Merrimack Salt Mitigation Discussion

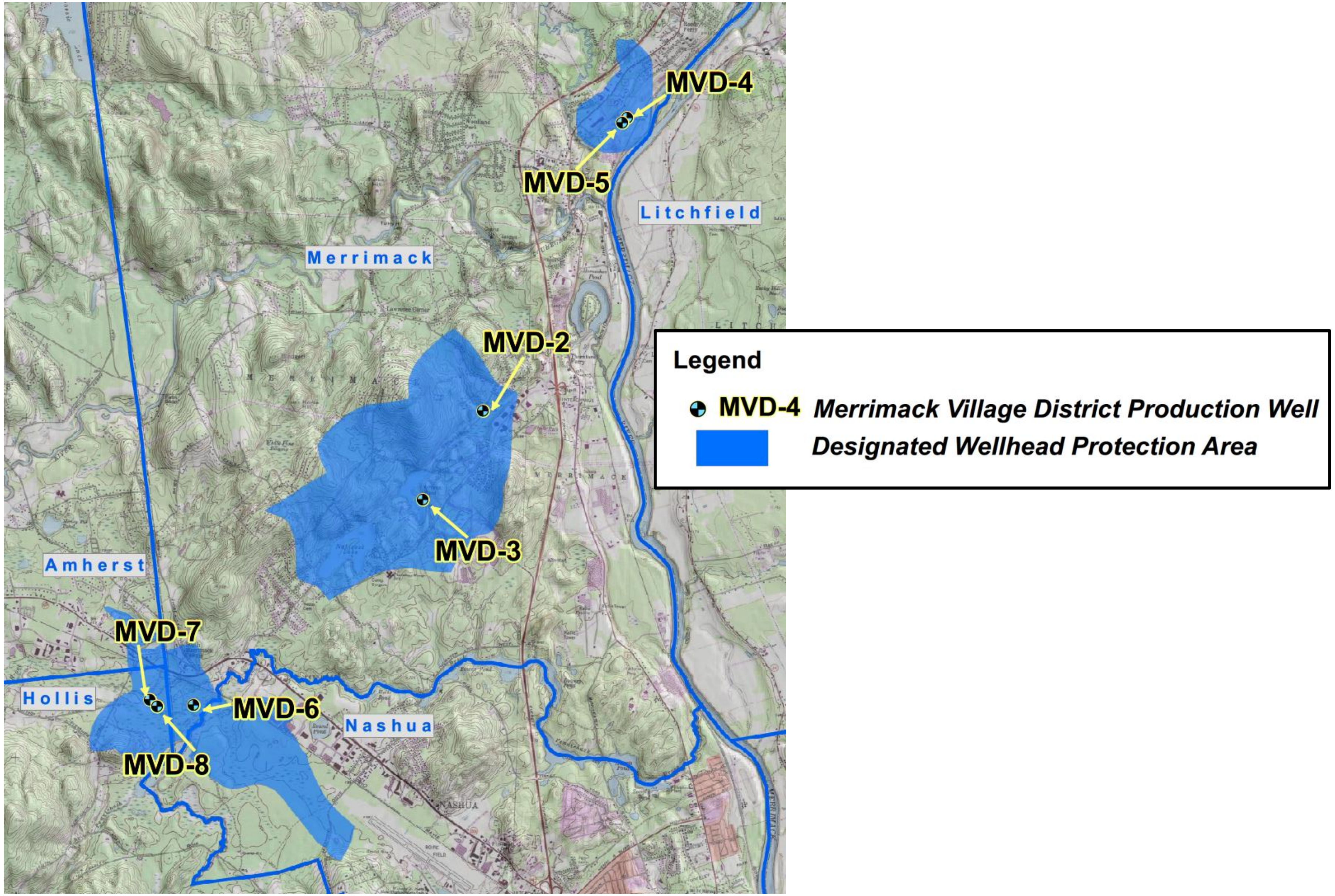
February 13, 2020
James Emery

Emery & Garrett Groundwater Investigations,
A Division of GZA

- The Merrimack Village Water District (MVD) relies exclusively on groundwater to supply nearly one billion gallons of water annually to over 9,300 connections in the Town of Merrimack, New Hampshire. Seven high-yield wells are owned and operated by the MVD which provide groundwater from glacial stratified drift deposits located in and around the Town of Merrimack .

- Currently well MVD-4, MVD-5, and MVD-6 are not in operation.

Merrimack Village District Production Wells and Wellhead Protection Areas (WHPAs)



Emery & Garrett Groundwater Investigations, A Division of GZA

- Over the past 30 years, sodium and chloride levels have increased in all the MVD Production Wells. To determine the source(s) of the sodium and chloride, the MVD applied for a 2011 Local Source Water Protection Grant from the New Hampshire Department of Environmental Services (NHDES). That Grant was used to evaluate the salt loading in the Wellhead Protection Areas (WHPAs) that surround the MVD Production Wells.

Problem: Salt!

Uncovered Salt Pile Near Well MVD-6

Chloride has a NHDES and EPA SMCL of 250 mg/l.

Sodium has an EPA Drinking Water Advisory of 20 mg/l for people on a sodium restricted diet.

EPA recommends keeping sodium levels below 30 to 60 mg/l for taste aesthetic reasons.

Sodium has a NHDES SMCL of 250 mg/l.

Uncovered salt piles shown here can be among the most serious sources of NaCl contamination. This pile has been removed since the photo was taken.

- Sodium chloride is the most common deicing agent used in the State of New Hampshire because of its low cost and effectiveness (other agents melt ice at lower temperatures but cost more). Demand for clear roads during, or immediately after, snow and ice events has led to increasing volumes of deicing material being applied to roadways. As the percentage of a watershed that is covered with roads, sidewalks, and parking lots increases, the amount of deicing material applied within the watershed also increases. Sodium and chloride readily dissolve in water and do not degrade in the environment like some other contaminants.

Why is this so important?

- Treatment costs to remove Sodium and Chloride are far greater than PFAS removal or removal of other groundwater contaminants (VOCs)

Common benefits of reduced sodium and chloride use besides the protection of groundwater resources include:

- Reduction in chloride contributions to stormwater pollution
- Water quality and ecosystem improvements
- Reduced presence of invasive plant species
- Reduced corrosion on vehicle fleets and equipment
- Reduced damage to highways and bridges
- Avoidance of Clean Water Act enforcement

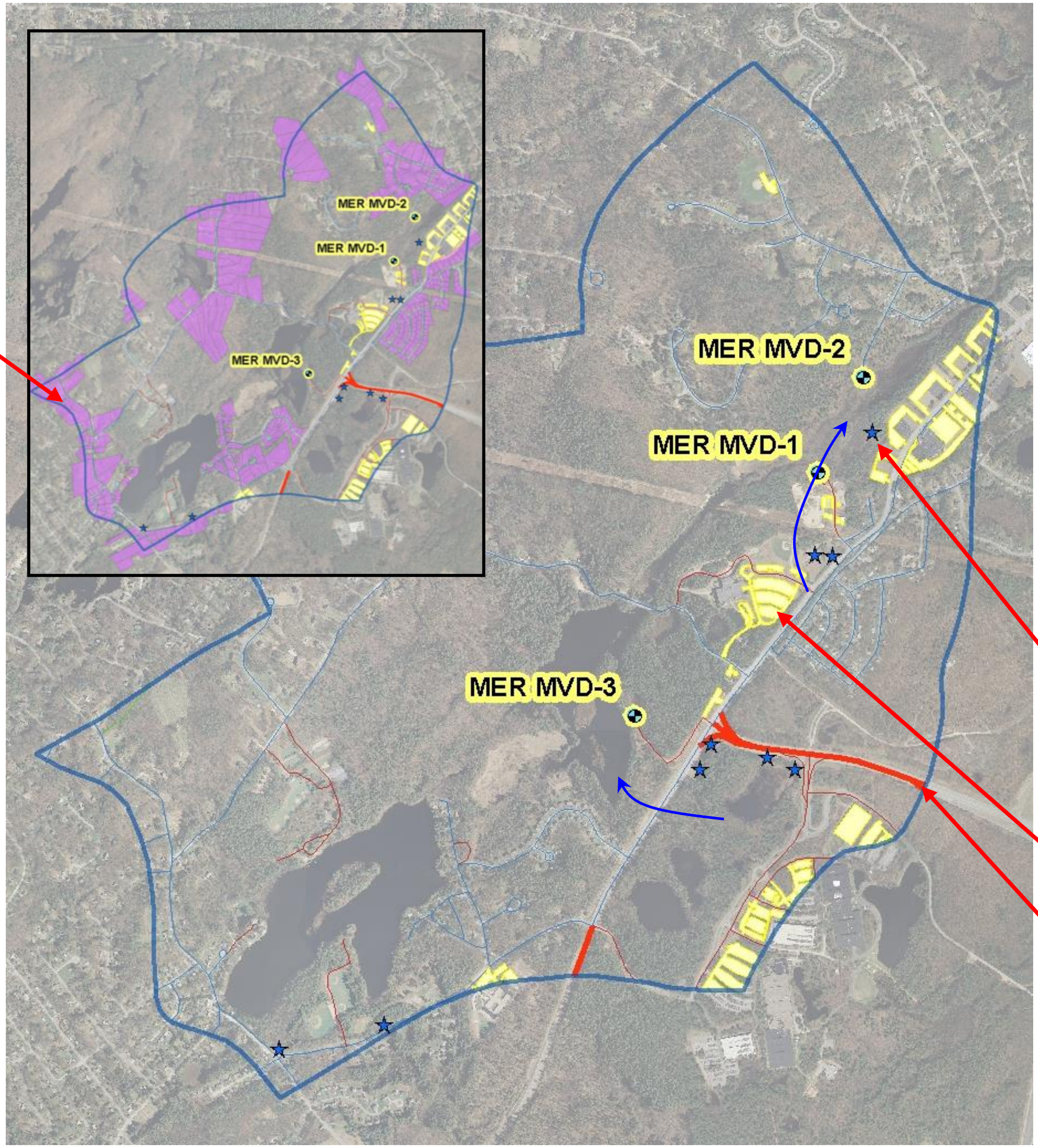
2011 NHDES Grant Tasks

- Task 1: Inventory NaCl Sources
- Task 2: Calculate Annual Mass Loading
- Task 3: Develop Mitigation Plan
- Task 4: Consult With Key Parties

Task 1: Inventory NaCl Sources

- State, Local, & Private Roads
- Parking Lots (e.g. PC Connections, Home Depot)
- Residential Driveways & Septic
- Atmospheric

Map Showing Potential Sources of Salt in the MVD Wells #1, #2 and #3 WHPA



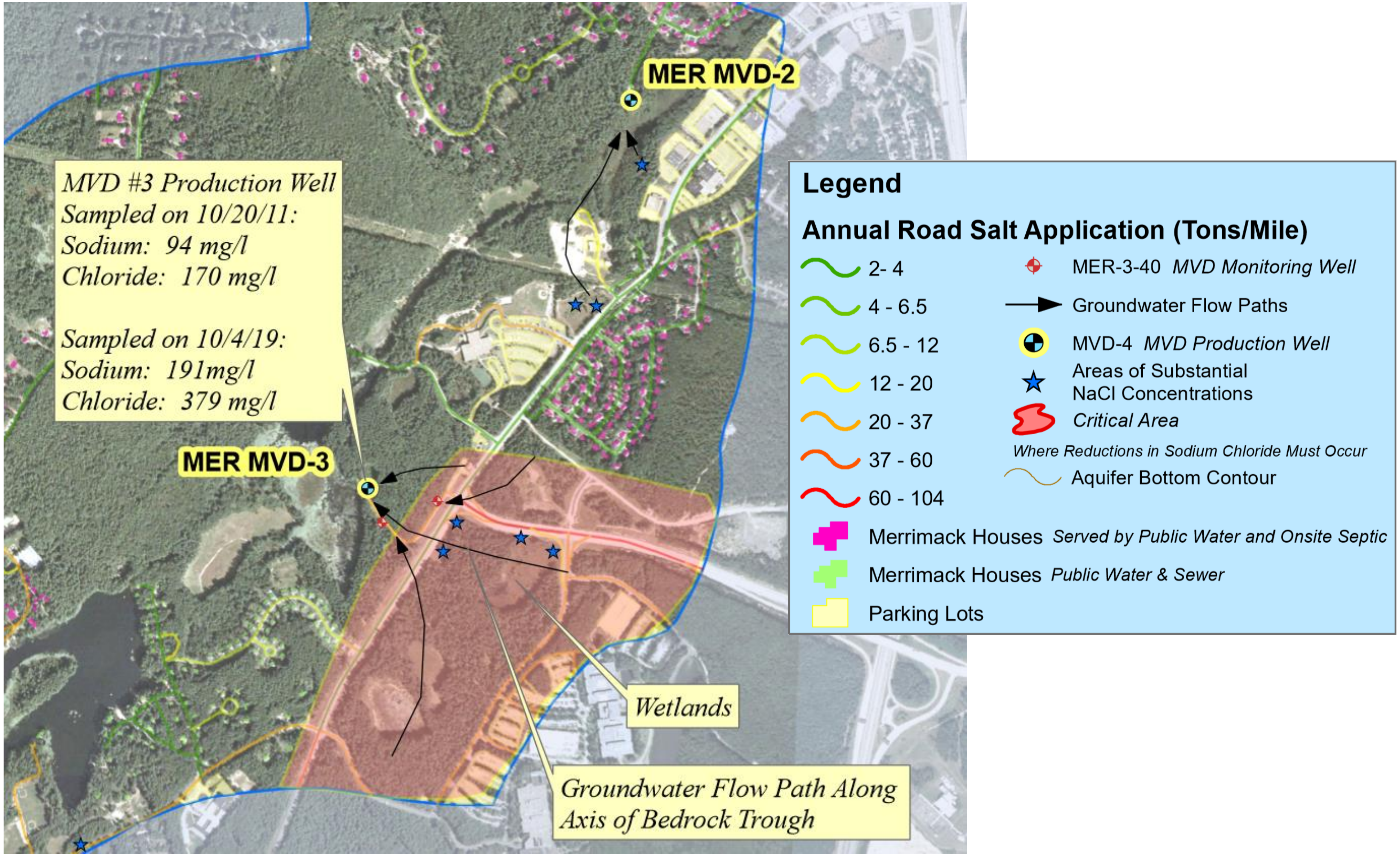
- Residential Developments
- Storm Drain Outfalls
- Parking Lots
- State Road

Task 2: Calculate Annual Mass Loading

Salt In – Salt Out = Salt Stored in the Aquifer

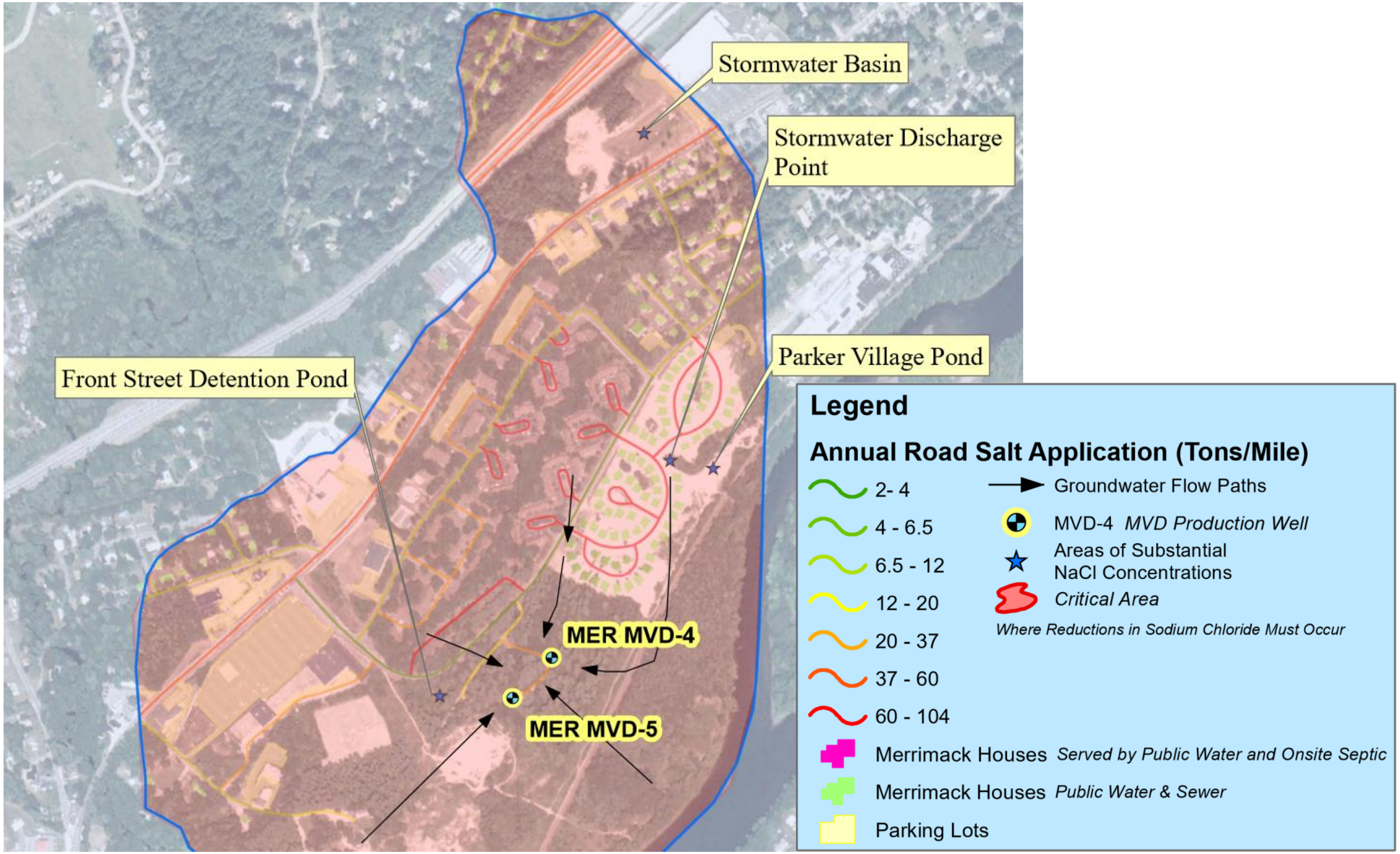
- Develop Loading Model for Each WHPA
- Prepare GIS Maps to Illustrate Loading
- Use Available Water Quality Data to Identify Trends
- Evaluate Drainage & Groundwater Flow
- Identify Key Stormwater Flow Paths and Salt Transport Mechanisms

Critical Salt Loading Areas in the MVD-2 & MVD-3 WHPA



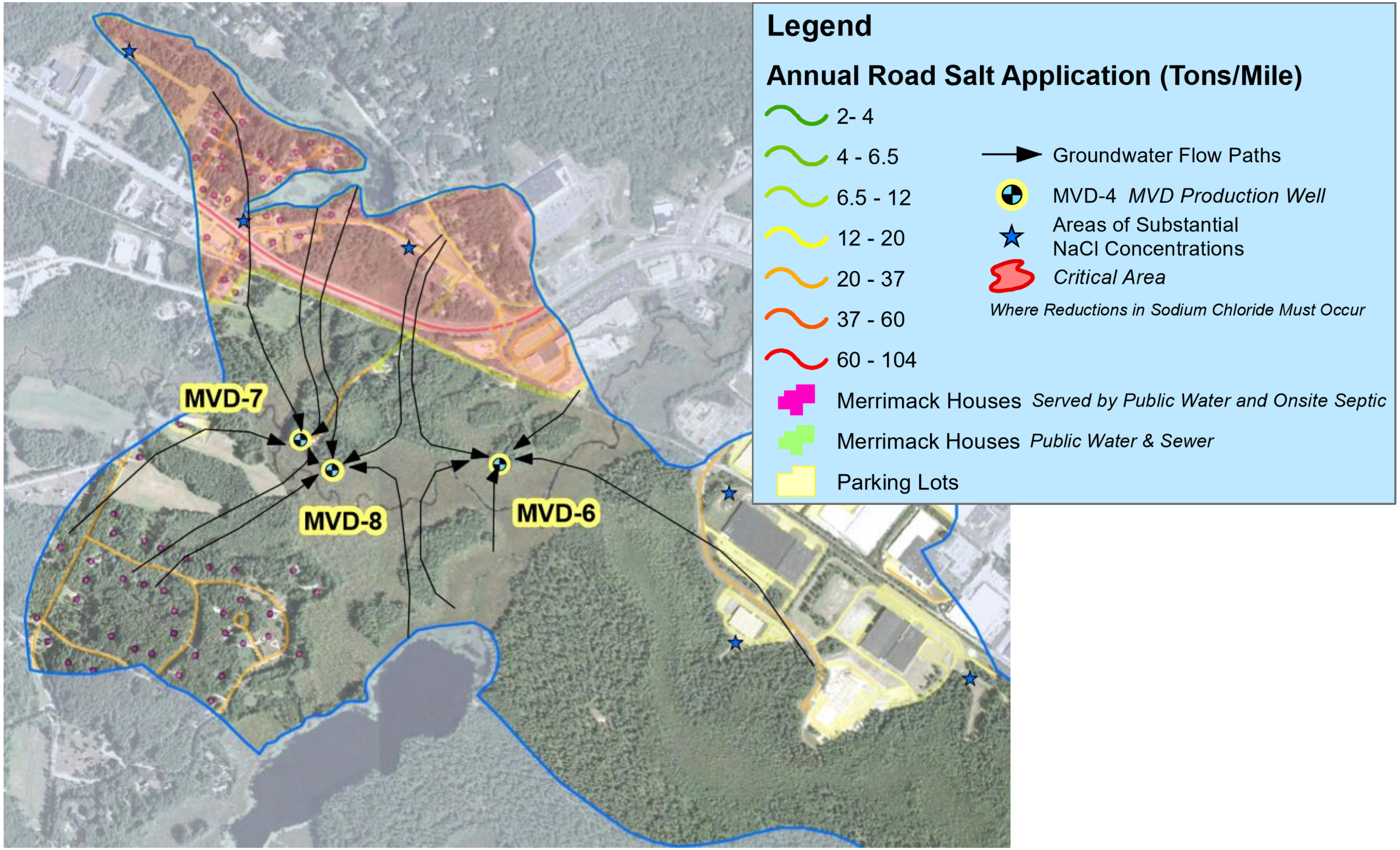
Emery & Garrett Groundwater Investigations, A Division of GZA

Critical Salt Loading Areas in the MVD-4 & MVD-5 WHPA



Emery & Garrett Groundwater Investigations, A Division of GZA

Critical Salt Loading Areas in the MVD-6, MVD-7, & MVD-8 WHPA



Emery & Garrett Groundwater Investigations, A Division of GZA

MVD Well #2 & #3 WHPA

Monitoring Locations Sodium and Chloride Results

Salt Loading Study
Merrimack, New Hampshire

Monitoring Location	Date of Sampling	Estimated Discharge / Flow (gallons per minute)	Temperature (degrees C)	Specific Conductance (microsiemens)	Laboratory		Calculated	
					Sodium (mg/l)	Chloride (mg/l)	Sodium (mg/l)	Chloride (mg/l)
MVD Well #2 & #3 WHPA								
NAT-1	3/11/2012	2500	2.0	161.2	17	30	19	32
"	5/13/2011	250	19.2	316	--	--	44	74
"	8/31/2011	20	22.0	216	--	--	28	47
"	3/9/2012	1500	7.8	279	--	--	38	64
NAT-2	3/11/2012	None	5.8	165	--	--	20	33
"	5/13/2011	None	19.7	215	--	--	28	47
"	8/31/2011	None	23.6	202	--	--	26	43
"	3/9/2012	None	6.7	78.9	--	--	6	10
NAT-3	3/11/2012	None	4.8	108	--	--	10	18
"	5/13/2011	None	14.5	47.2	--	--	1	1
"	8/31/2011	None	19.6	58	--	--	2	4
"	3/9/2012	None	13.5	45	--	--	0	1
NAT-4	3/11/2012	500	0.5	154	17	30	18	30
"	5/13/2011	300	15.1	233	--	--	31	52
"	8/31/2011	Dry	--	--	--	--	--	--
"	3/9/2012	2000	7.0	257	--	--	35	58
Swale 2	3/11/2011	75	1.2	326	48	74	46	77
Snow	3/11/2012	None	0.1	30	4	5	-2	-3
Puddle 1	3/9/2012	3	4.8	265	--	--	36	61

MVD Well #4 & #5 WHPA

Monitoring Locations Sodium and Chloride Results

Salt Loading Study
Merrimack, New Hampshire

Monitoring Location	Date of Sampling	Estimated Discharge / Flow (gallons per minute)	Temperature (degrees C)	Specific Conductance (microsiemens)	Laboratory		Calculated	
					Sodium (mg/l)	Chloride (mg/l)	Sodium (mg/l)	Chloride (mg/l)
MVD Well #4 & #5 WHPA								
Detention Pond 4-5	3/11/12	35	6.3	56.4	7	12	2	4
"	5/13/11	None	19.1	78.4	--	--	6	10
"	8/31/11	Dry	--	--	--	--	--	--
"	3/9/12	30	11.2	165	--	--	20	33
Swale 4-5	3/11/12	10	5.2	1314	210	350	207	345
"	5/13/11	2	10.2	503	--	--	75	125
"	8/31/11	1	17.5	465	--	--	69	115
"	3/9/12	60	8.9	330	--	--	47	78
Drain 4-5	3/11/12	100	4.4	72.6	10	16	5	8
"	5/13/11	15	10.9	656	--	--	100	167
"	8/31/11	10	17.7	428	--	--	63	105
"	3/9/12	60	9.8	326	--	--	46	77
Swale	3/9/12	1	11.0	2820	--	--	452	754
Parker Village Pond	3/9/12	None	13.0	3080	--	--	495	825
Drain 4-5 Junction	3/9/12	60	9.8	326	--	--	46	77
Trestle	3/9/12	70	10.7	551	--	--	83	138
NW Split	3/9/12	25	10.5	624	--	--	95	158

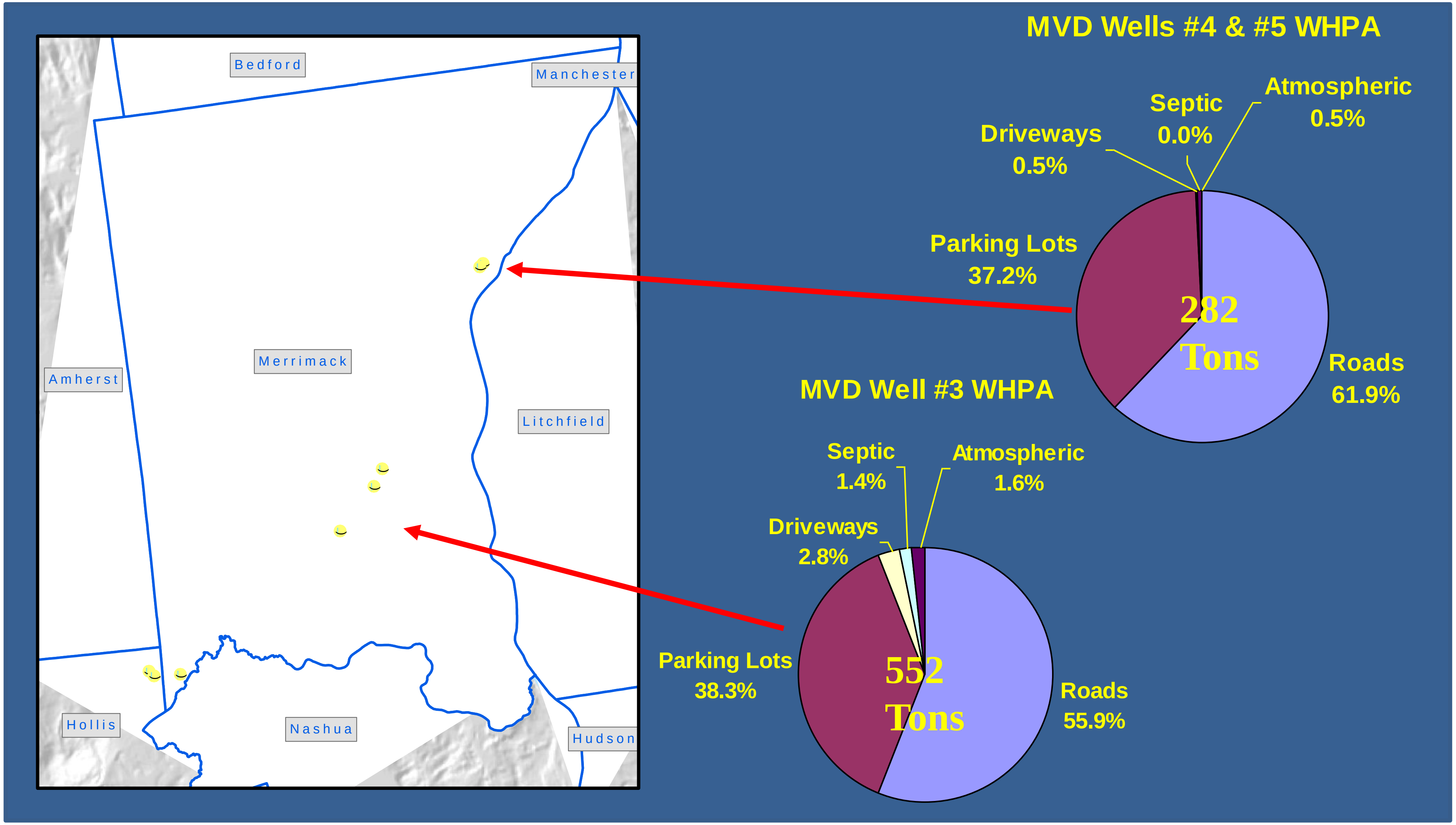
MVD Well #7 & #8 WHPA

Monitoring Locations Sodium and Chloride Results

Salt Loading Study
Merrimack, New Hampshire

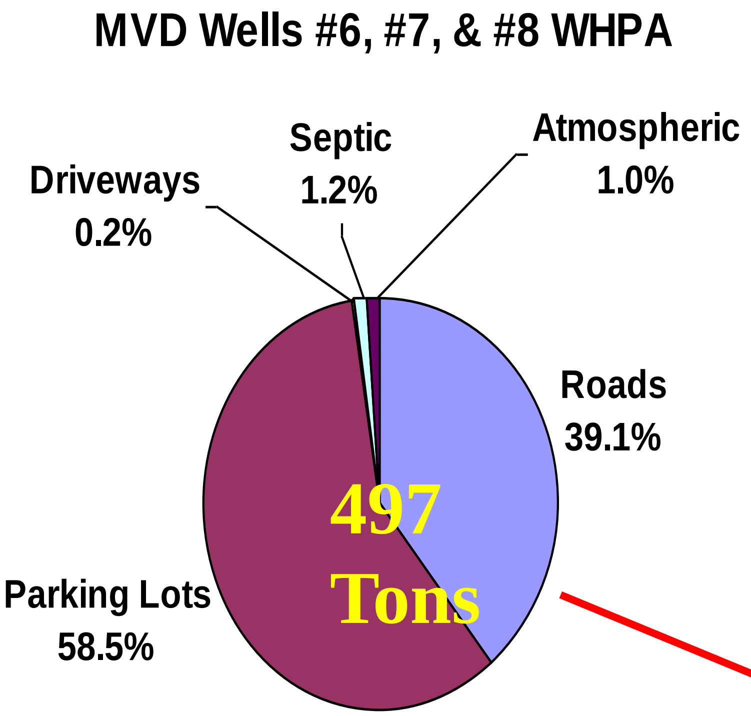
Monitoring Location	Date of Sampling	Estimated Discharge / Flow (gallons per minute)	Temperature (degrees C)	Specific Conductance (microsiemens)	Laboratory Sodium (mg/l)	Laboratory Chloride (mg/l)	Calculated Sodium (mg/l)	Calculated Chloride (mg/l)
MVD Well #6, #7, & #8 WHPA								
BR-1	3/11/12	1500	0.5	216	28	48	28	47
"	5/13/11	> 1000	18.6	235	--	--	31	52
"	8/31/11	600	23.1	156	--	--	18	31
"	3/9/12	1000	4.2	208	--	--	27	45
BR-2	3/11/12	>> 1000	0.2	114	12	21	11	20
"	5/13/11	> 1000	17.2	170	--	--	21	35
"	8/31/11	> 1000	19.9	139	--	--	16	26
"	3/9/12	>> 1000	8.0	160	--	--	19	32
BR-3	3/11/12	>> 1000	0.8	127	--	--	14	23
"	5/13/11	>> 1000	17.5	158	13	21	19	31
"	8/31/11	>> 1000	21.5	133	--	--	15	25
"	3/9/12	>> 1000	7.1	146	--	--	17	28
Home Depot	3/11/12	175	1.8	166	14	24	20	34
"	5/13/11	20	16.9	349	--	--	50	83
"	8/31/11	25	19.4	173	--	--	21	36
"	3/9/12	150	5.6	202	--	--	26	43
Home Depot Snow	3/9/12	--	--	747	--	--	115	191
PC Connection	3/11/12	--	3.8	326	34	64	46	77
"	5/13/11	1	22.1	579	--	--	87	146
"	8/31/11	--	19.2	470	--	--	69	116
"	3/9/12	50	7.0	257	--	--	35	58
Runoff PC-RR	3/9/12	1	--	423	--	--	62	103

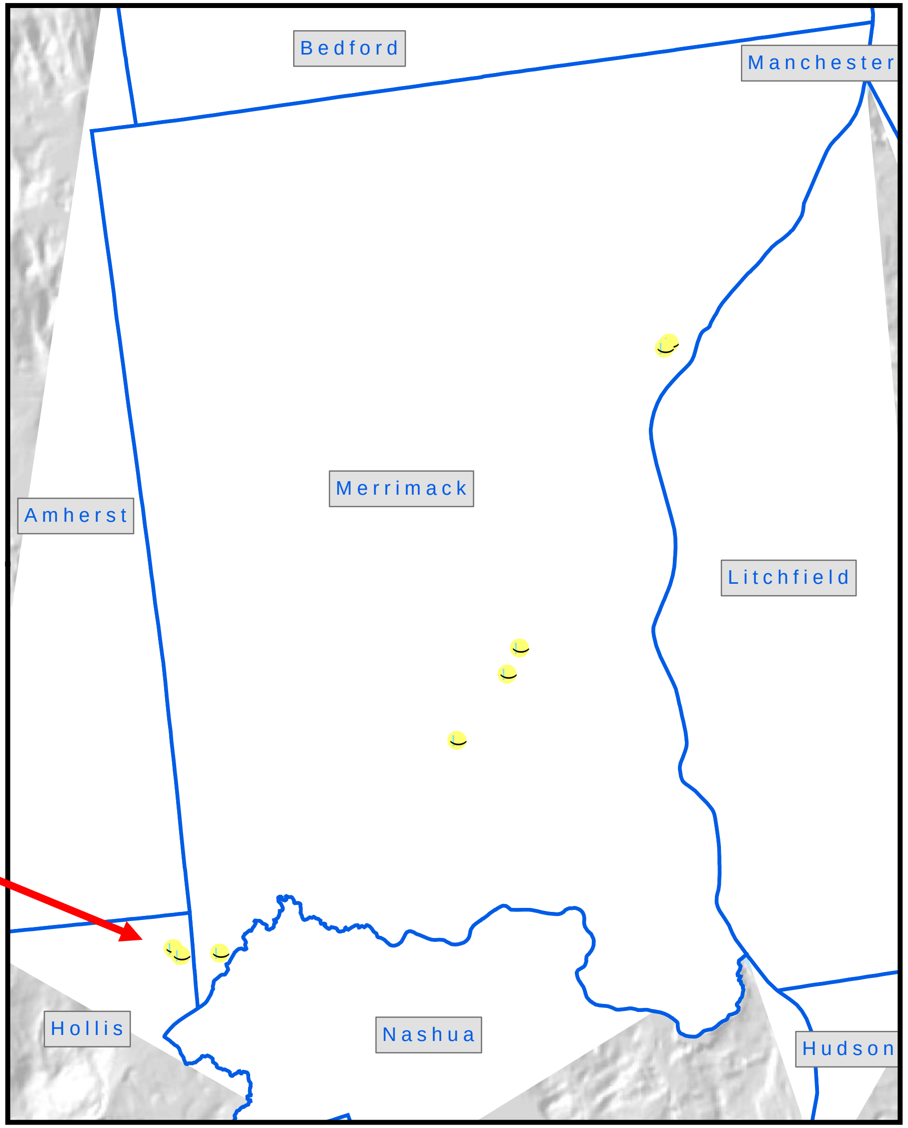
Salt Applied in MVD-4 & MVD-5 WHPA and MVD-3 WHPA



Emery & Garrett Groundwater Investigations, A Division of GZA

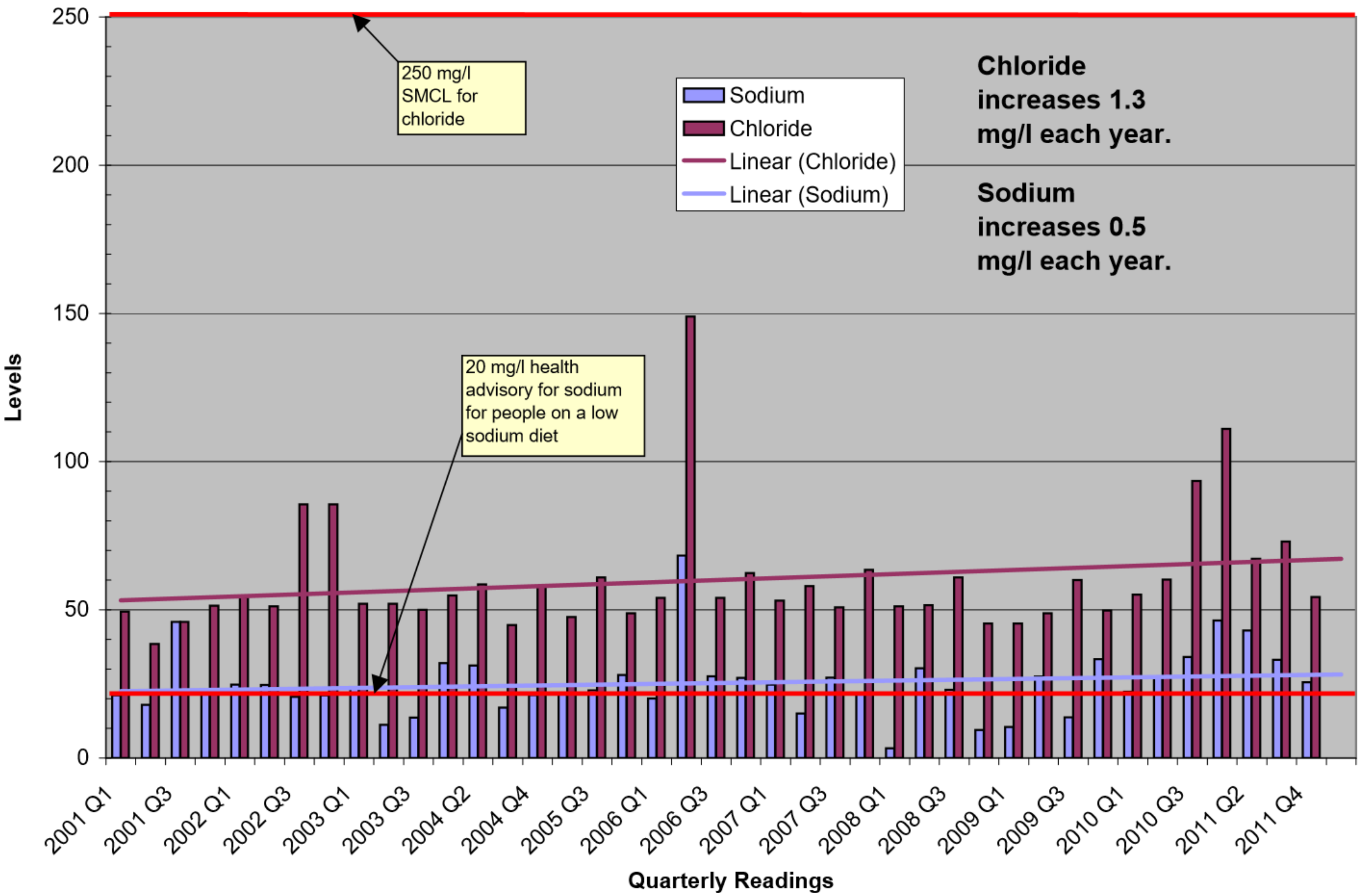
Salt Applied in MVD-6, MVD-7, & MVD-8 WHPA





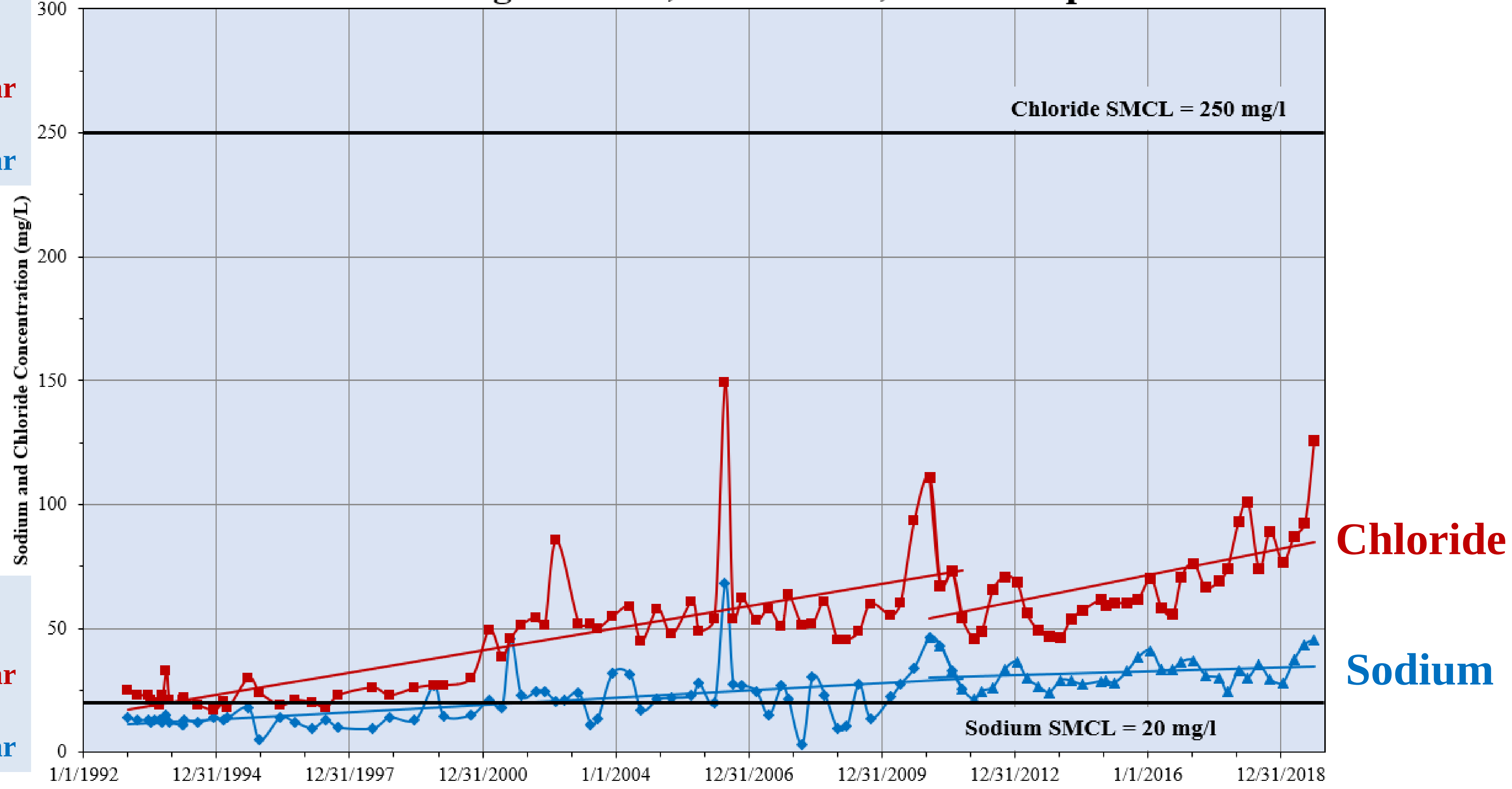
Emery & Garrett Groundwater Investigations, A Division of GZA

MVD-2 Sodium and Chloride History



1992-2011
Chloride Increases 2.99 mg/L Each Year
Sodium Increases 0.99 mg/L Each Year

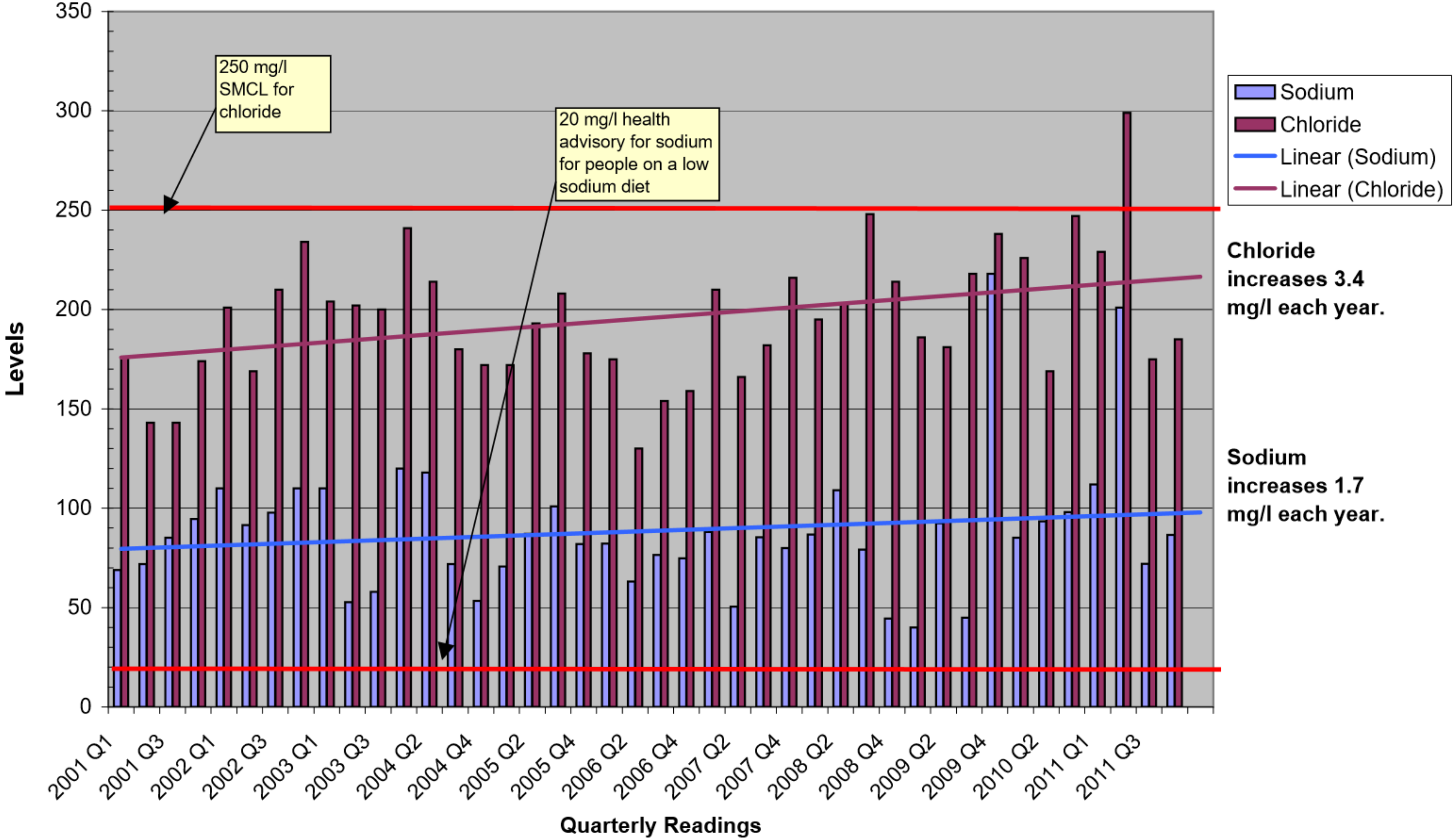
Sodium and Chloride Concentrations in Well MVD-2
Merrimack Village District, Merrimack, New Hampshire



2011-2019
Chloride Increases 3.54 mg/L Each Year
Sodium Increases 0.91 mg/L Each Year

Emery & Garrett Groundwater Investigations, A Division of GZA

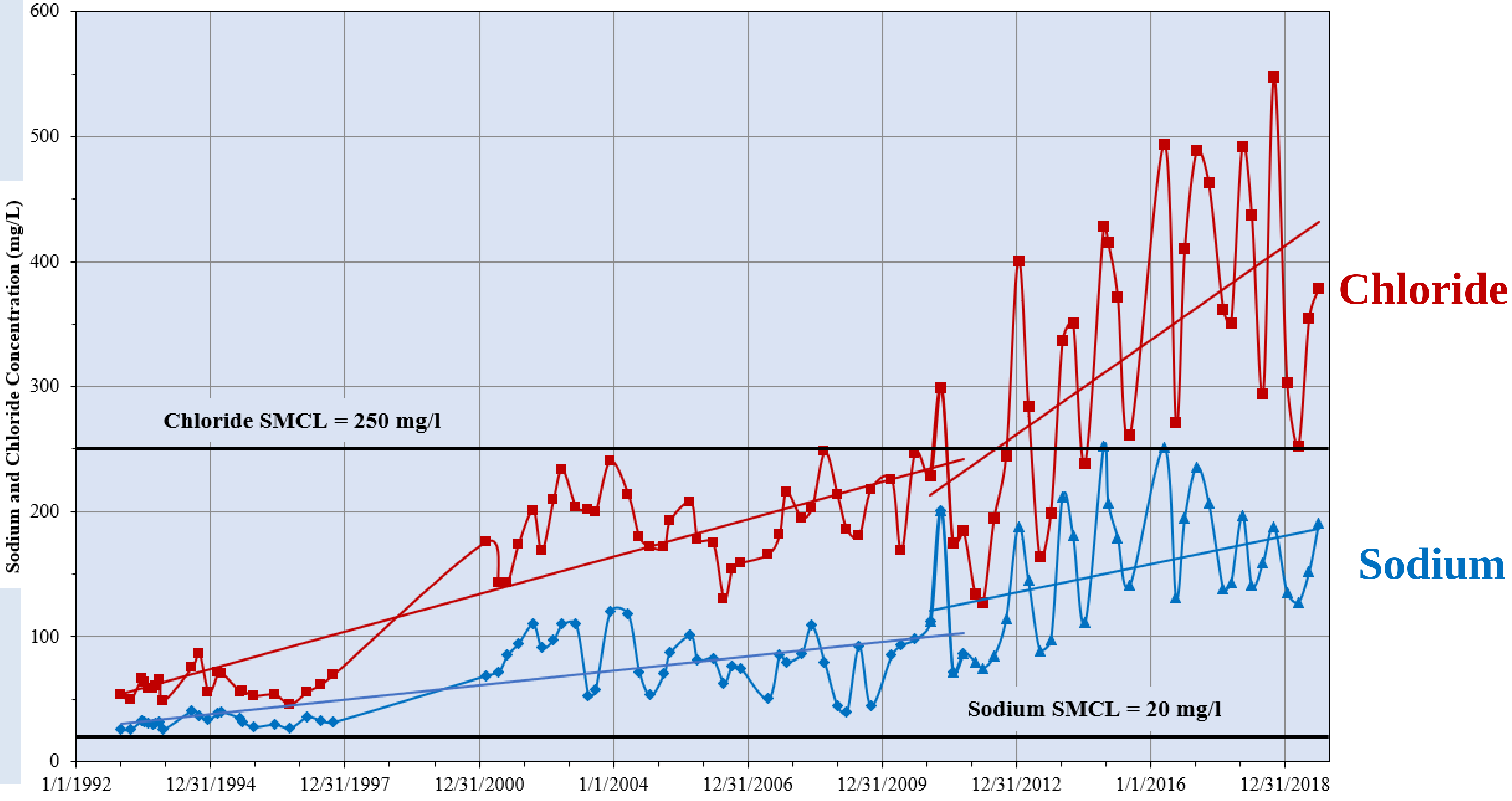
MVD-3 Sodium and Chloride History



Emery & Garrett Groundwater Investigations, A Division of GZA

Sodium and Chloride Concentrations in Well MVD-3
Merrimack Village District, Merrimack, New Hampshire

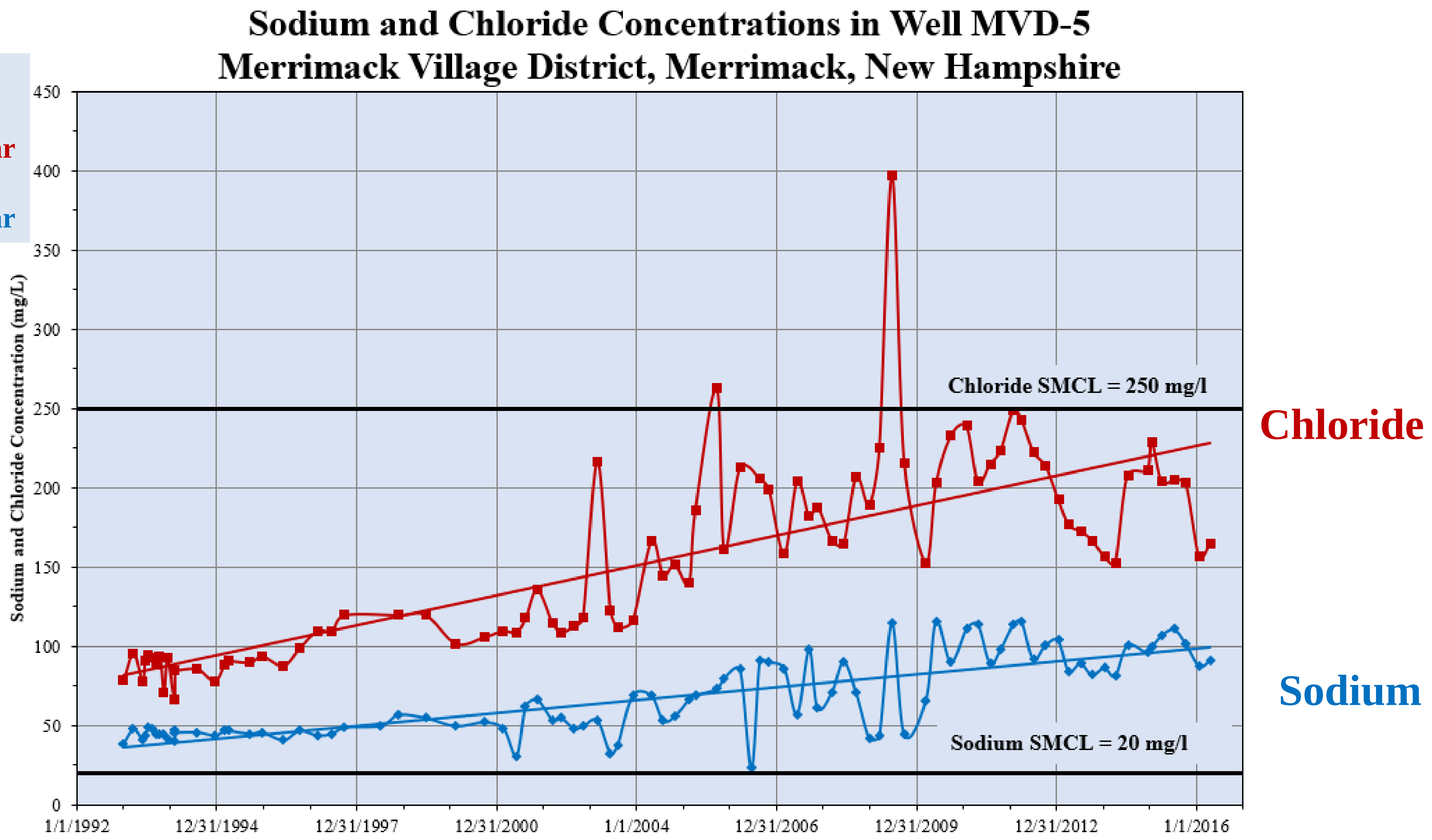
1992-2011:
Chloride Increases
9.96 mg/L Each Year
Sodium Increases
3.83 mg/L Each Year



2011-2019:
Chloride Increases
25.2 mg/L Each Year
Sodium Increases
7.63 mg/L Each Year

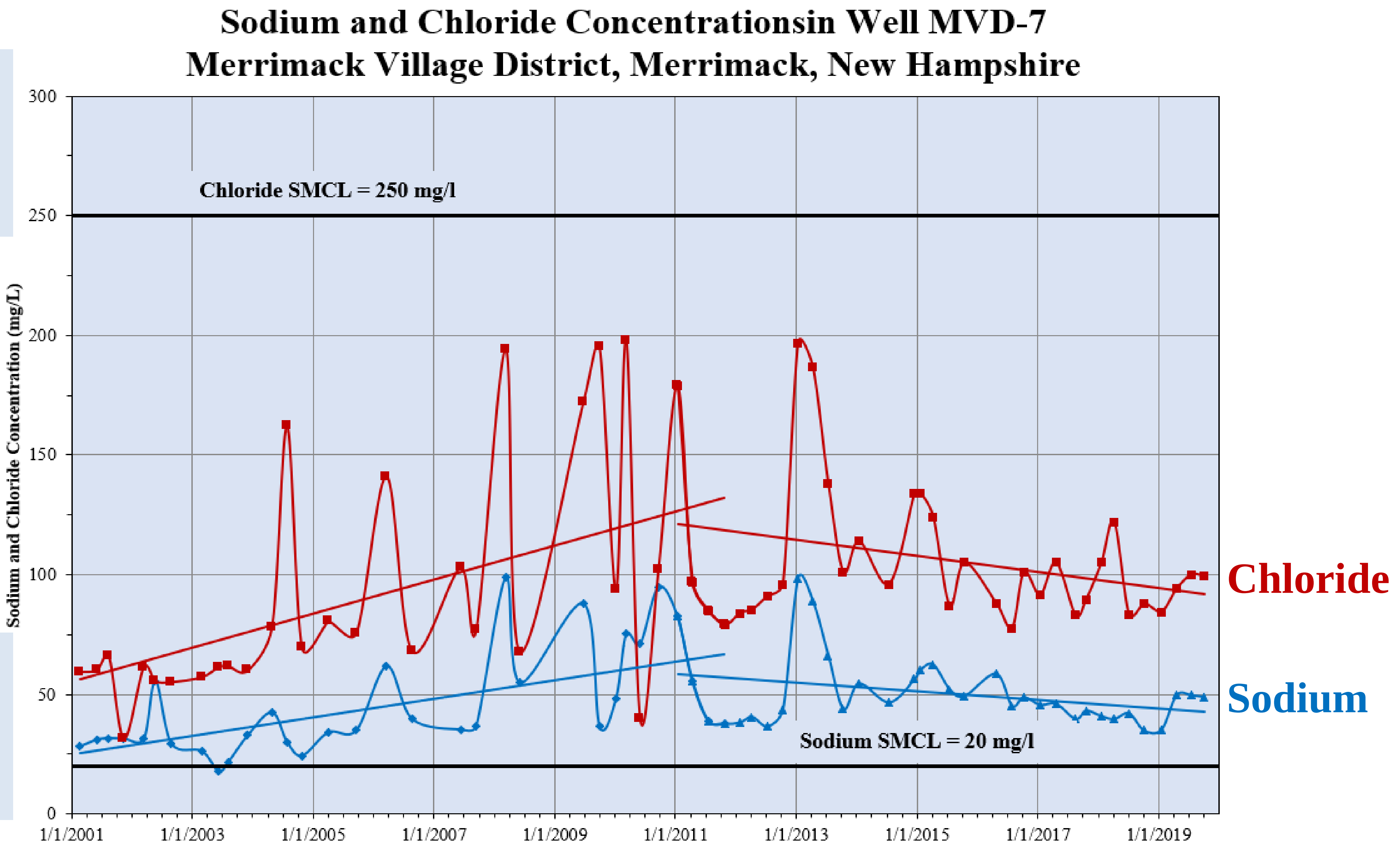
Emery & Garrett Groundwater Investigations, A Division of GZA

1992-2016
Chloride Increases 6.31 mg/L Each Year
Sodium Increases 2.71 mg/L Each Year



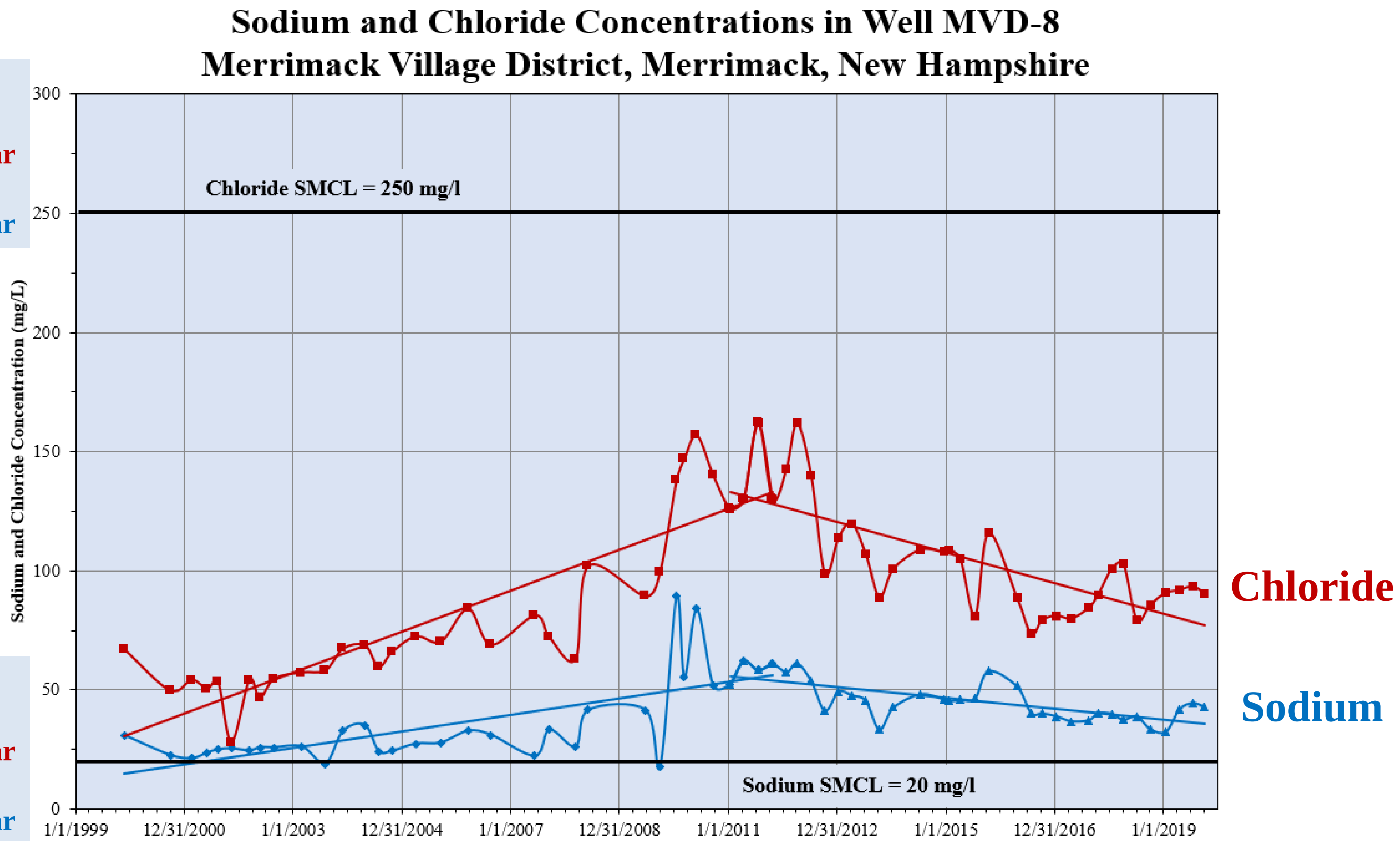
Emery & Garrett Groundwater Investigations, A Division of GZA

2001-2011
Chloride Increases 7.15 mg/L Each Year
Sodium Increases 3.87 mg/L Each Year



2011-2019
Chloride Decreases 3.36 mg/L Each Year
Sodium Decreases 1.79 mg/L Each Year

Emery & Garrett Groundwater Investigations, A Division of GZA



1999-2011
Chloride Increases
8.61 mg/L Each Year
Sodium Increases
3.47 mg/L Each Year

2011-2019
Chloride Decreases
6.42 mg/L Each Year
Sodium Decreases
2.23 mg/L Each Year

Emery & Garrett Groundwater Investigations, A Division of GZA

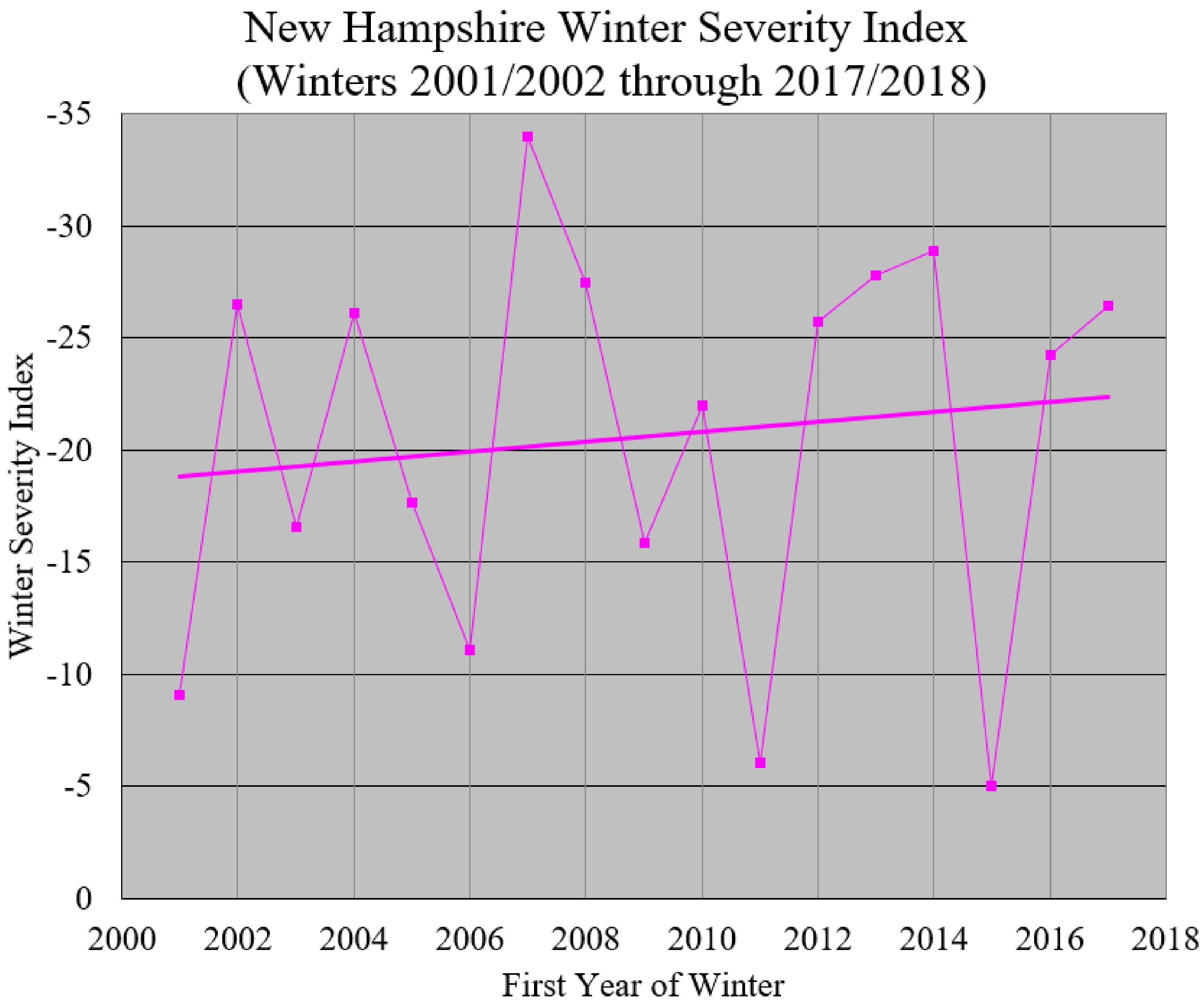
Comparison Between 1992 & 2019 Sodium and Chloride Concentrations

Well ID	1992		2019		Percent Increase	
	Sodium (mg/L)	Chloride (mg/L)	Sodium (mg/L)	Chloride (mg/L)	Sodium %	Chloride %
MVD-2	14.0	25.0	45.4	126.0	324%	504%
MVD-3	26.0	54.0	191.0	379.0	735%	702%
MVD-5	39.0	79.0	91.3*	165.0*	234%	209%
MVD-7	28.2**	59.4**	48.9	99.2	173%	167%
MVD-8	31.0***	67.0***	42.8	90.4	138%	135%

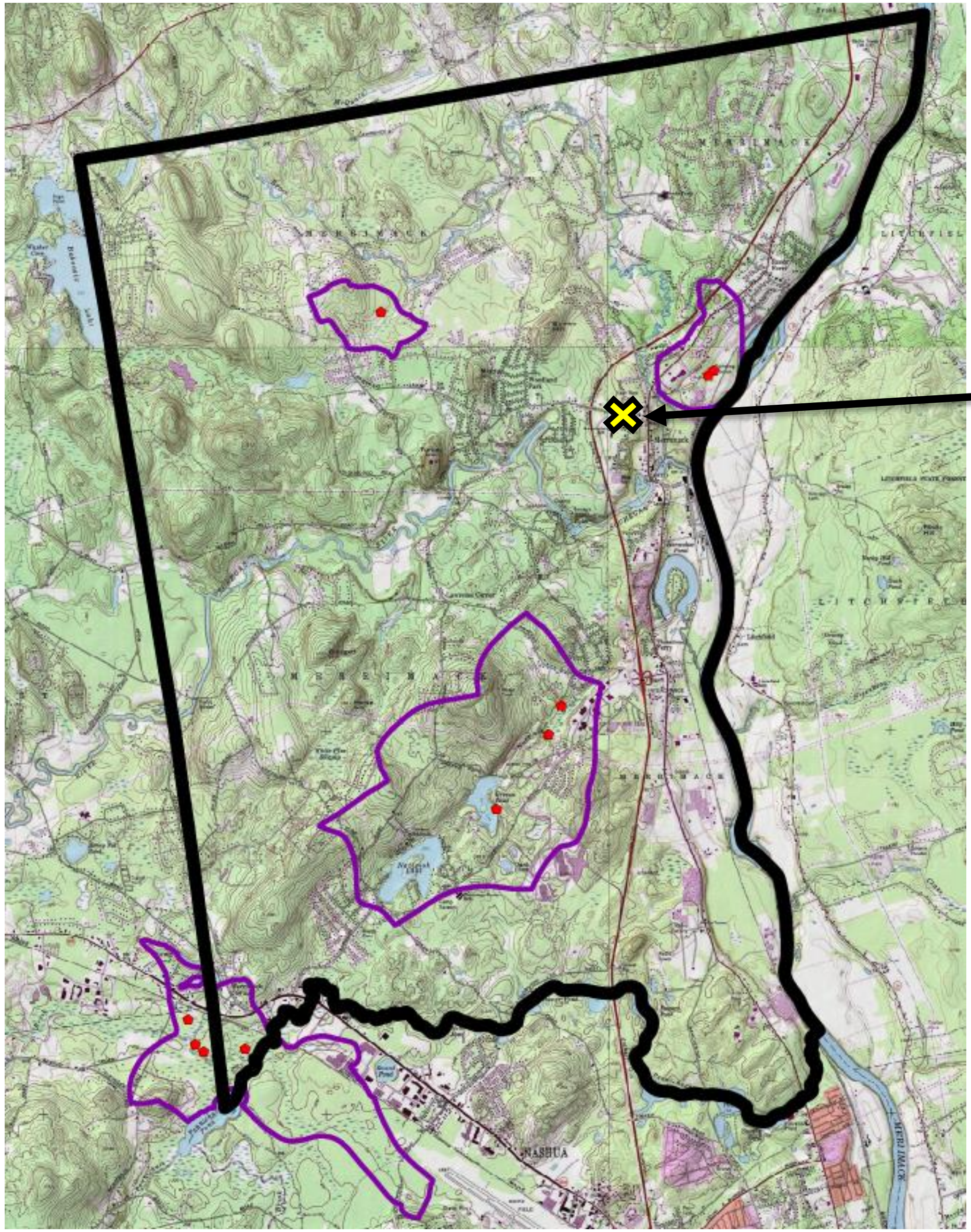
*Value from 2016

**Value from 2001

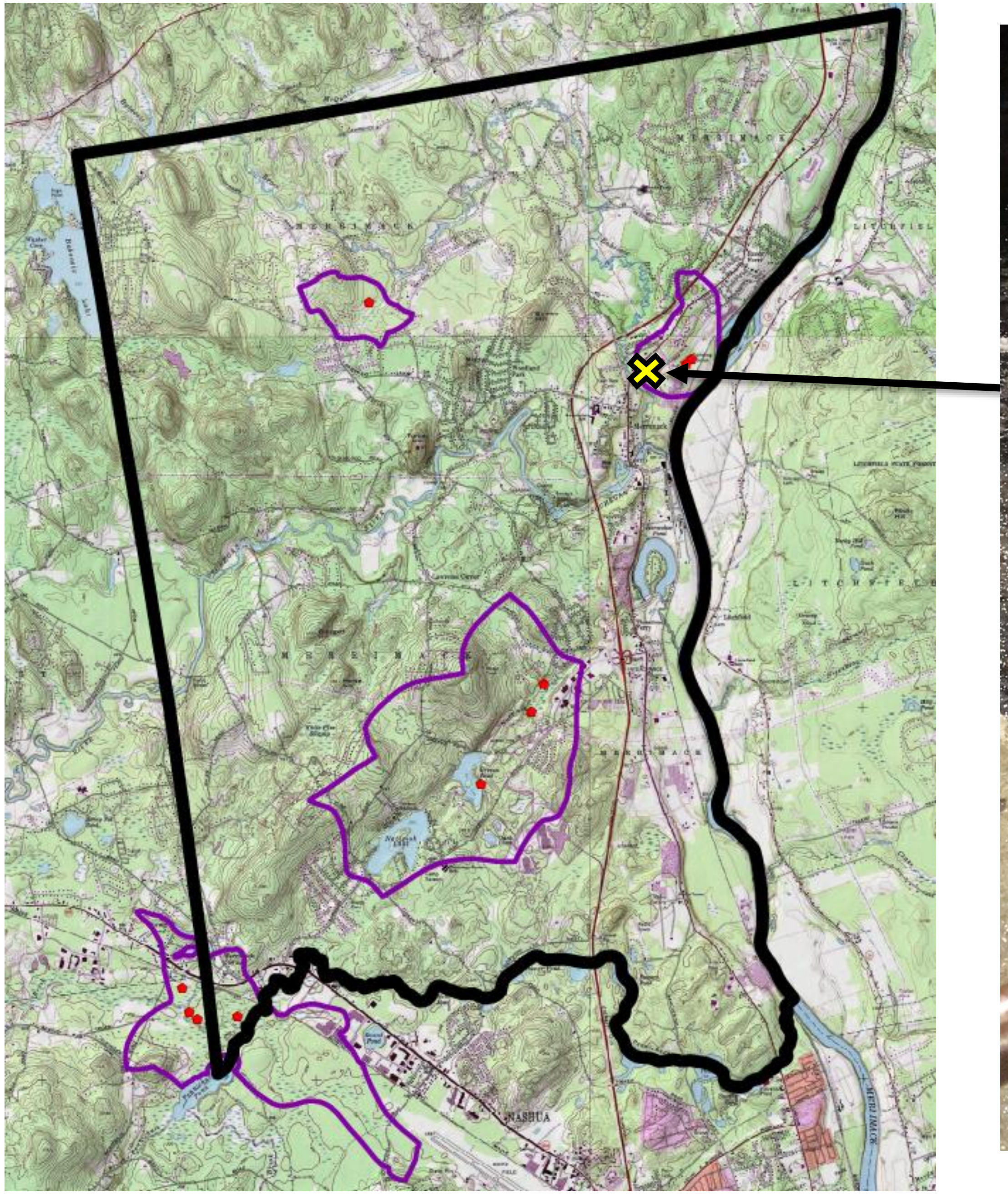
***Value from 1999

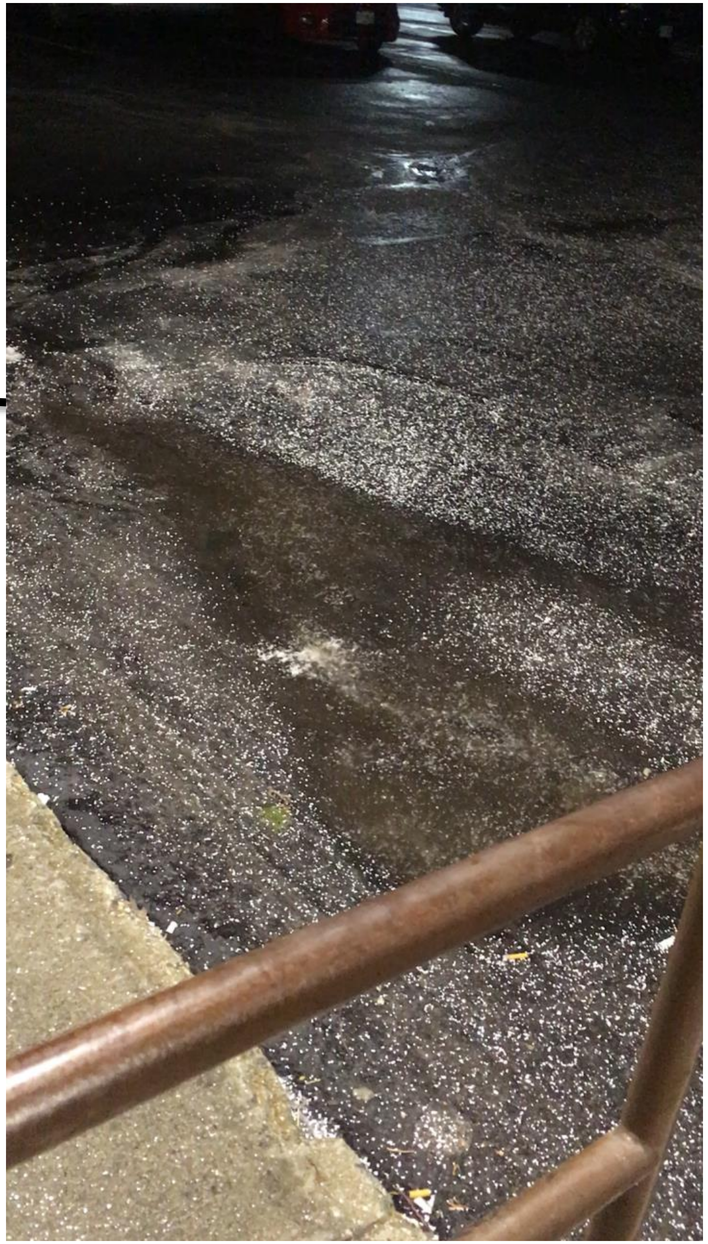


Emery & Garrett Groundwater Investigations, A Division of GZA

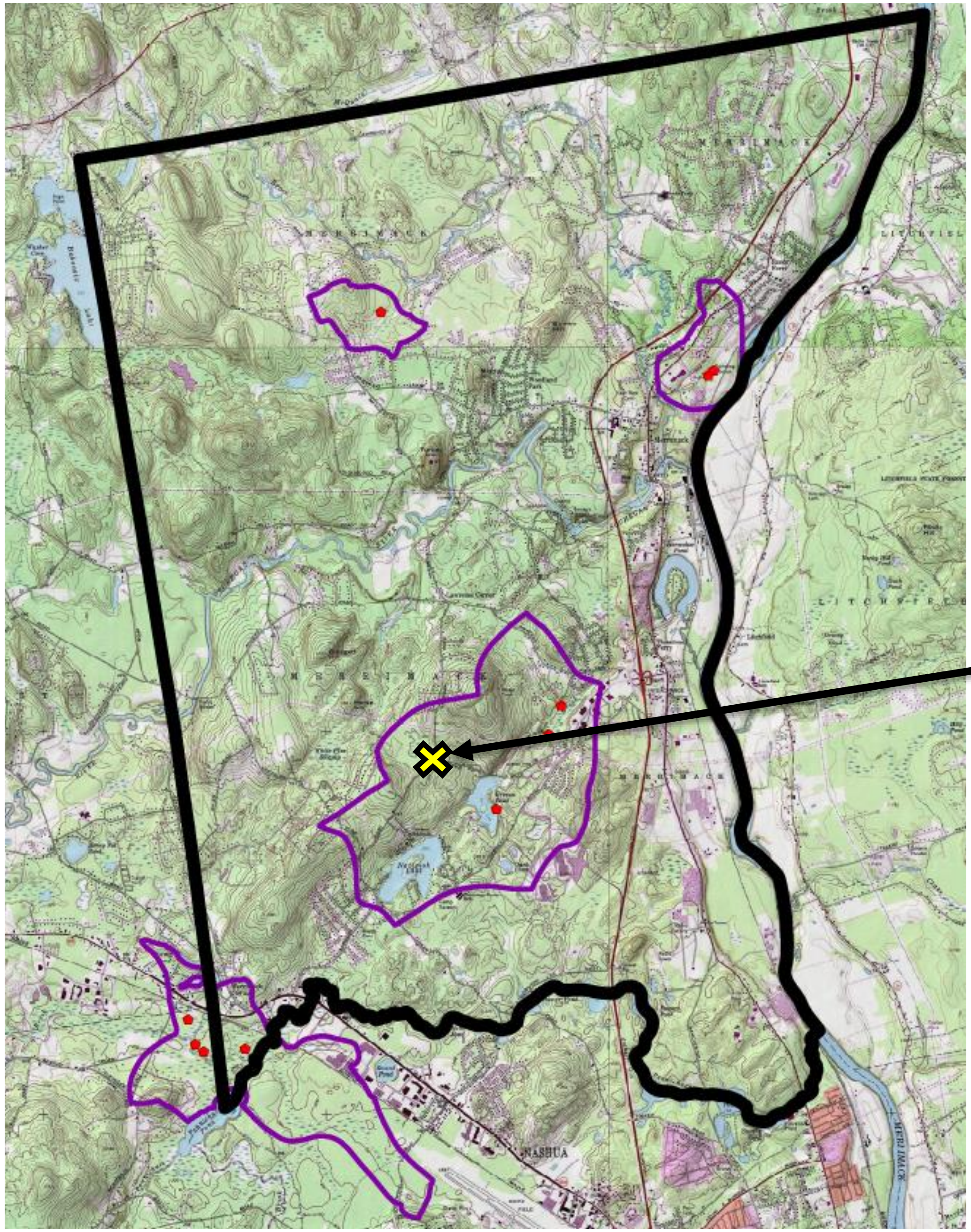


Baboosic Lake Road
-In front of Town Hall





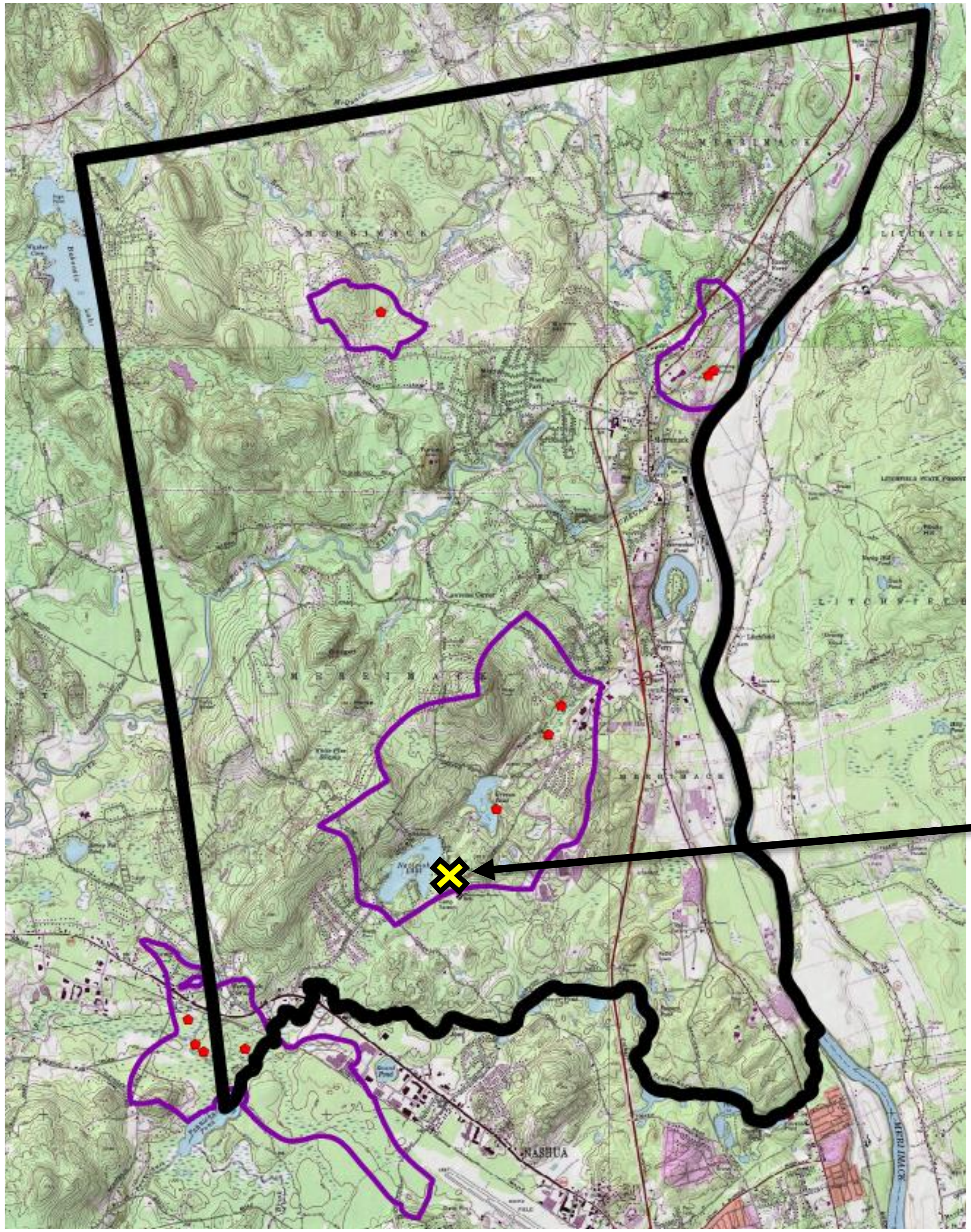
Restaurant Parking Lot

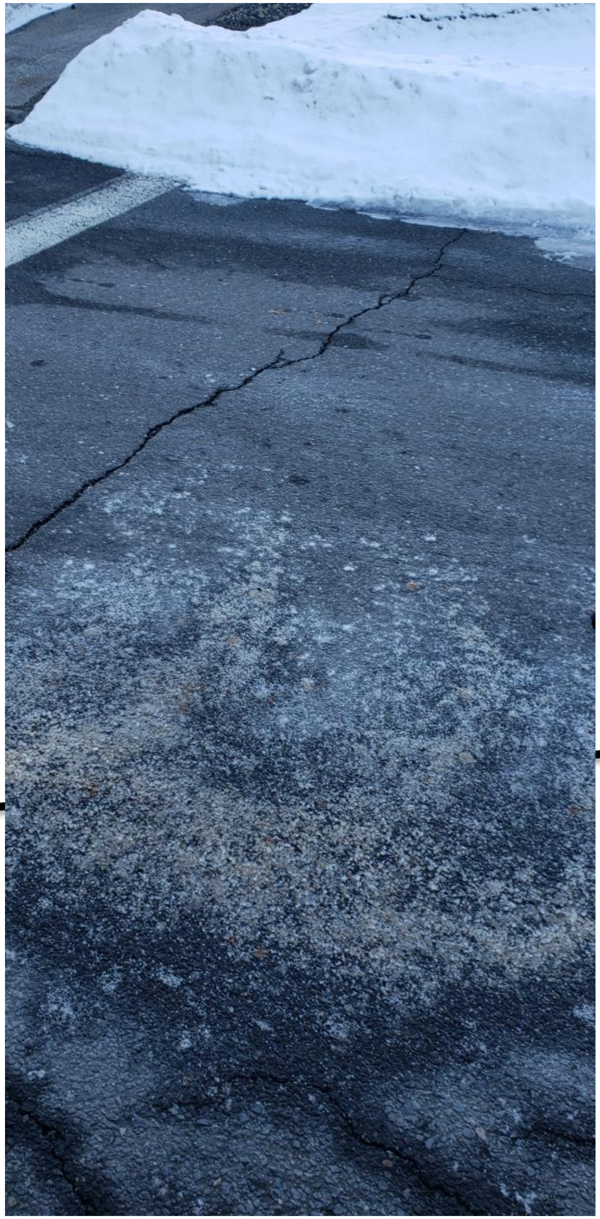


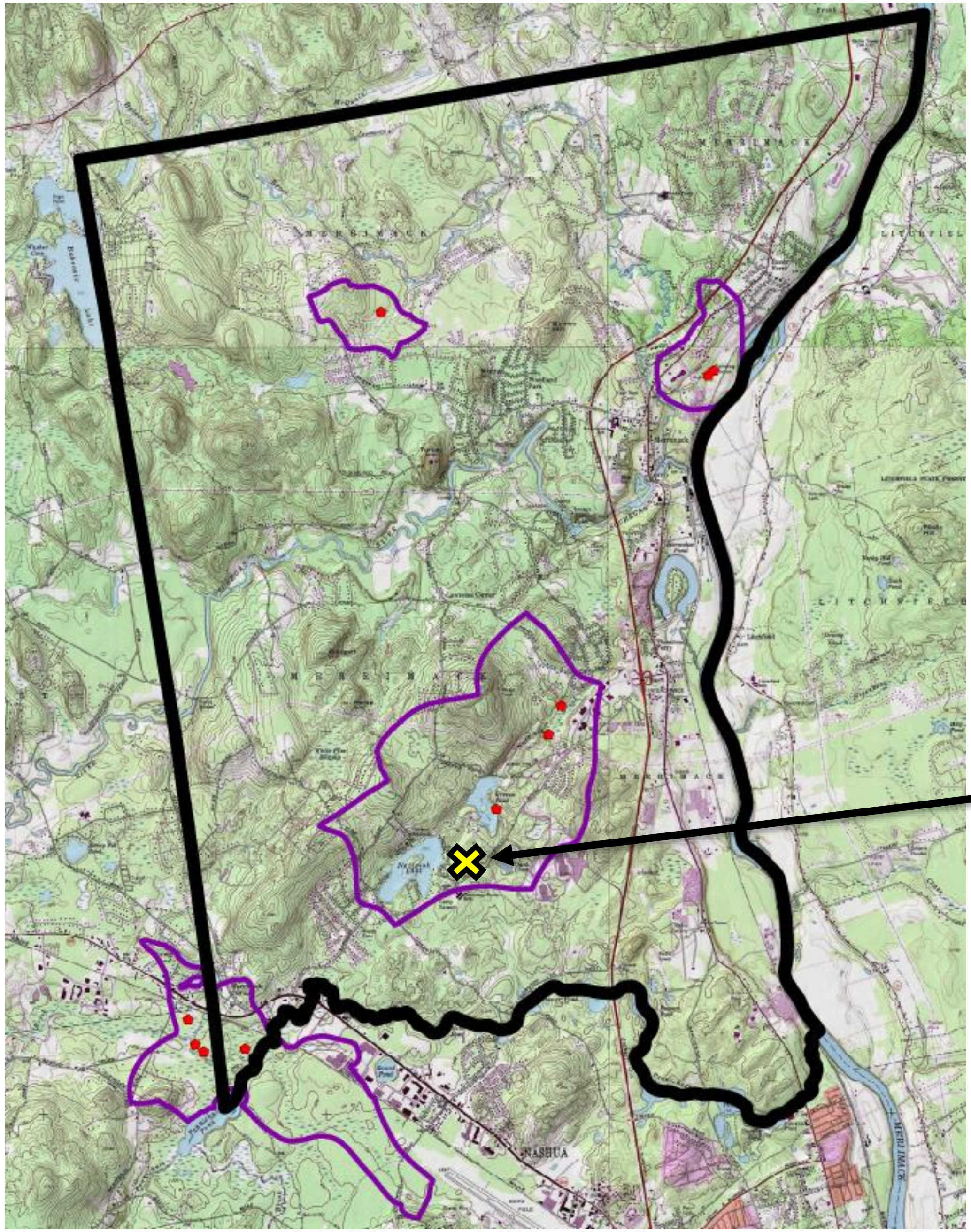
Greens Pond Road

Emery & Garrett Groundwater Investigations, A Division of GZA

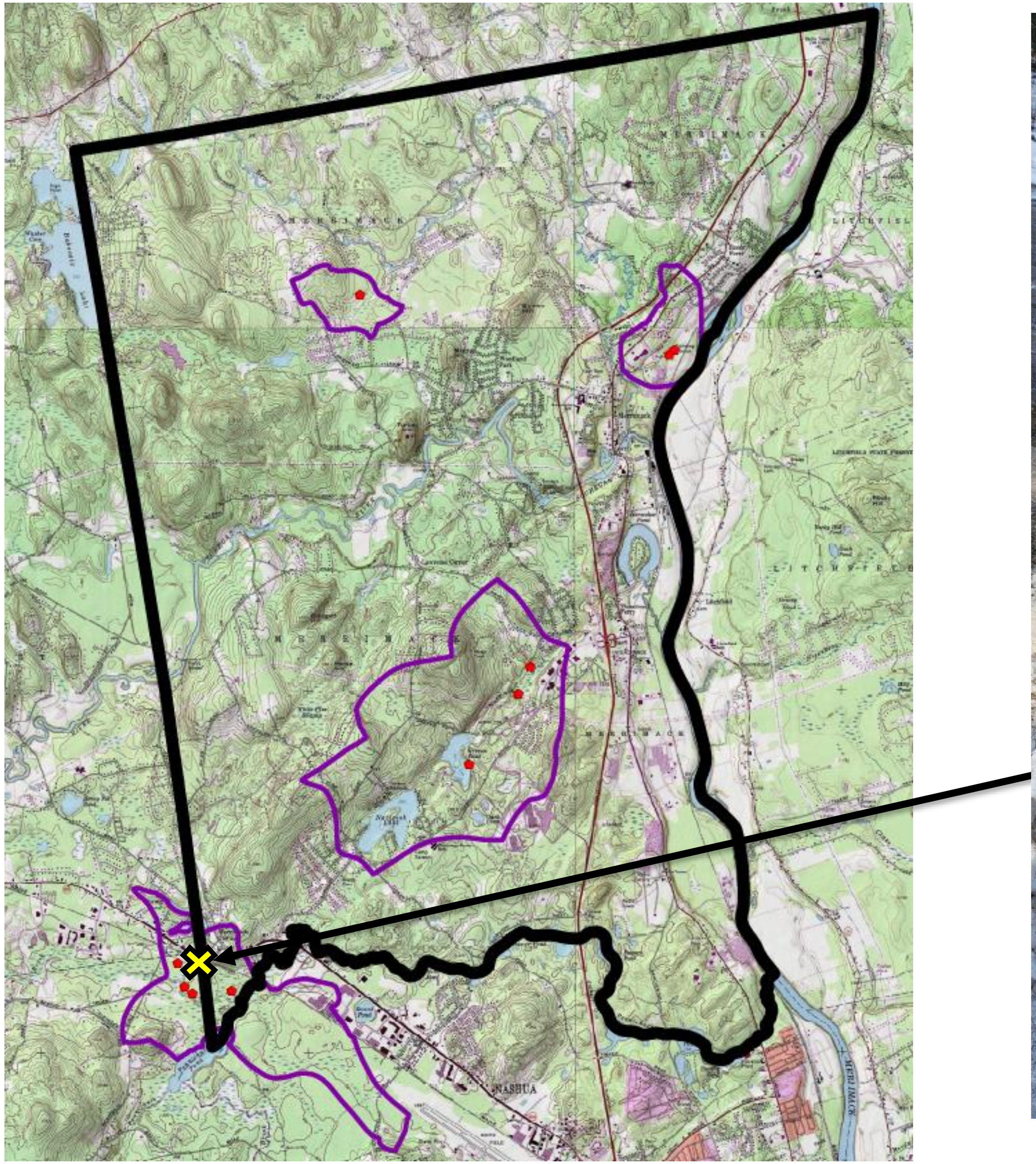
Ingham Road







Aldrich Circle

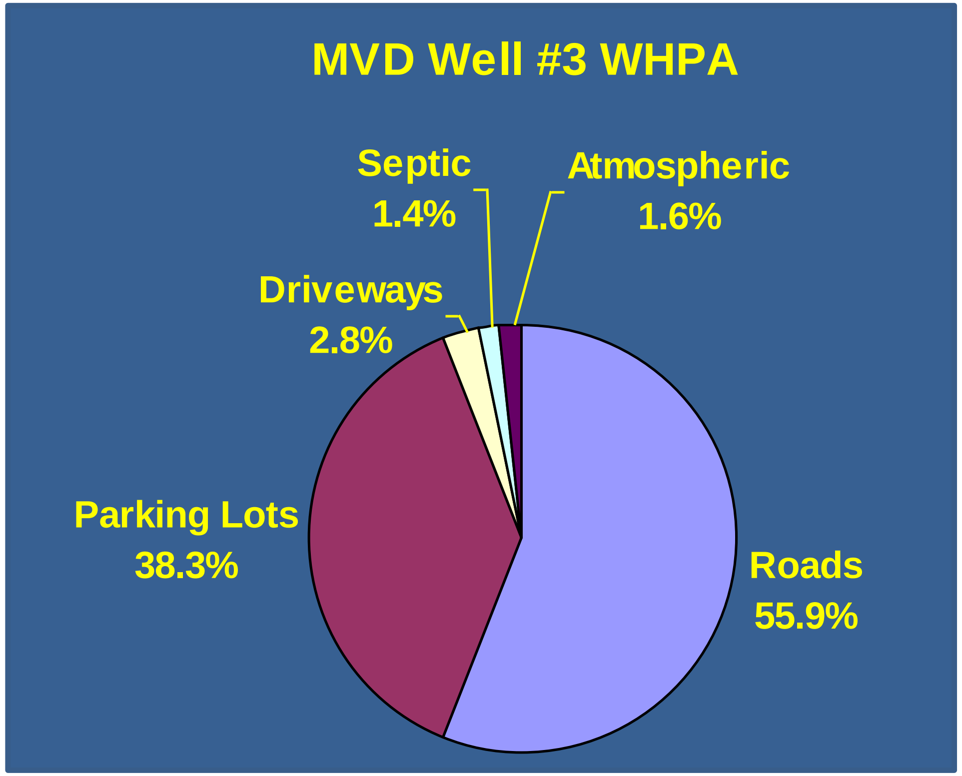


Entrance to Wells MVD-7 and MVD-8 Railroad Crossing

Emery & Garrett Groundwater Investigations, A Division of GZA

Mitigation Topics

- Private Roads, Parking Lots & Sidewalks
- Public Roads
- Public Education / Policy



Private Roads, Parking Lots & Sidewalks

1. Training and certification for operators (Green Sno Pro or other)
2. Use calibrated spreaders and appropriate application rates
3. Pre-wet salt
4. Anti-ice
5. Salt alternatives (Liquid Calcium and others)
6. Record keeping

Public Education / Policy

1. Define Low or No salt areas
2. Mailings to residents / MVD customers
3. Website
4. Automated signs along key roads
5. Reduced speed limits

Administrative Best Management Practices

1) Defining a Level of Service Needed
2) Pre-Storm and Post-Storm Meetings
3) Weather Forecasting Services

4) Automatic Vehicle Location Systems

What are they? Automatic Vehicle Locating Systems (AVL) are a data collection tool that uses the Global Positioning System (GPS), communication networks, and street mapping software to remotely track the location, direction of travel, and speed of snow removal vehicles during operations and display this information on a base mapping system. AVL systems can integrate with a whole host of onboard sensors and even dash mounted cameras, to collect data on material usage, air and pavement temperature and condition, plow position (up/down), and liquid systems output, and send this data with location data for a more complete picture of what is happening in the field. Snow removal operations managers use these data to observe, analyze, and optimize snow removal operations in real time and for post storm analysis.

Selected Survey Results from Web-Based Questionnaire Sent to Massachusetts DOT snow and Ice Personnel from Massachusetts DOT report:

"Operational Factors that Affect Road Salt Usage and the Effectiveness and Efficiency of Salt Spreading Operations and Equipment (2016)"

- What are the Biggest Difference(s) in the Level of Effort Needed to Maintain Reduced Salt Zones Versus Regular Spreader Routes?
  - More plowing time is needed with more frequent passes to prevent snowpack.
  - Greater application frequency is needed, and perhaps more overall material needs to be applied.
  - More time patrolling roads is needed.

Selected Recommendations from Massachusetts DOT report: "Operational Factors that Affect Road Salt Usage and the Effectiveness and Efficiency of Salt Spreading Operations and Equipment (2016)"

- Optimize routes to reduce route overlap
- Assign the best and most experienced operators to environmentally sensitive areas
- Employ the most efficient equipment (closed-loop controllers, use of brine and other liquids, etc.)
- Reduce and/or eliminate use of salt in Reduced Salt Zones

Brine Dispenser Truck, Dover, New Hampshire

Liquid Salt Spreader Equipment they have purchased to reduce salt load in their Wellhead Protection Areas

Pre-Wetting Brine and Salt Trucks

Brine Saddle Tank

Brine Wets the Salt Prior to Contact with the Road

Comments, Ideas to Reduce Salt?