Wetland Hydrology and the Impacts resulting from the proposed 518 South Avenue project.

25 March 2022

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A letter from Mr. Robert Gemma to the Weston Conservation Commission (December 21, 2020, and attached at the end of this note) addressed the issue of whether the infiltrated treated wastewater flow from the proposed 518 South Avenue site shall have an adverse impact on the hydrology of the wetlands immediately to the east of the proposed project. As that letter is part of the public record, it will not be repeated here save its conclusion that the proposed project at 518 South Avenue represents a small increase of flow to the wetlands in comparison to the flow from the entire watershed and therefore shall not result in demonstrable adverse impacts to the wetlands.

The context of this note is to address a concern that the infiltration of the treated wastewater at the proposed development shall adversely impact the wetlands via a dramatic change to wetlands hydrology. In this context, the source of water for the infiltrated treated wastewater is imported from outside of the Bogle Brook watershed, and therefore does represent an increase to the watershed water budget. For this hydrologic assessment it is best to first start with the wetland water budget: water inputs and outputs. Water inputs to the wetlands include groundwater, surface water, and direct precipitation. Water outputs include evapotranspiration, groundwater, and surface water. In a steady state fashion over the long term, inflows equal outflows with no net change in water storage in the wetlands. This change in wetland water storage is represented by the groundwater table at the wetland. If the wastewater flow significantly increases the groundwater elevation at the wetland, then one could conclude that this may result in an adverse impact to the wetland.

What might be considered a significant change to the groundwater level? None of the Peer-reviewers have offered any published guidance on this metric. Groundwater levels naturally vary over the year. In Figure 1 is plotted the water level fluctuations in a USGS groundwater well near to the 518 South Avenue site (https://dashboard.waterdata.usgs.gov/app/nwd/?region=lower48&aoi=default). This well is located in Wayland, MA and is completed in a similar sand/gravel formation as exists at the 518 South Avenue site. As may be seen in Figure 1, over the year, groundwater levels naturally vary over three feet and the annual variation in groundwater levels could be as large as five feet. Therefore a significant change in the groundwater level at the site wetlands (under a significant portion of the wetlands) might reasonably considered to be on the order of 0.2 ft or more over a large portion of the wetland. One observation about using a USGS well such as this: it does not appear to be located in a wetland, rather near to a large waterbody ~300 feet from (Lake Cochituate). A wetland groundwater level may not exhibit as large a swing in groundwater levels as groundwater farther away because the wetland surface acts as the relief valve at high groundwater levels.

The updated MODFLOW groundwater model using a constant head boundary at the intermittent stream and typical infiltrated water volumes, although not designed to perform wetlands hydrology, predicts an average increase in the groundwater elevation *at the western edge of the wetlands* to be less than 0.2 feet. Again, this is at the edge of the wetlands, not under the entire wetland system. Because of the very high soil permeability below the 518 South Avenue site which continues under the wetlands to the east, the infiltrated treated wastewater will flow below most of the wetland footprint, and the change in the groundwater level under the entire wetland therefore shall be much less that the ~0.2 feet predicted by the model when spreading out this wastewater flow under larger portions of the wetland rather than focusing on just the western edge. Therefore this groundwater model implies that the infiltrated treated wastewater does not dramatically change wetland groundwater levels and therefore there is no adverse effect to the wetlands.

Looking at the water budget for the wetlands, in an undeveloped state and on an annual basis, about 40% of precipitation is lost to evaporation and the remaining 60% goes to groundwater and runoff (Figure 2). The Bogle Brook watershed area above the downstream end of the 518 South Avenue site is 262 acres. Average annual precipitation for the watershed is approximately 44 inches. Therefore the water that goes to groundwater and runoff that supplies the wetlands east of the site is the product of the annual precipitation, the watershed area, and the fraction that is not lost to evaporation (0.6, Figure 2), or 576 acre feet per year. The average wastewater flow is 22,000 gallons per day or 24.6 acre feet per year, representing 4% of the groundwater and surface water input to the wetland. No documentation has been found that indicates that this small change in average annual hydrology will create an adverse effect on the wetland system. Coupled with the results of the groundwater model the conclusion found by the Gemma 2020 is supported by the further evidence presented here.

An interesting observation by the potential increase of groundwater levels at the western edge of the wetlands under discussion is that this may allow the wetlands to expand farther to the west, and in this scenario, rather that the infiltration of treated wastewater resulting in wetlands loss, it not only supports existing wetlands during the driest times of the year (although climate change is increasing extreme precipitation amounts like that of the 10-year storm, predictions are that the number of dry and very low precipitation days shall also increase, therefore in the future, drier periods shall become drier, https://science2017.globalchange.gov/chapter/7/), it may also lead to creation of new fringe wetlands.

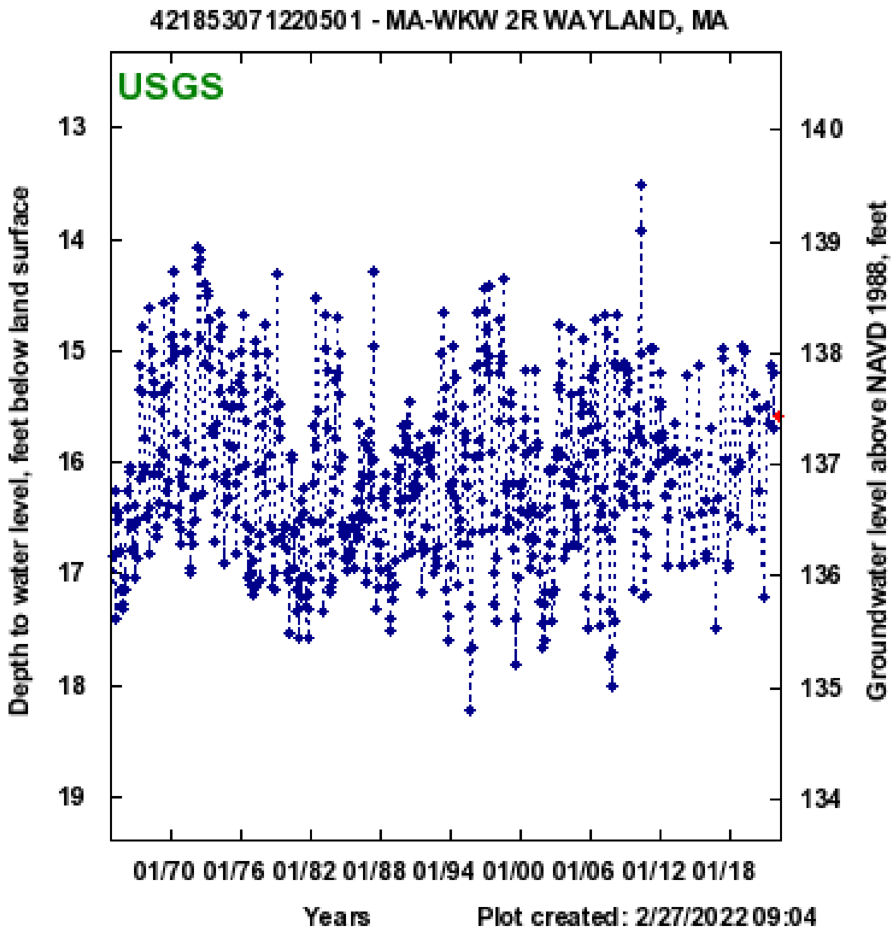

Figure 1. USGS water level data for Wayland, MA groundwater well (https://groundwaterwatch.usgs.gov/AWLSites.asp?mt=g&S=421853071220501&ncd=awl) .

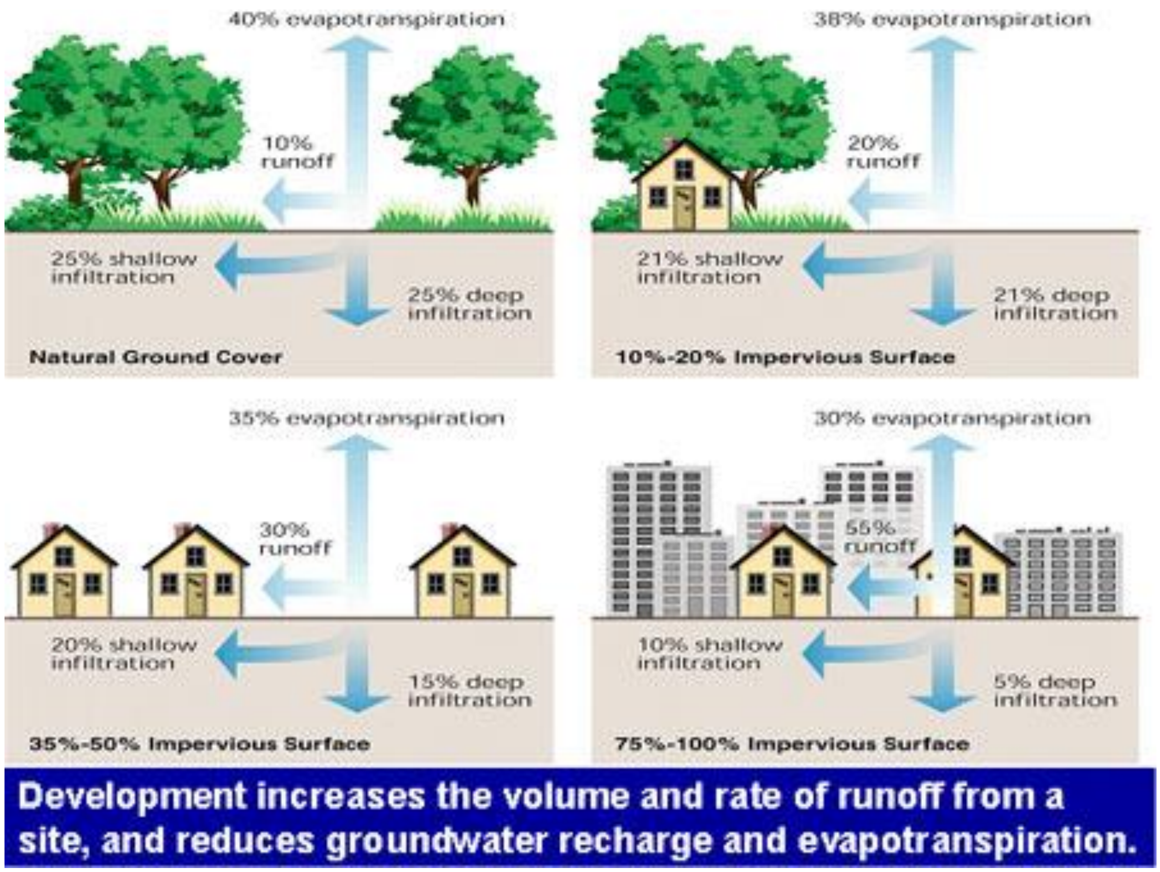

Figure 2. Typical water budgets for developed and undeveloped sites (https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=170#)

Lastly, the "Design Event" to consider the characteristics of mounding at the infiltration systems is: high groundwater table that is maintained for 90 consecutive days, high wastewater loading for 90 consecutive days, and the 10-year, 24-hour rainfall event. This design event has transformed in the eyes of some to be a common occurrence event in critiques of the proposed site design. To understand the probability of such an occurrence, the probability of each of these occurrences may be estimated and then multiplied together assuming that they are independent events. The selected high groundwater table is a groundwater level not exceeded 80% of the time therefore the exceedance probability (Pe) is 0.2. The USGS Wayland, MA gaged well shown in Figure 1 began daily reading of groundwater levels 24 February 2021. The daily data is displayed in Figure 3 and on that figure the yellow horizontal line is the groundwater depth created by Tropical Storm Ida. Clearly, the maximum groundwater elevation does not persist for more than one day, let alone 90 days. Groundwater elevations may remain high for a number of days, for example, using the depth to water of the Tropical Storm Ida event, which is not the highest of the year, one can see that for 16 consecutive days, the depth to groundwater was equal or shallower (meaning that the groundwater elevation was high). The Tropical Storm Ida event produced a groundwater elevation near the 80% highest level. In the Wayland well record, on two occasions in 2021 the depth to water was shallower than the 20% level (10.66 feet) (note:

shallow depth to groundwater means a high groundwater elevation). Without a very long record, assigning a probability of occurrence for 90 consecutive days with high groundwater elevation is difficult, however, July 2021 was reported to be the wettest July on record in Massachusetts (https://www.masslive.com/weather/2021/08/july-2021-is-officially-the-wettest-massachusetts-july-in-history-breaking-previous-record-by-134-inches.html and https://www.washingtonpost.com/weather/2021/12/29/wettest-2021-east-us/). 2021 was one of the wettest years on record for the Commonwealth (https://www.ncdc.noaa.gov/sotc/national/202113). Using the NOAA Lowell, MA weather station (https://www.ncdc.noaa.gov/cdo-web/) which has long term, near continuous monthly records back to 1892, July 2021 was the 11th wettest month on record (Pe = 0.74%) and the third wettest July on record (Pe = 2.6%). Since this very wet month resulted in only 16 consecutive days with the groundwater elevation higher than the highest level 80% of the time, a very conservative estimate of 90 consecutive days with the groundwater higher than the highest 80% level is Pe = 0.01 (one chance in 100 years).

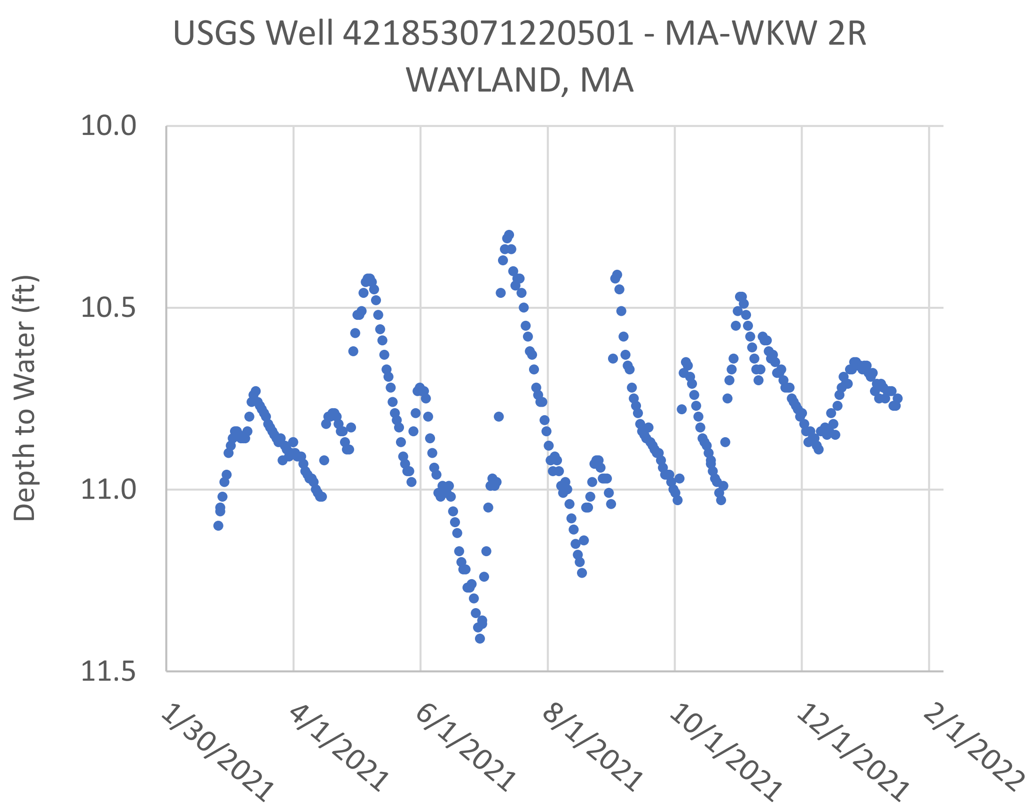

Figure 2. USGS Wayland MA well daily depth to water.

The 10-year, 24-hour rainfall depth for Lowell, MA is 4.89 inches (NOAA Atlas 14, https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). This probability is developed by identifying the largest 24-hours of precipitation each year and developing statistics around this very specific dataset (annual maxima). To develop the probability of getting that event or larger once or more times in 100 years, all days with rainfall were selected using the Lowell, MA NOAA climate data. The exceedance probability of 4.89 inches in the daily continuous record is 0.007% for the 129 years of record. For the purposes of this calculation, the probability of getting the 10-year, 24-hour storm will be 0.1.

Lastly, the high wastewater flow is not a common event, 90 consecutive days of that wastewater flow is a very rare occurrence, and without records, is challenging to associate with a probability, but a conservative value is set at 0.01 (one chance in 100).

Therefore, the probability of the Design Event {high groundwater table (Pe = 0.2) that is maintained for 90 consecutive days (Pe = 0.01), high wastewater loading for 90 consecutive days (0.01), and the 10-year, 24-hour rainfall event (Pe = 0.1)} is the simple product of all these probabilities or, 0.000002. This probability of occurrence is twice in one million years. By increasing the probability of the high wastewater flow to 0.1, that increases this probability to twice in 100,000 years. This incredibly low probability of occurrence should dispel any notion of using the design event for anything other than what it was intended: to understand groundwater mounding at and near to the infiltration systems.

MWE

Consulting Civil Engineers and Land Surveyors

MetroWest Engineering, Inc.

December 21, 2020

Mr. Joseph Berman, Chair
Weston Conservation Commission
Town Hall
PO Box 378
Weston, MA 02493

RE: 518 South Avenue Proposed 40B Housing Project
Assessment of Hydrologic Impacts of Wastewater Treatment Plant (WWTP) Sewage Discharge

Dear Mr. Berman and fellow Commission Members:

I was recently on a site walk with Patrick Garner at 518 South Avenue to inspect the stream for the presence of an "Oxbow" feature (which was not there). During our site inspection Mr. Garner inquired as to how the proposed 38,000 Gallon Per Day (GPD) sewage flows from the WWTP might be put into context in terms of the hydrology of the wetland resources located on the premises.

This letter is in response to that inquiry. Prior to providing my analysis, however, I do want to re-acquaint the Commission with my qualifications. While I have been a familiar face in front of your Commission for over 30-years, some of you may not be aware of my credentials.

First, my expertise lies within the subject area of surface water hydrology, drainage and stream mechanics. My master's degree in civil engineering is from Colorado State University (CSU), a leading institution for surface and groundwater hydrology, river morphology and atmospheric sciences. My master's program focused on river channel response to flood plain urbanization. While at CSU I created and ran movable bed physical models in the largest indoor flume in the United States. After graduating from CSU, I worked for a consulting firm providing water resources engineering throughout the southwest United States and ran computer simulation models of watersheds and rivers using the US Army Corp of Engineers HEC-1, HEC-2, HEC-HMS and HEC-RMS computer software. I believe it is fair to say that I am well-versed in the hydrologic sciences, stream mechanics, river morphology, sediment transport, and drainage systems.

I had worked for about 15-years as the sole peer review consultant to the Weston Conservation Commission. During that time period I reviewed a number of very large project with potentially significant wetland impacts, including the MWRA Norumbega covered storage tank, the re-construction of the Hultman aqueduct and the construction of a large vernal pool at the Weston Reservoir. I stopped providing this service when Donna Vanderclock became Town manager, as Ms. Vanderclock was concerned that there was an apparent conflict of interest in that role, as I also appeared before the Commission representing private clients. I have, however, continued to provide consulting services to town boards and committees (with guidance from the State ethics board). I have recently worked for the Zoning Board of Appeals as a peer review consultant for the Modera 40B project proposed at 751-761 Boston Post Road.

With that as background, I offer the following comments on the question that Mr. Garner posed to me:

1. Is 38,000 GPD sewage flow the right figure to consider?

Although I have not closely followed the proceedings for this project, my understanding is that Mr. Scott Horsley, working for project abutters, has opined that 38,000 GPD of flow from WWTP will alter the hydrology of the intermittent stream and Bordering Vegetated Wetland (BVW), as this flow is from the MWRA system and is not a flow natural to the contributing watershed. In essence his position is that this flow represents a diversion of out-of-basin flow of 38,000 GPD into the watershed, and this diversion is of sufficient magnitude to alter the hydrology of the watershed. The first question to consider is whether the 38,000 GPD figure is the appropriate flow to consider as a long-term, constant input into the watershed.

The short answer is that 38,000 GPD is not the appropriate value to use when considering long term impacts from a constant flow diversion into the watershed. Sewage flows, for the design of both septic system and WWTPs are derived from 310 CMR 15.203. Design flows are based upon **peak flows** not average daily flows. Design flows account for peak demand periods when flows spike. For a school, this might be dance recital day or graduation, while for a residence it might be for the once-a-year party. Design flows are estimated to be twice the average daily flow. In fact, when a facility use is not listed in 310 CMR 15.203, the code allows for water meter readings to be used to estimate the average daily flow from the facility or a similar facility. The design flow is then set at 200 percent of the calculated average daily flow.

In assessing the long-term impact of the sewage discharge on the groundwater table, as in a MOD-Flow groundwater mounding analysis, the proper figure to use is not the daily peak flow (which may only occur a few days a year), it is the average daily flow. Thus, in this instance, the groundwater mounding analysis of flows from the WWTP should be based on 19,000 GPD, not 38,000 GPD, as the latter figure will over-estimate the height of the mound that develops under the disposal bed.

2. Is 38,000 GPD a lot of water or a little?

The question of how much impact the introduction of an outside source of water will have on wetland resource areas is a function of the characteristics of the watershed in which the resources lie. The water that creates and supports the wetland resource areas is derived from the rainfall that falls within the limits of the watershed

The watershed characteristics and streamflow statistics for this watershed are easily derived by running the USGS StreamStats on-line program. The interactive program may be found at:

https://streamstats.usgs.gov/ss/

Running the program provides a wealth of useful data and statistics (please see attached report). Of note is the watershed size, at 0.39 square miles (SM) and the average annual precipitation, at 47-inches. These values may be used to calculate the total annual water budget for this watershed.

Using the total annual rainfall and the watershed area, the total volume of natural water that flows through the watershed, measured at the southerly terminus of the property, is 977.6 acre-feet (AF) or 4.2×10^7 cubic-feet (CF). This is water derived from rainfall.

The water introduced into the watershed on an annual basis from the WWTP, using the design flow of 38,000 GPD, is 42.5 AF, an order of magnitude less than the naturally occurring flow. If the more appropriate average daily WWTP flow of 19,000 GPD is used, the figure is halved to 21.3 AF or 2-percent.

Another way to assess the magnitude of the water being introduced into the watershed from the WWTP is in terms of an equivalent annual rainfall. In other words, if rather than being diverted into the basin from a WWTP, additional rain fell on the watershed, how much rain would that be? Assuming the 19,000 GPD average flow, the equivalent annual precipitation volume will equate to 0.08-feet or 1-inch of additional rainfall. Considering the 47-inches of average annual rainfall that falls over the watershed, this also equates to a 2-percent increase in precipitation volume.

3. Will the additional WWTP flow increase stream flows or flooding impacts?

To assess this question, I have assumed that WWTP flows discharge directly to the stream, ignoring the actual groundwater storage that occurs. This is a worst-case scenario, where all flow immediately breaks out of the ground and flows into the stream (in other words the system has completely failed). For this exercise I have also assumed that the stream flow is peaking on a day when the flows from the WWTP reach the design flow, which is 200-percent of the Average Daily Flow. While this is an extremely unlikely confluence of events, the exercise is useful in that highlights the scale of the wastewater flows compared to stream flows.

Design flow from the WWTP equates to 0.06 cubic feet per second (CFS). The impact of this additional flow on base flood flows is shown in the table below:

Storm Event (24-hour)	Base Flood Flow (CFS)	WWTP Flow (CFS)	Percent Increase
2-year	20.1	0.06	0.3%
10-year	45.5	0.06	0.1%
25-year	62.1	0.06	0.1%
100-year	91.0	0.06	0.0%

As noted above, this analysis assumes an extreme, worst case example where none of the wastewater effluent is retained within the soil matrix of the sub-surface sewage absorption system, a circumstance with almost no possibility of actually happening.

In my professional opinion the 0.06 CFS flow increase is well below the accuracy of the regression model employed to calculate the flood flows and is statistically insignificant.

4. Will the discharge from the WWTP alter the stream flow regime from intermittent to perennial?

Intermittent streams cease to flow when the water table drops below the bed of the stream during summer periods of high evapotranspiration. In order to alter the flow regime from intermittent to perennial, the discharge from the WWTP would need to be substantial enough to raise the water table during summer and early fall periods along the length of the channel where the water table has receded to a depth below the channel.

The subject stream is intermittent, based upon my direct observation and from applying various StreamStats simulations, from its origin north of South Avenue to the point where it joins a second stream, near the east end of the faculty parking lot at the Weston High School. This is a stream segment that is approximately 3500-feet long.

The groundwater mound that will develop from the sewage disposal bed is a localized impact that dissipates quickly as one moves away from the disposal bed. Impacts from this groundwater mound, if any, will be limited to a very short length of the stream channel, that is roughly parallel to the long dimension of the wastewater disposal bed. This is a length of about 200-feet or less than 6-percent of the length of the intermittent stream. To the extent that the mound has any local impact at all, it will not be of such a magnitude that the stream flow regime will change from intermittent to perennial.

5. Is this a unique situation?

Nearly every home, commercial, institutional and municipal facility in Weston is serviced by the MWRA water system and sub-surface sewage disposal systems. Every time a Weston resident or a person working in Weston opens a tap, a cross-basin diversion occurs whereby water from the Connecticut River Basin is diverted into a local watershed. The same is true for every community served by the MWRA.

While it is true that the proposed sewage disposal bed for this project is located relatively close to the intermittent stream, the watershed impacts are not dictated by the proximity to the stream but rather by the volume of water diverted from one basin to the other.

More importantly, the basin receiving the diversion is typically gaining the benefit of more water in the system to support natural habitat function, to the detriment of the Connecticut River Basin.

This situation is not even unique within the framework of recent projects that the Conservation Commission has reviewed and approved. The Modera Weston project at 751-761 Boston Post Road will discharge approximately 40,000 GPD of wastewater, also derived from the MWRA system, into a subsurface sewage disposal bed located 200-feet from a wetland that borders on Cherry Brook, a direct tributary the City of Cambridge water supply. Like the subject project, the 751-761 Boston Post Road project will divert MWRA water from the Connecticut River Basin in western Massachusetts to the Cherry Brook watershed and ultimately to the taps of residents in the City of Cambridge.

Another analogous project is the under-construction wastewater treatment plant at Pine Brook Country Club. That project is removing a direct effluent discharge line into Pine Brook in favor of a sub-surface sewage disposal bed adjacent to the brook.

These are just two examples among numerous projects in Weston that have proposed similar systems in similar environments. Other examples include systems at Meadow Brook School, The Cambridge School, The Rivers School, Weston Golf Club and the Brook School Apartments, a town-owned project.

6. Are there potential benefits that will result from the WWTP discharge?

The flow diversion into the watershed will likely have localized benefits to the system hydrology. Since the flow will be discharged into a sub-surface disposal bed, these flows will recharge ground water during periods of drought, when groundwater levels are depressed. This will help to support wetland vegetation and overall watershed habitat function during low-flow and drought periods. As noted above, the beneficial effects will be limited to the area in the immediate vicinity of the disposal bed.

7. Is the Title 5 Presumption Applicable to this sewage disposal bed?

Setback requirements for Sub-surface sewage disposal systems are stipulated in 310 CMR 15.211 (Title 5 Minimum Setback Distances). Systems that meet the minimum setback requirements are presumed to protect wetland resources, per 310 CMR 10.03 (3). While it is true that the WWTP and disposal system proposed for this project are regulated under 314 CMR 5.00, that body of regulations default to Title 5 as far as the disposal bed is concerned. Specifically, under definitions, 314 CMR 5.02 defines an On-site Subsurface Sewage Disposal System as "a system or series of systems for the treatment or disposal of sanitary sewage below the ground as defined in 310 CMR 15.002, Definitions". Accordingly, the Title 5 presumption concerning wetland protection applies if the system satisfies the minimum setback requirements. As the proposed system satisfies the minimum setback requirement of 50-feet to a BVW, the presumption is applicable.

8. Should the groundwater model for the sewage disposal bed consider the impact of porous pavement or pervious paving?

In terms of hydrologic function, porous or pervious pavement mimic a natural ground surface in that it allows rainfall to penetrate the ground surface and move downward through the soil matrix. When a surface is covered with porous pavement it behaves exactly as a surface covered with grass or even forest cover behaves. Sewage disposal beds are typically installed under grass lawns and installing a bed beneath a porous paving material is no different.

Groundwater mounding studies are intended to evaluate the impact of a surcharge of water being injected into an area that is greater than that would occur under natural conditions (in other words greater than the natural precipitation that falls over that area). In other words, the model studies the impact of a flow diversion into a finite recharge area constructed beneath the ground surface. In the case of porous or pervious pavement, the flow that passes through the pavement is the naturally occurring rainfall. This is the same rainfall that would penetrate the ground surface is the surface was grass. It is not a surcharge flow or a diverted flow.

Of all the issues I was requested to review, this one truly strikes me as absurd. This is such a non-issue that I find it hard to believe that is has been raised by someone with a background in the subject matter.

9. Should the groundwater model for the sewage disposal field and the stormwater infiltration systems be considered jointly?

The groundwater mound that develops under the sewage disposal bed does so based upon a continuous, long-term input of sewage flow into the groundwater. Over time, a surcharge develops where the local water table, over and immediately adjacent to the sewage disposal bed becomes elevated over the pre-development condition. This is a persistent, long-term condition that creates a permanent surcharge on the local water table.

The stormwater infiltration system, in contrast, responds to temporal, episodic events, due to time-specific storm events. A local surcharge on the water table, beneath and adjacent to the infiltration system, develops during the storm event and quickly dissipates after the cessation of rainfall. A long-term surcharge to the water table does not occur. As a result, infiltration systems do not produce conditions which permanently alter the watershed conditions or disrupt watershed hydrology.

The standards required by MADEP for groundwater mounding studies for infiltration systems and sewage disposal systems are very different. Mounding studies for sewage disposal systems, assess long term impacts and the height of a sustained mound that develops over time. The intent is to ensure that four feet of separation is maintained between the bottom of sewage disposal bed and the water table, after the mound reaches its maximum height. Accordingly, the groundwater study for that condition uses a continuous inflow modeled over an extended time period of 90-days.

Groundwater mounding studies for infiltration systems are not always required by MADEP; mounding analysis is only necessary when the bottom of an infiltration system is proposed within 4-feet of the naturally occurring water table. When mounding studies of infiltration systems are called for, they consider only short-duration time series, typically a 24-hour storm event. For infiltration systems, the analysis goal is to ensure not that a specific offset to groundwater is maintained but rather that the infiltration water does not "surface" or break out of the ground. Mounding sturdies for infiltration systems typically look at a 72-hour time period, contrasted with 90-days for a mounding sturdy of a sewage disposal system.

In short, because of the differing time durations groundwater models for sewage disposal systems and infiltration systems utilize, and the differing performance standards each model is targeted for, the models are incompatible with each other and produce "apples and oranges" results.

I hope that these comments are helpful as you deliberate the merits of the project. Please do not hesitate to contact me should you have any questions or if I can provide any additional information.

Sincerely yours,

Robert A. Gemma, PE, PLS
President