Sea Level Rise Impacts on Groundwater Levels and Water Quality: A Vulnerability and Planning Study in Durham, NH

Meeting #2

Town of Durham
November 6, 2020

Project Goals:

- Simulate changing groundwater flow patterns
- Simulate rising groundwater levels caused by sea-level rise
- Identify areas and assets vulnerable to rising groundwater
  - ✓ Drinking water (saltwater intrusion)
  - ✓ Septic systems
  - ✓ Hazardous waste disposal areas
  - ✓ Stormwater systems

Project Progress

Kyle Pimental, Strafford Regional Planning Commission

Accomplishments to Date:

- Kickoff Meeting in June 2020
- Meeting with Durham Conservation Commission in July 2020
- Data Collection
  - JFK Environmental Services, LLC
  - SRPC
- Construction of Model

Proposed Timeline

	Project Lead	CY2020									CY2021										
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Project Schedule																					
Task 1: Modeling																					
Task 1.1: Create MODFLOW/SEAWAT Grid for Durham	UNH																				
Task 1.2: Data Collection, Evaluation and Preparation for use in the Modeling Study	UNH																				
Task 1.3: Model Construction	UNH																				
Task 1.4: Meeting to Decide on Model Scenarios	UNH																				
Task 1.5 Run Simulations with Three Scenarios and Present Results	UNH																				
Task 1.6 Final Technical Report and Project Wrap Up	UNH																				
Task 2: Project Administration																					
Task 2.1: Organization and Coordination between Project Team and Municipal Staff	SRPC																				
Task 2.2: Kickoff Meeting with Project Team, Technical Advisory Committee, and NHDES	SRPC																				
Task 2.3: Progress Check-In Meeting with Project Team, Technical Advisory Committee, and NHDES	SRPC																				
Task 2.4: Final Wrap Up Meeting with Project Team, Technical Advisory Committee, and NHDES	SRPC																				
Task 2.5: Reporting, Invoicing, and Overall Project Management	SRPC																				
Task 3: Planning Recommendations																					
Task 3.1: Compile and Review Additional GIS Data Gaps	SRPC																				
Task 3.2: Use Groundwater Mapping to Identify Areas of Vulnerability	SRPC																				
Task 3.3: Develop Strategies and Recommendations	SRPC																				
Task 3.4: Final Report and Project Wrap Up	SRPC																				

NOTE: Red outline boxes mark important meeting dates and milestones throughout the project

Durham Groundwater Model Update

Jayne F. Knott, Ph.D., JFK Environmental Services LLC
Jennifer M. Jacobs, Ph.D., P.E., University of New Hampshire

Data Collection - Sources

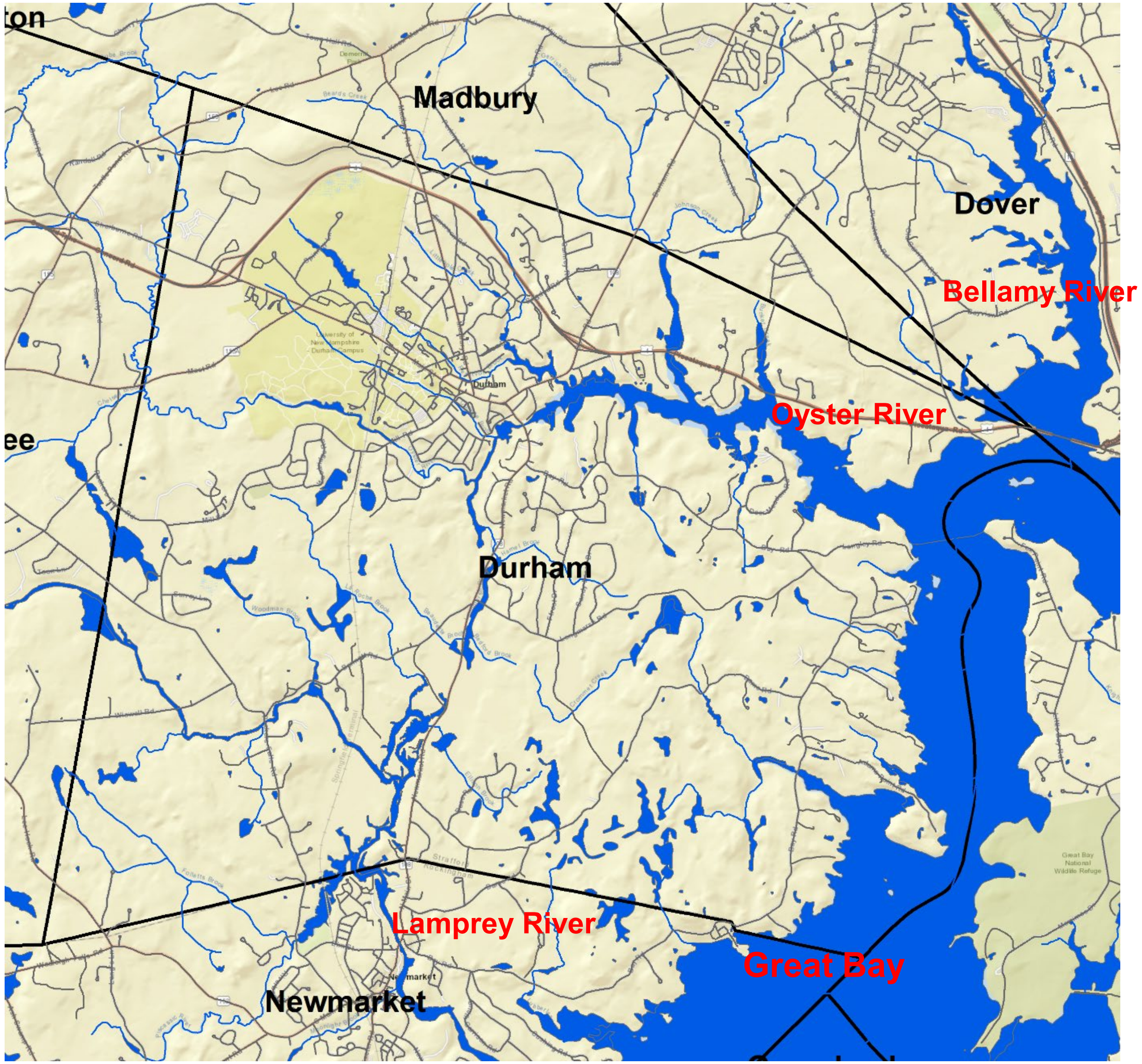
- NH Granit
  - LiDAR
  - Hydrography
  - Wetlands
  - Sea-level rise
- NHDES/NH Geological Survey
  - Watersheds
  - Wells – public water supply
  - Recharge/Evapotranspiration
  - Bedrock
- Aquifer properties from literature

- Mack, T. J. (2009), Assessment of ground-water resources in the Seacoast region of New Hampshire*, U.S. Geological Survey Scientific Investigations Report, 2008-5222*, 188.
- Hergott, M. A. (2012). Analysis of the geomorphic characteristics of streams with large wood hydraulic controls in coastal New Hampshire [M.S., University of New Hampshire]. http://search.proquest.com/docview/1325663351/abstract/28911ED6D974C2APQ/1
- Moore, R.B. Geohydrology and Water Quality of Stratified-Drift Aquifers in the Exeter, Lamprey, and Oyster River Basins, Southeaster New Hampshire, U.S. Geological Survey, Water-Resources Investigations Report 88-4128, Bow, New Hampshire, 1990 Revised, pp. 66.
- Truslow, Danna Butler, "Temperature moderation in a coastal coldwater stream a study of surface water, groundwater and hyporheic zone interaction" (2009). Master's Theses and Capstones. 499. https://scholars.unh.edu/thesis/499
- Wake, C., Knott, J., Lippmann, T., Stampone, M., Ballestero, T., Bjerklie, D., Burakowski, E., Glidden, S., Hosseini-Shakib, I., Jacobs, J. (2019). New Hampshire Coastal Flood Risk Summary – Part I: Science. Prepared for the New Hampshire Coastal Flood Risk Science and Technical Advisory Panel. Report published by the University of New Hampshire, Durham, NH.

Model Construction

- Land surface elevation – LiDAR
- Geology and aquifer properties
  - *Surficial geology*
  - *Bedrock*
- Hydrography: streams, lakes, and wetlands
- Aquifer Recharge
- Public supply wells; monitoring wells, domestic wells

Town of Durham



Development of Model Grid

Watershed Boundaries

Model Boundary

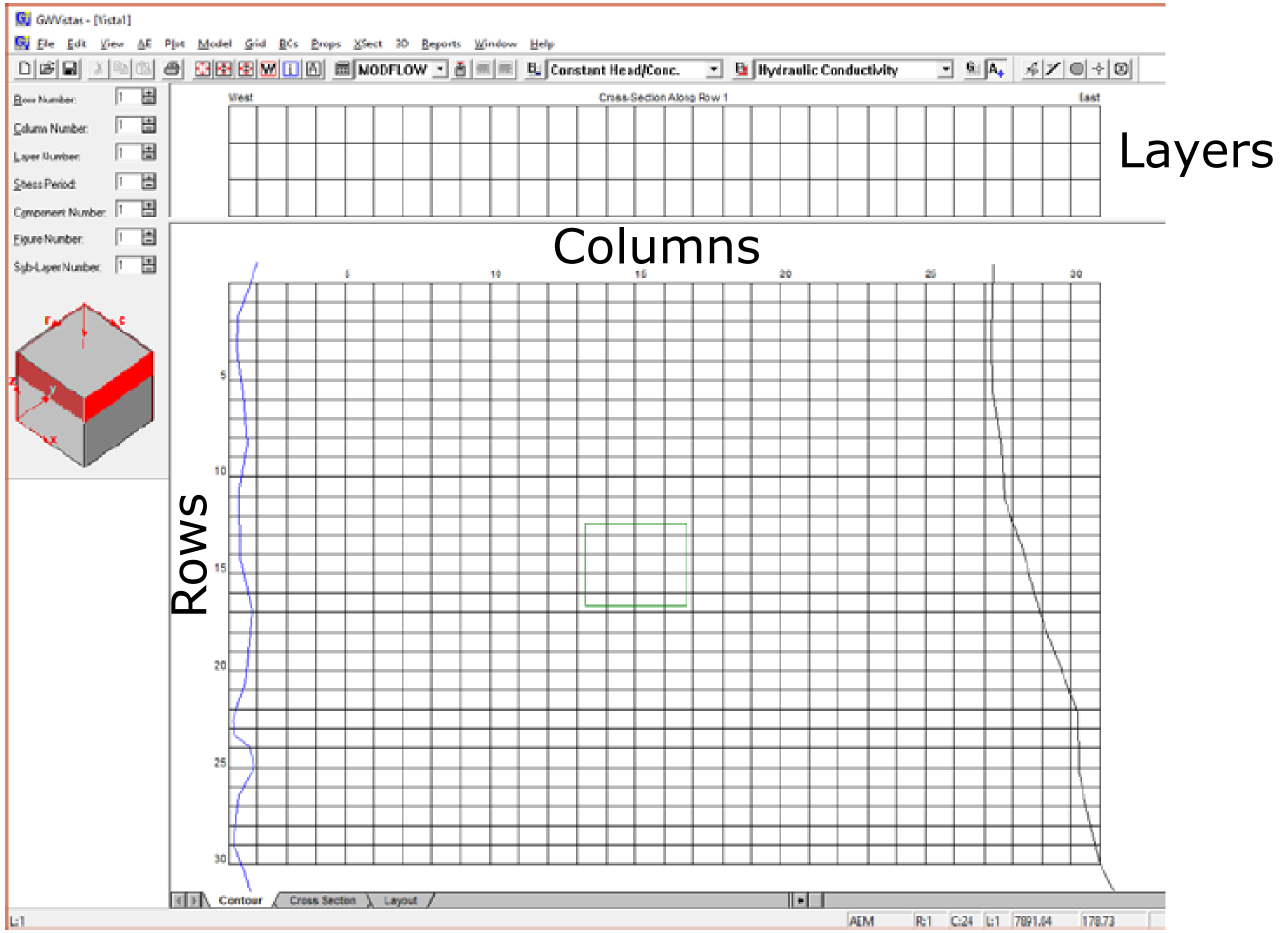
Model area is bounded by natural hydrologic features and watersheds

Brown hatched area = active model area

Data is compiled using ArcMap

Model Grid

- 260 rows and 330 columns
- Grid cell size - 200 feet x 200 feet
- 22 Layers
  - *Layer thickness ranges from 5 to 100 feet thick*
  - *Bottom of model is at 1100 feet*



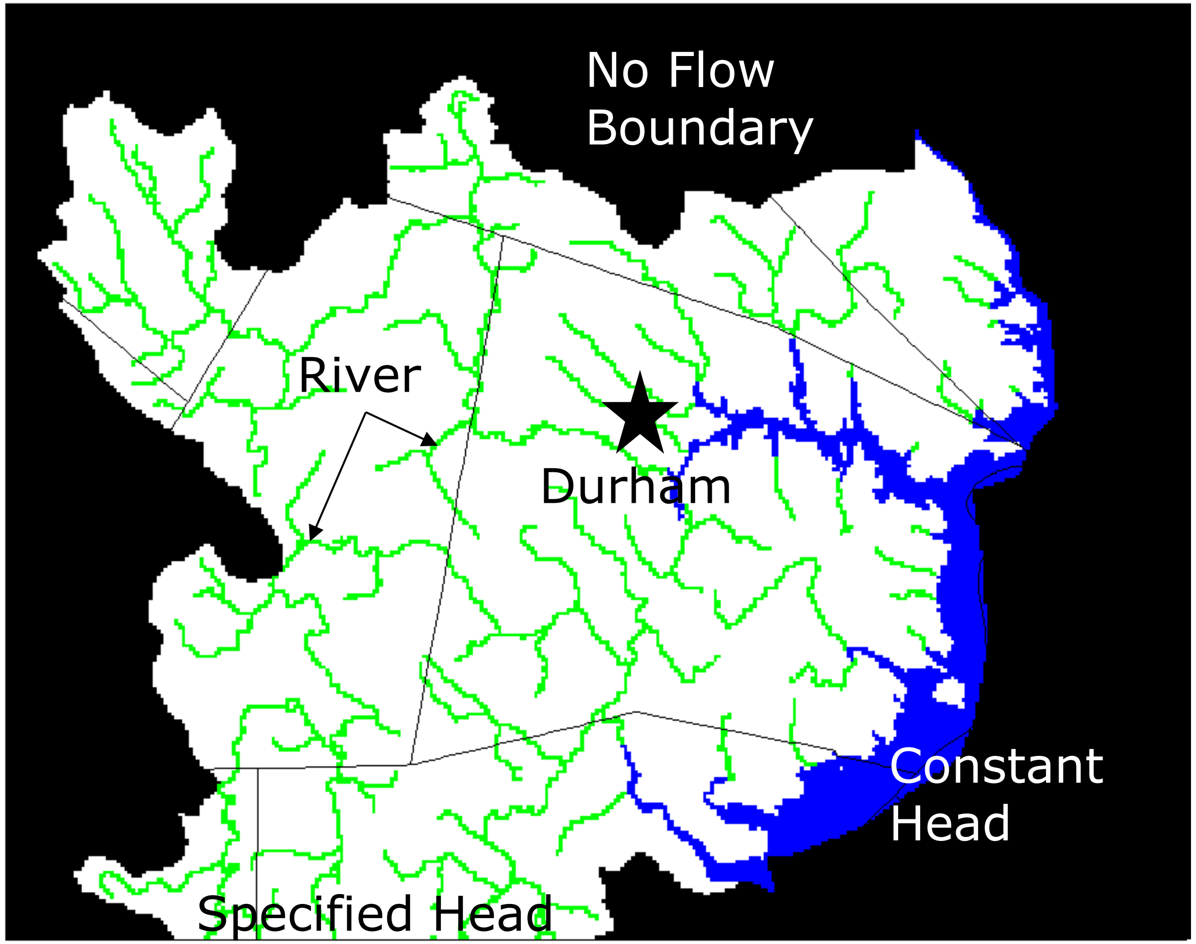
Boundary Conditions and Properties

- Boundary conditions:
  - *Rivers and streams*
  - *Coastline (constant head)*
  - *No flow boundaries*
  - *Specified flux (supply wells)*

- Properties:
  - *Layer top elevation*
  - *Aquifer recharge*
  - *Hydraulic conductivity*
  - *Storage/Sy/Porosity*

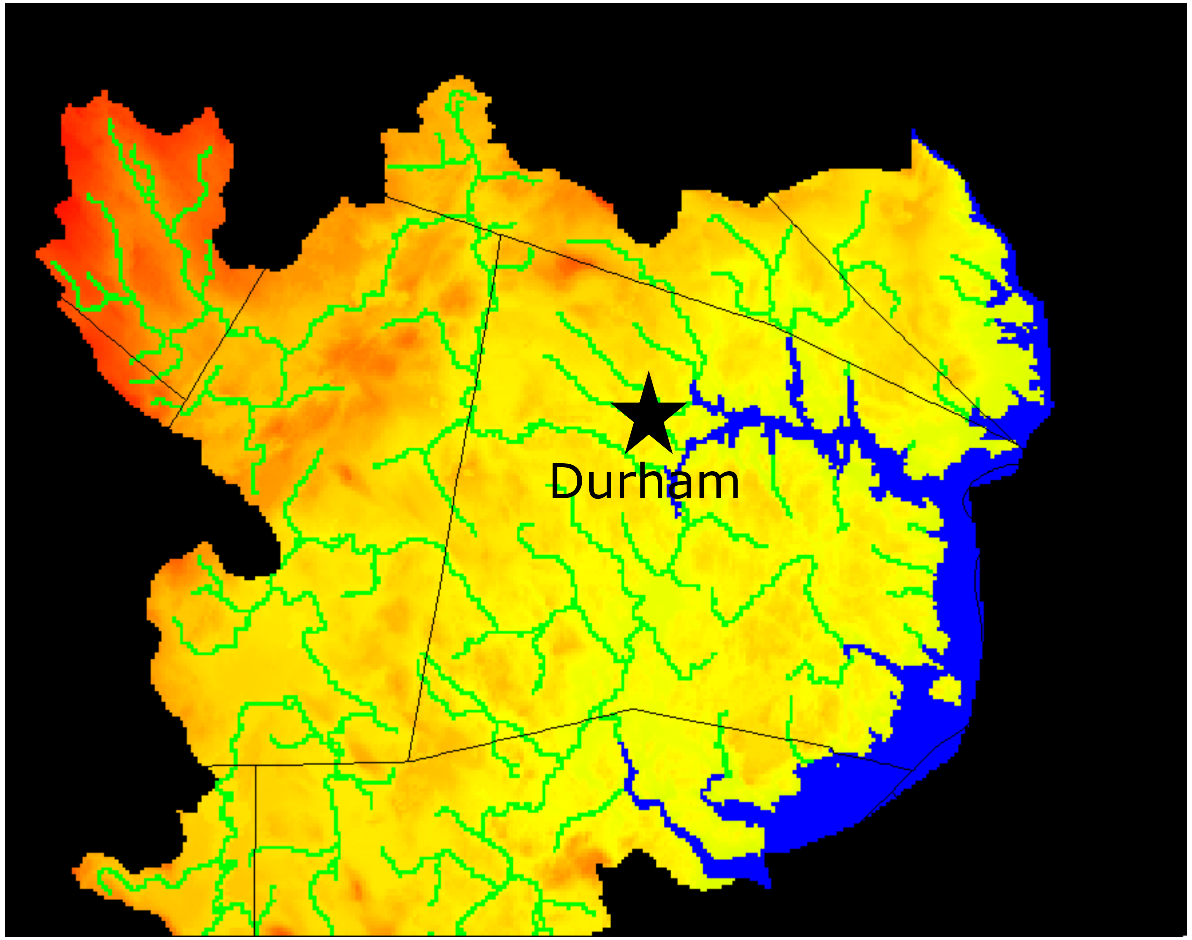
Boundary Conditions and Land Surface Elevations

Model Boundary Conditions



River cells – green; tidal water - blue

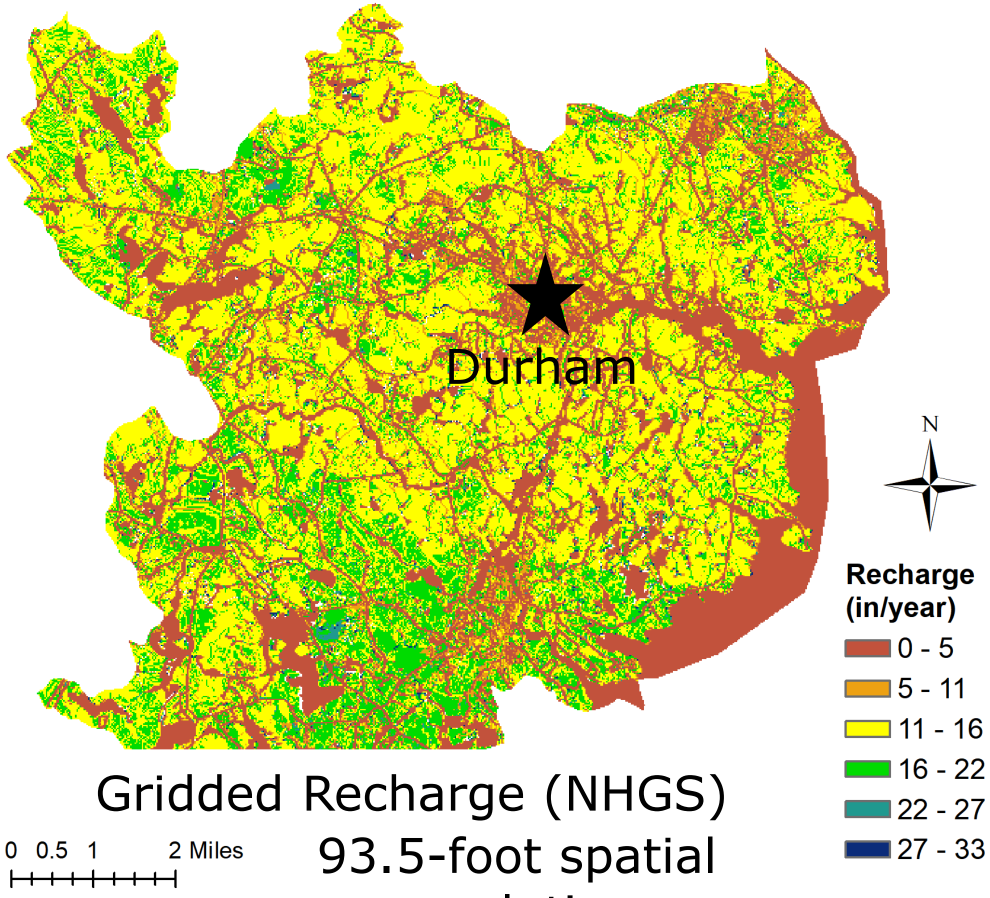
Layer 1 – Top Elevation



Land surface elevation (Orange = 356 feet; Yellow = 14 feet NAVD88)

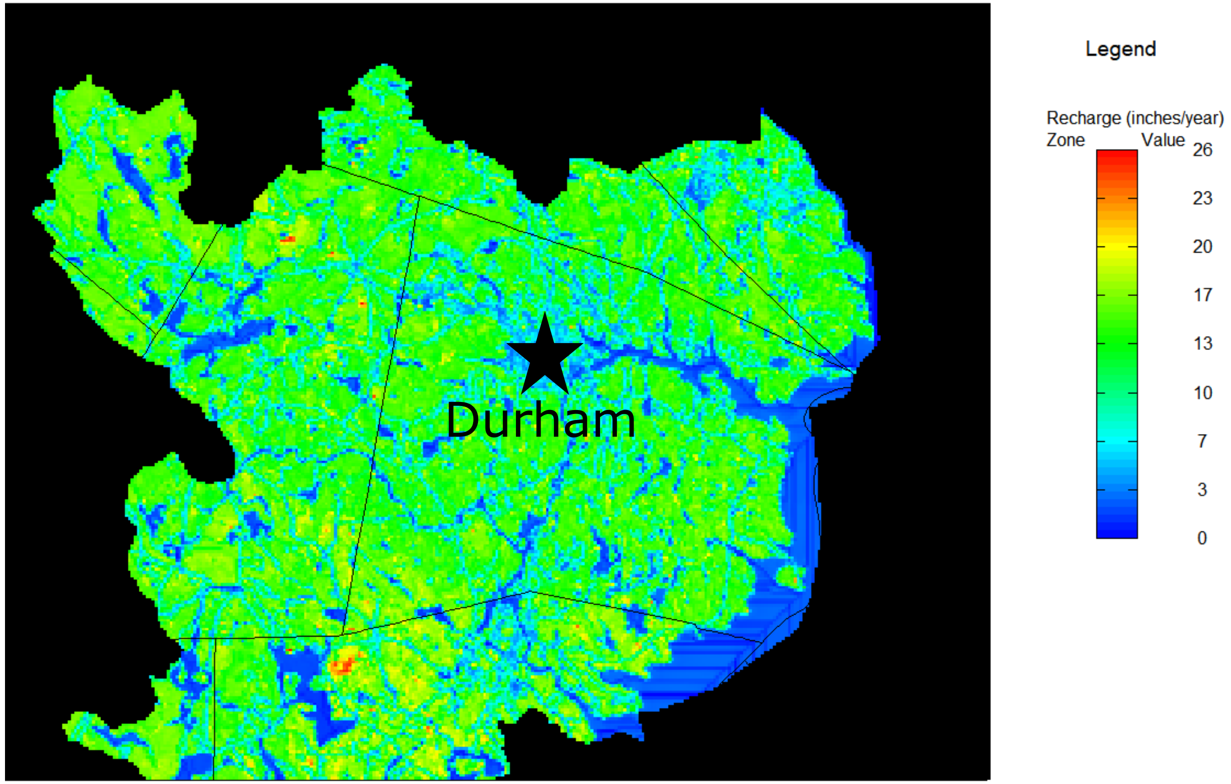
Aquifer Recharge Data and Model

ArcMap - Recharge



Gridded Recharge (NHGS)
93.5-foot spatial resolution

Same Recharge in Model

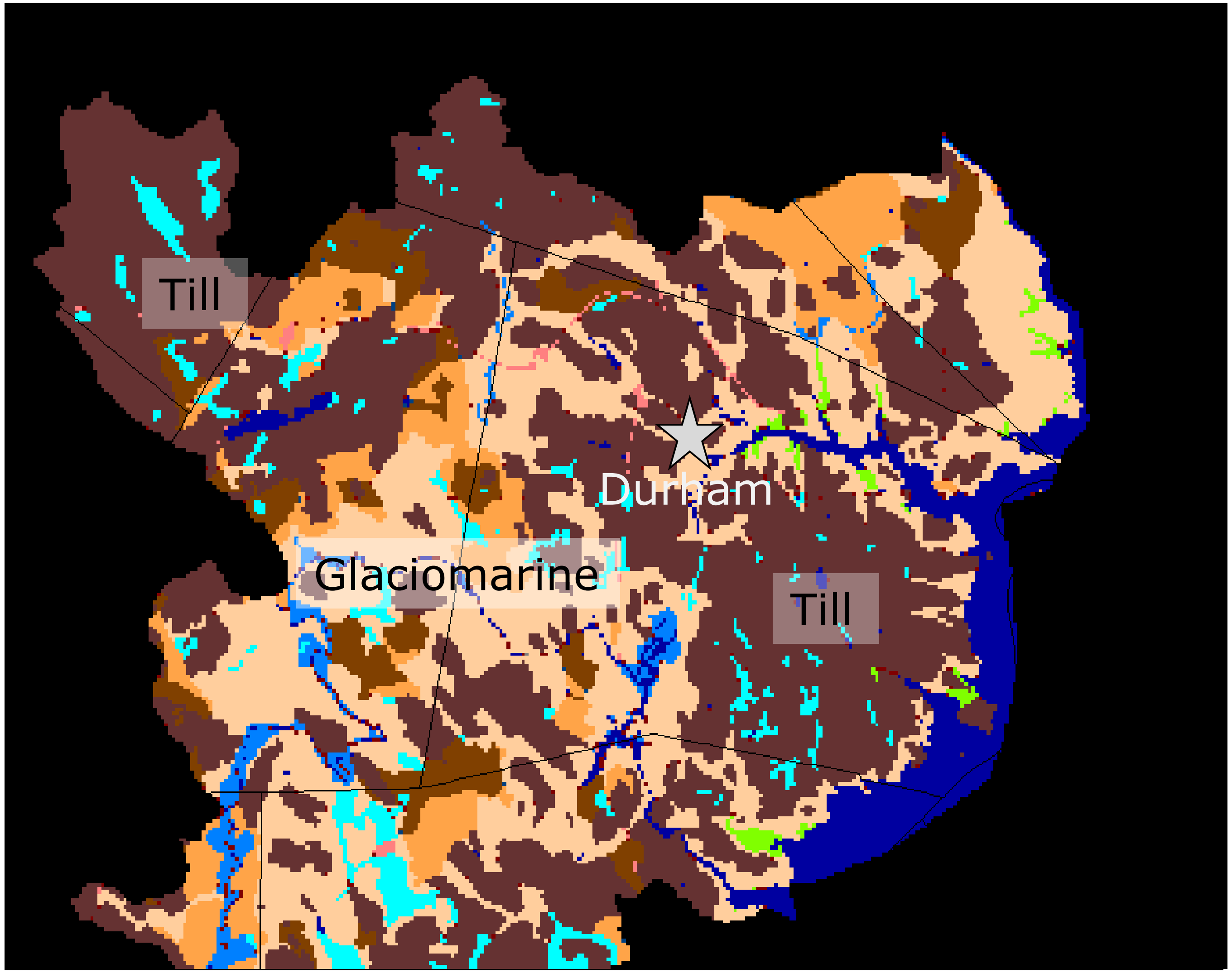


Aquifer Recharge in Model
200-foot spatial resolution

Gridded recharge was generated using a water Balance Model developed by Weston R. Dripps and Kenneth R. Bradbury of the Wisconsin Geological and Natural History Survey (2005).

Surficial Geology – Hydraulic Conductivity

Aquifer properties from the literature are used for the surficial deposits



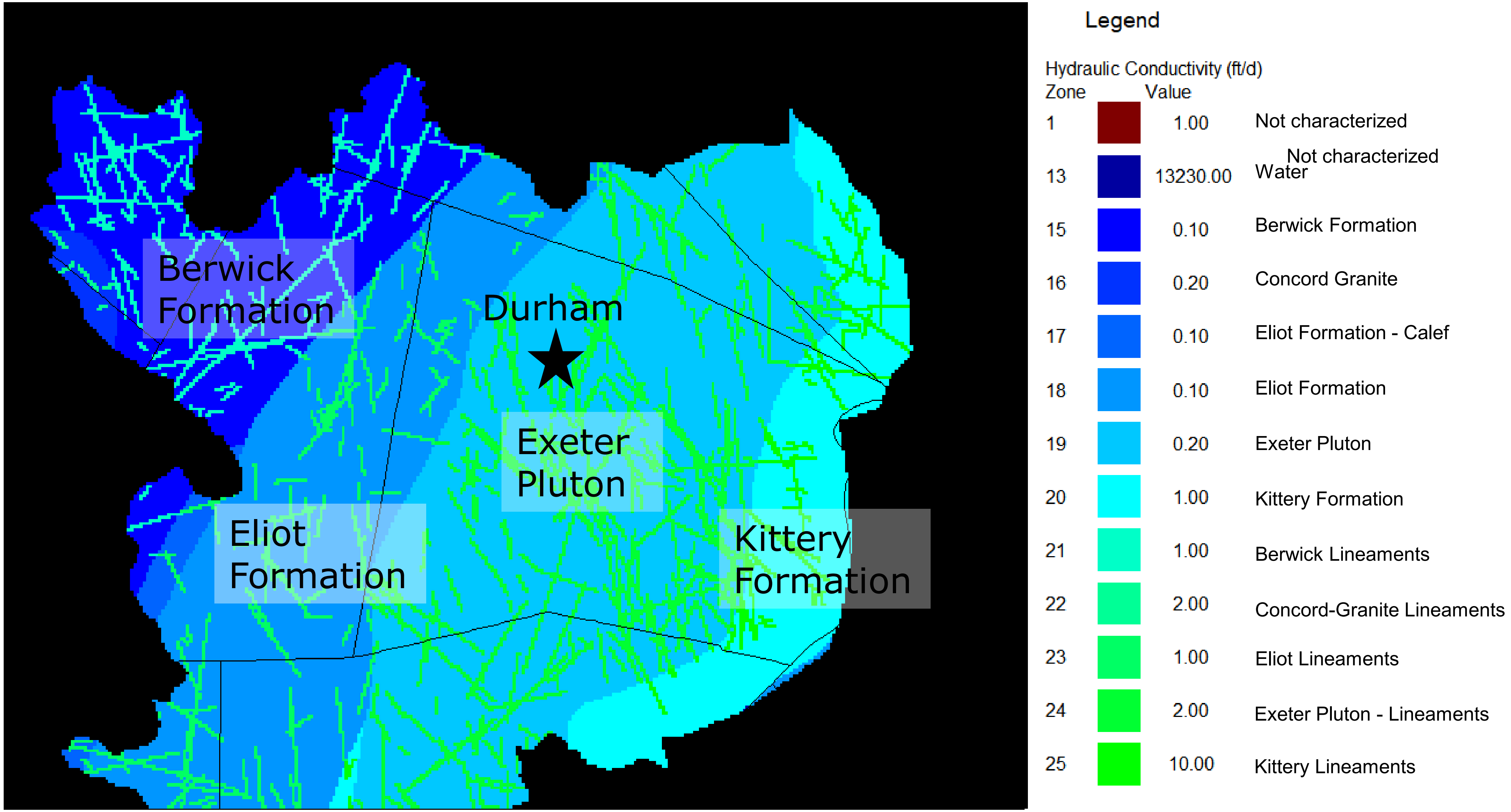
Legend

Hydraulic Conductivity (ft/d)

Zone	Value	
1	1.00	Not characterized
2	4.41	GM - Mixed sand and gravel
4	1.14	GM -Sand, minor silt
5	0.10	GM - Silt and clay
6	0.20	Bedrock outcrops
7	1.00	Alluvial - sand
8	1.96	Estuarine – salt marsh
9	0.03	Glacial Till
11	1.00	Glaciomarine
12	3.92	Palustrine
13	13230.00	Water
14	1.96	Fill – sand and gravel

Bedrock Geology – Hydraulic Conductivity

The bedrock geology is used to determine the bedrock properties



Next Steps

- Compile a groundwater level database – November - December
  - Plot groundwater elevation contours and create a DEM
  - Calculate and plot groundwater depth using LiDAR and the GWE DEM
- Calibrate the steady-state model to measured GW elevations -December
- Convert steady-state model to transient model - January
- Construct a SEAWAT model for saltwater intrusion simulations - January
- Run simulations with increasing sea levels – February - March

Post Processing

- Model Output
  - *Groundwater piezometric head (groundwater elevation)*
  - *Salt concentrations*

- GIS Analysis of model output
  - *Groundwater rise with sea level rise*
  - *Changes in depth to groundwater*
  - *Changes in salt concentrations*

Data Collection Update

Jackson Rand, Strafford Regional Planning Commission

Previously Collected Data:

- The study area for this project includes all parcels within 1 KM of tidally-influenced waters (Little Bay and Oyster River)
- Tommaso Wagner, a UNH Graduate Student Intern, had collected documentation showing the locations of the majority of the wells and septic systems in the study area
- Documentation includes construction documents, surveys, building permits, etc.
- Tommaso had also begun mapping into a GIS layer all wells and septic systems in the study area.
- This mapping work was not completed before Tommaso's internship ended, so SRPC has stepped in to help with the rest of the data collection

SRPC’s Data Collection Methodology:

1. Gather Existing Resources
2. Create GIS Data Points for All Wells and Septic Systems
3. Manually Move Well and Septic System GIS Data Points to Increase Location Accuracy

1) Gather Existing Resources:

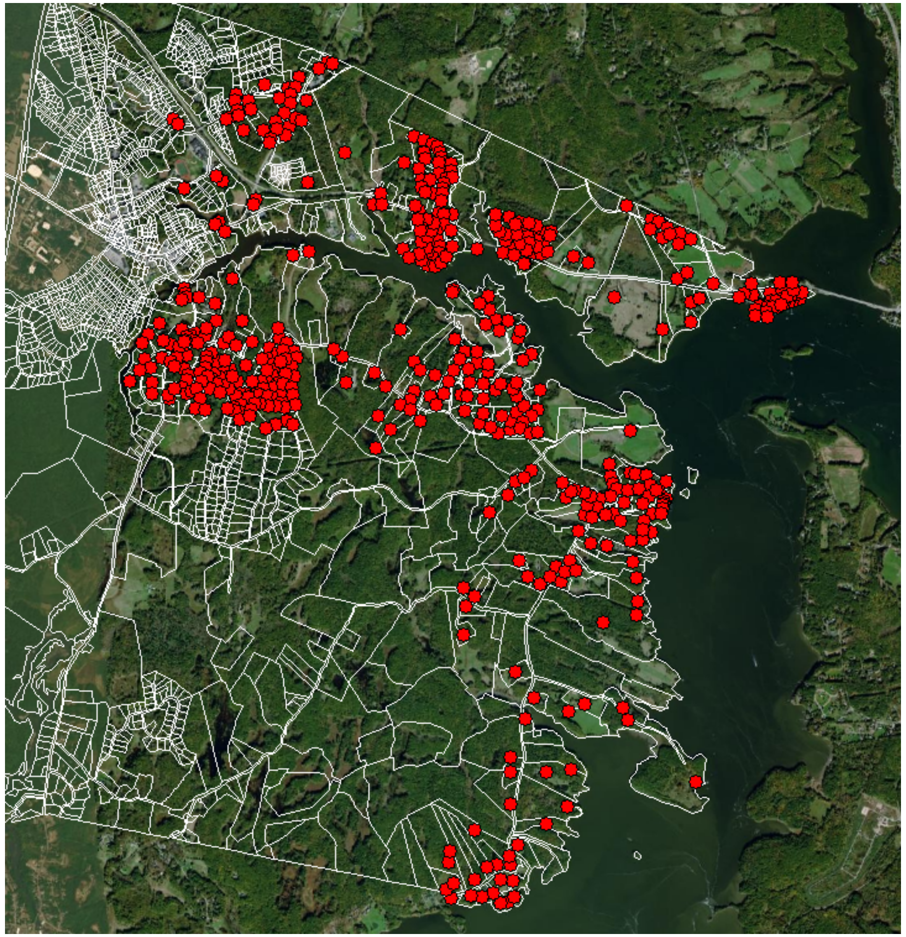
- SRPC downloaded all available documentation showing wells and septic systems locations (originally gathered by Tommaso)
- SRPC downloaded all existing wells and septic systems GIS data (originally created by Tommaso)

2) Create GIS Data Points for All Wells and Septic Systems:

- For all wells and septic systems that were not already mapped, SRPC created a GIS data point in the center of every parcel that is known to contain a well and/or a septic system
- The wells and septic systems GIS data are in two separate data layers
- There are 465 wells and 500 septic systems in the study area

2) Create GIS Data Points for All Wells and Septic Systems:

Septic Systems



Wells

Map not for Public

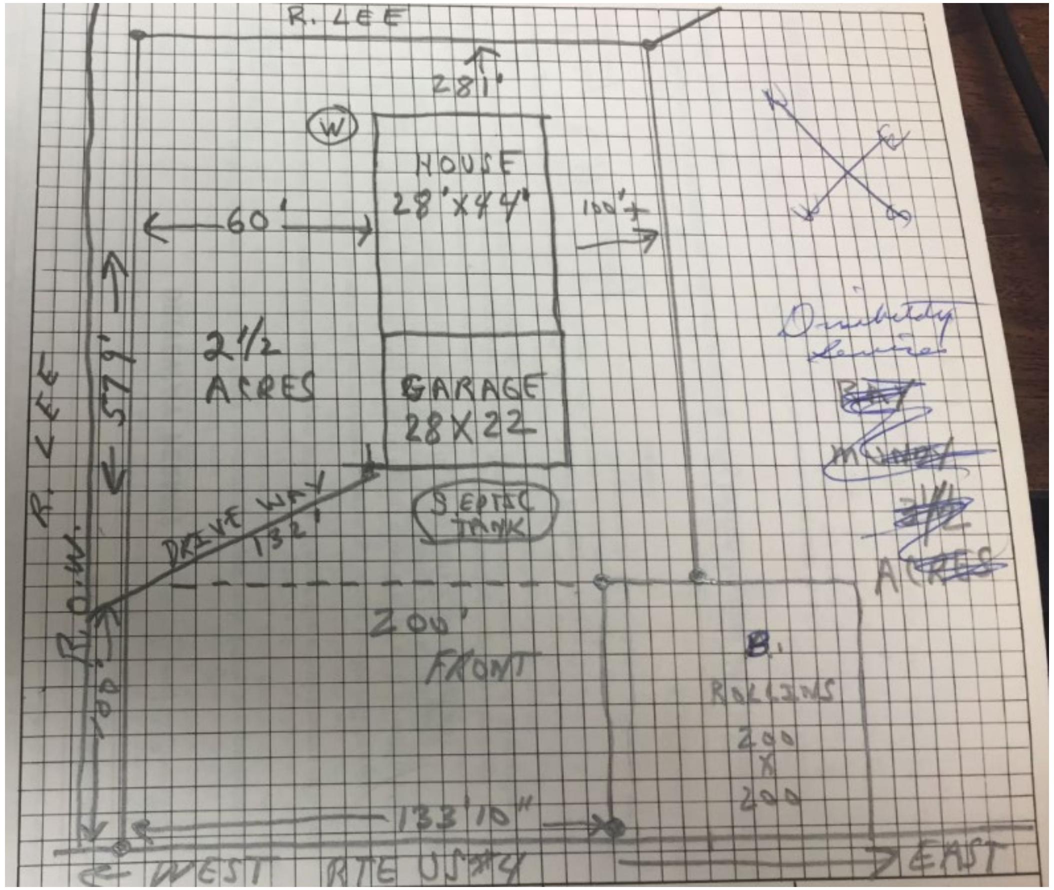
3) Manually Move Well and Septic System GIS Data Points to Increase Location Accuracy:

- The wells and septic systems GIS point data were reviewed alongside the existing documentation, and the points were manually moved to be in their true location
- For about 20% of the sites, we do not have documentation showing the true location of the well and septic system. For these sites, we placed the GIS data point on the house or structure, assuming that the well and/or septic system will be close to the house or structure.
- For about 10% of the sites, we do not have documentation showing the true location of the well and septic system, and we cannot clearly see a house or structure on the parcel. For these sites, we kept the GIS point in the center of the parcel.

3) Manually Move Well and Septic System GIS Data Points to Increase Location Accuracy:

Sites with Documentation
Well-GIS Data

Sites with Documentation
Well-Documentation



3) Manually Move Well and Septic System GIS Data Points to Increase Location Accuracy:

No Documentation
Point Placed on House/Structure

No Documentation
No House or Structure on Aerial, Used Centroid

Proposed Sea-Level Rise Projections to Use in Groundwater Model

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Sherry Godlewski, NH Department of Environmental Services

Kyle Pimental, Strafford Regional Planning Commission

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Sea Level Rise Projections for NH

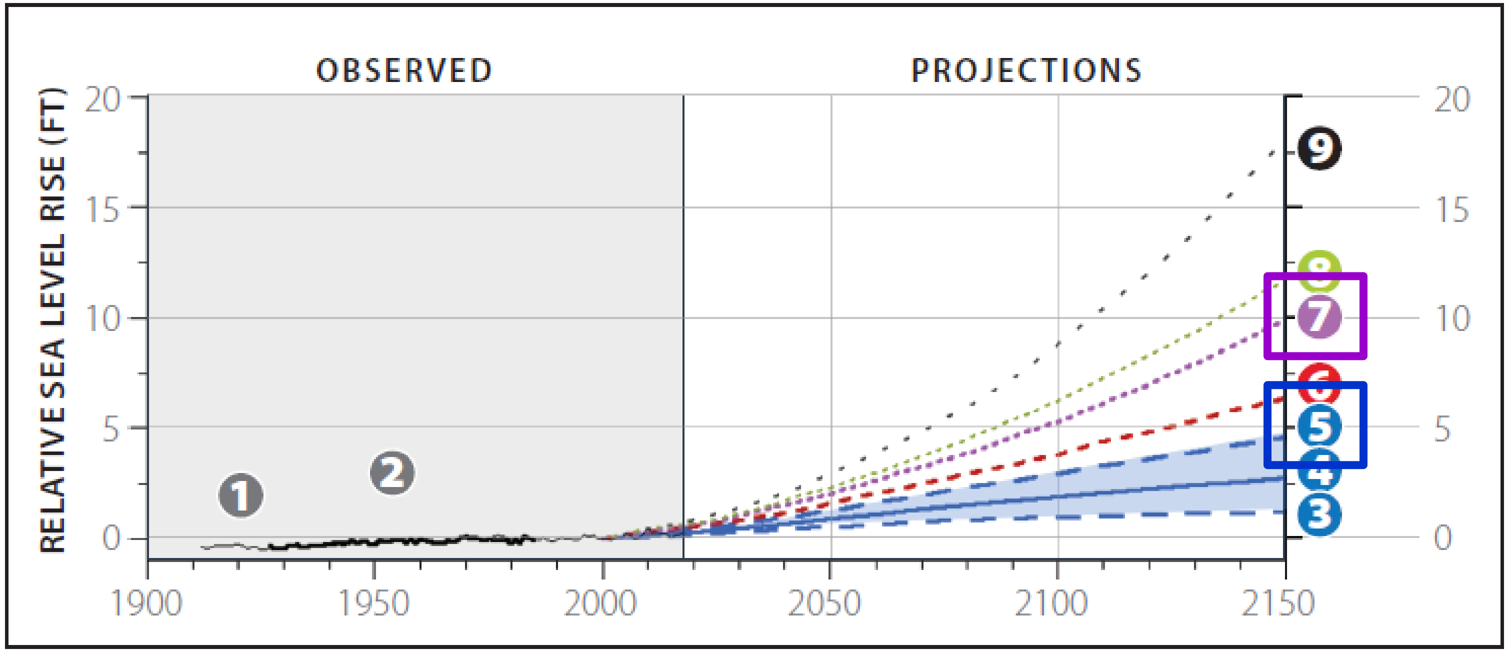

Figure 4.5. Observed and Projected Relative Sea-Level Rise for Seavey Island Tide Gauge K14 Projections | Stabilized Greenhouse Gas Concentrations (RCP 4.5).

1. Historical data for Portland, ME (1912-2018; thin black line)
2. Historical data for Seavey Island, ME (1927-1986; thick black line)
3. Lower end of "likely range"
4. Central estimate
5. Upper end of "likely range"
6. 1-in-20 chance estimate
7. 1-in-100 chance estimate
8. 1-in-200 chance estimate
9. 1-in-1000 chance estimate

Observed and Projected Relative Sea Level Rise for Seavey Island Tide Gauge - RCP 4.5 assumes stabilized greenhouse gas concentrations

Relative Sea-Level Rise = "the difference in elevation between the land and the sea surface" at a specific location (Wake et al., 2019).

Source: New Hampshire Coastal Flood Risk Summary Part 1: Science (2019)

Recommended Decadal RSLR Estimates

STEP 3 TABLE A. RECOMMENDED DECADAL RSLR ESTIMATES (IN FEET ABOVE 2000 LEVELS) BASED ON RCP 4.5, PROJECT TIMEFRAME, AND TOLERANCE FOR FLOOD RISK.

TIMEFRAME	**HIGH** TOLERANCE FOR FLOOD RISK	**MEDIUM** TOLERANCE FOR FLOOD RISK	**LOW** TOLERANCE FOR FLOOD RISK	**VERY LOW** TOLERANCE FOR FLOOD RISK
	Plan for the following RSLR estimate (ft)* *compared to sea level in the year 2000*			
	Lower magnitude, Higher probability	⟵	⟶	Higher magnitude, Lower probability
2030	0.7	0.9	1.0	1.1
2040	1.0	1.2	1.5	1.6
2050	1.3	1.6	2.0	2.3
2060	1.6	2.1	2.6	3.0
2070	2.0	2.5	3.3	3.7
2080	2.3	3.0	3.9	4.5
2090	2.6	3.4	4.6	5.3
2100	2.9	3.8	5.3	6.2
2110	3.3	4.4	6.1	7.3
2120	3.6	4.9	7.0	8.3
2130	3.9	5.4	7.9	9.3
2140	4.3	5.9	8.9	10.5
2150	4.6	6.4	9.9	11.7

Source: NH Coastal Flood Risk Summary, Part II Guidance (2020)

Proposed Relative Sea Level Rise Scenarios

We propose to simulate:

- #7 scenario (low tolerance for risk)

and produce results for:

- SLR 1, 2, 4, 6, and 8 feet

					#5	#7
Stress Period	Starting Year	Ending Year	Duration (yrs)	Duration (days)	RSLR relative to 2000	RSLR relative to 2000
1	2000	2020	20	7300	0.1	0.1
2	2021	2029	8	2920	0.6	1.0
3	2030	2040	10	3650	1.0	1.6
4	2041	2050	9	3285	1.3	2.0
5	2051	2060	9	3285	1.6	2.5
6	2061	2070	9	3285	2.0	3.0
7	2071	2084	13	4745	2.4	4.0
8	2085	2090	5	1825	2.6	4.5
9	2091	2100	9	3285	2.9	5.3
10	2101	2111	10	3650	3.3	6.0
11	2112	2120	8	2920	3.6	7.0
12	2121	2133	12	4380	4.0	8.0
13	2134	2140	6	2190	4.3	8.9
14	2141	2150	9	3285	4.6	9.9

Low Tolerance for Risk

High Tolerance for Risk

Benefits:

- Compatible with RSLR mapping on coastal viewer.
- Can cross-reference RSLR across scenarios

Thank you

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