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Planning & Development
Town of Waterford, CT

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February 7, 2023

Conservation Commission, Town of Waterford
15 Rope Ferry Road
Waterford, Connecticut 06385 - 2886

ATTN: Chairman Dimmock and Environmental Planner, Maureen Fitzgerald

RE: ***Application Review, Part 2, Impacts Assessment: App.*** # C22-15. 47-Unit Residential Subdivision, including affordable units; 141 Clark Lane. Owners: L & M Archambault; Applicant: Kingstown Properties, LLC

Carya Job No.: 23- WFD 3

Dear Commissioners:

Part 2 of the Carya Review focuses on the likely adverse impacts on the regulated resources from the proposed project. Several concerns have already been expressed orally on January 26th by Carya and by local residents. Part 1 of the report, dated January 26, 2023, focused on existing conditions, in the Fenger Book headwaters wetland system, and included figures at several scales. Part 1, with its attachments, was resubmitted electronically on January 29, 2023. Our concerns are further explained in this report, and their relevance to your commission is clarified. The list of materials we have reviewed is at the start of Part 1, the Existing Conditions report; several storm water resources in that list are attached to Part 2 of our review (Impacts Assessment), dated February 7, in Attachment B. They were referenced in the oral presentation on January 26th.

Additional field observations of on-site conditions within the regulated resources took place on February 2nd, 2023, supplementing the perimeter inspection on January 25, 2023. I was permitted to go onto the property for several hours, accompanied by Project Surveyor/Engineer David Held and Mark Branse, the attorney for the applicant.

Multifaceted and interrelated environmental problems are associated with this application. Based on our review, the major expected adverse impacts to wetland/watercourse resources, and also to human health and safety, can be linked 1) to the redistribution of runoff and

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groundwater into the excessively large stormwater management system at the south end of the site, and 2) to the extensive anticipated impacts to mature trees as a result of excessive density/impervious surface. We suggest changes, consistent with LID (Low Impact Design) principles, that would substantially reduce these impacts.

Significantly reducing the volume treated by the two basins will allow multiple improvements to the bioretention basin and the wet-bottom detention basin. The 13.736-acre drainage area for the retention basin includes 5.29 acres of impervious surface, partly along a 915-foot section of Clark Lane, and partly within the proposed development envelope. Substantial reduction in the volume of stormwater entering the southern basins (by over 30%) could be achieved without adversely impacting riparian wetlands or water quality in Fenger Brook.

1.0 <u>Clark Lane runoff through buffer to Fenger Brook.</u>

- ❖ First, we recommend continuing to allow the existing upland buffer to filter and treat the 15" discharge pipe between House #'s 113 and #115. This would require extending the pipe to the base of the new fill bank and installing a simple level spreader. Although the buffer is narrow (just over 50 feet) along much of the western perimeter of this property, the gentle northwesterly flow path, below the Clark Lane discharge pipe is ~300-feet long, from the fill slope between Units #14 and #15 to the wetland boundary. The flow path proceeds northeasterly, perpendicular to contour lines. The Clark Lane stormwater discharge spreads out and infiltrates into the deep Watchaug soils largely before reaching the downgradient vegetated riparian buffers. It is renovated naturally by sorption to soil particles, degradation and transformation by soil microbes, and uptake by vegetation. The moderate infiltration rate of the Watchaug soil series is preferred for stormwater filtration by soil.

- ❖ Multiflora rose thicket is the dominant cover type along the flow path. It is a tough species, not sensitive to disturbance, although it is valuable nesting habitat for songbirds and mice and provides good wildlife cover. Atty Branse stated incorrectly on January 26th that the post-agricultural habitat in the area to be developed offers poor quality wildlife habitat. In fact, the woodland cover type, with scattered tall trees, and dense shrub cover and herbs, is a declining and valuable habitat type. It is a valuable complement to red maple-dominated wooded swamp; it provides insect food and nest sites for songbirds and rabbit and rodent hunting habitat for owls, hawks, foxes, and bobcats, that reside mostly in the adjacent wetlands.

- ❖ We inspected the downgradient resources on 2-3-23, and found no evidence of impairment from Clark Lane runoff. Fenger Brook was inspected several hundred feet downgradient of the flow path to the brook from the discharge pipe. Low specific conductivity (151.3 us/cm) and salinity (0.1 ppt), and excellent instream habitat quality with no evidence of erosion, embeddedness, nutrient enrichment, or sedimentation, show that Clark Lane runoff is currently not degrading the stream. Adjacent riparian forested wetlands are also non-impaired on the stream banks, covered with moss and low herbs.

❖ Currently, just below the outfall, a ~ 80 foot-long, 2-foot deep, scoured channel traverses the proposed development footprint, before flow begins to spread out within a mature tree cluster. Those trees would be eliminated by the proposed filling. Site-specific planning to choose an appropriate spreading structure will be needed to prevent formation of a new scoured channel.

❖ A key question: How much will removing the Clark Lane drainage reduce the volume entering the detention and bioretention basins for the design storms? Without additional LED measures, will it address the anticipated adverse impacts?

Note that the applicant has just (afternoon of 2-6-23) submitted a brief alternative to the town, for this application: to allow the Clark Lane Drainage to continue, as currently, to flow through the existing upland buffer to Fenger Brook, by extending the discharge pipe to the eastern limits of the subdivision, with no mention of a spreader of any sort.

2.0 *Hydrologic Impacts from Reduced Infiltration*

❖ The applicant has provided the total impervious cover (IC) draining into the retention basin (5.29 acres), but not the IC from the Clark Road drainage versus that from the development. Based on Sheet 3 of the plans, we measured 1.75 acres (43%) of IC within the narrow, northern 4-acre portion of the development; no infiltration will take place where IC is present. Some of the rainfall infiltrating into the remaining pervious soil in this area, will be diverted into the gravel utility trenches and the gravel beds beneath the pavement, necessary to prevent road damage from frost heave. The trenches and gravel beds will also intercept much of the east-flowing groundwater from precipitation onto the residential properties along Clark Lane (mostly pervious). We estimate that over fifty percent of the rainfall falling in the development area will be diverted, as well as additional groundwater from the west. It will not reach the groundwater that flows westerly towards the wetlands, which are only about fifty feet away along the northern section; the buffer is only 38 feet wide adjacent to Unit #6.

- With climate change droughts are becoming more severe and frequent; loss of such a large fraction of infiltration will exacerbate the situation. When the water supply to a wetland is significantly diminished, wetland soil becomes drier, organic soil is mineralized and diminishes, and pools dry up earlier. These are all clear-cut physical impacts. Hydrophytic plant species are replaced by more upland species, and there are losses of aquatic fauna needing flooded areas to breed, including spring peepers, toads, and gray tree frogs, as well as vernal pool amphibians. Often few invertebrates remain other than mosquitos, which need only five days and very shallow water to breed, and may become abundant in the absence of predators. Production export and nutrient cycling functions are diminished, as are wildlife and aquatic habitat functions.

- Infiltrating roof runoff from the proposed manufactured homes in the northern and central portions of the project and eliminating units would provide additional reduction in the runoff volume to be handled by the two southern basins. Lowering home density and replacing their footprints with pervious green spaces would achieve a similar reduction in stormwater runoff volume, and increase in infiltrated volume, for each home eliminated. We note that the applicant has not provided groundwater recharge calculations. Each roof is 1283 square feet in area. Infiltrating the runoff from fifteen roofs would increase area available for infiltration by about 19,250 square feet (0.44 acres). Taking out 15 homes would eliminate about 25,660 square feet (0.59 acres) of impervious surface, including the shared parking areas.

3.0 Indirect wetlands impacts from tree mortality and dieback

These suggested changes to reduce IC would augment groundwater flow to the wetlands. Instead of being diverted to the southern basins, precipitation could continue to maintain existing hydrology and tree health to the west of the development in the upland review area. Drought-stressed trees are more vulnerable to infection by fungi, and insect attack and tree tips are more likely if root systems are weak. Even non-pathogenic fungal species can cause mortality in combination with drought stress (or stress due to excess water). How would adverse impacts to these trees also be adverse impacts to the wetland?

- Wetland trees and trees to the south or west of a wetland help to maintain its moist, cool microclimate, a physical characteristic needed especially by amphibians and by the more northern-affinity wetland species.

- Foliage volume is reduced by drought stress and disease, such that transpiration and uptake of nutrients and dissolved metals would diminish. Note that attenuation of nutrients and toxicants is a function that is active both in wetlands and in their upland review areas, a major reason that Upland Review Area's (URA) are protected.

❖ Likewise, healthy trees in the upland review area provide complementary and supplemental habitat and food for wetland-dependent wildlife.

❖ They shade streams and pools and are the source of the leaf litter at the base of the aquatic food chain.

❖ Downgradient of the northern half of the proposed development, substantial reduction of the volume of groundwater feeding the forested wetland and its URA will have an adverse impact on wildlife support and aquatic habitat functions, as well as on human use values, for citizens recreating in Bates Forest Park and adjoining forest.

4.0 Potential Rain Garden (s)

Another potential way to help prevent adverse hydrologic impacts and effectively treat the metals and toxic hydrocarbons in a portion of the pavement runoff would be to construct one or more small biofiltration basin(s) (aka raingardens), each taking the place of one house. A rain garden could replace Unit #6, where the fill slope is only 38 feet from the wetland boundary. Filtered groundwater, and overflow during major storms would discharge easterly into the forested upland buffer, where upland buffer vegetation would extract the remaining nutrients, since biofiltration BMP's do not remove more than 50% of the nutrients in stormwater. No underdrain would be necessary. Soils are suited to Low Impact Density (LID). The raingarden would also serve as a green space, reducing community density and improving quality of life.

Note that a long term study by the UNH Stormwater Center is comparing raingardens with different vegetation types; per the 2012 biennial report, contrary to expectation, meadow type vegetation, with grass and forbs fully retained its initial infiltration rate; infiltration declined with all other vegetation types. Apparently this is due to macropores formed by dying roots. Grass thatch did not reduce infiltration as feared; the CT manual erroneously recommends avoiding grass cover for that reason. Mulch does not need to be regularly replenished, and maintenance is limited to mowing a few times a season. The meadow raingarden should include patches of preferred flowering plants for pollinators and patches of some of the more graceful and attractive, heavy-seeding grass and sedge species.

5.0 Bioretention Basin

❖ . The bioretention basin is very large, about 0.35 acres in area with a 24" ponding capacity.

- The design of the large southern bioretention basin can be brought into conformance with University of New Hampshire guidance, with a forebay, an adequately thick flayer of filter media (24" to 30", not 18"), and dense, healthy vegetative cover.
- There will be less clogging over time by the fine particulate fraction of Total Suspended Solids (TSS), which is unavoidably poorly removed by all kinds of hydrodynamic separators, including Stormceptor, as explained at the meeting on January 26th by David Held, the Project Engineer.
- Dewatering by the proposed 6" diameter underdrain can be also reduced, with a smaller size perforated pipe, such that the groundwater table in the nearby wetlands to the west is not significantly lowered.
- Reducing amplitude and duration of flooding will allow much better development of vegetation.
- Perhaps the compost component of the media mix (usually 10%) was omitted to encourage faster drainage of high water volumes (ponding up to 24" deep)? Compost is important for healthy, vigorous vegetation growth and to support microbe populations.

Note that the applicant has already modified the bioretention design and added "submerged gravel wetland" component to the system in response to oral comments and the referenced UNH guidance. We are unable to review these changes if this report is to be submitted a few days before the next meeting.

6.0 Retention Basin

- The application proposes redistribution of most of the property's water to this one location. Rain falling on the development rectangle had previously soaked into the gently sloping ground and then proceeded as groundwater towards the Fenger Brook and its associated wetlands. The discharge from the large detention basin will reach 28.85 cfs in larger storms per the applicant's drainage report. Per this report the basin will hold 127,579 cubic feet during a 100 year storm. The interior of the large stormwater basin is 250 feet X ~130 feet, 0.97 acres. Maximum outflow is 28.85 cfs. We were told on January 26 that the basin will drain within one day, and the ten inch pipe set five feet below the seasonal water table is expected to flow nearly continuously. dewatering the area, lowering the water table to the west and the south of the basin. This will stress trees whose root systems are adjusted to existing hydrology, especially during droughts, which have become more frequent due to climate change.

- ❖ Tree mortality on a large scale will result from the large and continuous water inputs to the level red maple forest just past the level spreader. In this portion of the forested wetland, over an acre in area, the soil is already saturated to the surface and micro-topography is limited.

- ❖ With constant seepage as well as constant inflow from the underdrain of the detention basin, the current basin design is poorly suited to establishment of wetland vegetation. Seeds and poorly rooted seedlings will wash off the lower slopes, and seedling establishment is often poor on saturated soil.

- ❖ Most woody wetland plants do need aerated soil for their roots, and grow on hummocks and mounds. The plans do not include any woody plantings for the large detention basin. Nor does the plan does not incorporate micro-topography, micro-pools, or large woody debris to foster establishment of a diverse wetland community that would include sufficient mosquito predators. Atty. Branse emphasized that a wetland was being created. However, a stormwater wetland of this size without a woody component in the vegetation cannot approach the level of function of a natural wetland. Inland emergent wetlands are bordered by trees or shrub thickets.

- ❖ Mosquitos need minimal water depth to breed, and only five days to complete their life cycle. This basin, like any flat graded area will have local elevation differences where water collects. Even deer hoof prints would make depressions large enough for mosquito reproduction. Fully draining stormwater ponds are known to have more issues with mosquitos breeding in shallow residual puddles than constructed stormwater wetlands. They have enough plant and hydrologic diversity to support assorted mosquito predators. These predators include invertebrates like predaceous midges and dragonflies and amphibians like bullfrogs. The anticipated increase in mosquito breeding is a serious matter because of the immediately adjacent middle school. Mosquitos also feed on naked nestling songbirds, including wetland-associated species.

- ❖ Steep saturated lower basin slopes (2.3:1) will also be prone to erosion during intense rain events. This will be *an adverse impact on water quality discharged into the wetland*, undoing prior successful nutrient removal, due to the high phosphorus content of eroded sediment. Erosion Control Matting is usually required for slopes steeper than 3:1.

- ❖ The steep, slopes, up to 10 feet high, will also be slippery and dangerous, for children and for maintenance personnel collecting litter and doing other maintenance.

- If volume entering the basin is significantly reduced, the basin can be less deep, and the diameter of the discharge pipe can be reduced. The duration and volume of between-storm flows will be lower, as will the peak discharges during major storms. Likewise volume reduction will improve vegetative cover in the large detention basin, and shrubs can also be planted. This will improve vegetative uptake of nutrients and dissolved pollutants, less well filtered by the bioretention basin than the metals and hydrocarbons. Fine sediment will also be better filtered. No amendments to the excavated subsoil are proposed to foster plant growth. Organic matter also fosters N-nitrate transformation to nitrogen gas by microbes through denitrification. Organic matter will build up slowly under vegetation over time, but a compost amendment to the basin bottom during basin construction is suggested.

7.0 Threat of scour and channel formation along flow path to Fenger Brook

- Very importantly, a significant reduction in the proposed flow volumes and velocities from the retention basin will reduce the likelihood that discharge flows will form channels and ditches downgradient of the level spreader, resulting in scour, erosion, and additional nutrient loading en route to Fenger Brook, and also within the Brook. The Channel Protection Criteria in the CT Stormwater Manual have not been met. The flow path from the detention basin to Fenger Brook was inspected on February 3, 2023, and the contour are also informative. (See handout). Much of the flow path has a gentle slope but there is a steeper section about 200 feet upgradient of the brook, where flow concentration is likely to occur, if flows are not largely infiltrated before that point. Flow will enter a small feeder tributary before reaching the main brook.

- As noted above, a tree stand is at risk in an already very wet and level portion of the forested wetlands, about an acre in size, beginning just downgradient of the large level spreader, east of the stone wall. The roots of trees, red maples included, need sufficient oxygen. In an old growth forest with irregular micro-topography, woody plants are usually rooted on the better aerated hummocks and mounds. This level forest was farmed in the past, likely over 100 years ago.

- Channel erosion would occur during a large storm event, that had saturated the soil in the somewhat poorly drained wetlands, as well as in the very wet swamp forest at the start of the flow path. A deeper, narrow, eroded channel provides less contact with the substrate than sheet flow and is less effective at polishing the residual pollutants that leave the basins. The commissioners should remember that pollutant concentrations, including metals and toxic polycyclic hydrocarbons, are high in runoff from busy streets in dense neighborhoods like the proposed development. See the table of pollutant concentrations by land use in the excerpt from the NYS Stormwater

Management Manual, one of the stormwater resources entered into the record. Even with acceptable removal percentages, retention basin discharge should be "polished" by passing diffusely through a wetland buffer, not short-circuiting in an eroded channel.

- Reconcentration in a channel is a highly likely significant adverse impact with the currently proposed excessive discharge volume. Even a very broad stream buffer, such as this one, is vulnerable to scour from large flows, where the water table is already near or at the surface or when multiple recent rain events have reduced infiltration capacity of the upper soil horizon. Other projects with which I have been involved have stipulated regular repairs of incipient channels downgradient of level spreaders, a long term, and expensive maintenance task.

- Substantially reduced discharge volumes at this location (e.g. by 40% or more) during the higher frequency storms are much more likely to be well-accommodated, without channel formation and accompanying erosion. Although the wetland boundary will be just ten feet downgradient of the level spreader, the distance to Fenger Brook is almost 500 feet. Large portions of the buffer, past the saturated swamp, are drier spectrum forested wetlands with considerable capacity for infiltration and pollutant filtration and nutrient uptake. By significantly reducing the volume of discharge from the large detention basin, over an acre of tree "drowning" will be averted or at least much reduced.

8.0 Indirect Tree-related Adverse Impacts

- Impacts to trees will occur both within wetlands and upgradient of wetlands; during project construction and post construction. Manufactured homes will be placed on both sides of a central road in a long narrow rectangle (1300 feet by 187 feet). The proposal calls for flattening the currently gently sloping land, by cutting up to six feet along the west side of the proposed development and by filling up to eight feet along the east side, with the central road at grade. Significant soil disturbance up to the property line is allowed because the normally required setbacks to the property lines are waived for this affordable housing development. Conventional homes can be built on a gentle slope, but a manufactured home requires a level, concrete platform. Cut and fill quantities have not been provided. This will eliminate at least 390 trees on the north side of the project, conservatively assuming about fifteen trees in each 50-foot x 187-foot section. See the bullets in Section 3.0 for a list of wetland-related ecosystem services provided by trees.

- ❖ Soil will be compacted during construction, becoming less pervious. As discussed above, runoff will be directed from impervious surfaces into the drainage system causing drought stress, and some groundwater will also be diverted along the gravel roadbed and gravel utility trenches. Less groundwater will flow easterly. Many root systems of trees still standing will be truncated by cuts or partially buried by fill and deprived of oxygen. This will include trees at the base of the fill slope, in the upland review area, and trees at the rear of neighbor's properties, whose root systems extend onto the subject property. Within a few years, drought stress or damage to root systems stress is typically followed by disease, such as pathogenic fungal infections or bark beetle attacks, which will kill additional trees. We noted that heavy bittersweet vines are also stressing trees in the upland review area, mostly on town land. The applicant has not indicated any intention to cut and treat the bittersweet vines with triclopyr , using the very safe, highly effective, and efficient "cut-and-paint" technique.

- ❖ Trees in the proposed development rectangle are concentrated along its eastern and western perimeter where they screen the wetland and forest URA to the east from outdoor lighting nearer to Clark Lane. The tree screen reducing the broad array of adverse ecological impacts from artificial night-time illumination, of which large-scale mortality of night flying moths and beetles is most significant. Travis and Longcore (2000) prepared a thorough literature review on this topic. Many insect species unfortunately fly hundreds of feet from wetlands to a distant outdoor light source, "sucked" away from their natural habitat even if just a speck of light is visible. Foraging by nocturnal animals is inhibited by elevated light levels, an instinct to avoid predation on moonlit nights. The proposed light posts are low enough to be screened by building from many angles, but loss of the tree screen to the west will increase adverse light impacts within the URA.

- ❖ Indirect adverse impacts on wetland functions will also ensue from the loss of so many mature tall trees, including oaks, cottonwoods, tulip trees, and red maples: a substantial loss of insect gleaning habitat, nest sites, and perches for species with home ranges that encompass several hundred feet of adjacent upland habitat. The 2020 report by the Forest Subgroup of the GC3 (Governor's Council on Climate Change is a comprehensive treatment of trees' benefits to the environment and human society. See https://portal.ct.gov/DEEP/Climate-Change/GC3/GC3-Working-group-reports.

9.0 *Nutrient Releases to Groundwater*

- ❖ Quality of groundwater flowing into the adjacent wetland will decline for two reasons: loss of the felled trees' nutrient and metals uptake function, and substantial nutrient inputs to groundwater as the root systems of the felled trees decompose, especially those felled on the west side of the development. In particular, concentrations of dissolved phosphorus (normally very low in forested streams) have been shown to spike after substantial logging has taken place within the watershed of a forest stream (Binkley 2004). This finding is based on a very large data set published by USGS. Most invasive plants have been observed to grow and spread more rapidly in soil enriched by decomposing roots.

- In the southwestern portion of the site, substantial nutrient discharge into the north-west-flowing groundwater that feeds Fenger Brook will follow tree mortality in the wetland downgradient of the large level spreader. As explained above, tree mortality is expected there due to the much wetter soil conditions, as a result of the high volume of discharge from the detention basin.

10.0 <u>Ecojustice and Stormwater Maintenance Issues</u>

- Multiple issues related to tree losses will harm the existing modest Clark Lane neighborhood, including declining home values and high cost of tree removal. Stressed trees growing near the cut or fill zones will be safety hazards. Tree losses will mean less shade and evaporative cooling, and diminished filtration of air pollution and noise from the busy road. These impacts will apply to residents of the new neighborhood as well as to the Clark Lane neighbors.

- These ecojustice issues related to tree loss join others pointed out in oral testimony on January 26, 2023: the safety threats from steep fill banks just behind homes and from steep stormwater basin banks, especially just after large storms when water will be deep enough for drowning; and a project layout inviting littering and dumping. These would all seem initially to be non-wetlands issues, but in fact there will be relevant long term adverse effects. Neglect of stormwater facility maintenance will ensue if what could have been an attractive well-kept community becomes a depressed, low-rent neighborhood. It is reasonably likely that the landlord will cut corners on stormwater facility maintenance or sell the project to a new owner who does not understand their rationales.

CONCLUSION

It is our professional opinion that the impacts to regulated resources explained in this report are sufficiently serious, that the commission will not be able to permit this application. We suggest that the applicant prepare an alternative design with less impervious surface and substantially more infiltration and less volume entering the southern stormwater management system. Our goal is to increase infiltration on the project site. Reducing housing density will accomplish this and this is recommended. We want to minimize changes to the existing hydrology. These are all established LID goals.

Thank you for the opportunity to provide input.

Respectfully submitted,

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Registered Soil Scientist

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Appendix 1: Critique/Discussion of the Bioretention Basin Design

A. *A correctly sized forebay* can be added. It will settle out some of the fine sediment not removed by the Stormceptor (per the size class distribution in the specifications information included in the applicant's drainage report, corroborated verbally by the engineer Mr. Held, on 1-26-23. Per the NHS, fine sediment deposition is the primary reason that infiltration rates often decline over time in bio-infiltration basins.

B. *A sufficiently thick media layer (24" to 48")* is recommended by the 2009 UNH SWC, and also by the Virginia DEQ. A thick filter can be used instead of the proposed 18", which is not thick enough to achieve the removal rates expected for this BMP, about 44% for nitrogen See Biofilter row in UNH pollutant Removal Efficiency Table.in Attachment B. None of the four variants undergoing long-term testing have a filter layer as thin as 18". The need to drain the basin quickly is likely the reason that the plan calls for the thinner layer, as drainage is faster through a thinner filter, and the current plan calls for draining a very large volume, ponding up to 24" deep.

C. One aspect of the proposed media mix does not conform to biofilter media specs. Although proportions vary a good deal recommended media mixes all include: wood or bark chip mulch, sand, soil, and ~ 10% compost. The applicant's mix has *no compost,* which supports plant growth better than decomposed wood or bark chips. Compost could slightly slow down infiltration, but fostering vegetation is more important because plant roots and the macropores created by rootlet death each year, are highly beneficial for sustainable infiltration.

D. If volume to be treated is significantly reduced, meadow vegetation in the bioretention basin will not be compromised as it would be by the proposed plan. Ponding depth will be up to 24" deep (per the detail on Sheet 17), with a moderate rate of drainage through the media, resulting in conditions more suited to marsh vegetation. Bioretention basins function best when set several feet above the water table, with relatively fast-draining underlying soils. Use of underdrains is an acceptable approach, but the proposed plan has excessive water inputs.

E. One other question is whether the device to be used to separate the first flush from cleaner runoff from rainfall in the later portions of rain events may divert some of the first flush runoff from very high intensity storms because water depth will may be greater than the height of the weir. This would cause some of the first flush runoff to bypass the bioretention basin. With a smaller total runoff volume this issue would be less likely to be a problem. Filter media in bioretention basins are certainly more efficient at removing toxic metals and hydrocarbons in the first flush of pavement runoff, than the detention basin.

F. Finally, the bioretention basin would not need to be set so deep, and the underdrain could be smaller with less flow. This would reduce the dewatering hydrologic impact on the adjacent wetlands and upland review area, and the ongoing flow through the detention basin and level spreader.