Interoffice

National Radio Astronomy Observatory

Green Bank, West Virginia

2/11/80

To: File February 11, 1980

From: J. Coe, S. Smith

Subject: Microwave Link Path Investigation

We have investigated a number of possible microwave link paths by searching topographic maps, plotting terrain profiles, and computing path losses. The best path appears to be from the Monterville site to Hosterman Mountain and from there to Asbury Knob and then to the control building. A double passive reflector is required on Hosterman Mountain and a single passive reflector on Asbury Knob as shown in Figure 1. The plotted profiles taken from the topographical maps show adequate path clearance. We still want to check path clearance visually using a mirror or light as soon as the weather conditions permit. However, we are sure enough of this path to use it for our planning and cost estimates.

PATH CLEARANCE REQUIREMENTS

The microwave beam travels across the surface of the earth following a path of 4/3 earth radius under normal atmospheric conditions. This bending is caused by the denser parts of the atmosphere slowing the lower portion of the microwave beam in relation to the upper part.

If part of the microwave beam travels a path that is longer than the direct path, it could arrive at the antenna out of phase with the direct wave and reduce the received signal. The zone where the indirect path is one half wavelength longer is defined as the first Fresnel Zone.

To assure adequate clearance for reliable microwave transmission, the plotted path should clear all obstructions by 1.0 Fresnel Zone radius at 4/3 earth radius or 0.3 Fresnel Zone radius at 2/3 earth radius. Using these guidelines, the path clearance required in the middle of the 14 mile link would be 60 feet. Forty feet clearance is required at 3.9 miles on the 7.8 mile path. The clearance requirement is reduced near the ends of the paths. The Fresnel Zone radii were computed for a 16 GHz frequency link. Higher frequencies would require slightly smaller path clearances.

PATH LOSS CALCULATIONS

The general method for computing path loss is to compute the sum of the losses in decibels for each leg of the microwave link path, determine the gains for each of the passive reflectors and the transmitting and receiver antennas and take the difference as the overall path loss. The losses are listed below for a link frequency of 16 GHz.

14 mile path loss Monterville to Hosterman Mt.	143.5dB
7.8 mile path loss Hosterman Mt. to Asbury Knob	138.4dB
2.2 mile path loss Asbury Knob to Control Bldg.	127.4dB
Total Path Loss	409.3dB

The passive reflector gain depends on the projected area of the reflector perpendicular to the microwave beam. the 10' x 16' double passive reflectors on Hosterman Mountain, give a gain of 111 to 114 dB depending on the distance between the reflectors. The passive reflector on Asbury Knob would have a gain of 114 dB.

If six foot diameter, parabolic antennas are used at Monterville and the control building, a gain of 47dB for each or 94dB would result. The total gains for the reflectors and antennas would be:

Double 10 x 16 Passive Reflector	111dB	(worst case)
Single 10 x 16 Passive Reflector	114dB	
2 six foot diameter antennas	94dB	
Total Reflector & Antenna Gain	319dB	
Total Path Loss	409dB	
Total Reflector & Antenna Gain	-319dB	
OVERALL PATH LOSS	90dB	

SIGNAL TO NOISE RATIO

From the overall path loss, the receiver sensitivity and the transmitter power, the signal to noise ratio can be calculated. The noise level referred to the input of the receiver with no signals present is about -93dBm. The transmitter power in a 30 MHz band would be 0.5 watts or +27 dBm at the antenna. The received power with 3dB waveguide loss would be +27 - 90 - 3 or -66 dBm. The signal to noise ratio in a 30 MHz band would be 27dB which is the difference between the receiver noise and the received signal.

FADING MARGIN

A microwave transmission system will experience signal attenuation in excess of the predicted losses during abnormal atmospheric conditions. The amount of extra loss that can be tolerated is called the fading margin. A signal to noise ratio of 17dB would be adequate for the radiometer signals. At this level 2% of the power in the 30 MHz band would be contributed by the microwave link. The fade margin for the proposed link would be 10dB. Over the rough mountainous terrain the probability of severe fading is reduced. It is expected that each link would experience fading in excess of 10dB only for about 3 hours during each year.

RAINFALL ATTENUATION

At 16 MHz the extra attenuation caused by a heavy rain (.64 inch per hour) would be about 1dB per kilometer. If the rain was occuring over the full path then the extra attenuation would be forty dB and the link would fail. It should operate in a moderate rain (.16 inch per hour) as this would cause about 8dB extra attenuation.

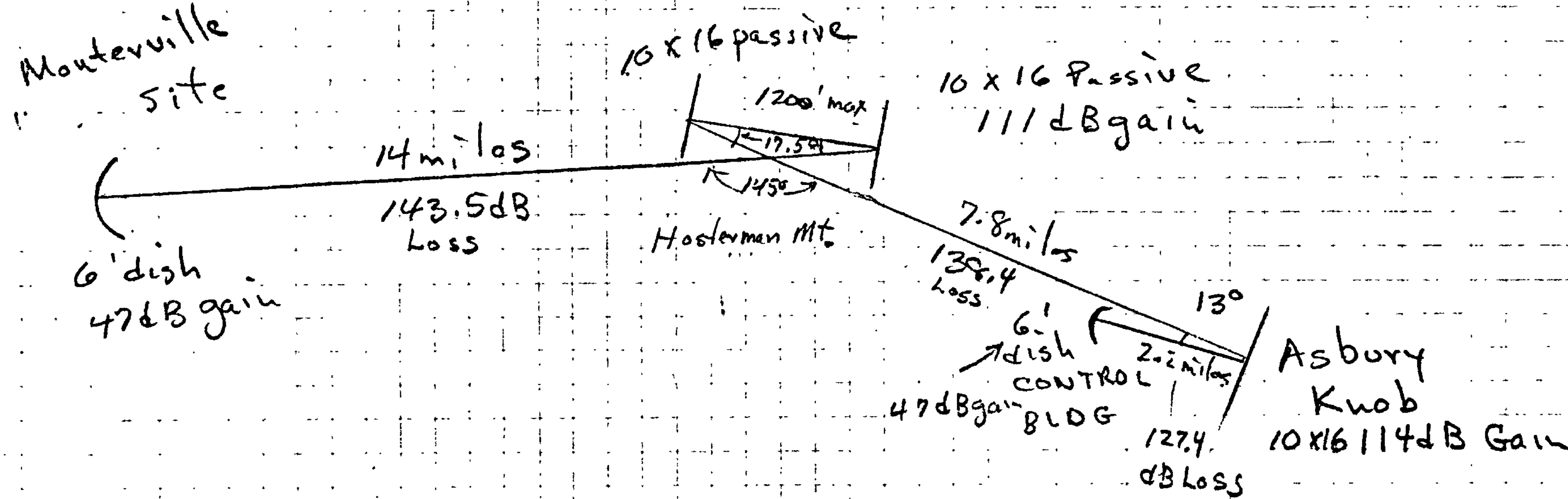
Multipath fading should not occur during rainstorms so the full 10dB margin would be available to compensate for the extra rainfall attenuation.

SUMMARY

The proposed link design should provide satisfactory operation. If it is determined that a greater signal to noise ratio is required, the diameters of the parabolic antennas at each end could be increased. If 10 foot diameter paraboloids are used the extra gain would be 9dB. Increasing the size of the passive reflectors is probably not desirable. The 10 x 16' reflector would have a half power beam width of 0.2° at 16 GHz. The 10 foot paraboloid has a beam width of 0.44°. The narrower the beam width, the more rigid the supporting structures must be to prevent wind loads from deflecting the reflectors.

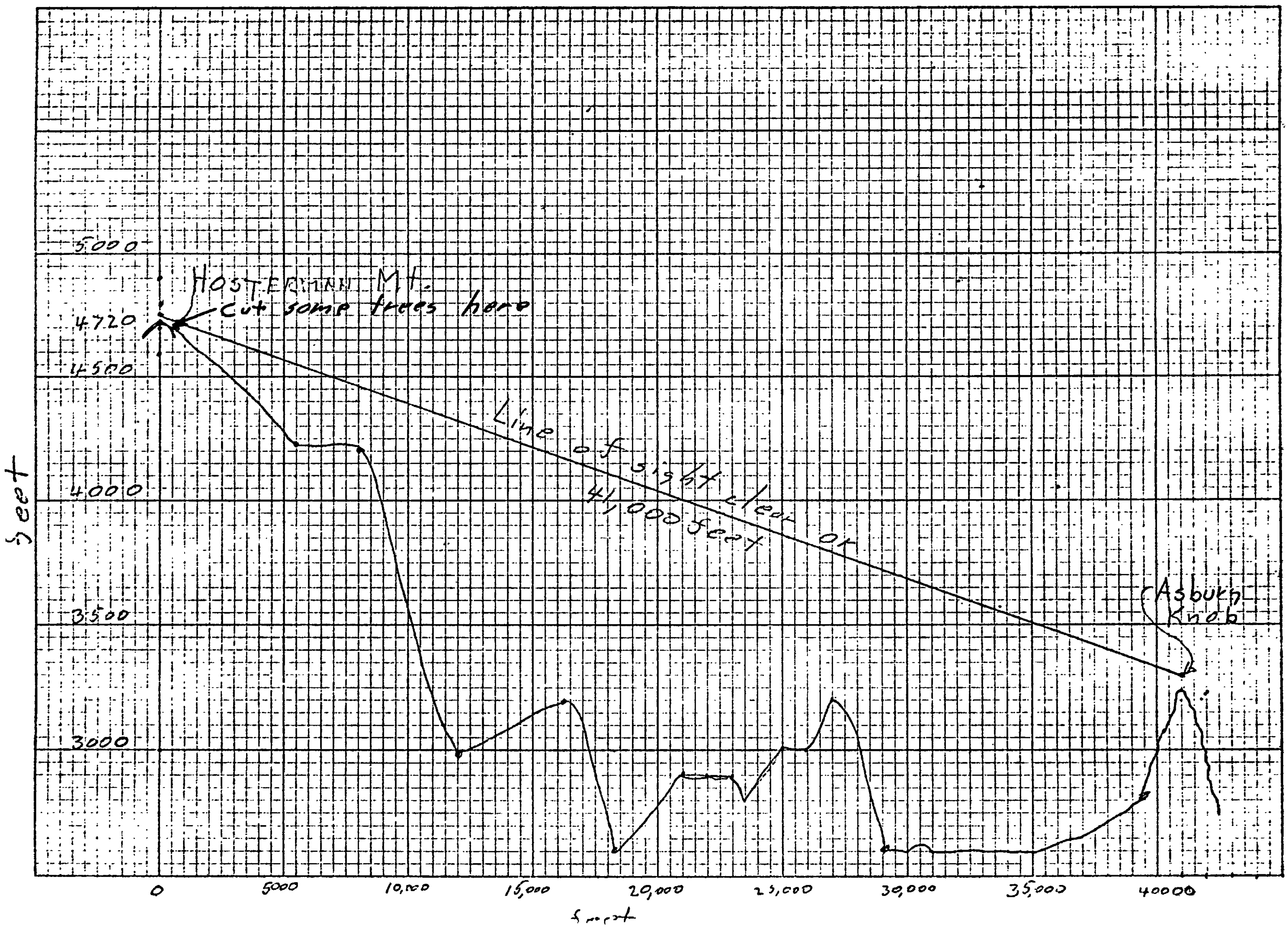
JC,SS/cz

Figure: 1 Monterville Site to Control Bldg Microwave Pat

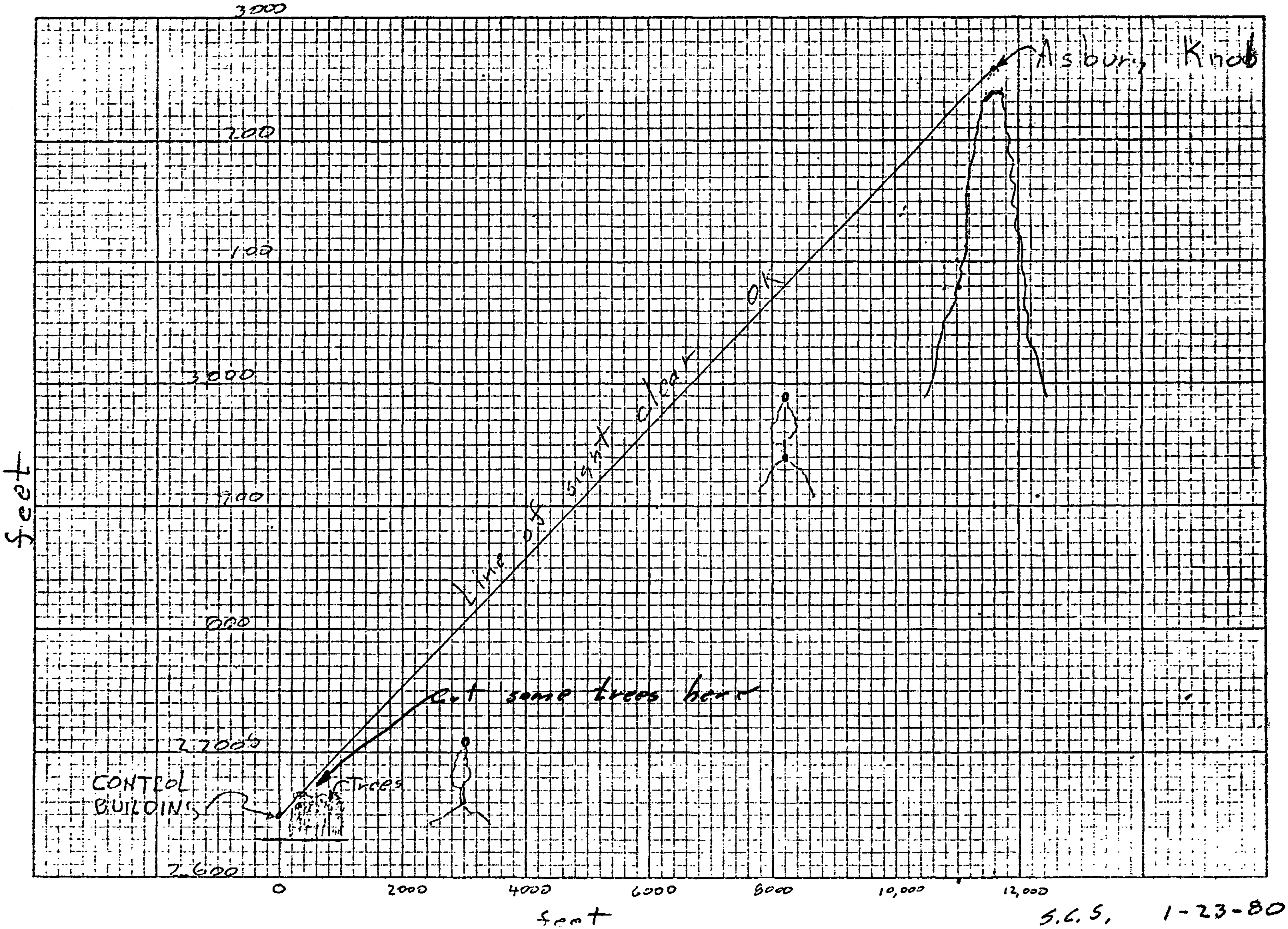


16 GHZ path Loss **90. dB**

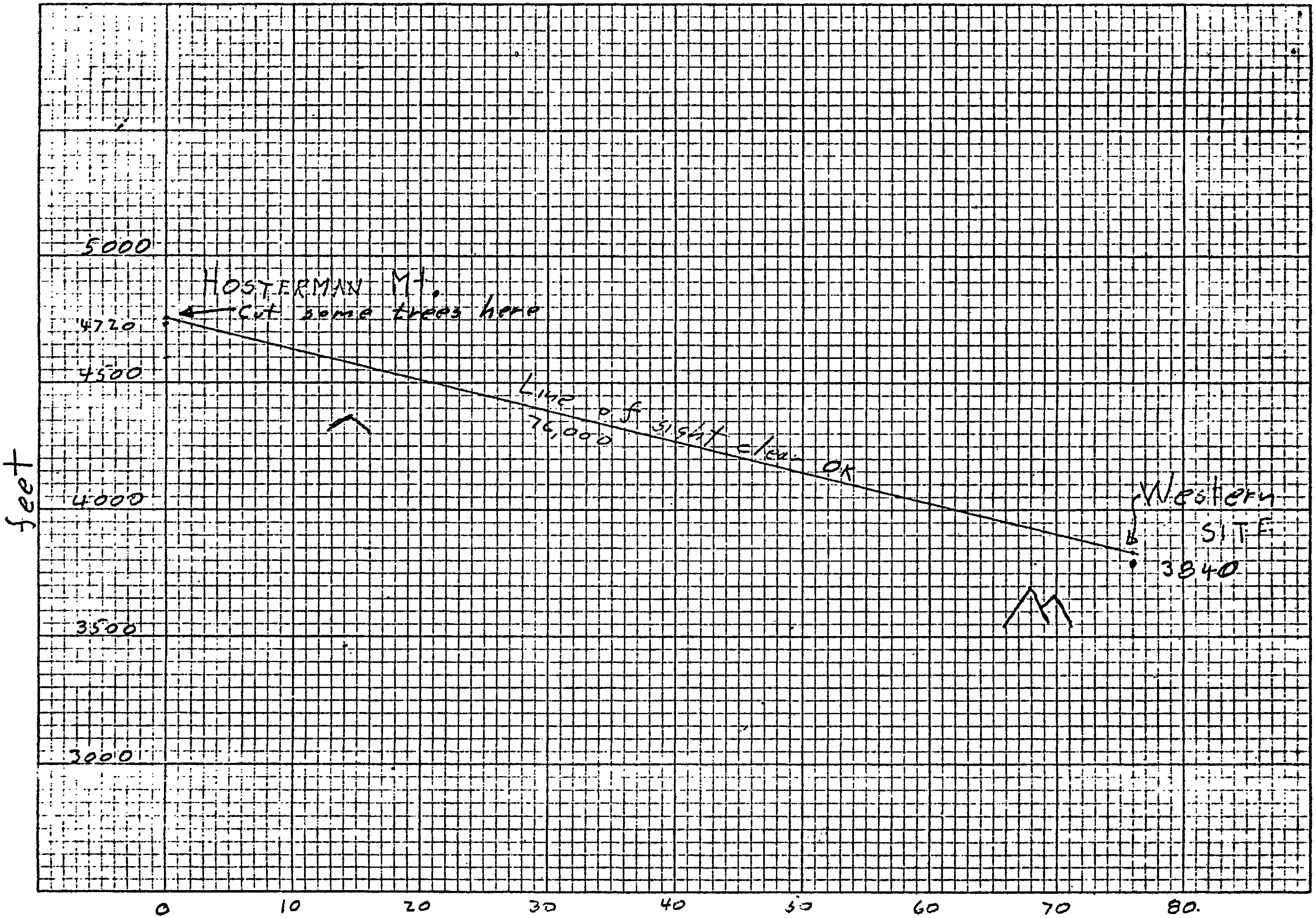
1/18/70



5000
4720
4500
4000
3500
3000
feet
HOSTERMAN Mt.
cut some trees here
Line of sight clear OK
41,000 feet
Asburn Knob
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
40000
feet



Asbury Knob
Line of sight clear OK
Cut some trees here
Trees
CONTROL BUILDING
3000
200
100
3000
700
800
2700
2600
feet
0
2000
4000
6000
8000
10,000
12,000
feet
S.C.S. 1-23-80



feet
5000
4720
4500
4000
3500
3000
HOSTERMAN Mt.
Cut some trees here
Line of sight clear OK
76,000
Western SITE
3840
0
10
20
30
40
50
60
70
80.

2-4-80

Memo

To : J. Coe
From : S. C. Smith
Subject : Passive Repeater Line No. 3 Rev. A