

APPENDIX A  
GEOTECHNICAL REPORT -- RENSSELAER TECHNOLOGY  
PARK CONNECTOR ROADWAY

## INTRODUCTION:

It is our understanding that the client proposes to construct a "Connector Roadway" from the upper plateau of the Technology Park to the proposed development area along the Hudson River south of the existing Treatment Plant. The elevations in the upper plateau are commonly 200 (M. S. L.) or higher and the elevations along the existing railroad track near the proposed lower level development are near 20 (M. S. L.) or lower.

The area being considered for the proposed Connector Roadway would be generally bounded on the north by the existing Niagara Mohawk Power Company right of way and on the south by the finger of upland bounding the southern edge of the major ravine or canyon which parallels the power company right of way just south of the power lines. We have indicated alternate general routes designated by the letters A, B, and C on the diagram (Figure 1). The routes marked A and C along the tops of the slopes were indicated to us as of primary interest, and the route B along the invert or bottom of the canyon was indicated as a possible route.

We have assumed for the purposes of this study that a 60-foot right of way would be adequate for the roadway contemplated.

We also understand that possible building development of the land surface just south of the proposed route A is of interest to the client.

The purpose of this report is to describe the preliminary investigation conducted and to present our preliminary recommendations for selection of the proposed route for the Connector Roadway.

## INVESTIGATION PROCEDURES:

No boring or laboratory testing work was performed specifically for this project. The results of earlier investigations conducted throughout the Technology Park have been utilized in performing the preliminary analyses conducted.

Our primary field investigation procedure was to walk over the proposed routes. We examined the surface conditions including the condition of trees, vegetation, and the topography.

The balance of our investigation included the preliminary stability analysis of the slopes along the proposed routes and consideration of the drainage and grading aspects of the potential designs.

#### SUBSURFACE CONDITIONS AND GEOLOGY:

The important geology for the Technology Park as it bears on this study is glacial geology. The soils of greatest interest are the lacustrine clays and silts which are prevalent throughout the park. These glacial lake clays were deposited during the late glacial period in what is known as glacial Lake Albany. These soils cover the upper plateau area of the Technology Park. The erosion through centuries has dissected this clay plateau forming the canyons or ravines which drain westerly to the Hudson River. The continuing erosion of these canyons has resulted in continuing instability of the sides of the canyons.

The glacial lake clays and silts rest on relatively dense glacial till or hardpan formations and the glacial tills in turn rest on bedrocks which are primarily shales in this area. The glacial tills and shales can be observed in the bottoms of some of the canyons or ravines.

The clay and silt deposits are known to have effective friction angles varying between about 23 degrees and 28 degrees in the weaker layers. The long-term cohesion values are quite low and can be assumed to be in the 25 psf to 100 psf range for the purposes of this preliminary study.

The key factor in the relative stability of the slopes and the clays on the site are the prevailing high groundwater tables. When the groundwater tables rise to very shallow levels the stable slopes can approach one half the friction angle in surface gradient. When the slopes are well drained the stable slopes can approach the friction angle itself in surface gradient.

The slopes in most of the canyons or ravines in the subject study area are marginally stable and locally unstable. Dead trees and fallen trees along with numerous tension cracks and scarp faces can be seen throughout the sloping areas indicating continuing shallow slope failures. These have occurred over decades and centuries. There is reason to believe that the works of man since the 17th Century have accelerated the erosion and with it the slope instability.

The gently rolling lands (shaped like fingers in the plan view) lying between these generally parallel canyons or ravines are very stable except for the edges adjacent to the

slopes described above. Failures occur along the edges periodically. These failures tend to disturb narrow strips of ground surface 10 to 30 feet wide or even less. Deep failures which would affect larger amounts of ground surface at the tops of slopes are apparently unusual or rare. The typical failures are surface or shallow failures typical of frictional materials rather than the very deep failures which can occur in soft, highly cohesive soils.

#### GROUNDWATER CONDITIONS:

Our observations and experience with the groundwater levels in this area indicate that the depth to the general groundwater table varies widely. Groundwater levels are generally closer to the surface and may be at the surface in the lower parts of the slopes and at the bottoms of the ravines. The groundwater tables near the western ends of the fingers of land tend to be lower and therefore the ground surface is more stable than in the eastern ends of these fingers of land where they join the mass of the upper plateau. The in-feed of groundwater into these clay deposits is largely horizontal from east to west. The horizontal permeability of the ground is much greater than the vertical permeability. The infiltration of surface water is relatively small on the sloping clay ground except for water which penetrates seasonal desiccation cracks that form in the upper 10 to 15 feet of the profile.

#### ANALYSIS:

##### General:

As indicated in the discussion above, the entire area of the side slopes of the canyon in the study area can be considered as marginally stable or unstable. This is also true of the strips of land along the tops of the slope.

The central portions of the wider finger or strip of land south of proposed Route "A" would be relatively stable due to the distance from the tops of the slopes flanking to the north and south.

The very bottom of the canyon along the proposed Route B would be relatively stable by its position at the lowest elevation or bottom of the slopes.

The existing unstable and marginally stable slopes can be stabilized, if necessary, by either flattening the slopes or improving the drainage. Flattening would typically be accomplished by adding material to the toe of the slope or removing material from the top of the slope or a

combination. Drainage would be accomplished by installing drains aligned up and down the slope or across contour at a depth great enough to lower or limit the rise of the groundwater.

In the project area the slopes are ranging up to 100 to 120 feet in height and up to 400 to 500 feet in horizontal distance from the top of slope to the bottom. Stabilizing such extensive slopes is a relatively expensive project. Therefore, the routes along the wider strips of land or at the inverts or bottoms of the canyons or ravines is favored in terms of cost.

The disadvantage of utilizing the wider strips of land such as that south of the Route "A" is that otherwise available building space would be used by the roadway. Also, the likely routes down at the west end of the finger are steep and will require extensive grading. A long stretch of relatively steep grade would be required.

#### Stability Analyses:

Stability analyses were performed at four representative cross sections or profiles along the south slope of the canyon or ravine between proposed Routes A and B. This slope can be assumed to be generally similar in behavior and characteristics to the other side of the same canyon between proposed Routes B and C. Further these analyses provide some indication of the effect of grading and drainage on the safety factors of other slopes in the Tech Park.

These profiles analyzed are shown in Figure 1 in the plan. Additionally, analyses of altered sections were performed. These were the same profiles as cross sections with about 10 feet of cut removed at the top of the slope and about 15 feet added as fill at the toe of slope. In those altered cross sections the stability was re-examined using historically high water table information gained from analyzing the existing natural profiles. The effect on the safety factor and stability of the slope with material removed from the top; added to the bottom; or, with improved drainage near the toe of the slope has been determined for the assumed conditions.

The technique used was to assume an existing safety factor of 1.0 based on the apparent instability indicated by tree growth and surface topography. Using the known range of soil strength values the historically high water tables were established in the form of pore pressure ratios. Then the slopes were reanalyzed using the altered surface topography with the derived groundwater data. A further extension of

this procedure was to analyze the same cross sections with improved drainage near the toe of the slope where the water table is commonly observed to come close to the ground surface.

The soil cohesion was assumed to be 25 psf. This is conservative, but in the range of the very low values found to prevail for long term stability of similar local slopes. The friction angle of the soil was assumed to be 24 degrees. The total unit weight of the soil was assumed to be 120 pcf.

#### Results of Slope Stability Analysis:

1. The historically high pore pressures ratios determined using the assumed soil conditions are shown below for each of the four profiles analyzed. A value of  $ru=0.50$  would be complete saturation of the failure mass.

##### Profile

1. 0.48
2. 0.44
3. 0.34
4. 0.26 (Note much better drainage near west end of finger of upland compared to the easterly slope)

2. The required safe building setbacks from the existing top of slope for each of the first 3 profiles. (Minimum F.S. = 1.3).

##### Profile

1. 60'
2. 60'
3. 80'

3. The required safe building setbacks measured from the same point (existing top of slope) after cuts and fills are made at top and bottom. (F.S. = 1.3)

##### Profile

1. 0'
2. 30'
3. 30'

4. The same safe setback as in "3" with drains at the toe.  
(F.S.  $\approx$  1.3)

Profile

1. -30'
2. -30'
3. 10'

The relative gain in stable or buildable land in the strip along the top of the slope can be seen from these results. These results are preliminary, but will serve as a guide.

RECOMMENDATIONS:

Proposed Route A

Analysis of the stability of cross sections of the slope along and to the north of the proposed Route A indicate that without any grading or alteration of the terrain that the safe setback distance from the top of the slope for such a roadway would be between 60 and 80 feet. Using this setback, a 60-foot roadway, and a similar setback required along the south edge of the same strip of land, the remaining land for development would vary from 0 to 200 feet. This is a relatively narrow strip of land and limits the use of the area. Flattening the slope by removing material from the proposed alignment of Route A at the top of slope or by adding material at the bottom of the slope allows the construction of the road closer to the top of the slope. Improved drainage allows a further reduction in the required setback.

Proposed Route B

The problem of stability is substantially less with the proposed Route B along the bottom or invert of the canyon. The effect of filling at the bottom is stabilizing to both sides of the canyon. The remaining stability problem is the problem of any further sloughing of slope materials down to the roadway below. This is less difficult to deal with.

It appears that 10 to 15 feet of fill at the bottom of the ravine would result in a roadway width of 60 feet depending on the local topography. The available roadway building space can be widened by increasing the depth of the fill placed. Sufficient width would need to be provided for drainage swales along each side of the roadway as well as space for a conduit to handle the upstream drainage run off

which now passes through the canyon on the way to the Hudson River.

Material for filling the proposed Route B could be obtained from the proposed Route A area along the top of the slope which would provide flattening of the slope by cutting at the top as well as filling at the bottom. Alternatively, it could be gained from other upland areas. Taking material from a bench cut at the top of the slope may provide for a second service road at the top.

The existing average gradient of the proposed Route B is approximately 6 to 7%. This is a relatively moderate grade compared to the grades which would be needed to descend efficiently from elevation 150, plus or minus, to the bottom levels along the proposed Route A as indicated above.

The use of Route B would accomplish erosion protection of the bottom of the ravine protecting the slopes on both sides.

#### Proposed Route C

It is our recommendation that the proposed Route C not be further considered at this time. The existing Jeep trail and alignment of the existing sewer occupy a relatively narrow ridge flanked on both sides by unstable slopes with continuing erosion of both canyon bottoms or stream bottoms at the foot of each slope. With the passing of time the instability of these slopes will tend to narrow the width of the bench at the top. A recent failure just east of the Niagara Mohawk tower can be seen where a strip along the north edge of the trail dropped several feet as a result of a slope failure toward the north.

#### Summary of Route Recommendations:

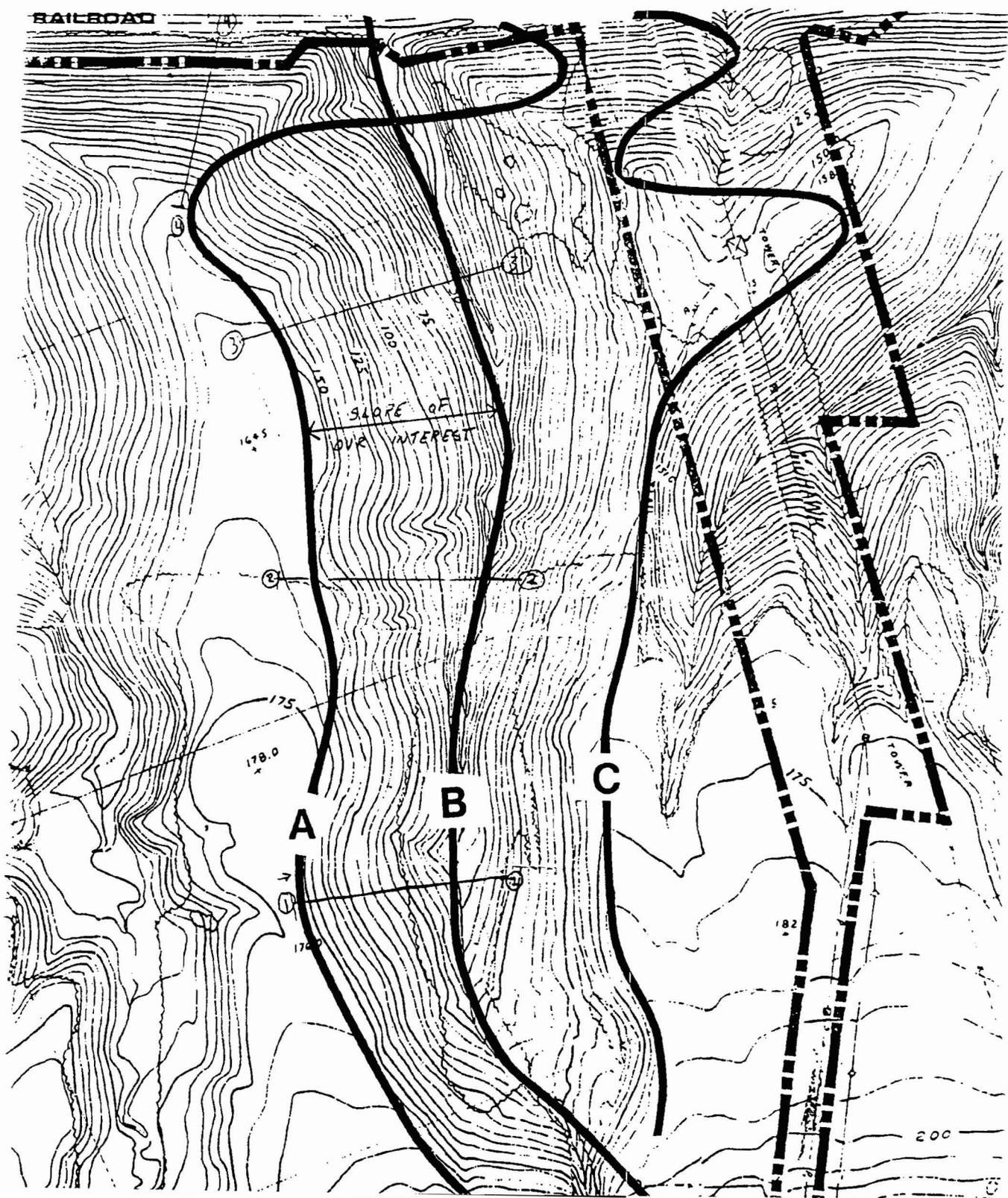
We recommend that the proposed Route B holds the most promise at this stage of our investigation. The ability to generate a relatively gentle gradient of 6 to 7% while not using available building land south of the proposed Route A makes this route more attractive than Route A itself. Development of the Route along A would require either the removal of some materials from the route itself or the placement of material along the Route B at the slope bottom or a combination. The only alternative would be to move Route A well out on the open land decreasing building space.

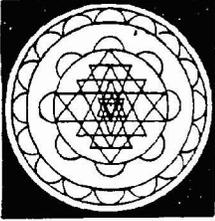
The proposed Route B seems to us more practical. Detailed cost studies and planning studies would be needed before a decision could be made.

The scope of this study does not include detailed recommendations for construction of the proposed roadway. Such detailed recommendations can be developed after a consideration of the contents of this report and a selection of routes for further study by the client. At that further stage of investigation a program of borings and soil testing along with additional stability analysis would be conducted. This work would be used to determine the extent of grading and drainage work required to construct the proposed Connector Road.

**Additional Recommendations:**

We would like to point out that the development of a roadway along the proposed Route B at the bottom of the canyon would provide an opportunity to arrest the continuing erosion along the bottom of that water course. This continuing erosion could eventually cause serious instabilities along the existing sewer alignment as well as instabilities along the edge of the potentially developable land south of the proposed Route A. A sufficiently-sized stormwater conduit could be constructed along Route B so that major amounts of stormwater from future development at the upper level could be safely conducted to the river. This approach could control erosion of this ravine and other ravines should water be diverted from those other ravines. Increasing development will inevitably increase the amount of erosion in all of the parallel ravines draining the upper Tech Park. It may become necessary locally to stabilize the bottoms of some of these canyons to stabilize the slopes which rise from these drainage courses. The recent instability along Route C is a case in point.





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October 14, 1988

Rensselaer Technology Park  
Att: Michael H. Wacholder, Dir.  
100 Jordan Road  
Troy, NY 12180

Gentlemen:

Re: The letter of August 29, 1988 from Michael Wacholder  
regarding additional recommendations desired by  
Daniel Schuster of Schuster Associates - File No. 3318

**INTRODUCTION:**

The information provided in this letter is to be regarded as supplementary to the recommendations included in our Report dated July 22, 1988.

I refer also to the letter dated August 4, 1988 from Schuster Associates which was enclosed with the letter from the Technology Park.

The items of additional information or recommendations desired were designated in the Schuster letter as follows:

Item 5 - Design criteria: Discussion of criteria and techniques regarding grading, slope stabilization, erosion and siltation control and landscaping to assure that adverse impacts will not result from construction and use of the road.

Item 6 - Typical design: Diagrams of typical roadway cross sections and profiles and any other typical details to illustrate application of the design criteria.

**Recommendations:**

Item 5 - Design Criteria:



At this stage of a preliminary design study, it should be adequate to address these matters of techniques for grading, slope stabilization, erosion and siltation control as well as landscaping in general terms as far as our geotechnical study is concerned. Detailed recommendations such as percentage of compaction; or the location and spacing of silt barriers; or the details of any proposed landscaping would best be done under a design study. It is common practice for the site designer to address these matters utilizing geotechnical recommendations. My earlier report addressed in some detail the matter of slope stability in itself.

It can be said that the soils on the site are typically varved silts and clays with surface topsoils and the subsoils derived through the weathering of the varved silt and clay deposit. Locally, there are outcroppings of rock and of the underlying glacial till. The typical silty and clayey soils on the site are probably average for the general area in their susceptibility to erosion. Clay soils are more resistant to erosion than silty or fine sandy soils found elsewhere in the area which do not have the plasticity and cohesion to resist wind and water erosion that clays do. The vegetative cover and the ability of the site soils to support vegetative growth is good.

Normal care during construction including the use of hay bales, silt fences, and possibly sedimentation basins at the bottoms of slopes or swales to clean runoff water of sediment would be adequate. The use of mulch, erosion fabric and rip rap in critical areas along with timely seeding of vegetative cover are recommended.

The recommended design approach of following the bottom of the existing ravine with the road alignment would tend to minimize the need to expose long slopes with the regrading of those slopes.

Cut-and-fill slopes should not exceed 2.0:1.0 (horizontal/vertical) without special design attention regarding erosion. Normally, slopes on this site need to be flatter than this for stability reasons.

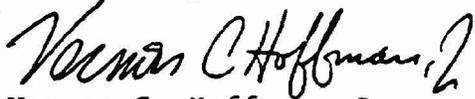
Roadway design and site layout design are not among my areas of specialization. However, I routinely make recommendations regarding pavement thickness designs and recommendations for stability of slopes and similar recommendations.

The cross section and profile of a proposed roadway aligned along the bottom of the ravines would not be unusual. They would be similar to any highway alignment descending/ascending in a cut section.

I have enclosed a conceptual cross section of a roadway which is similar to other roadways within the park. It is not intended for detailed design and does not necessarily include all the required features of a final design on the site.

If there are any questions with regard to this letter, or any other matter, please do not hesitate to contact me. If you feel that any additional roadway cross sections or profiles for the roadway need to be performed, I will contact a site designer to obtain a cost estimate for submitting such plans.

Yours truly,



Vernon C. Hoffman, Jr.  
N.Y.P.E. 44363

Enc.

cc: Percy Cotton, Percy B. Cotton Assoc.