EX 83

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January 19, 2011

Town of Old Saybrook
Planning Commission and Staff
302 Main Street
Old Saybrook, Connecticut 06475-1741

RE: The Preserve
Proposed Preliminary Open Space Subdivision Plan Modification

Dear Commissioners and Staff:

At the request of the Connecticut Fund for the Environment, Rema Ecological Services, LLC (REMA), we have continued our review of the materials that have been submitted into the record by the applicant, including items submitted at or since the January 5th, 2011 public hearing.

In this document, we present both additional specific testimony, in the form of a closer look at some of our major points made in our January 5th, 2011 report, and, by taking a step back, so to speak, we look at the "bigger" picture, in a more landscape-level approach. The first set of analyses gives additional detail on some specific impacts to natural resources at the three "pods" (i.e., Pianta Parcel/Bokum Road, Ingham Hill Road, and West PRD). The second, looks at each of the "pod" in its natural setting and in relation to adjacent and contiguous land, particularly and owned by River Sound Development, LLC.

1.0 PLANNING CONSIDERATIONS

1.1 Lack of Site-Specific Inventory of Natural Features and Resources

We have carefully read Section 56 of the Old Saybrook Zoning Regulations regarding Open Space Subdivisions. We are quite impressed with the clarity and scope of these regulations,

and the fact that they recognize that there is a great variety of significant and natural features that could be worthy of conservation and protection.

Unfortunately, the applicant has not provided all of the necessary information to allow for a clear understanding of the significant resources exist on the three pods. Yes, we do know where certain features area, such as steep slopes, wetlands, watercourses, and the like, but the applicant should have produced ***a separate document*** outlining, detailing, and discussing the natural features on these sites, based on a comprehensive inventory.

We understand that a significant volume of information, based on natural resource inventories, was produced for the original Special Exception granted by this Commission. However, even back then, with the exception of the vernal pool and wetland inventory, little site-specific information was given. However, in fairness to the applicant, the proposals have drastically changed for two of the pods, the Bokum Road and Ingham Hill Road parcels. For the former, no lots were proposed, just the entrance road to the overall development, and no development was proposed for the latter, except some modest road improvements.

Moreover, the data, if the applicant would chose to introduce them into the record, are over 5 years old, with much of the information over 7 years old. In ecological and natural resource inventory it is well known that data can change in just a few years. For example, much discussion has taken place regarding the vernal pools at the Pianta parcel, especially Vernal Pool #37, which according to Mr. Michael Klein, the applicant's wetlands and ecological consultant, is a low productivity pool. That may very well be the case, but he bases this opinion only on one Spring season inventory (Klemens 2005). The parcel contains three other vernal pools in close proximity to each other (within the 750' vernal pool terrestrial habitat envelope), which means that they are ecologically linked and rely on one another for long-term survival (i.e. meta-population dynamics). It is our opinion that the vernal pools should have been inventoried again in the Spring of 2010, before application was made for the modification.

Therefore, in our opinion, the applicant should have produced specific natural resource data for each of the three pods, based on recent (i.e. 2010) inventories, which would have also verified if there have been any substantial and material changes to the conditions of these parcels in the last 5-7 years.

1.2 Principles of Site Planning not Effectively Used

Once all natural features and resources are identified, inventoried and analyzed, a concern that was discussed in the previous section, the planning process should have continued, being sensitive to the most significant features to the extent possible.

The CT DEP has produced to seminal documents, extensively used in Connecticut, even written into many municipal regulations as standard references, which give excellent guidance in planning a development with the least possible impact to natural resources. These are the:

1. Connecticut Guidelines for Soil Erosion and Sediment Control (2002); and the
2. Connecticut Stormwater Quality Manual (2004).

In the 2002 Manual, *Part II – Selection & Planning Process*, outlines principles for site planning. Among these they list: (1) utilize the existing topography, (2) align roads on the contour wherever possible and use them to divert surface water, thereby reducing slope lengths, (3) concentrate development on the flattest area of the site to avoid excessive slope cuts or fills where possible, and (4) avoid steep slopes and soils with severe limitations for the indented uses.

The 2004 Manual, *Section 4.2 Planning and Design Concepts*, introduces and discusses several concepts: (1) Designing the Development to Fit the Terrain, (2) Limiting Land Disturbance Activities, (3) Reducing or Disconnecting Impervious Areas, (4) Preserving and Utilizing Natural Drainage Systems, (5) Providing Setbacks and Vegetated Buffers, (6) Minimizing the Creation of Steep Slopes, and (7) Maintaining Pre-Development Vegetation.

Taking such principles into account during the planning process, particularly for an Open Space Subdivision, would seem paramount to protecting and preserving important natural features on site, such as scenic bedrock dominated knolls and boulder trains with potentially high ecological significance.

For example, these principles have not been heeded at the Ingham Hill Road parcel, for siting of Lots 12 and 13, with massive cuts and fills for the short roadway and cul-de-sac, and in the siting of Lots 7 and 8, where the houses are shown on slopes steeper than 20 percent and where little land exists which have a slope less than 18%. This type of

planning is inviting adverse impacts to natural resources, particularly in the case of Lots 7 and 8, with headwater seepage wetlands immediately downgradient (Wetland 4).

Another example should be noted at the Bokum Road pod, that we believe does not take into account these basic principles. The most egregious violation of the basic planning principles is that of the access roadway, which have been designed to also provide potential future access to the remainder of River Sound holdings to the west. In the originally approved Special Exception granted by the Commission for this area, only an access road was shown. At that time this roadway followed the contours more closely, and was generally aligned with an existing woods trail in the area of now proposed Lots 3 and 4. The applicant in an effort to gain these two lots has shifted the alignment southwesterly, necessitating massive earth removal with cuts in the order of 20 to 30 feet. In doing so, some of the most scenic, and potentially ecologically diverse, sections of the site are being eliminated.

As ***a feasible and prudent alternative*** that would reduce or eliminated the reasonable likelihood of adverse impacts to natural resources, the applicant should re-align the access roadway at the Bokum Road pod and eliminate Lots 3 and 4. This will also reduce inevitable impacts to Vernal Pool #37 by the roadway, which impinges within the critical 100 foot wide vernal pool envelope (Klemens 2002)[1] and also adversely affects its long-term hydrology by diverting away a significant portion of its watershed.

1.3 Stormwater Management

As part of the Open Space Subdivision Plan the applicant should have selected and shown appropriate areas for stormwater management (i.e. water quality and water quantity best management practices). By not taking this important aspect of residential development into consideration in the Planning Phase, the Commission, and the public, would not know if sub-optimal areas would be chosen at a later time resulting in adverse impacts to natural resources, particularly wetlands, watercourses and vernal pools. This could foreclose the ability of choosing a more appropriate area in the future. Even beyond this potential future impact, however, without a full inventory of the natural resources on the site, the best location for a treatment basin for road runoff, could be end up being sited on a population

[1] Calhoun, A.J.K. and M.W. Klemens. 2002. Best Development Practices: Conserving Pool-Breding Amphibians in Residential and Commercial Developments in the Northeastern United States. MCA Technical Paper No. 5, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York.

of rare plants, or in an inappropriate area from an open space scenic and recreational perspective.

2.0 IMPACT-SPECIFIC CONSIDERATIONS

2.1 Bedrock Outcrops, Knolls, and High Rock Cover

It is our professional opinion that the record already has ample information about these features, to argue for preserving the entire land area in the proposed Ingham Hill Road pod as open space, as was previously proposed by the applicant. We already have enough evidence that this area is replete with significant natural features and resources, making it worthy to be set aside as Open Space. The proposed subdivision, by fragmenting the area and degrading views, will close off the opportunity for open space of exceptional quality.

Although REMA did not participate in the site walk, reviewed aerial photographs (example attached) clearly show the extensive light gray rock outcrop areas in the vicinity of the Ingham Hill pod. The presence of bedrock outcrops and shallow depth to bedrock is part of the definition of the Chatfield Soil series and the Charlton-Chatfield Complex (see soils map in the record). The distinct type of vegetation community supported by this soil series/bedrock type is also generally known, and well-documented in the scientific literature.

Ecological Integrity

The proposed homes and roads would *greatly reduce the ecological integrity* of the landscape in this area, aside from significantly reducing aesthetic and recreational value. In fact, the large quantity of outcrops on multiple knolls, substantially increases the biodiversity value from a population genetic standpoint. *Large populations* even of uncommon plants (e.g. over the widely used 200 individual threshold) are likely to have sufficient genetic diversity for long-term sustainability (e.g. able to evolve and adjust to climate change). Populations are also large enough to support host-specific insect species, like the miniature "butterflies" (skippers & dusky-wings) whose larvae feed on certain hilltop grasses and wildflowers, several of them state-listed (e.g. the endangered Columbine duskywing, *Erynnis lucilius*). Even without state-listed species, diverse uncommon species confer higher open space value than a common mid-slope oak forest community.

Adult Mortality

The significance of *roadkill* as an adverse impact on wildlife varies greatly with the organism. For some fast-moving species with a high reproductive rate, like Eastern Cottontail, roadkill is not a problem. It is a relatively minor mortality factor for relatively agile and naturally short-lived wood frogs, which breed explosively. However, *even low rates of adult mortality are known to be major factors in the decline of populations of Eastern box turtles and mole salamanders* (spotted and marbled), all of which are present at the Ingham Road site. Road kill is most well-known, but adults also die from other risk factors in residential areas, e.g. lawn mower injury, pet collection, and reduced food/habitat supply due to pesticide use/conversion to lawn). All three of these species are long-lived, slow-moving animals, and roadkill (or collection to be pets) usually occurs during seasonal movements outside of their smaller home ranges.[2]

The opportunity for a follow-up report allows us to provide additional supporting detail, for the points made in our previous report, regarding the elevated value of open space, per the town's criteria (aesthetics, recreation, wildlife and biodiversity) with rugged topography, bedrock outcrops, and talus.

Vernal Pool Productivity

As noted in the 1-5-10 REMA report, the vernal pools in the vicinity of the Ingham Hill Road pond are highly productive, because rocky forested terrain can support substantially higher populations of the terrestrial stage of spotted and marbled salamanders. The carrying capacity of a very rocky forested area is much higher than forest with few surface rocks because the crevices and cracks provide abundant alternative living areas, to the vacant shrew burrows used in a non-rocky forest. Such burrows are in relatively short supply in a typical forest, and typically limit the population size of mole salamanders around a vernal pool, in the absence of other limiting factors.

The Commission must also understand, that with a highly productive pool, the width of the envelope of terrestrial around the vernal pool that is used by a high density of adult

[2] Eastern box turtle has a slow reproductive rate (very high juvenile mortality), and salamander reproduction often fails, during dry summers. All are long-lived (30 is the maximum recorded longevity for spotted salamander, and an Eastern box turtles over 100 years has been recorded on Long Island, New York, such that repeated attempts at reproduction eventually succeed, provided their adults lives are not cut short prematurely by roadkill. Note that

salamanders, will greatly exceed 100 feet, with some usage even as far as or beyond the outer limit of the Klemens (2002) "critical terrestrial habitat" circle (750 feet). The proposed development envelopes in Lots 1, 2, 11, and 12 in the Ingham Hill Road pod, are certainly habitat for adult salamanders, and therefore, development of this lots are reasonably likely to have an unreasonable impact upon these resources. Because salamanders return each year to a small specific area, loss of those adult salamanders is expected.

Botany

The higher incidence of uncommon plant species in plant communities associated with rock outcrops was mentioned in our 1-5-11 report. One reason given was the fact that even in a landscape with a history of farming or logging, rugged terrain and poor soils for farming, allow remnant areas of interesting, often native species to persist, than in a more level, lowland forest. Additionally the dry growing conditions, where soil is very shallow and also acidic, support a distinctive *woodland* community (25-60% tree cover) quite similar to droughty, sandbarren communities on outwash plains, though pitch pine is less common.

Kenneth Metzler and Juliana Barrett (2006)[3] (and also Nature Serve on a regional scale) have classified two such plant communities: on summits and outcrops: (1) the "pitch pine/lowbush blueberry" vegetation class with characteristic herbs including bushclovers (*Lespedeza* sp), and *pinweeds* (*Lechea* spp) (p. 22), and (2) on talus slopes with acidic, crystalline rocks the "red oak/rock polypody" vegetation class on p. 24. Characteristic Lichens, ferns, sedges, and mosses are also associated with these communities. The disproportionate occurrence of state-listed and uncommon species in these habitats is apparent in a seminal botany treatise for this region: The Vascular flora of Southeastern Connecticut (1995)[4], which lists the habitats for all species found here, and whether they are rare, uncommon, abundant, etc. The genus *Asplenium* (spleenwort) is one example; *Panicum* is another example. Some of the uncommon wildflowers of these rocky, partly open habitats are exceptionally lovely, like yellow false foxglove (*Aureolaria* sp.).

Eastern box turtles are highly cryptic; with one observation, it can be assumed that a substantially larger number occurs in the Ingham Hill and West pods.

[3] Kenneth Metzler and Juliana Barrett. 2006. The Vegetation of Connecticut: a Preliminary Classification. State Geological and Natural History Survey, CTDEP, Hartford, CT. Report of Investigations No. 12.

[4] Gordon Tucker, 1995, Vascular flora of Southeastern Connecticut, Memoirs of the CT Botanical Society, No. 3.

In our professional opinion it is highly likely that the large Preserve Property has an alternative location that has substantially lower apparent value, as open space, while also not highly likely to adversely impact these resources, as discussed elsewhere. Therefore, we believe that ***feasible and prudent alternatives exist*** that would reduce or eliminated unreasonable impacts to natural resources and the Ingham Hill Road pod. The preferred ones are: (1) No lot development at this parcel, reflecting the original intent of River Sound in the approved Special Exception, and (2) elimination of Lots 1, 2, 7, 8, 11, and 12.

2.2 Adverse Nutrient Impacts

We testified to this commission on January 5th, 2011, that adverse nutrient enrichment of several wetlands and watercourses was very likely to result from construction of these un-sewered subdivisions on rocky, rugged terrain. Looking at the Preliminary Open Space Subdivision Plans, in two of the three proposed pods, that is, the Ingham Hill Road and the Bokum Road pods, multiple wetlands are just short distance downgradient of proposed house lots. Our statement is based on the partial set of test pit data that was provided; aerial photos that show high cover of rock outcrops; topographic maps showing rugged, irregular topography and steep slopes; and current on-line USDA-NRCS soils maps showing Chatfield-Hollis (soil depths mostly 20-40 inches, in slope category E (>15%). We evaluated all this in the context of our professional knowledge and experience with adverse wetland responses to nutrient inputs.

Algal proliferation triggered by nutrient enrichment adversely affects aquatic ecosystems; it leads to anoxic conditions, smothering of substrate and food supply, increased incidence of trematode infection in amphibians, and higher turbidity, which interferes with finding prey. An entire methodology for assessment of stream impairment (EPA RBA Rapid Bioassessment) is based on the progressive loss of aquatic invertebrate and fish diversity as nutrient levels increase, with ensuing proliferation of periphyton (Pflafkin 1989)[5]. Floristically distinctive wetland plant communities with existing low nutrient levels are also adversely altered by nutrient inputs, because they cause rank growth of nutrient tolerant species (such as jewelweed), which then shade out diverse species adapted to a low nutrient environment, such as northern bugle. The net result is a less complex plant community, an adverse ecological impact.

[5] Plafkin, J.L. M.T. Barbour, K.D. Porter, S.K. Gross, R.M. Hughes. 1989. Rapid Assessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish.

Groundwater, with variable nitrate-N concentrations, is discharged into headwaters streams, seeps, and vernal pools. Impacts of a given nitrate–N and total N concentration will vary depending on the size, flow speed, and dilution capacity of the resource. The adjacent wetland and watercourse resources in both pods have *low* dilution capacity, being predominately headwater systems.

One large scale study of groundwater fed streams in the Croton Watershed found that nitrate-N concentration was a function of the density of unsewered homes in the surrounding landscape (Paul Heisig, USGS 2000[6], abstract attached). Note that headwaters wetlands, both streams and pools, have concentrations of soluble nitrate-nitrogen well under 1.5 mg/liter (usually <0.2 mg/l) when they are *not* receiving excessive inputs from septic systems and/or fertilized lawns. This is an order of magnitude less than the 10 mg/l human health standard. The EPA draft criterion is 0.31 mg/l of nitrate + nitrite N for streams, based on a huge dataset from the entire country.[7] Some states, like Florida, already have final nutrient criteria: 0.35 mg/l nitrate + nitrite for clear springs and streams. The CTDEP is currently conducting a large study, under the direction of Mary Becker (pers. comm.), to establish state nutrient criteria for headwaters streams that will be consistent with healthy macroinvertebrate fauna and epiphyton flora. It should be noted that phosphorus is naturally available in the substrate of shallow streams and pools, such that elevated nitrate levels alone will have adverse impacts. However, phosphorus inputs further exacerbate algal proliferation, e.g. sediment from road cuts and grading on steep slopes, as in Lots 11, 12, 13 and the roadway adjacent to Lot 3, in the Ingham Hill Pod.

Nitrogen transformation and attenuation mechanisms do take place within a septic system, but it is a widely known fact that even a properly functioning, well-designed septic system is *not expected to treat more than 50 to 60 percent of the nitrogen in household effluent.* About 40-50% leaves the system as nitrate-N, dissolved in the leachate.

Dilution is the final stage for treatment of Nitrate-N in septic effluent, after it exits the formal septic system. Dilution of the nitrate-N reduces its concentration in groundwater. A formal DEP methodology (February 2006, written by Nathan Jacobsen Associates) now exists to model leachate dilution (renovation analysis). Obviously, the model cannot be run

[6] Paul Heisig. March 2000. Effects of Residential and Agricultural Landuses on the Chemical Quality of Baseflow of Smal Streams in the Croton Watershed, Southeastern New York. WRIR 99-4173 U.S. Geological Survey, Department of the Interior.
[7] In the EPA dataset for the Salmon River watershed in Middlesex County (used for draft criteria development) the highest nitrate-N concentration was 0.5 mg/l.

before exact locations of septic systems have been determined. However, one can evaluate the input parameters. This methodology takes into account the *upgradient drainage area*, and the *runoff coefficients of the soils* in that drainage area (from TR 55). When homes and septic systems are to be placed in upper slope landscape positions on knolls and ridges, as in each of these pods, the additional *drainage area* upslope of septic systems will be small. *Permeability* of rocky, Hollis/Chatfield[8] soils mapped for the Ingham Hill Road pod, for instance, is low, but saturated hydraulic conductivity is high. Groundwater flows quickly towards wetlands, following the underlying bedrock contours.

Although the 2006 DEP model was initially developed for use in permitting community septic systems, CTDEP allows it to be applied anywhere, provided data on soils and drainage areas are available.

The *depth* of the soil before a confining layer is reached (ledge or hardpan) affects the volume of soil (and soil water) available for nitrate dilution, and for microbe filtration. Seepage areas with active groundwater discharge are more prevalent where ledge or hardpan limits downward water percolation. For example, for the Ingham Hill Road lots, the plan show short distances (i.e., 100 to 150 feet) to the wetlands (#'s 4,6,7,8, and 9), over steep slopes, associated with Lots 1, 2, 3, 7, 8, 11, and 12. The 100-foot setback is not a "magic" protective distance. Depending on topography, soils, the sensitivity of the wetland, and the nature of the activities, activities well over 100 feet from a given wetland will cause adverse impacts. The fact that several of these wetlands are highly productive vernal pools increases their sensitivity.

Our health code does exclude certain areas with very shallow soil (48 inches to bedrock) and/or very high seasonal water tables from use for septic systems, based on the human health standard for Nitrate-nitrogen (10 mg/l); a portion of the western pod is problematic due to shallow ledge, though nearby wetlands are absent. However, considering the much higher sensitivity of headwaters wetlands than humans to elevated nitrogen, the available information shows that soil and topographic conditions are highly likely to result in adverse

[8] Note that the recent major NRCS soils mapping revision (post initial Preserve application) shows the Chatfield/Charlton complex , with E slopes (>15%) as dominant in the Ingham Hill pod, whereas the previous mapping shows the Hollis/Charlton complex mapping unit with a dominant Slope of C (8-15%). This is not a significant difference, as Chatfield, with a predominant soil depth of 20 to 40 inches may also have common bedrock outcrops and soil areas shallower than 20". The Chatfield series, intermediate between Hollis and Charlton) was added subsequent to the earlier soils mapping. In Hollis soils the predominant depth is less than 20 inches.

nutrient impacts to nearby wetlands from septic systems, which will be exacerbated by even modest sediment releases during construction, and any excess turf fertilizers, long-term.

3.0 CONCLUSION

It continues to be our professional opinion that the proposed application does not provide a fully documented basis for set-asides of open space, consistent with town regulations. As configured, given the available information, the proposed changes are reasonably likely to cause unreasonable adverse impacts to natural features and resources on the site, including wetlands, watercourses, vernal pools, wildlife, and ecological communities.

Please call us if you have any questions on the above.

Respectfully submitted,

REMA ECOLOGICAL SERVICES, LLC

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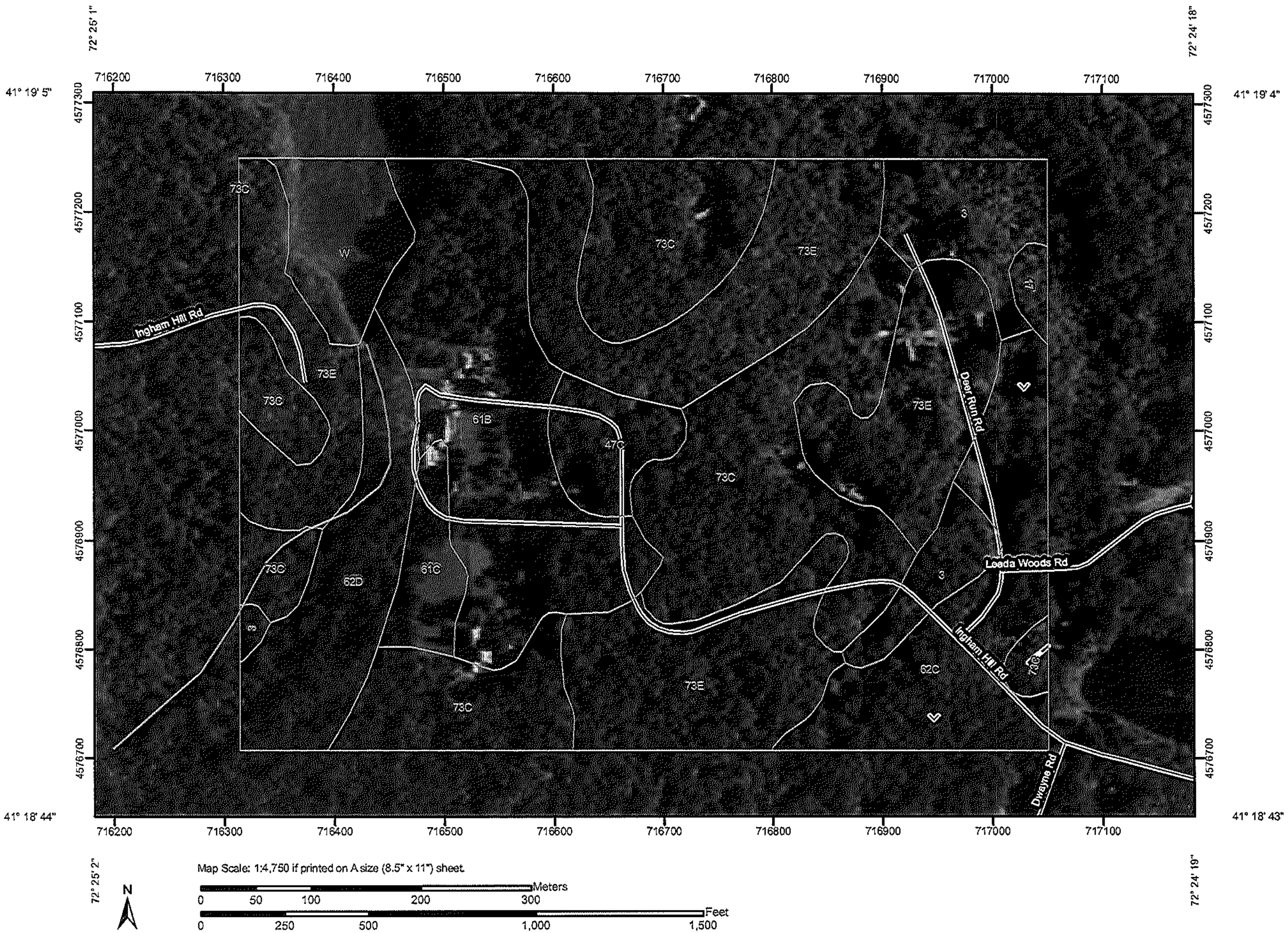
VIA HAND-DELIVERY

Attachments: Figure 1, Soil Survey (Ingham Hill Road), Heisig 2000 (reference)

Figure 1: 2008 Aerial Photograph of Ingham Hill Road Area (www.bing.com) showing Vernal Pools and Rocky Terrain.

Soil Map—State of Connecticut
(Ingham Hill Road Pod and Vicinity)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,750 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 18N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: State of Connecticut
Survey Area Data: Version 8, Dec 13, 2010

Date(s) aerial images were photographed: 8/16/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

State of Connecticut (CT600)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Ridgebury, Leicester, and Whitman soils, extremely stony	6.0	6.1%
17	Timakwa and Natchaug soils	0.6	0.6%
47C	Woodbridge fine sandy loam, 2 to 15 percent slopes, extremely stony	2.6	2.7%
61B	Canton and Charlton soils, 3 to 8 percent slopes, very stony	14.2	14.3%
61C	Canton and Charlton soils, 8 to 15 percent slopes, very stony	2.2	2.2%
62C	Canton and Charlton soils, 3 to 15 percent slopes, extremely stony	9.1	9.2%
62D	Canton and Charlton soils, 15 to 35 percent slopes, extremely stony	7.0	7.1%
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky	24.8	25.1%
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	28.6	29.0%
W	Water	3.7	3.7%
Totals for Area of Interest		**98.8**	**100.0%**

science for a changing world

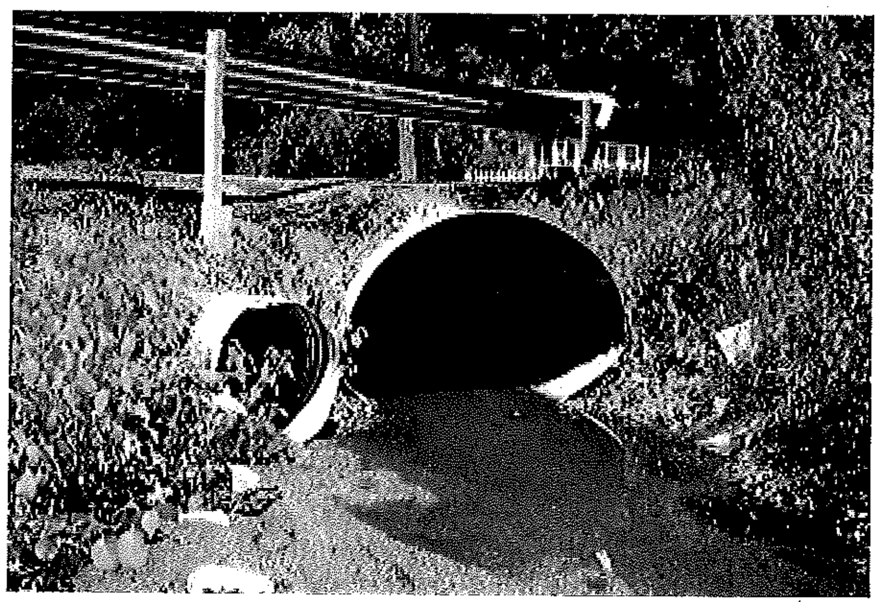
Prepared in Cooperation with the New York City Department of Environmental Protection

Effects of Residential and Agricultural Land Uses on the Chemical Quality of Baseflow of Small Streams in the Croton Watershed, Southeastern New York

Data on the chemical quality of baseflow from 33 small streams that drain basins of differing land-use type and intensity within the Croton watershed were collected seasonally for 1 year to identify and characterize the quality of ground-water contributions to surface water. The watershed includes twelve of New York City's water-supply reservoirs. Baseflow samples were collected a minimum of three days after the most recent precipitation and were analyzed for major ions, boron, and nutrients.

Findings—

- Concentrations of selected chemical constituents in baseflow were strongly affected by the predominant land use in a given basin. Land uses included forested undeveloped, unsewered residential, sewered residential, and agricultural (horse and dairy farms).
- A positive linear relation was indicated for chloride concentration in baseflow and the basin's annual rate of road-salt application (or density of two-lane roads). Chloride concentration exhibits a relatively stable relation to road-salt application rate or 2-lane road density throughout the year.
- Positive linear relations were indicated for nitrate concentration in baseflow and the basins unsewered housing density. Nitrate is characterized by a different relation to unsewered housing density for each season, with the highest observed nitrate concentrations during the winter and the lowest concentrations during the summer.
- Baseflow nitrate concentrations in sewered basins, and in unsewered basins with riparian wetland buffers between residential development and the stream, were lower than concentrations predicted from unsewered-housing density.



Croton watershed stream under baseflow conditions

SUMMARY

Concentrations of selected chemical constituents in stream-baseflow samples representing ground-water discharge from 33 small basins within New York City's Croton watershed were evaluated in relation to land use and two measures of the intensity of unsewered residential development. Four samples were collected at each site, one during each season from July 1996 through May 1997, and analyzed for major ions, boron, and nutrients. Estimates of ground-water discharge (baseflow) from two well-drained (minor wetland area) stream basins in the watershed indicate that it constitutes at least 60 percent of total annual streamflow.

Baseflow concentrations of the selected chemical constituents were elevated to differing degrees relative to concentrations in the undeveloped forested (control) basin, depending on the predominant land use (unsewered residential, sewered residential, or agriculture [horse and dairy farms]) in the given basin. Baseflows in the undeveloped forested basin had the lowest concentrations of all detectable constituents. The unsewered residential basin was characterized by the highest baseflow concentrations of chloride and sodium, predominantly from winter road-salting, and the highest baseflow concentrations of nitrate, sulfate, and boron, primarily from domestic wastewater disposal through septic systems. The sewered residential basin had elevated baseflow concentrations of all constituents (especially chloride, sodium, and nitrate), but to a lesser extent (except orthophosphate) than the unsewered basin; the elevated concentration of orthophosphate could be derived from leaking sewer lines near the stream, lawn fertilizers, or, less likely, housing that has not been connected to the sanitary sewers. The agricultural basin with the highest percentage (12 percent) of horse and dairy farms had the highest baseflow concentrations of ammonia, total ammonia plus organic nitrogen, and total phosphorus, and the second highest concentrations of the other nutrients. Concentrations of major ions and boron in baseflow from this basin were most similar to those of baseflow in the undeveloped forested basin, as a result of the low density of roads and septic systems.

The intensity of unsewered residential development was quantified through estimation of annual road-salt-application rates (or road density) and housing (septic system) density for each basin. Linear regressions of nitrate concentration in baseflow and housing density in unsewered basins as well as chloride concentration in baseflow and annual road-salt application rate (or road density for basins with only two-lane roads) indicate that these measures of unsewered residential development can be used to predict effects on baseflow chemical quality. Chloride concentrations in baseflow show relatively stable positive linear relations with annual road-salt application rates and density of two-lane roads throughout the year. Baseflow nitrate concentrations show a different positive linear relation with unsewered housing density for each season; the highest nitrate concentrations were during the winter, and the lowest were during the summer. This seasonal variation reflects increased biological activity, such as algal uptake of nitrate within streams, or microbial denitrification within riparian wetlands or beneath the streambeds, during the summer.

Nitrate concentrations in baseflow from sewered basins and from unsewered basins with riparian wetland between residential development and the stream were lower than those predicted by the relation of unsewered housing density to baseflow nitrate. Nitrate concentrations in baseflow from the two sewered basins were 49 and 68 percent below the values predicted for unsewered basins. Summer nitrate concentrations in baseflow from two unsewered basins with riparian wetlands downgradient of residential development were about 0.6 mg/L lower than those predicted by the regression equation.

The results of this study indicate that local land use affects shallow ground water and that ground-water discharge is both an important source of streamflow and a control on surface-water quality. Nitrate concentrations in baseflow of small streams that drain unsewered basins can be predicted from the density of housing (septic systems) in the basins. Chloride concentrations in baseflow of sewered or unsewered basins can be predicted from annual road-salt application estimates or from the density of two-lane roads in the basins. Nitrate concentrations in baseflow from a sewered basin indicate that sewering is at least 57 percent effective in preventing nitrate from entering baseflow. Additional nitrate contributions from leaking sewer lines, lawn fertilizers, and remaining septic systems are unknown.

By PAUL M. HEISIG