Ossipee Aquifer Advisory Committee
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OAAC

Mitchell Locker, P.G.
NHDES – WD / DWGB
Groundwater Recharge Program
PO Box 95, Concord, NH 03302-0095

Dear Mr. Locker,

On behalf of the Ossipee Aquifer Advisory Committee, please accept this letter detailing our concerns over the proposed groundwater discharge plan for Pinetree Power outlined in the Groundwater Discharge Permit Application Id# 199407004 dated 6/28/2019.

The Ossipee Aquifer Advisory Committee supports efforts to maintain the quality and quantity of groundwater within the Ossipee Aquifer system. Our mission is to work, in an advisory capacity, with local municipalities, agencies, boards and commissions to gather information and comment on developments that may impact groundwater in the region. The Ossipee Aquifer is the largest stratified drift aquifer in the State of New Hampshire (Moore and Medalie, 1995) and, as it crosses municipal boundaries, we seek to coordinate efforts across multiple municipalities. The coarse sands and gravels that make up much of this aquifer make it highly transmissive and susceptible to contamination. The majority of residents in the towns of Tamworth, Madison, Ossipee, Freedom and Effingham depend on this aquifer for their drinking water. In addition, the Ossipee Aquifer discharges directly into Ossipee Lake as well as into numerous tributary streams that feed the Saco River where more than 300,000 people in Saco and Biddeford draw their drinking water. The proposed project at Pinetree Power is located in the heart of this Aquifer (Figure 1).

Disposal of cooling tower wastewater (blowdown) by infiltration into groundwater is not an accepted practice. California's Water Quality Control Policy, enacted in response to the passage of the Clean Water Act, specifically states that discharge of wastewater from cooling towers to land disposal sites shall be prohibited except to salt sinks (California State Water Resources Control Board, 1975). The ban on land disposal is because these wastewaters have very high concentrations of dissolved salts (brines) and are contaminated with metals. Pinetree Power is proposing to discharge their cooling tower wastewater brine into one of the most transmissive parts of the Ossipee Aquifer which contains some of the most pristine groundwater in the region.

Even worse, Pinetree Power's proposed Rapid Infiltration Basins (RIBs) lie just outside the Well Head Protection Area (WHPA) of the Tamworth Pines Public Water System (PWS) (Id#2313020) that supplies water to over 100 people. Some of the RIBs are less than 100ft from the WHPA and the groundwater gradient determined during the RIB tests showed groundwater flowing directly toward the WHPA. It is therefore likely that the wastewater brine dumped into the RIBs will be drawn into the Tamworth Pines supply wells resulting in their contamination. Consequently, Pinetree Power's proposal to change their disposal practices to RIBs represents a direct, deleterious threat to water quality, that will likely result in contamination of large areas of the aquifer; including public water supply wells. We strongly object to this change in disposal practices and urge you to deny this permit in order to protect the health and safety of the area's drinking water resources, upon which New Hampshire residents, businesses and the local economy depend.

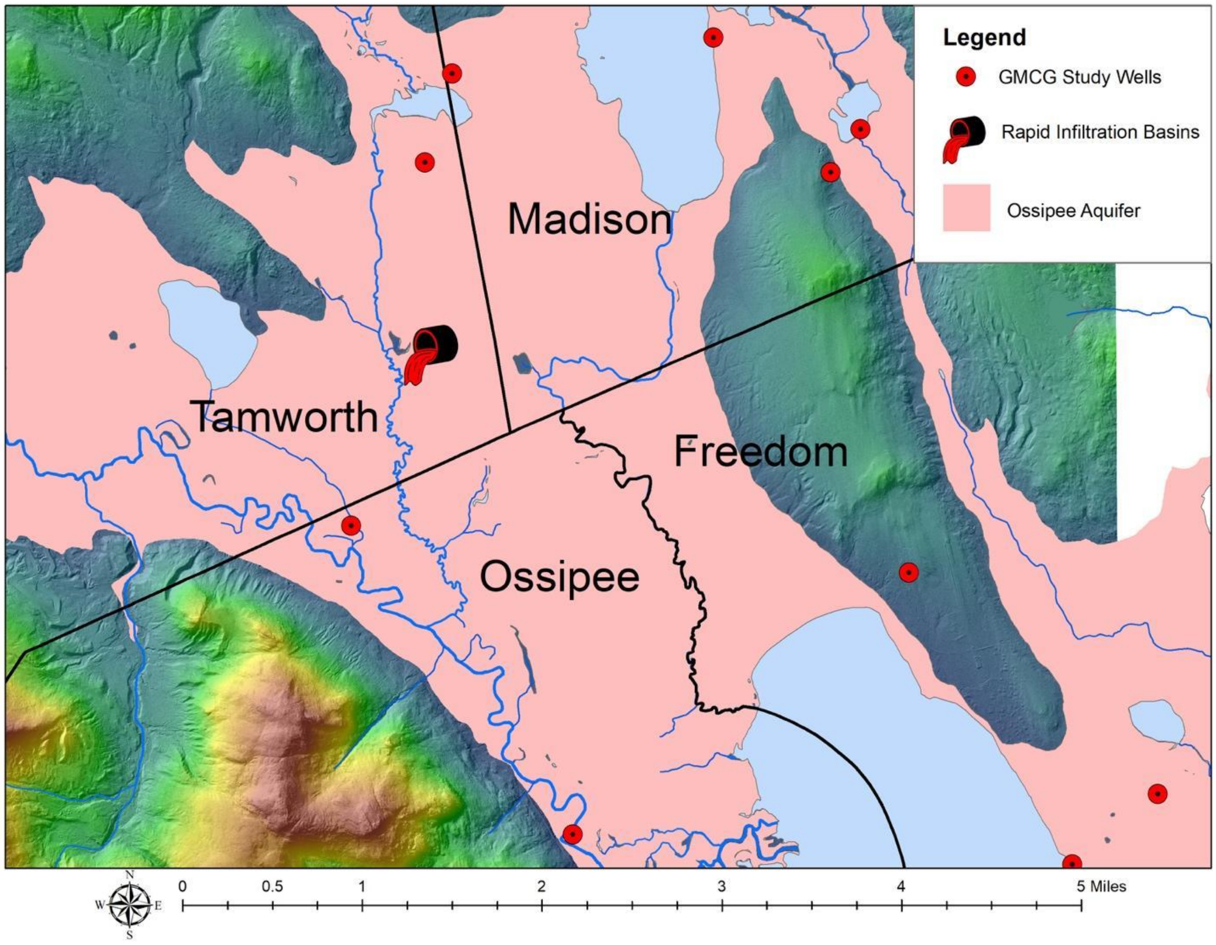

Figure 1. Map showing the extent of the Ossipee Aquifer in the area of Pinetree Power. The proposed infiltration site is shown by the open pipe symbol. Note that the location within the Town of Tamworth is adjacent to Madison, Ossipee and Freedom. Impacts can extend across town boundaries. Red dots represent domestic wells that are part of the GMCG-Smith College water quality study.

The following is a detailed list of some of our concerns:

1. A 2009 study done by Mia Akaogi, as part of her masters degree in the Rubenstein School of Environment and Natural Resources at the University of Vermont identified the area, where the proposed RIBs are to be located, as being the most vulnerable to groundwater contamination in the Ossipee Watershed (Figure 2)(Akaogi, 2009). This is the worst possible location for any wastewater discharge.

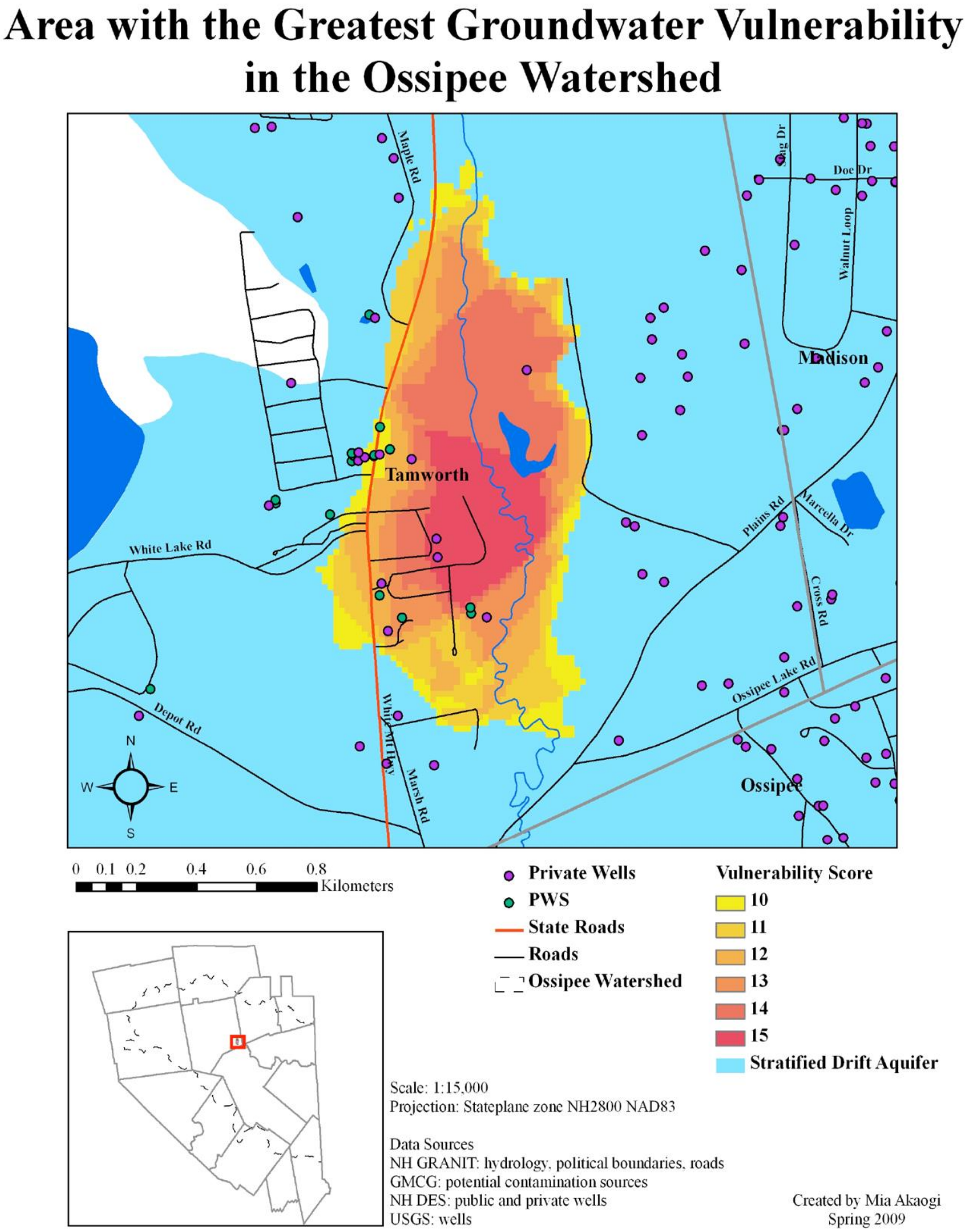

Figure 2. The RIBs lie within the area that is most susceptible to groundwater contamination.

2. Pine Tree Power's application did not disclose the chemicals that are added to the cooling tower water stream. From the reported chemistry of the circulation water we can assume that they must, at the very least, be injecting sulfuric acid, sodium hypochlorite (bleach) and some form of phosphate to the cooling water stream. This is consistent with what is done at most power plant cooling towers to control scale formation and biofouling (Buecker, 2009) and this is precisely why this wastewater is completely inappropriate for groundwater recharge. The cooling process is driven by evaporation, which concentrates these chemicals into a brine-like solution and is totally inappropriate for discharge into any aquifer, let alone next to a WHPA of the pristine Ossipee Aquifer.

3. If allowed, infiltration of this wastewater would render groundwater in large areas of this highly productive aquifer undrinkable. Although salts are not regulated under the Ambient Groundwater Quality Standards (AGQS), at high concentrations they make water non-potable as the ingested salt from drinking this water exceeds the ability of our kidneys to remove it from our body. At lower concentrations salts affect taste as recognized by EPA's Secondary Drinking water standard for chloride at 250mg/L; above that level water will taste salty. The secondary standard for Total Dissolved Solids (TDS) is 500mg/L. At higher concentrations the World Health Organization classifies waters with TDS 900-1,200mg/L as "poor quality" while waters with TDS values above 1,200 mg/L are considered "non-potable". The "circulation water" at Pinetree Power on 9/27/17 had a TDS in excess of 25,000 mg/L and a chloride concentration of 9,200 mg/L. It would take over 25 times the volume of ambient groundwater to improve this to just the "poor quality" minimally potable category. The circulation water was diluted with ambient groundwater during the first basin test in an attempt to lower the concentration of AGQS regulated chemicals below their maximum allowable values. The dilution during these tests was only 4 times (1 part circulation water, 3 parts ambient groundwater). Note that circulation water chemistry provided in Pinetree Power's proposal was not complete for the period of the loading tests and clearly had what we assume are transcription errors (e.g. specific conductance of 4 μS/cm which would be a value associated with distilled water).

4. It is instructive to compare the chemistry of the wastewater stream with the ambient groundwater in the area. GMCG has partnered with Smith College to do 3 different groundwater quality studies in the Ossipee Aquifer over the past 10 years. All samples were analyzed for major cations, anions, plus a suite of metals and stable isotopes. The 2016 study included an additional suite of VOC's (Table 1).

Table 1. Measured components and methods used in Ossipee Aquifer water quality studies.

2009 Ossipee Aquifer Study (70 domestic wells)	
Component	**Method**
Ca, Mg, Na, K, SiO_2	ICP - OES
pH, Alkalinity	Electrode/Autotitrator – Inflection/Gran
F, Cl, NO_3, SO_4	Ion Chromatography
As, Ba, Zn, Cu, Mn, Fe, Pb	Graphite Furnace Atomic Adsorption
Water Isotopes $\delta^{18}O$, $\delta^{2}H$	Cavity Ringdown Spectrometry
Specific Conductance	Conductance Electrode

2016 Ossipee Aquifer Study (69 domestic wells)	
Component	**Method**
Ca, Mg, Na, K, SiO_2	ICP - OES
pH, Alkalinity	Electrode/Autotitrator – Inflection/Gran
F, Cl, NO_3, SO_4	Ion Chromatography
Pb, Cu, Zn	Graphite Furnace Atomic Adsorption
Volatile Organic Compounds	Headspace/GC-Mass Spectrometry
Water Isotopes $\delta^{18}O$, $\delta^{2}H$	Cavity Ringdown Spectrometry
Specific Conductance	Conductance Electrode

2019 Ossipee Aquifer Study (80 domestic wells) in progress	
Component	**Method**
Ca, Mg, Na, K, SiO_2	ICP - MS
pH, Alkalinity	Electrode/Autotitrator – Inflection/Gran
F, Cl, NO_3, SO_4, NO_2, PO_4	Ion Chromatography
As, Ba, Zn, Cu, Mn, Fe, Pb	ICP - MS
Water Isotopes $\delta^{18}O$, $\delta^{2}H$	Cavity Ringdown Spectrometry
Specific Conductance	Conductance Electrode

The combined results from these studies provide a base line to evaluate the impact of the proposed RIBs. They show that the average TDS value for wells that lie within the stratified drift aquifer in the vicinity of the power plant is 49 mg/L compared to a value over 25,000 mg/L for the circulation water (9/27/17) and 6,250 mg/L after a 1 in 4 dilution (1 part wastewater, 3 parts ambient groundwater). The average chloride value of the ambient groundwater is 4.4 mg/L compared to 9,200 mg/L in the wastewater and 2,300 mg/L in the diluted water (Figure 3; Table 2). It is clear from this analysis that wastewater infiltration through the RIB's will have a dramatic negative impact on water quality. The ambient groundwater will go from a nearly pristine condition with an average specific conductance of 79 µS/cm to a highly mineralized brine with a specific conductance of 11,700 µS/cm and a TDS of 6,250 mg/L which is almost 6 times higher than the maximum value for potable water.

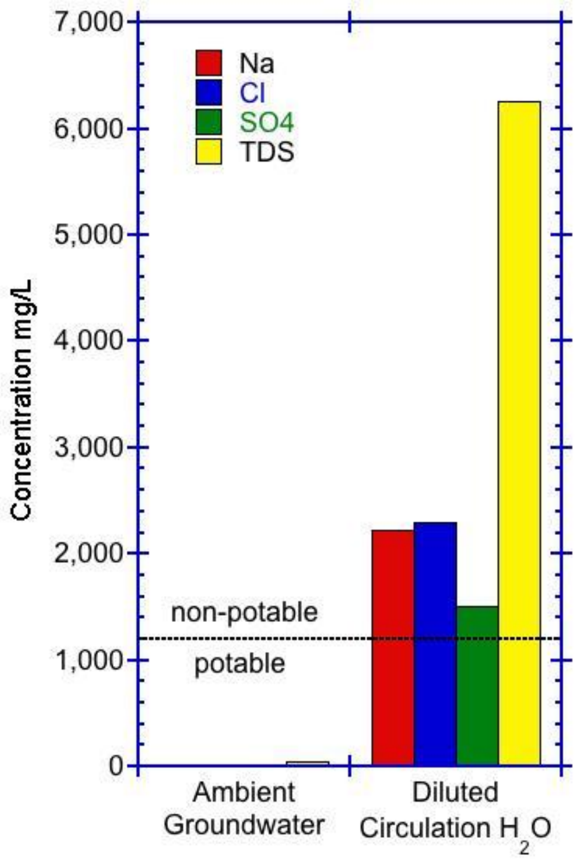

Figure 3. Bar graph comparing ambient groundwater (Aquifer) with diluted circulation water. Ambient concentrations are so low as to barely be visible on the graph.

Table 2 Comparison of aquifer water to wastewater

	Sodium	Chloride	Sulfate	TDS
Ambient groundwater	6	4	4	49
Diluted circulation H_2O	2,225	2,300	1,500	6,250
Circulation H_2O	8,900	9,200	6,000	25,000

All values in mg/L

5. The permit is for a staggering 100,000 gallons per day of wastewater infiltration. To get a better understanding of the scale of this impact on the aquifer here is a simple conceptual volume exercise. 100,000 gallons is equivalent to approximately 13,300 cubic feet of water. Assuming that the aquifer has a porosity of 0.3 and no specific retention, then this volume would saturate 44,300 cubic feet of the aquifer with wastewater. If we assume that this would cause the water table to rise one foot and that the water would spread in a circular pattern (it would actually be elongated along the groundwater flow line) then the radius of the circle would be 118 ft. With 100,000 gallons being infiltrated daily, this circle would

expand to almost 2,300 ft in one year. Throughout that area, the wastewater would be 1ft thick. Figure 4 shows where this circle lies on an air photo of the region.

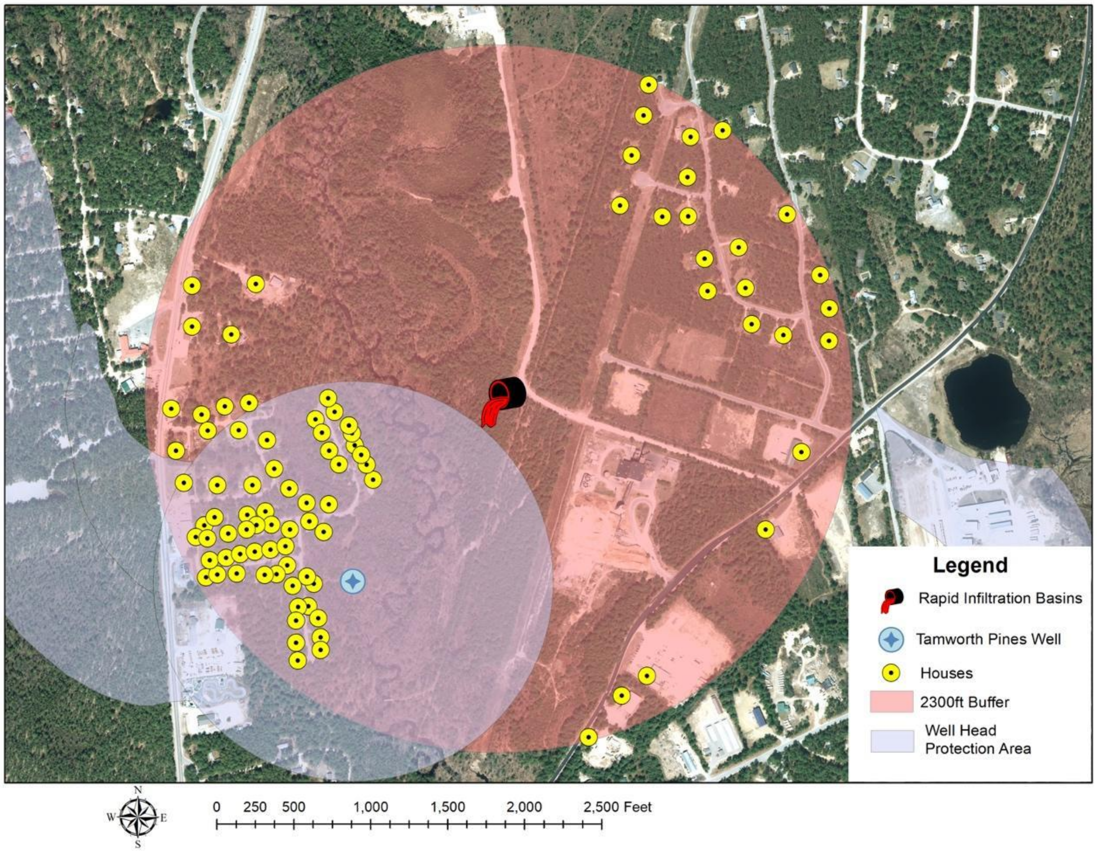

Figure 4. Map showing the areas that could potentially be impacted by the infiltration of wastewater assuming the requested 100,000 gallon per day rate for 1 year. The total volume of aquifer that would be filled by waste would the area shown in red to a thickness of 1ft. The areas shaded in blue show the WHPAs for public water supplies in the area.

Over 90 homes and businesses lie within this zone (represented by yellow dots). This is clearly a conceptual exercise, but it demonstrates that a huge volume of undrinkable water will be infiltrated into the aquifer and it will clearly spread to areas with both public and domestic wells. The ultimate extent of the contamination is difficult to predict. Given its density, the wastewater plume may sink to the bottom of the aquifer where its movements could be controlled in part by the bedrock surface topography. It is also possible that differences in temperature between the wastewater and the ambient groundwater could influence the direction of flow. Dilution of the plume by the surrounding groundwater will be limited, given that groundwater flow in surficial aquifers is laminar and the only mechanisms for dilution are diffusion and dispersion. Given the volume of the plume, the central portion will be essentially undiluted for a long distance downgradient. The high transmissivity (27,000 gal/dayft) of the aquifer in this area means that the plume will move far and fast. It will mainly go westward, towards the Chocorua River. Some wastewater will undoubtedly enter the stream, negatively impacting stream water chemistry, but the river is not fully penetrating and much of the wastewater will move under the stream and will likely contaminate the Tamworth Pines PWS. Thus, if permitted, the disposal of this waste will end up contaminating both domestic and PWS wells, as well as reducing the water quality of streams draining into Ossipee Lake.

6. The release of primary contaminants into the aquifer from the wastewater is important, but of equal importance is the release of secondary contaminants. These are chemicals that are released either directly from aquifer materials or from homeowners pipes in response to increased salinity. For example, arsenic was reported at concentrations up to 6 times above the AGQS (65 µg/L in tank FTS) during the hydraulic loading tests. Arsenic can be a natural contaminant released from weathering of minerals that occur in the area. However, the introduction of salt into the system will worsen the problem, as recent studies have shown that high salinity waters can interact with soil minerals to release arsenic, lead, and mercury (Sun, et al., 2015). It should also be noted, that the State of New Hampshire will be lowering the AGQS for arsenic from 10 µg/L to 5 µg/L in the near future so these values will be even further from the acceptable standard. In addition, high chloride concentrations, released into groundwater, have been shown to cause corrosion of pipes in homes with domestic wells, leading to the release of lead and copper directly into their drinking water (Stets et al., 2018). Finally, the disposal of wastewater in the RIBs will potentially create disinfection byproducts that will be carried into the groundwater system. Disinfection byproducts include known carcinogens and fall within the AGQS regulations. Unoxidized sodium hypochlorite (indicated by Chemical Oxygen Demand (COD)) that contacts organic matter in the infiltration basins or underlying soils will react to form disinfection byproducts that can be transported in the groundwater to nearby wells. These secondary releases of heavy metals and disinfection byproducts are just as hazardous as metals directly in the wastewater stream, and are reason enough, to deny the permit.

7. Pinetree Power relied on dilution with ambient groundwater to bring the concentration of AGQS regulated chemicals below their maximum allowable concentrations during loading test 1. For this to work in the long term, the ambient groundwater quality must be maintained. However, it is likely that at least some of the infiltrated wastewater will be drawn back into the cone of depression of the on-site pumping wells that are being pumped at over 300,000 gallons per day (Moore and Medalie, 1995). This reduction in well water quality will lead to the need for more pumping that will, in turn, lead to more wastewater being drawn into the well. This will create a vicious cycle that will ultimately lead to even higher concentrations of dissolved salts in the infiltrated water.

8. The monitoring wells at the site are inadequate for the purpose of tracking the plume of wastewater as they are only 50ft deep and the static water level was less than 10ft from the bottom of many of the wells. The aquifer is estimated to be 90-100ft thick at the site, based

on groundwater exploration studies, so they are sampling only the upper 15% of the saturated zone.

9. The Tamworth Pines PWS wells are most vulnerable to contamination and immediate efforts should be made to monitor their chemistry as they lie just over 1000 ft from the RIBs (Figure 5). Approximately 1 million gallons of wastewater was added to the aquifer during the time the temporary permit was in force (January-April 2019). This wastewater occupies almost half a million cubic feet of the aquifer and represents a potential threat to all nearby wells. Tamworth Pines PWS needs to be notified so that they can begin a chemical monitoring program to detect the possible approaching plume of contamination. This monitoring should include analyses for stable water isotopes ($\delta^{18}O$ and $\delta^{2}H$) as the cooling tower wastewater has a unique isotopic signature (highly enriched in $\delta^{18}O$ and $\delta^{2}H$) that will be easy to identify (Ingraham, et al., 1994).

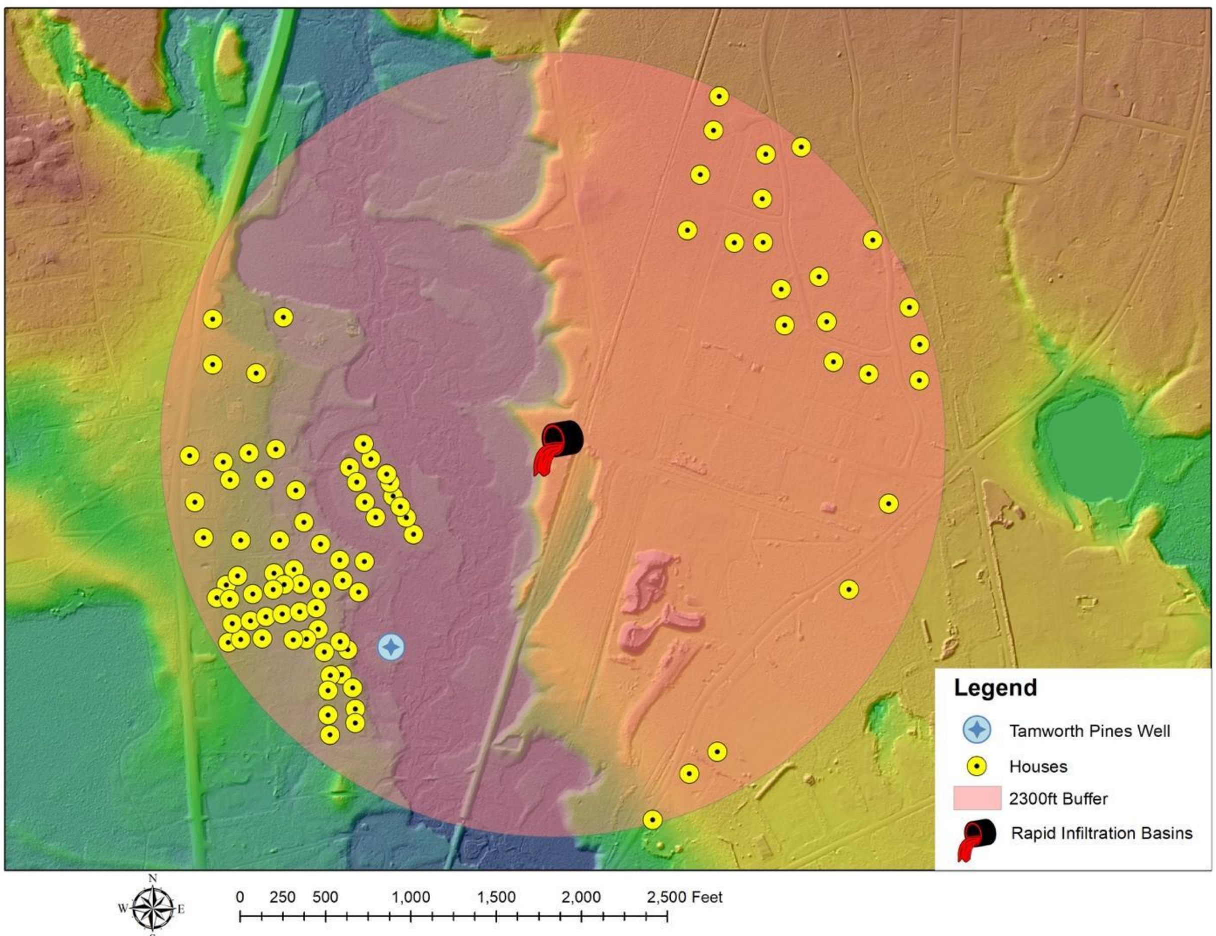

Figure 5. LiDAR based DEM of the area potentially impacted by the disposal of wastewater from Pinetree Power after one year of waste disposal. The red circles represent the homes and businesses serviced by both public and domestic wells. Note the cluster of wells on the floodplain of the Chocorua River (blue areas). These are the wells that will likely be first to be impacted.

10. The RIBs are located next to steep, 25+ degree slopes that drop over 40ft to the floodplain of the Chocorua River to the west and over 10ft to the abandoned sand pit to the east (Figure 5a and b). The concern here is that hydraulic loading could, under the right soil moisture conditions, lead to a slope failure either westward to the Chocorua River or eastward to the abandoned sand pit. It is worth noting that there are two channels shown on the LiDAR Digital Elevation Model (DEM) that dissect the slope edge (Figure 2). Both have small alluvial fans at their base and are likely the result of groundwater sapping during periods of high groundwater stage.

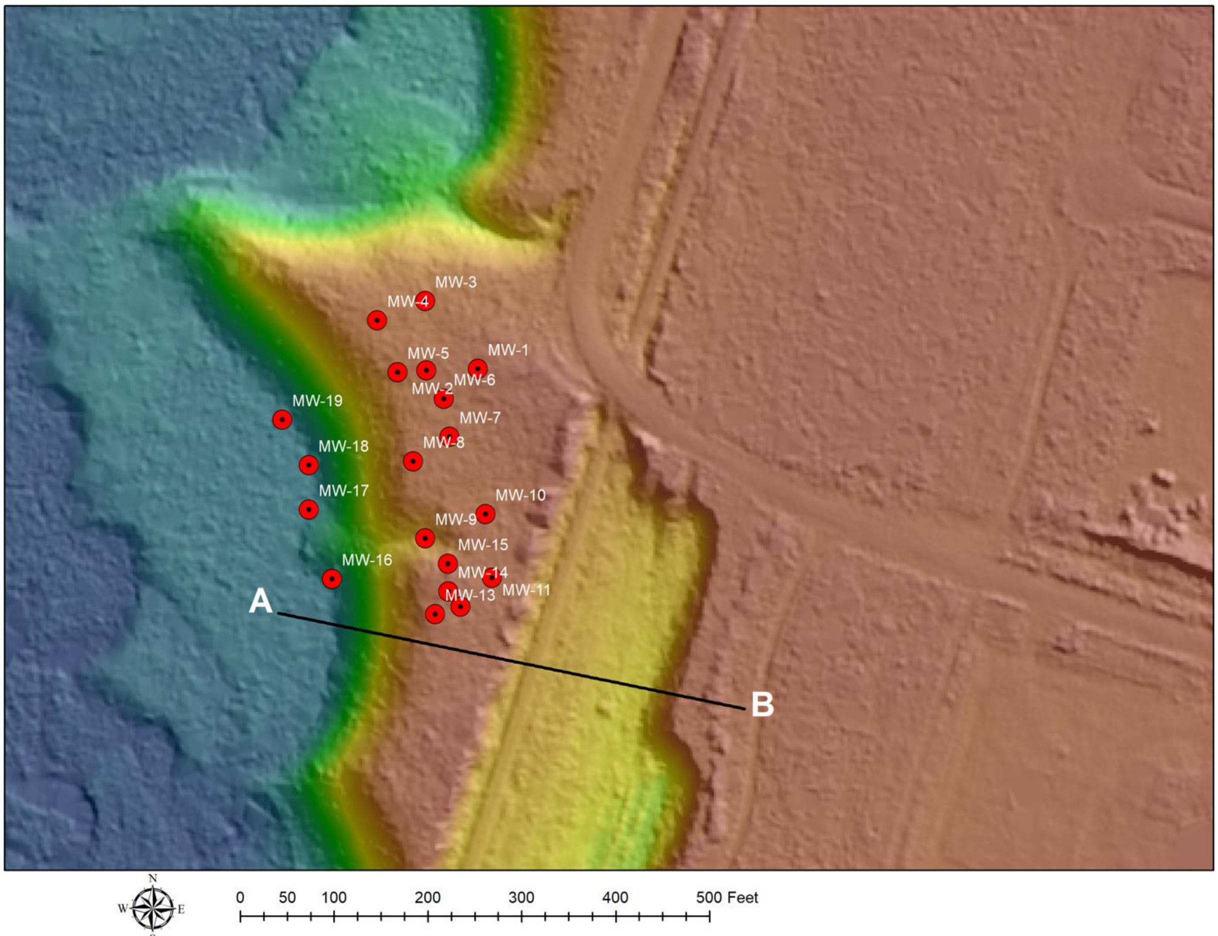

Figure 5a. Digital Elevation Model (DEM) of the RIBs site based on LiDAR data from New Hampshire GRANIT. Location of project monitoring wells are shown together with the line of topographic cross section (A-B). The dark blues represents low elevations and the brown higher elevations. For range see the topographic cross section in Figure 2b.

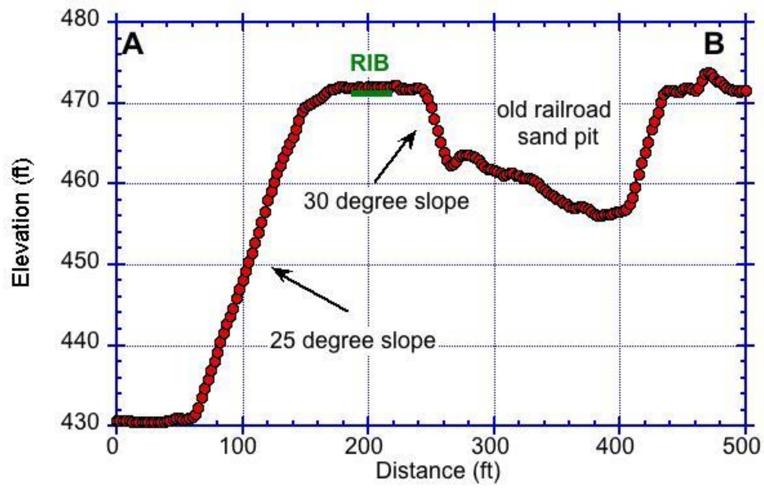

Figure 5b. Topographic profile from A to B from the Chocorua River floodplain at just over 430 ft on the west side of the graph to the surface of the outwash plain at 473ft where the RIBs are located. Note the steep slopes to the west of the RIBs and the even steeper slopes making up the sides of the old sandpit to the east.

In conclusion, this analysis shows that Pinetree Power's proposed change in the way that they dispose of cooling tower wastewater will have major negative impacts on groundwater quality in the Ossipee Aquifer. The water supply of hundreds of people and many businesses is likely to be compromised. This permit must be denied.

Sincerely,

Robert Newton,
Professor of Geosciences, Smith College, Northampton Massachusetts

Blair Folts,
Executive Director Green Mountain Conservation Group

For the following members of the Ossipee Aquifer Advisory Committee
Kit Morgan, Tamworth
Tara Schroeder, Tamworth
Theresa Swanick, Effingham
Rich Fahy, Ossipee
Robert Newton, Madison

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