	33	47	13
100.1-150.0	93	70	33
150.1-200.0	104	53	44
200.1-250.0	96	42	51
250.1-300.0	60	33	55
300.1-400.0	114	45	61
400.1-500.0	34	17	31
500.1-600.0	12	3	6

Well Depth Range (ft)	Number of Wells by Town		
	Blue Hill	Brooksville	Surry
600.1-800.0	1	0	2
800.1-1000.0	0	0	0
1000.1+	0	0	0

Climate change will likely lead to a decrease in groundwater recharge due to changing precipitation patterns. The Maine Climate Council Scientific and Technical Subcommittee (2020) provides a summary of precipitation trends for the State of Maine. The report outlines that while the total amount of annual precipitation in Maine has increased by approximately 6 inches since 1895, more of the precipitation is occurring during extreme rainfall events. Extreme rainfall events, or heavy precipitation over a relatively short period of time, often lead to less groundwater recharge than the same quantity of precipitation over a longer duration of time because there is less of a chance of the water infiltrating through the soil during intense rainfall where precipitation does not have enough residence time to infiltrate and therefore flows as runoff across the saturated ground. The increased frequency of extreme precipitation events likely to occur due to climate change would likely contribute to less groundwater recharge. Additionally, extreme rainfall events may contribute to increased runoff and contamination of freshwater drinking sources, including groundwater.

Recommendations

GEI has developed this study to evaluate impacts to drinking water from climate change by reviewing existing data on the sources and vulnerability of drinking water for the Towns of Blue Hill, Brooksville, and Surry, Hancock County, Maine (the "Towns"). From our evaluation, we have developed the following recommendations for consideration:

- Develop town-wide policies to manage threats to drinking water (i.e., guidelines for storage of petroleum and hazardous materials, fertilizer application guidance, testing for and protection from Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), recommended separation distances between the shoreline and new water supply wells, well to well, and well to septic systems).
- Consider landuse ordinance language to limit new well installation in areas prone to storm surges, flooding, erosion, and to limit new wells in areas where appropriate setbacks cannot be maintained between new wells and existing wells, septic systems, and the ocean.
- Review the Comprehensive Plan for the Towns to foster planning that protects vulnerable assets (wells, roads, utilities) from issues related to climate change (i.e., flooding from rain, inundation from sea level rise and wave runup).
- Review the zoning ordinance to foster activities to protect ground water resources and encourages recharge (i.e., limit impervious area for new development, encourage rain gardens).
- Review land use activities in the vicinity of water supply wells for water softeners, storage of materials, road salt, or other activities that might impact water quality in wells.
- Educate the public about the importance of water quality testing at private wells for constituents such as septic system contamination, saltwater intrusion, contributions from runoff during extreme precipitation events, and other suspected contamination sources.

- Consider creating a public water source that can be used in the event of power outages.
- Compile historic data on precipitation throughout the towns and encourage additional citizen weather stations such as those on Weather Underground (Fig. 5). This will help understand trends in precipitation and potential impacts (dry wells) during low precipitation conditions.

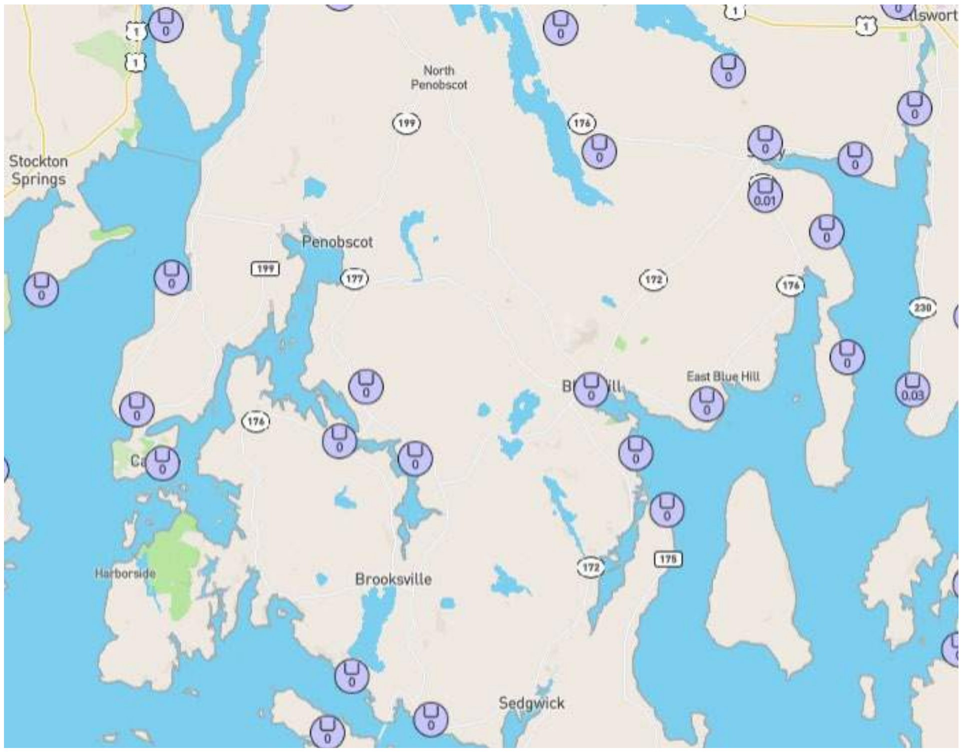


Fig. 5 Weather Underground Precipitation Stations for Hancock County, ME

- Contact the Maine Geological Survey to learn more about ongoing monitoring programs to understand the impact of sea level rise on ground water quality and drinking water wells.
- Take an inventory of impacts. For example, consider town-wide questionnaires to inquire about impacts to well water quantity and quality from drought, saltwater intrusion or other conditions.
- Check in with other communities like Islesboro who have distributed surveys and conducted monitoring programs to understand the health of the ground water as a drinking water source.
- Consider applying for grant funding available through USDA Emergency Community Water Assistance Grants (Attachment 5) to develop a public water supply system in denser areas of the towns (i.e., < ¼ acre lots) where water quality and quantity may be threatened. Grants of up to $1.0M are available for communities of 10,000 people or less to explore constructing new drinking water sources in response to drought or flood conditions.
- Consider implementing a public water source available during power outages.

Limitations

This memo presents the initial findings of drinking water vulnerability for the Towns of Blue Hill, Brooksville, and Surry, Maine based on readily available online information and published references. Reuse of this report for any purposes, in part of in whole, is at the sole risk of the user.

References

ASCE (2020). Report Card for Maine's Infrastructure. December. Retrieved from https://infrastructurereportcard.org/maine.

Carver, S. and Shaffner, R. (2017). Municipal Planning Assistance Program of the Maine Department of Agriculture Conservation and Forestry. Municipal Climate Adaptation Guidance Series: Drinking Water.

Caswell, W.B. (1987). Ground Water Handbook for the State of Maine. Maine Geologic Survey Bulletin 39.

Environmental Protection Agency (EPA) (2017). Consumer Confidence Reports (CCR). May. Retrieved from: https://ordspub.epa.gov/ords/safewater/f?p=136:102.

GEI Consultants, Inc. (2023). DRAFT Flood Vulnerability Analysis Results. Climate Vulnerability Assessment. Towns of Blue Hill, Brooksville, and Surry, Maine. November.

Maine Center for Disease Control and Prevention (CDC) (2023). Private Well Water. May. Retrieved from Maine Tracking Network: https://data.mainepublichealth.gov/tracking/private-wells.

Maine Climate Council (MCC) (2020). Scientific Assessment of Climate Change and Its Effects in Maine, August.

Maine Department of Health & Human Services (DHHS) (2023). Maine Public Water Systems By County. September. Retrieved from Information for Drinking Water Consumers: https://www.maine.gov/dhhs/mecdc/environmental-health/dwp/consumers.shtml.

Maine Department of Health & Human Services (DHHS) (2022). What is a Public Water System? December. Retrieved October 27, 2023, from: https://www.maine.gov/dhhs/mecdc/environmental-health/dwp/pws/whataPWS.shtml.

Maine Geological Survey (MGS) (2023a). Water Well Database. October. Retrieved from https://www.maine.gov/dacf/mgs/pubs/digital/well.htm.

Maine Geological Survey (MGS) (2023b). Lineament Digital Data. Retrieved November 2023 from: https://www.maine.gov/dacf/mgs/pubs/digital/lineaments250.htm.

Maine Geological Survey (MGS) (2012). Water Resources in Maine. Retrieved November 2023 from: https://www.maine.gov/dacf/mgs/explore/water/facts/water.htm.

Maine Geological Survey (MGS) (2005). Sand and Gravel Aquifers. Retrieved November 2023 from: https://www.maine.gov/dacf/mgs/explore/water/facts/aquifer.htm.

Maine Geological Survey (MGS) (1986). Lineaments, High-Yield Bedrock Wells, and Potential Bedrock Recharge Areas in the Bangor 2 Degree Sheet. Open-Fire No. 86-69.

NOAA (2023). National Integrated Drought Information System. Accessed November 2023 from: https://www.drought.gov/states/maine#historical-conditions.

Southern Maine Planning and Development Commission (SMPDC) (2023). Sea-Level Rise and Seawater Intrusion in Coastal Aquifers. Presentation by Ryan P. Gordon, Hydrogeologist with the Maine Geological Survey. Retrieved November 2023 from: https://smpdc.org/vertical/Sites/%7B14E8B741-214C-42E2-BE74-5AA9EE0A3EFD%7D/uploads/Dr._Ryan_Gordons_Presentation.pdf.

United States Census Bureau (US Census) (2023) Explore Census Data. Retrieved November 2023 from: https://data.census.gov/.

[LAP/ACB/LCR:bdp]

Attachments:

Attachment 1. Public Drinking Water Sources
Attachment 2. Public Water and Census
Attachment 3. MGS Maps
Attachment 4. Water Quality Results Data
Attachment 5. Emergency Community Water Assistance Grants Fact Sheet
Attachment 6. U.S. Drought Monitor for Hancock County

Attachment 1

Public Drinking Water Sources

HANCOCK

BLUE HILL

PUBLIC WATER SYSTEM NAME	PWSID	OPER-ATING CTGRY	WATER SYSTEM TYPE	SOURCE	SOURCE TYPE
MSU 93 BLUE HILL CONSOLIDATED SCHOOL	ME0000099	2T/1D	NTNC		
				250' BR WELL DECEMBER 1986 @ 25 GPM	WL
GEORGE STEVENS ACADEMY	ME0011183	1T1D	NTNC		
				DR WELL-450'	WL
BLAZE BLUE HILL	ME0011610	VSWS	NC		
				DR WELL 155'	WL
ARBORVINE REST/MOVEABLE FEASTS	ME0026292	VSWS	NC		
				DR WELL 238' BEDROCK	WL

System Type Codes:
NC = Transient *NTNC = Non-Community, Non-Transient* *C = Community*

Source Type Codes:
WL = Well (groundwater) *IN = Intake (suface water)* *SP = Spring*

Maine Public Water Systems By County

HANCOCK

PUBLIC WATER SYSTEM NAME	PWSID	OPER-ATING CTGRY	WATER SYSTEM TYPE	SOURCE	SOURCE TYPE
BLUE HILL					
BLUE HILL TERRACE	ME0092110	VSWS	C		
				360' BEDROCK WELL 1982 @ 15 GPM	WL
HARBORVIEW I & II	ME0092165	VSWS	C		
				DRILLED WELL 360'	WL
PARKER RIDGE RETIREMENT COMMUNITY	ME0092265	2T1D	C		
				205' BEDROCK WELL 1996 @ 10GPM	WL
				300' BEDROCK WELL @ 9GPM	WL
HANNAFORD-BLUE HILL	ME0092405	VSWS	NTNC		
				300' BR WELL 7-18-07 @10GPM	WL
HEWINS DRIVE REALTY LLC	ME0092474	1T1D	NC		
				148' BEDROCK WELL 1982 @ 25GPM	WL
BLUE HILL CO-OP-SOUTH STREET	ME0092678	VSWS	NTNC		
				360' WELL 1 10-12-2018 @ 30GPM	WL
LAWRENCE FAMILY COMMUNITY FITNESS CENTER	ME0092688		NC		
				360' BR WELL 2-26-2019 @ 40GPM	WL
SIAM SKY THAI CUISINE	ME0092692		NC		
				EXISTING BR WELL	WL
SANDYS BLUE HILL CAFE	ME0092693		NC		
				245' BR WELL @ 15GPM	WL
GOLDEN SUN CHILD CARE	ME0092764	VSWS	NTNC		
				WELL HEAD 1	WL
NORTHERN LIGHT BLUE HILL	ME0093954	VSWS	NTNC		
				DRILLED WELL 400'	WL
				DRILLED WELL 100'	WL

HANCOCK

PUBLIC WATER SYSTEM NAME	PWSID	OPER-ATING CTGRY	WATER SYSTEM TYPE	SOURCE	SOURCE TYPE
BLUE HILL					
BAY SCHOOL	ME0094442	VSWS	NTNC		
				145' DR WELL 1 5-1-2001 @ 7 GPM	WL
BARNCASTLE HOTEL & RESTAURANT	ME0094887	VSWS	NC		
				WELL HD 1	WL
MARLINTINIS GRILL INC	ME0094914	VSWS	NC		
				420' BEDROCK WELL 4-28-2004 @ 1.75 GPM	WL
FISH NET	ME0094959	VSWS	NC		
				DR WELL	WL
BLUE HILL PUBLIC LIBRARY	ME0094991	VSWS	NC		
				WELL 1	WL

System Type Codes:
NC = Transient *NTNC = Non-Community, Non-Transient* *C = Community*

Source Type Codes:
WL = Well (groundwater) *IN = Intake (suface water)* *SP = Spring*

Maine Public Water Systems By County

HANCOCK

PUBLIC WATER SYSTEM NAME	PWSID	OPER-ATING CTGRY	WATER SYSTEM TYPE	SOURCE	SOURCE TYPE
BROOKSVILLE					
MSU 93 BROOKSVILLE ELEMENTARY SCHOOL	ME0000123	VSWS	NTNC		
				DR WELL 240'	WL
HIRAM BLAKE CAMP	ME0002140	VSWS	NC		
				DR WELL 91'	WL
BUCKS	ME0023427	VSWS	NC		
				180' DRILLED WELL	WL

System Type Codes:
NC = Transient *NTNC = Non-Community, Non-Transient* *C = Community*

Source Type Codes:
WL = Well (groundwater) *IN = Intake (suface water)* *SP = Spring*

Maine Public Water Systems By County

HANCOCK

PUBLIC WATER SYSTEM NAME	PWSID	OPER-ATING CTGRY	WATER SYSTEM TYPE	SOURCE	SOURCE TYPE
SURRY					
SURRY ELEMENTARY SCHOOL	ME0000624	VSWS	NTNC		
				205' BEDROCK WELL 1983 @ 8.5 GPM	WL
UNDER CANVAS ACADIA	ME0092740		NC		
				500' DR WELL 1 8-25-2020 @ 7 GPM	WL
				600' DR WELL 2 8-27-2020 @ 6 GPM	WL
				600' DR WELL 3 7-31-2021 @ 20 GPM	WL

System Type Codes:

NC = Transient *NTNC = Non-Community, Non-Transient* *C = Community*

Source Type Codes:

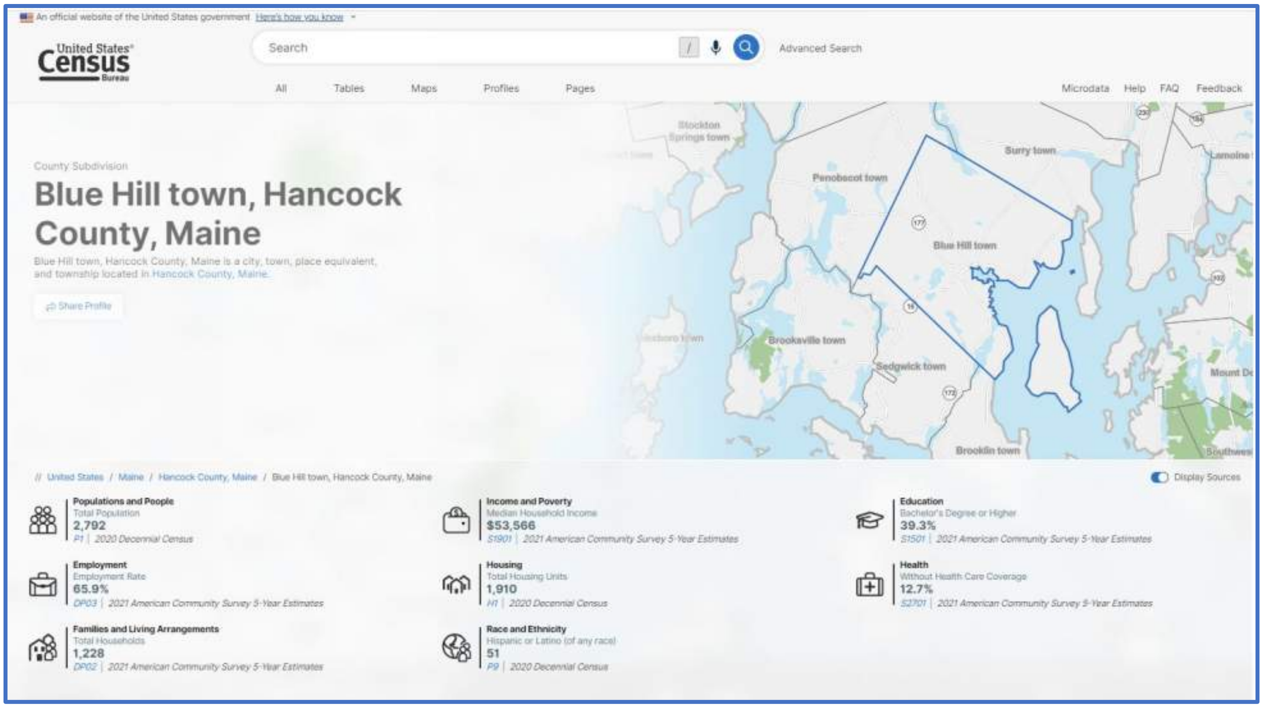
WL = Well (groundwater) *IN = Intake (suface water)* *SP = Spring*

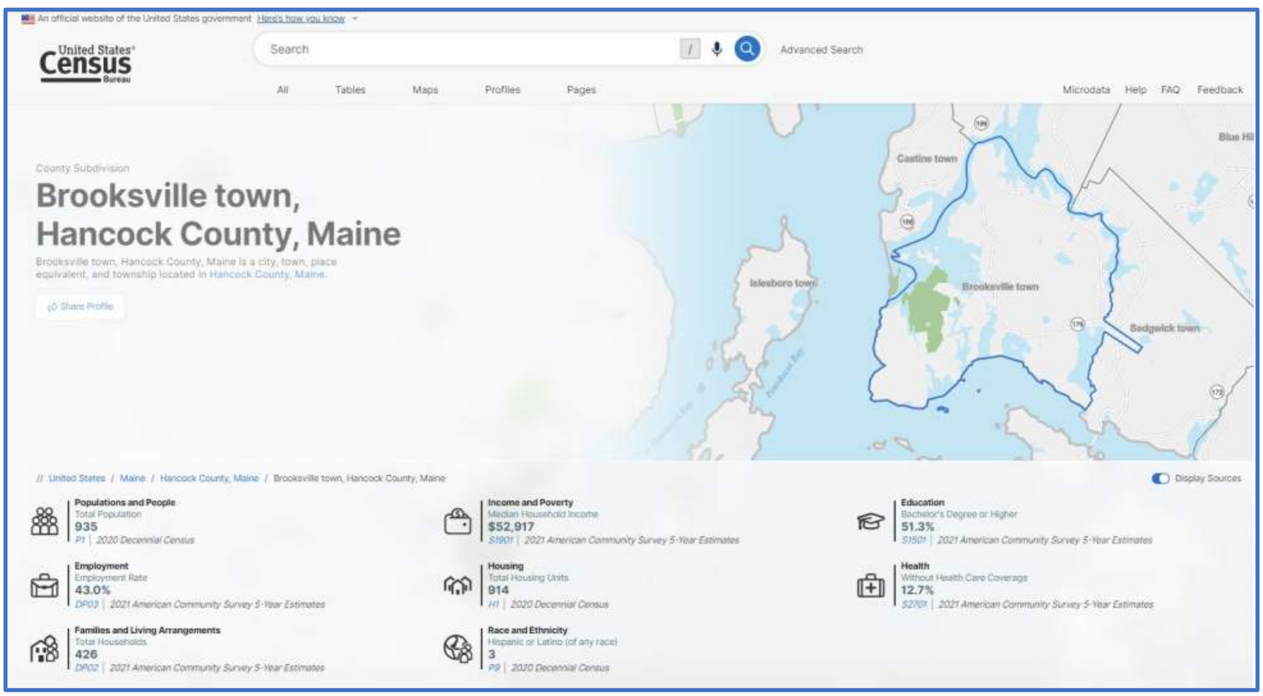
Attachment 2

Public Water and Census

Safe Drinking Water Act: Consumer Confidence Reports (CCR)
Annual Drinking Water Quality Reports for Maine
https://ordspub.epa.gov/ords/safewater/f?p=136:103::::::
Accessed 11/14/2023

Water System Name	Population Served	Source Type	System Address	Contact Phone	Cities Served	Counties Served
ARBORVINE REST/MOVEABLE FEASTS	296	Ground water	PO BOX 346 TENNY HILL BLUE HILL, ME 04614	207-374-2441	BLUE HILL	Hancock
BARNCASTLE HOTEL & RESTAURANT	237	Ground water	125 SOUTH STREET BLUE HILL, ME 04614	207-374-2300	BLUE HILL	Hancock
BAY SCHOOL	105	Ground water	PO BOX 950 BLUE HILL, ME 04614	207-374-2187	BLUE HILL	Hancock
BLAZE BLUE HILL	450	Ground water	PO BOX 824 BLUE HILL, ME 04614	207-374-7237	BLUE HILL	Hancock
BLUE HILL CO-OP-SOUTH STREET	67	Ground water	70 SOUTH STREET BLUE HILL, ME 04614	207-374-2165	BLUE HILL	Hancock
BLUE HILL PUBLIC LIBRARY	318	Ground water	5 PARKER POINT ROAD BLUE HILL, ME 04614	207-374-5515	BLUE HILL	Hancock
BLUE HILL TERRACE	60	Ground water	PO BOX 8 STONINGTON, ME 04681	207-974-8603	BLUE HILL	Hancock
FISH NET	68	Ground water purchased	PO BOX 720 MAIN STREET BLUE HILL, ME 04614	207-374-5240	BLUE HILL	Hancock
GEORGE STEVENS ACADEMY	360	Ground water	23 UNION STREET BLUE HILL, ME 04614	207-374-5081	BLUE HILL	Hancock
GOLDEN SUN CHILD CARE	28	Ground water	8 SOUTH STREET BLUE HILL, ME 04614	207-266-6509	BLUE HILL	Hancock
HANNAFORD-BLUE HILL	163	Ground water	145 PLEASANT HILL ROAD SCARBOROUGH, ME 04075	207-885-3691	BLUE HILL	Hancock
HARBORVIEW I & II	40	Ground water	49 MECHANIC STREET CAMDEN, ME 04843	207-236-8323	BLUE HILL	Hancock
HEWINS DRIVE REALTY LLC	100	Ground water	PO BOX 248 BLUE HILL, ME 04614		BLUE HILL	Hancock
LAWRENCE FAMILY COMMUNITY FITNESS CENTER	55	Ground water	32 MINES ROAD BLUE HILL, ME 04614	207-374-5358	BLUE HILL	Hancock
MARLINTINIS GRILL INC	252	Ground water	PO BOX 417 BLUE HILL, ME 04614	207-374-2500	BLUE HILL	Hancock
MSU 93 BLUE HILL CONSOLIDATED SCHOOL	322	Ground water	PO BOX 630 BLUE HILL, ME 04614	207-374-9927	BLUE HILL	Hancock
NORTHERN LIGHT BLUE HILL	308	Ground water	57 WATER STREET BLUE HILL, ME 04614	207-374-3498	BLUE HILL	Hancock
PARKER RIDGE RETIREMENT COMMUNITY	128	Ground water	63 PARKER RIDGE LANE UNIT 290 BLUE HILL, ME 04614	207-374-5789	BLUE HILL	Hancock
SANDYS BLUE HILL CAFE	114	Ground water	PO BOX 1281 BLUE HILL, ME 04614	207-374-5550	BLUE HILL	Hancock
SIAM SKY THAI CUISINE	96	Ground water	PO BOX 1103 BLUE HILL, ME 04614	207-374-7157	BLUE HILL	Hancock
BUCKS	180	Ground water	6 CORNFIELD HILL ROAD BROOKSVILLE, ME 04617	207-326-8683	BROOKSVILLE	Hancock
HIRAM BLAKE CAMP	54	Ground water	276 VARNUMVILLE ROAD BROOKSVILLE, ME 04617-3534	207-326-4951	BROOKSVILLE	Hancock
MSU 93 BROOKSVILLE ELEMENTARY SCHOOL	87	Ground water	PO BOX 630 BLUE HILL, ME 04614	207-374-9927	BROOKSVILLE	Hancock
SURRY ELEMENTARY SCHOOL	156	Ground water	PO BOX 630 BLUE HILL, ME 04614	207-374-9927	SURRY	Hancock
UNDER CANVAS ACADIA	130	Ground water	702 SURRY ROAD SURRY, ME 04684	215-740-1920	SURRY	Hancock


An official website of the United States government Here's how you know
United States Census Bureau
Search
Advanced Search
All
Tables
Maps
Profiles
Pages
Microdata
Help
FAQ
Feedback
County Subdivision
Blue Hill town, Hancock County, Maine
Blue Hill town, Hancock County, Maine is a city, town, place equivalent, and township located in Hancock County, Maine.
Share Profile
Penobscot town
Surry town
Blue Hill town
Brooksville town
Sedgwick town
Brooklin town
United States / Maine / Hancock County, Maine / Blue Hill town, Hancock County, Maine
Display Sources
Populations and People
Total Population
2,792
P1 | 2020 Decennial Census
Income and Poverty
Median Household Income
$53,566
S1901 | 2021 American Community Survey 5-Year Estimates
Education
Bachelor's Degree or Higher
39.3%
S1501 | 2021 American Community Survey 5-Year Estimates
Employment
Employment Rate
65.9%
DP03 | 2021 American Community Survey 5-Year Estimates
Housing
Total Housing Units
1,910
H1 | 2020 Decennial Census
Health
Without Health Care Coverage
12.7%
S2701 | 2021 American Community Survey 5-Year Estimates
Families and Living Arrangements
Total Households
1,228
DP02 | 2021 American Community Survey 5-Year Estimates
Race and Ethnicity
Hispanic or Latino (of any race)
51
P9 | 2020 Decennial Census


An official website of the United States government Here's how you know
United States Census Bureau
Search
Advanced Search
All
Tables
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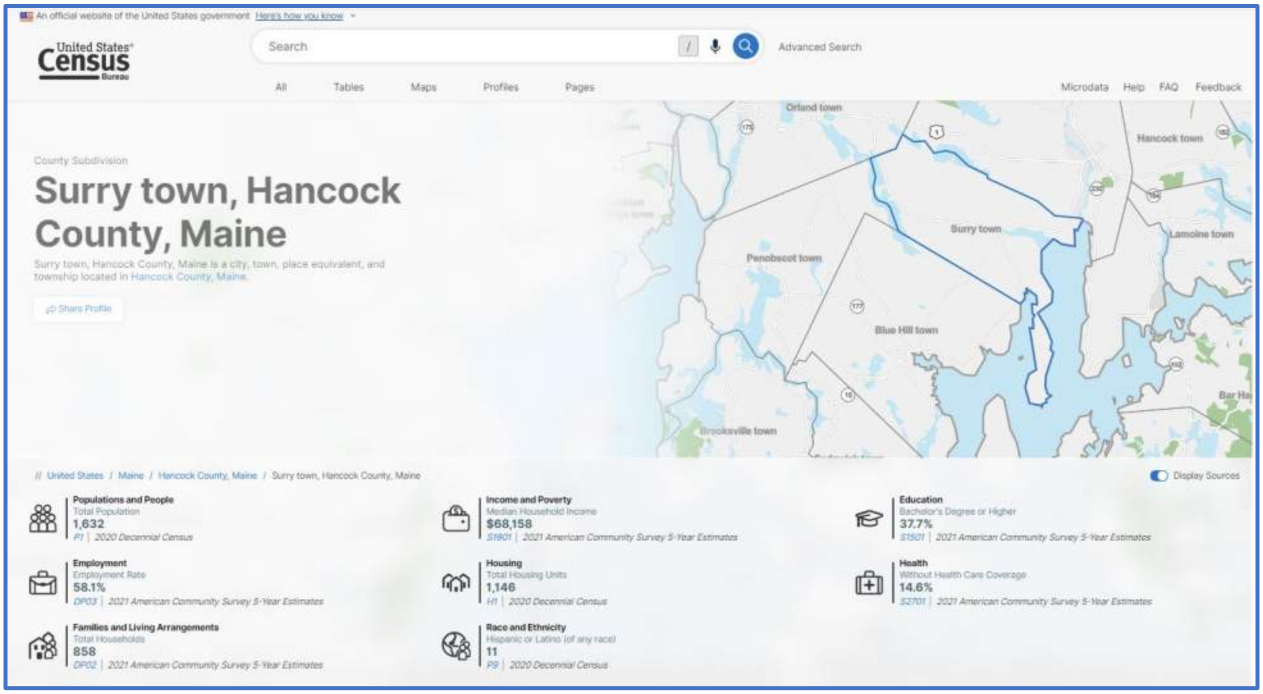
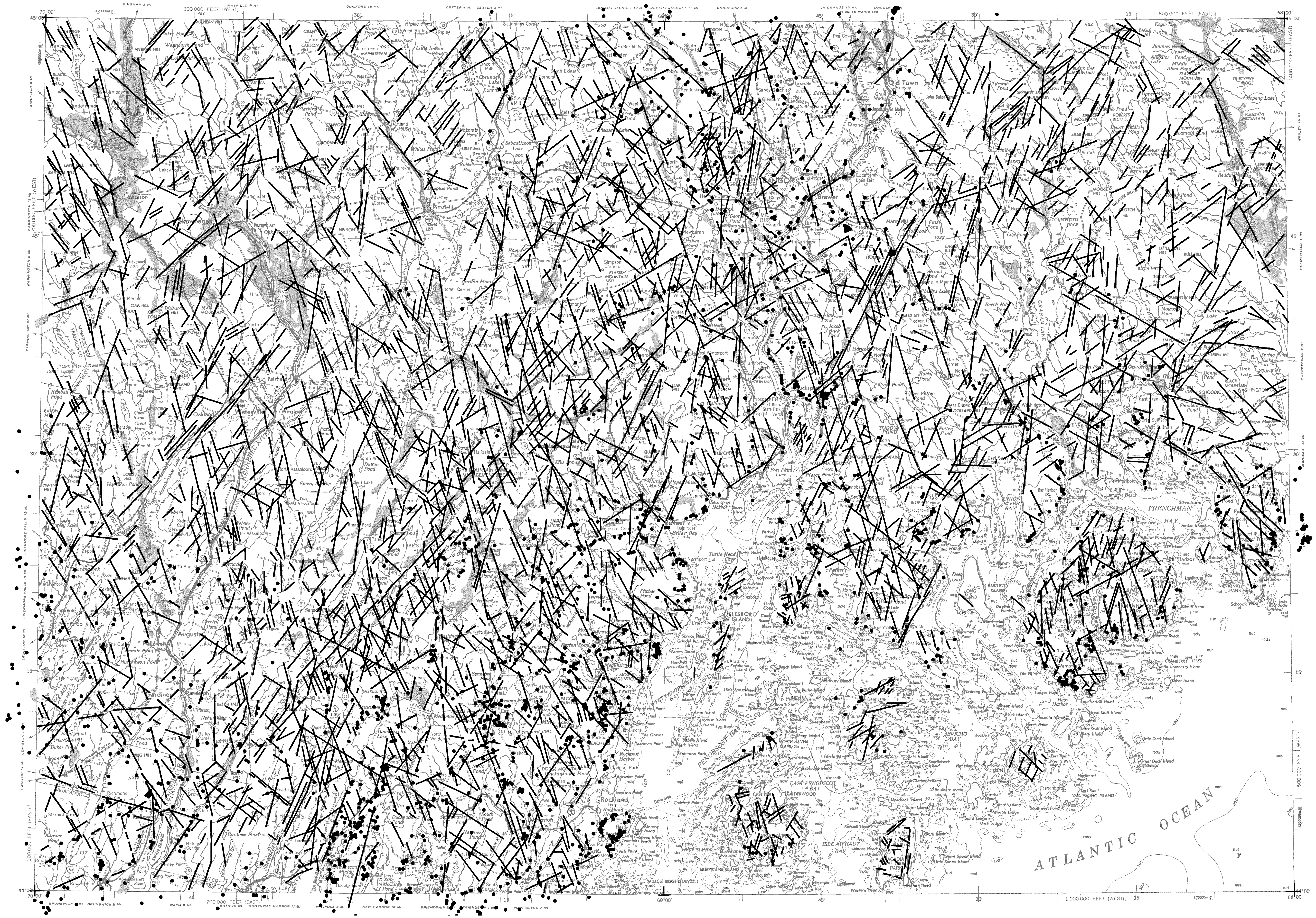
Profiles
Pages
Microdata
Help
FAQ
Feedback
County Subdivision
Brooksville town, Hancock County, Maine
Brooksville town, Hancock County, Maine is a city, town, place equivalent, and township located in Hancock County, Maine.
Share Profile
Castine town
Islesboro town
Brooksville town
Sedgwick town
United States / Maine / Hancock County, Maine / Brooksville town, Hancock County, Maine
Display Sources
Populations and People
Total Population
935
P1 | 2020 Decennial Census
Income and Poverty
Median Household Income
$52,917
S1901 | 2021 American Community Survey 5-Year Estimates
Education
Bachelor's Degree or Higher
51.3%
S1501 | 2021 American Community Survey 5-Year Estimates
Employment
Employment Rate
43.0%
DP03 | 2021 American Community Survey 5-Year Estimates
Housing
Total Housing Units
914
H1 | 2020 Decennial Census
Health
Without Health Care Coverage
12.7%
S2701 | 2021 American Community Survey 5-Year Estimates
Families and Living Arrangements
Total Households
426
DP02 | 2021 American Community Survey 5-Year Estimates
Race and Ethnicity
Hispanic or Latino (of any race)
3
P9 | 2020 Decennial Census



An official website of the United States government Here's how you know
United States Census Bureau
Search
Advanced Search
All
Tables
Maps
Profiles
Pages
Microdata
Help
FAQ
Feedback
County Subdivision
Surry town, Hancock County, Maine
Surry town, Hancock County, Maine is a city, town, place equivalent, and township located in Hancock County, Maine.
Share Profile
Orland town
Hancock town
Surry town
Lamoine town
Penobscot town
Blue Hill town
Brooksville town
// United States / Maine / Hancock County, Maine / Surry town, Hancock County, Maine
Display Sources
Populations and People
Total Population
1,632
P1 | 2020 Decennial Census
Income and Poverty
Median Household Income
$68,158
S1901 | 2021 American Community Survey 5-Year Estimates
Education
Bachelor's Degree or Higher
37.7%
S1501 | 2021 American Community Survey 5-Year Estimates
Employment
Employment Rate
58.1%
DP03 | 2021 American Community Survey 5-Year Estimates
Housing
Total Housing Units
1,146
H1 | 2020 Decennial Census
Health
Without Health Care Coverage
14.6%
S2701 | 2021 American Community Survey 5-Year Estimates
Families and Living Arrangements
Total Households
858
DP02 | 2021 American Community Survey 5-Year Estimates
Race and Ethnicity
Hispanic or Latino (of any race)
11
P9 | 2020 Decennial Census

Attachment 3

MGS Maps



5 0 5 10 15 20 STATUTE MILES

5 0 5 10 15 20 25 30 KILOMETERS

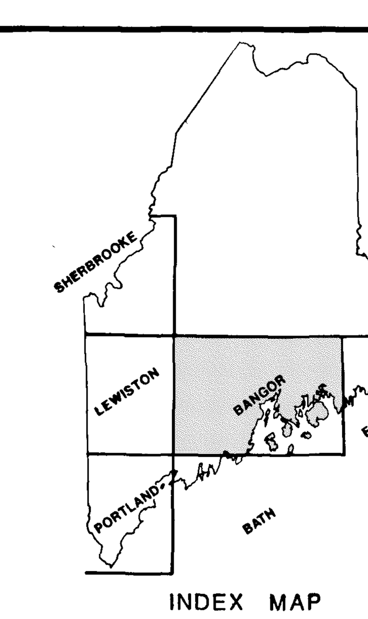
SCALE 1:250,000

• High-yield bedrock well, yield > 10 gallons per minute

Linear feature mapped from 1:250,000 scale Side Looking Airborne Radar imagery

Area of potential bedrock recharge

Preparation of this map was supported by funds furnished by the U.S. Department of Energy, Grant No. DE-FG02-81NE46640.



INDEX MAP

LINEAMENTS, HIGH-YIELD BEDROCK WELLS, AND POTENTIAL BEDROCK RECHARGE AREAS IN THE BANGOR 2 DEGREE SHEET

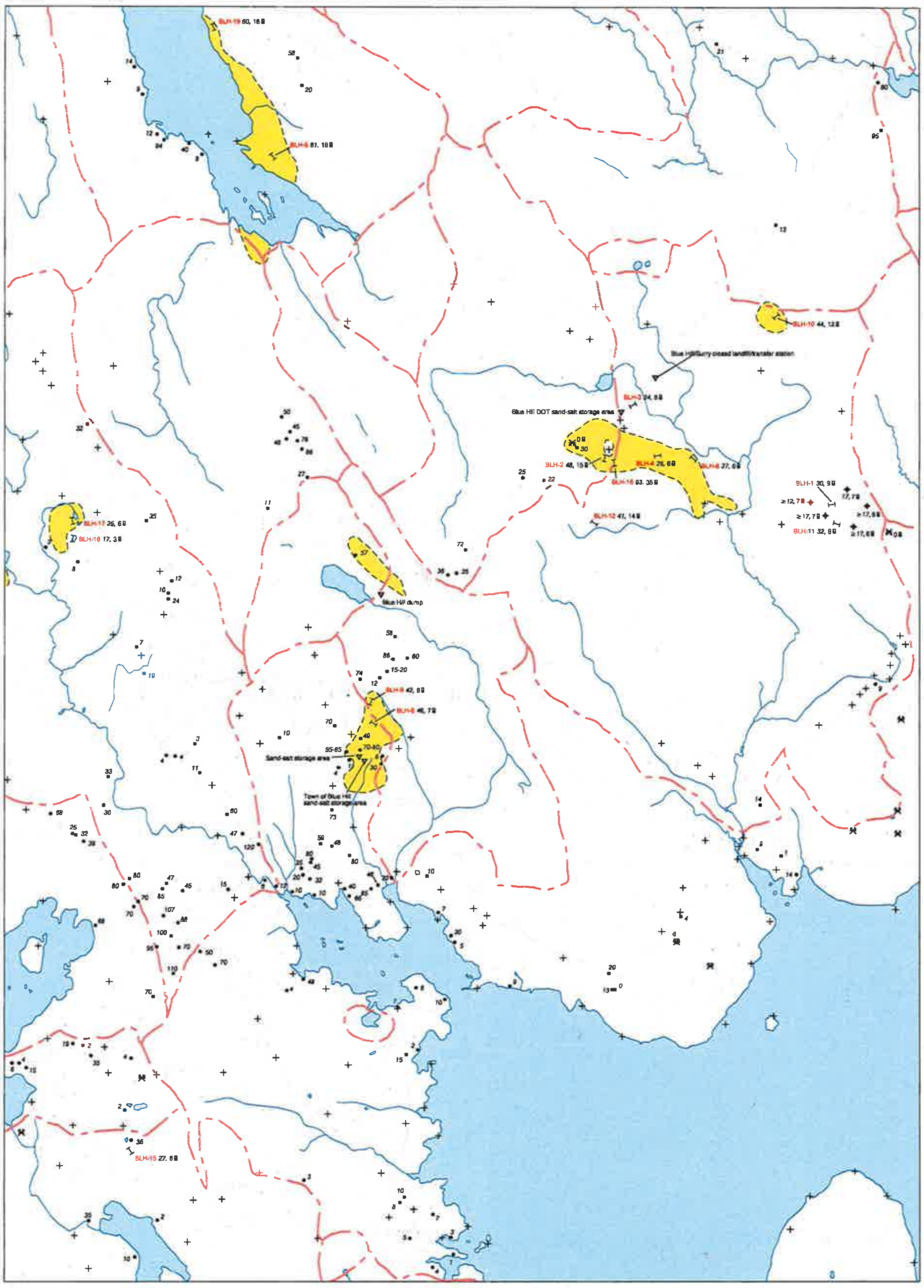
Prepared By
Caswell, Eichler, and Hill, Inc.

for the
Maine Geological Survey
DEPARTMENT OF CONSERVATION
Walter A. Anderson, State Geologist

OPEN-FILE NO. 86-69

1986

Significant Sand and Gravel Aquifers



Aquifer boundaries modified from Open-File Map 01-363 in 2007 based on 2001 field work by D.B. Locke. Additional materials and seismic data collected during the 200- field season. Additional well data collected in 2006.

Well inventory data collected by geologic field assistants during the 1981 field season.

Drainage basin boundaries compiled by U.S. Geological Survey, Water Resources Division, Augusta, Maine, with funding from the Maine Low-Level Radioactive Waste Authority.

Quadrangle Location

SCALE 1:24,000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

CONTOUR INTERVAL 6 METERS

TRUE NORTH

Topographic base from U.S. Geological Survey Blue Hill quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic map symbols.

The use of industry, firm, or local government names on this map is for location purposes only and does not impute responsibility for any present or potential effects on the natural resources.

SIGNIFICANT SAND AND GRAVEL AQUIFERS
(yields greater than 10 gallons per minute)

Approximate boundary of surficial deposits with significant saturated thickness where potential ground-water yield is moderate to excellent.

Surficial deposits with good to excellent potential ground-water yield; yields generally greater than 50 gallons per minute to a properly constructed well. Deposits consist primarily of glacial sand and gravel, but can include areas of sandy till and alluvium; yield zones are based on subsurface data where available, and may vary from mapped extent in areas where data are unavailable.

Surficial deposits with moderate to good potential ground-water yield; yields generally greater than 10 gallons per minute to a properly constructed well. Deposits consist primarily of glacial sand and gravel, but can include areas of sandy till and alluvium; yields may exceed 50 gallons per minute in deposits hydraulically connected with surface-water bodies, or in extensive deposits where subsurface data are available.

SURFICIAL DEPOSITS WITH LESS FAVORABLE AQUIFER CHARACTERISTICS
(yields less than 10 gallons per minute)

Areas with moderate to low or no potential ground-water yield (includes areas underlain by till, marine deposits, eolian deposits, alluvium, swamps, thin glacial sand and gravel deposits, or bedrock); yields in surficial deposits generally less than 10 gallons per minute to a properly constructed well.

SEISMIC-LINE INFORMATION

Profiles for 12-channel seismic lines may be viewed at the Maine Geological Survey. Length of 12-channel seismic lines as shown on the map is to scale. All single-channel lines ranged from 80 to 300 feet long and are not shown to scale. Seismic data may not be available for all quadrangles.

53 Depth to bedrock, in feet below land surface.

≥53 Depth to bedrock exceeds depth shown (based on calculations).

12 ▪ Depth to water level, in feet below land surface.

MAP-7 131, 23 ▪ Twelve-channel seismic line, with depth to bedrock and depth to water shown at the midpoint of the line, in feet below land surface.

69, 12 ▪ / MAP-E / 72, 12 ▪ Single-channel seismic line, with depth to bedrock and depth to water shown at each end of the line, in feet below land surface. Unless otherwise indicated, data shown above the line-identifier box refers to the northern end of the seismic line.

The 3-letter identifier for a line is an abbreviation for the topographic quadrangle. If the 3-letter identifier for the line is followed by a number (ex. MAP - 7, MAP - 4), the line is a 12-channel line. If the identifier is followed by a letter (ex. MAP - E, MAP - P), the line is a single-channel line.

GEOLOGIC AND WELL INFORMATION

50 Depth to bedrock, in feet below land surface.

≥13 Penetration depth of boring; ≥ symbol refers to minimum depth to bedrock based on boring depth or refusal.

6 ▪ Depth to water level in feet below land surface (observed in well, spring, test boring, pit, or seismic line).

✕ Gravel pit (overburden thickness noted in feet, e.g. 5-12').

⚒ Quarry

4 GPM Yield (flow) of well or spring in gallons per minute (GPM).

Spring, with general direction of flow

⊖ Drilled overburden well

■ Dug well

✦ Observation well (project well if labeled, nonproject well if unlabeled)

✧ Test boring (project boring if labeled, nonproject boring if unlabeled)

↓ Driven point

⊙ Test pit

• Drilled bedrock well

▽ Potential point source of ground-water contamination

+ Bedrock outcrop

Surface-water drainage-basin boundary; surface-water divides generally correspond to ground-water divides. Horizontal direction of ground-water flow generally is away from divides and toward surface-water bodies.

OTHER SOURCES OF INFORMATION

1. Prescott, G.C., Jr., and Locke, D.B., 2007, Surficial materials of the Blue Hill quadrangle, Maine: Maine Geological Survey, Open-File Map 07-1.
2. Thompson, W.B., and Borns, H.W., 1977, Reconnaissance surficial geology of the Blue Hill 15' quadrangle, Maine: Maine Geological Survey, Open-File Map 77-36.
3. Caswell, W.B., 1987, Ground water handbook for the state of Maine, Second Edition: Maine Geological Survey, Bulletin 39, 135 p.
4. Thompson, W.B., 1979, Surficial geology handbook for coastal Maine: Maine Geological Survey, 68 p. (out of print).
5. Thompson, W.B., and Borns, H.W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.

Blue Hill Quadrangle, Maine

Significant aquifers mapped by
Daniel B. Locke
Craig D. Neil

Digital cartography by:
Michael E. Foley
Susan S. Tolman

Robert G. Marvinney
State Geologist

Cartographic design and editing by:
Robert D. Tucker

Funding for the preparation of this map was provided in part by the Maine Department of Environmental Protection.

Maine Geological Survey
Address: 22 State House Station, Augusta, Maine 04333
Telephone: 207-287-2801 E-mail: mgs@maine.gov
Home page: http://www.maine.gov/doc/nrimc/nrimc.htm

Open-File No. 07-2
2007
This map supersedes Open-File Map 01-363.

WHAT IS AN AQUIFER?

Ground water, as the name implies, is water found below the land surface in the pore spaces between sand grains and in fractures in the bedrock (see diagrams below). An *aquifer* is a water-bearing geologic formation capable of yielding a usable amount of ground water to a well. In Maine there are two types of aquifers: loose soil materials (such as sand, gravel, and other sediments) and fractured bedrock. A sand and gravel deposit is considered a *significant aquifer* when a well in that deposit is capable of being continuously pumped at a rate of 10 gallons per minute (gpm) or more. To sustain a yield of 10 gpm or more, a deposit must be permeable enough for water to flow readily into the well (see section on *porosity* and *permeability* below), and there must be a sufficient depth of water in the well so that it will not be pumped dry.

The diagram below shows a schematic cross section of a sand and gravel aquifer in Maine. The symbols above the diagram correspond to the well symbols shown on the map at left. Information typically shown for these wells includes type of well, depth to bedrock, depth to water, and well yield. The blue line in the diagram is the *water table*. The area below the water table is called the *saturated zone*, where all pore spaces between the sediment particles are filled with water. In order to yield water, a well must extend below the water table into the saturated zone. Notice that the water table corresponds to the water levels in most wells and in the stream.

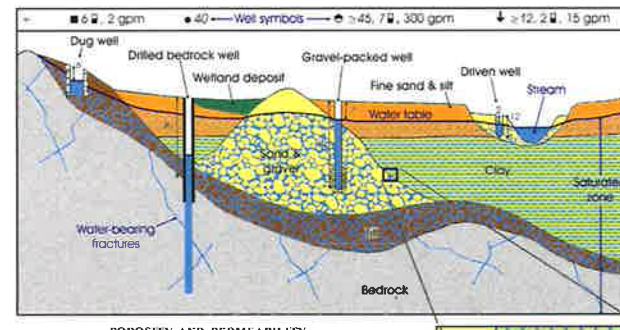
Several types of wells common in Maine are shown in the diagram. A *dug well* is a large diameter hole excavated by hand or backhoe. The hole is kept from caving in by installing a lining that may be stone, tile or cement blocks. The hole must be deep enough to extend below the water table. The shallow dug well in the diagram has a yield of 2 gpm. Although the yield is often low, dug wells generally supply enough ground water for a household because of the large amount of water stored in the well.

A *gravel-packed well* is usually installed into coarse-grained sediment and is drilled with a much larger diameter than the final casing and screen diameter. To increase the yield and pumping efficiency of the well, the space around the well screen is filled with selected gravel that increases the permeability in the immediate vicinity of the well. The gravel-packed well in the diagram has a high yield of 300 gpm. Such high-yielding gravel-packed wells are commonly drilled for municipal or industrial water systems.

A *driven well* or *well point* can be installed into sand and gravel where the water table is within about 20 feet of the ground surface. A 2 to 3 inch diameter pipe, equipped with a well screen at its lower end, is driven into the deposit until the screen is below the water table. This pipe serves as a casing, and water is pumped directly from the aquifer. The driven well in the diagram has a significant yield of 15 gpm. Although the yield is relatively high, driven wells generally only supply a single household because very little water is stored in the well casing.

Wells of any type constructed in the other sediments shown in the diagram (clay or fine sand and silt) would yield some water, but yields would be lower than for wells in coarse-grained sand and gravel deposits.

Another type of well common in Maine is the *drilled bedrock well*. This well is drilled into the underlying rock with steel casing to isolate the well from potential surface-water contamination. In this type of well, water is found where the well hole intersects water-bearing fractures in the bedrock. Notice how the water level in this well is not the same level as the water table. The well casing isolates the bedrock well from the overlying sediments. The water level is controlled by water pressure in the fractures in the bedrock and is not related to the water table in the overlying materials.

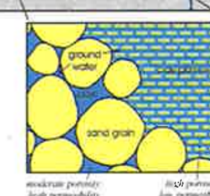


POROSITY AND PERMEABILITY

The diagram at right is an enlarged view of a section of the diagram above. Note that the section shown is below the water table and that ground water completely fills the pore spaces between the sediment grains. In an aquifer, the more pore space there is, the more water the aquifer can hold. This is called the *porosity* of a deposit. *Permeability* refers to the ability of a surficial deposit to transmit water. Permeability depends on the size of the spaces between the sediment grains.

Permeability is related to porosity, but is not the same. Porosity determines the capacity of the material to hold water. Permeability determines its ability to yield water. For example, clay is made of tiny particles with a large amount of pore space between them. However, the pore spaces are so small that they create a resistance to flow which reduces ground water permeability. Sand and gravel may not be as porous as clay, but the pore spaces are larger and better connected and the materials are much more permeable.

Permeability is an important characteristic since it determines whether ground water can actually be drawn into a pumping well.



moderate porosity, high permeability — *high porosity, low permeability*

HOW ARE AQUIFERS MAPPED?

Operating a twelve-channel seismograph, Piscataquis County, Maine.

When mapping sand and gravel aquifers, geologists visit gravel pits, stream banks, road cuts, and other surface exposures to describe materials and identify deposits. This surficial geology mapping is supplemented with seismic-refraction studies and the installation of observation wells and test borings. In addition, much information about an aquifer may already be available from water-company exploration, large construction projects, town well inventories, and other sources. This information, along with aerial photography and previously published maps, allows the geologist to define the boundaries of favorable surficial deposits and estimate how well the deposits will yield water to a well.

The boundaries of favorable surficial deposits do not necessarily coincide with the aquifer boundaries. In some areas, a thin cover of favorable coarse-grained material may overlie fine-grained sediments, till, or bedrock. A well in that material would not be able to sustain a yield of 10 gpm, so the area would not be mapped as an aquifer. In other areas, fine-grained sediments or till may overlie favorable coarse-grained sediments and the subsurface deposit may not be recognized as an aquifer.

Single- and 12-channel seismic-refraction studies are conducted to determine the saturated thickness of a deposit by establishing the depth to water table and bedrock surface. The 12-channel seismic survey has the additional advantage of providing the topography of the buried bedrock surface at a site.

Installing monitoring wells and drilling test borings provide direct information about the aquifer characteristics of a deposit. This work provides information on the depth to water table and bedrock surface, water quality, and how easily the sediment transmits water.

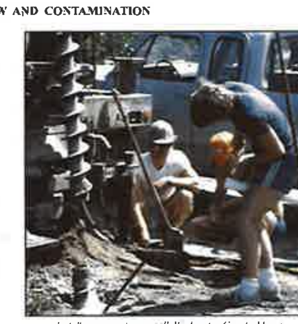
GROUND-WATER FLOW AND CONTAMINATION

Ground water is replenished or *recharged* by rainwater and melting snow that soak into the soil. This water percolates downward and eventually reaches the water table. When recharge is high during spring snowmelt and fall rains, the amount of ground water increases and the water table rises. When recharge is low during the late summer or when the ground is frozen during the winter, the water table becomes lower.

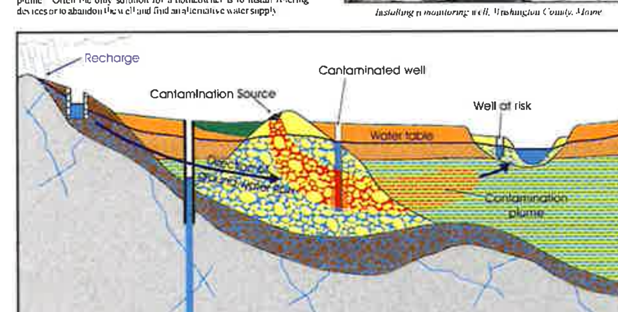
Notice in the diagram below that ground water is not static, it flows. This concept is very important, especially when ground water becomes contaminated. Once in the ground-water system, contaminants usually travel along the paths followed by ground water and are sometimes able to migrate considerable distances over time.

In the diagram below, a plume of contamination originates at the source in the sand and gravel deposit. This source could be a landfill, a leaking fuel storage tank, or an accidental spill. As the contaminant seeps into the subsurface system and enters the aquifer, it flows with the ground water. In the diagram, the plume contaminated the gravel-packed well as it passed by. The driven well near the stream is not contaminated, but is at risk since the plume is flowing in that direction. The dug well on the hillside, however, is not affected because it is upgradient of the source, hence the contaminated ground water flows away from this well.

Once ground water is contaminated, it is very difficult and expensive to correct. To design a clean-up plan, monitoring wells are installed under the direction of a hydrogeologist or other specialist. These wells define the three-dimensional extent of the affected area. Sometimes it is possible to pump contaminants to the surface using remediation wells within the plume. Often the only solution for a homeowner is to install filtering devices or to abandon the well and find an alternative water supply.



Installing a monitoring well, Washington County, Maine.



HOW TO USE THIS MAP

__Types of Information Shown on this Map:__ The yellow and red colored areas on the map indicate significant aquifers, zones where ground-water yield is estimated to be 10 gpm or greater. The boundaries of the aquifers are drawn by a geologist based, in part, on the well data shown on the map. Areas not mapped as aquifer may be thin or unsaturated sand and gravel deposits, surficial deposits other than sand and gravel, or bedrock.

The well data on the map provide information about the type of well, depth to water table, depth to bedrock, and yield of the wells in the area. This information is useful when making decisions about water supply, a drainage plan, or the need for blasting.

Information from seismic refraction studies also is shown on the map. Seismic studies give detailed information about depth to water table and depth to and shape of the bedrock surface. Geologic cross sections generated from seismic information are shown in associated reports listed in the references below the map at left.

Surface-water drainage-basin boundaries are also shown on the map. Horizontal direction of ground-water flow generally is away from drainage divides and toward surface-water bodies.

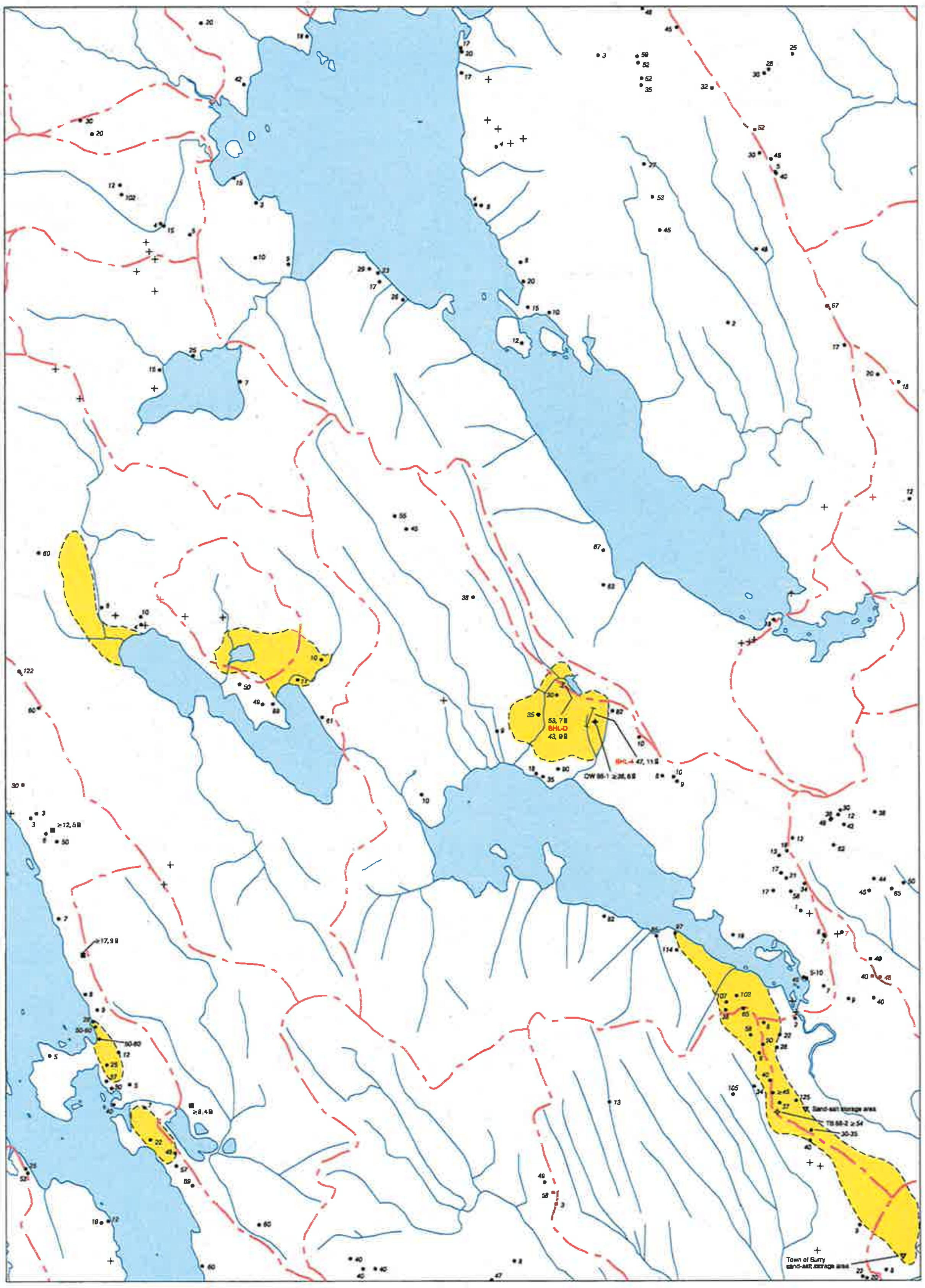
__Uses of this Map:__ Sand and gravel aquifer maps are useful in two major categories of decision-making: ground-water supply and ground-water protection. For ground-water supply, these maps are useful in locating areas favorable for developing water supplies for municipal, industrial, or residential use. Information on the map, such as depth to bedrock and well yield, indicate the potential for ground-water production.

Ground-water protection is another important function of these maps. Knowledge of the location and extent of sand and gravel aquifers is critical when siting potential contamination sites such as landfills and salt storage facilities. When used in conjunction with other geologic information, this map can help planners and municipal officials make much more informed decisions to guide industrial growth or residential development.

If ground-water contamination occurs, the general trend of the plume migration can be deduced from these maps by analyzing the drainage-basin boundaries and the local surface-water bodies.

For further assistance in interpreting this map, contact a geologist at the Maine Geological Survey.

Significant Sand and Gravel Aquifers



Aquifer boundaries modified in 2011 based on 2010 field work by T. K. Weddle and in 2007 based on 2004 field work by D. B. Locke. Aquifer boundaries modified from: Tolman, A. L., and Lanctot, E. M., 1981, Sand and Gravel Aquifer Map 28, Maine Geological Survey, Open-File Map 81-60, scale 1:50,000.

Well inventory data from U.S. Geological Survey Basic Data Reports and additional data collected by Maine Geological Survey field assistants during the 1988 field season. Additional well data collected in 2007 and 2011.

Drainage basin boundaries compiled by U.S. Geological Survey, Water Resources Division, Augusta, Maine, with funding from the Maine Low-Level Radioactive Waste Authority.

Quadrangle Location

SCALE 1:24,000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0 1 KILOMETER

CONTOUR INTERVAL 6 METERS

TRUE NORTH

Topographic base from U.S. Geological Survey Branch Lake quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic map symbols.

The use of industry, firm, or local government names on this map is for location purposes only and does not impute responsibility for any present or potential effects on the natural resources.

SIGNIFICANT SAND AND GRAVEL AQUIFERS
(yields greater than 10 gallons per minute)

Approximate boundary of surficial deposits with significant saturated thickness where potential ground-water yield is moderate to excellent.

Surficial deposits with good to excellent potential ground-water yield; yields generally greater than 50 gallons per minute to a properly constructed well. Deposits consist primarily of glacial sand and gravel, but can include areas of sandy till and alluvium; yield zones are based on subsurface data where available, and may vary from mapped extent in areas where data are unavailable.

Surficial deposits with moderate to good potential ground-water yield; yields generally greater than 10 gallons per minute to a properly constructed well. Deposits consist primarily of glacial sand and gravel, but can include areas of sandy till and alluvium; yields may exceed 50 gallons per minute in deposits hydraulically connected with surface-water bodies, or in extensive deposits where subsurface data are available.

SURFICIAL DEPOSITS WITH LESS FAVORABLE AQUIFER CHARACTERISTICS
(yields less than 10 gallons per minute)

Areas with moderate to low or no potential ground-water yield (includes areas underlain by till, marine deposits, eolian deposits, alluvium, swamps, thin glacial sand and gravel deposits, or bedrock); yields in surficial deposits generally less than 10 gallons per minute to a properly constructed well.

SEISMIC-LINE INFORMATION

Profiles for 12-channel seismic lines are shown in Appendix 2 of Open-File Report 92-2 (Neil and others, 1992). Length of 12-channel seismic lines as shown on the map is to scale. All single-channel lines ranged from 80 to 500 feet long and are not shown to scale.

53 Depth to bedrock, in feet below land surface

≥53 Depth to bedrock exceeds depth shown (based on calculations)

12 Depth to water level, in feet below land surface

MAP-7 131, 23 Twelve-channel seismic line, with depth to bedrock and depth to water shown at the midpoint of the line, in feet below land surface

69, 12 / MAP-C / 72, 12 Single-channel seismic line, with depth to bedrock and depth to water shown at each end of the line, in feet below land surface. Unless otherwise indicated, data shown above the line-identifier box refers to the northern end of the seismic line.

The 3-letter identifier for a line is an abbreviation for the topographic quadrangle. If the 3-letter identifier for the line is followed by a number (ex. MAP-7, MAP-4), the line is a 12-channel line. If the identifier is followed by a letter (ex. MAP-E, MAP-P), the line is a single-channel line. Single-channel seismic interpretations by T. T. Smith and C. D. Neil. Twelve-channel seismic interpretations by J. I. Steiger.

GEOLOGIC AND WELL INFORMATION

50 Depth to bedrock, in feet below land surface

≥13 Penetration depth of boring; ≥ symbol refers to minimum depth to bedrock based on boring depth or refusal

6 Depth to water level, in feet below land surface (observed in well, spring, test boring, pit, or seismic line)

Gravel pit (overburden thickness noted in feet, e.g. 5-12')

Quarry

4 GPM Yield (flow) of well or spring in gallons per minute (GPM)

Spring, with general direction of flow

Drilled overburden well

Dug well

Observation well (project well if labeled, nonproject well if unlabeled)

Test boring (project boring if labeled, nonproject boring if unlabeled)

Driven point

Test pit

Drilled bedrock well

Potential point source of ground-water contamination

Bedrock outcrop

Surface-water drainage-basin boundary; surface-water divides generally correspond to ground-water divides. Horizontal direction of ground-water flow generally is away from divides and toward surface-water bodies.

OTHER SOURCES OF INFORMATION

1. Neil, C. D., Steiger, J. I., and Weddle, T. K., 1992, Hydrogeology and water quality of significant sand and gravel aquifers in parts of Aroostook, Hancock, Penobscot, Piscataquis, and Waldo Counties, Maine: Maine Geological Survey, Open-File Report 92-2, 73 p.

2. Weddle, T. K., and Doughty, Dale F., 2011, Surficial materials of the Branch Lake quadrangle, Maine: Maine Geological Survey, Open-File Map 11-15.

3. Weddle, T. K., 2011, Surficial geology of the Branch Lake quadrangle, Maine: Maine Geological Survey, Open-File Map 11-16.

4. Caswell, W. B., 1987, Ground water handbook for the state of Maine, Second Edition: Maine Geological Survey, Bulletin 39, 135 p.

5. Thompson, W. B., 1979, Surficial geology handbook for coastal Maine: Maine Geological Survey, 68 p. (out of print).

6. Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.

Branch Lake Quadrangle, Maine

Compiled by
Lauren E. Foster and Troy T. Smith

Preliminary aquifer boundaries mapped by:
Dale F. Doughty

Digital cartography by:
Michael E. Foley
Susan S. Tolman

Robert G. Marvinney
State Geologist

Cartographic design and editing by:
Robert D. Tucker

Funding for the preparation of this map was provided in part by the Maine Department of Environmental Protection and the U. S. Geological Survey.

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Home page: http://www.maine.gov/doc/nrimc/nrimc.htm

Open-File No. 11-50
2011
This map supersedes Open-File Map 07-35.

WHAT IS AN AQUIFER?

Ground water, as the name implies, is water found below the land surface in the pore spaces between sand grains and in fractures in the bedrock (see diagrams below). An *aquifer* is a water-bearing geologic formation capable of yielding a usable amount of ground water to a well. In Maine there are two types of aquifers: loose soil materials (such as sand, gravel, and other sediments) and fractured bedrock. A sand and gravel deposit is considered a *significant aquifer* when a well in that deposit is capable of being continuously pumped at a rate of 10 gallons per minute (gpm) or more. To sustain a yield of 10 gpm or more, a deposit must be permeable enough for water to flow readily into the well as it is pumped (see section on *porosity* and *permeability* below), and there must be a sufficient depth of water in the well so that it will not be pumped dry.

The diagram below shows a schematic cross section of a sand and gravel aquifer in Maine. The symbols above the diagram correspond to the well symbols shown on the map at left. Information typically shown for these wells includes type of well, depth to bedrock, depth to water, and well yield. The blue line in the diagram is the *water table*. The area below the water table is called the *saturated zone*, where all pore spaces between the sediment particles are filled with water. In order to yield water, a well must extend below the water table into the saturated zone. Notice that the water table corresponds to the water level in most wells and in the stream.

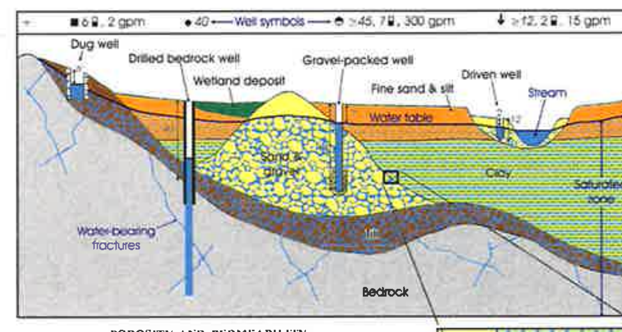
Several types of wells, common in Maine, are shown in the diagram. A *dug well* is a large diameter hole excavated by hand or backhoe. The hole is kept from caving in by installing a lining that may be stone, tile, or cement blocks. The hole must be deep enough to extend below the water table. The shallow dug well in the diagram has a yield of 2 gpm. Although the yield is often low, dug wells generally supply enough ground water for a household because of the large amount of water stored in the well.

A *gravel-packed well* is usually installed into coarse-grained sediment and is drilled with a much larger diameter than the final casing and screen diameter. To increase the yield and pumping efficiency of the well, the space around the well screen is filled with selected gravel that increases the permeability in the immediate vicinity of the well. The gravel-packed well in the diagram has a high yield of 300 gpm. Such high-yielding gravel-packed wells are commonly drilled for municipal or industrial water systems.

A *driven well* or *well point* can be installed into sand and gravel where the water table is within about 20 feet of the ground surface. A 2 to 3 inch diameter pipe, equipped with a well screen at its lower end, is driven into the deposit until the screen is below the water table. This pipe acts as a casing, and water is pumped directly from the aquifer. The driven well in the diagram has a significant yield of 15 gpm. Although the yield is relatively high, driven wells generally only supply a single household because very little water is stored in the well casing.

Wells of any type constructed in the other sediments shown in the diagram (clay or fine sand and silt) would yield some water, but yields would be lower than for wells in coarse-grained sand and gravel deposits.

Another type of well common in Maine is the *drilled bedrock well*. This well is drilled into the underlying rock with steel casing to isolate the well from potential surface-water contamination. In this type of well, water is found when the well hole intersects water-bearing fractures in the bedrock. Notice how the water level in this well is not the same level as the water table. The well casing isolates the bedrock well from the overlying sediments. The water level is controlled by water pressure in the fractures in the bedrock and is not related to the water table in the overlying materials.

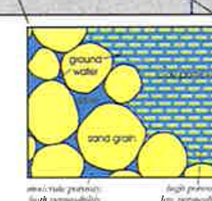


POROSITY AND PERMEABILITY

The diagram at right is an enlarged view of a section of the diagram above. Note that the section shown is below the water table and that ground water completely fills the pore spaces between the sediment grains. In an aquifer, the more pore space there is, the more water the aquifer can hold. This is called the *porosity* of a deposit. *Permeability* refers to the ability of a surficial deposit to transmit water. Permeability depends on the size of the spaces between the sediment grains.

Permeability is related to porosity, but is not the same. Porosity determines the capacity of the material to hold water. Permeability determines its ability to yield water. For example, clay is made of tiny particles with a large amount of pore space between them. However, the pore spaces are so small that they create a resistance to flow which reduces ground water permeability. Sand and gravel may not be as porous as clay, but the pore spaces are larger and better connected and the materials are much more permeable.

Permeability is an important characteristic since it determines whether ground water can actually be drawn into a pumping well.



moderate porosity, high permeability

high porosity, low permeability

HOW ARE AQUIFERS MAPPED?

Operating a twelve-channel seismograph, Piscataquis County, Maine

When mapping sand and gravel aquifers, geologists visit gravel pits, stream banks, road cuts, and other surface exposures to describe materials and identify deposits. This surficial geology mapping is supplemented with seismic-refraction studies and the installation of observation wells and test borings. In addition, much information about an aquifer may already be available from water-company exploration, large construction projects, town well inventories, and other sources. This information, along with aerial photography and previously published maps, allows the geologist to define the boundaries of favorable surficial deposits and estimate how well the deposits will yield water to a well.

The boundaries of favorable surficial deposits do not necessarily coincide with the aquifer boundaries. In some areas, a thin cover of favorable coarse-grained material may overlie fine-grained sediments, till, or bedrock. A well in that material would not be able to sustain a yield of 10 gpm, so the area would not be mapped as an aquifer. In other areas, fine-grained sediments or till may overlie favorable coarse-grained sediments and the subsurface deposit may not be recognized as an aquifer.

Single- and 12-channel seismic-refraction studies are conducted to determine the saturated thickness of a deposit by establishing the depth to water table and bedrock surface. The 12-channel seismic survey has the additional advantage of providing the topography of the buried bedrock surface at a site.

Installing monitoring wells and drilling test borings provide direct information about the aquifer characteristics of a deposit. This work provides information on the depth to water table and bedrock surface, water quality, and how easily the sediment transmits water.

GROUND-WATER FLOW AND CONTAMINATION

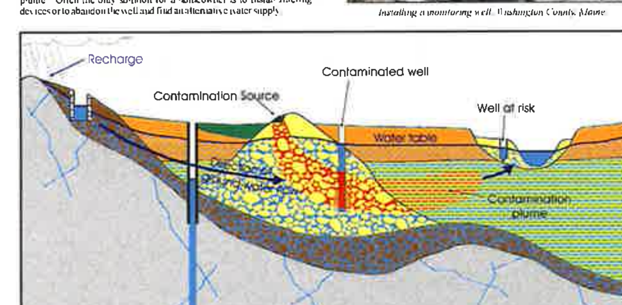
Ground water is replenished or *recharged* by rainwater and melting snow that soak into the soil. This water percolates downward and eventually reaches the water table. When recharge is high during spring snowmelt and fall rains, the amount of ground water increases and the water table rises. When recharge is low during the late summer or when the ground is frozen during the winter, the water table becomes lower.

Notice in the diagram below that ground water is not static, it flows. This concept is very important, especially when ground water becomes contaminated. Once in the ground-water system, contaminants usually travel along the paths followed by ground water and are sometimes able to migrate considerable distances over time.

In the diagram below, a plume of contamination originates at the source in the sand and gravel deposit. This source could be a landfill, a leaking fuel storage tank, or an accidental spill. As the contaminant seeps into the subsurface system and enters the aquifer, it flows with the ground water. In the diagram, the plume contaminated the gravel-packed well as it passed by. The driven well near the stream is not contaminated, but is at risk since the plume is flowing in that direction. The dug well on the hillside, however, is not affected because it is upgradient of the source, hence the contaminated ground water flows away from this well.

Once ground water is contaminated, it is very difficult and expensive to correct. To design a clean-up plan, monitoring wells are installed under the direction of a hydrogeologist or other specialist. These wells define the three-dimensional extent of the affected area. Sometimes it is possible to pump contaminants to the surface using remediation wells within the plume. Often the only solution for a homeowner is to install filtering devices or to abandon the well and find an alternative water supply.

Installing a monitoring well, Washington County, Maine



HOW TO USE THIS MAP

Types of Information Shown on this Map: The yellow and red colored areas on the map indicate significant aquifers, zones where ground-water yield is estimated to be 10 gpm or greater. The boundaries of the aquifers are drawn by a geologist based, in part, on the well data shown on the map. Areas not mapped as aquifer may be thin or unsaturated sand and gravel deposits, surficial deposits other than sand and gravel, or bedrock.

The well data on the map provide information about the type of well, depth to water table, depth to bedrock, and yield of the wells in the area. This information is useful when making decisions about water supply, a drainage plan, or the need for blasting.

Information from seismic refraction studies also is shown on the map. Seismic studies give detailed information about depth to water table and depth to and shape of the bedrock surface. Geologic cross sections generated from seismic information are shown in associated reports listed in the references below the map at left.

Surface-water drainage basin boundaries are also shown on the map. Horizontal direction of ground-water flow generally is away from drainage divides and toward surface-water bodies.

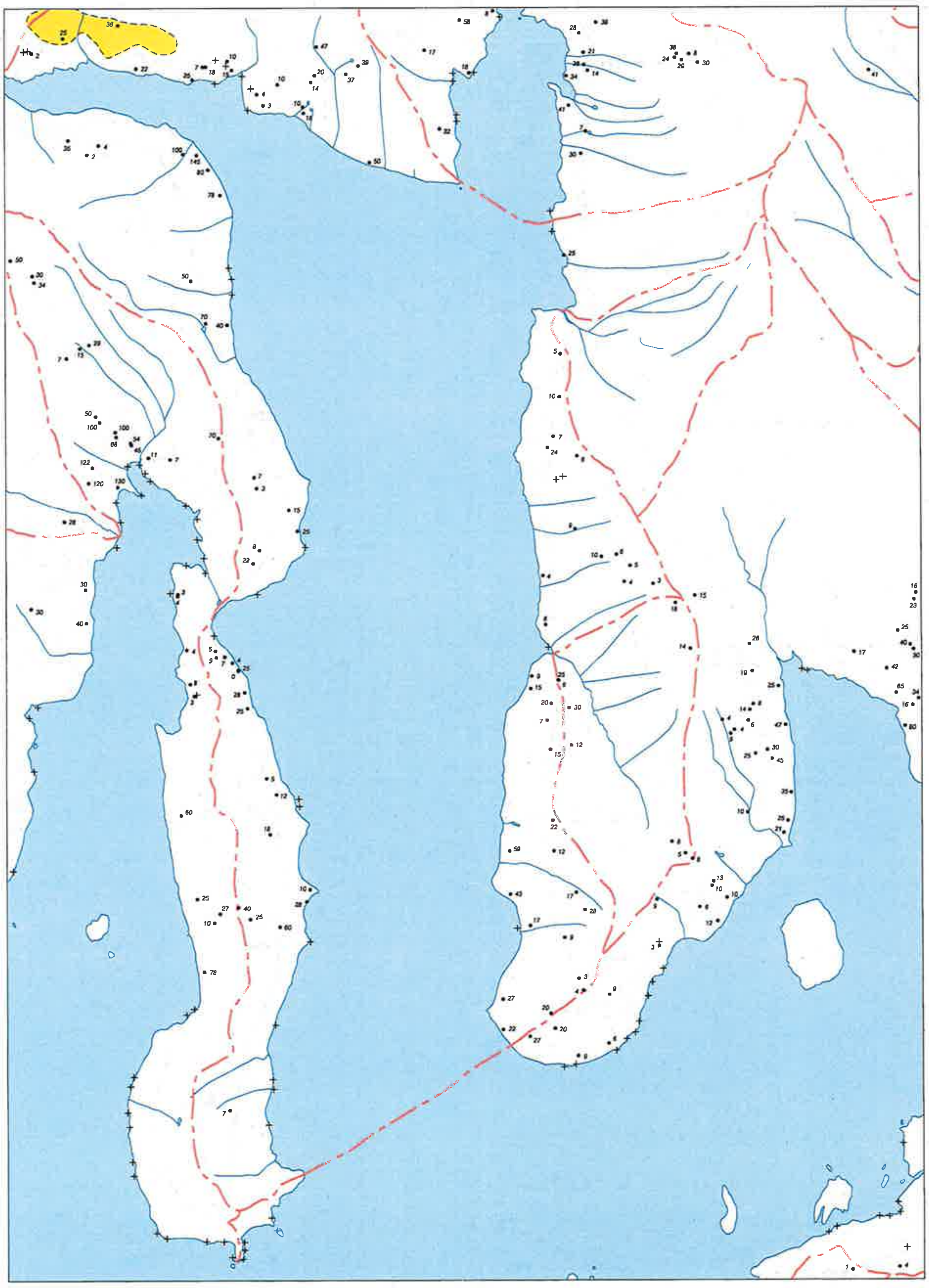
Uses of this Map: Sand and gravel aquifer maps are useful in two major categories of decision-making: ground-water supply and ground-water protection. For ground-water supply, these maps are useful in locating areas favorable for developing water supplies for municipal, industrial, or residential use. Information on the map, such as depth to bedrock and well yield, indicate the potential for ground-water production.

Ground-water protection is another important function of these maps. Knowledge of the location and extent of sand and gravel aquifers is critical when siting potential contamination sites such as landfills and salt storage facilities. When used in conjunction with other geologic information, this map can help planners and municipal officials make much more informed decisions to guide industrial growth or residential development.

If ground-water contamination occurs, the general trend of the plume migration can be deduced from these maps by analyzing the drainage basin boundaries and the local surface water bodies.

For further assistance in interpreting this map, contact a geologist at the Maine Geological Survey.

Significant Sand and Gravel Aquifers



Surficial materials data collected by Thomas K. Weddle during the 2011 field season. Well inventory data from the Maine Geological Survey bedrock well database.

Drainage basin boundaries compiled by U.S. Geological Survey, Water Resources Division, Augusta, Maine, with funding from the Maine Low-Level Radioactive Waste Authority.

Quadrangle Location

SCALE 1:24,000

CONTOUR INTERVAL 6 METERS

TRUE NORTH

Topographic base from U.S. Geological Survey Newbury Neck quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic map symbols.

The use of industry, firm, or local government names on this map is for location purposes only and does not impute responsibility for any present or potential effects on the natural resources.

SIGNIFICANT SAND AND GRAVEL AQUIFERS
(yields greater than 10 gallons per minute)

Approximate boundary of surficial deposits with significant saturated thickness where potential ground-water yield is moderate to excellent.

Surficial deposits with good to excellent potential ground-water yield; yields generally greater than 50 gallons per minute to a properly constructed well. Deposits consist primarily of glacial sand and gravel, but can include areas of sandy till and alluvium; yield zones are based on subsurface data where available and may vary from mapped extent in areas where data are unavailable.

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SURFICIAL DEPOSITS WITH LESS FAVORABLE AQUIFER CHARACTERISTICS
(yields less than 10 gallons per minute)

Areas with moderate to low or no potential ground-water yield (includes areas underlain by till, marine deposits, eolian deposits, alluvium, swamps, thin glacial sand and gravel deposits, or bedrock); yields in surficial deposits generally less than 10 gallons per minute to a properly constructed well.

SEISMIC-LINE INFORMATION

Profiles for 12-channel seismic lines are shown in Appendix 2 of Open-File Report 98-57 (Neil and others, 1998). Length of 12-channel seismic lines as shown on the map is to scale. All single-channel lines ranged from 80 to 300 feet long and are not shown to scale.

53	Depth to bedrock, in feet below land surface
≥ 53	Depth to bedrock exceeds depth shown (based on calculations)
12 ▮	Depth to water level, in feet below land surface
—MAP-7 131, 23 ▮	Twelve-channel seismic line, with depth to bedrock and depth to water shown at the midpoint of the line, in feet below land surface
69, 12 ▮ —MAP-E 72, 12 ▮	Single-channel seismic line, with depth to bedrock and depth to water shown at each end of the line, in feet below land surface. Unless otherwise indicated, data shown above the line-identifier box refers to the northern end of the seismic line

The 3-letter identifier for a line is an abbreviation for the topographic quadrangle. If the 3-letter identifier for the line is followed by a number (ex. MAP - 7, MAP - 4), the line is a 12-channel line. If the identifier is followed by a letter (ex. MAP - E, MAP - P), the line is a single-channel line.

GEOLOGIC AND WELL INFORMATION

50	Depth to bedrock, in feet below land surface
≥13	Penetration depth of boring; ≥ symbol refers to minimum depth to bedrock based on boring depth or refusal
6 ▮	Depth to water level in feet below land surface (observed in well, spring, test boring, pit, or seismic line)
✕	Gravel pit (overburden thickness noted in feet, e.g. 5-12')
⚒	Quarry
4 GPM	Yield (flow) of well or spring in gallons per minute (GPM)
	Spring, with general direction of flow
	Drilled overburden well
■	Dug well
✦	Observation well (project well if labeled, nonproject well if unlabeled)
✧	Test boring (project boring if labeled, nonproject boring if unlabeled)
↓	Driven point
⊙	Test pit
•	Drilled bedrock well
▽	Potential point source of ground-water contamination
+	Bedrock outcrop
	Surface-water drainage-basin boundary; surface-water divides generally correspond to ground-water divides. Horizontal direction of ground-water flow generally is away from divides and toward surface-water bodies

OTHER SOURCES OF INFORMATION

1. Weddle, T. K., 2012, Surficial materials of the Newbury Neck quadrangle, Maine: Maine Geological Survey, Open-File Map 12-5.
2. Weddle, T. K., 2012, Surficial geology of the Newbury Neck quadrangle, Maine: Maine Geological Survey, Open-File Map 12-4.
3. Caswell, W. B., 1987, Ground water handbook for the state of Maine, Second Edition: Maine Geological Survey, Bulletin 39, 135 p.
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Newbury Neck Quadrangle, Maine

Significant aquifers mapped by:
Thomas K. Weddle

Digital cartography by:
Susan S. Tolman

Robert G. Marvinney
State Geologist

Cartographic design and editing by:
Robert D. Tucker

Funding for the preparation of this map was provided by the Maine Geological Survey.

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Home page: http://www.maine.gov/doc/nrimc/nrimc.htm

Open-File No. 12-14
2012

WHAT IS AN AQUIFER?

Ground water, as the name implies, is water found below the land surface in the pore spaces between sand grains and in fractures in the bedrock (see diagrams below). An *aquifer* is a water-bearing geologic formation capable of yielding a usable amount of ground water to a well. In Maine there are two types of aquifers: loose soil materials (such as sand, gravel, and other sediments) and fractured bedrock. A sand and gravel deposit is considered a *significant aquifer* when a well in that deposit is capable of being continuously pumped at a rate of 10 gallons per minute (gpm) or more. To sustain a yield of 10 gpm or more, a deposit must be permeable enough for water to flow readily into the well as it is pumped (see section on *porosity* and *permeability* below), and there must be a sufficient depth of water in the well so that it will not be pumped dry.

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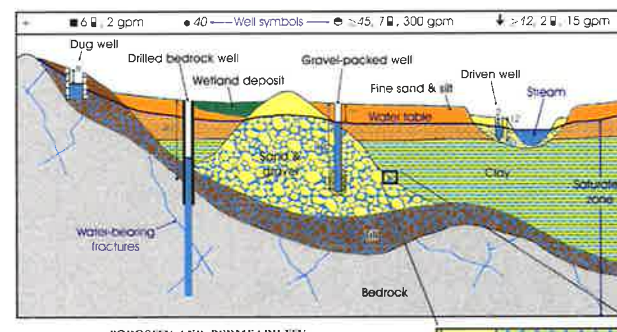

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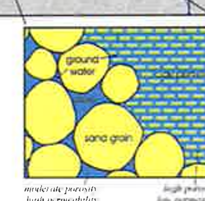

moderate porosity, high permeability *high porosity, low permeability*

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Operating a twelve-channel seismograph, Piscataquis County, Maine

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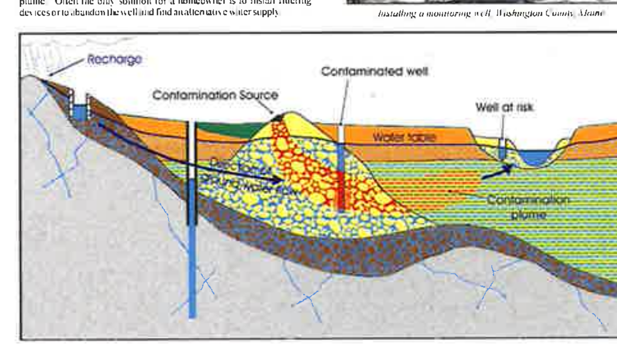
Notice in the diagram below that ground water is not static; it flows. This concept is very important, especially when ground water becomes contaminated. Once in the ground-water system, contaminants usually travel along the paths followed by ground water and are sometimes able to migrate considerable distances over time.

In the diagram below, a plume of contamination originates at the source in the sand and gravel deposit. This source could be a landfill, a leaking fuel storage tank, or an accidental spill. As the contaminant seeps into the subsurface system and enters the aquifer, it flows with the ground water. In the diagram, the plume contaminated the gravel-packed well as it passed by. The driven well near the stream is not contaminated, but is at risk since the plume is flowing in that direction. The dug well on the hillside, however, is not affected because it is upgradient of the source, hence the contaminated ground water flows away from this well.

Once ground water is contaminated, it is very difficult and expensive to correct. To design a clean-up plan, monitoring wells are installed under the direction of a hydrogeologist or other specialist. These wells define the three-dimensional extent of the affected area. Sometimes it is possible to pump contaminants to the surface using remediation wells within the plume. Often the only solution for a homeowner is to install filtering devices or to abandon the well and find an alternative water supply.

Installing a monitoring well, Washington County, Maine



HOW TO USE THIS MAP

Types of Information Shown on this Map: The yellow and red colored areas on the map indicate significant aquifers, zones where ground-water yield is estimated to be 10 gpm or greater. The boundaries of the aquifers are drawn by a geologist based, in part, on the well data shown on the map. Areas not mapped as aquifer may be thin or unsaturated sand and gravel deposits, surficial deposits other than sand and gravel, or bedrock.

The well data on the map provide information about the type of well, depth to water table, depth to bedrock, and yield of the wells in the area. This information is useful when making decisions about water supply, a drainage plan, or the need for blasting.

Information from seismic refraction studies also is shown on the map. Seismic studies give detailed information about depth to water table and depth to and shape of the bedrock surface. Geologic cross sections generated from seismic information are shown in associated reports listed in the references below the map at left.

Surface-water drainage-basin boundaries are also shown on the map. Horizontal direction of ground-water flow generally is away from drainage divides and toward surface-water bodies.

Uses of this Map: Sand and gravel aquifer maps are useful in two major categories of decision making: ground-water supply and ground-water protection. For ground-water supply, these maps are useful in locating areas favorable for developing water supplies for municipal, industrial, or residential use. Information on the map, such as depth to bedrock and well yield, indicate the potential for ground-water production.

Ground-water protection is another important function of these maps. Knowledge of the location and extent of sand and gravel aquifers is critical when siting potential contamination sites such as landfills and salt storage facilities. When used in conjunction with other geologic information, this map can help planners and municipal officials make much more informed decisions to guide industrial growth or residential development.

If ground-water contamination occurs, the general trend of the plume migration can be deduced from these maps by analyzing the drainage basin boundaries and the local surface water bodies.

For further assistance in interpreting this map, contact a geologist at the Maine Geological Survey.

Attachment 4

Water Quality Results Data

		County	Public Health District	Town		
	Location	Hancock	Downeast	Blue Hill	Brooksville	Surry
	Content Area	Private Well Water	Private Well Water	Private Well Water	Private Well Water	Private Well Water
Arsenic	Number of Wells Tested	2,623.00	3,834.00	175.00	99.00	176.00
	Percent Above Guideline	21.70	20.10	41.10	17.20	45.50
	Median (ug/L)	1.60	1.70	7.00	1.00	8.25
	95th Percentile (ug/L)	66.00	55.00	130.00	32.00	250.00
	Maximum (ug/L)	840.00	3,100.00	600.00	130.00	660.00
Chloride	Number of Wells Tested	1,592.00	2,310.00	84.00	54.00	73.00
	Percent Above Guideline	1.90	1.80	1.20	0.00	0.00
	Median (mg/L)	12.00	12.00	9.50	10.50	6.00
	95th Percentile (mg/L)	140.00	120.00	160.00	51.00	87.00
	Maximum (mg/L)	1,550.00	1,800.00	320.00	86.00	240.00
Fluoride	Number of Wells Tested	2,938.00	4,382.00	157.00	101.00	146.00
	Percent Above Guideline	5.90	4.50	8.30	1.00	17.80
	Median (mg/L)	0.28	0.20	0.40	0.10	0.90
	95th Percentile (mg/L)	2.20	2.00	2.80	1.03	3.30
	Maximum (mg/L)	6.40	6.40	4.50	2.30	6.40
Manganese	Number of Wells Tested	2,495.00	3,656.00	149.00	92.00	134.00
	Percent Above Guideline	6.40	6.30	10.10	10.90	8.20
	Median (mg/L)	0.01	0.01	0.02	0.01	0.02
	95th Percentile (mg/L)	0.39	0.38	0.44	1.00	0.42
	Maximum (mg/L)	3.90	7.10	1.30	2.50	1.50
Nitrate	Number of Wells Tested	2,899.00	4,323.00	163.00	109.00	139.00
	Percent Above Guideline	0.20	0.20	0.00	0.00	0.00
	Median (mg/L)	0.12	0.13	0.10	0.27	0.05
	95th Percentile (mg/L)	2.50	2.50	1.50	3.19	1.26
	Maximum (mg/L)	18.00	26.00	8.21	7.69	3.80
Nitrite	Number of Wells Tested	2,897.00	4,320.00	163.00	109.00	139.00
	Percent Above Guideline	0.00	0.00	0.00	0.00	0.00
	Median (mg/L)	0.03	0.03	0.03	0.03	0.03
	95th Percentile (mg/L)	0.03	0.03	0.03	0.03	0.03
	Maximum (mg/L)	0.26	0.33	0.15	0.26	0.06
Uranium	Number of Wells Tested	2,265.00	3,333.00	143.00	77.00	129.00
	Percent Above Guideline	7.90	6.00	5.60	1.30	7.80
	Median (ug/L)	0.93	0.80	0.70	0.25	0.52
	95th Percentile (ug/L)	52.00	39.00	44.00	6.90	41.00
	Maximum (ug/L)	880.00	880.00	190.00	120.00	88.00

Source: Maine CDC (2023)

Attachment 5

Emergency Community Water Assistance Grants Fact Sheet

Emergency Community Water Assistance Grants

What does this program do?

This program helps eligible communities prepare, or recover from, an emergency that threatens the availability of safe, reliable drinking water.

The following events qualify as an emergency:

- **Drought or flood**
- **Earthquake**
- **Tornado or hurricane**
- **Disease outbreak**
- **Chemical spill, leak, or seepage**
- **Other disasters**

NOTE: A federal disaster declaration is not required.

Who may apply for this program?

- **Most State and local governmental entities**
- **Nonprofit organizations**
- **Federally recognized Tribes**

What is an eligible area?

- Rural areas and towns with populations of 10,000 or less – check eligible addresses
- Tribal lands in rural areas
- Colonias

The area to be served must also have a median household income less-than the state's median household income for non-metropolitan areas. Contact your local RD office for details.

How may funds be used?

- Water transmission line grants up to $150,000 to construct waterline extensions, repair breaks or leaks in existing water distribution lines, and address related maintenance necessary to replenish the water supply
- Water source grants up to $1,000,000 to construct a water source, intake or treatment facility

Are matching funds required?

Partnerships with other federal, state, local, private, and nonprofit entities are encouraged.

How do we get started?

- Applications for this program are accepted year round online at https://www.rd.usda.gov/programs-services/rd-apply or through your local RD office.
- Program Resources are available online (forms, guidance, certifications, etc.).

Who can answer questions?

- Staff in your local RD office.
- Participating nonprofit associations

What law governs this program?

- Code of Federal Regulation, 7 CFR 1778
- Section 306A of the Consolidated Farm and Rural Development Act

"Why does USDA Rural Development do this?"

This program helps prevent damage or restore households and business' access to clean, reliable drinking water in eligible rural areas and towns following natural disasters. Funding can improve the natural environment and encourage manufacturers and other businesses to locate or expand operations.

NOTE: Because citations and other information may be subject to change, please always consult the program instructions listed in the section above titled "*What Governs This Program?*" You may also contact your local office for assistance. You will find additional forms, resources, and program information at rd.usda.gov. *USDA is an equal opportunity provider, employer, and lender.*

Last Updated July 2020

Attachment 6

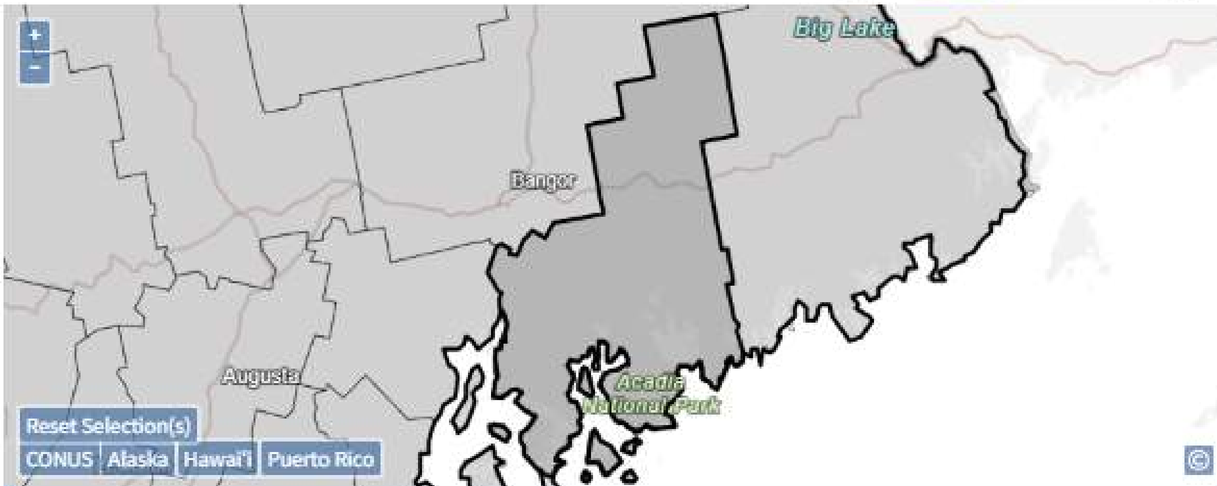
U.S. Drought Monitor for Hancock County

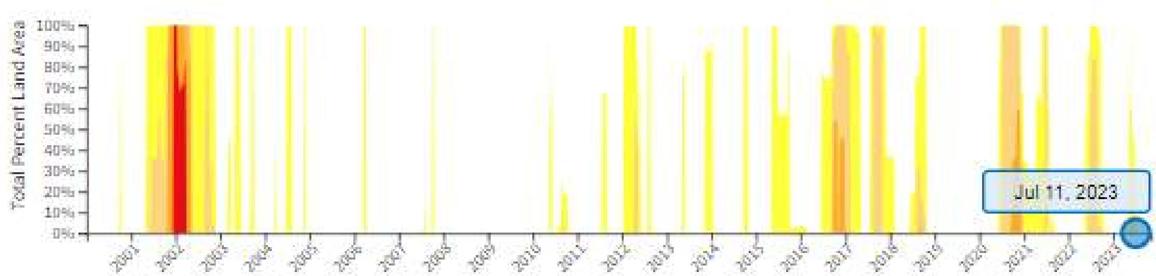
Explore Historical Drought Conditions

U.S. Drought Monitor (2000 - Present) | 9-Month SPI (1895 - Present) | Paleoclimate Data (0 - 2017)

U.S. Drought Monitor for Hancock

U.S. Drought Monitor for Hancock





Time Series Options

Time Period (Years): ____ to ____

UPDATE GRAPH | RESET GRAPH

Show Date Label | Show Data on Hover

Show Category: All

Combine States +

Combine Counties +

SOURCE(S): NOAA, USDA, National Drought Mitigation Center
LATEST AVAILABLE DATA: 2023-11-07

Map Legend

U.S. Drought Monitor Category	% of County
D0 - Abnormally Dry	0.0%
D1 - Moderate Drought	0.0%
D2 - Severe Drought	0.0%
D3 - Extreme Drought	0.0%
D4 - Exceptional Drought	0.00%
Total Area in Drought (D1 - D4)	0.00%

About This Dataset +