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November 13, 2023

Ms. Susan Chapnick, Chairperson
Town of Arlington
Conservation Commission
730 Massachusetts Avenue
Arlington, MA 02476

RE: Thorndike Place

Dear Chairperson Chapnick and Conservation Commissioners:

I was retained by the Arlington Land Trust to evaluate the hydrological impacts from a proposed housing development Thorndike Place consisting of 124 apartment units and 12 homeownership units on a tract of land owned by Arlington Land Realty, LLC (the "Developer") off of Dorothy Road and Littlejohn Street in Arlington, Massachusetts (the "Project" and "Site"). I performed an extensive review of the Notice of Intent, the project's civil engineering design plans, stormwater report, and other supporting documentation and calculations. I also reviewed the reports filed by peer review consultants retained by the Arlington Zoning Board of Appeals (the "Board") as part of the Comprehensive Permit proceedings.

Experience and Qualifications: I am a hydrologist with over thirty years of experience in evaluating water resources projects, including the interaction of groundwater, stormwater runoff and sources of water pollution. I have been retained as a consultant to federal, state, and local government agencies, non-governmental organizations, and private industry throughout the United States, Central America, the Caribbean, the Pacific Islands, Bulgaria, and China. I have served as an instructor for a nationwide series of USEPA workshops on drinking water protection and watershed management. I have also served on numerous advisory boards to the USEPA, the National Academy of Public Administration, Massachusetts Department of Environmental Protection (MADEP), Massachusetts Executive Office of Energy and Environmental Affairs, and the National Groundwater Association. I have received national (USEPA) and local awards for my work in the water resources management fields. I serve as Adjunct Faculty at Harvard University and Tufts University, where I teach graduate level courses in water resources policy, wetlands management, green infrastructure, and low impact development. These courses focus on the critical role of local governments who have the primary responsibility and authority of regulating land uses in critical water resource protection areas. I have served as an expert witness in several prior litigation matters in federal court on behalf of the U.S. Environmental Protection Agency and the U.S. Department of Justice as well as state court and administrative appeals before the MADEP.

General Comments: The Site is located in a neighborhood that is subject to flooding, constrained by shallow groundwater, and adjacent to extensive wetlands. The southern and eastern portions of the Site are largely within a regulatory floodplain. The Project's proposed stormwater management system relies on infiltration to groundwater utilizing subsurface infiltration chambers. The function of these proposed drainage/infiltration systems is dependent on a number of physical characteristics, including the volume of stormwater runoff proposed to be infiltrated, the permeability of the soils and the depth to groundwater.

The groundwater levels provided by the Applicant are inconsistent and are not compliant with the required methods to determine estimated seasonal high groundwater (ESHGW). The groundwater mounding analyses presented underestimate the impacts associated with the project. Based upon my analysis the proposed stormwater management system will not work as designed and may result in increased groundwater levels and surface flooding. My specific comments are as follows.

1. The reported groundwater levels are inconsistent with observed wetlands elevations and with each other. The site plan shows groundwater levels at ten test pits (see figure 1). These include two test pits conducted by BSC on November 25, 2020 and another eight by Whitestone on May 18 – 19, 2023[1]. Some of the reported water levels appear to represent measurements made at the date of the test pits and in other cases are an estimated seasonal high groundwater level (ESHGW).

The reported groundwater elevations do not conform with an expected and typical hydrologic gradient that generally slopes from higher elevations in upland areas (near Dorothy Road) to lower elevations (in the wetlands). Wetlands generally function as groundwater discharge areas obtaining their flow from adjacent upland areas where recharge occurs.

The site plan shows elevations of 5 and 6 feet along the wetland boundary. Groundwater levels in wetlands are generally within 12 inches of the surface during the summer growing season and are estimated at 4 – 5 feet along the wetland boundary. This would suggest that groundwater levels in the upgradient upland areas should be higher (> 4 – 5 feet). Yet several of the reported groundwater levels in upland areas are significantly lower. Two of the measurements are reported at -0.5 feet (TP-3, and TP7). In summary, these groundwater elevations are inconsistent.

According to notes on the test pit soil logs monitoring wells were installed in several test pits (TP-1, TP-6, and TP-7)[2]. However, groundwater level measurements at these wells have not been provided. Further analysis of groundwater levels is required.

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[1] A third test pit was conducted by BSC but no groundwater elevation was reported.

[2] BSC, Stormwater Report, Revised September 2023, pages 193, 200, and 202 of the PDF document

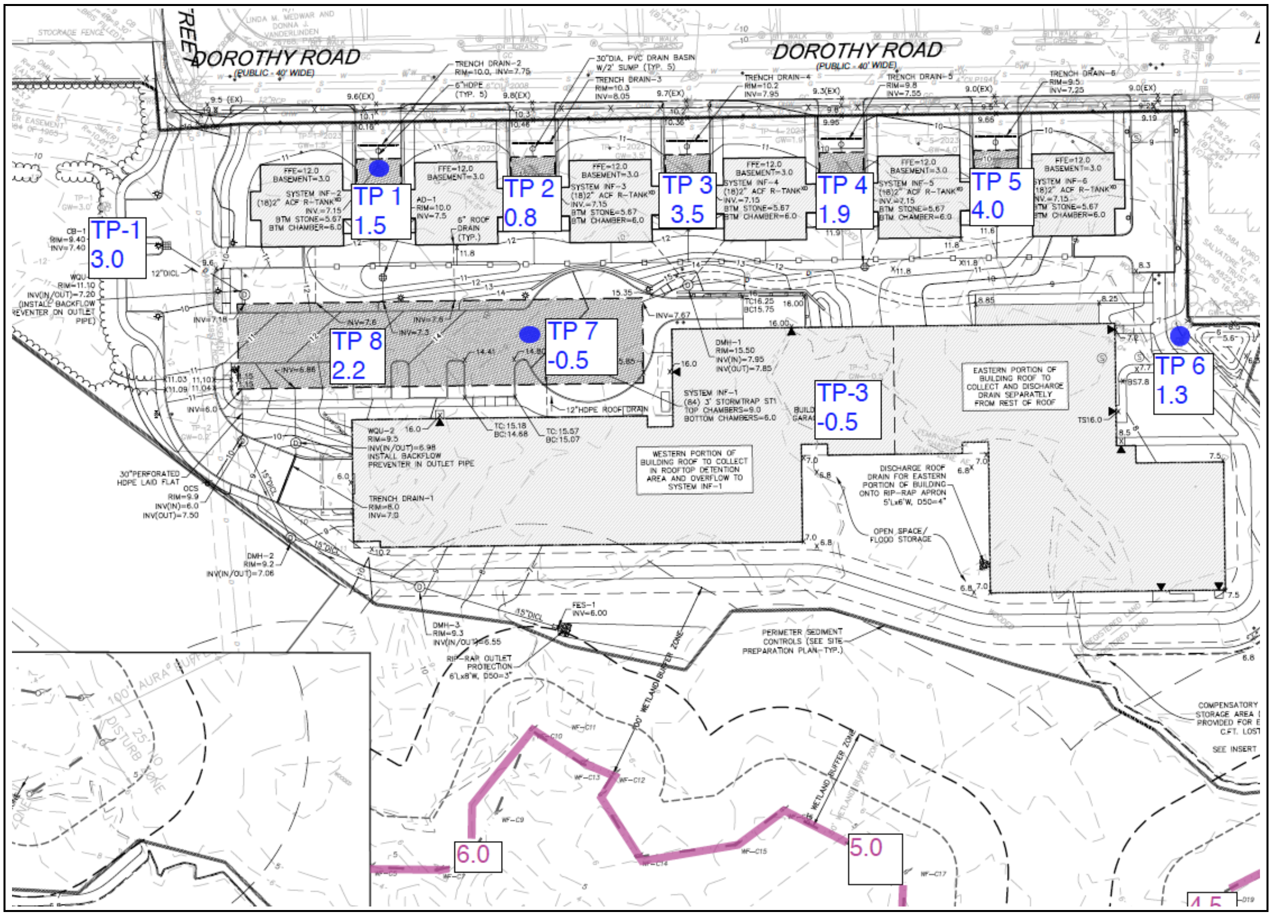

Figure 1 – Site Plan Hydrology (Groundwater Levels -Blue, Wetlands Elevations - Green)

2. Additional information for the estimated seasonal high groundwater levels (ESHGW) needs to be provided for all test pit and well locations at the proposed infiltration locations. Estimated seasonal high groundwater (ESHGW) levels are required for the design of the proposed stormwater infiltration systems. The MADEP Stormwater Standards require at least two feet of vertical separation between the bottom of the infiltration facilities and the ESHGW elevation.

The Applicant has not provided clear evidence for ESHGW levels at the proposed infiltration systems. Additionally, and as stated above, some of the ESHGW levels that have been provided by the Applicant are inconsistent with wetland elevations and each other.

The MADEP Stormwater Handbook, Volume 3 provides guidance on how to determine ESHGW elevations. It states, *"Seasonal high groundwater represents the highest groundwater elevation.*

Depth to seasonal high groundwater may be identified based on redox features in the soil (see Fletcher and Venneman listed in References). When redox features are not available, installation of temporary push point wells or piezometers should be considered. Ideally, such wells should be monitored in the spring when groundwater is highest and results compared to nearby groundwater wells monitored by the USGS to estimate whether regional groundwater is below normal, normal, or above normal (see: http://ma.water.usgs.gov)".[3]

No analysis of the nearby USGS groundwater wells is provided by the Applicant. My review of the USGS data suggests that 2 – 3 feet of elevation should be added to the reported groundwater levels. This will significantly change the required designs for the stormwater infiltration systems. The Applicant should submit additional verification of ESHGW levels including correlation with the USGS wells.

3. The groundwater mounding calculations underestimate the impacts associated with the proposed stormwater infiltration system. The Applicant proposes to infiltrate a significant volume of stormwater runoff into the ground. According to the Stormwater Report the required volume of stormwater recharge to match existing conditions is 2047 cubic feet and 10,497 cubic feet is proposed[4]. This represents more than a five-fold increase in recharge volume compared to existing site conditions.

This is a significant increase in annual groundwater recharge volume and will result in rises of the water table and groundwater mounding (see figure 2 below, illustrating the principle of mounding).

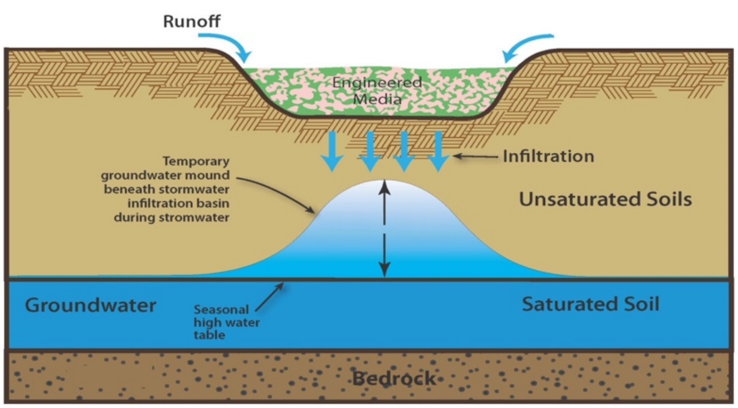

Figure 2 – Groundwater Mounding

The Applicant has provided groundwater mounding calculations using the Hantush model in the Stormwater report[5]. Despite the large scale of the impervious surfaces and stormwater infiltration system, their model results indicate a small water level increase of 0.38 feet or 4.6

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[3] MADEP, Stormwater Handbook, Volume 3: Documenting Compliance with the Massachusetts Stormwater Management Standards, page 12.

[4] BSC, Stormwater Report, Revised September 2023, page 156 of the PDF document

[5] BSC, Stormwater Report, Revised September 2023, pages 166 - 167 of the PDF document.

inches (see figure 3). However, the calculations provided in the Stormwater Report for the primary infiltration structure were limited to a duration (time of infiltration) of <u>0.046 days</u> or 1.1 hours.

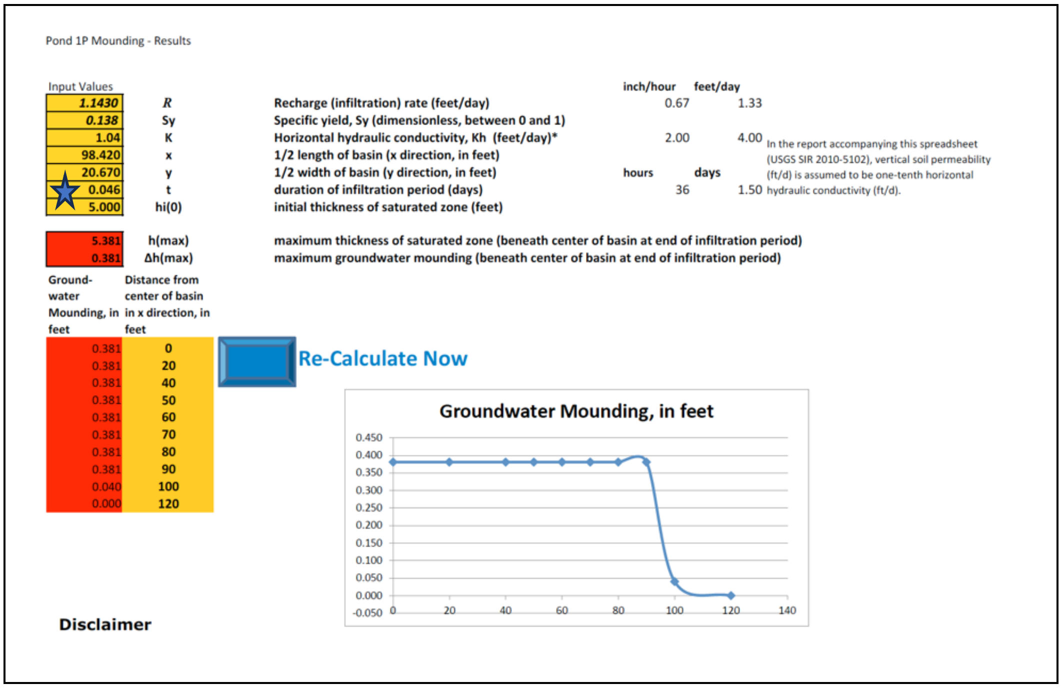

Figure 3 – Hantush Model Results (Duration 0.46 Days - BSC, Stormwater Report, Revised September 2023)

The design storms (10, 25, and 100-year) are required to be evaluated by the MADEP Stormwater Standards and are 24-hour duration events. The Applicant's model limits the analysis to 1.1 hours and is clearly inadequate to represent the full impacts of the 24-hour storm event. It also does not take into account the significant increase in annual recharge volumes noted above.

The groundwater mounding analysis is inconsistent with the HydroCAD model that was also submitted by the Applicant. The HydroCAD model indicates that the 10-year storm will infiltrate 18,710 cubic feet through the bottom area of the infiltration facility (8137 square feet) at an infiltration rate of 0.52 inches/hour (1.04 feet/day)[6]. Dividing the infiltration volume by the surface area and the infiltration rate indicates that an infiltration time (duration) of 2.23 days (53.5 hours) is required to process the 10-year storm. This longer infiltration time will result in significantly higher groundwater mounding than reported in the Applicant's Stormwater Report.

I applied the same Hantush model utilized by the Applicant with the corrected duration time of 2.23 days while maintaining the Applicant's input values for hydraulic conductivity, saturated thickness, and infiltration system dimensions. The adjusted model shows a potential

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[6] BSC, Stormwater Report, Revised September 2023, page 56 of the HydroCAD report, page 88 of the PDF document. The noted "discarded volume" is the proposed infiltration volume.

groundwater mound of 14 feet at the location of the primary infiltration system and 6.5 feet at a distance of 100 feet (see figure 4).

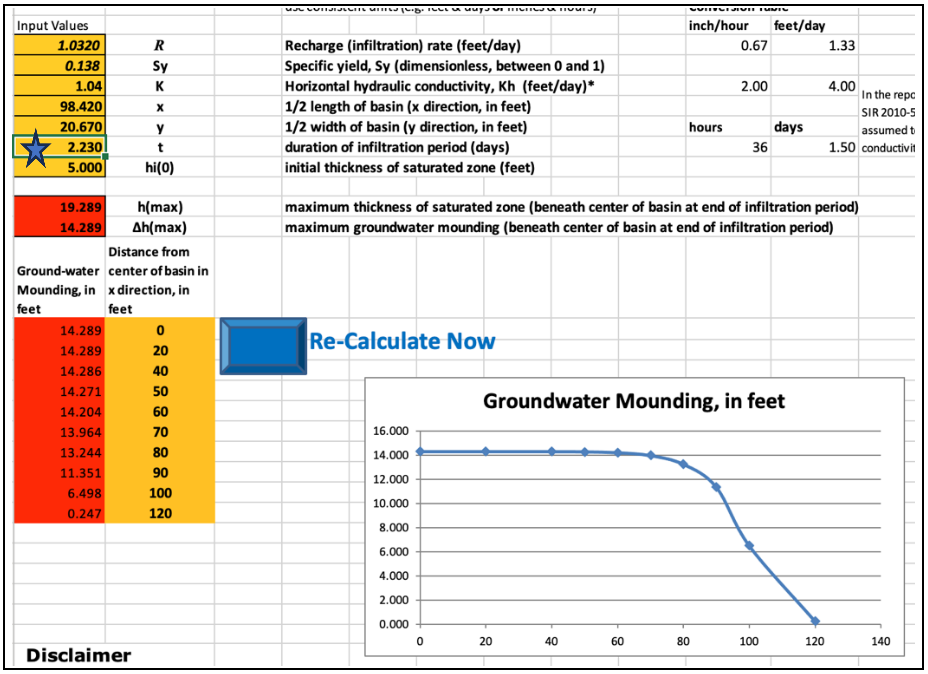


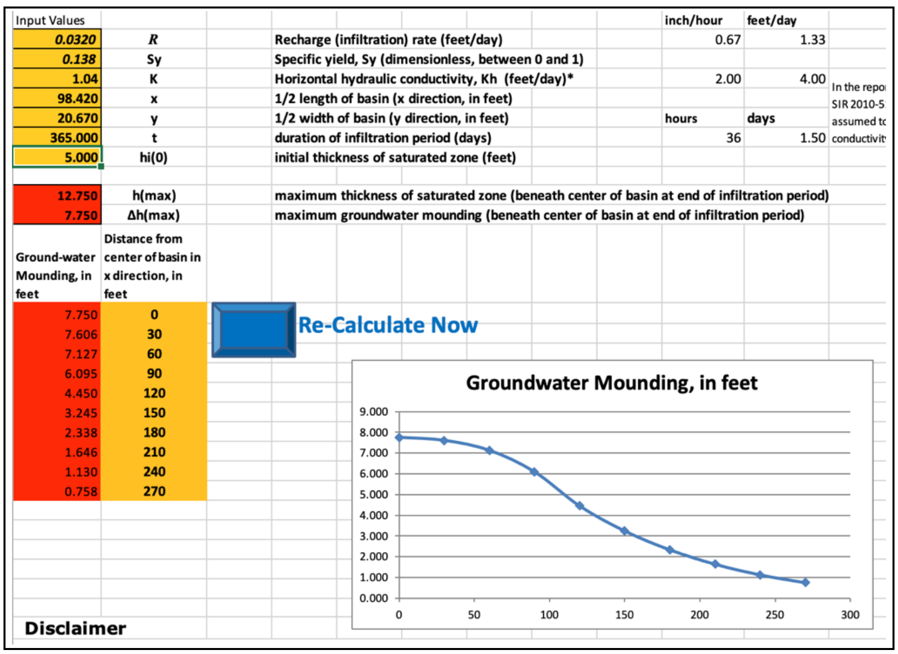
Figure 4 – Hantush Model Results (Duration 2.23 Days)

This mounding elevation exceeds the 3-foot separation that the Applicant claims exists between the bottom of the leaching facility and the estimated seasonal high groundwater (ESHGW) and indicates that the groundwater mounding will inundate the infiltration system during the storm event. The inundation of the bottom of the infiltration facility will significantly reduce the infiltration rate and will lengthen the drawdown time. The MADEP Stormwater Handbook, Volume 1 (page 7) states, *"Infiltration structures must be able to drain fully within 72 hours".* Further evaluation of drawdown times associated with the infiltration facility when it is inundated is required.

Groundwater mounding will occur both short term (associated with the larger design events) and long term (resulting from the cumulative, numerous, smaller rainfall events). The proposed project will convert existing forested areas to impervious surfaces, where runoff will be directed to infiltration facilities. This will result in a significant decrease in evapotranspiration rates and an increase in groundwater recharge rates on the property. I have conducted a preliminary analysis of the long-term groundwater mounding effects associated with the infiltration of runoff from the proposed impervious surfaces.

Under current conditions I have estimated a groundwater recharge rate of 17.5 inches/year[7]. Under post-development conditions the recharge rate associated with the impervious areas is estimated at 38 inches/year by multiplying the annual precipitation (47.5 inches/year) times a runoff coefficient for impervious surfaces of 0.8.

For the purpose of the long-term groundwater mounding analysis I applied the net change in recharge rate (17.5 to 38) of 20.5 inches/year. Applying the same values for hydraulic conductivity and saturated thickness provided by the Applicant I then simulated the long-term, steady-state groundwater mounding conditions (see figure 4). This analysis suggests that water table rises at the location of the infiltration system in excess of 7 feet (flooding the infiltration system) and approximately 2 feet at the wetland boundary. This is a significant alteration of the hydrologic regime of the bordering vegetated wetland. This level of mounding would also impact the basements of homes along Dorothy Avenue.



Input Values			inch/hour	feet/day	
0.0320	R	Recharge (infiltration) rate (feet/day)	0.67	1.33	
0.138	Sy	Specific yield, Sy (dimensionless, between 0 and 1)			
1.04	K	Horizontal hydraulic conductivity, Kh (feet/day)*	2.00	4.00	In the repo
98.420	x	1/2 length of basin (x direction, in feet)			SIR 2010-5
20.670	y	1/2 width of basin (y direction, in feet)	hours	days	assumed to
365.000	t	duration of infiltration period (days)	36	1.50	conductivit
5.000	hi(0)	initial thickness of saturated zone (feet)			
12.750	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)			
7.750	Δh(max)	maximum groundwater mounding (beneath center of basin at end of infiltration period)			

Ground-water Mounding, in feet	Distance from center of basin in x direction, in feet
7.750	0
7.606	30
7.127	60
6.095	90
4.450	120
3.245	150
2.338	180
1.646	210
1.130	240
0.758	270

Figure 5 – Hantush Model Results – Long-Term (Steady State Conditions)

Disclaimer and Recommendations: The groundwater mounding analyses that I have presented in this report are intended to be preliminary and are based upon available data from the Applicant's Stormwater Report and Site Plans. They are limited to the single, larger stormwater infiltration system identified as "P1" and do not account for other design storms or the

[7]United States Geological Survey, Simulation of Ground-Water Flow and Evaluation of Water-Management Alternatives in the Upper Charles River Basin, Eastern Massachusetts, Simulation of Ground-Water Flow and Evaluation of Water-Management Alternatives in the Upper Charles River Basin, Eastern Massachusetts
By LESLIE A. DESIMONE, DONALD A. WALTER, JOHN R. EGGLESTON, and MARK T. NIMIROSKI
Water-Resources Investigations Report 02-4234

cumulative groundwater mounding impacts associated with the five smaller townhouse infiltration systems or other facilities.

The results of these analyses suggest that the infiltration system may be inundated with a higher post-development seasonal high groundwater elevations resulting from increased annual recharge rates and may not be available to process the larger design storms (10, 25, and 100-year events).

I recommend that the Conservation Commission require a more detailed groundwater mounding analysis using the USGS MODFLOW model that can evaluate both the post-development steady state groundwater conditions and transient conditions associated with the larger design storms. The USGS MODFLOW model can also incorporate boundary conditions and a calibrated water table. The more detailed analysis should include additional groundwater level measurements from monitoring wells and ESHGW adjustments utilizing USGS index wells.

The model should evaluate both short-term (design events) and long-term (cumulative) groundwater mounding associated with year-round precipitation and recharge events that will result from the proposed project. It should also evaluate impacts at several locations including the stormwater infiltration structures, basements of dwellings (existing and proposed) and within the wetlands. It should also evaluate water level changes within floodplains and any potential losses of flood storage.

Thank you for the opportunity to provide these comments. Please contact me directly with any questions that you might have.

Sincerely,

Scott W. Horsley
Water Resources Consultant