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DEROGATION OF LOCALIZER COURSE DUE TO PROPOSED WATER TOWER PETERSON FIELD, COLORADO

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16. Abstract

The additional derogation to the localizer front and back courses caused by a water tower placed near the localizer site is predicted. This prediction is made with the Transportation Systems Center (TSC) localizer model. This additional derogation to the front and back courses is expected to amount to two or three microamperes.

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PREFACE

This study was undertaken in response to a request originating from the Rocky Mountain Region FAA for assistance in determining the possible course deterioration resulting from the construction of a proposed water tower in the vicinity of the localizer array at Peterson Field, Colorado Springs, Colorado.

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1. INTRODUCTION

The Transportation Systems Center (TSC) ILS Localizer model has been used to predict the course structure derogation which would result if a water tower were located in the vicinity of the localizer array at Peterson Field, Colorado Springs, Colorado.

The results of this study indicated that the addition of the proposed water tower would add no more than seven microamperes to the existing front course structure and no less than one and a half microamperes. Similarly, it was found that the water tower would add no more than four and a half microamperes to the existing back course structure and no less than one and a half microamperes. In both cases, the smaller values are the more likely ones, as will be explained below.

2. DESCRIPTION

The proposed water tower is a five million gallon cylindrical metal resevoir, 32 feet high and 165 feet in diameter. Its intended location is as shown in Figure 1, 2530 feet from the localizer array.

The existing localizer at Peterson Field is an eight-loop array with an assigned course width of 3.3°. It is located 1350 feet beyond the stop end of Runway 35. The runway length is 11,020 feet. The terrain from the localizer to the runway threshold slopes down 150 feet. This is a sizable downward slope, equivalent to an angle of 0.694°. The terrain between the proposed site of the water tower and the localizer array similarly slopes downward, the ground at the antenna being 20 feet below the ground at the proposed water tower site. This data is summarized in Tables 1-3.

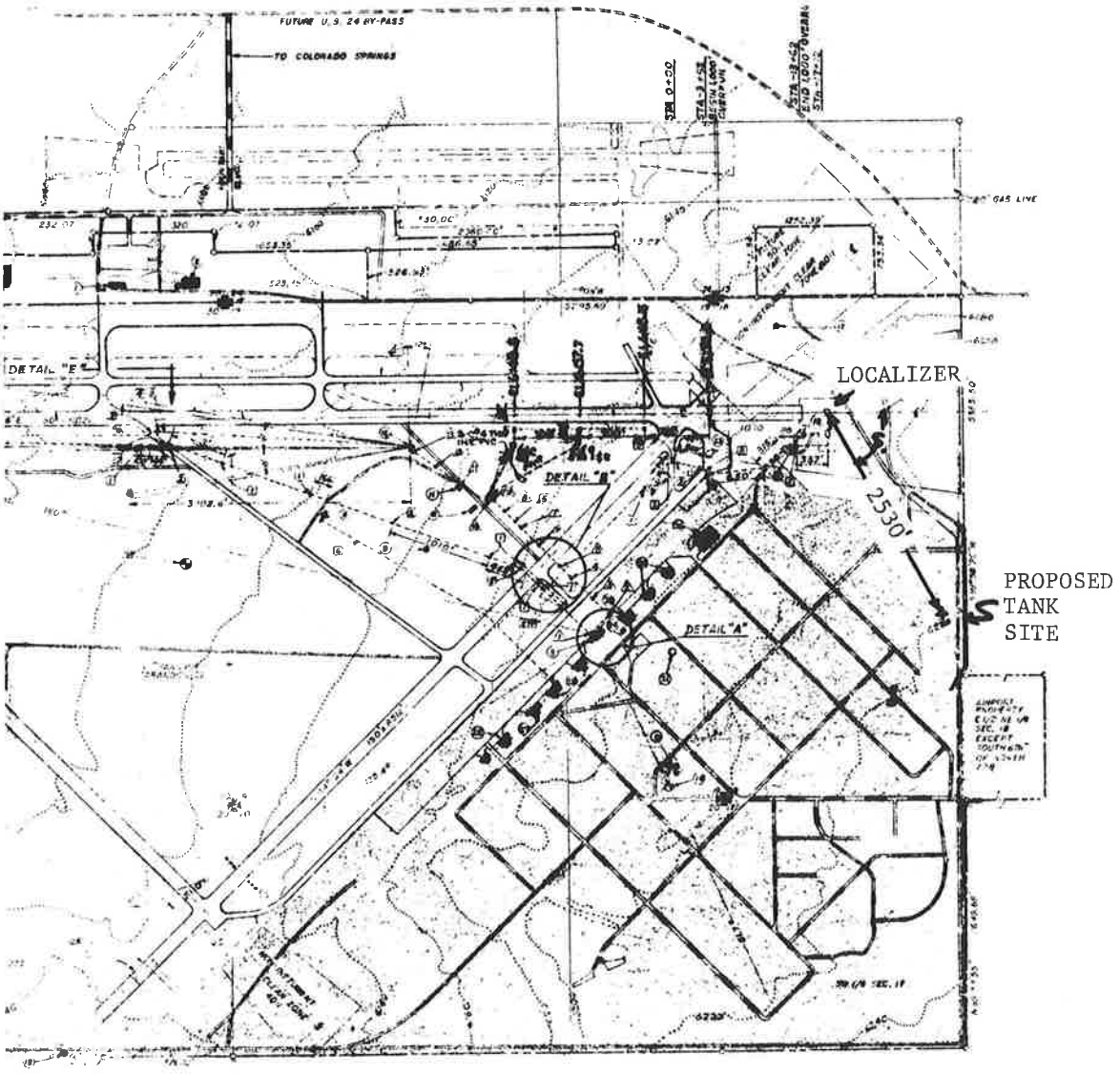

Figure 1. Airport Layout Plan Showing Location of Localizer, Runway and Proposed Water Tank Site

TABLE 1. RUNWAY DATA

Runway Number---17/35
Length---11,020 feet
Width----150 feet
Elevation on Runway Centerline

Threshold	6040 feet MSL
2000 feet	6060 feet MSL
4000 feet	6080 feet MSL
6000 feet	6100 feet MSL
8000 feet	6140 feet MSL
10,000 feet	6160 feet MSL
Stop End	6172 feet MSL

Note: Distances along runway in the above table are measured from the threshold of Runway 35.

TABLE 2. ARRAY DATA

Type----------8-Loop
Location----------1350 feet beyond stop end of Runway 35
Assigned frequency-------109.9 MHz
Course width----------3.3 degrees
Array element height above ground----6.5 feet
Elevation of array site--6190 feet MSL

TABLE 3. WATER TOWER DATA

Location----------2200 feet offset laterally
----------13,620 feet behind threshold longitudinally
----------60° from backcourse
Height of bottom--6219 feet MSL
Height of top-----6251 feet MSL
Shape and Size----5 million gallon water tank, steel-plate fabricated, cylindrical, 32 feet high 165 feet diameter.

3. RESULTS

The course structure derogation was predicted using the model under two different approximations.

The first approximation assumed the terrain to be horizontal rather than sloping. In this approximation the eight-loop antenna array and runway are assumed to be at the same mean sea level, while the water tower stands 29 feet above this level. The assumption of a discontinuous 29 foot rise in levels will produce a larger derogation than would occur in the actual case of terrain gradually rising 29 feet since the reflection from the water tower will be larger than would actually occur. It is larger because the derogation increases as the cube of the height of the reflecting object above the ground (for moderately high reflecting objects).

In order to make this approximation somewhat more realistic, the specular reflection point of the antenna was calculated and used to determine an effective horizontal plane which would contain both antenna array and runway. This horizontal plane is located 1.3 feet below the level of the ground at the base of the antenna. Thus the actual antenna height of 6.5 feet is replaced with its effective height of 7.8 feet and the actual height of 29 feet of the terrain at the water tower location is replaced by its effective height of 30.3 feet above the horizontal plane containing the base of the localizer antenna array and runway.

The resulting front course structure derogation under this approximation is shown in Figure 2. The figure shows the course deviation indication (CDI) measured in microamps for an aircraft flying from a distance of 50,000 feet from the localizer to about 10,000 feet from the localizer on a 2.75° glide path. The figure shows an almost uniform derogation along the entire flight path. This uniformity was expected from the water tower which is a uniformly scattering cylindrical object. The peak to peak amplitudes are approximately ± 7 microamps. These peak to peak excursions occur more often as the aircraft arrives closer to the scattering object, as expected.

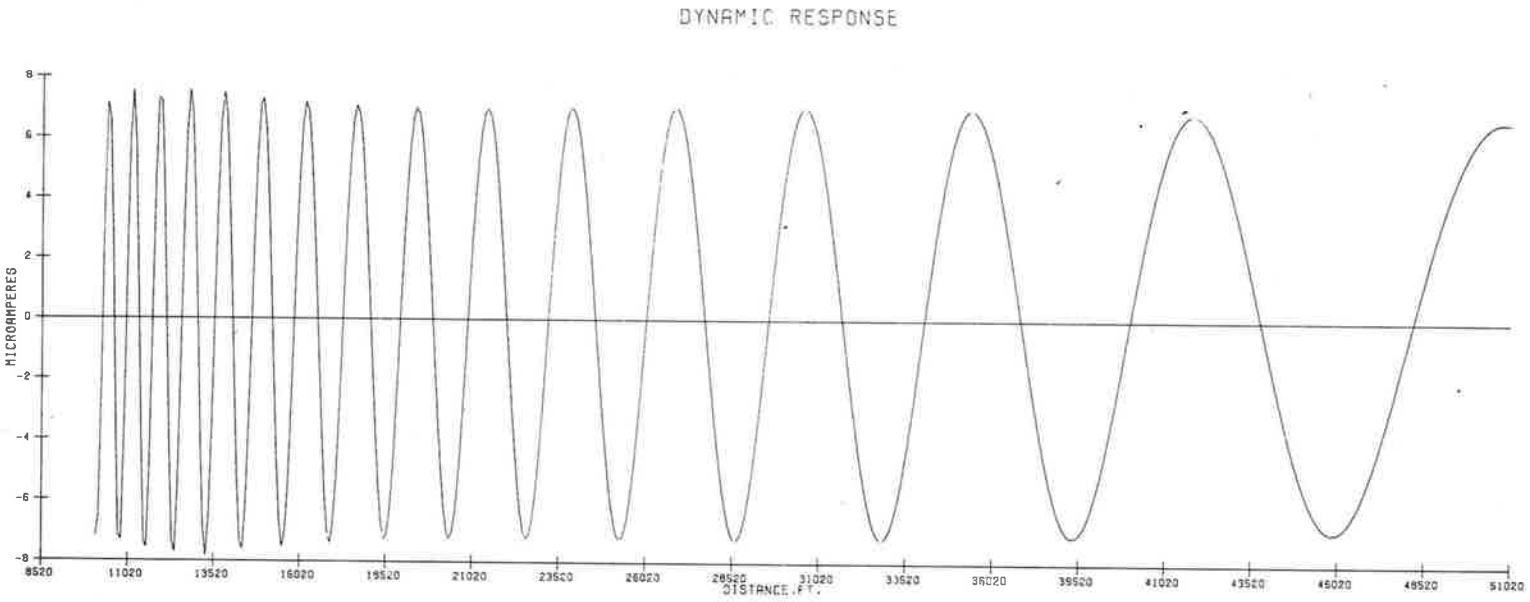

Figure 2. Front Course Structure, Horizontal Plane Approximation

Figure 3 shows the back course structure derogation for an aircraft flying the back course from 40,000 feet beyond the stop end of the runway to about 500 feet in front of it on a 2.75° glide path. Again, except for distances along the flight path which are close to the location of the water tower (located at a longitudinal distance of 2600 feet beyond the stop end of the runway), we see an almost uniform derogation. The amplitude of this derogation, however, is somewhat smaller than the front course CDI amplitude. The peak to peak amplitudes here are approximately ±4 microamps (compared to ±7 microamps for the front course). The reason for the smaller back course derogation is that the back course glide path lies essentially above the zone of direct reflections from the water tower side walls, whereas the front course path lies in the direct reflection zone. Also, because over much of the back course the angle from the course to the tower is larger than for the front course, the frequency of scalloping on the back course is generally higher.

Finally, in Figure 4 we show the results obtained from an orbit run in which the aircraft flies a 6 mile radius circle around the stop end of the runway at a height of 1000 feet. We see that the FAA requirement of at least 150 microampere deviation indication off-course is satisfied.

The derogation to the front and back course structure due to the presence of the water tower was next obtained without resort to the approximation of replacing the sloping ground with a horizontal one. The main assumption made in this second solution was to approximate the actual sloping terrain with a constant slope. In the case of the terrain between localizer and threshold, this is an excellent approximation. The eight-loop localizer antenna array stands on ground which is 150 feet higher than the ground at the threshold. The downward slope from antenna array to runway threshold is an almost uniform 0.694°. The ground at the water tower location, however, is 29 feet above the ground on which the antenna stands. Nonetheless, the downward slope between the water tower and the localizer antenna is assumed to be the same uniform 0.694°. This results in a lower ground level at the

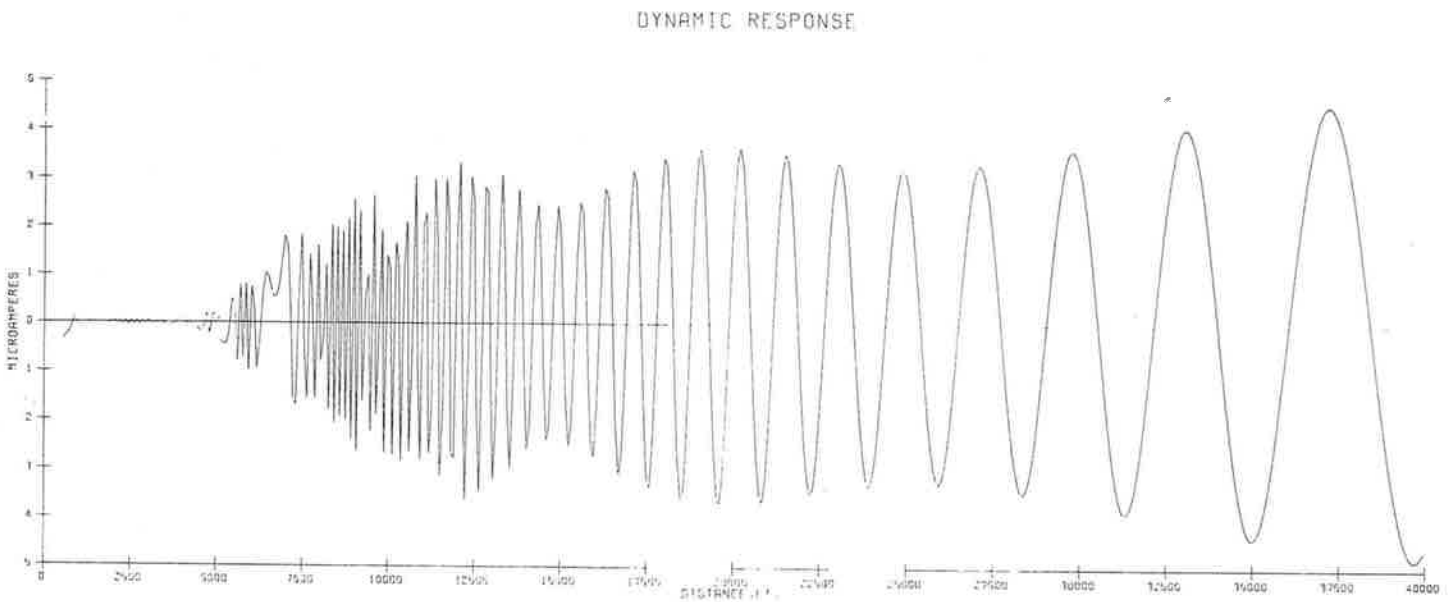

Figure 3. Back Course Structure, Horizontal Plane Approximation

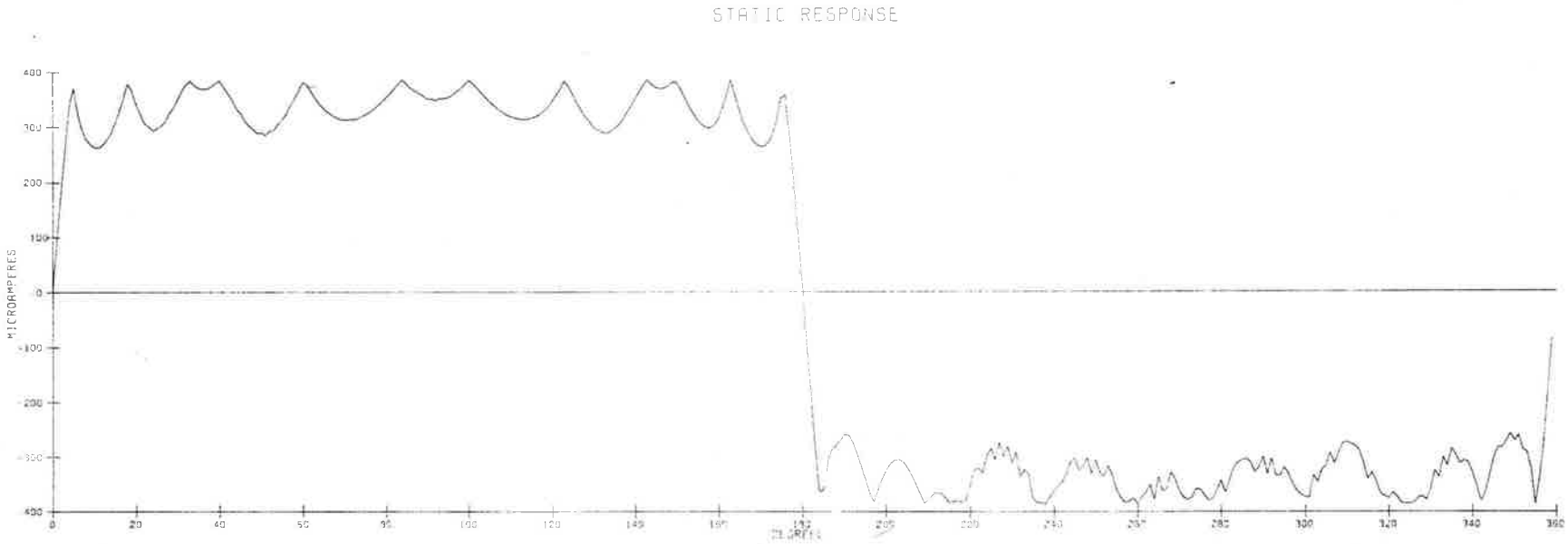

Figure 4. Orbit Run

water tower site than is actually the case. This method will therefore yield a derogation which is smaller than would be expected had the correct ground level been used. However, only slightly smaller, since the water tower in this case is situated on the ground, not above it, as was the case in the first approximation used. The cube dependence on the height, referred to above, depends upon the distance between the object and its image in the ground which is clearly larger when the object stands above the ground. Thus, even though the uniform slope approximation used here leads to a ground level at the tower site which is below that which actually occurs, the results will not differ much from the actual. In fact, this was verified by solving the problem for a slope which placed the height of the terrain at the tower site correctly relative to the ground at the antenna site (but incorrectly relative to the threshold height, of course). The results in this case are shown in Figures 5 and 6.

As seen in Figure 5, the amplitude of the derogation due to the water tower is very nearly uniform throughout the flight path in the front course (as was also found before, Figure 2). The magnitude of this peak to peak derogation is approximately ± 1.5 microamperes.

For the back course (Figure 6), the amplitude of the derogation is also very nearly uniform throughout the flight path except near the tower itself (also, as was found previously, Figure 3). The magnitude of this peak to peak derogation is approximately ± 1.5 microamperes.

These values will slightly underestimate the actual derogation, as explained above.

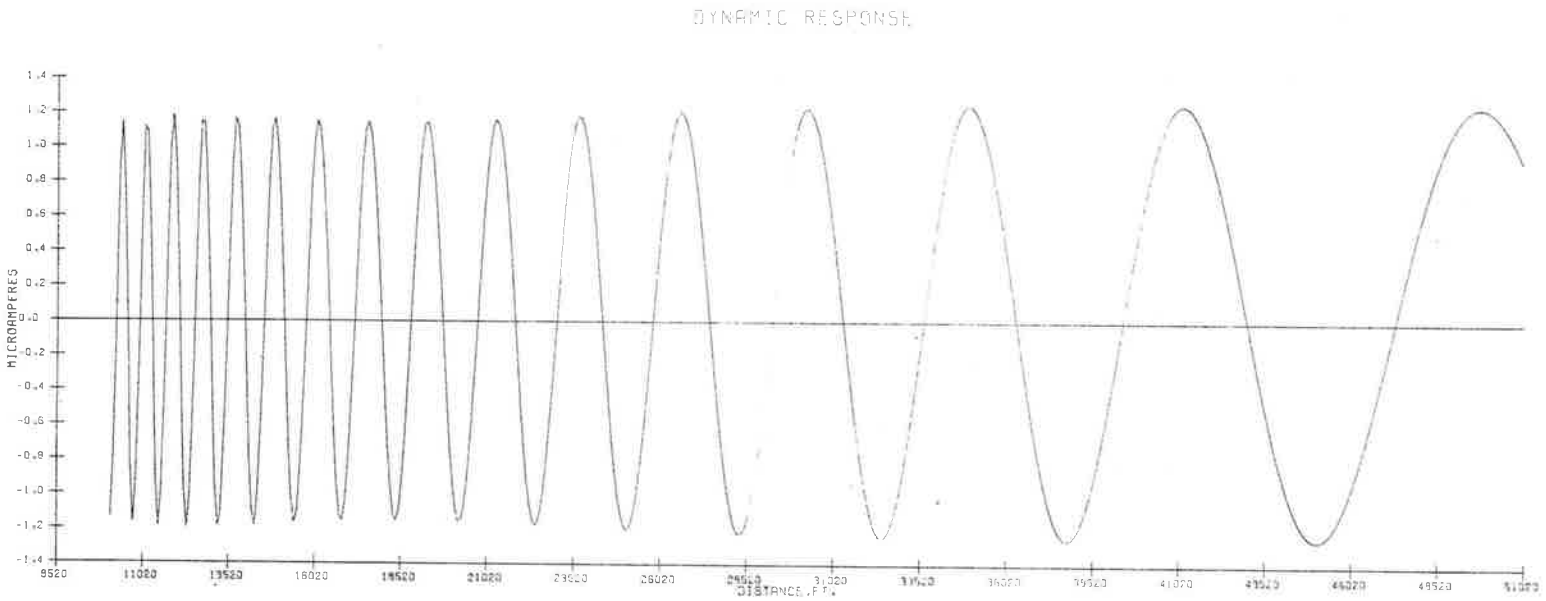

Figure 5. Front Course Structure, Uniform Slope Approximation

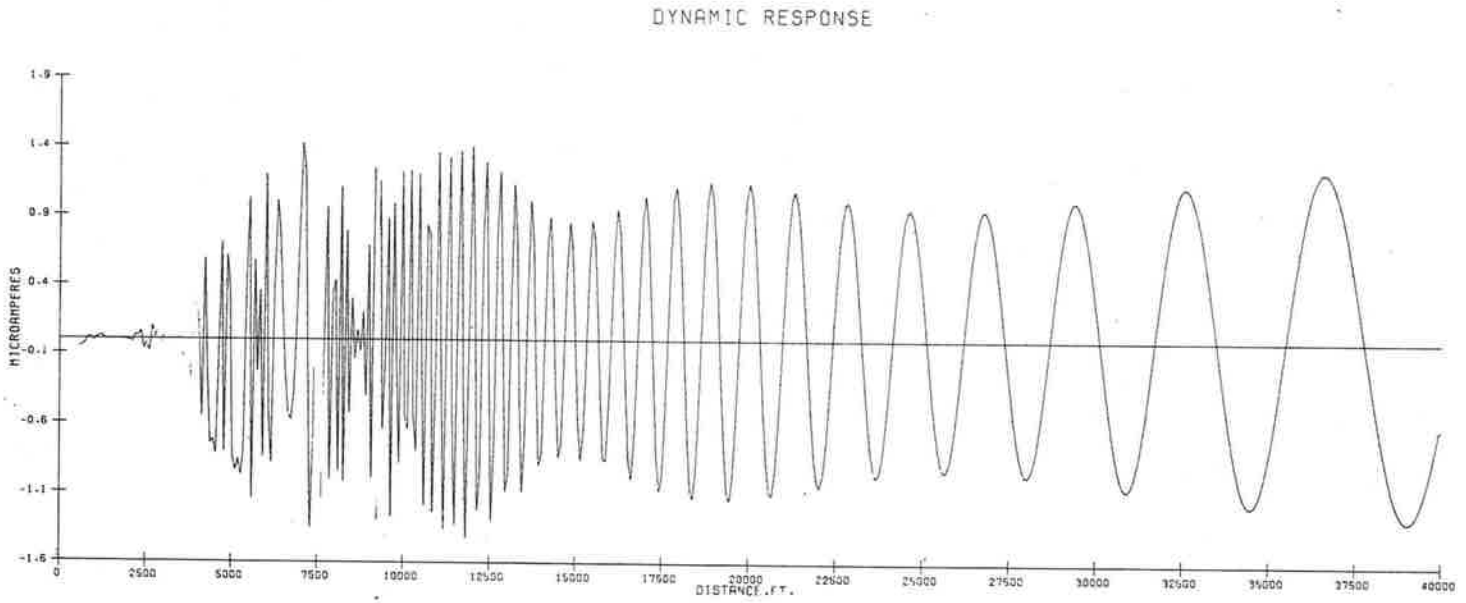

Figure 6. Back Course Structure, Uniform Slope Approximation

4. CONCLUSION

In conclusion, if the water tower is constructed at the site proposed, some derogation to both the front and back courses can be expected. The predicted range of this derogation is 1.5 to 7 microamps for the front course, and 1.5 to 4 microamps for the back course with the lower end of the range the more likely.