Hatch Mott MacDonald

March 2, 2011

Chairman Harry Mayo, III and All Planning Board Members
North Bergen Planning Board
Township of North Bergen
4233 Kennedy Boulevard
North Bergen, New Jersey 07047

Re: Geologic Consultation on the Appleview Site
7009-7101 River Road
North Bergen, NJ

Dear Chairman Mayo;

This report is in response to the Coalition to Preserve the Palisades Cliff's (CPPC) request for a geologic opinion on the referenced site. In preparing this, I have reviewed numerous documents including but not limited to the Appleview site plans, Johnson Soils reports and transcripts of the geotechnical engineer's testimony; resources made available by the State of New Jersey, including both the NJ Department of Environmental Protection and the NJ Geological Survey (NJGS), and various other sources available to me in-house at Hatch Mott MacDonald (HMM) and online. I also physically examined the property from River Road, Ferry Road, and the adjacent Galaxy Towers property on February18, 2011.

Geology

North Bergen is located within the Piedmont Physiographic Province of New Jersey. This Province covers approximately one-fifth of the state, extending from Bergen County in the northeast, to Hunterdon and Mercer Counties in the southwest. The Piedmont is commonly described as a gently sloping, rolling plain, that is interrupted by a series of higher ridges. The Piedmont ridges are the result of erosion-resistant rock layers that dip to the northwest (approximately 13 degrees in this area), thus most ridges have flat, gently sloping northwestern faces, and steep faces to the southeast that expose a cross section of the rock. The most prominent feature in the eastern portion of the Piedmont Province is the Palisades.

The name Palisades was applied to the escarpment along the Hudson River historically, because when the feature is viewed from the New York side of the river the columnar jointing in the exposed rock face has the appearance of a stockade-style fence, also known as a "palisade," which means "fence of stakes."

Geographically, the Palisades is often described as a Ridge, or an Escarpment. The geologic reason the Palisades occurs as a relative topographic high is due to the underlying igneous rock being more resistant to the forces of erosion than the surrounding sedimentary rock. The geologic term for this body of rock is a "sill," defined as a sheet-like igneous intrusion of rock that parallels the planar structures of the surrounding rock.

The Palisades sill is an early Jurassic aged (approximately 200 to 190 million year old) intrusion of a rock type called diabase. Palisades diabase is typically described as a medium to coarse-grained rock, dark-greenish gray to black. It is composed primarily of the minerals plagioclase feldspar (light colored), and clinopyroxene, and magnetite/ilmenite (dark colored), which can give it a "salt and pepper" appearance on a freshly exposed surface. The rock can also include accessory minerals in small percentages, such as: apatite, quartz, alkali feldspar, hornblende, titanite and zircon. The diabase is a magmatic intrusion formed parallel to the bedding of the pre-existing sedimentary rocks into which the magma was injected. The rock that was intruded had been deposited in the late Triassic period (approximately 230 to 200 million years old), and consisted predominantly of the Stockton formation – sandstones, mudstones, silty mudstones, argillaceous siltstones, and shale, and the Lockatong formation – mudstones, siltstones, fine-grained sandstones and silty limestones.

The characteristic columnar pattern exposed in the face of the Palisades extends throughout the diabase rock body and is a result of shrinkage of the material as it cools from a molten magma to a solid rock. Tensional forces within the shrinking body result in near vertical, polygonal cracks, or joints that are pervasive.

Geologic literature routinely cites the thickness of the sill as 1,000 feet. Some of this thickness remains buried in the subsurface and some has been eroded from the top of the sill, subsequent to exposure.

The columnar jointing is responsible for the steepness of the eastern slope of the escarpment. Erosional forces working on the exposed rock, including surface runoff and annual freeze-thaw cycles, are more effective on the pre-existing weakness in the rock (joints) than on the rock itself. Therefore the Palisades sill tends to erode by mass wasting of tall, vertical sections of the rock falling off the exposed face, and being deposited at the base of the face in the talus slope. Talus, also known as scree, is an accumulation of fragments that are the result of mechanical weathering of rocks. Typically it forms heaps of coarse debris at the base of steep rock slopes. Finer particles are sometimes removed from the talus by percolating water.

The current "Bedrock Geology Map of Northern NJ," published in 1996 by the NJGS, does not attribute any formal formation name to the diabase that supports the Palisades cliff. Rather than refer to it as the "Palisades Diabase" it is commonly referred to as "Jurassic diabase intrusives." This is due to the fact that the same-aged rock type occurs elsewhere in NJ, notably surrounding Round Valley Reservoir in Clinton Township.

Terminology

The term "cliff" is not a well-defined term. It is not often used in geologic texts. Virtually every English dictionary contains a definition of "cliff," unfortunately these definitions are not science-based, and vary greatly between editions. Of the various dictionary definitions of "cliff", the most complete and thorough was from Merriam-Webster online, which reads as follows:

> "Cliff - a very steep, vertical, or overhanging face of rock, earth, or ice"

A meaningful definition of the word "cliff" from a scientific perspective, can be found in a book specifically about cliffs: "Cliff Ecology: Pattern and Process in Cliff Ecosystems", authored by Douglas William Larson, Uta Matthes, Peter E. Kelly, first published in 2000 by the Cambridge University Press. In the introductory section of this book, entitled "What is a cliff?" the authors discuss the following definition (emphasis added):

> "...cliffs in the broad sense include a cliff-edge at the top, and a talus at the bottom of the face. The cliff-edge is a zone extending from the face back an arbitrary distance. It consists of rock in the process of weathering, whereas a talus or a talus slope is the accumulation of loose rock fragments and slabs derived from the weathering on the cliff-face. In some settings large blocks of talus can create a mosaic of hundreds of small cliffs at the base of a larger cliff. Both cliff-edge and talus share some of the physical characteristics of the free-face, support many of the same plants and animals and are linked by the same ecological processes. Therefore, this book is about cliffs in the broader sense of the definition, i.e. cliff-edge, free face, and talus slope as a single unit."

Additionally this book labels the higher elevation, behind the free face as "plateau," and the lower elevation, beyond the toe of the talus slope, is labeled as the "pediment."

Such a definition, which includes geological, ecological and geographical components is supported by points raised within the NJ Water Quality Management Planning Rule, N.J.A.C. 7:15-5.3, which discusses environmental reasons for restricting disturbances of steep slopes. These reasons include prevention of an accelerated erosion process, maintaining natural topography and drainage patterns, prevention of further fragmentation of forest and habitat areas, and compromised aesthetic values. The default value to define a steep slope in the current Planning Rule and Steep Slope Model Ordinance is a 20% grade, which is exceeded on the site in question. The intent of the state Rule is to minimize disturbances to slopes steeper than 20% grade in order to: 1) minimize adverse effects to water quality and quantity, 2) protect fragile ecosystems, and 3) protect public and private property from accelerated erosion processes.

The stated purpose of the Township of North Bergen Zoning Ordinance (Article III) is to preserve the view of and from the "cliff." As such the definition given above would apply to the entire cliff, not just the exposed rock, which on this site is a relatively small percentage of the acreage. See Exhibit O-1, dated 9/29/2010.

Additionally, the rear-yard setback regulation in the North Bergen Zoning Ordinance for P-2 designated lots requires a setback measured from the first habitable floor to the "cliff face." This is depicted on Figure 14; however, that figure does not discern what material the "cliff face" is made of, but rather merely labels a steep slope of greater than 30% and shows from where the setback should be measured. Presumably the 30% slope could consists of any material: exposed rock, soil, a mixture of eroded rock fragments and soil, or any other substance that is steep enough. Given the Appleview steep slope fits all these zoning requirements, my conclusion is that rear-yard setback calculations for Appleview should be made from the toe of the slope facing the first habitable floor, and not from higher up where the rock face is exposed.

Figure C2.1 from Appleview's development plan (revision dated 2-8-10) is a "Demolition Plan" which essentially shows existing conditions at the site and includes topographic contours at two-foot intervals. Using a 100-foot average horizontal distance, I find that everything on the site that is higher than the16 foot elevation contour is equal to or greater than a 30% grade. A visual estimate based on this map indicates about 40% of the acreage at this site is steeper than a 30% grade.

Potential Landslides

Other considerations for building in proximity to the Palisades should include the potential for landslides. The NJ Geology i-Map online data set identifies two Debris flows and four Rock falls within a two-mile radius of the site in North Bergen. The wedge of talus at the base of the free face is composed predominantly of eroded material that fell from the rock under natural conditions. In other words the talus is the result of landslides and eroded material accumulating over time.

Landslides could be triggered by disturbance of the talus wedge, which partially acts as a brace at the base of the free face. Earthquakes could also trigger landslides. The NJ Geology i-Map online data set identifies four earthquake epicenters within a five-mile radius of the site. The most severe of these earthquakes was also the closest, occurring approximately 3,145 feet north of the site, and measuring between 2.31 and 3.30 on the Richter Scale. The "Landslide Susceptibility Map for Hudson County, NJ" depicts the Palisades at the Appleview site as having a Landslide Class A IV – Strongly cemented rock, slope angle 30-40 degrees. The NJ Geological Survey uses the following description in their information circular "New Jersey Landslides": "One of the most active landslide areas is the Palisades located in northeastern New Jersey along the Hudson River."

Transco Gas Pipeline

During the site inspection I noticed the Transco Natural Gas Pipeline that runs along the Woodcliff Sewage Plant adjacent to Appleview's northern property line, and then cuts slightly to the south across the western portion of the Appleview site at a higher elevation near Ferry Road. Typical construction methods for such utilities involve excavating, possibly blasting, a trench of sufficient depth to bury the pipeline in order to protect it from disturbance. The trench bottom is usually lined with compacted, construction grade sand, the pipe laid on top, and then additional sand is backfilled around and on top of the pipeline. Topsoil and seed or some other surfacing material is usually placed to match the existing, surrounding grade.

It is my experience, and also the experience of the NJDEP, that backfill around subsurface utility lines frequently serves as a conduit for preferential migration of ground water and infiltrated surface water, due to the relative porosity of the construction backfill. There could be a concern that this utility line is acting as a subsurface drain for water flowing from the higher elevations west of the cliff. Excessive water could accelerate corrosion, unless considerations were incorporated into the construction of the pipeline, such as impervious cover, extra depth below the pipe

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invert for drainage, sacrificial anodes for corrosion protection, etc. Construction details of this pipeline are not known to me.

Of further concern to the Transco pipeline is that in the immediate vicinity of the Appleview site there are two Seismic Soil Classes: Soil Class A – Hard rock with less than 10 feet of soil cover, having a high shear wave velocity; and Soil Class E – Soft soil with a low shear wave velocity. The "Seismic Soil Class Map for Hudson County, NJ" depicts the boundary between these two classes of soil in proximity to, as well as parallel to, River Road. From a geologic perspective the concern is that subsurface vibrations will impact the pipeline within soils of both the Seismic Soil Class A and E simultaneously at the Appleview site, causing differential stresses on the pipeline. Sources of vibration could include: pile driving, blasting, excavating, earthquakes, and landslides triggered by other vibrations.

Yours truly,

Hatch Mott MacDonald

Robert T. Cunniff, PG, CPG
Associate
T: 973.912.2473 F: 973.912.2400
robert.cunniff@hatchmott.com

cc: Coalition to Preserve the Palisades Cliffs (CPPC), c/o Ms. Peggy Wong, President