April 20, 1956

NATIONAL RADIO ASTRONOMY FACILITY

Green Bank, West Virginia

for

ASSOCIATED UNIVERSITIES, INC.

under grant by

NATIONAL SCIENCE FOUNDATION

EGGERS AND HIGGINS
Architects
100 East 42nd Street
New York 17, N. Y.

SYSKA AND HENNESSEY, INC.
Engineers
144 East 39th Street
New York 16, N. Y.

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(Drawings 101 to 112 Inclusive)

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Architects
100 East 42nd Street
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1. SITE AND GENERAL REQUIREMENTS FOR SAME

In connection with the Feasibility Report of May 1, 1955, there were many proposed locations for this facility. After review in the field of these proposed locations, the Green Bank, West Virginia site was selected as being the best.

The following requirements as set forth in the Feasibility Report are substantially met in this site:

a. Very low noise level at all electric frequencies; this requires a location remote from industry, radio stations, electric trains, high voltage power lines, main highways and main airline courses.

b. Natural screening and shielding against radio interference through mountains or hills, surrounding the site, except toward the south, where observations are contemplated at or near horizon level.

c. Isolated location, if possible in forest areas, to permit the establishing of a security zone around the facility.

d. Location remote from the sea to avoid corrosion and high wind velocities.

e. The area for the site should be free of hurricane and tornadoes. Wind velocity not in excess of 50 miles per hour. The area should also be free of earthquakes.

f. Reasonable accessibility:

Not more than 10 miles to nearest good road.

Not more than 20 miles to nearest railroad station.

Not more than 20 miles to nearest communities with schools, shopping centers, etc.

Not more than 30 miles to nearest airport.

2. EQUIPMENT

The equipment as listed in the Feasibility Report has been slightly modified and includes the following:

25 ft. dia. radio telescope (to be located on top of Administration and Laboratory Building).

60 ft., 140 ft., 250 ft. and 600 ft. dia. radio telescopes.

The costs of radio telescopes and their foundations have not been included in this report. (These items are being designed by others.)

The proposed locations of these telescopes are shown on Drawing 102.

3. ROADS AND PARKING

The proposed roads and parking areas are shown on Drawings 102 and 103.

It is expected that any required widening or improvement of existing black-surfaced roads (such as Route No. 28) will be done by the State of West Virginia, without charge.

Paving of existing dirt trails and roads, also new roads, on and adjacent to the site, is included in this report. Parking Area just southwest of existing school is also included.

The roads generally will be paved with 24 ft. wide asphalt penetrated macadam 8" deep. An average 2 ft. earth cut has been assumed necessary.

4. SITE DEVELOPMENT

Site development is shown on Drawings 102 and 103.

As can be noted on Drawing 102, the selected site is unusually level and until a more accurate topographical survey is made, it is assumed that some clearing and leveling at the individual facilities will be required.

The extent of rock excavation will not be known until borings and/or test pits are made.

5. FACILITIES (other than telescopes and roads):

Below is found a list of required facilities included in this report.

a. Administration and Laboratory Building (two stories and basement), providing:

Office space for the Administration
Laboratories for Instrument Testing and Repair.
Laboratories for data processing.
Laboratories for staff scientists and visiting scientists.
Provision for 25 ft. radio-telescope on roof.
Air-conditioned rooms for computers.
Library, Lounge, Conference Rooms and Assembly Room.

All as shown on Drawings 104 to 107 inclusive.

b. Residence Hall and Cafeteria (two stories and basement):

The lower level of the Residence Hall includes five apartments for visiting Scientists and families and the upper level has 20 single or double bedrooms with bath for visiting scientists and technicians without families.

The Cafeteria provides seats for a Dining Room and a Cafeteria separated with a folding partition. Further space for kitchen, serving, storage, freezers, small snack bar for employees who work late.

All as shown on Drawing 108.

c. Site Maintenance Building (one story):

Providing small garage, filling station, waiting room for drivers, locker room for employees, storage space for materials and spare parts, and shops for automobile repair, carpenters, painters, electricians, plumbers and mechanics.

All as shown on Drawing 109.

d. Radio Telescope Maintenance Building (one story):

This building will provide space for storage of a large crane, a hydraulic extension ladder and other necessary material and equipment.

It will also provide toilet, locker and rest room spaces for employees.

All as shown on Drawing 110.

e. Electric Generator Building (one story):

This building will house the generating plant for the entire facility.

All as shown on Drawing 109.

f. Radio Telescope Control Buildings (one story):

There will be control buildings provided for the 60 ft. and 140 ft. radio telescopes. (Space for control of 250 ft. and 600 ft. radio telescopes will be provided within the framework of the supporting members for these telescopes.)

All as shown on Drawing 110.

g. Residential Buildings:

Reference to Drawing 103 will indicate provision for 10 residential buildings as follows: 4 buildings to be used for permanent residences:

Director of the Radio Astronomy Facility.
Site Superintendent.
Chief Radio Telescope Operator.
Chief of Radio Telescope Maintenance.

6 residences which will be rented to visiting scientists who desire to live with their families on the site.

6. SEQUENCE OF CONSTRUCTION

Under the first step, the following construction will be included:

a. 25 ft., 60 ft. and 140 ft. radio telescopes.

b. Necessary roads providing access to the above radio telescopes, Administration Building, Maintenance Building and electric generator plant.

c. Construction of center portion of Administration Building temporarily re-arranged to include a Cafeteria.

d. A portion of Radio-Telescope Maintenance Building.

e. First section of building to house electric generator plant.

f. Control Buildings for 60 ft. and 140 ft. radio telescopes.

g. Repair and remodeling of 4 existing residences to be used temporarily in lieu of residence hall.

The second step of this program is expected to be accomplished over a period of five years in several parts.

7. BUDGET ESTIMATE (Not including land acquisition, borings, telescopes and their foundations).

Prices are based on experience, information obtained from engineers and contractors and on estimates of similar construction work published in technical literature for remote locations such as this.

Fees for architects, engineers, consultants, and legal work are not included.

First Step

a. Topographical survey (approximately 500 acres at $25 per acre) and water tests . . . . . $ 17,000.

b. Re-building existing dirt road to 140 ft. telescope from Route No. 28 northwesterly to beginning of "S" turn (see Drawing No. 102) with 24 ft. wide by 8" deep, asphalt penetrated macadam.

2/3 mile at $60,000 per mile . . . . . 40,000.

c. Build on-site roads per Drawing 102, 24 ft. wide by 8" deep asphalt penetrated macadam.

1-5/6 miles at $70,000 per mile. . . . . 128,800.

d. Parking (black top) at various facilities and paving of utility area.

7,000 square yards at $3.25 per square yard. . 22,800.

e. Necessary site clearing at each facility.

Approximate total of 70 acres at $300. per acre . . . . . 21,000.

f. Construction of center portion of Administration and Laboratory Building temporarily rearranged to include Cafeteria.

245,000 cubic feet at $1.80 per cubic foot . . 441,000.

g. First portion of radio telescope Maintenance Building.

67,500 cubic feet at $1.00 per cubic foot. . . 67,500.

h. First portion of electric generator building.

27,200 cubic feet at $1.10 per cubic foot. . . 30,000.

i. Two Control Buildings for 60 ft. and 140 ft. radio telescopes.

11,100 cubic feet each at $1.50 per cubic foot . . . . . 33,300.

j. Repair and remodeling of four existing residences to be used temporarily in lieu of residence hall.

Approximately $5,000 each. . . . . 20,000.

k. Furniture and equipment for the above buildings. . . . . $ 20,000.

l. Mechanical and electrical items from Summary of attached Syska & Hennessey report.

Telephones (Item Ia(1)).	18,000.
Site generated power (Item Ia(2)).	400,000.
Sanitary Work, etc. (Item Ia(3))	200,000.
Installing underground, existing electric lines within radius of 5 miles of the site (Ia(4))	1,570,000.
(First Step) -- Total	$3,029,400.
If Alternate Scheme #1 is used (Item Ia(5)) add $65,000. making a total of	$3,094,400.
If Alternate Scheme #2 is used (Item Ia(6)) add $125,000. more making a total of.	$3,219,400.
If Alternate Scheme #3 is used (Item Ia(7)) add $225,000. more making a total of.	$3,444,400.

Second Step

NOTE: General Construction and building costs have been increasing for a good many years and the rise for the past five years has been a total of 26% and 22% respectively.

m. Rebuilding existing dirt roads to 600 ft. radio telescope from beginning of "S" turn (see Drawing No. 102) to point of departure from existing dirt road, with 24 ft. wide by 8 inches deep asphalt penetrated macadam.

1/3 mile at $60,000. per mile . . . . . $ 20,000.

n. Building on-site roads to 250 ft. and 600 ft. telescopes, and Residence Hall, per Drawing No. 102, with 24 ft. wide by 8 inches deep asphalt penetrated macadam.

1-1/2 miles at $70,000. per mile. . . . . 105,000.

o. Parking (black top) at 250 ft., 600 ft., telescopes and Residence Hall, also 12 ft. wide driveways for ten residences.

3,200 square yards at $3.25 per square yard. . . . . 10,400.

p. Site Clearing for 250 ft. and 600 ft. telescopes, Residence Hall and ten residences

Approximately 60 acres at $300. per acre		$ 18,000.

q. Construction of remaining portion of Administration and Laboratory Building to complete building in accordance with Drawings Nos. 105 to 107 inclusive.

425,000 cubic feet at $1.80 per cubic foot	$765,000.	
4,000 square feet of air-conditioning at $3. per square foot.	12,000.	777,000.

r. Construction of Residence Hall and Cafeteria in accordance with Drawing No. 108.

300,000 cubic feet at $1.50 per cubic foot	450,000.

Note: If any portion of the Residence Hall is omitted, the above cost should be reduced at the rate of $1.35 per cubic foot of space omitted.

s. Construction of Site Maintenance Building in accordance with Drawing No. 109.

185,000 cubic feet at $1.25 per cubic foot..	231,000.

t. Construction of remaining portion of radio telescope Maintenance Building to complete building in accordance with ultimate building shown on Drawing No. 110.

185,000 cubic feet at $1.00 per cubic foot	185,000.

u. Construction of remaining portion of electric generator building to complete ultimate building in accordance with Drawing No. 109.

60,000 cubic feet at $1.25 per cubic foot	75,000.

v. Construction of ten residential buildings.

14,000 square feet at $15 per square foot	210,000.

w. Furniture and equipment for the above portion of program (except residential buildings). .	$ 75,000.
x. Mechanical and electrical items from Summary of attached Syska & Hennessey report.	
Telephones (Item Ib(1)).	16,000.
Site generated power (Item Ib(2)).	684,000.
Sanitary Work, etc. (Item Ib(3))	135,000.
(Second Step) -- Total	$2,991,400.
If power supply is obtained from the Utility Company under the first step (Ib(4)) deduct $197,000. making a total of	$2,794,400.

8. GRAND TOTAL BUDGET ESTIMATE FOR SITE GENERATED POWER

First Step	$3,029,400.
Second Step.	2,991,400.
GRAND TOTAL	$6,020,800.

April 20, 1956

NATIONAL RADIO ASTRONOMY FACILITY

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ASSOCIATED UNIVERSITIES, INC.

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Mechanical and Electrical Items

SYSKA AND HENNESSEY, INC.
Engineers
144 East 39th Street
New York 16, N. Y.

A. First Step - 25 ft., 60 ft., and 140 ft. Radio Telescopes

I. HEATING, VENTILATING AND AIR CONDITIONING

No Air Conditioning has been included for the First Step. The heating costs have been included in the unit costs for each of the Buildings.

II. TELEPHONE SERVICE AND DISTRIBUTION SYSTEM

a. Basis of Design

The following assumptions have been made with regard to the telephone system:

(1) The service from the Pocahontas Telephone Company will be available at the site, and will run underground from a point on Route 28 near the existing school to the Administration Building and from there to the 140' and 60' telescopes to the Generator Building and to the Radio Telescope Maintenance Building.

(2) Provision has been made only for the underground conduit and manholes as the Telephone Company will furnish and install the wire and equipment.

(3) The telephone switchboard will be located in the Administration Building.

(4) The cost of telephone outlets has been included in the unit costs for each building.

b. Telephone System

Public Telephone Service will be supplied by the Telephone Company in conduit provided by the Owner.

The service and distribution conduit will be fibre conduit to and from the telephone switchboard in the Administration Building. The conduit will be run in a common trench with power lines maintaining a 12" horizontal separation wherever possible.

c. Cost Estimates

The excavation and backfill costs have been included in these estimates at $2.00 a cubic yard for earth and $20.00 a cubic yard for rock. It has been assumed that there will be 50% rock.

The following are the costs:

(1) Telephone System

8,500 L.F. fibre conduit @ $.75 per foot.	$ 6,400.
Four (4) manholes @ $500.00	2,000.

NOTE: For combination power and telephone manholes, see Power System.

(2) Excavation for Telephone System

425 cubic yards earth @ $2.00	$ 850.
425 cubic yards rock @ $20.00	8,500.
Total. . . .	$17,750.
Say. . . .	$18,000.

III. ELECTRIC POWER

a. Basis of Design

(1) Power will be generated on the site using three (3) 395 KW diesel generators, two (2) for full demand load and one (1) for standby. When elevation and azimuth motors for 140' telescope are not in operation, one of the two (2) normally operating generators may be shut down.

(2) The Primary Distribution will be at 4160 volts and the Secondary Distribution will be at 120/208 volts.

(3) The demand load for the first step of the facility will be approximately 575 KW.

(4) Electric Capacity has been provided for the use of electric ranges in the Administration Building Cafeteria.

(5) The 140' Telescope will require four (4) 40 HP motors to rotate it horizontally and four (4) 40 HP motors to rotate it vertically. It is assumed all motors will operate simultaneously and will be started in two (2) groups each with four (4) 40 HP motors.

(6) The 60' Telescope will require 8 HP.

(7) Both telescopes will operate at one time.

b. Electrical Service and Distribution

It is proposed as previously stated that there will be two (2) basic voltages on the site.

(1) 4160 volt Primary Distribution.

(2) 120/208 volt Secondary Distribution.

The 4160 volt supply will be generated by two of the three diesel generators and distributed to unit substations and transformers in the following locations to be transformed for use in the Secondary Distribution System:

(3) Radio Telescope Maintenance Building - 1 - 50 KVA Indoor Unit Substation.

(4) 140' Telescope - 1 - 500 KVA Outdoor Unit Substation.

(5) 60' Telescope - 1 - 50 KVA Outdoor Unit Substation.

(6) Administration Building - 1 - 225 KVA Indoor Unit Substation.

The Radio Telescope Maintenance Building and the Administration Building will each have its own power distribution panels. A motor-generator set at each telescope will supply 5 KW of regulated power

The distribution cable will be shielded so as to provide minimum interference and lead sheathed to provide maximum protection. The distribution conduit will be of fibre construction with heavy wall for direct burial and thin wall for concrete encased. Outside manholes will be of reinforced concrete in the sizes required.

c. Cost Estimates

It has been assumed that excavation and backfill will be 50% earth and 50% rock at a cost of $2.00 per cubic yard of earth and $20.00 per cubic yard of rock. The estimate includes

radio-interference elimination filters for distribution wiring, double wire mesh screening for all electrical equipment as required and special radio noise elimination construction for the diesel generators. Approximately 8,000 square feet of screening has been assumed. Electrical work inside the buildings have been included in the General Construction costs except that the transformer, switchgear, substations, large distribution panels, diesel generators and their associated equipment have been included in this cost estimate.

(1) Power System

13,000 L.F. fibre conduit @ $.75 per foot	$ 9,750.
Fourteen (14) manholes @ $1,200.00	16,800.
8,000 L.F. 5 KV cable @ $2.10 per foot	16,800.
1,200 L.F. 600 volt cable @ $6.00 per foot	7,200.
Substations, transformers and switchgear	111,000.
8,000 sq. ft. of shielding @ $1.00 per sq. ft.	8,000.
Filtering	20,000.
Two (2) Distribution panels @ $500.00	1,000.
Motor Controllers, mounting and connections	1,200.
Motor connections	600.
Weatherproof disconnect switches	4,000.
Three (3) 395 KW diesel generators, generating station	154,000.
Two (2) 5 KW motor-generators	2,000.

(2) Excavation for Power System

400 cubic yards earth @ $2.00	800.
400 cubic yards rock @ $20.00	8,000.
	$361,150.
10% Contingency	36,115.
Sub-Total	$397,265.
Say	$400,000.

(3) Preliminary cost estimate by Monongahela Power Company for installing underground, existing overhead high voltage lines within a 5-mile radius of the site.

.7 miles of three phase 12 KV lines. . . . . .$810,000.
34 miles of one phase 7.2 KV lines . . . . . 760,000.

NOTE: The Utility Company will also require an annual fee of approximately 7-1/2% of plant cost for additional maintenance and amortization for the underground system. $1,570,000.

Total . . . .$1,970,000.

(4) Estimated annual cost of site generated power . .$ 36,000.

(5) Alternate Power Scheme No. 1

(Main substation and Standby Generator Building located between 140' and 600' telescope sites and underground service entering site from the Northwest across Little Mountain.)

The alternate power system includes obtaining a 12 KV primary supply from the Monongahela Power Company and one (1) - 500 KW standby generator.

The service from the Utility Company would include capacity for the ultimate site demand of between 1500 and 2000 KVA with short time peaks of an additional 1000 KVA.

(a) Preliminary cost estimate by Monongahela Power Company for bringing underground power service to the site. (Cost to be paid in a lump sum or if underground installation is owned by power company they would charge 1-1/4% per month.) . . . . . $ 150,000.
(b) One (1) - 500 KW standby generator . . . . . 68,000.
(c) Site distribution system as outlined under basic system . . . . . 243,265.

Total. . . $ 461,265.

Say. . . $ 465,000.

(6) Estimated annual cost of purchased power plus 500 KW standby capacity under Alternate Power Scheme No. 1.
(a) Facilities charge covering installation & maintenance of Power Co. owned primary lines exclusively for site. . $ 42,750.
(b) Energy Charge. . . . 14,000.
(c) 500 KW standby generator . . . . . 11,000.

Sub-Total $ 67,750.

Say $ 68,000.

(d) Annual charge if Utility Company installs and owns underground section of service ($150,000 @ 15%). $ 22,500.

Estimated Total Annual Charge. . . . $ 90,500.

Say. . . . $ 90,000.

(7) Alternate Power Scheme No. 2

Alternate Scheme No. 2 is the same as Alternate Scheme No. 1 except that the main substation and standby generator would be located near the Site Maintenance Building.

(a) Estimated initial cost for Scheme No. 1. . . . . $ 465,000.

(b) Estimated additional cost to extend underground service to main substation near Radio Telescope Maintenance Building. . . . . 125,000.

Total. . . . $ 590,000.

(8) Estimated annual cost of purchased power plus 500 KW standby capacity with Alternate Power Scheme No. 2.

(a) Estimated annual cost for Scheme No. 1 . . . . . $ 90,000.

(b) Estimated additional annual charge if Utility Company installs and owns additional underground service ($125,000 @ 15%). . . . . 18,750.

Estimated Total Annual Charge. . . . $108,750.

Say. . . . $109,000.

(9) Alternate Power Scheme No. 3

Alternate Scheme No. 3 is the same as Alternate Scheme No. 2 except that the underground service would enter the site from the Northwest, starting underground at a point about five miles north of Green Bank.

(a) Preliminary cost estimate by Monongahela Power Company for bringing underground power service to the site with substation located near Site Maintenance Building. . . . . $500,000.

(b) One (1) 500 KW standby generator . . . . . 68,000.

(c) Site distribution system as outlined under basic system . . . 243,265.

Total. . . . $811,265.

Say. . . . $815,000.

(10) Estimated annual cost of purchased power plus 500 KW standby capacity with Alternate Scheme No. 3.

(a) Facilities charge covering installation and maintenance of Utility Company owned primary lines exclusively for the site.	$ 39,000.
(b) Energy charge. . .	14,000.
(c) 500 KW standby generator	11,000.
Sub-Total. . .	$ 64,000.
(d) Annual charge if Utility Company installs and owns underground section of service ($500,000 @ 15%).	$ 75,000.
Estimated Total Annual Charge. . .	$139,000.
Say. . .	$140,000.

IV. SANITARY

a. Basis of Design

(1) The sanitary drainage system is designed for 75 people. The ground has been assumed to be impervious enough to preclude percolation of sanitary wastes for the large building. One septic tank and one filter bed will be provided for the Administration Building with chlorine equipment for the entire project. The Site Maintenance Building will have an individual small sanitary waste disposal system to adjacent ground.

(2) The storm water drainage system will drain the roof areas of the building with interior leaders and discharge through sewers to adjacent stream.

(3) Laboratory acid waste water will flow through a neutralizing sump before discharging to the storm water sewer.

(4) The water supply system will be from wells supplying an elevated storage tank. The elevated storage tank capacity is for an estimated two-day supply for the entire project. It has been assumed that two wells, each 150 feet deep, will supply the initial water demand and the water will require treatment for domestic and laboratory use.

(5) "Bottle" gas will be supplied for domestic and laboratory use from an underground tank having an estimated 30-day supply for the entire project.

(6) Drainage sewers and water and gas mains will be installed, and where common with future buildings, will be sized for the entire project.

(7) The excavation and backfill is estimated at $2.00 a cubic yard for earth and $20.00 a cubic yard for rock. It has been assumed that there will be 50% rock.

b. Cost Estimate

(1)	Drainage Systems:		
	2500 L.F. Sewer Piping @ $3.00	$ 7,500.	
	10 Manholes @ $350.	3,500.	
	1 Septic Tank	3,500.	
	2000 sq. ft. Sand Filter @ $4.00	8,000.	
	1 Chlorinator	500.	
	2 Chlorine Pull Boxes @ $25.00	50.	
	1000 C.F. Chlorine Conduit @ $1.00	1,000.	
	1 Neutralizing Sump	350.	
	1 Individual Disposal System	600.	
			$ 25,000.
(2)	Water Supply System:		
	5000 L.F. Water Piping @ $10.00	$50,000.	
	2 Wells @ $1,500.	3,000.	
	2 Well Pumps @ $1,250	2,500.	
	2 Well Houses @ $500.	1,000.	
	Water Treatment	7,000.	
	1 Water Tank on Tower	32,000.	
			95,500.
(3)	Gas System:		
	1 Storage Tank.	$ 500.	
	1000 L.F. Gas Piping @ $2.00	2,000.	
			2,500.
(4)	Excavation:		
	2500 Cubic Yards Earth $2.00	$ 5,000.	
	2500 Cubic Yards Rock @ $20.00	50,000.	
			55,000.
	Total		$178,000.
	10% Contingencies		17,800.
	Grand Total		$195,800.
	Say		$200,000.

B. Second Step - 250 ft. and 600 ft. Radio Telescopes

I. HEATING, VENTILATING AND AIR CONDITIONING

a. Heating System

It is proposed that all buildings will have their own individual boiler plant for heating purposes.

b. Ventilation

Ventilation systems will be installed where required and no air conditioning is provided.

c. Air Conditioning

It is presently proposed to air condition such areas that require accurate temperature and humidity control such as the Control Buildings, the Electronic Computer Section and the Data Processing Laboratory. The units in the Administration Building that are air conditioned will be done from a central system located in the basement of that building, while the Control Buildings will be conditioned by means of self-contained units in their own building.

d. Cost Estimates

The costs for the required facilities have been included in the unit costs for each of the Buildings.

II. TELEPHONE SERVICE AND DISTRIBUTION SYSTEM

a. Basis of Design

The following assumptions have been made with regard to extending the telephone system for the Second Step.

(1) The distribution system will be extended from the 140' telescope to the 600' telescope, from the Administration Building to the Cafeteria Building and adjacent residences and from the Generator Building to the adjacent residences, to the Site Maintenance Building and to the 250' telescope.

b. Telephone System

The system for the Second Step will merely be an extension of the basic system established in the First Step.

c. Cost Estimates

The cost estimates for this step are on the same basis as those for the First Step. The following are the costs:

(1) Telephone System

8,500 L.F. Fibre conduit
@ $.75 per foot . . . . . $ 6,400.

NOTE: For manholes see Power System.

(2) Excavation for Telephone System

425 cubic yards earth @ $2.00	850.
425 cubic yards rock @ $20.00	8,500.
Total . . .	$15,750.
Say . . .	$16,000.

III. ELECTRIC POWER

a. Basis of Design

(1) Power will be generated on the site using two 1,000 KW diesel generators and one 1,000 KW standby unit in addition to the three 395 KW generators proposed for the first step. As approximately 80% of the site demand load is elevation and azimuth motors for the telescopes, the number of generators operating at any one time is dependent upon the usage of these motors.

(2) The demand load of the facility will be between 1,500 and 2,000 KVA with short time peaks of an additional 1,000 KVA.

(3) The 250' telescope will require 600 HP.

(4) The 600' telescope will require 8 - 50 HP motors to rotate it horizontally and 4 - 150 HP motors to rotate it vertically. Each group will start as a unit.

(5) It is assumed that the maximum load condition will occur when all telescope motors are operating except the 4 - 150 HP motors which will be starting.

b. Electrical Service and Distribution

The distribution voltages will remain the same for the Second Step. The 4,160 volt supply will be distributed to unit substations and transformers in the following additional locations to be transformed for use in the Secondary Distribution System:

(1) 250' Telescope - 750 KVA Outdoor Unit Substation.

(2) 600' Telescope - 1,500 KVA Outdoor Unit Substation.

(3) Site Maintenance Building - 75 KVA Indoor Unit Substation.

(4) Cafeteria Building - 150 KVA Indoor Unit Substation.

(5) Administration Building - An additional 225 KVA Indoor Unit Substation.

(6) Residences - 2 - 50 KVA subway type transformers, one at each group of houses.

The site Maintenance Building and Cafeteria Building will each have its own power distribution panels. A motor-generator set at each of the additional telescopes will supply 5 KW of regulated power.

The additional distribution cable, conduit and manholes will be the same as those specified for the First Step.

c. Cost Estimates

The cost estimate for the Second Step is based on the same general assumptions used for the First Step. Approximately 15,000 square feet of additional screening has been assumed.

(1) Power System

13,000 LF. Fibre conduit @ $.75 per foot.	$ 9,750.
Fifteen (15) manholes @ $1,200	18,000.
8,000 L.F. 5 KV cable @ $2.10 per foot	16,800.
6,000 L.F. 600 volt cable @ $6.00 per foot	36,000.
Substations, transformers and switchgear	150,000.
15,000 square feet of shielding @ $1.00 per square foot.	15,000.
Filtering.	10,000.
4 Distribution panels @ $500	2,000.
Motor controllers, mounting and connections.	2,400.
Motor connections.	1,200.
Weatherproof disconnect switches . .	8,000.
Three 1,000 KW diesel generators, generating station	385,000.
Two 5 KW motor - generators.	2,000.
40 Street lighting units @ $500. . .	20,000.

(2) Excavation for Power System

360 cubic yards earth @ $2.00. . . .	720.
360 cubic yards rock @ $20.00. . . .	7,200.
Total. . .	$684,070.
Say. . .	$684,000.

(3) Estimated Annual Cost of Site generated power (for Second Step installation only). . . . . $70,000.

(4) Alternate Power Scheme No.1:
The ultimate site capacity was included under the First Step. The load added under Second Step will require an additional 1,500 KW generator. . . . . $188,000.

(5) Estimated annual cost of purchased power for load added under Second Step plus added 1,500 KW standby capacity:

(a)	Energy Charge	$48,000.
(b)	1,500 KW standby generator	20,000.
		$68,000.

IV. SANITARY

a. Basis of Design

(1) The sanitary drainage system is designed for 200 additional people. The ground has been assumed to be impervious enough to preclude percolation of sanitary wastes from the larger buildings. One septic tank and three filter beds will be added to the initial installation. The smaller buildings will have individual small sanitary waste disposal systems to adjacent ground.

(2) The storm water drainage system will drain the roof areas of the larger buildings and discharge to the storm water sewers. The smaller buildings will discharge the storm water onto the ground.

(3) The water supply system will be increased and extended for the additional buildings. It has been assumed that two additional wells will be necessary, with additional water treatment equipment.

(4) The gas system will be extended for the additional buildings.

b. Cost Estimate

(1) Drainage Systems:

3,000 L.F. Sewer Piping @ $3.00	$ 9,000.	
4 Manholes @ $350	1,400.	
1 Septic Tank	3,500.	
6,000 Square Feet Sand Filter @ $4.00	24,000.	
10 Individual Disposal Systems @ $600	6,000.	
		$43,900.

(2)	Water Supply System:		
	2,000 L.F. Water Piping @ $10.00	$20,000.	
	2 Wells @ $1,500. . . .	3,000.	
	2 Well Pumps @ $1,250 .	2,500.	
	2 Well Houses @ $500. .	1,000.	
	Water Treatment . . .	7,000.	
			$ 33,500.
(3)	Gas System:		
	3,500 L.F. Gas Piping @ $2.00	$ 7,000.	7,000.
(4)	Excavation:		
	1,600 Cubic Yards Earth @ $2.00	$ 3,200.	
	1,600 Cubic Yards Rock @ $20.00.	32,000.	
			35,200.
	Total.		$ 119,600.
	10% Contingencies. . .		11,900.
	Grand Total.		$ 131,500.
	Say.		$ 135,000.

C. Summary of Preliminary Estimated Costs

I. ESTIMATED INITIAL COSTS

a. First Step - 25 ft., 60 ft. and 140 ft. Radio Telescopes.

(1)	Telephone System. . .	$ 18,000.
(2)	Electrical supply and distribution system with power generated on site. Capacity of system adequate only for First Step	400,000.
(3)	Sanitary, including drainage systems, water supply systems, fire protection system and gas system for First Step.	200,000.
		$ 618,000.
(4)	Cost for installing underground, existing overhead high voltage lines within a 5 mile radius of the site.	$1,570,000.
	Total	$2,188,000.

(5) Additional cost if the electrical power supply is obtained from the Utlity Company with Alternate Scheme 1.

(a) Primary supply from Utility Company (Estimated by Monongahela Power Co.)	$150,000.	
(b) One (1) - 500 KW Emergency Generator	68,000.	
(c) Site Distribution System	243,265.	
Sub-Total	$461,265.	
Say	$465,000.	
(d) Less cost of complete system with site generated power	$400,000.	$ 65,000.
Total (Purchased Electrical Power with Alternate Scheme 1)		$2,253,000.

(6) Additional cost if the electrical power supply is obtained from the Utility Company with Alternate Scheme 2.

(a) Additional cost to extend underground service to main substation near Radio Telescope Maintenance Building	125,000.
Total (Purchased Electrical Power with Alternate Scheme 2)	$2,378,000.

(7) Additional cost if the electrical power supply is obtained from the Utility Company with Alternate 3.

(a) Estimated cost of bringing underground service into site from Northwest, starting underground at a point about 5 miles north of Green Bank. (Estimated by Monongahela Power Co.)	$500,000.	
(b) Less cost of bringing underground service into site from the Northwest across Little Mountain	275,000.	225,000.
Total (Purchased Electrical Power with Alternate Scheme 3)		$2,603,000.
Say		$2,600,000.

b. Second Step - 250 ft. and 600 ft. Radio Telescopes.

(1) Telephone System (Additional facilities)	$ 16,000.

(2) Electrical supply and distribution system with power generated on site (Additional capacity for Second Step.)	$684,000.	
(3) Sanitary, including additional Drainage Systems, Water Supply Systems for Second Step	135,000.	
Total Cost of Second Step if Power is Site Generated. . .		$ 835,000.
(4) Deduction if the power supply is obtained from the Utility Company under the First Step. (Scheme 1,2,or3)		
(a) Three 1,000 KW diesel generators, generating station . .	$385,000.	
(b) Less cost of additional 1,500 KW emergency generator . . .	188,000.	
		197,000.
Total Cost of Second Step if Power is Purchased		$ 638,000.

II. ESTIMATED ANNUAL COSTS FOR ELECTRICAL POWER

a. Site Generated Power

(1) First Step.	$ 36,000.	
(2) Second Step	70,000.	
Estimated Total Annual Cost . . .		$ 106,000.

b. Purchased Power (Alternate Scheme 1)

(1) First Step

(a) Facilities charge	$ 42,750.	
(b) Energy charge. . .	14,000.	
(c) 500 KW generator for emergency use	11,000.	
Sub-Total	$ 67,750.	
Say	$ 68,000.	
(d) Annual charge if Utility Company installs and owns underground section of service	$ 22,500.	
Sub-Total	$ 90,500.	
Say	$ 90,000.	

(2) Second Step

(a) Energy charge. . .	$ 48,000.	
(b) 1,500 KW generator for emergency use	20,000.	
Estimated Total Annual Cost . . .		$ 158,000.

c. Purchased Power (Alternate Scheme 2)

(1) First Step

(a) Estimated annual cost for Scheme No. 1	$ 90,000.	
(b) Estimated additional annual charge if Utility Company installs and owns additional underground service	18,750.	
	$108,750.	
Say . . .	$109,000.	
(2) Second Step (Same as that under Scheme 1).	$ 68,000.	
Estimated Total Annual Cost . . .		$ 177,000.

d. Purchased Power (Alternate Scheme 3)

(1) First Step

(a) Facilities charge	$ 39,000.	
(b) Energy charge. . .	14,000.	
(c) 500 KW Standby generator	11,000.	
Sub-Total	$ 64,000.	
(d) Annual charge if Utility Company installs and owns underground section of service	$ 75,000.	
Sub-Total	$139,000.	
Say	$140,000.	
(2) Second Step (Same as that under Scheme 1).	$ 68,000.	
Estimated Total Annual Cost . . .		$ 208,000.