FEASIBILITY REPORT

for the

NATIONAL SCIENCE FOUNDATION

regarding site development
and building requirements

for a

NATIONAL RADIO-ASTRONOMY-FACILITY

by

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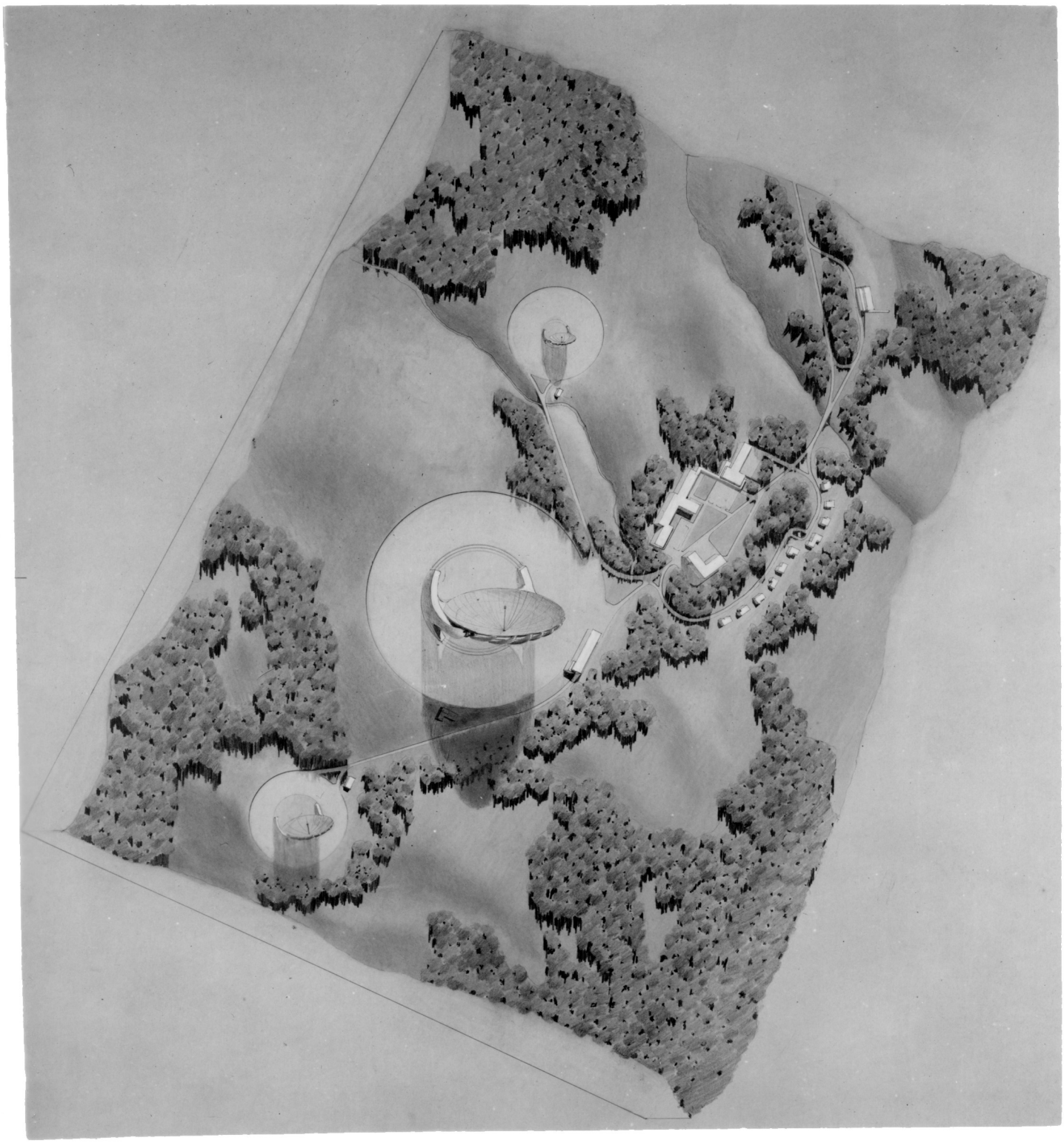
Consultants:

Syska & Hennessy, New York, N.Y.
Engineering Consultants on Site Development

Daniel F. MacNamee, Contractor, New Rochelle, N.Y.
Consultant on Excavation and Road Construction

General Bronze Corporation, Garden City, L.I., N.Y.
Consultants on Construction, Transportation, and
Erection of Reflectors

May 5, 1955



FEASIBILITY REPORT FOR THE NATIONAL SCIENCE FOUNDATION

ON CONSTRUCTION OF

A NATIONAL RADIO-ASTRONOMY-FACILITY

by

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100 East 42nd Street
New York 17, N. Y.

May 1, 1955
H. J. Bade

1. PURPOSE OF THIS REPORT

The use of radio equipment in astronomical research is relatively new. Studies, originating from first experience on war-time radar-equipment, have been carried on in Australia and England with larger reflectors specially designed for astronomical research, and have enabled scientists to establish certain basic requirements regarding the desirable location of such instruments. Previous experience with similar installations in the United States is not available.

This report has been prepared to investigate the feasibility of building a Radio-Astronomy-Facility in the United States, and to prepare a budget estimate of the approximate cost. The report is based on a hypothetical site, which meets the physical conditions for such an installation. This site has been taken from a selection of 14 sites contemplated by Associated Universities, Inc., and the cost analysis is based on conditions, as they will actually occur, and reflects the approximate cost of all items to be provided as a result of the special requirements under which this facility will have to be built. The itemized cost breakdown shows clearly, which parts of

the building program are likely to be of greatest influence on the total budget.

2. GENERAL REQUIREMENTS OF THE SITE

According to information available at this time, the following conditions are considered mandatory for the selection of the 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 hurricanes 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.

3. EQUIPMENT FOR RADIO-ASTRONOMY-RESEARCH

The Radio Astronomy Facility will be equipped with 3 reflectors. Present plans show one reflector of 150 ft. diameter, one of 250 ft. diameter, and one of 600 ft. diameter. It is contemplated to start the project with a 150 ft. reflector, and to add the larger equipment at a later date.

The cost of these reflectors and their foundations is not included in this report and cannot be determined without adequate plans and estimates from qualified manufacturers.

The site development plan and the budget estimate include, however, the location of these reflectors, and the cost of the preparation of their operating bases, access-roads, energy supply, and control buildings.

The locations selected on this site were determined by advantageous surface conditions. The three reflectors have been placed at three different levels, the smallest at 3150 ft. Elevation, the medium size at 3200 ft. Elevation and the largest at 3250 ft. Elevation. This is a result of surface conditions, with the additional advantage of reduced interference in the operation of the equipment. The distance from center to center of the reflectors is approximately 1500 ft., which is desirable in view of the size of this equipment and the development of the Radio-Astronomy-Facility in three different steps.

The reflector equipment itself is of such unusual size and weight, that the question of its transportation to the site, and its erection on a solid basis must be given very serious consideration. For the purpose of this report the total weight of the 600 ft. reflector is estimated with 6,000 tons. The wind pressure on this structure (at 30 lbs. per square foot) may amount to as much as 5,000 tons or more. The footings of this instrument should therefore rest on rock, and the tracks should be securely anchored to it. This will explain, that the amount of excavation estimated for this reflector is relatively high (1,550,000 cu. yds.) and may cost between 2 - 3,000,000 dollars, depending on surface conditions and soil formation. In the present estimate for the hypothetical site, corrections of the mountainside in back of the 600 ft. reflector are included to prevent possible damage from landslides, avalanches or storm water. These precautions have been considered mandatory for the reflector installation on the hypothetical site and should be given all necessary attention at the selection of the final

site. Extreme irregularities in surface conditions will necessarily be reflected in additional cost of excavation.

The circular operating bases or fields around the reflectors have a diameter of 1200 ft. for the large reflector, and 500 ft. for the two smaller reflectors. They are designed to accommodate trucks and movable service equipment,as large cranes and automatic extension ladders for the maintenance and repair of the reflectors. These areas should be at the same level as the base of the reflector structure, and could be built on fill obtained from the excavation of the actual reflector site. The site development for this project is based on a balance of excavation and fill, as shown on the profiles of various sections through the site. This fill should be well compacted and receive a pavement of 8" heavy duty macadam with asphalt penetration over the entire area of the operating field. The new embankments would receive topsoil and seeding. All electric cables for power supply to the reflectors are to be installed underground, as outlined in the report of Syska & Hennessy, Engineering Consultants.

The problem of building large reflectors of the proposed size in sections, which can be shipped to the site and reassembled, has been investigated through consultation with the General Bronze Corp., Garden City, L. I. This manufacturer is experienced in the construction of large precision structures in metal, including radar equipment, and feels that the reflectors can be built in sections requiring not more than a 60 ft. trailer truck for the transportation to the site. The use of these trucks requires a special permit. Normal state highways can accommodate these trucks without difficulties. Secondary roads, leading over a mountainside with narrow hairpin curves, will require corrections.

4. ROAD CONSTRUCTION FROM NEAREST STATE HIGHWAY TO THE SITE

The road from the nearest state highway and railroad station should meet the following requirements: it should accommodate long trailer trucks for the transport of reflector parts, and provide access to the site for heavy construction equipment, as steam shovels, cranes, etc. The conditions for the hypothetical site are shown on the general site location plan. A secondary improved rural road leads from the railroad station over a mountain ridge to a distance of 1.5 miles from the site. This road has two bridges with insufficient capacity for heavy equipment, and it has further 8 narrow hairpin curves, which cannot be used by long trailer trucks. The correction of hairpin curves is, according to information obtained from road construction firms, very costly. Such curves are generally bypassing cliffs or rock ledges, and the necessary improvement of the road may require in each case rock excavation of approximately 20,000 cubic yards with a cost of $100,000. for each such correction. On the other hand, rural roads are in many cases not the result of a complete engineering survey of the terrain, and it may be much more economical to relocate parts of the road in order to avoid these costly corrections. The road construction firm of Daniel F. MacNamee & Co., Inc., New Rochelle, feels that the subbase for a 24 ft. wide road with an average cut and fill of 10 ft. can be built at a cost of $45,000. per mile. Surface improvement with 8" asphalt-penetrated macadam would cost additional $56,000. per mile, so that the complete road could be built at a cost of $101,000. per mile. This may show that approximately two miles of relocated road at a cost of $200,000. would be considerably less expensive than 8 corrections of hairpin curves at an approximate cost between $500,000. to $800,000. The proposed relocated road for the hypothetical site is indicated in a dotted line on the general site location plan.

The following schedule of cost per mile for average cut and fill under different conditions will indicate how much the cost of road construction can be affected by adverse conditions. This information will be valuable for the final site selection. Prices are based on cost of subbase for a 24 ft. wide road.

Average cut and fill	Common excavation	1/3 Solid 2/3 Common	2/3 Solid 1/3 Common	Solid
2 ft.	$ 5,000.	$ 7,000.	$ 9,500.	$ 13,000.
5 ft.	14,000.	20,000.	26,000.	35,000.
10 ft.	32,000.	46,000.	60,000.	80,000.
15 ft.	54,000.	77,000.	100,000.	135,000.
20 ft.	75,000.	105,000.	150,000.	200,000.
30 ft.	140,000.	200,000.	260,000.	360,000.

The cost of surface improvement has to be added to these prices. An 8" asphalt-penetrated macadam road can be assumed at a cost of $56,000. per mile, 10" reinforced concrete road surface 24 ft. wide will cost approximately $170,000. per mile.

Small creeks and streams can be crossed most economically with the use of culvert pipes, built into the roadbed and sufficiently covered by roadbed and surface improvement. A 24 ft. wide road with shoulders requires generally 30 lin. ft. of culvert pipe at a cost of $50. per lin. ft. for 60" galvanized pipe, or a total cost of $1500. Existing small bridges of inadequate capacity for heavy equipment can be reinforced with additional structural steel beams and additional supporting elements. Under certain conditions it may be more advisable to bypass the existing bridge with a short piece of new road and built in culvert pipes. Such an installation may serve well for the construction time, and the normal traffic from and to the site can later return to using the existing bridge.

New bridges in steel or reinforced concrete construction for 25 ft. span and a road width of 24 ft. will vary in cost depending on soil conditions, and whether pile driving is required or not. $40,000. to $50,000. can be assumed as the average cost for such a bridge under the conditions of this project.

The prices for road construction, improvement, bridges and culverts, as listed before, indicate that a very careful appraisal of the accessibility of the site should be made. The approximate total cost of access improvements to the hypothetical site is calculated in the attached budget estimate.

5. SITE DEVELOPMENT AND IMPROVEMENT (Drawings No. 2, 3, 4, 5)

The development of the site for the proposed Radio-Astronomy-Facility will include the following work:

a. Site clearance and removal of existing trees as required for an area of approximately 320 acres (1/2 square mile).

b. Earth and rock excavation, fill and grading for the three reflector positions, the building sites, the connecting roads, required parking areas, and the necessary landscaping, as shown on the site plan and the profile sections through the site.

c. Building of concrete or field stone retaining walls, where required.

d. Building of 24 ft. wide roads with pavement designed for the use of heavy equipment, leading to all major installations on the site.

e. Building of secondary roads to the residential buildings.

f. Building of paved operating fields around the reflector positions, suitable for use with heavy equipment (cranes, etc.).

g. Building of 3 parking areas for employees, scientists, and visiting scientists.

h. Building of a visitors' parking area near the entrance road to the site, with adjacent picnic area for sightseers.

i. Landscaping, lawn-seeding and planting.

j. Building of a water reservoir for fire fighting purposes.

The absence of public utilities requires further:

k. The building of a power plant to supply the Radio-Astronomy-Facility with electric energy.

l. The installation of a water supply system with wells, pump station, and pipelines to all buildings and hydrants.

m. The installation of a sewage-disposal system.

The estimated cost of this work on the hypothetical site is shown in the attached budget estimate, together with information regarding the amount and kind of work to be performed. These prices may vary considerably on other sites, due to different surface and soil conditions, and different amounts of excavation and grading that may be required.

In view of the self-contained nature of this facility, a careful investigation of water availability, and the possibility of proper sewage disposal should be made. A special report by Syska & Hennessy, Engineering Consultants, on power supply, water supply and sewage disposal is attached to this report.

6. BUILDINGS REQUIRED: (Drawings No. 6, 7, 8, 9, 10, 11)

The cost of building construction on a remote site will be affected by additional cost for material transportation to the site, and by the cost of transportation of workers to and from the site and the installation of temporary shelter for those employed in the construction work.

It is therefore desirable to reduce the weight of construction material to a feasible minimum through use of lightweight materials where possible, and also to reduce the construction time through use of pre-assembled building units as pre-cast concrete slabs for floors and roofs, and exterior metal wall panels with windows.

The possibility of a forest fire makes fire-resistant materials for exterior work mandatory.

All buildings will have concrete or masonry foundations.

Two-story buildings for Administration and guest house should be built in steel framing with pre-cast concrete floor slabs and roof slabs on bar joists. Building fronts with windows are designed with metal wall and window panels with the advantage of savings in weight, space, and construction time. Additional advantages are, that this exterior wall system facilitates the change of interior partitions, and that it provides a screen against electrical noises. Walls without windows are designed in brick masonry. Interior partitions will be built in 4" concrete block for improved sound control.

One-story maintenance buildings will also have steel framing and combination window wall panels or brick masonry walls as shown. The reflector maintenance building should be constructed in steel framing with walls of insulated metal wall panels.

The residential buildings are assumed in wood framing with brick veneer, and with incombustible roofs.

The following buildings will be required for the operation of the Radio-Astronomy-Facility:

a. Administration Building:

Two-story construction, 46,000 sq. ft. gross area on first and second floor; 9,300 sq. ft. of basement space.

This building will provide space for the following:

Office space for the administration
Laboratories for instrument testing and repair
Laboratories for data processing
Laboratories for staff scientists and visiting scientists
Air conditioned rooms for computers
Library, Lounge, Conference Rooms.

The basement will accommodate a central heating plant for this building, and the adjacent guest house, cafeteria, and site-maintenance building.

b. Cafeteria and Guest House:

7,300 sq. ft. of Cafeteria building, one-story construction
17,300 sq. ft. of Guest House, two-story construction

The Cafeteria building provides space for a Dining Room and a Cafeteria separated with a folding partition, further space for Kitchen, Serving, Storage, Freezers, and small Snack-bar for employees who work late.

A covered walk connects this building with the Administration.

A lobby connects the Cafeteria building with the Guest House.

The lower level of the Guest House accommodates 5 apartments for visiting scientists with families, and the upper level has 20 single or double bedrooms with bath for visiting scientists and technicians without family.

c. Site Maintenance Building:

10,000 sq. ft., one-story construction
With space for:
- Garages - 1 heavy truck, 1 light truck, 2 cars
- Filling station with attendant's room
- Waiting room for drivers
- Automobile repair shop
- 2,000 sq. ft. of storage space for material and spare parts
- Carpenter Shop
- Paint Shop
- Electric Shop
- Mechanical Shop
- Plumbing Shop

The site maintenance building contains also a restroom for employees working on the site, and storage room for a power lawnmower , a power saw, heavy snow removal equipment.

d. Reflector - Maintenance Building:

12,000 sq.ft. gross area one-story construction.
This building is required for the following purposes: storage of a large crane and a hydraulic extension ladder for the reflector service; storage of steel cables and ropes to secure the reflectors in case of high winds; storage of reflector spare parts for replacements in case of damage; lubrication, painting, and maintenance of reflectors.

e. Reflector-Control Buildings:

One-story buildings, located near the 3 reflector positions. Each building has a large room for highly sensitive recording instruments. This room should be individually air conditioned to insure permanent reliable operation of the instruments. An additional room is required for the scientists, and a small room for the air conditioning unit. The size of these buildings has been estimated:

1,000 sq. ft. for the 150 ft. reflector
2,000 sq. ft. for the 250 ft. reflector
3,000 sq. ft. for the 600 ft. reflector

f. Residential Buildings:

The site plan provides space for 10 residential buildings; additional buildings may be added later as required.

4 buildings will be used as permanent residences for:

Director of the R. A. Facility
Site Superintendent
Chief Reflector Operator
Chief Reflector Maintenance Engineer

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

7. BUDGET ESTIMATE

The following budget estimate has been prepared on the basis of the hypothetical site selected for the purpose of this report.

The estimate includes the cost of road improvements for access to the site, road construction on the site, site development, utilities required, and the cost of the necessary buildings. The cost of the reflector and their foundations and tracks are not included.

Prices are based on experience, information obtained from Engineers and Contractors, and on estimates of similar construction work published in technical literature.

Additional allowances for the remote location of the site, and transportation difficulties, have been made.

Contractors' overhead and profit is included. Legal fees, architects' and consultants' fees are not included. It has been assumed that this Radio-Astronomy-Facility will be built in three different steps. (A) The installation of the 150 ft. reflector; (B) the installation of the 250 ft. reflector; and (C) the installation of the 600 ft. reflector.

All items in this estimate required for the initial site development, buildings, and the position for the 150 ft. reflector are marked "A" in a separate column adjacent to the cost. Those items incidental to later installations are marked "B" or "C".

No.	Item	Step	Total Cost
1.	Site Acquisition Required size: 3 square miles - 1920 acres. Approximate cost in remote forest areas on a mountain side - $200.00 per acre.	A	$ 384,000.
2.	Analysis of the Site: Geological survey, test borings, water tests, geodetical survey	A	46,000.
3.	Road construction and improvement of access to site The following conditions and prices have been assumed for this estimate: I. Existing unimproved rural road to be increased to 24 ft. width. Cost of excavation and 30 ft. wide subbase under favorable conditions $25,000 per mile. II. New roadbed on virgin ground, with 30 ft. wide subbase, average cut and fill 10 ft. Cost of excavation and subbase $45,000 per mile. III. 24 ft. wide road pavement with 8" heavy duty stone macadam, asphalt penetrated and with armour coat: $4 per sq. yd. - $56,000 per mile. IV. 6 acres of site clearance per mile at $500 per acre, cost $3,000 per mile. V. 2 - 60" galvanized steel culverts per mile, each 30 lin. ft. long - $3,000 per mile VI. New 24 ft. wide reinforced concrete bridge for 25 ft. span - $40,000. The following work has been estimated: a. The secondary improved road leading from the railroad station into the neighborhood of the		

No.	Item		Step	Total Cost
3 - a. continued				
	site crosses two small streams. The existing bridges are of insufficient capacity. In view of the permanent heavy traffic resulting from the step by step construction of the R. A. F. two new reinforced concrete bridges are to be built. Cost each - $40,000		A	$ 80,000.
b.	The correction of 8 hairpin curves in this road may cost $500,000. A survey shows that these curves can be avoided by relocating the road at two points with a total length of 2 miles of new road construction.			
	Cost:			
	2 miles of site clearance at $3,000 each	$ 6,000.		
	2 miles of 30 ft. wide new road bed at $45,000	90,000.		
	2 miles of road surfacing 8" macadam, asph. penetrated at $56,000 per mi.	112,000.		
	4 culverts 60" wide, 30 ft. long at $50 per ft.	6,000.		
	Total		A	214,000.
c.	From a point 1-1/2 miles from the site an unimproved rural road can be used for the final approach to the site.			
	Cost:			
	1.5 miles road bed to be increased to 30 ft. width excavation and sub-base $25,000 per mile	$ 37,500.		
	1.5 mile of 8" asph. penetrated stone macadam $56,000 per mile	84,000.		
	90 ft of 60" culvert at $50	4,000.		
	Total		A	126,000.
TOTAL - ACCESS ROAD IMPROVEMENT				$420,000.

No.	Item		Step	Total Cost
4.	Road Construction on Site.			
	2 miles of new 24 ft. wide road with heavy-duty pavement, leading to the building site, power plant and the 600 ft. reflector and 150 ft. reflector, are required for the first part of the development.			
	Cost:			
	1 mile of site clearance	$ 3,000.		
	2 miles of 30 ft. wide roadbed on virgin ground at $45,000. - p. mile	90,000.		
	2 miles of 8" asphalt penetrated stone macadam at $56,000. - p. mile	112,000.		
	150 ft. of culvert at $50.	7,500.		
	Total		A	$212,500.
	An additional 1/2 mile of the same road is required as connection to the 250 ft. reflector.			
	Cost: $53,000		B	53,000.
TOTAL: 24 FT. ROAD CONSTRUCTION ON SITE				$265,500.
5.	Site Development Cost:			
	a. Site clearance: 300 acres at $500		A	$150,000.
	b. Excavation, fill, embankment, and compacting, (except trench excavation) for building site, reflector positions and grade adjustments on the entire site:			
	For this work the following prices have been assumed:			
	Common excavation	$ .85 cu. yd.		
	1/3 solid, 2/3 common	1.50 cu. yd.		
	2/3 solid, 1/3 common	2.30 cu. yd.		
	Solid	3.00 cu. yd.		
	With an average price of $1.50 for the conditions on the hypothetical site:			
	Excavation and fill for step "A", Building Site and 150 ft. Reflector.			
	420,000 cu. yds. at $1.50		A	630,000.
	Excavation and fill for step "B", position of the 250 ft. reflector			
	280,000 cu. yds. at $1.50		B	420,000.
	Excavation and fill for step "C", position of the 600 ft. reflector			
	1,550,000 cu. yds. at $1.50		C	2,325,000.

No.	Item	Step	Total Cost
	c. Pavement of the operating fields around the reflector positions. 8" heavy duty macadam, asphalt-penetrated at $4. sq. yd.		
	for: 150 ft. reflector 25,000 sq. yds. @ $4.	A	$100,000.
	for: 250 ft. reflector 25,000 sq. yds. @ $4.	B	100,000.
	for: 600 ft. reflector 125,000 sq. yds. @ $4.	C	500,000.
	d. Secondary roads on site, leading to guest house, Administration, parking areas, and residences. 4,500 lin. ft. road 20 ft. wide at $5. per sq. yd. for roadbed and surfacing including curbs	A	90,000.
	e. Parking areas for 250 cars 6,000 sq. yds. at $3.00 per sq. yd.	A	18,000.
	f. Topsoil, seeding and landscaping 140 acres, total area, at $900. per acre.		
	Step "A", 80 acres at $900.00	A	72,000.
	Step "B", 20 acres at $900.00	B	18,000.
	Step "C", 40 acres at $900.00	C	36,000.
	g. Retaining walls in fieldstone masonry 440 cu. yds. at $50. per cu. yd.	A	22,000.
	h. Visitors' parking area: 300 cars 7,000 sq. yds. at $3. p. sq. yd.	C	21,000.
	i. Water reservoir for fire-fighting 100,000 gals. concrete basin	A	25,000.
	j. 25,000 lin. ft. of 60" chain link fence including steel posts, at $3. per ft.	C	75,000.
TOTAL: SITE DEVELOPMENT			$4,702,000.
6.	Building Construction: The cost of Building Construction has been estimated on the basis of prices per cu. ft. volume. Additional allowances for special conditions have been made.		
	a. Administration Building, 2-story including heating plant 900,000 cu.ft. at $1.80	A	$1,620,000.
	Additional cost for airconditioning of 4,000 sq. ft. computed space at $3.50	A	14,000.
	Additional cost of Assembly - wing 104,000 cu. ft. at $1.50	B	156,000.

No.	Item	Step	Total Cost
	b. Cafeteria Building and Guest House 310,000 cu. ft. @ $1.50	A	$465,000.
	Furniture and equipment	A	45,000.
	c. Site Maintenance Building. 150,000 cu. ft. @ $1.10	A	165,000.
	d. Reflector Maintenance Building 320,000 cu.ft. @ $.60	B	192,000.
	e. Control building f. 150 ft. reflector 12,000 cu.ft. @ $1.25	A	15,000.
	f. Control building f. 250 ft. reflector 24,000 cu. ft. @ $1.25	B	30,000.
	g. Control building f. 600 ft. reflector 36,000 cu. ft. @ $1.25	C	45,000.
	h. Building for electric generators, 15,000 cu. ft. @ $1.00	A	15,000.
	i. Residence for the Director 2,000 sq. ft. @ $15.	A	30,000.
	j. 3 permanent residences for staff, each 1600 sq.ft. @ $15. = $24,000	A	72,000.
	k. 6 rentable residences, each 1200 sq. ft. @ $15. = $18,000.	B	108,000.
	TOTAL: BUILDING CONSTRUCTION		$2,972,000.
7.	Utilities to be installed in connection with the Site Development (See special Report by Syska & Hennessy, Engineering Consultants)		
	a. Electric Power Plant and distribution	A	$ 808,000.
	b. Telephone	A	81,000.
	c. Water supply, sewage disposal and storm water disposal	A	250,000.
	TOTAL COST OF UTILITIES		$1,139,000.
8.	Summary of Construction & Development Cost		
	STEP "A": Part of site development, Roads Building, 150 ft. Reflector position		
	Site acquisition $384,000.		
	Site analysis 46,000.		
	Access-road improvement 420,000.		
	Main Roads on site 212,000.		
	Site Development 1,207,000.		
	Buildings 2,441,000.		
	Utilities 1,139,000.		$5,849,000.

No.	Item		Step	Total Cost
	STEP "B": Additional site Development, Buildings, and 250 ft. Reflector position.			
	Roads on site	$ 53,000.		
	Site Development	538,000.		
	Buildings	486,000.		$1,077,000.
	STEP "C": Additional site development and buildings, Position for 600 ft. reflector.			
	Site Development for 600 ft. reflector	$2,957,000.		
	Buildings	45,000.		3,002,000.
	GRAND TOTAL ACCORDING TO THIS ESTIMATE			$9,928,000.

8. CONCLUSIONS

The foregoing report and budget estimate shows two groups of expenses incidental to this project:

a. Expenses, that can be estimated with reasonable accuracy, as:

Building cost
Cost of Electric Energy Supply
Cost of Road Construction on the Site.

b. Expenses that may vary greatly, depending on location and geological conditions of the site selected, as:

Cost of land
Access roads to the site
Excavation, fill, site development cost
Water supply, sewage disposal.

Good access roads to the site may save up to $300,000. of the estimated cost, poor roads may add to the cost considerably.

Favorable site conditions with relatively flat surfaces and adequate bearing capacity of the soil, will require a minimum of excavation (primarily required for the reflector positions). This may save up to $2,000,000. of the estimated cost. Sites, requiring

excessive amounts of excavation, particularly rock excavation, may be unsuitable due to the extremely high expenses for such surface corrections.

The possible absence of adequate water sources at higher altitudes may also cause difficulties beyond what may be assumed as reasonable.

The number of sites considered as a possible location for this facility at the present time, will probably be narrowed down to 2 or 3 sites, either due to non-availability or other adverse conditions. The remaining prospective sites should be subjected to an expert study of those characteristics which are likely to affect the cost of this project severely. This analysis will require:

a. a careful appraisal of the accessibility of the site;

b. tests insuring the absence of electric interference from various possible sources, particularly in Southern direction;

c. expert study of geological formations, and test borings for an analysis of subsurface conditions;

d. careful appraisal of the amount of excavation, and fill required;

e. careful study of possible dangers to the facility from landslides, avalanches, or forest fires;

f. investigation of the availability of drinking water in adequate amounts, and investigation of possibilities for sewage disposal;

g. possibility of establishing a safe zone around the Radio-Astronomy-Facility, which will prevent the infiltration of commercial enterprises into this area, on a legal basis.

INDEX OF DRAWINGS AND MAPS PREPARED FOR THIS REPORT.

Drawing No.	
1	General site location plan
2	Plan showing existing topography of the site
3	Site Development plan with reflector positions, roads, buildings, parking areas, etc.
4	Profiles showing required surface corrections
5	Profiles showing required surface corrections
6 to 11	Plans of proposed buildings
12	Plan of Electrical installation and power plant
13	Plan of water supply and sewage disposal
14	Plan of central heating system
15	Birds-eye view of the site development
16	Reports prepared by Engineering Consultants

ENGINEERING SECTION

OF

FEASIBILITY REPORT

FOR A

NATIONAL RADIO ASTRONOMY FACILITY

(site to be determined)

EGGERS & HIGGINS
Architects

SYSKA & HENNESSY, INC.
Mechanical Engineers

ENGINEERING SECTION
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NATIONAL RADIO ASTRONOMY FACILITY
(site to be determined)

I. INTRODUCTION

The purpose of this study is to determine a satisfactory method and an estimate of the cost of providing the necessary utilities to enable the facility as planned by the Architect to function properly.

This study includes sections concerning Heating, Ventilating and Air Conditioning, Electric Power, Telephone and the necessary Sanitary Systems. Various assumptions have been made with regard to these utilities as the actual site has yet to be determined. However, these assumptions are listed and they are based on engineering experience, and believed to be sound. It is of course understood that when the actual site is selected a great deal of more detailed study will have to be made to determine the most economical method of providing these utilities.

II. HEATING, VENTILATING AND AIR CONDITIONING

A. Basis of Design

It has been assumed that the facility will be located on a site in the southeastern section of the United States and that normal weather conditions will prevail.

B. Heating System

It is proposed to have one central heating plant to serve the Site Maintenance Building, the Guesthouse and Cafeteria, and the Administration Building. This Plant will be located in, the Basement of the West Wing of the Administration Building, and will be of a low pressure type, consisting of three package type of boilers, each having a capacity of approximately 2,000 lbs. of steam per hour.

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

C. Ventilation

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

D. 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.

E. Estimate Costs

The heating costs have been included in unit costs

for each of the Buildings. At this time it is felt that cost of the Central Plant will not be appreciably different than if the buildings served by it were to have their own plants, however, it will save maintenance and operation costs.

The costs of air conditioning, based on a cost of $3.00 to $3.50 per sq.ft., and 10,000 sq.ft. to be conditioned would be between $30,000. and $35,000.

III. 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 local Telephone Company will be available five miles from the site, and will run from there underground to the facility.

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

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

4. Telephone outlets will be furnished in all Buildings.

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" vertical separation wherever possible.

C. Cost Estimates

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

The following are the costs.

1. Telephone System

40,000 L.F. fibre conduit @75¢ per ft. ..... $30,000.

NOTE: For manholes, see Power System.

2. Excavation for Telephone System

2,000 Cubic Yards Earth @ $2.	4,000.
2,000 Cubic Yards Rock @ $20.	40,000.
Total	$74,000.
10% Contengencies	7,400.
	$81,400.

IV - ELECTRIC POWER

A - Basis for Design

The following assumptions have been made because of the hypothetical site and other unknown conditions.

1) The Service from the Electric Power Company will be available at 22,000 volts and it will be necessary to run five (5) miles underground from the Power Company's lines to the site.

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

3) The Demand Load of the facility will be approximately 1000 KW.

4) Electric Capacity has been provided for the use of electric ranges if such are desired in lieu of the gas ranges.

5) The Administration Building will contain in addition to normal equipment, three electronic computers at 100 KW each.

6) Electric Capacity has been provided for 5600 linear feet of street lighting and a 300 car parking area all with incandescent lighting.

7) The 600' Reflector will require 8 - 125 HP motors to rotate it horizontally and vertically. It is assumed also that not more than 4 of these motors will operate at one time.

8) The 250' Reflector will require 4 - 50 HP motors for its drive.

9) The 150' Reflector will require 2 - 50 HP motors for its drive.

10) It is assumed that only one Reflector will operate at one time.

B - Electrical Service and Distribution

It is proposed as previously stated that there will be three basis voltages on the site.

a) 22,000 volt service from the Power Company.

b) 4160 volt Primary Distribution.

c) 120/208 volt Secondary Distribution.

The 22,000 volt service will terminate its run from the Power Company in the power plant where it will be transformed in a 1000 KVA unit substation to 4160 volts to be distributed on the site. Then, the Primary Distribution lines will run to unit substations and transformers in the following locations to be transformed for use in the Secondary Distribution System.

a) Site Maintenance Bldg. - 1-750 KVA Unit Substation.

b) In an underground vault between the 600' and the 250' Reflectors - 1-750 KVA Unit Substation.

c) Residence Area - 2-50 KVA subway type banked transformers.

d) 150' Reflector - 1-150 KVA subway type transformer.

The Site Maintenance Building, the Administration Building, and the Guesthouse will each have its own power distribution panels.

The Service and Distribution cable will be shielded so as to provide minimum interference and lead sheathed to provide maximum protection. The Service and Distribution conduit will be of fibre construction with heavy wall for direct burial and thin wall for concrete encased. Outside transformer vaults and 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. per cu. yd. of earth and $20. per cu. yd. of rock. The estimate included radio interference elimination filters for distribution wiring, and double wire mesh screening for all

electrical equipment as required. Approximately 10,000 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.

1. Power System

40,000	L.F. fibre conduit @ 75¢ per ft.	$30,000.	
39	manholes @ $1200. per manhole ...	46,800.	
27,000	L.F. 23 KV cable @ $2700. per Thousand Feet	72,900.	
11,000	L.F. 5 KV cable @ $2100. per Thousand Feet	23,100.	
3,000	L.F. 600 Volt cable @ $6000. per Thousand Feet	18,000.	
1	1000 KW substation and 500 KW standby diesel generator	145,000.	Either)
4	250 KW diesel generator, generating station	188,000.	Or)
	Rate schedule for purchased power at approximately		.017/Kw.Hr.
	Fuel schedule for purchased fuel delivered at		.012/Kw.Hr.
	Substations, transformers, and switchgear for purchased power ..	222,000.	
4	Transformer vaults	30,000.	
10,000	square feet of shielding @ $1. per square foot	10,000.	
	Filtering	20,000.	
6	Distribution panels @ $500.	3,000.	
	Motor controller, mounting and connections	1,500.	
	Motor connections	800.	
	Weatherproof disconnect switches.	5,000.	
	40 Street ltg. units @ $500.	20,000.	

2. Excavation for Power System

2,000	Cubic Yards Earth @ $2.	4,000.
2,000	Cubic Yards Rock @ $20.	40,000.
		$735,100.
	10% Contengencies	73,510.
		$808,610.

V - SANITARY

A - Basis of Design

The Drainage System has been designed for a maximum of 300 people, 78 of whom will reside on the site. The ground is assumed to be impervious for percolation of sanitary wastes.

The Water Supply will be from wells on the site. Since water is not generally available at higher elevations, it is assumed four rack wells each 500 feet deep will supply the demand of 75 GPM for domestic use and 100 GPM for air conditioning use.

Gas will be supplied for all working purposes and for 75 Laboratory outlets.

B - Drainage Systems

1) All drainage systems will flow by gravity. House drains will be cast iron and extend 5 feet outside building walls from which point they will be connected to vitrified clays house sewers.

2) Sanitary System: Sanitary drainage will connect to an underground settling tank having a six hour retention, and discharge from the tank to two open sand filter beds. Effluent from filter beds will discharge to adjacent stream after chlorination.

3) Laboratory waste water system: Laboratory waste water will flow through an underground neutralizing sump before discharging to the storm water house sewers.

4) Storm water system: Roof areas will be drained by interior leaders. Where feasible, paved areas will be drained to the storm water sewers which discharge to adjacent streams.

C - Water Supply Systems

1) Water supply will be from rock wells filling a reservoir having a two day supply. A concrete reservoir will be provided underground if permitted by local Health Department regulations. Required pressure will be maintained by automatic hydro-pneumatic equipment adjacent to the reservoir, unless reservoir can be located at an elevation 230 feet above building roofs.

2) Hot water will be generated at each building, with steam storage tank heaters in the larger buildings, and with electric domestic units in the residences.

D - Fire Protection System

1) Exterior fire protection will consist of a system with hydrants supplied by hydro-pneumatic equipment, and by an automatic dual drive electric and diesel fire pump. Suction for the fire pump will be direct from the reservoir, and an auxiliary supply from the swimming pool.

2) For the larger buildings, an interior first aid fire standpipe system (1½" valves and hose) supplied from the domestic water system will be provided. In areas housing electrical equipment CO/2 fire extinguishers will be provided.

E - Gas System

Gas will be "bottle gas", supplied from an underground storage tank having a 30 day supply.

F - Swimming Pool

Equipment for a standard 55,000 gallon swimming pool will be provided. This pool will accommodate 32 bathers at one time. Equipment consists of surge tank, chlorinator, recirculation pump, chemical feeders, and sand filters with all required accessories, based on an 8 hour recirculation.

G - Estimate of Cost

ESTIMATE OF COST #1

1. Drainage Systems

6,000	L.F. Piping @ $3.	$18,000.
16	Manholes @ $350.	5,600.
1	Settling Tank	3,500.
1	Distribution Box	50.
8,000	sq. ft. Sand Filter @ $6.	4,800.
1	Chlorinator	300.
1	Chlorine Pull Box	25.
1	Chlorine Contact Box	300.
300	L.F. Chlorine Conduit @ $1.	300.
1	Neutralizing Sump	350.
		$33,225.

2. Water Supply

4	Wells @ $5,000.	$20,000.
4	Well pumps @ $7,500.	30,000.
	for Dual Drive, add $6,000.	
1	Reservoir & Equipment Rm.	2,000.
4,000	L.F. Piping @ $4.	16,000.
2	House Pumps @ $600.	1,200.
1	Pressure Tank	600.
1	Compressor	900.
4	Well Houses @ $500.	2,000.
		$72,700.

3. **Fire Protection**

1 Fill Pump	$ 600.	
1 Fire Pump	7,500,	
1 Pressure Tank	800,	
3,000 L.F. Piping @ $5.	15,000.	
		$23,900.
		$129,825,

ESTIMATE OF COST #2

$129,825.

4. **Gas System**

1 Storage Tank	$ 400.	
2,500 L.F. Piping @ $2.	5,000.	
		$ 5,400.

5. **Excavation**

4,000 Cubic Yards Earth @ $2.	$ 8,000.	
4,000 Cubic Yards Rock @ $20.	80,000.	
		$ 88,000.
Total		$223,225.
10% Contingencies		22,325.
		$245,550.

Respectively submitted,

SYSKA & HENNESSY, INC.

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