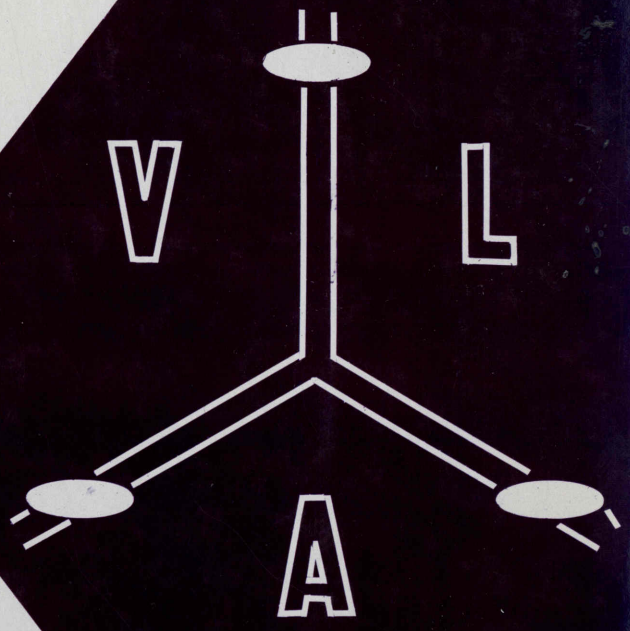
TITLE I DESIGN REPORT
VERY LARGE ARRAY PROJECT
MAGDALENA, NEW MEXICO



PREPARED FOR

ASSOCIATED UNIVERSITIES, INC.

NATIONAL RADIO ASTRONOMY OBSERVATORY

BY

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BWH-CVR JOINT VENTURE

TITLE I ENGINEERING REPORT

VERY LARGE ARRAY - SITE FACILITIES DESIGN

PREPARED FOR

ASSOCIATED UNIVERSITIES, INC.

SUBCONTRACT NO. VLA-5

CONTRACT NO. NSF-C-780

FEBRUARY 1, 1974

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INTRODUCTION

1. SCOPE

This Title I report presents the preliminary design for the VLA site facilities between Magdalena and Datil, New Mexico. Included are design discussion, drawings, specifications, and cost estimates for all Central Site buildings, Control, General Maintenance, Cafeteria, and Visiting Scientists' Quarters. A master plan of the Central Site has been prepared with designs and related data for all utilities including water, power, sewer, telephone, access roads, and a nearby airstrip.

The Wye Configuration is discussed with designs and related data included for the earthwork and drainage, railroad trackage, wye power, antenna station foundations and the wave guide.

2. CONFERENCES

BWH-CVR Joint Venture representatives held numerous conferences with representatives of the NRAO-VLA staff as well as Bechtel, Socorro Electric Cooperative, Mountain Bell and consultants to establish and confirm design criteria and project direction. A list of these major conferences is as follows:

Date	Location	Groups Involved
6/18-22/73	Charlottesville & Green Bank	NRAO Staff & JV Design Team
7/18-19/73	Albuquerque & Socorro	VLA Staff SEC Staff
7/24/73	VLA Site	JV Design Team
8/7/73	Dallas	F&C, VLA Staff
8/14/73	San Francisco	Bechtel, VLA Staff
8/15-16/73	Albuquerque	Bechtel, F&C, VLA Staff
8/27/73	Dallas	F&C, VLA Staff
8/28/73	Albuquerque	VLA Staff
9/12-13/73	Charlottesville	VLA Staff, NRAO Staff JV Design Team, Bechtel
9/25/73	Dallas	F&C
9/28/73	Los Angeles	W/McN
10/3/73	Los Angeles	W/McN
10/9-12/73	Albuquerque	VLA Staff, W/McN
11/1-2/73	Albuquerque	VLA Staff

Date	Location	Groups Involved
11/6/73	Charlottesville	VLA Staff
11/14/73	Albuquerque	VLA Staff
11/16/73	San Francisco	Bechtel, VLA Staff
12/10/73	Albuquerque	VLA Staff

3. REFERENCE MATERIAL

An extensive list of reference material pertaining to the VLA has been procured from NRAO and other sources and used in developing the conceptual design and design criteria. Major documents are listed below:

1. The VLA - A Proposal for a Very Large Array Radio Telescope, Vols. I thru IVA.
2. Engineering Study - Site Development & Facilities - Requirements for VLA, November 1966.
3. Engineering Study - Site Development & Facilities - Requirements for VLA, December 1969.
4. Concept Study of Transport Vehicle for VLA.
5. Review of VLA Transport Concept.
6. RFP Data - Radio Telescope Procurement.
7. RFP Data - Transport Vehicle.
8. Antenna RFP Response - E-Systems.
9. Bechtel Wave Guide Study - Preliminary & Final Drafts.
10. VLA Task 2.3 - Soil Data Report.
11. VLA Task 2.3 - Resistivity & Chemical Soil Test Data.
12. NRAO Building sq. ft. Requirements - 7/16/73.
13. NRAO Room Detail Sheets & Revisions Thereto.
14. VLA - Operating On-Site Antenna Locations.
15. Plotting Manuscripts & Data Processing Cards for all Wye Arms.
16. Topographic Map - Center Section.
17. Estimate of electrical usage for VLA Antennas - 7/13/73.
18. Aerial Photography Negative Rools 485 & 486.
19. Electronics and Digital Control Area revised criteria & drawings - 10/2/73.
20. Preliminary NRAO Concept Drawings for Antennas & Track Configuration.
21. Final Environmental Statement - VLA.

DESCRIPTION OF PROJECT

1. MASTER PLAN OF PROJECT

The master plan of the project is principally dedicated to the functional relationships within the central site activities of the VLA. The antenna arm configurations are predicated on scientific astronomical concerns and except for antenna stationing discussed in Section II - 4, geometry dictates with no complication that the arms of the wye configurations are at 355° true of 0° north, 116° south & east of north and 235° south and west of north.

With regard to the central site, the functional relationships of the complex were designed to meet the following principal criteria:

A. 1500' clear zone around the center of the wye.

B. 5° vertical angle to the south & 30° vertical angle to the north antenna operational clearance.

C. Compactness of the site building complex with separation of diverse functional activities.

D. Cost effectiveness of site access and physical arrangement.

E. Maintenance of environmental compatibility with the Plains of San Augustin.

F. Maximization of operational activities particularly with respect to inter Wye vehicle transfer, antenna assembly and electronics assembly construction activity.

Reference is made to the Topographic Map which shows the recommended site plan.

The entire complex is physically and functional related to the central portion of the SW arm which is to be constructed initially. Not only is the arrangement functionally proper, but the natural building orientations which evolve provide for the most spectacular viewing of the Plains of San Augustin by site operations people and visitors. Functionally, the hub of initial operations relates to the antenna and electronic assembly areas. The antenna assembly building has been oriented along the antenna centerline, a potentially dead observing area. The building is placed approximately 1300' south of Station CW3 which provides clearance for 5° operation of immediate access to existing roads and temporary and permanent power. The facility is separated operationally from other activities by old U.S. 60 which traverses the site. In this location, off main line, trackage has been cut to a minimum with respect to operational considerations. In conjunction with the antenna assembly operation, the electronics assembly activity is paramount initially. Station CW3 has been utilized for this function. As a logical

sequence of this location, the permanent General Maintenance Facility has been placed in this area, as well as all central site maintenance activities, i.e., electrical substation, well, and reservoir. These operations are accessible during construction to temporary power and permanently to related site activities.

Having established the antenna and electronics assembly operational functions, the Control Building, Cafeteria, and Visiting Scientists' Quarters follow logically. The Control Building as the central building of the complex is oriented toward the center wye configuration. It is within walking distance of all operations except possibly the Antenna Assembly. Sufficient space has been programmed to allow expansion of the complex and provide for a future laboratory building between the control and electronics maintenance activities. Main entrance to the project is incorporated into the Control Building area.

The Cafeteria Building and Visiting Scientists' Quarters complete the present building complex. These are separated from the Control Building, but are an integral part of the central site with respect to architectural considerations. The two complexes are physically separated to provide for maximum privacy and comfort of visiting scientists. The Cafeteria Building, a day long noisy activity, is serviced conveniently from all elements of site without interfering with sleeping and control activities. The Visiting Scientists' Quarters have been designed for comfort, sleeping privacy during the day and the potential for future expansion in a logical manner.

As an overall site development consideration, access for service vehicles is programmed to the rear of most buildings, in particular, the Control, Cafeteria and Visiting Scientists' Quarters. This allows separation of internal site vehicle operations from external vehicles. Deliveries can be directed to the General Maintenance Building and internally maintenance crews are free to move between the antenna assembly site and electronics maintenance, Control, Cafeteria, Visiting Scientists' Quarters, independent of external and visitor traffic while at the same time creating minimal disturbance to ongoing operational activities in these areas.

Provisions have been made for on site sewage and solid waste disposal as depicted. The location indicated is consistent with the total environment of the site complex and workers therein. From a visual and air quality consideration these locations impact the site minimally, yet at the same time are economically located with respect to total cost and operation.

The Wye trackage configuration depicted minimizes excess trackage and provides for transfer between all legs of the Wye which is simple and directionally obvious.

Provisions have been made for future on site residential development on the hillside overlooking the entire site. No design of these homesites is suggested, however, utilities design contemplates their possibility.

In the documentation to follow the individual elements mentioned herein as well as the broader Wye drainage, alignment and earthwork, wave guide, etc., are discussed in detail. Also the physical locations of the airport and access roads which traverse the central site are discussed.

2. CENTRAL SITE UTILITIES

2.1 Access Roads and Site Grading

From the junction of State Road 78, 3.2 miles westerly (to just past the airstrip access road), old Highway 60 will be used in place with weeds removed from the paved surface and shoulders and patching where necessary. The existing surface is only 18' wide with no shoulders over most of the section which provides a very substandard access facility.

The access roads and parking areas are scheduled for two stage construction. The initial stage will consist of grading and gravel surfacing. The second stage will include subgrade preparation and the construction of a 2" asphalt concrete (road mix) surface course.

All Central Site access roads will have 20' wide by 6" gravel surfacing and 4' gravel shoulders except the sewage lagoon maintenance access road, which will have a 10' wide by 2" gravel surface and no shoulders, the sewage lift station road and the well house reservoir road, both of which will have 20' wide by 2" gravel surfacing with no shoulders. Dust will be a problem until Stage II is complete.

2. CENTRAL SITE UTILITIES

2.2 Airstrip

The airstrip is needed for access to the site by private planes and small commercial carriers under charter. The original VLA proposal called for a Basic Utility Airstrip which would enable operation of DC-3 and similar aircraft. The proposal called for a 75' paved strip 5,200 feet long.

Contact was made with the local office of the Federal Aviation Administration and their suggestions and design aid were enlisted. Their design charts require an eight thousand, seven hundred (8700) foot runway for DC-3 operation at an elevation of 7000 feet above MSL and with average summer high temperatures of over eighty (80) degrees Farenheit.

The airport is located southwest of the Central Site and approximately parallel to the Southwest leg of the wye. The airstrip and clearance zones are situated so as not to interfere with contiguous antenna stations. Drainage is mostly sheet flow from the Northwest and is being diverted around the East end of the strip.

The airstrip is also scheduled for two stage construction. The first being clearing, grubbing, excavation, grading and surfacing consisting of 5-1/2" of granular base course and 4" portland cement treated subbase. The second stage will be subgrade preparation and a 2" asphalt concrete (road mix) surface course. (See appendix for alternative location.)

2. CENTRAL SITE UTILITIES

2.3 Power

Serving Utility: The serving utility is Socorro Electric Cooperative (SEC) with the home office in Socorro, New Mexico. SEC operates a 69KV transmission line to Magdalena, New Mexico, where a transmission substation and switching station steps the voltage down to 14.4/24.9KV. One existing aerial 14.4/24.9KV circuit passes the VLA site and is available for temporary construction power, but it lacks the capacity, reliability, and quality required for the VLA final operation.

New Feeder: SEC will construct a new VLA express feeder which will originate in the Magdalena switch station as a separate 14.4/24.9KV feeder from the 69KV transmission line. An oil circuit reclosure and automatic voltage regulator will be included at the Magdalena station. The feeder will consist of #4/0 ACSR phase conductors on 10 foot crossarms with saddle pins, with a #1/0 neutral carried in the overhead static position, with nominal 40 foot wood poles. The routing of the new feeder will follow the new Highway 60 and approach the central site from the northeast, leaving the existing feeder in its present location, and maintaining 40 foot separation.

SEC-VLA Substation: SEC will construct a new 2500 KVA substation on the VLA site to step the voltage down to 7200/12470 volts, three phase, four wire, grounded neutral. The substation will have fuse protection on the 24.9KV primary. The secondary will consist of a master power meter, a main oil circuit breaker, one oil circuit breaker for the central site circuit, and three oil circuit reclosers for the three wye circuits serving the three arms of the wye. Power failure relays and reverse power relays will be provided to prevent paralleling the generators with SEC. The substation will be served by the new express feeder with provisions for emergency connection to the existing SEC feeder. Fault current available will be 243 amps three phase and 163 amps to ground on the 7200/12470 volt secondary.

Substation Location: The SEC-VLA substation will be located approximately 50 feet north of new SEC express feeder, paralleling the access road to the General Maintenance Building. This will minimize the cost of SEC feeder, will minimize the cost of access roads to the substation, will provide a 500 foot clearance to the nearest antenna, will allow SEC to have emergency back-up service from the existing SEC feeder, and will keep the substation out of normal viewing of the array.

Substation Connections and Grounding: The SEC-VLA substation will have one 2500KVA transformer with wye-wye connections on the primary and secondary. The grounding electrode for the substation will consist of a copper ground mat under the substation.

Projected Loads: The projected peak demand loads for the entire project are as follows:

1973 - 22 KVA		1977 - 1308 KVA	
1974 - 80 KVA		1978 - 1504 KVA	
1975 - First Half	- 252 KVA	1979 - 1700 KVA	
Second Half	- 350 KVA	1980 - 1945 KVA	
1976 - First Half	- 350 KVA	1981 - 2239 KVA	
Second Half	-1075 KVA		

Substation Installation Time: The new VLA express feeder and SEC-VLA substation will require two years to put into service, after agreements have been signed. The new feeder will be available at the end of 1975 or early 1976 at the earliest. According to the projected loads, VLA will be requiring a peak demand of 350KVA to 1075 KVA, including possibly 6 antennas operating on the west arm (3 km). This coincides with the SEC capacity of 600KVA to 1000KVA available to VLA from their existing feeder.

Temporary Power: The requirements for construction power will commence in early 1974, with the building complex and central site scheduled for completion by the summer of 1976, including two antennas. Temporary power for construction will be furnished by SEC from the existing SEC feeder. Aerial pole lines will be constructed by SEC at the construction Contractor's request to the construction sites where pole-mounted transformer banks will serve aerial drops to power meters at the desired construction voltage. As soon as the SEC-VLA substation is complete, the substation will be temporarily connected to the existing SEC feeder and will serve construction power through the VLA primary circuits. Until the SEC-VLA substation and new SEC express feeder are in operation, some power interruptions and voltage transients can be expected. Precise operations are not scheduled to begin during this period.

Central Site Electrical Distribution: Electrical distribution for the central site will originate with a feeder circuit breaker in the SEC-VLA substation. The circuit will consist of 3 #1/0 15KV aluminum cables with HM polyethelene or ethylene propylene insulation and concentric wrap neutrals, direct-buried, 42 inches minimum below grade. The feeder will be designed as a loop-feed radial circuit to pad-mount transformers located by the buildings.

Pad-Mount Transformers: The pad-mount transformers will be fully metal-enclosed, weatherproof, oil-insulated, self-cooled, three phase, 12470 Grd-Y/7200V - 480 Grd/Y/277 volt, wye-wye connections, with taps. The primary will include an oil-immersed, four-position, loop feed, load-break, gang-operated switch with fuse protection in each phase. The secondary will consist of spade terminals only. Estimated transformer ratings are 750KVA for the Control Building, 500KVA for the General Maintenance Building, 225KVA for the Antenna Assembly Building, and 500KVA for the Cafeteria Building and the Visiting Scientists Quarters. Transformers will have four-legged or five-legged core designs to eliminate interference and improve operation.

Exterior Lighting: Exterior lighting will be provided for walkways and parking areas. Streetlighting and antenna floodlighting will not be provided. Exterior lighting fixtures will be incandescent, since mercury vapor or high intensity discharge fixtures would interfere with electronic signals.

Emergency Power: Emergency power is required by the antennas in order for the antennas to drive to stow position during a power outage with accompanying high winds, thereby preventing damage to the antennas. This emergency power requirement is 410KVA for a period of 30 minutes while the antennas are driving to stow position, after which the antenna emergency power will be 270KVA. Two 250KW (313KVA) engine generators will be provided. When the antennas are idling in the power-fail mode, the engine-generators will have 356KVA spare capacity (626-270). This spare capacity will be used for emergency power for the central site, and will serve only the lighting, minimum heating, telephone equipment, and essential water supply and sewage systems. The building loads associated with air conditioning, computer, electronics, shops, kitchen equipment, and domestic hot water equipment will not be served. These non-essential loads will be automatically dropped out by magnetically-held contactors, and may be manually reconnected if the generator loading permits. When the commercial power from SEC fails, all power and lighting will be off except for battery-operated emergency lights. There are no critical loads requiring non-interruptible power nor generator power within 10 seconds. However, automatic load transfer is required since a maintenance electrician will not be on duty at all times. Power failure relays with time delay will trip the main circuit breaker in the SEC-VLA substation and drop all central site loads except the water pumping system which is required for the fire sprinkler operation. During this time delay period the engine-generators will automatically start and automatically parallel. At the end of the time delay period the engine-generators will transfer to load and will serve the antenna wye circuits and the water pumping system. Relays in the SEC-VLA substation will prevent the reclosing of the main circuit breaker while the generators are operating, and thus prevent parallel operation. Wattmeter relays on the generators will sense the peak demand and whenever the antenna wye load reaches the idling set-point (270KVA), the essential loads in the central site will be automatically energized. Conversely, if the total generator load approaches an overload condition, the central site essential loads will be dropped to allow full power to the antennas. Load re-transfer to commercial power will have sufficient time-delay to assure stable power, since there is no urgency to retransfer.

Engine-Generators: The engine-generators will be located in the General Maintenance Building and will consist of two 250KW (316KVA) engine-generator sets with automatic engine starting and automatic generator paralleling. Fuel for the engines will be diesel, with underground storage tanks sized for 24 hour minimum operation.

2. CENTRAL SITE UTILITIES

2.4 Telephone

As of November 15, 1973, no definite requirements have been provided for types of telephone service required at the antenna sites along each arm. BWH-CVR Joint Venture prepared three cost estimates assuming VLA would own the distribution system. The estimates were based on the following assumptions:

A. Assuming three lines per antenna site.

B. Assuming one line per antenna site.

C. Assuming eight antenna sites per line (rural party system).

The material cost for a system based on three lines per antenna site came to $162,146.81. Catalogs were ordered from several telephone equipment manufacturers, and the cheapest material available for a direct buried distribution system were used in preparing the cost estimate.

At a meeting of Mountain Bell representatives, VLA representatives, and BWH-CVR Joint Venture representatives on November 14, 1973, all three cost estimates were briefly discussed. At the same time a request was made to the telephone company to provide a system design wholly owned by Mountain Bell. As soon as definite requirements are provided for the distribution, formal request will be submitted to Mountain Bell.

2. CENTRAL SITE UTILITIES

2.5 Water System

The system chosen to service the VLA site consists of a well, ground storage tank, hydro-pneumatic pressure system and booster pumps for domestic use, and an auxillary pump for fire protection. The system can easily be staged to reflect construction only as facilities are required. Phase I can be constructed and utilized until such time as there are definite needs for fire protection. At this time Phase II can be constructed and the entire system completed.

Phase I will consist of constructing the well, pump house, hydro pneumatic tank and constrols and distribution to the first buildings requiring service. The well pump is designed to pump the ultimate required flow rate to ground storage. However, in Phase I water will be pumped directly to the hydro-pneumatic system at a reduced rate.

Pumping into the pneumatic tank requires pumping against forty-five more psi than pumping into a ground reservoir. This increased pressure will drop the flow rate of a typical well pump from the designed flow of one hundred twenty gallons per minute to seventy-three gallons per minute. Seventy-three gallons per minute is not adequate for the entire complex but is adequate to supply peak flows to the Maintenance Building, the Control Building and the Antenna Building which are the first buildings to be built. When the complex is expanded so that higher flow rates are required, Phase II must be constructed.

Phase II will consist of constructing the reservoir and installing booster pumps, fire pumps and their associated controls. This would be accomplished when construction reached a point that fire protection became a critical requirement.

The fire pump and electric motor are sized to supply 400 gpm to any sprinkler system and 500 gpm at 45 psi at the nozzle of a 200' long fire hose connected to a fire hydrant. The reservoir will hold 70,000 gallons and this coupled with a well pump capacity of 120 gpm will enable the fire pump to supply a 900 gpm fire flow for ninety minutes. This should provide adequate fire protection anywhere in the system without the aid of a pumper truck or any other auxiliary equipment. The adequacy of the system should be reviewed by the fire insurance underwriters and no design should be considered complete until it is approved by the underwriters.

2. CENTRAL SITE UTILITIES

2.6 Sewage System

Due to present trends in philosophy concerning environmental pollution and the ultimate goal of no discharge of effluent that may have a potential to pollute, such a system was viewed as desirable for the VLA site. These goals can easily be achieved with a total evaporation lagoon system.

A total evaporation lagoon system is designed such that the average yearly effluent to the system is balanced by the net evaporation from the free water surface of the lagoons at their average operating depth. In areas such as the VLA site, where relatively high values of net annual evaporation occur, such a system can be designed and constructed economically. Coupled with the near absence of operation and maintenance expenses this type of system is highly desirable.

The lagoon system was designed with operating levels of 3 to 5 feet and an average depth of 4 feet. Freeboard of 2 feet will be provided above the high water level resulting in a total depth of 7 feet. Side slopes of 2:1 outside and 4:1 inside with a 10 foot driving lane on the berm tops will be provided. The embankment height above finished grade was set such that all earthwork will approximately balance. It is a requirement by the State Environmental Improvement Agency that all lagoons shall have lining on internal side slopes and that the bottoms of the lagoons will be treated to reduce percolation rates to a maximum of .25 inches per day. To accomplish this a 5" thickness of soil cement will be prepared and compacted in the bottom and on the sides of the lagoon. Piping will be arranged to allow series and parallel operation.

The design parameters resulted in the definition of a two cell lagoon system. Each cell is to be square in shape and have dimensions of 253 feet per side at the average depth of four feet resulting in a total surface area of 2.93 acres. The resulting organic loading on the system falls considerably below 50# BOD/Acre-Day, the conservative loading commonly used in designs for lagoon systems in the southwest. For this reason it is felt that in series or parallel operations the lagoon system will seldom experience odor problems.

Sewage collection lines 6" in diameter are adequate to carry projected flows; however, it is the practice of the State Environmental Improvement Agency to require a minimum of 8" diameter lines for all new sewer main construction. This will also allow for future expansion at the site.

Polyvinyl chloride material has been specified for use in all sewer main and lateral construction. The 20-foot lengths, light weight and ease of handling should reduce construction costs. The material is approved by the State Environmental Improvement Agency for such construction. However, an alternate for the selection of

vitrified clay pipe by the Contractor will be provided. A lift station has been specified to be constructed in the vicinity of the maintenance building to facilitate transmission of the sewage to the lagoon site. Savings will be realized in the construction of the force main due to decrease in required line size, elimination of excessive cuts required for gravity lines, reduction in total number of manholes and reduction in the required cut at the treatment location. Those savings will partially offset the cost of the lift station.

The lift station type is determined by its pumping requirements. For pumping rates less than 100 gpm, an ejector can handle rags and large solids efficiently and reliably and maintain adequate velocities through the force main. Therefore, an ejection system was selected for the VLA project with standby pumping capabilities in order to provide a reasonably trouble free system. A Dual 50 GPM ejector was selected, thus providing a total pumping rate of 100 GPM.

During the initial construction phase of the project a septic tank system will be used to provide sewage treatment and disposal for the Maintenance Building. This type of system will be designed to handle the projected flows from this building with the exception of flows from the car wash pad. An identical system can be constructed to serve the Antenna Assembly Building on a permanent basis. The septic system for the Maintenance Building will be constructed in the event the building is to be constructed prior to the permanent site sewerage system.

3. CENTRAL SITE BUILDINGS

3.1 CONTROL BUILDING

A. Architectural - Structural

The building is a two-story structure above grade, constructed of reinforced masonry exterior bearing walls with a poured in place concrete substructure and a precast concrete double tee roofing system. There are two distinct functions housed within the building and are defined in the design by different roof heights and a projection. The "Working Function", comprised of spaces for Digital and Electronic equipment, Control Room, Computer Equipment, Laboratory Space and Mechanical Equipment, is in an "L" shape configuration with overall dimensions of one hundred forty-two feet (142'-0") in length by fifty feet in width for the long leg and eighty feet in length by forty-two feet in width for the short leg and is twenty-eight feet eight inches (28'-8") from finish lower floor to top of roof tees with a one foot four inch (1'-4") high parapet making a total overall height of thirty feet above finish lower floor level. The "Administration Function", comprised mainly of office spaces, is a basic box form projecting from the interior angle of the "L" with overall dimensions of fifty-five feet by fifty-one feet and is twenty-four feet eight inches (24'-8") from lower floor line to top of roof tees with a one foot four inch (1'-4") parapet, making a four foot difference in roof heights.

The lower level finish floor elevation for the entire building is set one foot six inches (1'-6") above the existing grade to accomodate drainage away from the building and still allow for equipment delivery and personnel access with a minimum amount of exterior stairs. The vertical differential for equipment delivery is by ramping of access drives.

The exterior treatment of the building is mainly of load bearing "Slump block", a concrete masonry unit in which the forms are removed before the concrete is set and allowed to slump giving the unit an "Adobe" feeling with an irregular face, overall face dimensions of the unit are four inches high by sixteen inches long. The southwest wall of the office block has precast concrete panels of large exposed aggregate across its entire length and full height (26'-0") of the wall. At the office roof is an overhang of eighteen inches (on the southeast and northwest) with precast concrete fascia panels attached to the end of the double tees and closed with a stucco soffit. Across the entire northeast face of the building is a visitors observation deck at the upper level floor line (+16'-0") cantilevered from the building. The observation deck is covered by the cantilevered roof but not enclosed, precast concrete fascia panels and stucco soffits of the same design as on the office block extend across the face of the building at the roof and at the walking surface. A metal tubular guard rail, forty-two inches high and running the entire length of the observation deck, is bolted to the top of the fascia panels for visitors protection. The building has windows with fixed glazing of "solar bronze" tint that are full height

of the structure in the office block. There are smaller windows of fixed glazing in the lower level laboratory spaces with sill heights of three feet to accomodate laboratory furniture and at the upper level there are fixed glass windows located along the visitors observation deck for viewing into the Computer room, Control room and the Electronics Equipment room.

Access to the observation deck is from a pair of triple run stair towers at each end of the deck. The tower is open faced with the sides constructed of load-bearing slumpblock to match the rest of the building. The risers, treads and platforms of the stairs are steel framed with metal pan and concrete fill.

The main entrance to the building (on the Southeast side) is of aluminum storefront frame with "solar-bronze" fixed glazing the full height of the building. A staff entrance has been provided on the southwest side of the office block, the door and frame are of aluminum three feet wide by seven feet high. Double hollow metal doors for equipment access are located on the lower level into the lab space and mechanical equipment rooms and a single hollow metal door is provided from the exterior into the Electrical Equipment room on the northeast side of the building.

The roof of the building is of pre-stressed concrete double tees, eight feet wide and depth as required, with a lightweight insulating concrete fill (five inches maximum sloping to two and one half inches at roof drains) covered by a three-ply built-up bituminous and gravel roofing system. A roof scuttle with a metal ladder located in the Janitors Room on the upper level gives access to the lower roof and an exterior metal ships ladder gives access from lower roof to higher roof.

The lower level floor system will be concrete slab on compacted fill, raised approximately eighteen inches above natural grade. The slab is four and/or six inches thick, reinforced with welded wire mesh and will have a chemical hardener applied in all areas to be left exposed.

The interior of the lower level "office block" is divided into a main lobby, nine offices, coffee and lounge area and a men's toilet by metal stud and gypsum board partitions to six inches above the ceiling, the interior side of the slump block enclosing walls are to be left exposed, and the interior side of the concrete panels are to be furred with metal furring channels with gypsum board over. All doors into offices are wood veneer, solid core, set in hollow metal frames. The ceiling of the entire office block is an exposed "T" grid system with lay-in acoustical panels at nine feet above floor line except in the mens' toilet and Janitors' room which will be lay-in gypsum board panels at eight feet above floor line. The mens' toilet will have a ceramic tile floor on a depressed slab and setting bed, all the rest of the floors in the office will be vinyl-asbestos tile. All gypsum wall board is to be taped and textured and painted except in the mens' toilet where there is a ceramic tile wainscot thinset, four feet high; and on the southwest and north walls of the lobby and stairwell which are to receive a 1" x 6"

vertical wood stripping from top of base to four inches below ceiling line. Ceiling heights in all these areas are nine feet with the exception of the toilet and janitors space at eight feet.

The remainder of the Lower Level consists of two Mechanical Rooms, an Electrical Equipment Room, Programmers office and a large open Laboratory and work area. The Mechanical Room in the southwest portion of the building is to house the air conditioning system for the Digital and Electronics equipment only. Computer equipment along with the central and building air handling systems are located in the northeast mechanical room. A concrete block, sand filled, wall to the underside of the structure above separates the mechanical rooms and the Electrical Equipment room from the lab space, all surfaces within the mechanical and electrical spaces are to be painted or sealed. The remaining area in the lower level has been left open for laboratory and work spaces that will be allocated and partitioned off in the future by means of seven foot high demountable partitions located as required. Except for a metal stud and gypsum board enclosure in the southeast corner of the lab space, this space will be utilized for computer programmers and is to have a lay-in acoustical ceiling, the walls of the room will also extend to structure above. There will be no ceiling in lab and work spaces to allow for easy access to cable trays, wiring, wave guides, etc.

A poured-in-place concrete shaft located in approximately the center of the building will house a hydraulic freight elevator and mechanical duct chases. An Elevator Equipment Room and a Telephone Equipment Room are located below the mechanical chases and will have a two hour fire-rated (U.L.) gypsum board ceiling at eight feet above lower level floor line.

The interior stairs are of steel framed construction with concrete fill over metal pans for treads and landing covered with rubber safety treads and vinyl asbestos tile at the landing. The total rise of the stairs is twelve feet eight inches (12'-8") with one intermediate landing.

The upper level "office block" is a concrete flat slab floor system, eight inches thick, with a finish floor to finish floor height of twelve feet eight inches (12'-8") overall, and a vinyl asbestos tile covering throughout except for ceramic tile on a setting bed in the toilets. All interior partitions in the office block are metal stud and gypsum board extending four to six inches above the ceiling, taped, textured and painted with ceramic tile wainscotting, thinset and four feet high in the toilets. All "slump block" walls will be left exposed and the southwest precast concrete panel wall will be furred with metal furring channels and finished with gypsum wallboard the same as the lower level. Ceilings in the upper level are lay-in acoustical board with an exposed "T" grid, except the toilets will have lay-in gypsum board. A steel ladder is located in the Janitors room and leads to a metal roof scuttle directly above.

The "Working Function" of the upper level is a concrete beam and slab structural floor framing system monolithically poured-in-place and is of different floor to floor heights depending on the requirements of a computer type access finish floor. The overall finish floor to finish floor height is sixteen feet no inches, and the depth of the access flooring system is one foot eight inches (1'-8").

The Digital Equipment room is to be completely enclosed in a 24 gauge galvanized sheet metal R.F.I. shield, the shield enclosure is a pre-fabricated, job-site erected item of wood frame construction. The finishing of the room is gypsum wallboard on the wood shield frame, taped and textured, a lay-in acoustical ceiling on suspended "T" grid from the ceiling of the shield frame and a computer type access floor with vinyl-asbestos tile. The door of the shielding enclosure is an integral part of the enclosure and is furnished by the enclosure manufacturer complete with all hardware. Immediately adjacent to the Digital room is the Electronics Equipment room, separated by a load bearing concrete block wall, sand filled and painted, extending to the double tee roof above. The floor of the Electronic Equipment is concrete, at sixteen feet above lower level floor line, with vinyl asbestos tile over and eighteen inch square equipment holes through the slab to the lab area below at equipment locations. "Slump Block" walls on the northwest and northeast are left exposed on the interior with an exit only door and two observation windows, each eight feet long by three feet high with "solar bronze" glazing set in hollow metal frames, on the northeast wall along the observation deck. A metal stud and gypboard partition on the southeast completes the enclosure of the Electronics Equipment Room, a large portion of this wall is of clear glazing in hollow metal frames with a sill height of three feet for direct visual contact with the Control Room and Operators room. There is also a double door in the wall to allow for equipment access and personnel access from the corridor and a single leaf door with a large viewing panel from the equipment area to the Control Room.

The Computer Room, located at the southeast end of the upper level, will have a structural floor slab of concrete at fourteen feet - four inches (14'-4") above the lower level finish floor to accommodate a computer type access floor twenty inches deep. There is to be a galvanized wire mesh R.F.I. shield encompassing this space, and the Control Room as a continuous enclosure. The three exterior walls will have wood furring strips from structural slab to precast double tee roof structure above over which the galvanized R.F.I. screen will be applied, after the screening is attached to the furring the walls will be finished with an acoustical wall board from structural slab to structure above. On the northeast wall are located three openings, one for an emergency exit door with a brass threshold and two observation windows eight feet long and three feet high with "Solar-Bronze" glazing set in hollow metal frames attached to the hollow metal frames and stretching across the glazing is the galvanized R.F.I. screening cloth set in removable frames but in contact or tied to the screen cloth in the walls to maintain the shielding continuity across the openings. In lieu of a separate screening cloth, screened glass is being investigated and will be used if available.

Between the Computer Room and Electronics Equipment room is the Control Room, an Operators Room, an Observers Room, Toilet, Coffee area, Tape Storage Room and a Corridor. All these rooms or spaces have a computer type access floor over the structural slab, only the Control Room is to be shielded with the R.F.I. screen cloth enclosure to be tied directly with the Computer Room shielding. The exterior wall of the Control Room is to be furred and shielded the same as the Computer Room except gypboard will be used in lieu of acoustical wall board, the windows will be framed and screened also in the same manner as the Computer Room. Metal stud and gypboard partitions with glazing in hollow metal frames complete the enclosure of the Control Room, with the exception of the southeast wall, all partitions will have the galvanized wire screen shielding between the studs and the gypboard on the Control Room side of the partition. Interior glazing in partitions to receive R.F.I. shielding is to be clear wire glass, with the wires in contact with the metal frame for continuity of the shield, all other interior glazing is clear plate glass. With the exception of the Tape Storage Room all ceilings in the upper level "Working function" of the building is lay-in acoustical ceiling panels in a suspended exposed "T" grid system at nine feet above finish floor.

The Tape Storage Room, due to flamibility of the proposed contents, is to have two layers of 5/8 in. thick gypboard on metal studs with staggered joints for the walls from structural slab to structure above and a suspended two hour (U.L. rated) suspended gypboard ceiling.

All doors in the upper level are to be wood veneer, solid core, sealed and varnished with glass panels where scheduled in hollow metal frames, except the special R.F.I. shielded door that is provided by the shield room manufacturer and the two emergency exit doors onto the observation deck, both of which are hollow metal.

3. CENTRAL SITE BUILDINGS

3.1 CONTROL BUILDING

B. Mechanical: The building will be served by three (3) air handling systems and a central refrigeration equipment space.

1. Refrigeration and Heating Equipment: Total projected building heating requirements at design conditions are approximately 75% of the equipment cooling requirements, in equivalent units. It is therefore proposed that a heat pump "bootstrap" type heating system be provided to maximize the use of available energy. Since refrigeration cooling is required throughout the year, the heat rejected from the air conditioning space can be utilized to provide the necessary heating. To accomplish this, it is proposed that refrigeration compressor media cooling be provided by circuiting normal condensing water piping through heat enchangers. When the cooling load exceeds the heating load, water from the closed condensing circuit would be directed through the shell side of the heat exchanger, which would be cooled by the water from the cooling tower on the tube side. When the heating demand exceeds the cooling demand, condensing water bypasses the heat exchanger and the heat is rejected through heating coils into the hot duct of the building dual-duct air system. In this manner, the chiller heat of rejection is utilized for the heating system rather than being wasted by dissipation to atmosphere through a cooling tower.

For several reasons, it is felt that this type system provides advantages over a conventional chilled water system with heating boilers. These are as follows:

(a) Since cooling is required on a year-round basis, in lieu of wasting the heat by means of cooling tower, this heat can be beneficially used in the heating side of the air systems. This will result in a conservation of energy and a subsequent considerable operating cost savings.

(b) With this type of system, either heating or cooling is available year-round with no need for winterizing the system. In order to maintain comfort conditions in the building, it is necessary to have chilled water available year-round.

(c) It is required that a new electric steam boiler of sufficient capacity be installed for humidity control in special areas. This same unit can serve as back-up in the event that there is the loss of any of the refrigeration equipment and resultant loss of heating capacity.

(d) The system has simplicity of operation. The operation will be completely automatic. Water treatment requirements will be minimized since the amount of cooling tower water pumped on a yearly basis will be greatly reduced. This will reduce the cost of water treatment and subsequent scaling and cleaning of condensing tubes throughout the year. An additional benefit is the subsequent reduction in the sewage lagoon size to which tower effluent discharges, since tower operation is minimized.

To provide adequate back-up for the cooling system and insure a reasonable assurance of continuity of service, each of two (2) chillers will be sized to provide for the total electronic equipment cooling requirements, i.e., approximately 60% of total projected building load. The chilled water, condensing water and heating/condensing water pumps will be similarly selected.

All major pieces of rotating equipment shall be isolated from the structure with spring vibration isolators and inertia pads or with isolated slabs. The Central Equipment Room will contain a steam to hot water convertor, condensate return system, hot and chilled water expansion tanks, duplicate circulating chilled water and heating water pumps, duplicate water chillers, a tower water pump, and the respective air handling systems.

Air tempering coils will have 3-way modulating valve control with a secondary circulating pump in the Digital/Electronics reheat coil circuit for control of flowing fluids and affected air temperatures.

Humidifiers are of the steam atomization type with high limit control and fan interlock to prevent condensate in the duct.

2. Personnel Heating and Air Conditioning System: It is proposed that all personnel areas of the building be served by dual-duct, medium velocity system, with central fan equipment located in a Lower Level Equipment Room.

(a) Offices shall be zoned for temperature control. Air supply to each room shall be provided by a ducted overhead distribution system. Return air shall make use of the ceiling space as a return air plenum. Sound traps shall be provided for all offices so that sound transmission is minimized.

(b) Penetrations of fire chases and fire rated walls are protected with fire dampers. The air system will be designed to have automatic smoke removal, should smoke be detected in the return air. Under this condition all motorized return air dampers shall be driven closed and all motorized

relief air dampers shall be driven open. The system shall remain in this condition until manually reset or shut down. Water coil freeze-up and subsequent possible failure during this mode of operation will be protected against, through the use of low limit temperature sensor which will stop fan operation when energized.

(c) A 100% outside air ventilating cycle will be provided in order to conserve on refrigeration requirements in the winter time. An economizer cycle - mixed air temperature control system would be incorporated into the central air handling unit design. This would automatically provide "free" space cooling capability, utilizing maximum outdoor air, as outdoor ambient temperatures allow. This is reflected in a reduction of nominal unit cooling operating costs of approximately 20 - 30% when compared to the fixed outdoor-return air type of system.

3. Computer/Control Room Equipment Heating and Air Conditioning System: It is proposed to supply this equipment from a 100% recirculated air system comprised of dry bag type filters, sound attenuators, chilled water cooling coils, heating water coils, and axial flow, Class II supply-return fans with manually adjustable inlet vanes.

(a) The unit will have automatic temperature and humidity control. Air will be ducted to an underfloor plenum which serves this area. Penetration into the plenum will be protected with fire dampers.

(b) Air quantities delivered to the Computer and Control Room plenums will be determined by criteria requirements, respectively.

(c) Smoke detection is alarmed, but will not affect system air flow. However, the design incorporates a positive, manual selection capability for unit shut-down instituted by personnel when desired.

(d) The occupied space is served from the Personnel heating and air conditioning unit - see 2. above.

4. Digital/Electronic Equipment Rack Heating and Air Conditioning System: It is proposed to supply the Digital/Electronic equipment from 100% recirculated air system comprised of dry bag type filters, sound attenuator, chilled water cooling coils, hot water primary reheating coils, centrifugal DWDI Class II supply-return fans with manually adjustable inlet control valves, and electric duct mounted secondary reheat coils. All equipment will be located in the Mechanical Room immediately below the Digital/Electronic Equipment area.

(a) Digital Area Equipment: An underfloor plenum space will be served by a multiple ducted air supply. Air quantity is predicated on criteria requirements. Secondary, duct mounted electric reheat coils control air temperature to the plenum.

(b) Electronics Area Equipment: Individual banks of racks will be served with ducted air "hard" connected to the individual racks. Each bank of racks will be served with a quantity of air sized to dissipate the heat load designated by criteria documents. Secondary, duct mounted, electric reheat coils will serve each bank of racks and control air temperatures to the racks. See 5. following (Temperature Controls) for complete description.

(c) Digital and Electronic Equipment air will be relieved to the room and taken into the area ceiling space. The ceiling space shall be utilized as a plenum to convey air back to the system fans. Personnel HVAC system will be intermixed since both will be essentially at the same temperature.

(d) The system will be designed to utilize ionization smoke detectors throughout the system. Air system shut-down will be by positive action instituted by personnel and will not automatically respond to a smoke detection alarm.

(e) All penetrations from the mechanical space to the Digital area will be protected with Radio Frequency interference filters, range as required.

(f) The occupied space is served from the Personnel heating and air conditioning unit - see 2. above.

5. Temperature Control:

(a) Personnel System: In areas served by the medium velocity double duct system, individual room thermostats or zone thermostats will control mixing boxes so that heated, cooled, or tempered air is delivered to the room, as required. The controls will be of the proportioning type so that when the thermostat is satisfied, intermediate temperature air will be supplied. At the central fan system, an automatic mixed air control system will proportion the return, relief and outside air dampers to provide a predetermined mixture temperature to the unit. The mixed air temperature will be selected to provide a minimum ventilation rate in severe weather. The controls will also provide up to 100% outside air in mild weather as temperatures allow.

(b) Computer/Control System: Air being delivered to the Computer/Control Room under floor space will be under the control of a discharge air temperature sensing element. The controls will be of the proportioning type so that air temperature will be continuously regulated to prescribed levels through modulation of chilled water-heating water coil control valves. Humidity control of discharge will be maintained within required limits through use of a plenum mounted humidistat and discharge duct mounted high limit humidistat which regulate the response of central unit mounted steam humidifiers. An electrical interlock will prevent humidifier operation when the main system fans are inoperative. This will prevent excessive moisture accumulation in the system.

(c) Digital/Electronics System: In essence, the temperature controls described for the Computer/Controls system apply for the Digital/Electronics system. However, to achieve the close temperature control required by this equipment, secondary duct mounted electric reheat coils are added to the system. As noted previously, secondary reheat coils will service the equipment racks. Operation and output of each coil will be monitored and regulated through use of an "infinite" position controller responding to rack inlet temperature sensors. In this manner, the ambient condition within the individual racks will be indirectly controlled and not exceed the criteria limits, i.e., 58°F. to 76° F. $\pm$ 2°F. with a maximum rise across a given rack not to exceed 18°F. - based on criteria data.

6. Fire Protection: All areas of the building will be sprinkled, including toilets, closets, and mechanical spaces, but excluding the Electrical Switchboard equipment room. It is proposed to use the automatic reset type of sprinkler head in the Digital/Electronics and Computer/Control areas.

3. CENTRAL SITE BUILDINGS

3.1 Control Building

C. Electrical:

Electrical Service: Service to the building will be 277/480 volts, three phase, four wire, grounded neutral, in underground conduit from the pad-mount transformer located outside the building. A circuit breaker type switchboard will be provided in the building. Switchboard instruments will include a voltmeter, ammeter, and watthour meter with demand register.

Emergency Power: Emergency power will be provided by the engine-generators located in the General Maintenance Building. When commercial power from the Socorro Electric Cooperative (SEC) fails, the building will be without power or lights except battery-operated emergency lights. As soon as the antennas are in their idling mode (maximum 30 minutes), engine-generator power will be automatically supplied to all building lights, minimum heating and telephone equipment. Non-essential loads such as air conditioning, computer, electronics, digital, shops, and domestic hot water heating equipment will remain locked out until manually reset after restoration of commercial power.

Electrical Distribution System: The electrical distribution system will be 277/480 volts, three phase, four wire. Fluorescent lighting will be 277 volts and large feeders and motor loads will be 480 volts. Incandescent lighting, receptacles, and small power will operate on 120/208 volts, three phase, four wire derived from dry-type transformers.

Panelboards: Distribution and branch circuit panels will be circuit breaker type, with capacities selected from connected loads and code requirements. Nominal spare breakers and feeder capacities will be provided.

Motor Control Centers: Fusible type motor control centers, Class II, Type C will be provided at locations of major motor concentration, and will operate at 480 volts with 120 volt individual control transformers for each motor.

Wiring: Feeder wiring will be installed in underground non-metallic conduits where possible, with rigid steel risers. Branch circuits will be in steel conduits installed in walls and ceilings to facilitate future remodeling. EMT conduits will be utilized for applications above ground in dry locations. All wiring will be copper conductors; aluminum conductors will not be used. A separate equipment grounding conductor (green wire ground) will be included with all service, feeders, and branch circuits.

Devices: All receptacles will be the grounding type, specification grade or better. Wall switches will be flush tumbler type 15A-120/277V minimum. Device plates will be stainless steel with brushed satin finish.

Lighting: Lighting will generally be recessed fluorescent, nominally 48 inches long with standard F40CW lamps. Design lighting levels will follow IES recommendations except where specific criteria is furnished. Programmers offices and observers offices will have incandescent lights with manual dimmers so extremely low light levels may be obtained. Incandescent lighting will be used in the Digital Equipment Room to eliminate high frequency radio interference from fluorescent lights in the shielded room. All fluorescent fixtures will have radio interference suppressors. Multiple switching of lamps or fixtures in all areas will be provided to permit energy conservation and to minimize generator loading during power failures. Battery-operated emergency lights will be provided for interim lighting until the engine-generator power is available.

Telephone Service: Telephone service will be underground to a main telephone equipment room which will be utilized for the major equipment racks and terminal boards for the entire project. Telephone outlets will be connected to the terminal boards with 3/4 inch conduit minimum and a maximum of two outlets with one inch conduit. Emergency power will be supplied to the telephone equipment to permit telephone operation during power failures.

Lightning Protection: A lightning protection system will be provided for the building, due to the high incident rate at the site location.

Clocks: All clocks will be standard synchronous electric clocks with manual reset.

Fire Alarm System: A fire alarm system will be provided with closed circuit, electrically supervised, coded, zone annunciated, continuous ringing, combination manual and automatic features, with annunciation and alarm trip on sprinkler flow. Manual reporting stations will be located at all major exits, and fire alarm bells will be provided throughout the building. Battery standby power will be provided. A master annunciation panel will be located in the Control Building to record a fire alarm trip from any zone in the Control Building or any trip from another building. Smoke detectors will be ionization type and will be located in the mechanical fan systems as required by code.

Smoke Removal: The fan systems for the personnel air conditioning system will be placed in a smoke removal function automatically whenever the fire alarm system is tripped. Smoke removal will provide 100% fresh air and 100% exhaust, with freezestat safety control.

Early Warning: Ionization type smoke detectors will be provided on the ceilings of the Computer Room, Electronic Equipment Room, and the Digital Equipment Room to give early warning of smoke, prior to fire sprinkler operation. The early warning systems will alarm in the respective rooms, but will not trip the fire alarm nor start smoke removal.

Snowmelting: Snowmelting systems for exterior walkways will not be provided.

Grounding: The main ground bus will be in the main switchboard with connections to the building steel and a bond to the metallic interior water piping system. The exterior water piping will be non-metallic. A supplementary ground field will be installed consisting of a minimum of 3 stainless steel ground rods interconnected with insulated copper cable, with the insulated copper cable connected to the main ground bus.

Quiet Grounds: A quiet ground will consist of a separate insulated copper cable from the supplementary ground field up to the Computer Room. Similar quiet grounds will be provided for the Control Room, Electronic Equipment Room, and Digital Equipment Room.

3. CENTRAL SITE BUILDINGS

3.2 CAFETERIA BUILDING

A. Architectural - Structural

The single story, load bearing, reinforced masonry wall structure is built on a concrete slab on compacted fill with a poured in place concrete substructure of continuous spread footing and stem walls. The roof is a precast concrete double tee structural system with lightweight insulating concrete fill and a conventional three-ply built-up roof, finish floor to top of double tee height is twelve feet with a two-foot high masonry parapet above for an overall building height of fourteen feet. There is an entrance-foyer appendage on the south side of the building that will have a roof structure of poured-in-place flat slab construction with conventional three-ply built-up roofing, finish floor to top of slab height is eight feet eight inches with a one-foot eight inch (1'-8") masonry parapet and precast concrete fascia panels over the entrance doors.

The exterior treatment of the building is to be consistant with the Control Building; load bearing "Slumpblock" concrete masonry units left exposed; large expanses of anodized aluminum storefront framing, floor to ceiling, in the dining area and a sill height of three foot six inches (3'-6") with stucco inset panels below sill height in the Recreation Room. All window glazing will be fixed "solar-bronze" tinted glass. Located over the window areas are precast concrete fascia panels of the same design and texture as those on the Control Building. There is to be a prefinished, corrugated metal equipment screen enclosure located on the roof, access to which is by means of a roof scuttle and steel ladder located in the janitors room. Exterior doors, other than those located in aluminum store fronts or the main entry doors, are to be flush, hollow metal set in hollow metal frames. An exterior concrete patio slab is located on the northeast and southeast side of the building immediately adjacent to the dining area, for outside dining or lounging. An exterior concrete slab is also located on the northwest side of the building and connecting to the parking area access road for the purpose of shipping and receiving, also located adjacent to the "delivery dock" is a walled in Trash Storage Area with walls of "Slumpblock" construction six feet high and a tubular steel gate four feet wide.

The interior of the building is divided mainly into three areas, the kitchen-service area, the dining area and the recreation area. The recreation area being the smallest of the three, one room of exposed slumpblock, aluminum window wall to a sill height of three foot six inches (3'-6") with metal stud and gypboard below and full thick batt insulation between the studs. A wood folding partition separates the recreation room from the dining room allowing for additionai dining space with the partition open, the partition will be full height, floor to ceiling, and separating at the center. Along the northwest interior slumpblock wall is a base cabinet

of wood construction with a laminated plastic top, a sink unit and a space for an undercounter refrigerator and overhead wall hung cabinets of the same construction. The dining area will also be of exposed slumpblock wall construction except where large expanses of aluminum window walls occur. The window wall construction in the dining area is to be from floor to ceiling with a wood chair rail at two feet six inches above floor line except at door openings and a drapery track in the ceiling at all glazed areas.

The floor covering for the dining room, recreation room, corridor, coat room and foyer areas is to be vinyl-asbestos tile, 1/8 inch gauge, twelve inches square. The ceilings for the same areas and the vending area are to be acoustical lay-in tile twenty-four inches by forty-eight inches (24" x 48") on an exposed tee grid system suspended to nine feet above floor line in the dining and recreation areas and to seven feet six inches (7'-6") elsewhere.

The toilets and janitor area are to be separated by metal stud and gypboard partitions to above ceiling height, taped, textured and painted and a ceramic tile wainscot. Where indicated on the plans, "Slumpblock" walls are to be left exposed. The floor for the entire area is ceramic tile on a depressed slab and setting bed, the ceiling is gypboard at a height of seven feet six inches (7'-6") above finish floor.

An exposed "Slumpblock" bearing wall separates the dining area from the kitchen-service area, providing a masonry fire wall and reducing the span of the roof tees. Openings in this wall will have to be fire rated (U.L. label) with fusible link closures.

The entire kitchen and service area floor is to be quarry tile on a depressed slab and setting bed, except in the mechanical and electrical rooms which will have a chemical hardener over exposed concrete. The ceiling of the same area is to be gypboard panels twenty-four inches by forty-eight inches (24" x 48") on an exposed tee grid system at nine feet above finish floor and exposed concrete roof tees in the mechanical and electrical rooms. The walls enclosing the mechanical and electrical rooms are of standard concrete block construction with sand filled cells to the structure above and painted. All other interior partitions are metal stud with gypboard lath and a cement plaster finish; the interior, or kitchen side, of the masonry walls are to have a cement plaster finish on self furring metal lath. Standard concrete block divider walls (six inches thick and six feet high) separate the pot-washing area from the dishwashing area and dishwashing from the dining room access door. A stainless steel pass window for soiled dishes is located in the wall between the dining area and the dishwashing area.

The Kitchen equipment and Serving Line equipment have been layed out on a separate drawing from the building floor plan for sizing of equipment and work spaces around the equipment. The quantity and type of equipment has been based on the seating capacity of the dining area (70 people), and the required amount of storage necessary due to the remoteness of the complex.

3. CENTRAL SITE BUILDINGS

3.2 CAFETERIA BUILDING

B. Mechanical: The building will be served with two (2) unitized roof-top air conditioning units and an evaporative cooler with make-up air unit and exhaust fans.

1. Refrigeration and Heating Equipment: Refrigerated air conditioned spaces (Dining Room, Recreation Room and Foyer area) will be served with unitized packaged roof-top heat pump type units, utilizing direct expansion, refrigerated cooling and supplemental electric resistance heating.

2. Evaporative Cooling/Heating/Make-Up Air Equipment: The Kitchen area will be heated and ventilated only, with evaporative cooling being provided for summer peak day cooling. Heating would be accomplished utilizing an electric furnace with blower, filters and resistance heating elements installed in the ducted forced air stream. Evaporative cooling will be accomplished utilizing a separate roof mounted, two-speed blower unit. Speed selection will be an automatic operation in response to space temperature requirements. The main broiler hood will be served with a packaged make-up air-exhaust fan unit using electric resistance elements.

3. Exhaust Systems: Exhaust systems will be provided in response to desired functions. Minimum supply air to the exhausted space will be set to equal or exceed exhaust system requirements. The main kitchen will have exhaust fans connected to broiler hood and dishwasher hood. Air flow across the hoods will be maintained to insure complete removal of all broiler and dishwasher exhaust products when these hoods are in operation.

4. Plumbing System: The design will incorporate all necessary components to meet Federal, State or local code requirements, whichever are more applicable.

5. Temperature Control:

(a) Air conditioned spaces will be served by a combination heating-cooling thermostat which will regulate the operation of the appropriate system in response to the temperature set point desired. A heat pump design concept is utilized to minimize energy use requirements.

(b) Evaporative Cooled Spaces: A zone heating thermostat will control the operation of the electric furnace blower and heating coil. A space cooling thermostat will, when activated, lock out furnace heating, call for low speed, subsequent high speed evaporative cooler fan operation and finally, evaporative cooling spray water - all automatically in response to nominal kitchen area indoor temperature. All air will be filtered through replaceable media filters.

6. Fire Protection: The entire building will be sprinkled in accordance with NFPA 13 requirements. A CO_2 extinguisher system or similar system will be provided for the large broiler-grill areas in the Kitchen area.

3. CENTRAL SITE BUILDINGS

3.2 Cafeteria Building

C. Electrical:

Electrical Service: Service to the building will be 277/480 volts, three phase, four wire, grounded neutral, in underground conduit from the pad-mount transformer located outside the building. A circuit breaker type switchboard will be provided in the building. Switchboard instruments will include a voltmeter, ammeter, and watthour meter with demand register.

Emergency Power: Emergency power will be provided by the engine-generators located in the General Maintenance Building. When commercial power from the Socorro Electric Cooperative (SEC) fails, the building will be without power or lights except battery-operated emergency lights. As soon as the antennas are in their idling mode (maximum 30 minutes), engine-generator power will be automatically supplied to all building lights, minimum heating and telephone equipment. Non-essential loads such as air conditioning, kitchen equipment, and domestic hot water heating equipment will remain locked out until manually reset after restoration of commercial power.

Electrical Distribution System: The electrical distribution system will be 277/480 volts, three phase, four wire. Fluorescent lighting will be 277 volts and large feeders and motor loads will be 480 volts. Incandescent lighting, receptacles, and small power will operate on 120/208 volts, three phase, four wire derived from dry-type transformers.

Panelboards: Distribution and branch circuit panels will be circuit breaker type, with capacities selected from connected loads and code requirements. Nominal spare breakers and feeder capacities will be provided.

Wiring: Feeder wiring will be installed in underground non-metallic conduits where possible, with rigid steel risers. Branch circuits will be in steel conduits installed in walls and ceilings to facilitate future remodeling. EMT conduits will be utilized for applications above ground in dry locations. All wiring will be copper conductors; aluminum conductors will not be used. A separate equipment grounding conductor (green wire ground) will be included with all service, feeders, and branch circuits.

Devices: All receptacles will be the grounding type, specification grade or better. Wall switches will be flush tumbler type rated 15A-120/277V minimum. Device plates will be stainless steel with brushed satin finish.

Lighting: Lighting will generally be recessed fluorescent, nominally 48 inches long with standard F40CW lamps. Design lighting levels will follow IES recommendations except where specific criteria is furnished. All fluorescent fixtures will have radio interference suppressors. Multiple switching of lamps or fixtures

in all areas will be provided to permit energy conservation and to minimize generator loading during power failures. Battery-operated emergency lights will be provided for interim lighting until the engine-generator power is available.

Telephone Service: Telephone service will be underground to a telephone terminal board. Telephone outlets will be connected to the terminal board with 3/4 inch conduit minimum and a maximum of two outlets with one inch conduit. Emergency power will be supplied to the telephone equipment to permit telephone operation during power failures.

Lightning Protection: A lightning protection system will be provided for the building, due to the high incident rate at the site location.

Clocks: All clocks will be standard synchronous electric clocks with manual reset.

Fire Alarm System: A fire alarm system will be provided with closed circuit, electrically supervised, coded, zone annunciated, continuous ringing, combination manual and automatic features, with annunciation and alarm trip on sprinkler flow. Manual reporting stations will be located at all major exits, and fire alarm bells will be provided throughout the building. Battery standby power will be provided. A master annunciation panel will be located in the Control Building to record a fire alarm trip from this building. Smoke detectors will be ionization type and will be located in the mechanical fan systems as required by code. The fire detectors in kitchen hoods will be connected to the fire alarm.

Snowmelting: Snowmelting systems for exterior walkways will not be provided.

Grounding: The main ground bus will be in the main switchboard with connections to the building steel and a bond to the metallic interior water piping system. The exterior water piping will be non-metallic. A supplementary ground field will be installed consisting of a minimum of 3 stainless steel ground rods interconnected with insulated copper cable, with the insulated copper cable connected to the main ground bus.

3. CENTRAL SITE BUILDINGS

3.3 VISITING SCIENTISTS' QUARTERS

A. Architectural - Structural

The Visiting Scientists' Quarters are based on two bed motel type rooms in two single story buildings consisting of five units and a mechanical and storage area in each building. Each unit will have a private bath, and clothes closet. Two units in each building will have an interior connecting door.

Construction of the Scientists' Quarters will be consistant with the Control Building and the Cafeteria Building in respect to materials; reinforced masonry bearing walls of "Slump block" construction exposed on the interior with interior partitions of metal stud and gypboard, taped, textured and painted. The roof of the units is of flat slab, poured in place concrete, with insulating concrete fill and bituminous built-up roof. The ceiling of the units are to have a sprayed-on acoustical coating on the exposed concrete of the roof structure. The floor of the structures are concrete slabs on grade, reinforced with welded wire fabric, carpeting is to be installed in the bedroom areas and vinyl-asbestos tile in the baths with the slab left exposed with a chemical hardening agent in the Mechanical Rooms and Storage areas.

The toilet ceiling is a suspended gypboard at seven feet - eight inches (7'-8") above floor line. A prefabricated fiber-glass shower enclosure is located in each toilet along with a built-in vanity with laminated plastic top and splash. A built-in desk-dresser combination with a wood grained laminated plastic top and wood facing is to be installed in the bedroom area.

A hollow metal framed window with clear plate glass glazing is located in each bedroom unit, with an aluminum sliding glass door opposite the window and facing the main apex of the Array. Except for the Mechanical Room, all doors are to be wood, in hollow metal frames, solid core at exterior openings, hollow core at interior openings. The Mechanical Room doors are hollow metal in hollow metal frames.

A short canopy, with precast concrete fascia panels, will partially cover a small concrete patio slab directly outside the sliding glass doors facing the Array.

3. CENTRAL SITE BUILDINGS

3.3 VISITING SCIENTISTS' QUARTERS

B. Mechanical: Each building will be served with a central water chiller and domestic hot water system.

1. Refrigeration and Heating Equipment: Each of the occupied spaces of the building will be treated with ceiling hung, concealed, multi-speed fan coil units. Heating and cooling will be provided by valve controlled coils located in the units. Operation of the cooling coils or heating coils would be thermostatically controlled. Unit speed and space air circulation will be a manual selection operation. By utilizing a remote, central chiller the major source of noise pollution, i.e., the refrigeration compressor, can be removed from the space. Heating water will be provided by utilizing the domestic hot water generator.

2. Plumbing and Exhaust Systems: Each individual room bath would be exhausted to atmosphere with a 3- to 6-minute air change. Fan operation will be manually energized. Domestic hot water would be provided from a centrally located hot water generator-storage tank and pump arrangement. The central design allows utilization of diversity and storage not available with individual room water heaters.

3. Fire Protection: No sprinklers will be installed in these buildings, since they are of a one-story construction, and individually isolated by room, with immediate access to the outside available. However, smoke detectors are recommended to be installed in each space to energize an audible alarm in the event of fire.

3. CENTRAL SITE BUILDINGS

3.3 Visiting Scientists' Quarters

C. Electrical:

Electrical Service: Service to the building will be 277/480 volts, three phase, four wire, grounded neutral, in underground conduit from the pad-mount transformer located outside the building. A main panel will be provided in the building.

Emergency Power: Emergency power will be provided by the engine-generators located in the General Maintenance Building. When commercial power from the Socorro Electric Cooperative (SEC) fails, the building will be without power or lights. As soon as the antennas are in their idling mode (maximum 30 minutes), engine-generator power will be automatically supplied to all building lights, minimum heating and telephone equipment. Non-essential loads such as air conditioning and domestic hot water heating equipment will remain locked out until manually reset after restoration of commercial power.

Electrical Distribution System: The electrical distribution system will be 277/480 volts, three phase, four wire. Fluorescent lighting will be 277 volts and large feeders and motor loads will be 480 volts. Incandescent lighting, receptacles, and small power will operate on 120/208 volts, three phase, four wire derived from dry-type transformers.

Panelboards: Distribution and branch circuit panels will be circuit breaker type, with capacities selected from connected loads and code requirements. Nominal spare breakers and feeder capacities will be provided.

Wiring: Feeder wiring will be installed in underground non-metallic conduits where possible, with rigid steel risers. Branch circuits will be in steel conduits installed in walls and ceilings to facilitate future remodeling. EMT conduits will be utilized for applications above ground in dry locations. All wiring will be copper conductors; aluminum conductors will not be used. A separate equipment grounding conductor (green wire ground) will be included with all service, feeders, and branch circuits.

Devices: All receptacles will be the grounding type, specification grade or better. Wall switches will be flush tumbler type rated 15A-120/277V minimum. Device plates will be stainless steel with brushed satin finish.

Lighting: Lighting will generally be recessed fluorescent, nominally 48 inches long with standard F40CW lamps. Design lighting levels will follow IES recommendations except where specific criteria is furnished. All fluorescent fixtures will have radio interference suppressors. Heat lamps will be provided in the bathrooms. Battery-operated lights will not be provided.

Telephone Service: Telephone service will be underground to a telephone terminal board. Telephone outlets will be connected to the terminal boards with 3/4 inch conduit minimum and a maximum of two outlets with one inch conduit. Emergency power will be supplied to the telephone equipment to permit telephone operation during power failure.

Lightning Protection: A lightning protection system will be provided for the building, due to the high incident rate at the site location.

Clocks: Clocks will not be provided.

Fire Alarm System: A fire alarm system will be provided with closed circuit, electrically supervised, coded, zone annunciated, continuous ringing, combination manual and automatic features. Manual reporting stations and fire alarm bells will be provided on the exterior of the building. Battery standby power will be rovided. A master annunciation panel will be located in the Control Building to record a fire alarm trip from these buildings. Smoke detectors will be ionization type and will be located on the ceilings of the bedrooms and will trip the fire alarm system.

Snowmelting: Snowmelting systems for exterior walkways will not be provided.

Grounding: The main ground bus will be in the main switchboard with connections to the building steel and a bond to the metallic interior water piping system. The exterior water piping will be non-metallic. A supplementary ground field will be installed consisting of a minimum of 3 stainless steel ground rods interconnected with insulated copper cable, with the insulated copper cable connected to the main ground bus.

3. CENTRAL SITE BUILDINGS

3.4 GENERAL MAINTENANCE BUILDING

A. Architectural - Structural

The General Maintenance Facility has been designed as four separate functions, any one of which may be built by itself or in combination with another to allow for ease of construction phasing. The basic structural concept for three of the four functions (Warehouse, Electronic Maintenance and Site Maintenance) is of precast concrete double tee enclosure walls, and roof system, with the fourth function (general offices) constructed of load bearing, reinforced masonry exterior walls and a precast concrete double tee roof system. The roof of the office area is at a lower height than the rest of the building to minimize the amount of unusable space above the ceiling. All roofs will have lightweight concrete fill over the double tee structure, five inch maximum at the perifery sloping to two and one-half (2-1/2") inches minimum at the roof drains. A three-ply built-up bituminous roof system with gravel is applied over the lightweight fill for the finish roof. A roof scuttle with a metal ladder located in the warehouse area gives access to the higher roofs with an exterior metal ships ladder giving access from high roof to the low roof of the office area.

The entire building has a flooring system of concrete slab on grade, with a constant finish floor elevation, reinforced with a welded wire mesh. Thickness of the slab is six inches in the warehouse and site maintenance areas and four inches in the electronics and office areas. The slab will be left exposed in the warehouse and site maintenance areas but will be treated with a chemical hardener, all other areas will have a floor covering in accordance to the finish schedule.

With the exception of an office located in the southwest corner of the area, the warehouse portion is a large open space with all concrete surfaces left exposed. Seams and joints in the precast double tee walls will be caulked or grouted to render the space weathertight. Two ten-foot wide by ten-foot high steel roll-up doors, electrically operated, are located in the north and west exterior walls, one in each wall, for shipping and receiving.

The east wall of the warehouse area is metal stud and gypboard partition with two layers of 5/8 inch gypboard, staggered joints, on the warehouse side of the partition and will extend to the underside of the structure above. A hollow metal door and frame with a one and one-half (1-1/2) hour U.L. label design is located in the partition for access of personnel and small equipment or parts into the Electronic Maintenance portion of the building. The office area in the southwest corner of the warehouse is a metal stud and gypboard enclosure to a height of eight feet above finish floor, there will be no ceiling in the office space and the floor is to have a vinyl-asbestos

tile covering. In addition to the door in the east wall, there is a single leaf personnel door in each of the precast concrete double tee walls of hollow metal construction, the frames for which are integrally cast into the wall at the time of fabrication of the tees.

The Electronics area of the building is subdivided by means of metal stud and gypboard partitions, to above ceiling line, taped, textured and painted. The interior partitions enclosing the engineers offices will have sound attenuation blankets installed in the walls for sound control. All ceilings in the electronics area are an acoustical lay-in panel with an exposed "tee" grid system, suspended to eight feet above finish floor except in the storage area which will have a ceiling height of ten feet. Flooring throughout the entire area is a vinyl-asbestos tile, 1/8 inch gauge and twelve inches square. The interior of the precast concrete double tee exterior walls are to be furred with two-inch metal studs, insulated with medium batt blanket insulation and finished with gypboard taped, textured and painted to match the surroundings.

All doors and windows in the precast double tee walls are to have hollow metal frames integrally cast into the wall at the time of fabrication of the tees. The glazing for the windows will be a "solar-bronze" tinted plate glass, and the door leafs will be hollow metal. The rest of the doors in the electronic maintenance are to be wood veneer, solid core wood doors in hollow metal frames.

The Site Maintenance portion of the building is situated adjacent to the warehouse and is separated by a precast concrete double tee wall for two reasons: 1.) the fire resistance qualities of concrete as opposed to metal stud and gypboard and 2.) due to the length of spans of the roof tees a bearing wall or a column and beam support structure is required. Since the building is subject to construction phasing, the decision to use a bearing wall of precast concrete tees became apparent as this wall may be left as an exterior wall for a few years. The east wall of the space is a reinforced masonry bearing wall of "Slumpblock" construction to a height of twelve feet four inches (12'-4") above floor line for the purposed construction phasing of the office area. Short panels of precast concrete tees are to be placed on top of the "Slumpblock" wall to extend the enclosing wall to match that of the other wall tees.

The entire site maintenance space is to be left open for partitioning at a later date with the exception of the Auto Shop, located in the southeast portion of the space. Due to the highly flammable materials used within the Auto Shop, the space requires a masonry dividing wall of 8" concrete block to the underside of the structure above. Vehicle access into the Auto Shop is by three metal overhead doors, electrically operated, in the double tee wall on the south side of the space. A personnel door of hollow metal set in a hollow

metal frame integrally cast in the double tee exterior wall on the east side, two additional hollow metal doors in hollow metal frames are set in the shop enclosing masonry walls for access to the interior open space. A pair of hollow metal double doors, two hollow metal personnel doors and an overhead metal door give access to the site maintenance area on the west side of the building. The floor of the entire space including the Auto Shop, is to be exposed concrete six inches thick with a chemical hardener over. Roof tees are also to be left exposed over the entire space.

The office block is a low roofed appendage of precast double tee roof structure on load-bearing reinforced masonry exterior walls of "Slumpblock", exposed on the interior as well as exterior. The interior space is divided into six offices, a first-aid room and toilets by means of metal stud and gypboard partitions taped, textured and painted with sound attenuation blankets to above ceiling height. The ceilings in all offices, first-aid room and corridors are lay-in acoustical panels on an exposed tee grid system, suspended to a height of eight feet above floor line. A gypboard ceiling at eight feet above floor line is located in the toilets and janitors room. The toilets and the janitors room are to have ceramic tile floors on a setting bed and a thinset ceramics tile wainscot four feet high on the fixture wall. All the remaining floors are to be covered with vinyl-asbestos tile, 1/8 inch gauge, twelve inches square.

The doors and windows in the exterior masonry walls are of hollow metal frames with "solar-bronze" tinted glazing for windows and single leaf, hollow metal doors with clear wired glass glazing. All interior doors are wood veneered hollow core wood set in hollow metal frames. A precast concrete fascia panel system with a stucco soffit similar to that used on the Control Building is used to close the roof tee overhang on the south and east sides of the office block.

An above grade loading ramp with dock bumpers is located fifty feet to the west of the warehouse facility and is constructed of reinforced concrete walls and ramp. A large concrete drive pad is situated on the west and north sides of the building for material and equipment deliveries. On the south east side of the Office Area is a parking lot of bituminous paving with spaces for fourteen vehicles and concrete walks to the building.

3. CENTRAL SITE BUILDINGS

3.4 GENERAL MAINTENANCE BUILDING

B. Mechanical: The building will be served with packaged roof-top air conditioning units, unit heaters and evaporative cooling units.

1. Refrigeration, Evaporative Cooling and Heating Equipment: The office spaces, laboratory and electronics stores areas will be served with unitized packaged heat pump type roof-top units. These units will utilize the direct expansion of refrigerant gases as the cooling media. Supplemental electric resistance heating elements will be used to provide heating greater than that available from the heat pump cycle.

   The shops and warehouse areas will be, generally, heated and ventilated only with evaporative cooling being provided for summer peak day cooling. Heating would be accomplished utilizing electric resistance heating elements installed in the ducted forced air stream or unit heaters.

   Temperature control is accomplished on a zone basis - i.e., each group of offices, shop or laboratory to comprise a zone. Air flow to the evaporative cooled spaces will be two-level. Low speed operation will be utilized for heating; high speed will be utilized for ventilating and evaporative cooling. Zone heating thermostats will control the operation of the individual zone electric heating elements or unit heaters. A centrally located cooling thermostat will, in turn, lock out all zone heating thermostats, call for high speed fan operation and subsequent evaporative cooling spray water - all automatically in response to nominal zone indoor temperature. All refrigerated air will be filtered through replaceable media filters.

2. Exhaust Systems: Laboratory and shop area exhaust systems would be provided to meet the space function requirements or as dictated by Federal, State or local codes to maintain acceptable personnel environments. Toilet facilities would be heated and ventilated to provide an acceptable temperature level and a 3- to 6-minute air change. The total building, however, will be pressurized, positively, with respect to atmosphere.

3. Plumbing System: Plumbing system design, including domestic hot and cold water service, soil, waste and vent, and laboratory services for the Laboratory, shop and toilet areas will be provided in accordance with Federal, State or local codes, whichever is the more applicable.

4. Fire Protection: All areas of the building will be sprinkled, including toilets, closets, and warehouse spaces in accordance with NFPA 13.

3. CENTRAL SITE BUILDINGS

3.4 General Maintenance Building

C. Electrical:

Electrical Service: Service to the building will be 277/480 volts, three phase, four wire, grounded neutral, in underground conduit from the pad-mount transformer located outside the building. A circuit breaker type switchboard will be provided in the building. Switchboard instruments will include a voltmeter, ammeter, and watthour meter with demand register.

Emergency Power: Emergency power will be provided by the engine-generators located in the warehouse area. When commercial power from the Socorro Electric Cooperative (SEC) fails, the building will be without power or lights except battery-operated emergency lights. As soon as the antennas are in their idling mode (maximum 30 minutes), engine-generator power will be automatically supplied to all building lights, minimum heating and telephone equipment. Non-essential loads such as air conditioning, shops, and domestic hot water heating equipment will remain locked out until manually reset after restoration of commercial power.

Electrical Distribution System: The electrical distribution system will be 277/480 volts, three phase, four wire. Fluorescent lighting will be 277 volts and large feeders and motor loads will be 480 volts. Incandescent lighting, receptacles, and small power will operate on 120/208 volts, three phase, four wire derived from dry-type transformers.

Panelboards: Distribution and branch circuit panels will be circuit breaker type, with capacities selected from connected loads and code requirements. Nominal spare breakers and feeder capacities will be provided.

Motor Control Centers: Fusible type motor control centers, Class II, Type C will be provided at locations of major motor concentration, and will operate at 480 volts with 120 volt individual control transformers for each motor.

Wiring: Feeder wiring will be installed in underground non-metallic conduits where possible, with rigid steel risers. Branch circuits will be in steel conduits installed in walls and ceilings to facilitate future remodeling. EMT conduits will be utilized for applications above ground in dry locations. All wiring will be copper conductors; aluminum conductors will not be used. A separate equipment grounding conductor (green wire ground) will be included with all service, feeders, and branch circuits.

Devices: All receptacles will be the grounding type, specification grade or better. Wall switches will be flush tumbler type rated 15A-120/277V minimum. Device plates will be stainless steel with brushed satin finish.

Lighting: Lighting will generally be recessed fluorescent, nominally 48 inches long with standard F40CW lamps. Design lighting levels will follow IES recommendations except where specific criteria is furnished. All fluorescent fixtures will have radio interference suppressors. Multiple switching of lamps or fixtures in all areas will be provided to permit energy conservation and to minimize generator loading during power failures. Battery-operated emergency lights will be provided for interim lighting until the engine-generator power is available.

Telephone Service: Telephone service will be underground to a telephone terminal board. Telephone outlets will be connected to the terminal boards with 3/4 inch conduit minimum and a maximum of two outlets with one inch conduit. Emergency power will be supplied to the telephone equipment to permit telephone operation during power failures.

Lightning Protection: A lightning protection system will be provided for the building, due to the high incident rate at the site location.

Clocks: All clocks will be standard synchronous electric clocks with manual reset.

Fire Alarm System: A fire alarm system will be provided with closed circuit, electrically supervised, coded, zone annunciated, continuous ringing, combination manual and automatic features, with annunciation and alarm trip on sprinkler flow. Manual reporting stations will be located at all major exits, and fire alarm bells will be provided throughout the building. Battery standby power will be provided. A master annunciation panel will be located in the Control Building to record a fire alarm trip from this building. Smoke detectors will be ionization type and will be located in the mechanical fan systems as required by code.

Engine-Generators: The engine-generator sets will be located in the warehouse area of the Maintenance Building due to the centralized location in relation to the central site distribution and due to the close proximity to the SEC-VLA substation.

Busducts: Busducts will be installed overhead in the shop areas for future connection of shop equipment.

Snowmelting: Snowmelting systems for exterior walkways will not be provided.

Grounding: The main ground bus will be in the main switchboard with connections to the building steel and a bond to the metallic interior water piping system. The exterior water piping will be non-metallic. A supplementary ground field will be installed consisting of a minimum of 3 stainless steel ground rods interconnected with insulated copper cable, with the insulated copper cable connected to the main ground bus.

Quiet Grounds: A quiet ground will consist of a separate insulated copper cable from the supplementary ground field up to the Waveguide Test Room. Similar quiet grounds will be provided for the Front End Repair Room and Cryogenic Lab.

3. CENTRAL SITE BUILDINGS

3.5 Antenna Assembly Building

It is our understanding that the permanent antenna maintenance activities as contained in the program of space requirements July 16, 1973 will be housed in the antenna erection structure when it is made available to VLA. These activities include:

Machine Shop	- 1875 Sq. Ft.
Welding Shop	- 450 Sq. Ft.
Fabrication Shop	- 1875 Sq. Ft.
Tool Crib	- 900 Sq. Ft.
Paint Shop	- 900 Sq. Ft.
	6000 Sq. Ft.

Present site building plans contain no provision on a permanent basis for these activities. It is understood that during construction some temporary space allocation may be made in the General Maintenance Facility. Equipment and power loads have been estimated so that the activities can be accommodated in a temporary location. On a permanent basis, equipment and power loads have been estimated so that service to the antenna erection facility can be designed into the permanent site utilities; in particular, power, water, fire protection and sewage. Site grading for a 100' by 150' building has been suggested along with provisions for a septic drain system. These remain to be coordinated with the antenna contractor for final determination. In addition, pending further wave guide alignment studies the exact placement of the building may be modified.

4. ANTENNA WYE CONFIGURATION

4.1 Earthwork and Drainage

A. Earthwork:

The quantity and composition of the material moved to construct the track embankment prism constitutes the earthwork on the project. The horizontal alignment on the project is fixed and is not adjustable with the exception of the last few thousand feet of the East arm, where a 450 ft. line shift has been implemented to reduce drainage problems and embankment quantities. Therefore the greatest variable is the vertical alignment or grade of the trackage system. The earthwork quantities are dependent upon the grade. Types of material are also defined to a certain extent by the grade location.

Another factor is the slope selection. The slopes used on the project must be less than the angle of repose of the excavated or filled material. This criteria can generally be met by 1-1/2:1 slopes. However, for reduced maintenance costs, less erosion, and also to make natural vegetation possible, a much flatter slope of 3:1 shall be used. It follows that the use of the flatter slopes will increase quantities, but overall project costs on a long time basis will be reduced. The final impact of the project will be less harmful to the existing environment by the use of flatter slopes.

The slope selection on the West arm is also dependent upon the "hearing" angle of 5° for the antennas above the southern horizontal projection of the base of the antenna. In some instances the slope beyond the 3:1 limits must be flattened to provide this clearance.

The grade must match crossings of existing highways wherever possible. This imposes certain restrictions on the vertical alignment on two of the arms.

It is required that all cuts and fills be minimized to keep overall project cost down. Grade is to be limited to 2% whenever possible, and vertical curves should be long for a smooth transition and fairly continuous vertical alignment without abrupt changes. This will facilitate easier transport of the antennas.

Grade on the wye centerline for antenna stations must be correlated with the trackgrade. Very little deviation from the track grade to the station elevations will be allowed in the short distances from track to station. The grade at the antenna stations has been flattened to a maximum of 1% to allow easier transition of direction for the transport vehicle.

A factor to be considered in using very low grades is drifting snow and sand. Snow removal when necessary will not be a serious problem. However, sand removal may be quite difficult. Where the rails are below ground surface in the valley fill areas sand will drift over them until they are completely covered. An annual maintenance cost of such sand removal must be balanced against the cost of fill required to

raise the rails above the sand zone. The orientation of the tracks will have considerable effect on this problem. The West arm is orientated with the wind and should not catch a large amount of blowing sand. Also when vegetation cover is good the sand is generally well anchored. The North arm will probably have areas where blowing sand will be a problem.

The Title I Drawings include a general drainage map with areas delineated, a typical subgrade section and typical plan and profile sheets, and typical antenna location sheets. The typical section is based on an A.R.E.A. Section, modified to fit the requirements of the array. Because soil conditions define a poor subgrade, recompaction of the subgrade and a stabilized sub ballast is recommended in the valley fill zone. Final depths of recompaction and sub ballast will depend upon final recommendations from the soils investigation team and from the trackage design analysis. The grades shown on the plan and profiles show the vertical alignment suggested by grade controls, drainage, and a balance in earthwork to the best practical extent.

A computer implemented computation of the earthwork has been accomplished and a refined grade worked out. A "plan in hand" inspection of the entire Wye to evaluate the grade and drainage shall be accomplished in the Design Phase and grade adjustments made if necessary.

Although the grading and drainage of the VLA track system is probably contrary to that found on any highway or railway, it should serve the intended purpose. The track will only carry a 225 ton load on 4 trucks at an estimated speed of 5 miles per hour, and movement will be fairly infrequent, at most one or two trips per week with some months with no travel except light maintenance travel. Under these conditions temporary closure due to flooding or sand cover, and a temporary change in grade due to settlement will not be of major importance. There will be ample time to repair differential settlements or horizontal track displacements. It should be understood that before an antenna is moved on the track, the condition of the tracks should be inspected, especially if such movement will follow a heavy storm or a long period of nonuse. A means of checking the 18 foot spacing should be developed, as well as special plows or power shovels for sand or snow removal which can travel on the tracks.

The Central site grade is now located within about 2.5 feet of natural ground. Drainage will collect at this area and may cause more flooding. However, lowering the grade has saved some 150,000 cubic yards of borrow material at the central site.

There is still work to be accomplished on grading and drainage, which will depend upon soil recommendations, wave guide placement, and track location field inspection. An important aspect of the earthwork is the shrinkage of excavated material when compacted into embankments and the amount of subsidence which may occur under embankment loading. The soil test program has yielded general guidelines for determining shrinkage. Limited Proctor lab testing will be conducted during Title II design to further define compaction characteristics of the in situ embankment materials.

B. Drainage:

The alignment for the Wye places the construction in three distinct construction zones. One zone is on valley fill composed of clay and silt deposits with an overlay of wind blown sand and silt. A small portion of the East arm, all of the North arm and about 9 miles of the West arm is located in this zone. A second zone consists of out-wash gravels, sand, and silts from the arroyos leading from the adjacent mountain slopes. These out-wash plains are relatively flat and form deltas for the arroyos. About 9 miles of the East arm is located in this zone, and about 3 miles of the West arm. The third zone is an erosional slope from rock outliers consisting of eroded canyons cut into an old out-wash plain and into bedded rocks below. Slopes are steep and rock outcrops are present over much of the area. About 2 miles of the East arm is located in this zone.

Drainage which will cross the tracks comes from three types of flow channels which are located in the previously mentioned zones. The drainage in the valley fill zone is extremely flat with little or no evidence of concentrated flow. Although large areas drain across this zone, most flows are sheet flows. In most areas the terrain is characterized by a bumpy surface with grass humocks from a few inches to 2 feet in height. Sand dunes are prevalent and flowing water is impeded by the landscape and vegetation. Although most of the zone is probably underlain by clays, the several feet of sand and silt affords a good percolation and runoff is very much retarded and absorbed.

The drainage on the pediment of out-wash gravels and silts is characterized by shallow channels and broad flow lines. Quantities of flow can be quite large due to the mountains feeding the arroyos located on the pediment surface. Infiltration is still present in channel locations.

The drainage on the steep hillsides is characterized by steep walled, deeply incised arroyos with severe runoff conditions. However, areas are small and quantities of runoff do not require large drainage structures. Velocities in the channels will be high.

Preliminary observation of the soil investigation program indicates that ponding of water to any significant depth in the valley fill zone could lead to serious collapse of the sub strata and consequent settlements. This leaves two alternatives. One is to provide adequate structures to immediately drain the water without ponding for the 100 year storm, or to allow flow over the tracks and ballast with a minimum of ponding. The first alternative would require a large area of opening with a very low headwater depth. This would mean endless batteries of 30" to 36" culverts or a very wide (several hundred feet) multiple box culvert with only about 2' to 3' of height. This solution is costly and also will be a maintenance problem. Therefore the water should be passed over the tracks in all cases where possible. This could cause ponding on occasion, but limit depths to a maximum of 1 or 2 feet and thereby limit hydraulic head which tends to accellerate infiltration and saturation of the sub strata.

The overflow sections should be defined dips or depressions in the grade to insure that the flow line location is not seriously changed and to prevent flow from paralleling the tracks. For the larger drainage sections these dips may exceed 2,000 feet in length.

The following discussion takes up each arm in turn and discusses the apparent problems or significant points about the drainage.

The North Arm:

This arm is all in the valley fill zone and the grade is held as close to the ground as possible. A significant dip is provided in the first mile to allow drainage from the west to pass to White Lake. This flow line has an immense area including White House Canyon and Main Canyon above Datil. The N.M.S.H.D. placed 9 - 9'x10' concrete box culverts in the relocation of U. S. 60 where this flow line crosses approximately 6 miles upstream. The boxes have been in place for over 10 years and no evidence of significant flow can be observed. A 100 year flood could theoretically cause a sheet flow of over 20,000 cubic feet per second. The dip provided can accomodate such a flow if necessary.

There are two other large transverse flow lines on the North Arm. Neither crossing is distinct. One crosses in the vicinity of the "earth cracks" which are the subject of a special soils investigation. These flow lines can be carried over the tracks in long flat dip sections.

There will be a small culvert required adjacent to U. S. Highway 60 to drain accumulated flows at this point. Close study may indicate a need for some relief pipes and probably some diversion ditches and dikes to avoid ponding adjacent to the tracks.

The East Arm:

The first mile from the center point is located in the valley fill zone. Because of accumulated drainage in the central sites and two small aroyos leading from the pediment terrace to the south, it is necessary to provide a battery of culverts to carry the first drainage across the tracks. This will flow directly to White Lake.

The grade is roughly controlled by a crossing of State Road 78 and subsequent flow lines. The first flow line east of S.R. 78 will be passed in a dip. It is possible that infrequent flooding could flow over State Road 78 with little or no damage.

With the exception of two or three large drainage areas the remaining flow lines on the pediment are adequately incised to install culverts. One of the largest areas, Durfee Canyon, has spread across approximately 1/2 mile of the pediment and overflows the old U. S. 60 location. This flow is to be allowed to flow over the tracks in a dip section. Higher velocity of water during infrequent flooding could cause a maintenance problem. This will be true of all the arroyos on the pediment and side hill surface where they are allowed to overflow. Culverts have been sized for 25 and 50 year floods.

The drainage in the side hill section of this arm is well defined and velocities are quite high. For this reason major culverts have been sized for 50 year floods to minimize the frequency of damage or loss of tracks due to overflow and erosion.

A line shift is shown for the last few thousand feet of the East Arm. As originally laid out the trackage and Wye crossed Monica Canyon. This canyon would require two thirteen (13) foot diameter culverts several hundred feet long. In order to protect the fill against high flows rip rap would have to be provided for over two thousand feet of the line to the last antenna station.

By moving the last station 450 feet northerly the crossing on Monica Canyon is avoided with a substantial savings in drainage. The Station will remain at the same radial distance from the center point.

The West Arm:

The center point and approximately 1/2 mile of this arm lies in the valley fill zone. This arm crosses old U. S. 60. This route is still designated as a county road but traffic is extremely light. The VLA traffic to the proposed air strip will probably be a major contributing factor. The crossing is to be completely rerouted.

One drainage occurs before the tracks cross old U. S. 60. It is proposed to deflect this drainage in the site grading to culverts mentioned above on the SE Arm. The next drainage occurs on the South of old U.S. 60. At present old U. S. 60 deflects this drainage away from the central site. The proposed grade line will tend to deflect flows over the tracks at the present overflow area. The location of several turnouts to antennas in this area may help to deflect this flow and force it over the tracks. A firm prediction of where this flow will be located in any one storm is not possible to predict.

Additional drainages will be accomodated by dips for the next mile or more. Then the grade line climbs out of the valley fill zone onto the outwash pediment and over a rather large hill side.

A rather large fill occurs just west of this pediment. A large canyon is passed through this fill with two large culverts.

The next drainage crossing is the valley fill zone and is a change of direction. All accumulated drainage north of the tracks will flow to the South. The track line and Wye follows this drainage path for a few thousand feet. A dip has been provided to allow this flow to cross the tracks in about the same location as is done presently.

Two more large drainage areas cross the tracks from North to South. Location of the crossing points are very indistinct and it is probable that no actual flow has been witnessed for many years. The grade line is low enough in these areas to enable flow over the tracks in several locations. Two relief pipes have been located at this time. A more detailed inspection on the ground and review of the grade and drainage may point out the need for additional relief drainage.

Drainage on the entire Wye was calculated using a combination of the Rational Method, the Talbot Method, and the McMath and Fullers formulas. The results of these calculations were compared and worked out for 100 yr., 50 yr., and 25 yr. flood frequencies. A flood of a given c.f.s. was selected for each flow line according to conditions and requirements of grade and protection. The flood computations will be further analyzed by the Unit Hydrograph method in the design phase of the project. A few representative areas have been computed by this method and a good correlation obtained. One of the important factors affecting the drainage is percolation and infiltration. After the soil survey is completed and recommendations reviewed, a better analysis of drainage can be accomplished.

Climatic data including temperature, rainfall and wind data has been obtained from the New Mexico School of Mines at Socorro, New Mexico for as much of the plains area as possible. This data helps in the evaluation of drainage data and basin characteristics.

4. ANTENNA WYE CONFIGURATION

4.2 WYE TRACKAGE

Trackage for movement of the antennas from location to location will consist of two standard gage tracks on 18-foot centers, extending, with minor variations in the central "wye" area parallel to, and 100 feet off, the antenna site axis. Similar trackage will be constructed as spurs to provide access from the main track to the antenna locations. Three systems for providing access from main tracks to spur tracks were investigated in detail to determine the one most feasible. The "90-degree rail insert system", as shown on the attached drawings and described in the following paragraphs, is proposed for the VLA transporter track system since it will be significantly less costly than the alternates, and will provide satisfactory operational service. The alternate plans are discussed in Appendix B.

The "90-degree rail insert system" as proposed, will allow construction of the main tracks to be continuous through the spur track interchange area. The spur track rails will be constructed approximately four inches higher than, and will have gaps to clear, the main track rails. Rail inserts for filling the gaps in the spur track rails will be carried on the transport vehicle. To effect the transfer of the transport vehicle from the main tracks to the spur tracks, the transport vehicle will be positioned with the truck assemblages over the rail crossings. The transport vehicle will be supported on foundation pads, the truck assemblages raised and rotated 90 degrees, the rail inserts placed in the gaps, the trucks lowered to the spur track rails, and the supports removed, thus placing the transport vehicle in position for movement on the spur tracks. Transfer of the vehicle from the spur tracks to the main tracks will be made in a similar manner.

The proposed plan will require that the transport vehicle include some specialized equipment for effecting the transfer from main to spur tracks such as facilities for supporting the frame assembly and raising and rotating the trucks. In addition, the transport vehicle must have vertical clearance to safely clear the spur track rails when operating on the main track through the interchange area. The transport vehicle design engineers have concurred in the trackage plan as proposed, and foresee no undue design problems or unwarranted expense in providing this specialized equipment.

The preliminary plan and cost estimates developed in this investigation, using Design Criteria developed from original information furnished by NRAO, presume use of new 90-pound rails and fastenings, and 6" x 8" x 8' treated timber ties. In the interchange areas, 7" x 9" x 8'-6" treated timber ties will be used, and special treated timber ties will be used within the turnout and rail crossing frog limits. It is proposed to utilize nineteen ties per 39-foot rail, resulting in a tie spacing of 24.63 inches, center to center. A minimum of six inches of ballast will be placed beneath the ties. Under design loading conditions, 40,000 pounds per wheel (dead load plus impact), the bearing pressure on the

subgrade will be about five tons per square foot. We were advised December 11, 1973 that the transport vehicle would have three (3) axle truck assemblages with axle centers of fifty (50) inches and wheel loads of 22,300 pounds. Included in Appendix "E" are design calculations reflecting this information.

Transport vehicle criteria given in Appendix A limit the maximum deviation of tracks to ±0.500 inches in any eighteen-foot section of the track reference plane. Although trackage can be constructed to the specified tolerances, it should be noted that the cost of stabilizing some sub-surface soils may be prohibitive, resulting in the need in some areas for frequent inspection and probably surfacing and lining adjustments. The use at the maximum tie spacing based on the design information furnished December 11, 1973 will produce a track structure that will be capable of sustaining the loads involved but will not have the stiffness factor specified by the above maximum deviation from the track reference plane.

Because of the difference in elevation of spur rails and main line rails, it appears desirable that service vehicles designed for rail transportation be equipped with standard rail-type wheels rather than pneumatic rubber tires and rail guide wheels with the capability of off-track operation.

In preparation of the track cost estimates, we feel that it is desirable to provide NRAO with a track cost estimate based on use of all new materials as well as the track cost estimate based on secondhand rail, joint bars, tie plates and crossties. This is considered necessary because the supply of relay rails and other secondhand track materials is known to be scarce, and quotations received at this time may be wholly unrealistic at the time of construction. However, in an attempt to minimize first costs, efforts should be made by NRAO to purchase relay rail and secondhand track material for stockpiling and later use. Relay rail as light as 60 pounds could be considered if found in suitable condition and at a favorable price. Detailed planning should also give consideration to use of concrete instead of treated timber ties.

The proposed plan will require about 81.3 miles of track, 102 "90-degree rail insert systems", and two sets of No. 6 turnouts with one rail crossing frog each.

The estimates of cost are based on the preliminary trackage plans as described in the foregoing paragraphs. The maximum tie spacing for the four axle truck transporter vehicle is 25 inches and the estimated total cost of new trackage, including ballast but not subgrade, earthwork, road crossings, drainage structures, engineering or contingencies is $13,596,000. The maximum tie spacing for the six axle truck transporter vehicle is 29.25 inches and the estimated total cost of relayer trackage, including ballast but not subgrade, earthwork, road crossings, drainage structures, engineering or contingencies is $10,236,000.

4. ANTENNA WYE CONFIGURATION

4.3 ANTENNA STATIONS AND FOUNDATIONS

Introduction: This discussion is based on the preliminary information which is now available. Further details will be submitted as additional data are generated.

The primary objective of the effort to design the antenna foundations has been to provide the necessary stiffness to keep foundation displacements within prescribed limits while the antenna is operating under nominal scanning conditions. Other considerations include survival under extreme environmental conditions, limited permanent set under severe conditions, protection of the wave guide as it comes into an antenna station and cost.

Design Requirements: The requirements to be discussed in the following paragraphs have been taken from NRAO publications [1,2] and modified and amended in discussions with NRAO personnel.

The allowable pointing error due to foundation rotation has been given as 2.5 arc seconds. This limit applies under nominal scanning conditions which have been defined as 15 mph winds with gusts of ± 3 mph and 0.1 cm ice coating. The allowable error has been converted into displacements at the tops of the foundation pedestals for rocking motion and twisting motion. For rocking motion, the maximum vertical displacement of a pedestal with respect to the other pedestals is ± 0.004 inches. For twisting motion, the maximum horizontal displacement of the top of a pedestal in the direction normal to a line from the top of the pedestal to the centroid of the triangle defined by the pedestals is $\pm .00027$ inches.

In order to avoid possible interaction of the antenna and foundation, the lowest natural frequency of vibration of the foundation should be as high as possible. In the absence of a specific requirement, this has been set at 6 c.p.s.

Finally, the permanent "set" of the foundation due to overloading is to be kept to a minimum. In oral communication, it was agreed that the allowable set be limited to 1/2" under a wind loading of 60 mph.

Soil Conditions: The type of foundation which can be used is dependent to a large extent on the soil at the antenna stations. The soils data which have been included in earlier NRAO publications is not compatible with that compiled during the recent, more extensive investigation. In particular, some of the data included in the proposal of the antenna contractor are erroneous. The foundation design contained therein will not be adequate for the conditions at the site.

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(1) Design, Manufacture, Erection and Test of 28 Radio Telescopes, RFP-VLA-01, Section 03, December 8, 1973.

(2) A Proposal for a Very Large Array Radio Telescope, Volume III, Chapter 5, January 1969.

Two unfavorable soils conditions have been disclosed by the current investigation. The first is a highly desiccated clay capable of considerable swell in the presence of water. The forces which can be generated by this material are so great that the foundation structure can not resist them. The foundation must instead be isolated from the expansive soil.

The second bad soil encountered is a collapsing material. In this case, the soil can collapse a significant amount when exposed to water. The foundation structures in these areas must be designed without relying on the poor material.

Foundation Systems: Two different types of foundation structure have been studied. The first is a shallow system consisting of a reinforced concrete mat resting on engineered fill. The depth of material to be removed is dependent on the depth of the unfavorable material at each station. Under these circumstances, preliminary calculations indicate that a mat of diameter in excess of 50 feet and thickness of approximately 1/10th the diameter would be necessary to achieve the required stiffness.

The other system being studied is a deep system consisting of drilled concrete piers or driven steel piles. The drilled piers appear to be more attractive at this time. There is some doubt about the ability of the steel piles to resist uplift forces due to the expansive soils and it would be difficult to isolate them from those forces. It may be possible to use steel piles in areas of collapsing soils.

Whether steel piles or drilled concrete piers are used, it will be necessary to tie them together at grade to increase their stiffness. These grade beams can also be used to protect the wave guide as it enters the antenna station.

Two drawings accompany this section. They give preliminary sizes and configurations for two different concrete drilled pier foundation systems. One is a three pier system with interconnecting grade beams. The other is a six pier system with circumferential grade beams plus grade beams interconnecting the three piers supporting the antenna pedestals. The piers have belled ends which are to provide resistance to uplift. Also shown is the method proposed to isolate the foundation from uplift forces. This precaution will be necessary in those areas designated as Soil Profile I (See VLA Soil Investigation Analysis).

The approximate location of the wave guide is also indicated. It will pass under the grade beam or beams which in turn are under the railroad tracks. The beam or beams will be designed to transfer the weight of the loaded transporter to the adjacent piers without transmitting load to the wave guide.

No attempt has been made to show the detail at the top of the pedestals. That presented by NRAO and that proposed by the antenna contractor differ substantially. Further guidance is required before the interface design can be completed.

4. ANTENNA WYE CONFIGURATION

4.4 TRANSPORTER TRANSFER FOUNDATIONS

At each intersection of main and spur tracks, a foundation system is required to resist the loads created by the jacks on the transporter as the transporter is transferred from one set of tracks to the other. The system recommended consists of four drilled concrete piers. These piers will be approximately 20 feet long and will not be interconnected at their tops. They will be designed to carry vertical loads only.

The piers can be expected to settle, in some cases substantially, over a period of time. It is recommended that the jacks on the transporter be designed with enough capacity to be able to tolerate moderate settlement (less than one inch). Should larger settlements occur, the piers can be modified to increase their top elevation.

The alternative to this approach is to design the foundation to prevent settlement. This would require a more elaborate and costly system.

4. ANTENNA WYE CONFIGURATION

4.5 Wave Guide

Wave guide installation recommendations are being provided to AUI by Bechtel. The BWH-CVR Joint Venture has provided Bechtel with copies of the Task 2.3 Soil Data Report and additional test data on soil resistivity, and, in addition, met on several occasions to discuss problems of mutual concern, principally in the areas of wave guide and station lightning protection and wave guide cathodic protection. Interrelated concerns have been outlined in conference meetings with the following preliminary conclusions:

1) The Wave Guide will be located outside the antenna stations.

2) Power cables, bare copper, can be placed within 50 feet of the wave guide.

3) Grounding of stations can proceed considering normal power ground requirements or better.

4) Special wave guide grounding and cathodic protection will be recommended by Bechtel.

In general, final determination of these requirements will be made by Bechtel. No compatibility problems are anticipated with other aspects of the site facilities, however, final design considerations are at this point best estimates and subject to further study by the Joint Venture in the Title II effort. In addition, the manhole configuration and station entrance details are unresolved at this point and subject to further detailed study as detailed design parameters become known.

4. ANTENNA WYE CONFIGURATION

4.6 Wye Power

Wye Electrical Distribution: The electrical distribution for the wye will originate with the three oil circuit reclosers furnished, installed, owned, and maintained by the Socorro Electric Cooperative (SEC). The reclosers will be located in the SEC-VLA substation to be constructed in the central site. Each arm of the wye will be served by its own recloser and primary circuit to provide maximum reliability and facilitate maintenance.

Circuit Reclosers: Circuit reclosers were selected for circuit protection of the wye circuits because of their ability to automatically reclose after a transient disturbance on the circuit has cleared itself. Where a circuit breaker will trip open and stay open on a momentary self-clearing disturbance, the recloser will trip open and attempt to reclose. If the disturbance continues, the recloser locks out. This is a desirable feature for the wye circuits which have severe exposure to lightning strikes on the antennas and rails. It precludes the prolonged outage time and cost for an SEC lineman to come out from Magdalena or Socorro to reset a breaker that tripped on a transient disturbance. By providing a separate recloser and circuit for each arm, disturbances or faults are restricted to the arm involved, and maximum reliability is achieved with minimum costs.

Wye Circuits: Each of the three wye circuits will be rated 12470 Grd-Y/7200 volts, three phase, four wire, grounded neutral, and consists of 3 #1/0 15KV aluminum cables with HM polyethelene or ethylene propylene insulation and concentric wrap neutrals. The circuits will be designed as a loop-feed radial circuit to pad-mount transformers.

Circuit Installation: The wye circuits will be direct-buried 42 inches minimum below grade. The direct-buried telephone-communication cables will be installed in the same trench as the power circuits.

Antenna Power Requirements: The power requirement per antenna is as follows:

9mph Wind	18 mph Wind	45 mph & Over	
2.0 KVA	2.0 KVA	2.0 KVA	Servo electronics
14.0	14.0	14.0	Tower-Vertex Room A/C
2.0	2.0	2.0	Lights
.7	2.7	20.0	Drive Motor
18.7 KVA	20.7 KVA	38.0 KVA	Subtotal
10.2	10.2	10.2	Electronics at antenna
28.9 KVA	30.9 KVA	48.2 KVA	Initial operating demand
13.8	13.8	13.8	Future electronics
42.7 KVA	44.7 KVA	62.0 KVA	Ultimate operating demand

Motor-generator sets may be added to the antennas if the power service should have voltage spikes. The M-G sets will not be installed until operations require them. Should the M-G sets be required, the antenna loading would be:

9 Mph Wind	18 mph Wind	45 mph Wind	
28.9 KVA	30.9 KVA	48.2 KVA	Initial operating demand
8.2	8.2	8.2	M-G set
37.1 KVA	39.1 KVA	56.4 KVA	Initial operating demand
13.8	13.8	13.8	Future electronics
11.8	11.8	11.8	M-G set
62.7 KVA	64.7 KVA	82.0 KVA	Ultimate operating demand

There are 99 antenna stations and 27 antennas, with the antennas distributed 7 on the north arm, 9 on the east arm, and 11 on the west arm. Other antenna arrays may be utilized; however no more than 11 antennas will be operating on any one arm.

Antenna operations for the first two years of project construction will be for testing and adjusting. During this same period the new express feeder will be under construction and temporary power will be served from the existing feeder which could experience voltage transients or minor power interruptions. This is not expected to be a problem during the testing period.

Antennas will drive to stow in 5 minutes. Under normal power and 60 MPH winds, the load per antenna will be 48 KVA initially and 62 KVA ultimately without M-G sets. All antennas on any one arm may drive to stow simultaneously under normal power.

Antenna Emergency Operation: Antennas will not have on-board emergency engine-generators, and minimum emergency power must be supplied by central engine-generator sets to allow emergency operation of the antennas to prevent damage. Antennas will start a 10-minute time-delay on loss-of-signal, and then will automatically drive to stow position if power is available. On failure of normal power, the array ceases to operate but a minimum of 6 KW (7KVA) per antenna must be supplied for the cryogenics compressors within 15 minutes. A design load of 10 KVA per antenna will be used. For the 27 antennas, this will require 270 KVA generator capacity when the antennas are in stow position and idling.

On failure of normal power during a storm with high winds, the antennas must be driven to stow position and during a concurrent power failure the central engine-generator sets must provide this power as follows:

190 KVA = 5 Antennas driving to stow at 38 KVA
220 KVA = 22 Antennas idling at 10 KVA
410 KVA Total Simultaneous Load

With 27 antennas driving to stow in groups of 5 at 5 minutes per group, the 410 KVA emergency load would sustain for 30 minutes, and then drop to 270 KVA. This dictates an engine-generator requirement for the antennas of 500 KW, or two 250 KW engine-generators (313 KVA).

On failure of normal power, the central site power circuits will be automatically switched off and the entire engine-generator capacity connected to the 3 wye circuits for antenna operation. After the antennas are in the stow position, the central site power feeder will be reconnected to the engine-generators. All non-essential loads on the central site feeder will be automatically dropped out by magnetically-held contactors. The engine-generators will continue to serve the idling loads of the antennas with the spare 356KVA generator capacity being utilized for essential loads in the central site.

Pad-Mount Transformers: Pad-mount transformers will be installed to serve the antennas. Where feasible, more than one antenna station will be served by one transformer. The electrical loading for one antenna requires a 75 KVA transformer capacity. Even under the most severe conditions of winds 45 mph or over, with the ultimate electronics load, and ultimate motor-generator load the antenna loading is 82KVA which represents an acceptable 9.3% overload for short durations on a 75KVA oil transformer.

The pad-mount transformers will be fully metal-enclosed, weatherproof, oil-insulated, self-cooled, three phase, rated 12470 Grd-Y/7200V - 208 Grd-Y/120V, wye-wye connections, with taps. The primary will include an oil-immersed, four-position, loop feed, load-break, gang-operated switch with fuse protection in each phase. The secondary will consist of spade terminals, with a 225 amp three-pole circuit breaker for each antenna served. The circuit breakers will be mounted in the secondary compartment of the transformer. Transformers will have four-legged or five-legged core designs to eliminate interference and improve operation.

Antenna Power Service: Power service to the antenna will be 120/208 volt, three phase, four wire, grounded neutral. An underground service consisting of three phase wires, one neutral wire and one ground wire will be extended in conduit from the 225 amp circuit breaker in the pad-mount transformer to a weatherproof receptacle surface-mounted on the antenna foundation. The receptacle will be rated 200 amps, 120/208 volts, 4 pole, 4 wire. A 4 pole, 5 wire receptacle is unavailable, therefore the equipment ground contact will be through the receptacle and plug case.

Grounding: Ground provisions will be made at each antenna station and each pad-mount transformer. Where they occur together, the antenna station ground will be used for the transformer ground. Insulated ground wires will be extended to the power system ground in the transformer, the receptacle on the antenna foundation, the waveguide, and to a cable attachment on the antenna foundation for the lightning protection system on the antenna. All connections will be welded.

By minimizing the use of bare copper in earth, the cathodic protection system for the waveguide will be improved. The concentric neutrals of the direct-buried primary power cables are coated copper wires and will be grounded at each transformer.

Wye Crossings: The existing SEC pole lines cross the wye arms a total of six times; four single phase and two three phase. The antennas will require a minimum of 90 to 100 foot clearance over the tracks, requiring all crossings be placed underground at a direct cost to VLA. Estimates by Socorro Electric Cooperative have been made for this cost.

4. ANTENNA WYE CONFIGURATION

4.7 General Soil Recommendations

Recommendations regarding treatment of subsurface soils at the VLA site for all facilities are discussed in a separate report entitled "VLA Soil Investigation Analysis" submitted to the BWH-CVR Joint Venture by their Soils Consultant, Woodward-McNeill & Associates. The report and an earlier Task 2.3 Soil Data report are presently being reviewed by the Joint Venture engineers and are being used to formulate detailed designs for the site buildings, wye trackage, and antenna foundations.

CONSTRUCTION COST SUMMARY

Construction costs are contained in the table on Page 63. The cost estimate is based on 1973 construction costs. Detailed takeoffs were made from the preliminary drawings and costed. Backup cost estimate sheets are contained in Appendix F which is submitted as a separate volume.

The estimate shows a range of costs for several items. The bracketed numbers represent estimated costs consistent with the system discussion in the main body of the report. The unbracketed numbers represent estimated costs should a number of the alternates discussed in Appendix B be selected during Title II detailed design.

Although not discussed in detail in this section, the alternatives are broadly outlined below so the reader may understand the table.

Item	Approx. Cost Reduction (1000's)	Alternative
Site Work	$27.9	Asphalt paving of roads
Electric Wye	32.0	1 circuit instead of 3 on Wye
Cafeteria Bldg.	3.0	HVAC to Evap. Cooling
V.S.Q.	16.0	HVAC to thru wall units
Maint. Bldg.	17.0	Air Comp., Auto exhaust, dust collector & evap. cooling - shops area
Maint. Bldg.	17.0	HVAC to Evap. - Office & Labs
Maint. Bldg.	17.0	Conc. load dock & major conc. exterior slabs
Airstrip	100.1	Paving
	$230.0	

Depending upon options which can be exercised during Title II design the estimated construction costs are 2.2 to 2.4 million above the Feb. 16, 1973 budget provided to the Joint Venture. Although individual costs vary from the budget, the principal cost increases are reflected in two items:

1. Wave Guide Installation - approximate 1.4 million increase based on the installation costs presented in the Bechtel report.

2. Railroad Construction and Earthwork combined - approximate $780,000 increase. Principally in the railroad cost where current construction costs are rising very rapidly, in particular new and relayer rail and ties. The present estimate assumes that relayer rail and ties can be procured at reasonable costs.

Extending the cost estimates to phased construction is discussed in the section on construction phasing since escalation is a function of when the various elements are constructed.

TITLE I CONSTRUCTION COST ESTIMATE

Item			Estimated Cost 1973 Dollars
Site Work - 5' Outside Bldgs. Fencing, Roads, Parking, Etc.			$ 59,100 ($ 87,000)
Wye			$15,312,300
Earthwork & Drainage	$1,370,700		
*Wave Guide Installation	2,522,600		
Trackage	10,235,900		
Antenna Stations	1,183,100		
Utilities			$ 1,559,500 ($1,591,500)
Water Supply	$ 83,300		
Sewer	78,000		
Telephone	101,200		
Electric - Wye	1,139,800	($1,171,800)	
Electric - Central Site	157,200		
Buildings			$ 1,519,200 ($1,589,200)
Control-22,064 sq.ft.@$41.93	$ 925,100		
Mechanical	$305,600		
Electrical	149,500		
Arch.-Struct.	470,000		
Cafeteria-5,317 sq.ft.@32.27	$ 171,600	($174,600)	
Mechanical	$ 35,600	($38,600)	
Electrical	29,600		
Arch.-Struct.	106,400		
Visiting Scientists' Qtrs. 3,472 sq.ft.@31.84	$ 108,800	($124,800)	
Mechanical	$ 20,500	($36,500)	
Electrical	18,500		
Arch.-Struct.	69,800		
General Maint. Bldg. 15,510 sq.ft.@20.23	$ 313,700	($364,700)	
Mechanical	$ 55,100	($89,100)	
Electrical	57,900		
Arch.-Struct.	200,700	($217,700)	
Airstrip			$ 167,900 ($ 268,000)
Total Site Facilities			$18,618,000 ($18,848,000)

*As per Bechtel Report

( ) numbers represent costs for options to be made during Title II design.

IV CONSTRUCTION PHASING

Construction phasing is directly tied to the level of construction funds appropriated during the life of the project. With the 1974 funds cut to 5 million some slippage may occur in the initial years. To keep construction unit costs reasonable, the project should be bid with the maximum amounts of similar work in each phase. It is also desirable to bid a sufficient volume of work at regular intervals so that the work level at the site is maintained at a reasonably constant level. This minimizes mobilization and demobilization costs.

Using Title I cost estimates, objectives of volume bidding, unit costs shown below (based on 61000 mtrs.) and the desirability of radial array completion suggests discrete construction elements.

Item	Approx. Unit Cost	Total
Wave Guide	$ 41.40/mtr.	$ 2,525,400
Earthwork & Drainage	22.50/mtr.	1,372,500
Trackage Straight	144 /st. track mtr. = 142 /running track mtr.	8,662,000
101 Interchanges	9900 ea.	999,900
101 Antennas	5600 ea.	565,600
2 Turnouts	29300 ea.	58,600
101 Antenna Foundations	11700 ea.	1,181,700
Power Wye & Telephone	13.00/mtr.	793,000
100 Power @ Stations	4700 ea. (with 3 circuit)	470,000
Site Work & Site Utilities	(with paving)	405,500
Airstrip (without paving)		167,000
Buildings (with options)		1,589,200
		$18,790,400*

*Totals do not match Title I numbers exactly in that unit costs do not carry odd dollars & cents. Trackage unit costs are averages that reflect rail size and tie spacing alternatives and availability of new or relayer for special interchanges and antenna areas.

Many combinations of discrete elements may be made pending funding levels. For purposes of flexibility in combining discrete elements, the total project by separable elements has been broken down considering earthwork balance points (contained in Appendix G) and array by array completion. For example:

Construction Element	Cost (1000's)
Site Work, Utilities Airstrip (no paving) & Central Buildings (with options)	$2,161.7

D-Array

West Arm

Earthwork & Drainage	(DW1-BW6+)	4390 mtrs.@22.50	$ 98.8
Straight Trackage	(DW1-DW11)	535 mtrs.@142	76.0
Interchanges	(DW1-DW11)	11 @ 41.40	108.9
Antenna Areas	(DW1-DW11)	11 @ 5600	61.6
Wave Guide	(DW1-DW11)	535 mtrs.@41.40	22.1
Foundations	(DW1-DW11)	11 @ 11,700	128.7
Power Wye & Tele.		535 mtrs.@13.00	7.0
Station Power		11 @ 4700	51.7
			$ 554.8

East Arm

Earthwork & Drainage	(DE1-BE5+)	3780 mtrs.@22.50	$ 85.0
Straight Trackage	(DE1-DE9)	490 mtrs.@142	69.6
Interchanges	(DE1-DE9)	9 @ 9900	89.1
Antenna Areas		9 @ 5600	50.4
Wave Guide		490 mtrs.@41.40	20.3
Foundations		9 @ 11,700	105.3
Power Wye & Tele.		490 mtrs.@13.00	6.4
Station Power		9 @ 4700	42.3
1 Turnout		1 @ 29,300	29.3
			$ 497.7

North Arm

Earthwork & Drainage	(DN1-BN5+)	3323 mtrs.@22.50	$ 74.8
Straight Trackage	(DN1-DN7)	450 mtrs.@142	63.9
Interchanges		8 @ 9900	79.2
Antenna Areas		8 @ 5600	44.8
Wave Guide		450 mtrs.@41.40	18.6
Foundations		8 @ 11,700	93.6
Power Wye & Tele.		450 mtrs.@13.00	5.8
Station Power		8 @ 4700	37.6
1 Turnout		1 @ 29,300	29.3
			$ 447.6

C-Array

West Arm

Earthwork & Drainage		None	$ -0-
Straight Trackage	(DW-11-CW11)	1425 mtrs.@142	202.4
Interchanges		13 @ 9900	128.7
Antenna Areas		13 @ 5600	72.8
Wave Guide		1425 mtrs.@41.40	59.0
Foundations		13 @ 11,700	152.1
Power Wye & Tele.		1425 mtrs.@13.00	18.5
Station Power		12 @ 4700	56.4
			$ 689.9

East Arm			
Earthwork & Drainage		None	$ -0-
Straight Trackage	(DE9-CE9)	1510 mtrs.@142	214.4
Interchanges		8 @ 9900	79.2
Antenna Areas		8 @ 5600	44.8
Wave Guide		1510 mtrs.@41.40	62.5
Foundations		8 @ 11,700	93.6
Power Wye & Tele.		1510 mtrs.@13.00	19.6
Station Power		8 @ 4700	37.6
			$ 551.7
North Arm			
Earthwork & Drainage		None	$ -0-
Straight Trackage	(DN7-CN7)	1323 mtrs.@142	187.9
Interchanges		6 @ 9900	59.4
Antenna Areas		6 @ 5600	33.6
Wave Guide		1323 mtrs.@41.40	54.8
Foundations		6 @ 11,700	70.2
Power Wye & Tele.		1323 mtrs.@13.00	17.2
Station Power		6 @ 4700	28.2
			$ 451.3
B-Array			
West Arm			
Earthwork & Drainage	($BW6^{+}$-$AW3^{+}$)	4820 mtrs.@22.50	$ 108.5
Straight Trackage	(CE11-BW11)	3920 mtrs.@142	556.6
Interchanges		9 @ 9900	89.1
Antenna Areas		9 @ 5600	50.4
Wave Guide		3920 mtrs.@41.40	162.3
Foundations		9 @ 11,700	105.3
Power Wye & Tele.		3920 mtrs.@13.00	51.0
Station Power		9 @ 4700	42.3
			$1,165.5
East Arm			
Earthwork & Drainage	($BE5^{+}$-$BE9^{+}$)	2240 mtrs.@22.50	$ 50.4
Straight Trackage	(CE9-BE9)	3880 mtrs.@142	551.0
Interchanges		8 @ 9900	79.2
Antenna Areas		8 @ 5600	44.8
Wave Guide		3880 mtrs.@41.40	160.6
Foundations		8 @ 11,700	93.6
Power Wye & Tele.		3880 mtrs.@13.00	50.4
Station Power		8 @ 4700	37.6
			$1,067.6
North Arm			
Earthwork & Drainage	($BN5^{+}$-$BN7^{+}$)	4451 mtrs.@22.5	$ 100.1
Straight Trackage	(CN7-BN7)	3547 mtrs.@142	503.7
Interchanges		7 @ 9900	69.3
Antenna Areas		7 @ 5600	39.2
Wave Guide		3547 mtrs.@41.40	146.8
Foundations		7 @ 11,700	81.9
Power Wye & Tele.		3547 mtrs.@13.00	46.1
Station Power		7 @ 4700	32.9
			$1,020.0

A-Array

West Arm

Earthwork & Drainage	($AW3^{+}$-AW11)	11890 mtrs.@22.50	$ 267.5
Straight Trackage	(AW11-BW11)	15120 mtrs.@142	2,147.0
Interchanges		10 @ 9900	99.0
Antenna Areas		10 @ 5600	56.0
Wave Guide		15120 mtrs.@41.40	626.0
Foundations		10 @ 11,700	117.0
Power Wye & Tele.		15120 mtrs.@13.00	196.6
Station Power		10 @ 4700	47.0
			$3,556.1

East Arm

Earthwork & Drainage	($BE9^{+}$-AE9)	15090 mtrs.@22.5	$ 339.5
Straight Trackage	(BE9 -AE9)	15120 mtrs.@142	2,147.0
Interchanges		7 @ 9900	69.3
Antenna Areas		7 @ 5600	39.2
Wave Guide		15120 mtrs.@41.40	626.0
Foundations		7 @ 11,700	81.9
Power Wye & Tele.		15120 mtrs.@13.00	196.6
Station Power		7 @ 4700	32.9
			$3,532.4

North Arm

Earthwork & Drainage	($BN7^{+}$-AN7)	11190 mtrs.@22.5	$ 251.8
Straight Trackage	(BN7 -AN7)	13680 mtrs.@142	1,942.6
Interchanges		5 @ 9900	49.5
Antenna Areas		5 @ 5600	28.0
Wave Guide		13680 mtrs.@41.40	566.4
Foundations		5 @ 11,700	58.5
Power Wye & Tele.		13680 mtrs.@13.00	177.8
Station Power		5 @ 4700	23.5
			$3,098.1

Alternatively discrete elements may be lumped by separable trades, for example:

Construction Element	Cost (1000's)
Building (with options)	$1,589.2
Site Work & Utilities (with paving)	405.5
Airstrip (no paving)	167.0

CONSTRUCTION ELEMENT

Array	Earthwork & Drainage	Straight Trackage	Interchanges	Antenna Areas	Wave Guide	Foundations	Power Wye	Station Power
West - D	$ 98.8	$ 76.0	$108.9	$ 61.6	$ 22.1	$ 128.7	$ 7.0	$ 51.7
- C	-0-	202.4	128.7	72.8	59.0	152.1	18.5	56.4
- B	108.5	556.6	89.1	50.4	162.3	105.3	51.0	42.3
- A	267.5	2147.0	99.0	56.0	626.0	117.0	196.6	47.0
	$474.8	$2982.0	$425.7	$240.8	$869.4	$ 503.1	$273.1	$197.4
East - D	$ 85.0	$ 69.6+29.3	$ 89.1	$ 50.4	$ 20.3	$ 105.3	$ 6.4	$ 42.3
- C	-0-	214.4	79.2	44.8	62.5	93.6	19.6	37.6
- B	50.4	551.0	79.2	44.8	160.6	93.6	50.4	37.6
- A	339.5	2147.0	69.3	39.2	626.0	81.9	196.6	32.9
	$474.9	$3011.3	$316.8	$179.2	$869.4	$ 374.4	$273.0	$150.4
North - D	$ 74.8	$ 63.9+29.3	$ 79.2	$ 44.8	$ 18.6	$ 93.6	$ 5.8	$ 37.6
- C	-0-	187.9	59.4	33.6	54.8	70.2	17.2	28.2
- B	100.1	503.7	69.3	39.2	146.8	81.9	46.1	32.9
- A	251.8	1942.6	49.5	28.0	566.4	58.5	177.8	23.5
	$426.7	$2727.4	$257.4	$145.6	$786.6	$ 304.2	$246.9	$122.2
TOTALS	$1376.4	$8720.7	$999.9	$565.6	$2525.4	$1181.7	$793.0	$470.0

Any combination of the foregoing discrete elements may be combined for construction within a given year, however depending upon the year, these 1973 costs should be escalated by at least 6 percent per year.

The initial construction work is closely tied to other subcontractors to AUI, in particular the antenna and transporter subcontractors. Critical dates are assumed as follows:

Date	Items	Reason
Nov. 74	Construction Facilities, minimal utilities, SW arm trackage to serve antenna contractor.	To make antenna construction timetable.
Jan. 75	Master Foundation, CW-3 (electronics assembly) CW-10, earthwork & drainage, (wye ctr. to 1st SW arm balance point), Wave Guide & power.	To provide for antenna construction timetable, storage facilities, foundations for antenna delivery, electronics assembly & initial system testing.
June 76	Central Site complex continuation of SW arm Wye system	Site complete, bldgs. ready for electronic, digital, computer & other equipment.
Summer 81	Project Complete	----------

In light of the above committments and limited initial funding the following construction schedule is recommended.

Spring - 1974

Earthwork & Drainage (DW1-BW6+)	4390 mtrs.@22.5	$ 98.8
Straight Trackage (CW3-CW10)	1120 mtrs.@142	159.0
Full Interchanges (CW3,CW10,CW7, Master, Antenna Bldg.)	5 @ 9900	49.5
Allowance for 6 partial interchanges	6@2000	12.0
Full Antenna Areas	5 @ 5600	28.0
Foundations	5 @ 11700	58.5
Power Wye & Tele. (CW3-CW10)	1120 mtrs.@13.00	14.6
Station Power	5 @ 4700	23.5
Rehab. old U.S. 60, Access Rd. to Antenna Bldg. Site Grading @ Antenna Bldg., Build old U.S. 60 west arm crossing landfill road		24.0
Well & small service pump		12.0
Wave Guide	1120 mtrs.@41.40	46.4
		$526.3

Fall - 1974

Remaining Central Site Work & Utilities (with paving)			$ 369.5
Central Site Buildings (with options)			1,589.2
Complete C&D Array - West Arm			759.1
Straight Trackage	840 mtrs.@142	$119.3	
Full Interchanges	13 @ 9900	128.7	
Complete Partial Interchanges	6@7900	47.4	
Antenna Areas	19 @ 5600	106.4	
Foundations	19 @ 11700	222.3	
Power Wye & Tele.	840 mtrs.@13.00	10.9	
Station Power	19 @ 4700	89.3	
Wave Guide	840 mtrs.@41.40	34.8	
		$759.1	
Airstrip (without paving)			167.0
			$2,884.8

It should be noted that the Spring 1974 work does not call for any buildings nor utilities other than the well and temporary power. Since electronics field testing and antenna assembly operations are scheduled for early 1975, it is recommended that in the Fall 1974 construction contract the General Maintenance and the Antenna Assembly Building be scheduled for January 1975 completion and/or partial occupancy by VLA personnel. It should also be noted that because of the varied work and small dollar volumne of the Spring 1974 work the unit costs may bid substantially higher than estimated.

The above construction provides by 1976 the complete central site and the West arm portions of the C&D Arrays comprising approximately 2 kilometers of the wye.

Construction scheduling of the remaining portions of the wye at this time could be done; however, it is recommended that these schedules be made later after definitive funding levels are known.

APPENDIX A - SUMMARY OF DESIGN CRITERIA

A.1 ARCHITECTURAL

1. Control Building - Lower Level:

		Sq. Footage
Mechanical	C-114	1,040.00
Lab and Work Area	C-125	4,135.00
Electric Equipment	C-124	160.00
Mechanical	C-123	1,824.00
Programmer	C-122	155.50
Elevator Equipment	C-120	80.00
Telephone Equipment	C-119	116.00
Janitor	C-118	33.75
Men's Toilet	C-117	114.00
Vestibule	C-116	24.00
Coffee and Lounge	C-113	335.00
Lobby	C-101	264.00
Stair	C-100	144.00
Office	C-112	126.50
Office	C-111	126.50
Office	C-109	136.00
Office	C-108	114.00
Office	C-107	114.00
Office	C-106	114.00
Office	C-105	145.00
Office	C-104	120.00
Office	C-103	126.00
Corridor	C-110	80.50
Corridor	C-102	56.00
Corridor	C-121	50.25
Corridor	C-115	116.50

2. Control Building - Upper Level:

Digital Equipment	C-216	1,040.00
Electrical Equipment	C-218	2,040.00
Control Room	C-224	956.00
Computer Room	C-227	2,544.00
Operator	C-220	128.00
Observer	C-221	128.00
Coffee	C-222	32.50
Toilet	C-223	37.00
Tape Storage	C-225	211.75
Mechanical		196.00
Janitor	C-214	27.75
Men's Toilet	C-213	84.75
Women's Toilet	C-212	75.00
Stair	C-200	144.00

Control Building - Upper Level (Cont'd.)

		Sq. Footage
Upper Lobby	C-201	394.00
Office	C-209	133.00
Office	C-208	139.00
Office	C-207	135.00
Office	C-206	135.00
Director	C-204	228.00
Office	C-203	136.00
Conference	C-211	319.00
Corridor Space	C-210	59.00
Corridor Space	C-205	112.75
Corridor Space	C-202	59.00
Corridor Space	C-215	116.00
Corridor Space	C-226	102.50
Corridor Space	C-219	276.00
	TOTAL	
Lower Level Assignable Space		9,850.50
Upper Level Assignable Space		9,989.00
Total Assignable Space		19,839.50
Total Enclosed Space		22,064.00 @ 11,032 per floor
Observation Deck		1,215.00

3. Cafeteria Building

Dining Room	1,566.18
Kitchen	1,314.08
Serving	293.30
Office	64.00
Storage	157.50
Recreation	822.25
Vending	62.85
Toilets	216.71
Foyer	192.10
Mechanical	100.00
Electrical	46.70
Total Assignable Area	4,835.67
Total Enclosed Space Including Walls & Corridors	5,316.62

4. Visiting Scientists' Quarters

10 Sleeping Rooms @ 219.0/unit	2,190.00
10 Baths @ 50.0/unit	500.00
2 Mech. @ 97.85/each	195.70
Linen	42.22
Laundry	42.22
Total Assignable Space	2,970.14
Total Enclosed Space Including Wall	3,472.00

5. General Maintenance Building

		Sq. Footage
Warehouse		5,168.00
Six Offices		688.50
First Aid		143.00
Men's Toilet		90.00
Women's Toilet		65.00
Janitorial Closet		19.25
Auxillary Area		3,106.50
Auto Maintenance		1,209.50
Electronic Maintenance		
Office	M-107	120.75
Office	M-108	140.00
Office	M-109	123.25
Storage		740.25
Wave Guide		308.75
Front End Repair		819.00
Cryogenic Lab		493.50
Clean Assembly		162.70
Test Area		162.70
Total Assignable Space		13,560.65
Total Enclosed Space Including, walls, corridors, etc.		15,510.62

APPENDIX A - SUMMARY OF DESIGN CRITERIA

A.2 Structural

1. General: All loads used for design meet or exceed the minimum values specified in Chapter 23 of the Uniform Building Code, 1970 edition.

2. Gravity Loads:*

   A. Control Building:

      1) Roof: 20 psf live load.**

      2) Stairs and Public Areas: 100 psf live load.

      3) Administrative Areas: 20 psf partition load, 50 psf live load.

      4) Control Room, Computer Room, Digital Equipment Room: 200 psf equipment load, 50 psf live load.

      5) Electronic Equipment Room: 1500 lb. per equipment rack, 50 psf general equipment load, 50 psf live load.

   B. General Maintenance Building, Cafeteria Building, Visiting Scientists' Quarters:

      1) Roof: 20 psf live load.**

3. Lateral Loads: Typical for all Buildings.

   A. Wind:
   Direct - 20 psf.
   Suction - 10 psf.
   Uplift - 23 psf.

   B. Seismic:
   Zone 2 - Z = 0.50
   Box System - K = 1.33
   One or Two Story - C = 0.10

   Base Shear Factor (ZKC) = .0665

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* Applied loads in addition to weight of structure and all fixtures and equipment permenently attached to the structure.

** Equivalent to approximately 4 ft. of snow or 4 in. of ice.

APPENDIX A - SUMMARY OF DESIGN CRITERIA

A.3 MECHANICAL

1. Outdoors

	db°F.	wb°F.
Summer	100	65
Winter	0	--

2. Indoors

	Summer		Winter	
Area	db°F.	rh %	db°F.	rh %
Control Building:				
Personnel Spaces	75°±4	45 max.	75°	--
Inlet to Digital Equipment	58°±2	40±5	58°±2	40±5
Inlet to Electronic Equipment	58°±2	40±5	58°±2	40±5
Inlet to Computer Equipment	55°±4	40±5	55°±4	40±5
General Maint. Bldg:				
Personnel Offices	75°±4	45 max.	72°±4	--
Electronic Stores	75°±4	40±10	72°±4	40±10
Cryogenics, Front End, Wave Guide Labs	75°±4	40±10	72°±4	40±10
Shops, Lockers, Warehouse	80°	--	72°	--
Cafeteria Building:				
Dining, Recreation, Serving Area	75°±4	45 max.	72°±	--
Kitchen	80°	--	72°	--
Visiting Scientists' Quarters				
Typical Room	75°±4	45 max.	72°±4	--

A.4 ELECTRICAL

1. National Electrical Code: For general design.

2. Illuminating Engineering Society: Recommended lighting levels where specific criteria is not given.

3. NRAO Letter: 16 February 1973 with Attachments A through H (minus I).

4. NRAO Letter: 1 May 1973 with enclosures A through D.

5. Room Data Sheets: 21 March 1973 from NRAO, covering Control Building and Lab area in General Maintenance Building.

6. Room Data Sheets: Undated; received 31 August 1973, covering preliminary requirements in General Maintenance Building and Antenna Assembly Building.

7. Power Requirements for Antenna Assembly Building: 6 September 1973 interoffice letter, Horne to Wells.

8. Charlottesville and Green Bank Site Visit: 18-21 June 1973, conference on project criteria.

9. Socorro Electric Cooperative Meeting: 19 July 1973, in Socorro, to discuss power service (U-L Memo 4 September 1973).

10. Socorro Electric Cooperative Fault Current: 14 August 1973, letter to Uhl and Lopez.

11. Study of Total Project Electrical Load: 15 August 1973, by Uhl and Lopez. Up-dated 7 September 1973. (U-L Memo 28 August 1973).

12. Power Estimate Review: 5 September 1973 interoffice letter, Campbell to Lancaster.

13. Schematic Design Submittal and Review: 12-13 September 1973, Charlottesville (U-L Memo 1 October 1973).

14. Schematic Design Comments: 4 October 1973, NRAO.

15. Antenna Loads: 25 September 1973 interoffice letter, Dorr to Uhl, including complete revision of total project electrical loads and power billings.

16. Electronics and Digital Control Area Review: 2 October 1973 interoffice letter, Campbell to Egler.

17. Socorro Electric Cooperative Meeting: 8 October 1973, in Socorro, to discuss power service (U-L Memo 13 November 1973).

18. Waveguide Meeting: 16 November 1973, in San Francisco at Bechtel's offices (U-L Memo 19 November 1973).

APPENDIX A - SUMMARY OF DESIGN CRITERIA

A.5 CIVIL

1. Water System:

   A. Original components suggested by letter of February 16th and Feasibility Report:

      1 - Well
      1 - 65000 gallon elevated reservoir
      1 - 5000 gpd chlorinator
      1 - 5000 gpd water softener
      5000 Lin. Ft. - 2½" galvanized supply line
      1000 Lin. Ft. - 6" A.C. distribution line

   B. Hydrogeologic Information: The San Augustin Plains are underlain with high plasticity impervious clays with wide spread gravel deposits and surface sand deposits of a few inches to 10 feet in thickness. The underlying aquifer is not well defined. Water may be encountered from 50 to 100 feet. Existing wells range from 75 to 250 ft. deep. The well water should be potable, and be within allowable limits of flouride, chloride and sulphates.

   C. Requirements of Flow:

      1) Total resident staff is estimated at 53 persons.

      2) Antenna assembly crews to be furnished water.

      3) Electronics Building to have 18 people - some on double shift.

      4) Consider 5 residences on the hill.

      5) Consider fire sprinklers for about 26,000 sq. ft.

      6) General plan is for 80 to 100 people on site including tourists.

      7) There will be 100 additional construction workers for first 8 years - daytime only.

      8) Sprinkler heads to be 30 gpm.

   D. Existing Equipment at Green Bank:

      1) 100,000 gallon elevated reservoir 100 ft. high to 121 ft. high levels.

2) Hypo chlorinator.

3) 3 wells on the site.

4) 750 gallon pumper truck.

5) Record use is 20,000 gallons per day.

2. Sewer System:

A. From original reports:

1) Package type sewage plant for 100 daytime employees and 20 visiting scientists.

2) Treatment with 2-1/2 acre cells. 3000 ft. of 6 in. C.I. pipe.

3) Need 20 manholes, 3 valves, and 1600 lin. ft. of cyclone fence.

B. Climatalogical & Geologic Data:

1) Elevation is 6960 above msl.

2) Location is approximately at

N 34°04' Latitude and
W 107°37' Longitude

3) Temperatures:

Summer average daily high	= 90°F
Winter average daily low	= 15°F
Highest recorded	= 104°F
Lowest recorded	= -22°F
Average Summer temperature	= 70°F
Average Winter temperature	= 31°F

4) Average Yearly Precipitation = 12"
Max. day = 2.25" Max. Month = 4.66 "

5) Relative Hunidity - 30% day - 75% night.

6) 70% available sunshine.

7) Prevailing west wind - average velocity 9.6 mph.
Maximum wind velocity - 77 mph.

8) Valley floor is a thick alluvial quatenary deposit underlain by high plasticity, impervious clays.

9) Source of high plasticity clay 1.5 mile S.W. of apex.

C. Treatment Criteria:

1) B.O.D. of 0.20 lb. per day.

2) Use a 20 day minimum retention period.

3) Cells should operate at 5 ft. level maximum and 3 ft. level minimum.

4) Cells should be alternated for use.

D. Additional data from Green Bank trip:

1) 5 residences plus 10 double room dormitory.

2) No unusual disposal problems except a chromate tank in Machine Shop.

3) Should be only about 100 people on site daily including construction workers.

3. Access Road:

A. General Road Requirements from original reports and Green Bank trips:

1) Rehabilitate old U.S. 60 - 18'± width.

2) Design all roads and parking areas for gravel surfaces - paved alternates.

3) No curbs to be used.

4) Design for 45 mph & 300' sight distances.

5) Use 7% maximum grade.

6) Provide adequate drainage.

7) Entrance road to be 24' wide with 2' shoulders.

8) Design on basis of 18000 pound axle loads.

B. Available Materials and Geology:

1) No record of seismological activity.

2) Surface material is quatenary terrace and alluvial material underlain by high plasticity impervious clays with widely distributed sand dunes.

3) Gravel may be available at higher elevations in the plains. There are two recommended sources:

a) 1/2 mile north of U.S. 60, and south of East arm at the 10 mile point. Both require quarries.

4) The nearest commercial source of aggregate is Socorro, 50 miles east of the site. Many local aggregates contain unstable silica which may react with cement.

4. Airstrip:

A. From Original Reports and Data:

1) 75' paved macadam runway 5200 ft. long with hardstand area & approach road.

2) No lighting or services except wind cone.

3) Design for DC-3 class aircraft.

4) Follow FAA standards of construction.

5) Total strip width is to be 150'.

6) Design for a 15000 lb.wheel load.

7) Design as a basic utility air strip for FAA criteria Stage IIB.

8) Provide 1000' clear zone.

9) Provide 20:1 glide approach.

10) Provide 150' x 200' paved apron.

11) Location of strip is north of old U.S. 60 and just east of S.R. 78.

B. Climatological & Geological Data:

1) Site is at 6960 feet avove msi.

2) Vegetation consists of sparce stand of grass with scattered sagebrush.

3) Temperatures:

Average Daily High = 90°F.
Average Daily Low = 15°F.
Highest Recorded = 104°F.
Lowest Recorded = -22°F.
Average Summer Daily = 72°F.
Average Winter Daily = 31°F.
Mean Annual = 52.5°F.
Mean Maximum = 85°F.

4) Precipitation = 12"; maximum daily = 2.25" and Maximum monthly = 4.66".

5) Relative Humidity = 35% day and 75% night.

6) 70% of available sunshine.

7) Prevailing wind from west with average velocity of 9.6 mph and maximum velocity of 77 mph.

8) A high incidence of thunderstorms in the area with an average of 80 per year.

9) The site is encircled by peaks ranging from 9500 to 10000 feet.

10) The valley floor is quatenary terrace deposits underlain by high plasticity clays. Sand deposits are widespread.

11) There are two or three possible aggregate sources.

12) Apex of the wye is at Latitude N 34°04' and Longitude W 107°37'. It is 22 miles west of Magdalena.

C. Information from FAA office in Albuquerque, on July 23, 1973:

1) Runway should be 8600 feet long for propeller driven craft and 7700 feet long for small jet craft.

2) VFR Zone begins 200 feet from runway end and 500 feet and 700 feet by 1000 feet.

3) For IFR the zone is 500 feet and 1010 feet by 1700 feet with a 34:1 approach zone.

4) Clearance over highways must be 15 feet, and over railroads must be 25 feet.

APPENDIX A - SUMMARY OF DESIGN CRITERIA

A.6 RAILROAD

PART 1 - GIVEN DESIGN CRITERIA

1. CRITERIA LISTING:

A. Trackwork:

1. Standard gauge Railroad track, consisting of:

(a) 90 pound rail.

(b) Untreated hardwood, random cut, industry grade ties.

(c) Ties at 28-inch spacing.

(d) Six inches ballast under the ties.

(e) Tie plates and joint bars used material with other accessories being new.

2. Loadings:

(a) Weight of Antenna, 200 tons.

(b) Transport Vehicle - 4 Axle Truck, 75 tons.

(1) Taking into account wind loads, dynamic loads, acceleration loads and all combinations, the maximum wheel load is 62,000 pounds.

(c) Transport Vehicle - 6 Axle Truck, 67.6 tons.

(1) Taking into account wind loads, dynamic loads, acceleration loads and all combinations, the maximum wheel load is 40,200 pounds.

3. Transport Vehicle Information:

(a) The level contour of the tracks will be adjusted so as not to exceed a maximum of $\pm$0.500 in. in any 18 ft. section from a common horizontal reference plane and will be subject to random variations on all four rails. The spur track will be identical to the main track except in the vicinity of the telescope foundation where the rails will be supported on a concrete track bed. The length of this concrete foundation will be at least 20 ft. so that all wheels of the vehicle will be solidly supported during the installation of the telescope. At this location the top surfaces of all rails will be flat and parallel within $\pm$.250 in. and will be located in respect to the top mounting plane of the foundation within a tolerance of $\pm$.250 in.

PART 2 - DESIGN CRITERIA USED

1. CRITERIA LISTING:

A. Trackwork:

1. Standard gauge railroad track, consisting of:

(a) 90 pound new or relay rail.

(b) New or good quality secondhand creosote treated wood ties, sizes 3, 4 and 5 to meet AREA requirements, all woods acceptable.

(c) Maximum tie spacing of 25 inches.

(d) Minimum of six inches of ballast under the ties.

2. Loadings:

(a) The actual estimated dead load on one wheel of the transporter vehicle is 34,375 pounds. This compares with the dead load on the wheel of common Diesel Electric Locomotives which is 35,000. Railway design usually allows for impact, which varies with speed; however, for speeds less than ten miles per hour an impact factor of 20 percent is generally used. The top design speed of the transporter vehicle is 5.0 miles per hour. The load to be designed for is:

Estimated dead load on wheel	34,375 pounds
Impact at 20 percent	6,875 pounds
Total	41,250 pounds

Say 40,000 pounds due to extremely low speeds.

PART 3 - DESIGN CRITERIA USED - SIX AXLE TRUCK TRANSPORT VEHICLE

1. A. Trackwork:

1. Standard gauge railroad track consisting of:

(a) 90 pound new or relay rail.

(b) New or good quality secondhand treated wood ties, sizes 3, 4 and 5 to meet AREA requirements, all woods acceptable.

(c) Maximum tie spacing of 29.25".

(d) Minimum of six inches of ballast under the ties.

(e) New or secondhand joint bars and tie plates with other track materials being new.

2. Loading:

(a) Specified wheel load of 22,300 pounds plus 18% for impact.

A.7 Wave Guide

See Bechtel Report.

APPENDIX B - ALTERNATIVES CONSIDERED

B.1 ARCHITECTURAL

1. CONTROL BUILDING:

A. Visitors Observation: The observation area was originally designed as an interior space over the operators and observers office area on what would have been a third level element to the building completely enclosed by glass and having a view toward the apex of the Array as well as an over-the-shoulder view of the Control Room, Computer Room and the Electronic Equipment Room. This concept was discarded because:

1. The additional cost of construction of a third level element for visitors only was deemed inappropriate.

2. Control of site-seeing visitors wandering into working areas of the building would become a problem with escorted groups.

3. To meet State and Federal building codes, a separate emergency exit would have been required, resulting in an exterior stair tower to the roof, access of which would have been by a walkway across the roof.

B. Partitioning of Lower Level Lab Area: Since the lower level lab spaces could not be specifically defined and required a certain amount of flexibility, a demountable type partitioning system was suggested for this area. It was then deemed appropriate that the demountable partitions could be installed by in-house maintenance personnel at a time when space requirements became evident, thus eliminating the partitioning system from the initial construction cost.

C. Construction Materials:

1. Stone: A massive wall of non-load bearing stone was originally considered for the southwest face of the office block as a main design element for the complex entrance. Due to the inadequate availability of good construction stone in the area and the cost of transporting and construction of good stone materials the wall has been changed to a precast concrete load-bearing panel system with a large exposed aggregate face, rendering the wall close to the same aesthetic feeling as stone and at a lesser cost.

2. Wood: All exterior wood treatment on the project has been eliminated. Due to the maintenance requirements necessary to preserve wood from the climatic conditions of the region and to retard any unsightly conditions, a more permanent and maintenance-free material such as stucco and precast concrete fascia panels were used.

2. CAFETERIA BUILDING:

A. Kitchen Area: The floors and walls of the kitchen area are of a hard surface for ease of cleaning and durability of the area.

1. Flooring: Although higher in initial cost, quarry tile in lieu of vinyl asbestos tile has been used in the food handling areas because of its durability to constant cleaning, resistance to wear, and its non-absorbant quality.

2. Walls: All walls in food handling areas are cement plaster over gyplath or self-furring metal lath in lieu of gypboard and exposed masonry for reasons of sanitation and maintenance.

3. GENERAL MAINTENANCE BUILDING: At the onset of the project there existed a requirement for temporary construction facilities, after reviewing the requirements and some discussion, it was decided that the cost of temporary structures could be utilized more efficiently if these functions could be incorporated with and utilized later as a part of a permanent structure. It was then decided to combine all maintenance type facilities into one large structure that could be constructed in a whole or in stages at various times.

A. A single building involves least construction cost.

B. Two types of construction were investigated for the building, a premanufactured metal building system and a prestressed concrete double tee tilt-up wall system. Both systems are relatively easy to assemble within a short period of time and are comparible in cost per square foot of construction.

C. In consideration of the aesthetic values and the environmental impact on the site, it was decided to use the prestressed concrete tee structure for the major portions of the building with an office appendage of reinforced masonry that is consistant with the rest of the building designs.

D. Due to less important need for site maintenance facilities and specific space requirements, the portion of the structure designated for their different activities have been left open for future partitioning.

As an alternative to reduce construction cost associated with the General Maintenance Building, the concrete loading dock and west sides of the building may be eliminated and replaced with graveled surfaces at an approximate savings of $17,000.

APPENDIX B - ALTERNATIVES CONSIDERED

STRUCTURAL

1. CONTROL BUILDING: The structure is a two story building consisting of load bearing slump rock walls with supplementary columns supporting a poured-in-place floor system at the second floor and precast concrete tees at the roof. Studies of different types of structural systems were limited to the floor and roof framing. No other vertical load carrying system was considered.

   The different areas of the second floor were studied separately because of their differing purposes. No attempt was made to make one system fit all conditions.

   At the digital and electronic equipment rooms and at the computer and control rooms, a beam and slab system was chosen. Other systems considered for these areas were steel joists supporting a concrete slab, precast tees with a topping slab, and both conventionally reinforced and posttensioned concrete slab systems. None of these systems provides the flexibility, load carrying capacity and relatively shallow depth that the beam and slab system does.

   In the administrative area, lighter loads and smaller floor to floor height suggested the use of a concrete flat plate. The columns required for this system are concealed within interior partitions. Also studied were a concrete slab supported on steel joists, precast tees with a topping slab and cast-in-place beams and slabs. These systems would have required greater structural depth and more complex connection details or would have been undesirable architecturally.

   At the roof, the use of open web steel joists was considered in addition to the precast tees used. The joists were not used because deeper members and more elaborate framing at the overhangs would be required. In addition, there is uncertainty about availability and delivery dates for the joists.

2. GENERAL MAINTENANCE BUILDING: The structural system used for this building consists of a precast double tee wall panel and roof system. In addition there is a small office area with slump rock walls and precast roof tees.

   The other structural system considered was a prefabricated metal building. The advantages of this type of building are cost and speed of construction. However, these attributes are shared by the precast concrete system and it is more flexible because of the longer spans available. It is also aesthetically more pleasing than the metal building.

3. VISITING SCIENTISTS' QUARTERS: The structural system used consists of a concrete flat slab supported on load bearing slump rock walls. This system was chosen because of the relatively small depth of structure required and because of its flexibility.

   Two other systems, bar joists and precast flat slabs, were also considered. The former were not used because of the greater depth required and because of the difficulties in framing the overhangs at doors and windows. Precast slabs were considered because of the remoteness of the site. They were not used when it became obvious that any economies due to precasting would be lost because of the number of dissimilar forms required and the difficulties of connection.

4. CAFETERIA BUILDING: The structural system used in the Cafeteria Building consists of precast concrete tees supported by slump rock walls. The decision to use tees was prompted in part by their use in certain other buildings. In addition, the use of tees provides more flexibility within the building by eliminating columns while maintaining a relatively small depth of structure.

   Other systems considered were steel joists and a concrete flat plate. The first would have required a greater depth than the tees and would have presented some problems at the overhangs over the windows. The flat plate system has advantages in ease of forming and simplicity of connections to the bearing walls. However, these advantages are gained at the cost of adding a number of interior columns, thereby reducing the flexibility of the building.

APPENDIX B - ALTERNATIVES CONSIDERED

B.2 MECHANICAL

1. GENERAL: The relative remoteness of the general site area suggests a need to evaluate the availability and reliability of the energy source which is to be used to drive the mechanical systems - particularly the Heating, Ventilating and Air Conditioning systems. Available, as a prime source, are electricity, natural gas, liquified petroleum gas, oil and coal.

   More extensive studies of these sources have been conducted by others at an early date. These studies concluded, as evidenced by our criteria instructions, that electricity offered the most reliable and accessible energy source. A superficial examination, therefore, was made at this time to evaluate any information which could alter this conclusion. None was found! Information and trends have more strongly confirmed the correctness of the original conclusions. Therefore, all Heating, Ventilating and Air Conditioning systems were designed using electrical energy as the prime source.

   (a) Control Building: The Control Building constitutes the heart of the overall site operation. Therefore, a system of high reliability and predictable performance in maintaining environmental conditions is required. It is considered that any financial advantages offered will not offset system shortcomings.

System	Reason for Rejection
(1) Packaged Air Handling Units	Equipment Quality Control.
(2) Central-Single Air Handling System	Lack of area system independence.
(3) Conventional A/C - Boiler System	Inefficient use of available energy source.
(4) Conventional Low Velocity Primary Air Distribution, Ductwork	Large volumes of air would require large ducts.
(5) Variable Volume Air Distribution	In addition to normal low velocity air distribution objection -- needs a secondary building "skin" treatment system.

   (b) Cafeteria Building: The building requirements are of "normal" nature. Therefore, only considerations of appearance and of efficient utilization were made.

System	Reason for Rejection
(1) Conventional HVAC Units	Heating capacity would be larger than necessary. Inefficient use of available energy.
(2) Unit Heaters/Cooling Units	Unsightly, inefficient use of equipment, space.
(3) Wall Mounted Radiation	Inefficient use of required equipment, space.

It should be noted that if a requirement for HVAC in the Dining-Recreation areas were relaxed, a net savings of approximately $3,000.00 can be achieved with the substitution of evaporative cooling/heating units. Minor alterations in internal space appearance would result.

(c) Visiting Scientists' Quarters: The criteria imposed was to provide an environment of minimum noise.

System	Reason for Rejection
(1) Unitized Room Units	Provide a possible source of room noise.

It should be noted that if the criteria for a minimum noise environment were relaxed to allow unitized, through-the-wall HVAC units, a net savings in anticipated construction costs of approximately $16,000.00 can be achieved.

(2) Conventional Boiler/ Cooling Unit	Inefficient use of required equipment, space.
(3) Individual Roof-Top Units	Inefficient use of required equipment, space, increased maintenance.

(d) General Maintenance Building: The laboratory, office spaces were provided with temperature controlled environments and in some areas humidity controlled environments. The shop, warehouse areas were provided with the basic requirements for heating, ventilating and some generally cooling at peak conditions.

System	Reason for Rejection
(1) Conventional HVAC Units	Heating capacity would be larger than necessary. Inefficient use of available energy.
(2) Unitized Room Units	Inefficient, noisy, high in maintenance.
(3) Central Steam Generator for Humidification.	Too complex for required service.

(4) In the interest of providing a "minimum" building space in the shops/warehouse areas, the presently designed evaporative cooling-exhaust-relief systems and equipment (air compressor, auto exhaust system, dust collector system) can be delayed in their installation for a net savings in anticipated, initial, construction costs of approximately $17,000.00. The design would remain as shown. Equipment schedule items, however, would be noted as N.I.C. (Not in Contract).

(5) If criteria were relaxed for the environment requirement for the Office-Laboratory areas and evaporative cooling-heating units were substituted for the presently designed HVAC units (with humidification control in specific areas), a net construction cost savings of approximately $17,000.00 can be anticipated.

It must be strongly emphasized and noted that the proposed mechanical systems shown on drawings and described in design analysis sections are the most economical and best suited for achieving the criteria performance levels initially imposed.

APPENDIX B - ALTERNATIVES CONSIDERED

B.3 ELECTRICAL

A. Wye Circuits: An alternate was considered for serving all three arms of the wye with one primary circuit in lieu of three circuits. The estimated cost savings would be:

$16,470.00	- 18,300 LF primary cable @ $.90/LF
15,600.00	- 2 ea. OCB's in SEC-VLA sub @ $7,800
-0-	- Trenching remains unchanged
$32,070.00	

However, if a fault developed on one arm, the one circuit breaker would trip causing a power failure on all three arms. Since VLA will not have a high voltage electrician or lineman on duty, the entire array would be down until an SEC lineman could come out from Magdalena or Socorro, and then the outage time and cost to VLA would be greater due to the time required to locate the fault. By using three circuits with each arm on its own circuit, maximum reliability is afforded and down time for maintenance is minimized. The savings did not appear to justify the decrease in reliable service.

B. Distribution Voltage: An alternate was considered for using a distribution voltage of 14.4/24.9KV in lieu of the 7.2/12.4KV. The estimated increase in cost would be:

$82,179.00	- Cable increase, 632,146' x ($1.03 -$.90)
8,470.00	- 75KVA transformers, 55 x $154
4,136.00	- 150 KVA transformers, 22 x $188
217.00	- 225 KVA transformer, 1 x $217
628.00	- 500 KVA transformers, 2 x $314
2,736.00	- 750 KVA transformer, 1 x $2,736
9,405.00	- HV cable terminations, 627 x $15
7,200.00	- Switching vacuum circuit breaker, not available in pad-mount 25KV. Alternate switching scheme required.
$114,971.00	- Increase in costs for 24.9KV distribution.

At the time of the design selection, the Socorro Electric Cooperative had a rate schedule in effect which offered the choice of voltages without additional charge if the projected revenue justified the required construction. Studies were made which indicated the revenues would more than cover the SEC costs in less than four years, justifying the choice of 7.2/12.4KV distribution voltage with the resultant savings. On 8 October 1973 SEC advised that the rate schedule had been cancelled and a new schedule would need to be negotiated, which would include contracting for the cost of the SEC-VLA substation. This cost was given by SEC on 2 August 1973 as:

$80,000.00	- 2,500 KVA substation
39,000.00	- 5 OCB's at $7,800
$119,000.00	

Using a distribution voltage of 14.4/24.9KV would greatly reduce the $119,000.00 cost to SEC; however, it would not eliminate it, since some switching and circuit protection would still be required. The net result would depend on the negotiations with SEC and the development by SEC of alternate designs and estimated costs.

C. Antenna Station Circuits: The number of antenna stations served by one transformer was studied to determine the optimum arrangement to minimize overall costs. Voltage regulation is critical to the antenna operations and a maximum of 1% voltage drop from the transformer to the station was selected. A No. 4/0 cable is required to serve the antenna load, and without increasing the cable size the maximum distance from the transformer to the station is 123 feet, or 246 feet between stations with the transformer located midway. Only the close-in stations could be combined and the station to station distances chosen range from 131 to 344 feet with the average being 202 feet. A comparison was made using one larger transformer for 3 stations with the following costs:

2 Stations				3 Stations
$112,420 =	55	75 KVA transf. @ $2,044	60 =	$122,640
55,308 =	22	150 KVA transf. @ $2,514	12 =	30,168
-0-	-0-	225 KVA transf. @ $2,904	5 =	14,520
-0-	-0-	WP Panels @ $ 700	5 =	3,500
-0-	-0-	Oversized runs @ $ 300	10 =	3,000
$167,728				$173,828

In addition to the larger cost, the 3 station design requires the same quantity of transformers but in 3 sizes, and more 75KVA transformers. While the voltage drop can be maintained by larger cables, the power losses are increased. Adjustment of the antenna voltage by tap-changers in the transformers serving 3 stations would be extremely limited by the possibility of overvoltages to the center station while trying to adjust the end stations. The 2 station design incorporates the secondary breakers in the transformer, whereas the 3 station design requires a separately mounted weatherproof distribution panel due to space limitations in the transformer. Locating the breakers in the transformers has many advantages: cost, appearance, cooling, protection, and grounding. All comparisons favored the 2 station design over the 3 station design. Another method studied for serving more than 2 stations per transformer was to use step-up transformers at the transformer station and to distribute 480 volts and use step-down transformers at the remote stations. This approach was discarded due to the double transformation required, the concern on voltage regulation, and the unavailability of pad-mount oil transformers rated 480-208/120 volts. Pad-mount dry-type transformers are not deemed suitable for this application.

D. Fire Pump: The feasibility of operating the fire pump with an electric motor in lieu of a separate diesel engine drive was studied. The increased cost of the engine-generators would be $18,000 compared to $8,000 for the diesel drive. Other increased costs were not estimated. This additional cost is balanced by additional component cost in the pumphouse. Due to maintenance of the separate diesel engine and operating costs for it, an electric motor for the fire pump is feasible for the overall installation.

APPENDIX B - ALTERNATIVES CONSIDERED

B.4 CIVIL

1. DRAINAGE

There are several methods by which the Wye trackage drainage can be accomplished. The first method that parallels current highway and railway design methods is to construct an elevated embankment and provide drainage culverts to carry the maximum expected flow. In case of the VLA this would require many large culverts and many millions of cubic yards of embankment. Although this method would probably be the safest method as to drainage, it cannot yet provide absolute safety. There are several notable storms in the Southwest which have destroyed highways and railroad structures where designs have been predicated on maximum storm expectancy.

The next alternative is to assume an element of risk and equate repair or damage losses against cost of provided drainage structures. In highway design this method is seldom used because it is equating possible loss of human life against dollars. However, for the VLA the risk is in dollars and lost observing time with almost no risk of human life. Therefore it is feasible to reduce structure size and effect an initial cost savings. In areas on the East arm and part of the West arm the drainages are incised and lend themselves to culverts without any appreciable ponding of water at high flows. However, on the North arm and the major portion of the West arm extensive ponding would result. Soil conditions are very bad in these areas and ponding could result in expansion and/or collapse of the underlying soils. For this reason the use of culverts was decided against in these areas and the grade lowered to reduce any ponding which may occur.

The alternative posed by the original alignment of the East arm proved to be very costly in terms of embankment and drainage structures. Therefore the line was shifted eliminating the need for drainage structures in Monica Canyon. These structures and the protection for the embankment in this canyon would be very expensive.

2. EARTHWORK

The alternative designs for earthwork were principally dependent upon the drainage system chosen and have been discussed under Drainage.

The line shift on the East Arm in Monica Canyon has also been discussed in Drainage. This line shift saved over 100,000 yards of embankment and many yards of rip rap or stone embankment protection.

An earthwork design requires the selection of several grade lines to achieve the best balance obtainable with the information at hand. This has been done on the Wye trackage with from two to four computational runs for each arm.

B.4 CIVIL

1. AIRPORT

The original VLA proposal located the airstrip to the East of the Central site just east of State Highway 78. This afforded excellent access and placed the airstrip on relatively stable soil. Additional design work emphasized two problems with this location.

The first problem is the location of the airstrip relative to the SE leg of the wye. The clear zones for approach to the strip must be adjusted to be free of the antennas moving on the Wye and of the vehicles moving on State Road 78. The second problem is one of drainage. Three drainage areas converge at the airstrip location. Two of the drainage areas can be combined and the third one may be deflected around the east end of the runway. However, the combined drainage will require a battery of 18-36" diameter culverts of approximately 200 feet in length. The fill requirements over these culverts increases the embankment. This drainage is in conformance with FAA requirements for a 5 year storm.

The use of the West Arm airstrip location over the original proposal allows a saving in earthwork of 280,000 cubic yards of borrow and 6,000 lin. ft. of 36 inch diameter culvert. Excavation quantities may increase by 8,000 cubic yards.

The West arm airstrip location was recommended in the Schematic Design Presentation and subsequently approved.

The airstrip is proposed with a paved surface. Such a paved paved surface should consist of a gravel base with a bituminous top. The airstrip is also proposed as a Basic Utility Airstrip.

In an effort to reduce construction costs to conform with early estimates the FAA recommended length for the airstrip may not be used and a 6,000 foot strip proposed. This length will accomodate aircraft weighing less than 12,500 lbs. The paving may also be removed from the airstrip.

If sufficient funding is available, the measures necessary to provide an airstrip in conformance with FAA recommendations for a Basic Utility Strip will cost the following amounts:

SUMMARY OF AIRSTRIP ALTERNATES

Description	Dirt Strip	Gravel Strip	Bituminous Pavement
6000' Airstrip	$40,061	$ 88,286	$167,900
8500' Airstrip	$47,241	$126,331	$268,000

B.4 CIVIL

1. WATER SUPPLY ALTERNATES:

A. The first alternate considered was the placement of the storage reservoir on adjoining property to the south of the central site on a rise of adequate height to insure pressure could be supplied by gravity. This system would offer the greatest flexibility in terms of future expansion of the system if the site should increase in size and number of facilities requiring service. The disadvantages of this system are that there would be no flexibility in construction phasing during the initial phase of the project and longer and larger diameter runs of transmission line would be required.

If land acquisition problems could be resolved, this system would be very attractive for the reason of simplicity of operation and future expansion. However, this system would require a pumper truck to provide a standard fire stream from a 200' hose at the outdoor hydrants. Available elevation head for the reservoir is only 230 feet with the reservoir placed 10,000 feet south of the Central Site near the center of Section 13 at elevation 7200 feet. This elevation would provide only 2/3 of the standard fire stream pressure and would not be adequate for building protection.

The cost of this system would be initially higher although the long term cost could be lowered due to annual maintenance and fuel requirements for a fire booster pumping station. Equivalent items of initial cost are shown below:

Reservoir on Hill

10,000 Linear ft. of 10" transmission line	= $ 73,000
Fire pumper truck - 750 gallon capacity	35,000
	$108,000

Reduction in Proposed System

Reduce pump house structure & piping	= $ 10,860
Fire pumps and controls	7,790
Booster pumps	2,550
Hydropneumatic tank & controls	2,350
	$ 23,550

The reservoir on the hill would be $84,450 more expensive in first cost, including a pumper truck. In addition it is felt that serious problems associated with the acquisition of land for the reservoir site and transmission lines would have to be resolved. For these reasons this type of system was not evaluated further.

B. The second alternate evaluated was the construction of an elevated storage reservoir in the vicinity of the well site. Initial investigations concerning the cost of such a facility indicated that the new elevated tank alone would cost a minimum of sixty to sixty-five thousand dollars. In addition the location of a structure approximately 120 feet in height in the vicinity of the central site would be difficult when the hearing angle of the antenna is considered. If location problems can be resolved, an elevated storage tank would cost a total of $60,000 for the reservoir and tower plus $35,000 for the pumper truck. The tank would have to be located South of old U.S. 60 towards the old gravel pit to be below the "hearing angle" of the antennas. This would require approximately 800 linear feet of 10" line at a cost of $5,840.00 or somewhat cheaper than the reservoir on the hill. For these reasons, this system was not evaluated further.

C. Fire Pump Alternate: Size and cost of the water system can be reduced by using a pumper truck in conjunction with the fire pump.

With a pumper truck the pressure supplied by the fire pump can be reduced so that 20 psi is supplied at the sprinkler heads.

LOCATION FROM	TO	LENGTH	PIPE DIA.	FLOW (GPM)	HEAD LOSS	LOCATION FROM	TO	LENGTH	PIPE DIA.	FLOW (GPM)	HEAD LOSS
(1)	(2)	200	8"	900	4.61	(4)	(5)	300	8"	900	6.95
(2)	(3)	350	8"	900	8.07	(5)	(6)	130	6"	900	12.63
(3)	(4)	1100	8"	900	25.36	(2)	(8)	1550	6"	500	46.48

FIRE FLOW LOSSES

Piping Head Loss	44.96'
Elevation Differential	35.00'
Required Head = 35 x 2.31 =	80.85'
TOTAL HEAD REQUIRED AT PUMP	160.81'

Pump size is a 900 gpm pump @ 161' of head.

Use of a gasoline or a diesel engine for powering the fire pumps was studied with the following conclusion:

(1) The gasoline engine was immediately eliminated from consideration because there is not an approved gasoline engine for the altitude at the VLA site.

(2) The diesel engine system was considered and found technically feasible.

I Diesel System

a.	6" pump, Cummins engine and base	$13,800.00
b.	Controller (with remote alarm panel)	2,750.00
c.	Fuel tank and system (550 gal.)	206.00
d.	Battery, rack and cables	400.00
e.	Exhaust system	100.00
	TOTAL	$17,256.00

II Electric System

a.	6" pump, electric motor and base	$ 2,690.00
b.	Fire pump controls & Misc. cable	5,100.00
	TOTAL	$ 7,790.00

The use of the electric system in the pump house would save $9466.00 in components. Consideration must be given to the added generating capacity necessary to operate these pumps. The cost of this added capacity is estimated to be $10,000 in generator cost alone, with possible additional distribution costs.

However, additional maintenance in the diesel engines, added pump-house structure size, and long term operating costs will easily offset the price differential.

2. ACCESS ROADS AND SITE GRADING:

Following the original criteria, the roadways and parking areas have been proposed with a paved surface at ultimate construction. During the first construction contracts it may be possible to leave these roads with a gravel surface and then pave them in a subsequent construction stage. This will effect an early cost savings and also allow time for embankments to reach their final state before paving. It would be possible for operations to proceed without paving, however dust and maintenance costs would be indetrimental in the overall operation.

Costs without paving for the site work are estimated at $59,100. Paving costs are estimated at $27,900, bringing total cost to $87,000.

B.4 CIVIL

1. SEWAGE TREATMENT ALTERNATE: An acceptable method of treatment and disposal consists of providing secondary treatment to the waste flows, then applying the treated effluent to the land for final disposal. The evapotranspiration which occurs above the established ground cover plus the infiltration through the root zone would provide much greater losses than the evaporation from a free water surface.

   A. Activated Sludge Treatment Process: The process would be designed to operate in the extended aeration range. This would enable the plant to produce the highest quality effluent with the least sludge handling and disposal problems.

   B. Storage Lagoon Volume: The storage lagoon volume would be of such size that winter flows may be stored and then used during the growing season on the spray irrigation plot. A minimum depth of 1 foot would be maintained in the storage basin. For 6 months the lagoon would fill above the 1 foot level and for 6 months during the growing season the spray field would accept twice the average daily flow per day which would be pumped from the lagoon. The volume of the lagoon would have to be equal 1/2 the total yearly flow above the 1 foot depth, plus 2 feet of freeboard.

   C. Spray Field Design: The spray field would be sized to handle a daily flow of twice the average daily flow. The field would be segmented into three sections with each section receiving flow every third day and resting two days between applications.

   REASON FOR REJECTION: Analysis of this treatment alternate indicated that the costs of this system were comparable if not slightly higher than those for the total evaporation lagoon system. However, operation and maintenance of the alternate system would have been considerably more expensive and time consuming. For these reasons the evaporation lagoon system was chosen as the most practical.

APPENDIX B - ALTERNATIVES CONSIDERED

B.5 RAILROAD

PART 1 - PLANS

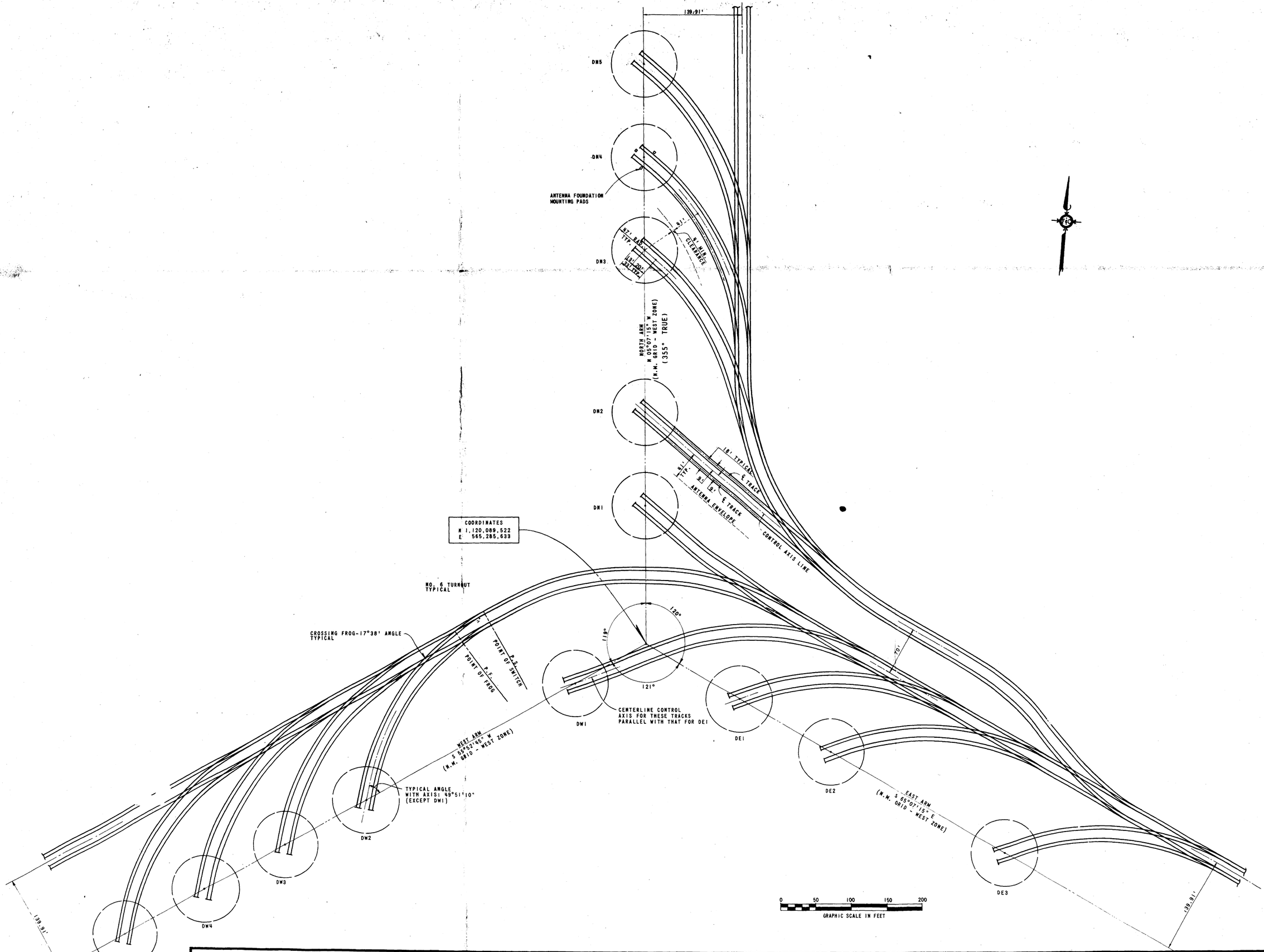
1. PLAN LISTING:

SHEET NO.	TITLE
1	Transporter Track Configuration, Turnout System
2	Transporter Track Configuration, 90 Degree Rail Crossing Frog System

PART 2 - DISCUSSION

1. TURNOUT SYSTEM: This system utilized conventional railroad No. 6 turnouts and rail crossing frogs which would provide direct movement of antenna transport vehicle and service vehicles to antenna locations. Each set of two turnouts would be controlled by one heavy duty automatic safety adjustable switch stand with reflectorized target. It is a desirable system based on reliability and convenience, however, due to cost consideration and directions from NRAO the turnout system was eliminated.

2. 90 DEGREE RAIL CROSSING FROG SYSTEM: This system utilized standard 90 degree rail crossing frogs for constructing a trackage system. Each interchange area leading to an antenna location would be served by track consisting of four 90 degree rail crossings. The transport vehicle would be transferred from the main track to the spur track by use of a mechanical system powered by hydraulic means. This system would be reliable, however due to cost considerations and direction from NRAO the 90 degree rail crossing frog system was eliminated.



V L A

BWH - CVR JOINT VENTURE

4010 CARLISLE BOULEVARD NORTHEAST

ALBUQUERQUE , NEW MEXICO 87110

STATE OF TEXAS — B. E. CROMER, JR. — 19834 — REGISTERED PROFESSIONAL ENGINEER

URS/FORREST AND COTTON, INC. - CONSULTING ENGINEERS

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URS SYSTEMS AFFILIATE

V. L. A. PROJECT

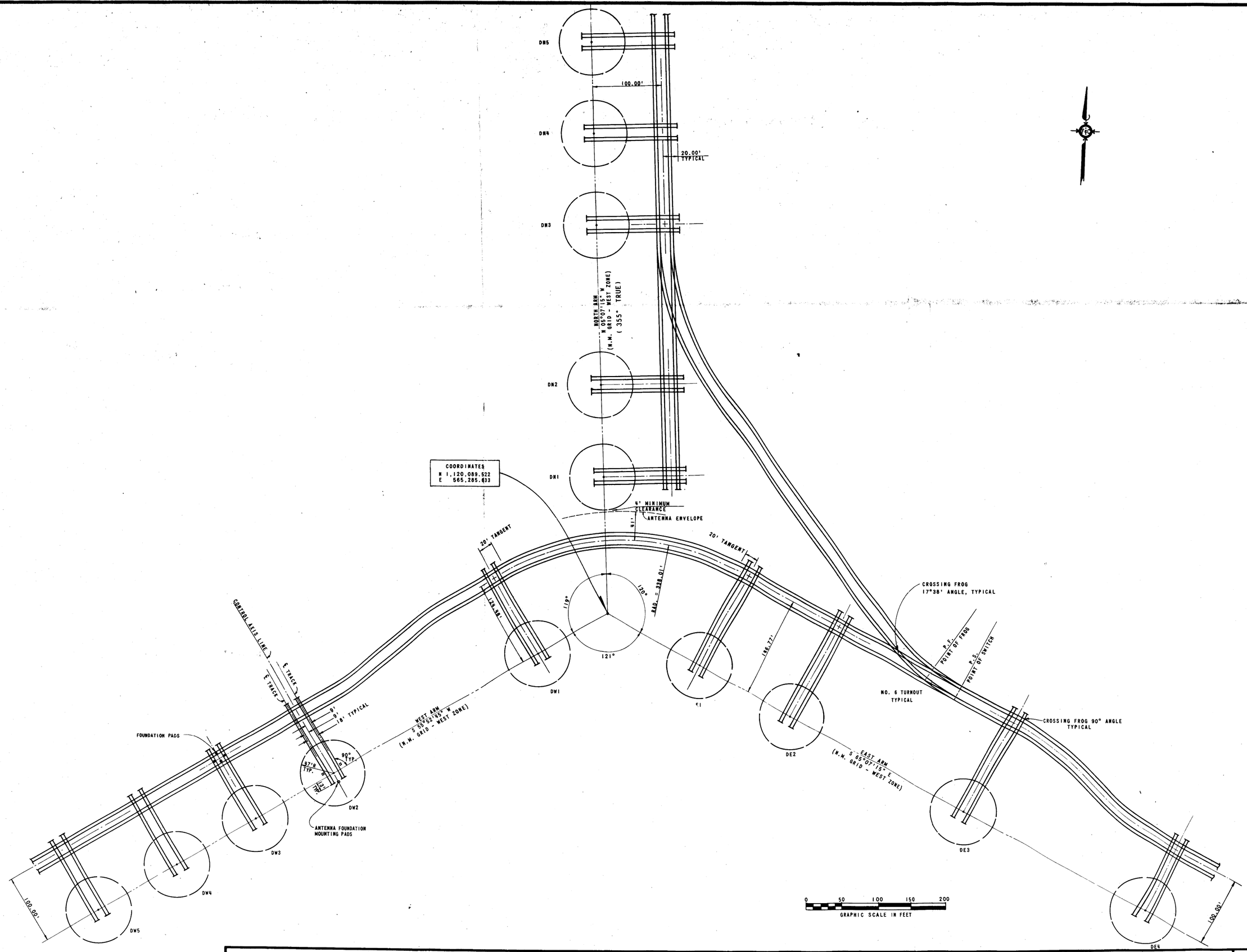
MAGDALENA , NEW MEXICO

TRANSPORTER TRACK CONFIGURATION

TURNOUT SYSTEM

SHEET NO. 1 OF 2 SHEETS

FILE NO. 580-12-1



BWH - CVR JOINT VENTURE
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URS SYSTEMS AFFILIATE

V. L. A. PROJECT
MAGDALENA , NEW MEXICO

TRANSPORTER TRACK CONFIGURATION
90 DEGREE RAIL CROSSING FROG SYSTEM

SHEET NO. 2
OF 2 SHEETS
FILE NO. 580-12-2

APPENDIX C - PROJECT BID DOCUMENTS SUMMARY

C.1 DRAWINGS

The attached list of drawings represents our best estimate of Title II contract drawings for all phases of the work at this time. Work on most of these drawings has commenced; however, due to the repetitive nature of many of the drawings, they have not been formally included in this report. For the record, two complete sets of all drawings commenced to date will be submitted under separate cover.

The drawings are grouped principally by work to be performed and are separable by disciplines for general and subcontractor use. With phasing of construction and/or letting of separate contracts, reproduction of all 260 plus drawings will not be required.

C.2 TECHNICAL SPECIFICATIONS

The technical specifications are as outlined in Appendix B. The Construction Specifications Institute sixteen-division format has been used. In this format each item of work is assigned to a division and further assigned a section number and subtitle within the division. The numbering and titling are taken from published standards of the Institute which are commonly used and understood by the construction industry.

Within each subsection (subtitle of work) the specification is further divided into three parts. These parts are as follows:

Part I (1.0) General & Scope of Work Included
Part II (2.0) Products to be Used
Part III (3.0) Execution of the Work

For this Title I report the Outline Specifications as contained in Appendix B include for the most part only the Products Portion of the technical specifications. In some instances i.e., Earthwork, the product is the natural material and hence elements of the general and/or execution sections of the specification are contained therein to explain the intent of the work. The Products portion of the specification along with the Title I drawings describes the principal features to be incorporated into Title II work. All specifications will be expanded to include the three-part system in Title II.

C.3 BIDDING DOCUMENTS

Bidding Documents referred to herein include those documents which pertain to the administrative portion of the construction. They may include the following either as separate or combined documents:

Advertisement (Invitation) for Bids
Information for Bidders (Scope & Procedures for Bidding)
Bid Form
Bid Bond (Bid security usually 5% of Bid)
Agreement Form (Between Owner & Contractor)
Payment Bond (Guarantee of lien releases to the Owner)
Performance Bond (Guarantee of Contractor performance)
Notice of Award (Owner to Contractor)
Notice to Proceed (Owner to Contractor)
General Conditions (AUI Terms & Conditions)
Special or Supplemental Conditions (Special Conditions Applicable to the project)
Wage Rates (Davis-Bacon Wage Determination)

We have received preliminary documents from the AUI-NRAO contracts group and will be working closely with them in the final documents preparation during Title II.

C.4 TITLE II LIST OF DRAWINGS

DRAWING NO.	TITLE
C-1	Location Map - Site Vicinity Plan
C-2	Site Plan - Central Building Area
C-3	Grading Plan - Central Building Area
C-4	Site Improvements - Misc. Details
C-5	Site Utility Plan - Water & Sewer
C-6	Sewer - Plan & Profile - Water Plan
C-7	Sewer - Manhole & Trenching Details
C-8	Sewer - Misc. Details & Lift Station
C-9	Sewer - Treatment & Disposal System
C-10	Sewer - Lagoon Details
C-11	Water - Distribution System Details
C-12	Water - Reservoir Details
C-13	Water - Pump House Details
C-14	Water - Pump House Schematics
C-15	Water - Well Details
C-16	Water - Well Location & Details
C-17 - 26	Road Plans & Profiles - Central Site
E-1	Central Site Electrical Distribution
E-2	Electrical - Antenna Stations
E-3	Electrical - Legend & Schedules
E-4	Electrical - Grounding Details
E-5	Electrical - One Line Power Diagram
S-1	Control Bldg. - Foundation Plan
S-2	Control Bldg. - Second Floor Framing Plan
S-3	Control Bldg. - Roof Framing Plan
S-4	Control Bldg. - Sections and Details
S-5	Control Bldg. - Sections and Details
S-6	Control Bldg. - Central Core Sections
S-7	Control Bldg. - Details
A-1	Control Bldg. - Lower Level Floor Plan
A-2	Control Bldg. - Upper Level Floor Plan
A-3	Control Bldg. - Room Finish Schedule
A-4	Control Bldg. - Door Schedule and Details
A-5	Control Bldg. - Elevations
A-6	Control Bldg. - Building Sections and Details
A-7	Control Bldg. - Stair Sections and Details
A-8	Control Bldg. - Wall Sections
A-9	Control Bldg. - Wall Sections
A-10	Control Bldg. - Details
A-11	Control Bldg. - Interior Elevations and Details
A-12	Control Bldg. - Lower Level Reflected Ceiling Plan
A-13	Control Bldg. - Upper Level Reflected Ceiling Plan

DRAWING NO.	TITLE
M-1	Control Bldg. - Equipment Schedules
M-2	Control Bldg. - Equipment Schedules
M-3	Control Bldg. - Equipment Schedules
M-4	Control Bldg. - Lower Level Mechanical Plan
M-5	Control Bldg. - Upper Level Mechanical Plan
M-6	Control Bldg. - Mechanical Room East
M-7	Control Bldg. - Mechanical Room West
M-8	Control Bldg. - Details/Schematics
M-9	Control Bldg. - Control Diagrams
P-1	Control Bldg. - Lower Level Plan
P-2	Control Bldg. - Upper Level Plan
P-3	Control Bldg. - Schematics
P-4	Control Bldg. - Sprinklers - Lower Level
P-5	Control Bldg. - Sprinklers - Upper Level
E-1	Control Bldg. - Lower Level Lighting Plan
E-2	Control Bldg. - Upper Level Lighting Plan
E-3	Control Bldg. - Lower Level Power Plan
E-4	Control Bldg. - Upper Level Power Plan
E-5	Control Bldg. - Schedule and Details
S-1	Cafeteria - Foundation and Roof Framing Plans
S-2	Cafeteria - Sections
S-3	Cafeteria - Sections
S-4	Cafeteria - Details
A-1	Cafeteria - Floor Plan
A-2	Cafeteria - Room Finish Schedule
A-3	Cafeteria - Door Schedule, Window Elevations & Details
A-4	Cafeteria - Elevations & Details
A-5	Cafeteria - Wall Sections
A-6	Cafeteria - Wall Sections
A-7	Cafeteria - Kitchen Equipment Layout
A-8	Cafeteria - Reflected Ceiling Plan
M-1	Cafeteria - Mechanical Plan
M-2	Cafeteria - Details
P-1	Cafeteria - Plumbing Plan - Schematics
P-2	Cafeteria - Kitchen Plan
E-1	Cafeteria - Electrical Floor Plans, Lighting & Power
E-2	Cafeteria - Electrical Details
S-1	Visiting Scientists' Quarters - Foundation & Roof Framing Plans
A-1	Visiting Scientists' Quarters - Floor Plans
A-2	Visiting Scientists' Quarters - Door Schedule and Details
A-3	Visiting Scientists' Quarters - Details
A-4	Visiting Scientists' Quarters - Wall Sections

DRAWING NO.	TITLE
M-1	Visiting Scientists' Quarters - Mechanical Plan
P-1	Visiting Scientists' Quarters - Plumbing Plan & Schematics
E-1	Visiting Scientists' Quarters - Electrical Plans, Lighting & Power, Details
S-1	General Maintenance Bldg. - Foundation Plan
S-2	General Maintenance Bldg. - Roof Framing Plan - Tee Schedule
S-3	General Maintenance Bldg. - Sections and Details
S-4	General Maintenance Bldg. - Sections and Details
S-5	General Maintenance Bldg. - Sections and Details
A-1	General Maintenance Bldg. - Floor Plan
A-2	General Maintenance Bldg. - Room Finish Schedule
A-3	General Maintenance Bldg. - Door & Window Schedule & Details
A-4	General Maintenance Bldg. - Elevations
A-5	General Maintenance Bldg. - Wall Sections
A-6	General Maintenance Bldg. - Wall Sections
A-7	General Maintenance Bldg. - Wall Sections & Details
A-8	General Maintenance Bldg. - Wall Sections & Details
A-9	General Maintenance Bldg. - Reflected Ceiling Plan
M-1	General Maintenance Bldg. - Mechanical Plan
M-2	General Maintenance Bldg. - Sections and Details
P-1	General Maintenance Bldg. - Plumbing Plan
P-2	General Maintenance Bldg. - Plumbing Schedule & Schematics
E-1	General Maintenance Bldg. - Electrical Plan, Lighting & Details
E-2	General Maintenance Bldg. - Electrical Plan, Power & Details
C-27	Wye Configuration - Drainage Map
C-28 - 38	Drainage Structure Section Sheets
C-39	Culvert Summary Sheets
C-40 - 42	Road Crossing Sheets
C-43	Embankment - Typical Section Sheet
C-44 - 63	Wye Arms - Plan & Profile Sheets
C-64 - 115	Antenna Station Plan & Grading Sheets
C-116 - 121	Earthwork Mass Sheets
C-122	Misc. Detail Sheets
C-123 - 125	Borrow Pit Sheets
C-126	Fence Detail Sheet
C-127	Construction Warning Signs
C-128 - 147	Wave Guide Plan & Profile Sheets Power Plan & Profile Sheets
C-148	Wave Guide - Plan & Profile - Central Site Bldg.
C-149	Wave Guide - Plan & Profile - Central Site Bldg.
C-150	Wave Guide - Misc. Detail Sheet

DRAWING NO.	TITLE
S-20	Wave Guide - Manhole Detail Sheet
S-21	Antenna Assembly Bldg. - Foundation Plan
S-22	Antenna Assembly Bldg. - Foundation Details
S-23	Antenna Station Foundation Plan - Typical
S-24	Antenna Station Foundation Details - Typical
S-25	Antenna Station Foundation Details - Typical
S-26	Antenna Station Foundation Schedules
S-27	Antenna Station Foundation Schedules
S-28	Antenna Station Foundation Schedules
R-1	Railroad - Central Section Plan
R-2	Railroad - Typical Straight Section
R-3	Railroad - 90° Interchange Plan
R-4	Railroad - Antenna Station Plan
R-5	Railroad - Turnout Plan
R-6	Railroad - Road Crossing Plan
C-157	Railroad - Antenna Assembly Bldg. Plan
C-158 - 160	Railroad - Reserved - Railroad

APPENDIX D - OUTLINE SPECIFICATIONS - TECHNICAL

DIVISION 2 - SITE WORK

SECTION 02102 - CLEARING & GRUBBING

2.01 DESCRIPTION: The work shall consist of clearing, grubbing, scalping, and disposing of vegetation and other matter designated to be removed.

2.03 CONSTRUCTION REQUIREMENTS:

A. The Engineer will establish construction limits and designate all items for removal.

B. All unsightly material shall be removed and disposed of by burying or burning at locations and times approved by the Engineer.

SECTION 02221 - TRENCHING, BACKFILLING & COMPACTING

2.01 WATER AND SEWER LINES: Trench excavation, backfill, and compaction shall conform to Section 550 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico or as specified on the drawings.

SECTION 02222 - EXCAVATION FOR MINOR STRUCTURES

2.01 DESCRIPTION: The work shall consist of the excavation, backfill, and disposal of all materials required for the construction of culverts and other minor structures.

2.03 CONSTRUCTION REQUIREMENTS:

A. Excavation for minor structures shall consist of all material to be removed as shown on the plans or as directed by the Engineer. Suitable surplus material may be used in embankments or backfill with approval of the Engineer.

B. Backfill shall consist of suitable materials placed adjacent to structures and uniformly compacted to 95% of optimum density as determined by AASHO T-180, Method C.

C. Granular backfill shall be defined by gradation and Atterburg Limits.

D. Rock or other unsuitable material shall be removed below design grade to a depth of 12 inches.

E. Culvert bedding shall conform to the Class of Bedding shown on the plans.

F. Footings, where required, shall be placed on excavated surfaces only. Backfill below footings shall be of concrete.

SECTION 02223 - EXCAVATION AND BORROW

2.01 DESCRIPTION: This work shall consist of excavation of material from the roadway or in providing borrow as required and the placement of this material in embankments or as directed by the Engineer.

2.03 CONSTRUCTION REQUIREMENTS:

A. Excavation and borrow areas shall be finished in compliance with the lines and grades on the plans or as established by the Engineer.

B. All excess or unsuitable material shall be disposed of as directed by the Engineer.

C. Borrow shall be obtained from the sources shown on the plans or from sources approved by the Engineer.

D. Embankments shall be constructed in horizontal layers on the prepared subgrade and compacted to the required densities.

E. Moisture and density control shall be monitored to provide adequate compaction as determined by AASHO T-180 Method C and AASHO T-147.

SECTION 02225 - OVERHAUL

2.01 DESCRIPTION: This work shall consist of transporting material obtained as excavation or borrow in excess of a free haul distance of 1320 ft.

SECTION 02244 - SUBGRADE PREPARATION

2.01 DESCRIPTION: This work shall consist of excavating and recompacting of the top surface of the natural ground or embankment to the depths shown on the plans or as directed by the Engineer.

2.03 CONSTRUCTION REQUIREMENTS: The required depth of the subgrade shall be compacted to not less than 95% of maximum density as determined by AASHO T-180 and T-147. The moisture content shall not exceed optimum or be less than 5% of optimum unless directed by the Engineer.

SECTION 02513 - DRAINAGE CULVERTS

2.01 DESCRIPTION: This work shall consist of the construction of culverts in compliance with the specifications, lines, and grades shown on the plans or as established by the Engineer.

2.02 MATERIALS:

A. Corrugated Steel Pipe: Culvert and coupling bands shall conform to AASHO M-36 or if welded to AASHO M-209.

B. Corrugated Aluminum Pipe: Culvert and coupling bands shall conform to AASHO M-196.

C. Reinforced Concrete Pipe: Culvert shall conform to AASHO M-170 for the specified diameters and strength classes. Joints shall be gasketed with joint mortar in compliance with AASHO M-198.

2.03 CONSTRUCTION REQUIREMENTS:

A. Trenches and bedding shall conform to those requirements listed in Excavation for Minor Structures.

B. Culvert shall be laid from the down stream end. Where applicable bell grooved ends shall face upstream, or all laps or seams shall be at the sides of the culvert.

C. Joints shall be closed by gaskets and joint mortar or by coupling bands as may be applicable.

D. Where flexible culvert in excess of 48 in. diameter is used, it shall be field strutted to a vertical diameter increase of 5%.

SECTION 02555 - WATER DISTRIBUTION SYSTEM

2.01 PUMP HOUSE PIPING:

A. Ductile Iron pipe shall conform to AWWA C151-65.

B. Gate valves shall conform to AWWA Standards C500-61 of latest revision.

C. Check valves.

2.02 VACUUM RELEASE VALVE:

2.03 FLOW METER:

2.04 HYDRO PNEUMATIC TANK:

2.05 HYDRO PNEUMATIC TANK CONTROLS:

2.06 COMPRESSOR:

2.07 BOOSTER PUMPS:

2.08 FIRE PUMP:

2.09 FIRE PUMP CONTROLS:

2.10 CHLORINATION (GAS):

2.11 VALVE BOXES:

2.12 GATE VALVE: Shall conform to AWWA C500-61.

2.13 PVC PLASTIC PRESSURE PIPE (1", 4", 6", 8"):

A. Working Pressure 200 psi.

B. Shall conform to applicable requirements of ASTM D-1784, ASTM D-2241, ASTM D-1869 and Commercial Standards CS-256-63.

2.14 FIRE HYDRANTS: AWWA Standard C502-64.

2.15 DUCTILE IRON PIPE (12" and 14"): AWWA C151-65.

SECTION 02580 - WATER WELL

2.01 WATER WELL: Shall conform to AWWA A-100-66 or as specified on the plans.

2.02 CASINGS:

A. Shall have minimum weight and dimensions:

1. 8" (ID) casing; 27.44 lb. per linear foot.

B. Material, fabrication, and joints shall conform to applicable requirements of AWWA C201-66 and C202-64.

2.03 WELL SCREENS:

A. Shall have minimum nominal diameter of 6" ID and a minimum length of 115 ft.

B. Screen shall be of the horizontal louver type or mill slotted pipe of equivalent opening.

C. Openings shall be a minimum of 5.75 square inches of open area per linear foot of screen.

2.04 CEMENT GROUTING: Shall be proportioned of cement and the minimum quantity of water (not over six gallons per cubic foot of cement) required to give a mixture of such consistency that it can be forced through the group pipe.

2.05 WELL EQUIPMENT - PUMP AND CONTROLS:

SECTION 02581 - WATER RESERVOIR

2.01 WELDED STEEL RESERVOIR:

A. 70,000 Gallons.

B. Size: 24' diameter and 23.5' high water line above foundation.

C. To include specified features and shall be constructed as detailed.

D. Design, materials, fabrication, erection, and workmanship shall conform to all requirements of the New Mexico Department of Health and Social Services and AWWA D100-67 and AWWA D102-64.

2.02 SUBGRADE AND EMBANKMENT: Shall be free from large stones, clods, debris and vegetation. Shall be compacted to 90% maximum density (ASTM D1557-70).

2.03 GRANULAR FILL: Crushed rock or screened volcanic cinder, one and one-half inch maximum size. Natural gravel will not be acceptable.

2.04 CONCRETE: Shall conform to Section 101, Portland Cement Concrete of the Uniform Standards Specifications for Public Works Construction Projects, Municipalities and Counties of New Mexico of latest revision. Reinforced concrete 3000 psi.

2.05 REINFORCING STEEL: Shall conform to Section 102, Steel Reinforcement of the Uniform Standard Specifications for Public Works Construction Project, Municipalities and Counties of New Mexico of latest revision.

2.06 STRUCTURAL STEEL: Shall conform to Section 2 of AWWA Standards C500-61 of latest revision.

2.07 All gate valves shall conform to AWWA Standards C500-61 of latest revision.

2.08 GALVANIZED STEEL PIPE: Shall conform to ASTM A120-71 or A53-71a.

2.09 DUCTILE IRON: Shall conform to AWWA C151-65.

SECTION 02590 - SEWAGE LAGOON

2.01 UNCLASSIFIED EXCAVATION: To be constructed to grades and elevations shown on the plans. Lagoon embankments shall be compacted to 90% maximum density (AASHO T-180-61).

2.02 SOIL CEMENT LINING: To be placed as detailed on plans. Cement contend shall be 10% by volume. Soil cement compacted to 90% maximum density (AASHO T-180-61).

2.03 FLOW SPLITTER BOX:

A. To be constructed as detailed on plans.

B. Sluice gates shall conform to AWWA C501-67.

C. Concrete to conform to Section 101 of Uniform Standard Specifications for Public Works Construction for Use of Municipalities and counties in New Mexico. Reinforced Concrete 3000 psi.

D. API Threaded Steel Pipe (4" to 6") ASA Schedule 40.

E. Forged Steel Screwed Fittings.

F. Frame and cover shall conform to Section 162 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico or as specified on drawings.

2.04 PVC PLASTIC GRAVITY SEWER PIPE (6"):

A. Shall conform to all applicable requirements of ASTM D-1784, ASTM D-2412, and ASTM D-2444.

B. Anchor Blocks: Concrete to conform to the Uniform Standards Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico. Reinforced Concrete 3000 psi.

2.05 OVERFLOW STRUCTURE:

A. To be constructed as detailed.

B. 6" welded steel pipe - Schedule 40.

C. Forged Steel Socket - Welding fittings.

D. Seepage collars shall be constructed as detailed.

SECTION 02591 - SEPTIC TANKS AND DRAIN FIELD

2.01 PRECAST REINFORCED CONCRETE SEPTIC TANK: Concrete shall conform to Section 101 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico or as specified on the plans. Reinforced concrete 3000 psi.

2.02 PVC PLASTIC GRAVITY SEWER PIPE (4"): Shall conform to applicable requirements of ASTM D-1784, ASTM D-2412, and ASTM D-2444.

2.03 PVC PLASTIC PERFORATED PIPE (4"): Shall conform to ASTM 2729.

2.04 BUILDING PAPER: Untreated - 30#.

2.05 GRAVEL: 1/2" rounded wash gravel noncalcareous.

2.06 DISTRIBUTION BOX: To be constructed as specified on the plans. Reinforced concrete 3000 psi.

SECTION 02595 - WASTE WATER COLLECTION SYSTEM

2.01 PVC PLASTIC GRAVITY SEWER PIPE (4" AND 8"): Shall conform to applicable requirements of ASTM D-1784, ASTM D-2412, and ASTM D-2444.

2.02 PVC PLASTIC PRESSURE PIPE (4"):

A. Working Pressure 200 psi.

B. Shall conform to applicable requirements of ASTM D-1784, ASTM D-2241, ASTM D-1869, and Commercial Standards CS 256-63.

2.03 MANHOLES: To be constructed as detailed on plans.

A. Sewer manhole brick shall conform to Section 108.1 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico or as detailed on the plans.

B. Cement mortar and grout for brick and concrete block manholes shall conform to Section 510.12 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico or as specified on the drawings.

C. Concrete manholes and concrete block manholes shall conform to Section 512 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico or as detailed on the drawings.

D. Manhole frame, cover and steps shall conform to Section 162 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico or as specified on drawings.

E. Concrete shall conform to Section 101 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico. Reinforced concrete 3000 psi.

2.04 DUCTILE IRON PIPE (10"): Shall conform to AWWA C151-65.

SECTION 02601 - BITUMINOUS MATERIAL

2.02 MATERIALS:

A. Rapid curing cutback asphalt (RC) shall consist of uncracked petroleum asphalt base stock blended with naphtha or gasoline type solvent and shall be within the penetration range of 70 to 150.

B. Medium curing cutback asphalt (MC) shall consist of uncracked petroleum asphalt base stock blended with kerosene-type solvent and shall be within the penetration range of 100 to 300.

C. Slow curing liquid asphalt (SC) shall consist of natural uncracked residual oils which do not volatilize easily.

D. Asphalt cement designated by the penetration range shall be uncracked petroleum asphalts carefully refined from asphaltic base crude petroleum at a temperature less than 700° F.

SECTION 02612 - ROAD MIX BITUMINOUS PAVEMENT

2.01 DESCRIPTION: This work shall consist of constructing one course of road mixed bituminous pavement on a prepared base in substantial compliance with the specifications and typical cross-sections shown on the plans.

2.02 MATERIALS:

A. Road mix bituminous pavement shall be composed of a mixture of bituminous material and aggregate.

B. The bituminous material and aggregate shall meet all requirements of the specifications.

2.03 CONSTRUCTION REQUIREMENTS:

A. The placing and processing of road mix bituminous pavement will not be permitted during wet weather nor when the atmospheric temperature is less than 50 degrees F.

B. The equipment used by the Contractor shall include scarifying, mixing, spreading, finishing and compacting equipment, a bituminous distributor, and bituminous heating equipment.

C. The surface upon which the bituminous pavement is to be placed shall be cleaned of all loose and deleterious material, and free from frozen material.

D. Aggregates shall be uniformly spread on the roadbed by the use of spreader boxes or similar equipment.

E. The bituminous material shall be uniformly distributed in successive applications immediately followed by mixing equipment.

F. After final application of bituminous material, complete mixing by blading will be performed.

G. The Contractor may use any type of equipment to obtain required density without injury to the pavement. Densities will be determined in conformity with AASHO Designation T-166.

H. The finished surface shall not deviate in excess of 1/4 inch in any direction when tested with a 10-foot straightedge.

SECTION 02619 - PRIME COAT

2.01 DESCRIPTION: This work shall consist of providing bituminous material and blotter material, if required, and preparing and treating existing surface with the materials in accordance to plans and specifications.

2.02 MATERIALS: The prime coat shall be composed of bituminous material and blotter material, if required of the type and grade specified in the contract.

2.03 CONSTRUCTION REQUIREMENTS:

A. Bituminous material shall not be applied on a wet surface, nor when the atmospheric temperature is below 50° F., unless otherwise authorized in writing by the Engineer.

B. The equipment used by the Contractor shall include compacting equipment, a pneumatic tired roller, a bituminous distributor, and a heater for bituminous material.

C. The surface to be primed shall be prepared as set forth in the specifications prior to application of prime coat.

D. Bituminous material shall be applied by means of a pressure distributor in a uniform and continuous spread.

E. Blotter material shall be used in quantities as necessary to absorb any excess bituminous material.

SECTION 02620 - PORTLAND CEMENT CONCRETE CURBING

2.01 DESCRIPTION: This work shall consist of the construction of curb as set forth by the plans and specifications.

2.02 MATERIALS:

A. Concrete and manufactured curbing materials will be subject to inspection and tests at the plants for compliance with quality requirements.

B. Concrete curbing shall be placed on an approved foundation of compacted earth.

C. Concrete curbing shall be constructed with concrete conforming to all requirements set forth in these specifications.

D. Preformed expansion joint filler shall conform with requirements of AASHO Designation M-33 or AASHO Designation M-153.

2.03 CONSTRUCTION REQUIREMENTS:

A. When required, excavation shall be made to required depth, and the base upon which the curb is to be set shall be free of soft and unsuitable material and compacted to a firm even surface.

B. Forms will be of wood or metal, straight, free of warp and of such construction that there will be no interference with inspection.

C. Concrete shall be proportioned, mixed and placed in accordance to the plans and specifications.

D. Curbing shall be constructed in sections of uniform length as shown on the plans.

E. Expansion joints shall be formed at the intervals shown on the plans using a preformed expansion joint filler having a thickness of 3/4 inch.

F. Immediately following completion of the finishing the curbing shall be kept moist for three days, or curbing shall be cured using membrane forming material.

G. After the concrete has set, the spaces adjacent to the curb shall be refilled with suitable material, which shall be thoroughly tamped, in layers of not more than six inches.

H. With the approval of the Engineer, the curb may be constructed by the use of a curb forming machine.

SECTION 02630 - PORTLAND CEMENT CONCRETE SIDEWALK 4" THICK

2.01 DESCRIPTION: This work shall consist of the construction of concrete sidewalks in substantial compliance with the specifications and plans or established by the Engineer.

2.02 MATERIALS:

A. Concrete sidewalks shall be constructed of concrete conforming with the provisions of the specifications.

B. Preformed expansion joint filler shall conform with the requirements of AASHO Designation M-33 or AASHO Designation 153.

C. Bed course material for sidewalks shall consist of cinders, sand, slag, gravel, crushed stone or other approved material of such gradation that all particles will pass 1/2-inch sieve.

D. Concrete mixes will be subject to inspection and tests at the mixing plants for compliance with quality requirements.

2.03 CONSTRUCTION REQUIREMENTS:

A. Excavation shall be made as required for installation and proper bracing of forms.

B. Bed course material shall be placed as shown on plans and thoroughly compacted.

C. Forms shall be of wood or metal and extend the full depth of the concrete.

D. Proportioning, mixing and placing of concrete shall be in accordance to requirements for the class of concrete specified.

E. The surface shall be finished with a wooden float.

F. Expansion joints shall be of the dimensions specified, and shall be filled with the type of premoulded expansion joint filler noted.

G. Concrete shall be cured for at least 72 hours by means of membrane, moist burlap, or mats or by other approved methods.

SECTION 02646 - AGGREGATE FOR BASE COURSE & BITUMINOUS PAVING MIXTURES

2.01 DESCRIPTION: The work shall consist of furnishing, hauling, placing, spreading, watering, processing, compacting, and shaping base course aggregate in accordance with plans & specifications.

2.02 MATERIALS:

A. Base course & bituminous paving aggregate shall be composed of materials consisting of crushed stone, crushed or screened gravel, caliche, sand, or a combination of such material.

B. Aggregate shall be free from vegetable matter and all other deleterious materials.

C. The aggregate will be tested in accordance with the following AASHO methods.

1. Mechanical Analysis - AASHO T-27.

2. Passing #200 Sieve - AASHO T-11.

3. Liquid Limit - AASHO T-89.

4. Plasticity Index - AASHO T-90.

5. Los Angeles Abrasion - AASHO T-96.

6. Soundness - AASHO T-104.

7. Linear Shrinkage - Mat'ls. Testing Control Manual (NMSHD)

2.03 CONSTRUCTION REQUIREMENTS:

A. The Contractor shall produce material conforming to all requirements of these specifications.

B. When base course material is produced from designated pits of quarries, all oversize rocks up to and including 10 inches in greatest dimension shall be crushed and mixed with other material.

C. Fifty (50) percent of all plus No. 4 material shall have at least two mechanically fractured faces.

D. The subgrade and subbase upon which the base course is to be placed shall be free from all loose, deleterious and frozen material, with the top 6 inches having a moisture content not exceeding optimum as determined by AASHO Designation T-180, Method C or D.

E. The Contractor will spread and compact the base course in layers which will permit the required density to be obtained, as set forth by AASHO Designations T-180 & T-147.

F. The top of the base course shall not deviate more than 3/8 " when tested with a 10-foot straightedge in any direction.

SECTION 02647 - REHABILITATION OF OLD HWY. 60

2.01 DESCRIPTION: The work shall consist of removing all vegetation and patching existing pavement as needed.

2.02 MATERIALS: Patchwork will be done using a bituminous mix that shall be approved by the Engineer.

2.03 CONSTRUCTION REQUIREMENTS:

A. All vegetation shall be removed from existing pavement.

B. All cracks and chuck holes will be repaired using bituminous hot mix.

SECTION 02648 - REMOVAL FOR SECTION OF HWY. 60

2.01 DESCRIPTION: Work shall consist of removal & disposal of old pavement as shown on plans or designated by the Engineer.

2.03 CONSTRUCTION REQUIREMENTS: Pavement shall be broken up and disposed of as designated by the Engineer.

SECTION 02711 - FENCE

2.01 DESCRIPTION: This work shall consist of the construction of fence and gates in compliance with the lines as shown on the plans or as established by the Engineer.

2.02 MATERIALS:

A. Material Test Certificates, where required, shall be submitted by the Contractor to the Engineer.

B. Barbed wire fence shall conform to ASTM A-121 Class 3 with two strands of 12-1/2 guage wire with 4 point, 14 guage round barbs spaced at 5 inches. Staples shall be galvanized 9 guage, 1-1/2 inches long. Tie wires shall be 12-1/2 gauge and galvanized. Stays shall be not less than 9-1/2 guage galvanized wire.

C. Woven wire fabric shall conform to ASTM-A116, Design No. 832-6-11.

D. Chain link fabric shall conform to AASHO M-181 with 9 guage galvanized wire and a 2 inch mesh.

E. All corner, brace, gate, and line posts shall be metal or wood and of the type, size, and lengths shown on the plans. Metal post shall conform to ASTM A-1, A-499, or A-120, and be galvanized in conformance with ASTM-A-123. Wood posts shall be Southern yellow pine, lodgepole pine, or ponderosa pine, and shall be pressure treated with wood preservatives conforming to AASHO M-133. Cedar or juniper posts may be used with acceptance of the Engineer. Chain link fence shall have tubular or H column posts, galvanized in accordance with ASTM A-120 and with steel to conform to ASTM A-36. All hardware shall conform to ASTM A-153.

F. Gates shall be tubular steel frame with woven wire fabric or chain link fabric as applicable, conforming to the dimensions and type shown on the plans. All materials shall be galvanized.

1.03 CONSTRUCTION REQUIREMENTS:

A. All posts are to be set at the spacing shown on the plans. All chain link fence posts are to be set in concrete. Other posts shall be set in concrete where required by the plans or the Engineer. Concrete shall have a seven day curing period before tension is applied. Posts shall be set to the required depth and alignment. No posts shall be cut off without permission of the Engineer.

B. All wire shall be stretched taut and installed at the proper elevations. Wire will not be stretched by pulling with a motor vehicle.

SECTION 02722 - HIGHWAY WARNING SIGNS AND REFLECTIVE DELINEATOR

2.01 DESCRIPTION: This work shall consist of furnishing and installing delineators and appurtenances in substantial compliance with the specifications and shown on the plans or designated by the Engineer.

2.02 MATERIALS:

A. Posts shall be 7' in length of galvanized rail or billet steel conforming to ASTM Designation A-1 or A-499 or Commercial Standard 184.

B. Posts of aluminum alloy 6061-T6 conforming with requirements of ASTM Designation B-221 may be used in place of steel posts.

C. The reflective delineators shall be acrylic prismatic reflectors housed in 0.020 inch rust proof metal with a center mounting hole.

D. Posts and reflectors shall be inspected for compliance with specifications herein by the Engineer.

2.03 CONSTRUCTION REQUIREMENTS: Delineators shall be installed as shown on the plans in the locations staked by the Engineer.

SECTION 02821 - RESEEDING SLOPES AND DISTURBED AREAS

2.01 DESCRIPTION: This work shall consist of scarifying and reseeding all construction slopes and disturbed areas.

2.02 MATERIALS: The seed used for this item shall be specified on the plans or as directed by these specifications.

2.03 CONSTRUCTION REQUIREMENTS:

A. Seeding shall be accomplished at a time when, in the opinion of the Engineer, germination conditions will be at an optimum. Water shall be applied to the seed bed before preparation and at least once after seeding if the Engineer requests watering to assist germination.

B. Seed shall be applied to the scarified areas in the proportions specified on the plans or in these specifications.

SECTION 02851 - TRACKWORK

2.01 BALLAST

A. Quality Requirements:

1. Deleterious substances shall not be present in prepared ballast in excess of the following amounts:

Soft and flexible pieces	5 percent
Material finer than No. 200 sieve	1 percent
Clay lumps	0.5 percent

2. The maximum allowable percentage of wear is 40 after 500 revolutions, as determined by ASTM Serial Designation C-131, "Method of Test for Abrasion of Course Aggregate by Use of Los Angeles Machine", A grading.

3. The maximum loss permitted is 10 percent weighted average at five cycles when tested for soundness in magnesium sulfate in accordance with ASTM Standard C88. In addition, the right is reserved to perform such other tests as may be considered necessary to determine the acceptability of the ballast.

B. Grading Requirements:

1. The grading of prepared ballast shall be determined by test with laboratory sieves having square openings and conforming with current ASTM Specifications, Designation E11.

2. Crushed stone for prepared ballast shall be Size No. 5 AREA Specifications and conform to the following requirements for grading:

Square Mesh Sieve Size	Percent Passing by Weight	
1 1/2 inches	100	
1 inch	90	100
3/4 inch	40	75
1/2 inch	15	35
3/8 inch	0	15
No. 4	0	5

C. Handling: Prepared ballast shall be handled at the producing plant in such a manner that it is kept clean and free from segregation. It shall be loaded only into cars or trucks which are in good order, tight enough to prevent leakage and waste of materials, and which are clean and free from rubbish or any substance which would foul or damage the ballast.

D. Inspection: The ballast shall be inspected and tested by an approved commercial testing laboratory and results of tests furnished to the Engineer.

2.02 WOOD CROSS TIES, TREATED:

A. General:

1. All wood cross ties shall comply with all applicable requirements of the AREA Manual, Chapter 3. All ties for the interchange areas shall be eight feet six inches (8'-6") in length and AREA No. 5 size. All other ties shall be eight feet zero inches (8'-0") in length and AREA No. 3 size. All woods listed in the AREA Manual are acceptable.

2. All wood cross ties shall be conditioned in accordance with AREA Chapter 17, Part 1, "Plant Practice," adzed, and bored for the tie plates and spikes prior to treatment.

3. Shop drawings showing hole boring layout shall be submitted to the Engineer prior to commencing tie fabrication.

B. Preservative Treatment: Cross ties shall be treated in a retort using the "empty cell" process in accordance with current requirements of Chapter 17, "Wood Preservation" of AREA Manual. The preservative treatment for ties shall conform to one of the following requirements:

1. A solution containing not less than fifty percent (50%) creosote and no more than fifty percent (50%) petroleum by volume with a preservative retention of eight (8) pounds per cubic foot or refusal.

2. A solution containing seventy percent (70%) creosote and thirty percent (30%) coal tar by volume with a preservative retention of seven and one-half (7 1/2) pounds per cubic foot or refusal.

C. Inspection: Ties shall be inspected and certified by an approved commercial testing laboratory that the ties to be used meet the Specifications. Results of tests and inspection shall be furnished to the Engineer.

2.03 SWITCH TIES:

A. General: Switch ties shall be treated oak wood ties conforming to all applicable requirements of AREA Manual, Chapter 3, and shall be the number and lengths as shown on the drawings. Switch ties shall be treated in accordance with ITEM B.2., Preservative Treatment, and inspected in accordance with ITEM B.3.

2.04 RAIL:

A. New 90 Pound Rail: All tracks shall be new section 90 RA-A conforming to current AREA Specifications and shall be control cooled. All rails shall be drilled for use with four (4) hole joint bar in accordance with AREA Manual, Page 4-1-14. All rails shall be No. 2 quality, thirty-nine (39) feet in length, except that up to eleven percent (11%) of the entire order will be acceptable in shorter lengths varying by one (1) foot from twenty-five (25) feet to thirty-eight feet (38).

B. Inspection: Rails shall be inspected by an approved commercial testing laboratory and inspection report shall be furnished to the Engineer.

2.05 JOINT BARS:

A. Joint bars for 90 Pound Rail: Joint bars for 90 pound rail shall be new twenty-four (24) inch, four (4) hole, head free and toeless and shall conform to current AREA specifications for Quenched Carbon Steel Joint Bars, Chapter 4. Joint bars shall be punched with oval and circular holes to match the rail furnished and in accordance with AREA Manual, Page 4-1-14. Joint bars shall be inspected as specified for rails.

2.06 TRACK BOLTS AND NUTS:

A. General: Track bolts shall conform to current AREA specifications for heat treated carbon steel track bolts, rolled thread with medium carbon nuts and wrench turn fit. Track bolts shall be oval neck one (1) inch overthread by five and one-fourth (5 1/4) inches long. Nuts shall be one inch nominal diameter and one inch in thickness.

2.07 SPRING WASHERS:

A. General: Spring washers shall be new and shall be improved Hi-Power nut locks as manufactured by National Lock Washer Company or approved equal to fit track bolts specified in accordance with AREA Chapter 4.

2.08 TRACK SPIKES:

A. General: Track spikes shall be new five-eights (5/8) inch x six (6) inches and shall conform to current AREA "Specifications for Soft Steel Cut Tract Spikes".

2.09 TIE PLUGS:

A. General: Tie plugs shall be new, of the dimensions shown in, and shall conform to the AREA specifications in the current AREA Manual, "Specifications for Tie Plugs". Tie plugs shall be treated to conform to these specifications for cross ties and switch ties.

2.10 TIE PLATES:

A. General: Tie plates shall be new and conform to current AREA Manual, "Specifications for Low-Carbon Steel Tie Plates" copper bearing, or "Specifications for Hot-Worked, High-Carbon Steel Tie Plates". All tie plates are for 90 pound rail and shall conform to AREA Plan No. 1 with Punch A or approved equal.

2.11 RAIL ANCHORS:

A. General: Rail anchors to be new, Improved Fair, as manufactured by Portec, Chicago, Illinois, or Channeloc rail anchor as manufactured by the True Temper Corporation, Cleveland, Ohio, or approved equal.

2.12 SWITCHES:

A. General: Number 6 turnouts shall have eleven (11) foot switches complete as shown on applicable drawings. Number 6 turnout switches shall be 90 pound rail section.

2.13 FROGS:

A. General: Number 6 turnouts shall have bolted rigid number 6 frogs to AREA Plan 322-59. Number 6 frogs shall be of specific 90 pound rail section.

2.14 GUARD RAILS:

A. General: Number 6 turnouts shall have guard rails to AREA plan 520-71.

2.15 SWITCH STANDS:

A. General: For each set of two (2) number 6 turnouts, require one (1) Racor 22 Switch Stand with single red reflectorized target and lamp tip complete with rigid connecting rod.

2.16 ROAD CROSSINGS:

A. General: Road Crossing, complete with hardware (drive spikes) shall be furnished and installed as shown on the applicable drawings.

2.17 CREOSOTE OIL:

A. General: Creosote oil used for saturating field cut surface of cross ties or for any other purpose required by this section, except when otherwise specified, shall comply with the requirements of AREA Specification 17-2-1 for Creosote.

2.18 OIL FOR OILING TRACK FIXTURES:

A. General: Oil for oiling track fixtures shall be Texaco 904 or approved equal.

D. Rail, Joint Bars, and Tie Plates:

1. General. Rail, Joint Bars, and Tie Plates for this project shall be new or approved good quality relay (secondhand) rail meeting the specifications as hereinafter.

2. Relay Rail. Relay rail for all tracks shall be of 85 pounds minimum section and shall have originally conformed to the American Railway Engineering Association, Engineering Division, Association of American Railroad Manual of Recommended Practice, Volume 1, Chapter 4, Rail. Relayer rails shall be free from split or crushed heads, piped or split webs, split or broken bases, or kinks or crooks which will prevent their being spikes to line and gage when layed. Rails shall meet the following requirements:

Weight per Yard (Original) Lb.	85 Minimum
Wear:	
Maximum Top Wear (In.)	3/16
Maximum Side Wear (In.)	5/16
Length:	
90% of lot 30 Ft. and Longer	
10% of lot between 20 Ft. and 30 Ft. Long	
Defects Permitted:	
Headburn (In.)	Maximum 1 1/2" in Diameter Maximum 1/32 Deep
Maximum Lip (In.)	3/32

Top wear shall be measured at the center of the rail. Side wear shall be measured at the side of the head, 5/8 inch below the original top of the rail and shall be total, both sides. Lip is defined as flow of metal from the crown and shall be measured at the side or end or both of the rail.

a. Drilling. All rails of the same section and weight per yard shall be of the same drilling pattern. All holes shall be drilled, not punched or burned. A hole shall not be closer than 1 1/2 inches to the edge of another hole.

b. Length. Rails shall not be joined by welding in order to meet length requirements.

c. Workmanship. Rails shall be free from burrs, fins, and sharp edges.

d. Inspection. Each rail shall be examined as specified below and the presence of one or more defects shall be cause for rejection:

(1) Length of rails not specified.
(2) Rail section and weight not as specified.
(3) Rail bolt holes not as specified.
(4) Rail worn beyond specified limitation.
(5) Rail end defects.
(6) Rail sections not of uniform base width.
(7) Variations in drilling pattern.

(8) Holes perforated by punching or burning.
(9) Head burns larger than specified.
(10) Lip greater than specified.
(11) Hole drilled too close to another hole.
(12) Workmanship not as specified.

3. Joint Bars. All joint bars shall be toeless joint bars to fit the rail section furnished and shall be free from breaks, excessive wear, or rust pitting.

4. Tie Plates. All tie plates shall fit the rail section furnished and shall be free from breaks, excessive wear, or rust pitting. Minimum size of tie plates shall be 7 1/2" x 9".

5. Inspection. All rail, joint bars, and the plates shall be inspected by the Engineer or his authorized representative. The Contractor shall have written approval prior to installing rail joint bars and tie plates.

DIVISION 3 - CONCRETE

SECTION 03200 - CONCRETE REINFORCEMENT

2.01 MATERIALS:

A. Deformed Reinforcing Bars: ASTM A-615, Grade 40 for column ties, beam stirrups. Grade 60 for all other uses.

B. Welded Anchors: ASTM A-615, Grade 40 with carbon content less than or equal to 0.40% and manganese content less than or equal to 1.30%.

C. Prestressing Tendons: ASTM A-416, Grade 270, 3/8 in. and 1/2 in. nominal diameter.

D. Welded Wire Fabric: ASTM A-185, Grade 60.

E. Accessories, Chairs, Etc.: Conform to ACI-315.

SECTION 03310 - CAST IN PLACE CONCRETE

2.01 MATERIALS:

A. Cement: ASTM C-150, Type I; Type IA for air entrained concrete.

B. Coarse Aggregate: ASTM C-33, washed gravel or crushed stone. All aggregate - 3/4".

C. Fine Aggregate: ASTM C-33.

D. Water: Potable.

E. Curing & Hardening: "Demicon" manufactured by Castle Chemical Corporation.

F. Abrasive Compound: "Aquabar" non-slip aggregate manufactured by Castle Chemical Corporation.

G. Expansion Joints:

1. Interior: 30# asphalt impregnated felt where indicated.

2. Exterior: 1/2 in. asphalt impregnated resilient fiber where indicated.

H. Construction Joints within Slabs: 14 gage galvanized metal as detailed.

2.02 MIXES:

A. Design mixes on basis of water-cement ratio for specified cured strength @ 28 days.

1. Footings, except antenna piers and transporter jacking pads; slabs; other not included below: 3,000 p.s.i.

2. Columns; beams, including grade beams; walls; antenna piers; transporter jacking pads: 4,000 p.s.i.

B. Entrained Air Content: 4-6% in all exterior flat work and curbs.

SECTION 03351 - CAST IN PLACE EXPOSED AGGREGATE CONCRETE

2.01 MATERIALS:

A. Concrete as specified in Section 03310 with following additions:

1. Aggregates:

a. Material: Natural Gravel.

b. Gradation: 1/2 - 1/4 in.

2.02 MIXES:

A. Procedures same as for cast-in-place concrete, Section 03310.

B. 28 day compressive strength: 3,000 psi minimum.

C. Slump: 3 in. maximum.

D. Entrained Air Content: 4% minimum; 6% maximum.

SECTION 03372 - NON-SHRINK NON-CORROSIVE AGGREGATE GROUT

2.01 MATERIALS: Five Star Grout manufactured by U. S. Grout Corporation.

SECTION 03410 - PRECAST CONCRETE PANELS

2.01 MATERIALS:

A. Cement: ASTM C-150, Type I or IA.

B. Nonexposed Coarse Aggregate: ASTM C-33, washed gravel or crushed stone, maximum size 3/4 in.

C. Fine Aggregate: ASTM C-33.

D. Exposed Aggregate: To be selected by the Engineer.

E. Ready Mix Concrete: ASTM C-94.

2.02 MIXES: Design mixes on basis of water-cement ratio to achieve a 28 day cylinder strength of 5000 psi.

SECTION 03431 - PRECAST PRESTRESSED CONCRETE

2.01 MATERIALS:

A. Cement: ASTM C-150, Type I.

B. Coarse Aggregate: ASTM C-33, washed gravel or crushed stone, maximum size 3/4 in.

C. Fine Aggregate: ASTM C-33.

D. Water: Potable.

E. Ready Mix Concrete: ASTM C-94.

2.02 MIXES: Design mixes on basis of water-cement ratio to achieve a 28 day cylinder strength of 5,000 psi.

DIVISION 4 - MASONRY

SECTION 04100 - MORTAR & GROUT

2.01 MORTAR: Shall conform to ASTM C-270, Type S, minimum compressive strength 1,800 P.S.I. at 28 days.

2.02 GROUT: Shall conform to ASTM C-476, minimum compressive strength 2,000 P.S.I. at 28 days.

2.03 MORTAR COLORING: True tone mortar colors achieved by fine mineral oxides.

SECTION 04150 - MASONRY ACCESSORIES

2.01 JOINT REINFORCEMENT: ASTM A-82, standard weight truss or ladder design with No. 9 cross and side or truss rods, uncoated finish.

2.02 STEEL REINFORCING: ASTM A-615, Grade 40 Billet Bars.

2.03 CONTROL JOINTS: Solid rubber in widths required and of standard design as located and detailed on plans.

2.04 ANCHORS AND TIES:

A. Dovetail Anchors: 16 ga. galvanized iron to mate with embedded slots or inserts.

B. "Z" Anchors: 3/16 in. diameter, zinc coated steel, ASTM A-153 Class B1, B2, or B3, 3 in. shorter than width of wall with legs minimum of 2 in. long.

C. Wall Ties: 22 ga. corrugated galvanized iron.

SECTION 04200 - UNIT MASONRY

2.01 CONCRETE MASONRY UNIT:

A. Hollow Load Bearing Units:

1. Slump Block: ASTM C90-70, Type 1, Grade N, nominal face dimensions 4 in. x 16 in. Color: Adobe.

2. Standard Concrete Block: ASTM C90-70, Type 1, Grade N, Nominal face dimensions - 8 in. x 16 in.

B. Hollow Nonload-Bearing Units:

1. Slump Block: ASTM C 129-64 Type 1, Nominal face dimensions - 4 in. x 16 in.

2. Standard Concrete Block: ASTM C 129-64, Type 1, Nominal face dimensions - 8in. x 16 in.

DIVISION 5 - METALS

SECTION 05120 - STRUCTURAL METAL

2.01 STRUCTURAL STEEL: ASTM A-36.

2.02 STEEL PIPE: Fed. Spec. WW-P-406, Type I, Class A.

2.03 BOLTS: ASTM A-307.

2.04 STAIRS: Steel stringers, metal pan treads and landings with concrete fill.

SECTION 05400 - LIGHT METAL FABRICATION

2.01 STEEL: ASTM A-36.

2.02 WROUGHT IRON: ASTM A-41 for bolts, rods & bars, A-42 for plates and A-162 for sheets.

2.03 BOLTS, NUTS, STUDS AND RIVETS: Fed. Spec. FF-13-571.

2.04 GALVANIZED IRON AND STEEL: Fed. Spec. QQ-5-775a, Class D.

1. Corrugated Metal Decking.

SECTION 05500 - MISCELLANEOUS METAL

2.01 ROUGH HARDWARE: Bolts, anchors, expansion bolts, toggle bolts, strap anchors, etc. required for all work other than those furnished by other trades for installation of their material.

2.02 MISCELLANEOUS STEEL ITEMS: Threshold anchor bars, shelf and clip angles, door frame stiffeners, tubular gate, guard rails, pipe guard rails, ladders, corner guard angles, channel rain trough and all other miscellaneous metal items detailed or implied from drawing or methods of construction.

DIVISION 6 - CARPENTRY

SECTION 06100 - ROUGH CARPENTRY

2.01 ROUGH LUMBER: Construction grade Douglas Fir; maximum moisture content - 19%.

2.02 ROUGH HARDWARE: Nails, Bolts, Screws, etc. Provide as required.

SECTION 06200 - FINISH CARPENTRY

2.01 LUMBER:

A. Softwood Trim: C-Select - Ponderosa Pine.

B. Hardwood Trim: FAS - Black Willow.

C. Plywood: Grade A - White Birch.

2.02 MISCELLANEOUS WOOD SHELVING: Nominal 1 in. material, Ponderosa Pine or 3/4 in. Grade A-B, Fir Plywood.

SECTION 06400 - ARCHITECTURAL WOODWORK

2.01 CABINET WORK:

A. Solid Material: 1 in. nominal thickness C-Select Ponderosa Pine or FAS White Birch were hardwood is indicated.

B. Plywood: Paint Grade Birch or Gum, Grade A White Birch where hardwood is indicated.

C. Laminated Plastic: 1/16 in. thick, textured finish and solid colors.

2.02 WOOD WALL TREATMENT: FAS Black Willow Hardwood.

2.03 CHAIR RAIL: FAS Black Willow.

DIVISION 7 - MOISTURE PROTECTION

SECTION 07100 - WATERPROOFING

2.01 WATERPROOFING MEMBRANE: Under all ceramic tile & quarry tile setting beds, on all sub-slabs on grade and on all walls against earth.

A. Elastomeric Sheet: Rubberized asphalt integrally bonded to polyethylene sheet, minimum thickness - .060 in.

B. Install on horizontal and vertical surfaces.

SECTION 07150 - DAMPPROOFING

2.01 WATER REPELLANT COATING: Chemstop regular masonry waterproofing, manufactured by Chemstop Manufacturing Corporation, Burbank, Calif.

SECTION 07200 - BUILDING INSULATION

2.01 BATT INSULATION: Non-combustible, fiberglas foiled faced, full thickness unless otherwise noted on plans.

2.02 MASONRY FILL INSULATION: Zonolite vermiculite water repellent masonry fill.

SECTION 07400 - PREFORMED METAL SIDING

2.01 MECHANICAL EQUIPMENT SCREEN: Prefinished heavy duty corruform on metal frame work as detailed on plans.

SECTION 07510 - BUILT-UP BITUMINOUS ROOFING

2.01 ROOFING SYSTEM: U.L. Inc. Class A roof, GAF Specifications 230-G.

A. Base Sheet: GAF Universal base sheet (1 ply).

B. Felts: GAF Strata-Ply 30 roofing felt (2 plies)

C. Bitumen: GAF special roofing bitumen, for top coating.

D. Nails: Zonotite nails as recommended by supplier of insulating concrete.

E. Surfacing: Clean roofing gravel, approximately 3/8 in. size. 100% passing 1/2 in. mesh, 30 to 50% passing No. 4 mesh and no greater than 5% passing No. 16 mesh.

F. Plastic Cement: GAF Flashtite cement.

G. Plastic Flashing: GAF T/NA 200 flashing (white).

SECTION 07570 - TRAFFIC TOPPING

2.01 WALKWAY SYSTEM:

A. Primer: Scotch-Clad brand primers.

B. Liquid Coating Material: Scotch-Clad brand deck coating - Gray in color.

C. Integral Aggregate: 3M Brand 20-24 silicon carbide aggregate.

SECTION 07600 - FLASHING AND SHEET METAL

2.01 SHEET METAL REGLETS: By Lane-Aire Manufacturing Company - .020 aluminum.

2.02 SHEETMETAL COUNTER FLASHING: By Lane-Aire Manufacturing Co. for use with reglets - .020 aluminum.

2.03 PITCH PANS, STACK VENTS AND MISCELLANEOUS FLASHING: .032 aluminum.

A. Provide 6 in. sheetmetal stack vents in all roofing over insulating concrete fill, one per every 500 square feet of roof area.

SECTION 07800 - ROOF ACCESSORIES

2.01 ROOF HATCH: Type S, 2'-6" x 3'-0", steel with prime coat, as manufactured by Bilco Company.

SECTION 07951 - SEALANTS AND CALKING

2.01 SEALANT: One component polysulfide base synthetic rubber sealant, Pecora Synthacaulk GC-9. Color selected by Architect.

2.02 PRIMER: Non-staining, manufactured by, and installed as recommended by sealant manufacturer.

2.03 JOINT BACKING MATERIAL: Neoprene, rubber or polyurethane strips, tubing or foam.

DIVISION 8 - DOORS & WINDOWS

SECTION 08100 - HOLLOW METAL DOORS AND FRAMES

2.01 FABRICATION:

A. Doors: Of type, design and sizes indicated on drawings. Constructed of finest quality cold-rolled steel. Two face plates made of formed-up sheets, not less than 16 guage, reinforced with continuous interlocking channel stiffeners, full height of door, and spaced 8" apart. Doors sound deadened with rock wool batts, asbestos, cork or equal sound deadening material, packed-in solidly between interlocking vertical members.

B. Frames: Cold rolled steel, 14 guage, mitred at head and jambs, welded continuously and ground smooth.

2.02 PREPARATION FOR HARDWARE:

A. Doors and frames factory mortised, reinforced, drilled and tapped to conform with templates furnished by hardware supplier.

B. Provide 1/4 in. x 1-1/2 in. x 11 in. joggled hinge reinforcing, 11 guage lock and strike reinforcing and 14 guage surface closer and trim reinforcing.

2.03 ANCHORS:

A. Three standard "T" anchors per jamb for masonry walls and four 10 guage, "Z"-shaped anchors for frames in stud partitions.

B. Furnish angle clip at bottom of each jamb for anchorage to floor with 2 ramset anchors into concrete through each clip.

C. Provide U.L. Inc., approved anchors at labeled doors and frames.

SECTION 08112 - CUSTOM HOLLOW METAL WORK

2.01 DOOR, WINDOW AND SIDE LITE FRAMES: Cold rolled steel, 14 guage for door frames, 16 guage for all others - with integral rebates. Mitered at head & jambs, weld continuously & ground smooth. Glazing stops shall be 1/2 in. x 5/8 in. steel channels.

SECTION 08210 - WOOD DOORS

2.01 FABRICATION:

A. Door manufactured by Weyerhauser or U.S. Plywood of types and sizes indicated on the drawings.

B. Provide all doors with CS 171-58 good grade rotary birch face veneer with hardwood edge strips. All glass lights shall be framed with Anemostat-West FGS 75 metal frame.

1. Fire Doors: Weyerhauser DFM-90 (B-Label, 1-1/2 hour). Cores shall be incombustible mineral-asbestos. Temperature rise shall not exceed 450° F., compliance shall be indicated on the U.L. Inc., label.

2. All Other Wood Doors: Weyerhauser DPC-1, solid wood flake core, identified with gold-red-gold dowel.

SECTION 08300 - SPECIAL DOORS

2.01 ROLL-UP STEEL DOORS: As manufactured by Walter Balfour & Co., Inc., of sizes indicated on drawings. Composed of galvanized steel flat slat curtain, angle roller guides, counter balanced, motor operated & face of wall mounted with hood.

2.02 ROLL-UP COUNTER DOOR: As manufactured by Walter Balfour & Co., Inc., Pygmee type, of size indicated on drawings, aluminum frame complete with standard concealed sliding bolt deadlock, extruded aluminum curtain slats and hood, face mounted.

2.03 SLIDING GLASS DOORS: Aluminum Series 890 as manufactured by the Kawneer Company. All members shall be extruded aluminum with a finish selected by the Architect.

2.04 ACCESS DOORS: Furnish in sizes indicated on drawings.

A. Wall Type: Milcor Style M, steel prime coat. Keyed cylinder lock.

SECTION 08400 - ENTRANCES AND STORE FRONTS

2.01 All aluminum sections 6063-75 extruded aluminum alloy. #40 dark bronze permanodic finish.

2.02 Framing members to be Kawneer Tri-Fab narrow line "450" series, shear block method. Member sizes 1-3/4" x 4-1/2". Pocket design for flush glazing with Neoprene gaskets.

SECTION 08500 - WINDOWS

2.01 HOLLOW METAL: Cold rolled steel, 16 guage with integral rebates, mitered head & jambs, welded continuously and ground smooth.

2.02 ALUMINUM: All sections including sill and accessories, shall be 6063 extruded aluminum.

A. Framing members to be Kawneer Tri-Fab narrow line "450" series, Pocket design for flush glazing with neoprene gaskets.

SECTION 08710 - FINISH HARDWARE

2.01 HINGES: All doors shall have a minimum of 1-1/2 pair butts, steel.

2.02 KICK PLATES AND ARMOR PLATES: 16 ga. metal, secured by oval head screws finished to match.

A. Kick Plates: 8 in. high and 2 in. less than door width.

B. Armor Plates: 36 in. high and 2 in. less than door width.

2.03 LOCK SETS: 5 in. back set and 3/4 in. throw required on all exterior doors - Sargent Tyler Design.

2.04 CLOSERS: On all exterior doors except dormitory doors, interior U.L. labeled doors, toilet room doors & other doors specifically scheduled. Sargent Powerglide.

2.05 CABINET HARDWARE: Stanley.

SECTION 08730 - WEATHER STRIPPING

2.01 THRESHOLDS:

A. Metal - 3/4 in. Skuff-Guard.

B. Aluminum - Kawneer, of extruded aluminum.

2.02 WEATHERSTRIPPING: Pemko No. 303A extruded aluminum with vinyl insert.

SECTION 08800 - GLASS AND GLAZING

2.01 WIRE GLASS: LOF, 1/4 in. cross weld, polished.

2.02 PLATE GLASS: LOF, 1/4 in. Parallel-O-Plate.

2.03 TINTED TEMPERED GLASS: LOF, 1/4 in. Tuf-Flex, Bronze Tint.

2.04 TINTED GLASS: LOF, 1/4 in. Parallel-O-Bronze.

2.05 COATED GLASS: Solar Control Products, Solar-x. Bronze film applied to exterior wire glass.

SECTION 08900 - WINDOW WALLS

2.01 HOLLOW METAL: Cold rolled steel, 16 guage with integral rebates, mitred at head and jambs, welded continuously and ground smooth.

2.02 ALUMINUM: All aluminum sections, including sill section and accessories, shall be 6063 extruded aluminum.

A. Framing members to be Kawneer Tri-Fab narrow line "450" series, Pocket design for flush glazing with Neoprene gaskets.

DIVISION 9 - FINISHES

SECTION 09110 - FURRING AND LATHING

2.01 METAL LATH: 3.4 #/Sq. Yd. flat expanded and painted for all interior work and 3.4 #/Sq. Yd. galvanized self-furring for all exterior work - U.S. Gypsum Co.

2.02 CHANNELS: 1-1/2 in. C.R. at .500 #/Ft. for runners; 3/4 in. C.R. at .300 #/Ft. for cross furring or standard metal furring channels by U.S. Gypsum Co.

2.03 HANGERS: No. 8 guage galvanized wire.

2.04 TIE WIRE: 18 guage soft annealed galvanized wire for tieing metal lath, 16 guage required for attaching furring channels to runner.

2.05 METAL TRIM ACCESSORIES:

A. Base Screed: USG 6A.

B. Casing Beads: USG 66

C. Corner Beads: USG 1A or 10A, as applicable.

D. Control Joint: USG No. 75 for exterior stucco.

2.06 GYPSUM SHEATHING: 1/2 in. Firecode Sheathing.

SECTION 09160 - PLASTER AND STUCCO

2.01 MATERIALS:

A. Sand: Clean plastering sand conforming to ASTM C-35.

B. Base Coat Plaster: USG red top wood fiber plastic.

C. Finish Coat Plaster: USG structo-guage.

D. Lime: USG ivory for plaster and USG Morta-seal for stucco.

E. Stucco: USG oriental exterior stucco.

2.02 PLASTER MIXES:

A. Scratch Coat on Metal Lath: 2 cubic feet sand to 100 lbs. neat wood fiber gypsum base coat plaster.

B. Brown Coat: 3 cubic feet sand to 100 lbs. neat wood fiber gypsum base coat plaster.

C. Base Coat on Masonry: 3 cubic feet sand to 100 lbs neat wood fiber gypsum base coat plaster.

D. Finish Coat: For all plaster, 1 part USG Structo-guage mixed with 2 parts (by dry weight) lime.

2.03 STUCCO MIX:

A. Scratch Coat: One sack Portland Cement, 2 sacks Mortaseal, 2-1/2 cubic feet sand and 2 lbs of fiber.

B. Brown Coat: One sack Portland Cement, 2 sacks Mortaseal and 9 cubic feet sand.

C. Finish Coat: USG Oriental Exterior Stucco-neat.

SECTION 09250 - GYPSUM WALLBOARD

2.01 DRYWALL FURRING CHANNELS: U.S.G. metal furring channels for all ceiling gypsum board and wall furring.

2.02 TIE WIRE: 16 guage soft annealed galvanized wire for attaching drywall furring channels to runners.

2.03 STUDS: U.S.G. 25 guage metal studs (3-5/8 in. unless otherwise indicated).

2.04 FLOOR AND CEILING RUNNERS: USG 25 guage metal runners; Electro-galvanized steel.

2.05 GYPSUM BOARD: 48 in. wide and in lengths as required.

A. 5/8 in. Sheet Rock S.W. Firecode: For first and finish layer in double layer, staggered joint, 2-hour installation, and for all single layer installations.

B. 5/8 in. Sheet W/R Gypsum Wallboard: Use as base for applied tile wall surfacing.

C. 1/2 in. Smooth Wall Sheetrock: For exposed ceiling surfaces.

2.06 METAL TRIM: Perf-A-Bead for all exterior corners; 200-A at intersecting dissimilar walls.

2.07 FASTENERS: USG, 1 in. or as required, Type 5.

2.08 INSULATION: USG Thermafiber sound attenuation blankets - 1-1/2 in. x 16 in. x 48 in.

2.09 CAULKING: Presstite 579.64.

SECTION 09300 - TILE WORK

2.01 FLOOR TILE:

A. Ceramic Tile: Unglazed, dust-pressed, porcelain type ceramic moisaics, all-purpose edged, standard grade - size 2 in. x 2 in. complete with all trim shapes as required.

B. Quarry Tile: Shall be of standard grade quality and manufactured by the extrusion process, ground to size (6 in. x 6 in. x 1/2 in.) after firing and shall conform to requirements of ANSI (USAS) A 137.1 - 1967, complete with all trim shapes as required.

1. Base Units shall be cove, square top.

2.02 WALL TILE:

A. Ceramic Tile: Unglazed, dust-pressed, porcelain type ceramic mosaics, all purpose edged, standard grade, size 1 in. x 1 in. complete with all trim shapes as required.

2.03 SETTING BED: Portland Cement, ASTM C-105, Type I on clean, well graded from fine to coarse sand.

2.04 GROUT: Hydroment ceramic tile grout as manufactured by the Upco Co. - Gray color.

2.05 WALL PRIMER: Product of and as recommended by Miracle Adhesive Corporation.

2.06 ADHESIVE FOR WALL TILE: Miracle Adhesive, MA-200 "Golden Stripe".

SECTION 09500 - ACOUSTICAL TREATMENT

2.01 CEILING SUSPENSION SYSTEM: DV exposed grid system as manufactured by Donn Products, Inc. consisting of main tee and cross tees and No. 12 guage galvanized wire hangers. Components fabricated from commercial quality cold rolled steel, electro-zinc coated and pre-painted.

2.02 CEILING TILE:

A. Acoustical Tile: 24 in. x 48 in. x 5/8 in. U.S. Gypsum, Auratone firecode, fissured design.

2.03 GYPSUM BOARD PANELS: 24 in. x 48 in. x 5/8 in. U.S.G. Firecode gypsum panels with 2 hour U.L. label rating.

2.04 WALL TREATMENT: Fibreglas, by Owens-Corning, 48 in. x 96 in. x 1 in. nubby, glass cloth, square edged, non-combustible with flame spread of 25 or less.

SECTION 09650 - RESILIENT FLOORING

2.01 VINYL-ASBESTOS: 1/8 in. guage, 12 in. x 12 in. thru-chip tile. Armstrong, excelon, imperial modern.

2.02 VINYL BASE: Kentile vinyl wall base, 4 in. straight.

2.03 SAFETY STAIR TREADS: R.C. Musson No. 625 molded rubber with integral square nosing.

2.04 EDGE STRIPS: Tapered hard black phenolic composition strips.

2.05 ADHESIVES AND PRIMERS: Types recommended by manufacturer for each item specified.

SECTION 09680 - CARPETING

2.01 CARPETING: All carpeting shall be 3 ply stock dyed Antron II yarn, with minimum characteristics as follows:

A. Pitch or Guage: 1/8 in.

B. Stiches per Inch: 28 per 3 inches.

C. Pile Height: 1/4 in. - 3/8 in.

D. Face Weight: 30 oz. per square yard.

E. Latex Weight: 25 oz. per square yard.

F. Primary Backing: 4 oz. polypropylene.

G. Total Weight: 59 oz. per square yard.

H. Yarn: 3 ply, alternate loop.

I. Texture: Level Loop.

J. Adhesives: Waterproof cements as recommended by carpet manufacturer.

SECTION 09900 - PAINTING

2.01 MATERIALS: All materials to be delivered and stored in manufacturer's original containers with labels intact and seals unbroken.

2.02 PAINT SCHEDULE:

A. Exterior:

1. Steel, iron and sheet metal - one coat red oxide primer two coats all-purpose enamel (3 coats on metal doors & frames).

2. Concrete (vertical surfaces) - two coats flat latex.

B. Interior:

1. Steel, iron and sheet metal (including metal doors, windows, frames and trim) - one coat metal primer two coats semi-gloss enamel.

2. Concrete block - one coat block filler, two coats satin enamel.

3. Concrete Walls - one coat primer sealer, two coats satin enamel.

4. Gypsum Board:

a.) Toilet rooms - one coat primer sealer, two coats satin enamel.

b.) All other - one coat primer sealer, two coats alkyd flat.

5. Plaster - one coat primer sealer, two coats epoxy coating semi-gloss.

6. Wood:

a.) Hardwood (includes wood doors, wood chair rails & wood wall facing) - one coat sealer, two coats Vel-sheen varnish.

b.) Softwood, plywood & hardboard (including cabinet interiors) - one coat primer sealer, two coats enamel semi-gloss.

SECTION 09950 - WALL COVERING

2.01 VINYL WALL COVERING: Grass cloth weighing not less than 16 ounces per square yard. Flame spread rating shall be 20 or less.

DIVISION 10 - SPECIALTIES

SECTION 10100 - CHALKBOARD AND TACKBOARD

2.01 TO BE DETERMINED BY OWNER AT FUTURE DATE:

SECTION 10162 - TOILET COMPARTMENTS

2.01 TOILET PARTITIONS: Pre fabricated metal, floor mounted, overhead braced, including all hardware.

2.02 URINAL SCREENS: Pre-fabricated metal, flush type, wall hung.

SECTION 10170 - SHOWER AND DRESSING COMPARTMENT

2.01 SHOWER COMPARTMENT: Pre-fabricated fiber-glass pan & wall construction.

SECTION 10260 - WALL AND CORNER GUARDS

2.01 STAINLESS STEEL CORNER GUARDS: 16 ga., type 302, No. 4 finish with hemmed edges, apply with epoxy adhesives.

2.02 STEEL CORNER GUARD ANGLES: ASTM A-36 - clean, new stock.

SECTION 10270 - ACCESS FLOORING

2.01 Removable (24 in. x 24 in.) panels mounted on adjustable pedestals to form an under floor approximately 20 in. high.

2.02 The access flooring shall support a uniform live load of 250 lbs. per sq. ft. with a deflection of not more than 0.04 inches.

2.03 The wearing surfaces of the panels shall be factory applied vinyl asbestos tile.

SECTION 10350 - FLAGPOLE

2.01 Cone tapered aluminum, complete with all fittings, ground set, standard type, 30 ft. exposed height above ground by 33 ft. total length.

2.02 Pole shall be machine-made of 6063-T6 seamless extruded aluminum, wall thickness throughout of not less than .188 in. and shall have a uniform taper throughout. Outside butt diameter shall be 6 in., tapered portion 13'-9", outside top diameter 3-1/2 in.

SECTION 10400 - IDENTIFYING DEVICES

2.01 TO BE DETERMINED BY OWNER AT FUTURE DATE.

SECTION 10600 - PARTITIONS

2.01 FOLDING PARTITION: Factory prefinished wood panels complete with track and hangers. Two single partitions with end posts joining in the center of the opening.

SECTION 10670 - STORAGE SHELVING

2.01 TO BE DETERMINED BY OWNER AT FUTURE DATE.

SECTION 10800 - TOILET AND MISCELLANEOUS ACCESSORIES

2.01 ACCESSORIES:

A. Toilet Tissue Holders: Furnish one for each water closet - stainless steel finish.

B. Paper Towel Dispenser & Waste Receptacle Combination: As located on drawings, semi-recessed - satin stainless steel finish.

C. Paper Towel Dispenser: Surface mounted, enamel finish, located in kitchen.

D. Mirror 16 in. x 24 in. : - satin stainless steel frame with vandel-proof mounting. Install where indicated on drawings.

E. Mirror 60 in. x 24 in. : satin stainless steel frame, install where indicated on drawings.

F. Soap Dispensers: Stainless steel finish, install one unit at each lavatory - except in dormitory units.

G. Soap Dishes: Chrome plated - one at each lavatory in dormitory units.

H. Towel Bars: Chrome plated - one for each lavatory in dormitory units.

I. Mop & Broom Holder: Provide one unit in each janitors room.

J. Coat Rack: Wall mounted - install where indicated on drawings.

DIVISION 11 - EQUIPMENT

SECTION 11061 - PNEUMATIC EJECTOR

2.01 PNEUMATIC EJECTOR PACKAGE LIFT STATION:

A. Two ejectors with pumping rate of 50 gpm each.

B. 40' total dynamic head.

C. Air storage tank with piston compressors.

D. Two receivers 50 gallons each.

E. Intake elevation at 58.02.

F. Discharge elevation at 63.77.

G. 4" Intake and discharge lines.

2.02 CONCRETE: Shall conform to Section 101 of the Uniform Standard Specifications for Public Works Construction for Use of Municipalities and Counties in New Mexico.

SECTION 11400 - FOOD SERVICE EQUIPMENT

2.01 All equipment shall be new and in first class operating condition and appearance, heavy duty commercial type and fabricated to best standards of industry.

2.02 Equipment shall be as drawn and scheduled on kitchen equipment drawing, specific equipment manufacturers numbers will be specified under Title II Specifications.

SECTION 11630 - LAUNDRY EQUIPMENT

2.01 TO BE DETERMINED BY OWNER FOR TITLE II SUBMITTAL.

SECTION 11875 - DOCK BUMPERS

2.01 4-1/2 in. thick, tire tread laminated type, reinforced with 3/4 in. diameter steel rods running full length of bumper and closed with two 3 in. x 2-1/2 in. x 1/4 in angles.

DIVISION 12 - FURNISHINGS

SECTION 12330 - METAL CASEWORK

2.01 All metal casework shall be fabricated of cold rolled prime furniture steel and shall be of factory finished, welded steel construction.

2.02 FINISHES: All surfaces sprayed with one coat of polymer type baking primer and a finish coat of high-temperature baked enamel.

2.03 COUNTER TOPS: Shall be 1/16 in. laminated plastic bonded to water-resistant, resin sealed particle board.

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13700 - SPECIAL PURPOSE ROOMS

2.01 RADIO FREQUENCY SHIELDING: A pre-fabricated single shielded, modular panel enclosure with panel to panel bolted connections to provide positive shielding. Walls, floor & roof.

2.02 Digital equipment shielding shall be 24 ga. sheet steel.

2.03 Computer Room & Control Room shall be hot dipped galvanized standard hardware cloth.

DIVISION 14 - CONVEYING SYSTEMS

SECTION 14200 - ELEVATORS

2.01 The freight elevator shall be hydraulicly lifted with a load capacity of 2,500 pounds, and shall travel to a speed of 50 feet per minute with a constant potential at controller of 480 V, 3 phase, 60 cycles current.

2.02 The car shall travel from first to second level, approximately 16'-0" stopping at two landings and serving two openings in line.

A. Car Platform Size: Approximately 5'-4" x 7'-0".

B. Doors: Center opening 5'-0" x 7'-0" baked enamel.

2.03 HYDRAULIC JACK: Plunger of polished steel tubing with stop plate welded to bottom. Steel cylinder casing.

2.04 All pertinent equipment, controls, etc. to be furnished by elevator contractor.

DIVISION 15 - MECHANICAL

SECTION 15010 - GENERAL PROVISIONS

PART 1 - GENERAL

1.01 SCOPE: Refer to DIVISION 1 - GENERAL REQUIREMENTS, SCOPE OF WORK and CONTRACT SPECIFICATIONS AND DRAWINGS.

1.02 REQUIREMENTS OF REGULATORY AGENCIES:

A. The mechanical work shall be performed in strict accordance with the applicable provisions of the Standard Plumbing Code and Gas Ordinances of the State of New Mexico, and the National Fire Protection Association regulations regarding fire protection. The Contractor shall hold and save the Owner free and harmless from liability of any nature or kind arising from his failure to comply with codes and ordinances.

B. Permits necessary for the prosecution of the work under this Contract shall be secured and paid for by the Contractor.

1.03 ELECTRICAL SERVICES:

A. Motors: Provide and install all motors as manufactured by General Electric, Reliance Motor Co., Louis Allis, or approved equal. Each motor shall be of the horsepower specified and suitable for use at an altitude of 7,000 feet. Motors for V-belt drives shall be provided with NEMA cast-iron or steel base, with slide rail and adjustable screw device. The Contractor shall line up motors and drives and place motors and equipment on foundations ready for operation.

B. Electrical Control Equipment: The Mechanical Contractor must refer to the electrical control equipment and wiring shown on the electrical drawings.

1.04 ELECTRICAL SYSTEM CONTROLS:

A. Requirements: All disconnect means, motor controllers, and all electrical control, protective, and signal devices for equipment furnished under Division 15 of these specifications will be furnished, installed, and connected under Division 16 with the following exceptions.

1. Items scheduled, noted, or shown on the drawings or in the specifications to be furnished under Division 15.

2. Apparatus furnished with, mounted on and connected integral with equipment furnished under Division 15.

3. If the substitution of equipment, devices, or systems furnished under this division result in changes, to the con-

tract drawings, specifications and/or changes to the installation requirements not covered by contract change orders, the complete responsibility and costs shall be assigned to the section of these specifications under which the equipment is furnished.

4. Electrical items not shown on the electrical drawings but which are required for equipment furnished under Division 15 of this specification shall be furnished under the section of this specification under which the equipment is furnished, and shall be installed and electrically connected under Division 16.

B. Submittals:

1. Submittal data for each individual electrically operated or electrically controlled item of equipment or device furnished under this division of these specifications shall include complete electrical wiring diagrams and elementary control diagrams (ladder form) showing all internal and external wiring connections and services. The submittal data shall itemize all electrical characteristics that are of a special nature or critical to the electrical installation or control system. Such equipment and devices will not be considered for approval until these requirements are met.

C. Revised Drawings: After the Architect has approved the marked copy of the control diagrams submitted by the Prime Contractor the contract drawings will be revised and the Contractor will be issued ten revised prints. The revised control diagrams shall be certified in writing as being acceptable to the Mechanical Design Engineer, Electrical Design Engineer, Mechanical Contractor, Electrical Contractor, and the Controls Contractor.

D. Changes During Construction: The complete responsibility and costs for revisions during construction, the approved control diagrams, and the resultant changes to the installation requirements, not covered by contract change orders, shall be assigned to the respective section of these specifications under which the equipment is furnished.

E. Installation: No control work shall be performed until the revised control diagram prints have been re-issued to the Contractor, unless written permission is obtained from the Architect.

1.05 OPERATION AND MAINTENANCE INSTRUCTIONS: The Contractor shall furnish the Owner complete operating and maintenance instructions covering all units of mechanical equipment herein specified, together with parts lists.

1.06 SCHEDULES AND INSTRUCTIONS: All valve schedules, pipe identification legends instructions, and diagrams shall be furnished in duplicate and framed and mounted under glass and shall be mounted in the locations as directed by the Onwer's representative.

1.07 QUALIFICATIONS:

A. All mechanics shall be capable journeymen, skilled in the work assigned to them.

B. All welders shall be certified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code, 1965 Edition.

PART 2 - PRODUCTS

2.01 QUALITY OF MATERIALS: All equipment and materials, except items specified to be reinstalled, shall be new, and shall be the standard product of manufacturers regularly engaged in the production of plumbing, heating, ventilating and air-conditioning equipment and shall be the manufacturer's latest design.

2.02 EQUIPMENT SCHEDULE: All major items of equipment are specified in the equipment schedules on the drawings and shall be furnished complete with all accessories normally supplied with the catalog item listed and all other accessories necessary for a complete and satisfactory installation.

2.03 SUBMITTALS: As soon as possible after the Contract is awarded, the Contractor shall submit to the Architect seven copies of submittal data for all equipment to be furnished.

2.04 ALTITUDE RATINGS: Unless otherwise noted, all specified equipment capacities are for an altitude of 7,000 feet above sea level and adjustment, to manufacturer's ratings must be made accordingly.

2.05 V-BELT DRIVES: V-belt drives shall be of fabric and rubber construction of approved manufacture. Multiple belts shall be matched and all belts shall be adjusted to drive the apparatus properly and to precent slippage and undue wear in starting. Drives shall be designed for 150 percent of the specified motor name plate ratings. Motor pulleys shall be adjustable or variable speed.

2.06 BELT GUARDS: The Contractor shall provide for each V-belt drive a galvanized iron belt guard which shall be constructed around an angle iron frame, securely bolted to the floor or apparatus. Furnish wire mesh screen cover for double inlet fans installed so as not to restrict the air flow.

2.07 LUBRICATION: The Contractor shall provide all oil for the operation of all equipment until acceptance.

PART 3 - EXECUTION

3.01 COOPERATION WITH OTHER TRADES: The Contractor shall refer to other parts of these specifications covering the work of other trades which must be carried on in conjunction with the mechanical work, so that the construction operations can proceed without harm to the Owner from interference, delay or absence of coordination.

3.02 DRAWINGS: The mechanical drawings show the general arrangement of all piping, ductwork, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. The architectural and structural drawings shall be considered as a part of the work insofar as these drawings furnish the Contractor with information relating to design and construction of the building. Architectural drawings shall take precedence over mechanical drawings.

3.03 FIELD MEASUREMENTS: The Contractor shall verify the dimensions and conditions governing his work at the building. No extra compensation shall be claimed or allowed on account of differences between actual dimensions and those indicated on the drawings.

3.04 CUTTING AND PATCHING: Mechanical work shall be laid out in advance of building construction to permit building in pipe sleeves, inserts, hangers, supports, fixture carriers, etc., so as to eliminate unnecessary cutting of structural members.

3.05 PROTECTION OF MATERIALS: Pipe openings shall be closed with caps or plugs to prevent lodgement of dirt or trash during the course of installation. Plumbing fixtures shall not be used by the construction forces. At the completion of the work, fixtures, equipment and materials shall be cleaned and polished thoroughly and delivered in a satisfactory condition.

3.06 MANUFACTURER'S DIRECTIONS: The Contractor shall install all equipment in strict accordance with all directions and recommendations furnished by the manufacturer.

3.07 TESTS: All tests shall be witnessed and approved by the Owner's representative.

3.08 TESTING AND BALANCING OF THE MECHANICAL SYSTEMS: The actual testing and balancing procedure shall be performed by an independent service, whose services shall be procured and paid for by the Contractor, under this contract. Testing and balancing of the mechanical systems will be coordinated by the Prime Mechanical Contractor, who shall be responsible for furnishing test locations and assistance in obtaining the data required by the test procedure.

A. Test and Balance Procedure: The Testing and Balancing Contractor shall perform the following tests, compile the test data and submit seven (7) copies of the complete test data to the Owner for evaluation and approval. During the testing and balancing period, the Prime Mechanical Contractor shall provide services of a qualified manufacturer's representative for the temperature controls, cooling towers and refrigeration plants.

1. Air Distribution Systems:

(a) In cooperation with controls subcontractor and equipment supplier test and adjust blower operation to design requirements.

(b) Test and record motor full load amperes.

(c) Make pilot tube traverse of main supply ducts and obtain design cfm at fans within the range of the specified quantities and plus 5 percent.

(d) Test and record system static pressures, suction and discharge.

(e) Test and adjust system for design recirculated quantity air flow rates.

(f) Test and adjust system for design cfm outside air.

(g) Test and record entering air temperatures. (D.B. heating and cooling.)

(h) Test and record entering air temperatures. (W.B. cooling.)

(i) Test and record leaving air temperatures. (D.B. Heating and cooling.)

(j) Test and record leaving air temperatures. (W.B. cooling.)

(k) Adjust all main supply and return air ducts to proper design cfm.

(l) Adjust all mixing units to proper design supply cfm.

(m) Adjust all zones to proper design cfm, supply and return.

(n) Test and adjust each diffuser, grille, and register to within 10% of design requirements.

(o) Each grille, diffuser, and register shall be identified as to location and area.

(p) Size, type, and manufacturer of diffusers, grilles, registers, and all tested equipment shall be identified and listed. Manufacturer's ratings on all equipment shall be used to make required calculations.

(q) Readings and tests of diffusers, grilles, and registers shall include required fpm velocity and test resultant velocity, required cfm and test resultant cfm after adjustments.

(r) Contractor shall make setting adjustments of automatically operated dampers to operate as specified, indicated, and/or noted. Testing agency shall check all controls for proper calibrations and list all controls requiring adjustment.

(s) All diffusers, grilles, and registers shall be adjusted to minimize drafts in all areas.

(t) As a part of the work of this Contract, the Contractor shall make any changes in the pulleys, belts and dampers or the addition of dampers required for correct balance as recommended by the Test and Balance Team at no additional cost to the Owner.

(u) All high pressure ductwork shall be tested for tightness with a portable pressure blower until a 6-inch water gauge static pressure is obtained at which time all leaks shall be sealed. This testing should be accomplished prior to the installation of insulation.

(v) Exhaust fans shall be tested and adjusted and set for requirements as shown on plans and as specified.

2. Chilled Water and Heating Water Systems:

(a) Open all valves to full open position. Close bypass stop valves. Set mixing valves to full flow through system component.

(b) Remove all strainers and clean same.

(c) Examine water in system and determine if cleaned.

(d) Check pump rotation.

(e) Check expansion tanks to determine they are not air bound and the system is completely full of water.

(f) Check all air vents at high points of water systems and determine all are installed and operating freely.

(g) Set all temperature controls so all coils are calling for full cooling. Same procedure when balancing hot water coils, set on full call for heating.

(h) Check operation of automatic control valves.

(i) Check and set operating temperatures of convertors and chillers to design requirements.

(j) Complete air balance must have been accomplished before actual water balance begins.

(k) Set chilled water, hot water and condensing water pumps to proper gallons per minute delivery or check and adjust the flow controls to obtain the desired water flow rate.

(l) Adjust condensing water control valves.

(m) Adjust water flow of chilled water through chiller.

(n) Adjust water flow of hot water through convertors.

(o) Check leaving water temperature and return water temperatures through chiller, condenser, and convertors. Reset to correct design temperatures.

(p) Check water temperatures at inlet side of cooling and heating coils. Note rise or drop of temperatures from source.

(q) Balance each chilled water coil and hot water coil.

(r) After adjustments to coils are made, recheck settings at the pumps, chillers, and convertors and readjust if necessary.

(s) Install pressure gauges on coil, read pressure drop through coil at set flow rate on call for full cooling and on full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.

(t) Record and check the following items at each cooling and heating element.

(1) Inlet water temperatures.

(2) Leaving water temperature.

(3) Pressure drop of each coil.

(4) Pressure drop across bypass valve.

(5) Pump operating suction and discharge pressures and final T.D.H.

(6) List all mechanical specifications of pumps.

(7) Rated and actual running amperage of pump motor.

B. Report: Upon completion of the testing and balancing, all information shall be presented in a complete test and balance report. Seven (7) copies of report shall be furnished to the Architect.

3.09 DRAWINGS, COORDINATED, COMPOSITE, AS-BUILT, ETC.: The Contractor shall prepare and submit to the Architect large scale, coordinated composite layouts of mechanical equipment areas showing on both plan and elevation, all equipment, gear, ducts, piping, and electrical equipment, etc., in all congested areas. All electrical and mechanical services shall be shown on each composite drawing. The Contractor shall submit four (4) copies of each drawing to the

Architect for approval. Two (2) copies of each will be withheld and two (2) copies will be returned to the Contractor. Before the completion of the project, the Contractor will provide two (2) copies of each of the coordinated composite layouts with corrected as-built data incorporated thereon, for the purpose of permanent as-built records.

SECTION 15060 - PIPE AND PIPE FITTINGS

2.01 PIPE AND PIPE FITTINGS: Pipe and pipe fitting material requirements are specified under the sections covering the various piping systems. All welding fittings used in the welding system shall be manufactured by Tube Turns, Inc., Taylor Forge and Pipe Works, Midwest Piping & Supply Co., or Bonney Forge & Tool Works for "Weld-O-Let" or "Thred-O-Let", or approved equal fittings and shall match the pipe in which they are installed. Welding fittings shall conform to ASA Standards.

2.02 FLOOR, WALL AND CEILING PLATES: Where uncovered, exposed pipes pass through floors, finished walls, or finished ceilings, they shall be fitted with chromium plated spun brass flanges.

2.03 UNIONS: Piping 2 inches and larger shall have bolted flange unions with gaskets of material suitable for the specified service. Unions shall be installed at all valves and equipment connections.

2.04 HANGERS: All horizontal pipes shall be securely supported from split ring and rod type or trapeze hangers. Hanger spacing shall be as follows:

A. Cast-iron soil waste and vent piping shall have hangers at each pipe joint and at each fitting.

B. Steel pipe - maximum spacing
1" and under - 7'-0"
1-1/4" thru 4" - 10'-0"
5" thru 8" - 18'-0"
10" and larger - 20'-0"

C. Copper tubing - maximum spacing
3/4" and under - 6'-0"
1" thru 1-1/2" - 8'-0"
2" thru 4" - 10'-0"
5" thru 8" - 12'-0"
10" and larger - 15'-0"

Hangers for copper tubing shall be insulated from the tubing. Hangers for chilled water piping shall be placed outside of the insulation with 12-inch long protection sleeve (Elcen Fig. 218), with a 12-inch long hard maple insulation saddle (Elcen Fig. 216) at each hanger. In lieu of the separate protection sleeve and maple saddle, the Contractor may use special pipe insulated shield with calcium silicate insert as manufactured by Pipe Shields, Inc., Sunnyvale, California. Hangers for hot piping may be installed inside of the insulation.

SECTION 15080 - PIPING SPECIALTIES

2.01 STRAINERS: Crane #989-1/2 or #988-1/2, iron body, 125# SWP, flanged for sizes 2-1/2 inches and larger with 1/8 inch perforations for water, 1/16 inch perforations for steam. Provide blow-off valves full size of strainer tapping.

2.02 PRESSURE GAUGES: Marshalltown "Permagage", Ashcroft "Duragage" or Trerice No. 500X, or approved equal. Dials shall be 4-1/2 inches unless otherwise noted. Provide Crane No. 88 or approved equal needle valve for each gauge, and syphon for each steam gauge.

2.03 THERMOMETERS: Where indicated on the drawings and the piping diagrams, thermometers shall be installed as manufactured by the H. O. Trerice Co., Moeller or Albert Weiss, or approved equal. Thermometers shall be provided with glass, red reading column, mercury filled, 9-inch scale, and shall be provided with stems, as required by their location in the piping system.

2.04 THERMOMETER WELLS: Machined brass test wells with screwed caps and chains. H. O. Trerice No. 5573 or 5574 as required, or approved equal.

2.05 TEMPERATURE AND PRESSURE TEST PLUG: Where shown on the drawings provide temperature and pressure test plugs with Nordel valve cores and 1/2 inch NPT brass body with gasketed cap as manufactured by Universal Controls Corp.

2.06 AIR VENTS: Manual air vents shall be 1/2-inch brass needle valves, Crane No. 88 or approved equal.

SECTION 15100 - VALVES

2.01 GATE VALVES, 2 INCHES AND UNDER: Crane 428UB, rising stem, wedge disc, bronze body, 125 psi working pressure.

2.02 GATE VALVES, 2-1/2 INCHES AND LARGER: Crane 465-1/2 or 465 rising bronze stem, wedge disc, iron body, O.S.&Y., 125 psi working pressure.

2.03 SWING CHECK 2 INCHES AND SMALLER: Crane No. 34, all bronze, 125 pounds W.S.P. Check valves at the discharge of pumps shall be non-slam type.

2.04 SWING CHECK, 2-1/2 INCHES AND LARGER: Crane No. 372 or 373, iron body, bronze trimmed. Check valves installed at discharge of pumps shall be non-slam type.

2.05 GLOBE VALVES 2 INCHES AND SMALLER: Crane No. 7, 150 psi, bronze body with renewable disc.

2.06 GLOBE VALVES, 2-1/2 INCHES AND LARGER: Crane No. 350 or 351, iron body, bronze trimmed.

2.07 GATE VALVES FOR COPPER PIPE: Crane No. 1320, all bronze, wedge disc, tapered seat, rising stem, 125 pounds W.S.P.

2.08 GLOBE VALVES FOR COPPER PIPE: Crane No. 1310, bronze body, composition disc (for laboratory compressed air).

2.09 SWING CHECK VALVES, COPPER PIPE: Crane No. 1303, all bronze, 125 pounds W.S.P.

2.10 BALANCING COCKS:

A. 1-1/4 inches and under, Crane No. 250 square head brass cock.

B. 1-1/2 inches and over, Rockwell Figure 143, "Permaturn" lubricated plug valve.

2.11 BUTTERFLY VALVES: Lug type butterfly valves, ductile iron body and blade, stainless steel shaft, and with Hycar liner for tight shut-off at 150 psig or less. Valves to be suitable for mounting between flanges, with lugs drilled and tapped so that pipeline can be disconnected with the valve still holding pressure. Valves 3 inches or smaller to have lever operators with locking throttling positions. Valves 4 inches and larger to have worm gear and hand wheel manual operators. Butterfly valves may be used in lieu of gate valves.

2.12 RELIEF VALVES: For hot water generators, ASME labeled temperature and pressure relief valves shall be installed on each hot water generator. Valves shall be sized for the full heater capacity. Discharge from valves shall be piped to the nearest floor drain.

2.13 DRAIN VALVES: Crane No. 460.

SECTION 15160 - VIBRATION ISOLATION

2.01 PRODUCTS:

A. All vibration isolating equipment supports shall be the product of manufacturers experienced in the field of vibration isolation.

B. All vibration isolating mountings shall be as indicated on the drawings.

SECTION 15180 - INSULATION

2.01 INSULATION: Insulation shall be as manufactured by Owens Corning Fiberglas, Certain-Teed, Johns Manville, Armstrong, or approved equal and shall be equal to that specified below. All insulation material shall have a composite (insulation, jacket and adhesive) fire and smoke hazard rating not exceeding: Flame Spread - 25; Smoke Developed - 50. All accessories and materials used for fittings shall have same ratings.

A. Domestic Hot Water Piping: Domestic hot water piping, 1-inch thickness glass fiber pipe insulation with a factory applied white vapor barrier jacket. All fittings, except unions, strainers or valves shall be insulated with asbestos free insulating cement or preformed insulation and covered with pasting canvas applied with a full strength coating of Fosters 30-36 Lagging Adhesive, to give the specified fire and smoke ratings. Zeston jackets may be used on fittings.

B. Hot Water Heating Piping (Including Combination Heating and Condensing Water): Hot water heating piping with 1-inch-thickness glass fiber pipe insulation with a factory applied white vapor barrier jacket. All fittings, except unions, strainers, flanges or valves shall be insulated with asbestos free insulating cement or preformed insulation and covered with pasting canvas applied with a full strength coating of Fosters 30-36 Lagging Adhesive, to give the specified fire and smoke ratings. Zeston jackets may be used on fittings.

C. Chilled Water Piping: Chilled water piping, glass fiber pipe insulation with a factory applied white vapor barrier jacket and self-sealing lap. Thickness of the insulation shall be 1 inch for pipe sizes up to and including 3-inch pipe and 1-1/2 inches for pipe sizes over 3 inches. All fittings, including unions, strainers, valves, and flanges shall be insulated with material similar to the pipe insulation and finished with pasting canvas applied with a full strength coating of Fosters 30-36 Lagging Adhesive, to give the specified fire and smoke rating and form a complete vapor barrier. Zeston jackets may be used on fittings.

D. Roof Drain Pipe Insulation: Roof drainage piping and fittings above ceilings either 1/2-inch-thickness glass fiber pipe insulation with a factory applied white vapor barrier jacket, as specified for chilled water, or 1-inch-thickness blanket insulation with a factory applied .002 aluminum foil vapor barrier applied as specified for cold ducts, properly sealed.

E. Domestic Cold Water Piping: Domestic cold water piping located above ceilings in the Mechanical Equipment Rooms, or within 24 inches of an outside wall, 1-inch thickness of glass fiber pipe insulation with a factory applied white vapor barrier jacket and self-sealing lap. All fittings, except unions, flanges, strainers and valves shall be insulated with asbestos free insulating cement or preformed insulation and covered with pasting canvas (or glass cloth) applied with a full strength coating of Fosters 30-36 Lagging Adhesive, to give the specified fire and smoke ratings.

F. Emergency Generator Exhaust Piping: Engine generator muffler and exhaust piping within the building shall be insulated with 1-1/2-inch-thick Johns Manville "Metal-On" pipe insulation.

G. Engine Coolant Piping: Engine coolant piping within the building shall be insulated as specified for hot water heating piping.

H. Exposed Piping: All exposed insulated pipe except engine exhaust piping shall be completely covered with a white PVC jacket as manufactured by Zeston or approved equal.

I. Supply Ducts: All supply heating and cooling ducts, except ducts with acoustical lining, flexible connectors, or supply ducts exposed in the area they serve shall be insulated.

1. Heating Ducts: Supply ducts handling heated air only shall be insulated with 1-inch-thick, Fiberglas Type 100P, Johns Manville, CSG or PPG 1-pound density blanket insulation.

2. Cooling Ducts: Supply ducts handling cold air shall be insulated with 1-inch-thick Fiberglas ED 100 FRK, or J-M, CSG or PPG, 1-pound density blanket with an FSK facing.

3. Exposed Ducts: Supply ducts in Mechanical Equipment Rooms and exposed in occupied areas they do not serve, 3-pound glass fiber board with foil-scrim-kraft facing. Complete vapor barrier shall be maintained. Ducts may be insulated with 1-pound density plain blanket applied with adhesive and finished with 6-ounce canvas.

J. Acoustical Lining:

1. Ducts: All ducts shall be lined where indicated on the drawings with glass fiber duct liner, 1-1/2-pound density in the thicknesses as shown.

2. Plenums: All field fabricated supply plenums, except pre-insulated panels, floors, and other surfaces where indicated on the drawings, shall be lined with 2-inch-thickness.

K. Water Chillers: Water chillers shall be completely factory insulated.

SECTION 15402 - WATER SUPPLY SYSTEM

2.01 PIPING:

A. Domestic water piping, including hot and cold water, chilled drinking water, and circulating hot water piping shall be either Type L hard-drawn copper tubing with solder type wrought copper fittings, or Schedule 40 galvanized steel pipe with galvanized malleable iron screwed fittings.

2.02 SHOCK ABSORBERS:

A. Shock Absorbers and Air Cushions: Install a 1-inch shock absorber, Josam 1485-3, Zurn No. 2-1700, size 300 Wade W-20, or Smith No. 5020.

2.03 STERILIZATION: All water piping shall be sterilized as follows: Chlorine shall be applied to provide a dosage of not less than 250 parts per million. The chlorinating material shall be introduced into the water line in a manner approved by the Architect. After a contact period of not less than eight hours, the system shall be flushed with clean water until the residual chlorine content is not greater than 0.2 parts per million. All valves in the line being sterilized shall be opened and closed several times during the contact period.

2.04 TESTS:

A. General: All tests shall be conducted in the presence of the Architect or his representative. Any systems failing to meet the specified test requirements shall be corrected and retested until the test requirements are met.

B. Water Systems: The complete water systems shall be hydrostatically tested at a pressure of 125 psi and shall show no loss of pressure for a period of one hour.

SECTION 15403 - SOIL AND WASTE SYSTEM

2.01 PIPING:

A. Soil and waste piping shall be service weight, coated cast-iron below ground, and either service weight cast-iron or galvanized steel pipe aboveground. Piping may be either hub-and-spigot or No-Hub.

B. Vent piping 2 inches and larger shall be either service weight cast-iron or galvanized steel. Vent piping 1-1/2 inches and smaller shall be standard weight galvanized steel pipe with galvanized malleable iron fittings, except that all vent piping below ground shall be cast iron.

2.02 FLOOR DRAINS:

A. Drains shall be Zurn, Josam, Wade or Smith and shall be equal to those specified below.

B. Floor drains for equipment rooms shall be Zurn-Z-500C, coated cast iron with 8-inch diameter grate and clamping device.

C. Floor sinks shall be Zurn-Z-323-1.

D. Floor drains for finished areas shall be Zurn No. Z-415 with 6-inch polished nickel bronze Type A strainer.

2.03 CLEANOUTS:

A. Cleanouts shall be as manufactured by Zurn, Smith, Josam or Wade and shall be of the same size as the pipe, except that cleanout plugs larger than 3 inches will not be required. Cleanouts installed in connection with cast-iron soil pipe shall consist of a long sweep, quarterbend or one or two eighth bends extended to an easily accessible place, or as indicated on the drawings. A standard cleanout fitting, Zurn, Figure Z-1324, or approved equal, shall be caulked into the hub of the fitting and finished flush with the floor. Where cleanouts in connection with threaded pipe are shown and are accessible, they shall be cast-iron drainage T-pattern, 90-degree branch fittings with square head brass screw plugs of the same size as the pipe up to and including 3 inches.

2.04 TESTS:

A. The entire sanitary system shall be tested in accordance with the requirements of the Unified Plumbing Code of the State of New Mexico.

SECTION 15405 - COMPRESSED AIR SYSTEM

2.01 PIPING: Compressed air piping shall be schedule 40 black steel pipe with black malleable iron screwed fittings or forged steel welding fittings.

2.02 AIR SUPPLY: Air supply shall be taken from new house air system.

2.03 VALVES: Valves are specified in Section 15100.

2.04 TESTS:

A. The complete air system shall be tested with an air pressure of 125 psi and shall show no loss in pressure for a period of one hour.

SECTION 15404 - ROOF DRAINAGE

2.01 PIPING:

A. All piping aboveground, including offsets in furred spaces shall be either standard weight black steel pipe with forged steel welding fittings or screwed cast-iron recess-type drainage fittings, or service weight cast-iron soil pipe and fittings. All gravity drain piping below ground shall be service weight cast-iron soil pipe and fittings, hub-and-spigot.

2.02 ROOF DRAINS:

A. Roof drains shall be Zurn No. Z-100-ERC or approved equal as manufactured by Smith, Wade, or Josam.

2.03 TESTS:

A. Roof drainage piping shall be tested by filling the system to the highest level with no drop in water level for a period of 15 minutes.

SECTION 15450 - PLUMBING FIXTURES AND TRIM

2.01 FIXTURES:

A. Fixtures shall be as manufactured by Crane, Koehler, Eljer or American Standard, except as otherwise specified and shall be equivalent to those specified in the schedule on the drawings.

SECTION 15500 - FIRE PROTECTION

2.01 PIPING:

A. Pipe shall be Schedule 40 galvanized steel.

B. Fittings shall be galvanized malleable iron screwed fittings.

2.02 FIRE HOSE CABINETS: Install surface or recessed mounted fire hose cabinets of furniture steel, all exposed corners mitered, welded and ground smooth. Cabinets shall be factory finished with white baked enamel finish on outside and inside. Door shall be hung on continuous piano hinge and shall have full 1/4-inch polished plate glazing. Cabinets shall be W. D. Allen Co. or Standard Fire Hose Co., with fire hose rack, UL labeled, for 1-1/2" valve and 1-1/2" hose; hose of 75 ft. length with fog nozzle. All exposed metal parts shall have polished chrome plate finish. In each cabinet provide a spanner wrench on support bracket and a UL labeled pressurized water extinguisher.

2.03 SPRINKLER SYSTEMS: Standard installations of automatic sprinklers, arranged as wet pipe systems, shall be installed throughout all areas of the buildings, where required by code.

A. Sprinkler Heads: Sprinkler heads shall be automatic closed type sprinkler heads of ordinary degree temperature rating, type as required.

B. Spare Heads: The Contractor shall furnish spare heads in a metal cabinet and sprinkler head wrench as required by Paragraph 3660 of NBFU Pamphlet No. 13.

C. Alarm Check Valves: Alarm check valves shall be standard U.L. labeled wet pipe alarm check valves.

D. Alarm Facilities: Equipment necessary to accomplish a local water-flow signal and a transmitted water-flow signal and one set of normally open auxiliary contacts shall be installed at the automatic control valve.

E. Transmitted Alarm Circuit shall be provided for the transmission of water flow signals from coded water flow transmitter or relays and auxiliary functions.

F. Local Alarm: Local alarm shall consist of a water motor alarm gong mounted where shown on the drawings.

G. Siamese Fire Department Connection: Where shown on the drawings, install 2-way, 2-1/2 x 2-1/2 x 4 Siamese connection, W. D. Allen Co. No. 273 with caps and chains, nameplate and threads to match local Fire Department equipment. Nameplate shall read "Automatic Sprinkler System".

2.04 CO_2 EXTINGUISHER SYSTEM: Furnish CO_2 extinguishing system for broiler-kitchen hoods as noted on drawings. Install in accordance with manufacturer's recommendations and applicable NFPA code.

2.05 TESTS:

A. The entire system shall be tested and proven tight at a hydrostatic pressure of 150 psi.

SECTION 15605 - FUEL HANDLING SYSTEM

2.01 TANKS:

A. Tanks, including storage tank and day tank, shall be of the size and capacity shown on the drawings, constructed and installed in accordance with the requirements of NFPA Pamphlet No. 31 of black sheet steel. Tanks shall be provided with connections for filling, manual gauging, vents, oil supply, oil return, remote gauge, access manhole, and other connections shown on drawings. Contractor has the option of using a UL listed fiberglass tank in lieu of steel tank.

2.02 PIPING:

A. Fuel oil piping, including fill lines, shall be Schedule 40 black steel pipe with either forged steel welding fittings or black malleable iron screwed fittings.

B. Vent piping shall be Schedule 40 galvanized steel pipe with galvanized malleable iron screwed fittings.

C. Remote fuel gauging lines shall be hard drawn, Type K copper tubing with solder fittings.

2.03 PUMPING UNIT: A pumping unit of the type and capacity indicated on the drawings shall be furnished and installed where shown on the drawings. Pumping unit shall be complete with duplex strainers, duplex pumps, electric alternator and interconnecting piping.

2.04 FILL AND VENT CAPS: The fill pipe shall be provided with a hinged locking type cap. The vent pipe shall terminate with a screened weatherproof cap, 8 feet minimum abovegrade.

2.05 REMOTE LIQUID LEVEL INDICATOR: Remote liquid level indicator shall be Liquidometer Hydraulic type with Industrial Junior Model Indicator, as manufactured by Simmonds Precision or approved equal.

2.06 TANK ACCESSORIES: Furnish and install all tank accessories and piping indicated on the drawings.

2.07 PUMP CONTROL: Furnish and install a McDonall-Miller pneumatic liquid level controller on the day tank for the emergency generator to start and stop the fuel oil pumps through an electric alternator in order to maintain the desired fuel oil level in the day tank.

2.08 OIL CHARGE: All fuel oil will be furnished by the Owner.

2.09 TESTS:

A. All fuel oil piping shall be tested and proven tight with an air pressure of 150 psi.

B. Tank guaging lines shall be tested and proven tight at an air pressure of 50 psi.

SECTION 15608 - EMERGENCY GENERATOR PIPING

2.01 Exhaust piping shall be Schedule 40 black steel pipe with forged steel welding fittings.

A. Muffler and flexible connection will be furnished with the engine under Division 16 and shall be installed under this section.

SECTION 15650 - REFRIGERATION

2.01 WATER CHILLER: Water chiller is specified in the equipment schedule on the drawings and shall be furnished as a complete factory assembled unit.

2.02 COOLING TOWER:

A. See equipment schedule for detailed specifications.

B. Cooling tower must be constructed to fit alotted space and shall be completely fire-proof construction.

2.03 PUMPS: Pumps shall be of the type and capacity listed in the equipment schedule, shaft sleeves shall be stainless steel, monel or ceramic material. Pumps shall be selected so that the motors will not overload under any operating conditions. All pumps shall have drain pans with tapped pipe connections and 3/4-inch drain line extended to floor drain. Pumps shall be installed so that they may be removed without removing the associated piping.

2.04 PIPING: All piping shall be Schedule 40, black steel pipe with either black cast-iron screwed fittings or forged steel welding fittings.

2.05 WATER TREATMENT:

A. Furnish and install a complete water treatment system for the cooling towers as specified in the equipment schedule. All chemicals will be purchased by the Owner.

B. The water treatment system installation and adjustment shall be under the direct supervision of a qualified representative of the equipment manufacturer.

2.06 TESTS:

A. The entire cooling tower piping system shall be tested and proven tight at a hydrostatic pressure of 100 psi.

B. The entire refrigeration system shall be operated by a qualified representative of the manufacturer of the water chilling unit for a period of not less than four (4) eight-hour days during which time all necessary adjustment shall be made to assure proper operation.

SECTION 15700 - LIQUID HEAT TRANSFERS

2.01 PIPING: Chilled water and heating water piping shall be Schedule 40, black steel pipe with either black cast-iron screwed fittings or forged steel welding fittings.

2.02 VALVES:

A. Valves other than automatic control valves are specified in Section 15100 - Valves.

B. Automatic control valves are specified in Section 15900 - Controls and Instrumentation.

2.03 COILS: Supplier of heating and cooling coils shall furnish complete calculations including altitude corrections to establish the number of rows of tubes required in each coil. Calculations shall be in accordance with standard catalog information furnished by the coil manufacturer. In no case shall specified air or water pressure drops be exceeded more than 10 percent. Number of rows shall be at least 1/2 row more than the calculated number. Coils shall be Carrier, Trane, York, Marlo, Bohn, McQuay, Aerofin, Buffalo, Recold, or American Blower, as specified in the equipment schedule on the drawings.

2.04 PUMPS: Pumps shall be of the type and capacity listed in the equipment schedule, and shall be furnished with dripproof motors. Shaft sleeves shall be stainless steel or ceramic material. Pumps shall be selected so that the motors will not overload under any operating conditions. Furnish one spare mechanical seal of each size used on the job.

2.05 EXPANSION TANKS: Expansion tanks shall be ASME labeled for 125 psi working pressure and shall be of the type and size listed in the equipment schedule.

2.06 HEAT EXCHANGERS: Heat exchangers shall be shell and tube type, ASME labeled for 125 psi working pressure, with size and capacity as listed in the equipment schedule on the drawings.

2.07 TESTS:

A. All piping shall be proven tight at a hydrostatic pressure of 100 psi.

B. Testing and balancing of the water circulating systems is specified in Section 15010 - General Provisions.

SECTION 15800 - AIR DISTRIBUTION

2.01 EQUIPMENT SCHEDULES:

A. All major items of equipment are specified in the equipment schedule on the drawings and shall be furnished complete with

all accessories normally supplied with the catalog item listed and all other accessories necessary for a complete and satisfactory operating system.

B. All registers, grilles and diffusers shall be as listed in the schedule on the drawings.

2.02 DUCTWORK:

A. Materials and Gauges: Construct all ducts, casings, plenums, etc., of galvanized steel sheets, of the gauges specified below, unless otherwise shown. High velocity rectangular ductwork shall be constructed of metal two gauges heavier than specified for low velocity ductwork with "K-Lok" special reinforcing duct couplings as manufactured by Ventfabrics Inc.

Schedule for Rectangular Sheet Metal Duct Construction

Gal. Steel U.S.S.Gage	Max. Side Duct, Inches	Transverse Joint Connection *	Max. Length of Section
26	Up to 18"	S-slip	8'-0"
24	19" to 30"	1" standing pocket slip (gov't. lock)	4'-0"
22	31" to 40"	1-1/2" standing pocket slip (gov't. lock)	4'-0"
20	41" to 60"	1-1/2" pocket slip with 1" x 1/8" reinforcing bar	4'-0"
18	61" and up	1-1/2 " x 1-1/2" x 1/8" angle connection including plenums - with bolts on 6" centers	4'-0"

B. Round ducts and fittings for high velocity systems shall be spiral lockseam conduit as manufactured by United Sheet Metal Company, Inc., 540 Drexel Avenue, South; Columbus 9, Ohio, or approved equal. All 90-degree elbows shall be at least 5-piece construction. Standard manufactured ducts of other than spiral construction will be acceptable if constructed of the following gauges with welded seams. Sizes through 12-inch diameter shall be 22 gauge, 23-inch through 36-inch diameter shall be 20 gauge, 37 inches and over shall be 18 gauge.

C. Flexible ducts for connections between rigid ductwork and mixing boxes shall be factory insulated flexible conduit capable of holding 5 inches W.C. without developing leaks and shall not exceed a flame spread of 25 or a smoke development of 50, Genflex IHPL-181. For connection of diffusers downstream of mixing boxes and other low pressure applications, use factory insulated flexible conduit equal to Genflix SLR-181.

D. Plenums shall be constructed as detailed on the drawings.

2.03 FIRE DAMPERS:

A. At the location shown on the drawings, there shall be provided

fire dampers. Provide access doors at all fire damper locations of sufficient size to allow easy re-setting of fire damper linkages. Fire damper links shall be of the test strength recommended to prevent nuisance closing. All fire dampers in heated air shall have 200-degree fusible links. Cold and return dampers shall have 160-degree fusible links. All fire dampers shall conform to the requirements of NFPA Pamphlet 90A.

B. High Velocity Round or Oval Fire Dampers: High velocity fire dampers shall be of the folding blade type with the hinged damper blades completely out of the air stream so as to cause a minimum of static pressure drop. Fusible links shall be accessible from either side of the damper.

C. Rectangular Fire Dampers: Fire dampers for rectangular ductwork shall be of the folding blade type with the hinged blades completely out of the air stream. Fusible links shall be accessible from either side of the damper.

D. Size of access doors shall be 2 inches less than the width of the duct by 12 inches, up to a maximum size of 12 inches by 24 inches.

2.04 ACCESS DOORS:

A. Wall and Ceiling Access Doors: Wall, ceiling and duct access doors at fire dampers shall be Control air 16-gauge access door with continuous hinge, neoprene gasket and thumb screw locks and baked aluminum enamel finish. Doors shall be sized for easy access and not less than the sizes given in Paragraph D above.

B. Walk-Through Access Doors:

1. Door Construction: Doors shall be provided with a flat iron or angle iron stiffening frame and so constructed that they can be operated without twisting or distortion. Doors on insulation ductwork shall be double panel construction provided with an approved type insulated filler, not less than 1 inch thick.

2. Door Frames: Door frames on insulated ductwork shall be placed on an extended metal collar flush with the face of the finished insulation.

3. Door Fasteners: Latches shall be operable from either side of door and shall be "Ventlok" No. 310 or approved equal.

2.05 LOUVERS:

A. Louvers in outside walls will be furnished and installed by the General Contractor.

2.06 FILTERS:

A. Filters shall be as listed in the schedule on the drawings. Contractor shall replace the pre-filters with new filters when the system is ready for balancing. Contractor shall furnish and deliver to the Owner, one complete replacement set of both pre-filters and final filters.

B. Filters shall have a smoke development not exceeding 50 as tested by an approved authority.

C. Furnish and install a filter gauge for each bank of filters. A separate gauge is required for the pre-filters and for the final filters. Guages shall be inclined tube type with oil reservoir, static pressure tips, 3-way vent valve, inter-connecting tubing and manometer oil. Range shall be 0-1.0-inch W.G. for the pre-filters and 0-1.5-inch W.G. for the final filters.

2.07 COILS: Cooling and heating coils are specified in Section 15700 - Liquid Heat Transfer, and shall be installed under this section.

2.08 TURNING VANES:

A. Turning vanes shall be installed in all square elbows where it is not possible to use radius elbows as detailed on the drawings. Turning vanes shall be high efficeincy profile type with double surfaced airfoil bladed shapes equal to Aero/Dyne Co., Airson, Elgen, or approved equal.

2.09 FANS:

A. Fans shall be as listed in the schedule on the drawings and shall be as manufactured by American Blower, Trane, Carrier, Buffalo, New York Blower, Chicago Blower, Peerless, Recold, or Joy.

B. All fans shall be rated in accordance with AMCA requirements.

C. See Section 15160 - Vibration Isolation and the details on the drawings for special fan bases.

2.10 TEMPERATURE MIXING UNITS:

A. Temperature mixing units shall be as manufactured by Aneomostat, Barber Coleman, Tuttle and Bailey, Carnes, Krueger, Titus or an approved equal.

SECTION 15900 - CONTROLS AND INSTRUMENTATION

2.01 AUTOMATIC DAMPERS: Dampers shall be of the double surfaced louver type constructed of galvanized iron, each leaf reinforced and provided with roller bearings and trunnions constructed of non-corrosive materials. Dampers shall be of the 1 percent leakage type with butyl rubber seals at all four surfaces of each blade equal to Johnson Proportion/aire.

2.02 SUPPORTING DAMPERS: Automatic dampers shall be supported by properly reinforcing the ductwork or sheet metal walls at damper locations to carry the weight of the dampers, or shall be supported independent of ductwork from the ceiling or floor, as conditions at the site determine.

2.03 THERMOMETERS AND AIR GAUGES: On the air supply lines to and from all duct thermostats, valves, air motors, etc., there shall be installed air pressure gauges so that the operation of each air control can be checked. At each duct thermostat, and at other locations as shown on the drawings, there shall be installed direct reading thermometers furnished and calibrated by the Controls Contractor with 1/4 percent accuracy, 3-1/2-inch dial. All thermometers shall be field tested and calibrated. At each air gauge there shall be installed a stamped metal plate which shall indicate equipment controlled and whether the air pressure shall be on or off for the opening or closing of various dampers, etc.

2.04 DAMPER MOTORS: Damper motors shall be provided with diaphragms or motors of proper size so that the motors will operate against the static pressure of the systems.

2.05 AUTOMATIC CONTROL VALVES: The Controls Contractor shall provide all automatic control valves. These shall be made by the manufacturer of the control equipment. All pneumatic control valves 2 inches and smaller in size shall be brass body and trim; 2-1/2 inches and larger shall be iron body, brass or stainless steel trimmed. Valves shall be designed for a water pressure of 150 psi. Valves shall be provided with a "V"-port or throttling type seats. Valves 2 inches and smaller shall be screwed; valves 2-1/2 inches and larger shall be flanged. All sequencing valves shall have positive positioners. Valve operators shall be designed to operate valves against 125 psi pressure.

2.06 ELECTRO-PNEUMATIC SWITCHES: Furnish and install electric-pneumatic relays as shown. Electric wiring will be provided by the Electrical Contractor to P-E and E-P relays.

2.07 THERMOSTATS:

A. Pneumatic: Two pipe thermostats shall be provided with thermometers and temperature adjustment device. Remote bulb thermostats shall be of the averaging type. Furnish separate remote bulb thermometer at each remote bulb thermostat location.

2.08 LOCAL PANEL: EP switches, pneumatic transmitters and receivers, and thermometers, etc., shall be installed in an enclosed unit control panel with hinged door.

2.09 ELECTRICAL CONTROLS: All electric temperature controls shown on Schematic Electrical Control Diagrams on electrical drawing and designated "M" and electric controls shown on pneumatic control drawings shall be furnished by the Controls Contractor for wiring under the Electrical Section of the Specifications.

2.10 SMOKE AND FIRE DETECTORS: The air duct fire detector units shall be Pyr-A-Larm Model CDA-1. They shall be listed by Underwriters' Laboratories, Inc. The units shall be designed for detection of combustion gases, fire and smoke in air conditioning and ventilation system ducts in compliance with the National Fire Protection Association, Recommended Practices Pamphlet No. 90A. It shall consist of a Pyr-A-Larm ionization-type-detector with self-contained control unit. The assembly shall consist of a casting to accommodate sampling tubes which extend across the duct of the ventilation system.

A. The unit shall provide the following function:
Furnish necessary DC power for operation of the detector.
Supervise the detector circuit and all relay coils.
Provide power to the neon alarm indicators.
Provide one set of normally open and one set of single pole-double throw alarm operated relay contacts (5A., 120V., AC).
Provide one set of single pole-double throw trouble-operated relay contacts (5A., 120V., AC).

B. The unit shall operate from a two-wire 120 volt, 60 cycle power source and shall be operable over a range of 102-132 volts. The trouble circuit shall activate if the unit becomes inoperative due to low input voltage. The standby power consumption, excluding any external devices, shall not exceed 1 watt.

C. The unit shall include power and alarm indicator lights. It shall have a key operated momentary switch for resetting the unit. It shall be possible to check the detector's sensitivity under actual air flow conditions using Pyr-A-Larm Sensitivity Checker.

D. Sampling tubes shall be EMT tubing, 1/2-inch minimum diameter, length and supports shall be furnished as required to extend across duct or plenum to give representative samplish of air, quantity and location of sampling tubes shall be as recommended by manufacturer.

2.11 AIR PIPING: Air piping shall be Type "k" rigid copper tubing with sweat fittings, Type "l" soft copper with sweat fittings or polyethylene tubing with barbed fittings. Soft copper tubing may be used only in finished walls from room thermostat head location to ceiling space in hallways or rooms above thermostat locations where these areas are furnished with removable ceilings. Polyethylene may be used in accessible finished ceilings to run from thermostat branch copper line to control device located in room ceiling or the adjacent hallway ceiling. Building main air lines shall be not less that 3/8-inch OD size, with not less than 1/4-inch OD take-offs to controlled devices. No more than six controlled devices shall receive main air from any 1/4-inch OD pipe.

2.12 COMPRESSED AIR SUPPLY: Compressed air supply for pneumatic controls shall be supplied by a compressor unit with receiver as specified on the Mechanical Equipment Schedule.

2.13 DRYER: A refrigeration type dryer shall be furnished and installed by Controls Contractor. This unit shall be complete with a pre-filter and float operated automatic drain with shut-off and bypass valves.

2.14 TESTS AND INSTRUCTION: The integrity and accuracy of each function and control point shall be demonstrated to the satisfaction of the Architect and to the Owner's operating personnel. A second check and re-adjustment is to be made during the final days of the guarantee period.

DIVISION 16 - ELECTRICAL

SECTION 16010 - GENERAL PROVISIONS

2.01 MATERIALS:

A. Requirements: Furnish all labor, materials, service, equipment, and appliances required to complete the installation of the complete electrical systems.

B. Codes and Standards: Conform to National Electrical Code, New Mexico State Electrical Code, Underwriters' Laboratory Standards, National Fire Protection Association Standards, Illuminating Engineering Society Standards.

C. UL Label: Required where applicable.

D. Material List: Submit for approval prior to ordering.

E. Shop Drawings: Submit for approval prior to ordering, show complete outlines, dimensions, electrical services, control diagrams, and pertinent data. In addition to specific requests, submit for switchboards, panelboards, lighting fixtures, clock system, and sound system.

F. Materials: Similar materials and equipment to be the product of the same manufacturer.

G. Performance Tests: Test for proper operating condition and freedom from grounds and short circuits. All equipment, appliances and devices to be operated under load conditions to demonstrate their acceptability.

H. Identification and Signs: Mark each individual motor controller, disconnect switch, transformer and remote control device to identify each item with its respective service. Provide engraved nameplates in finished areas.

SECTION 16110 - RACEWAYS AND FITTINGS

2.01 MATERIALS:

A. Conduits: Rigid threaded, thick-wall steel and electrical metallic tubing. Flexible metal conduit for equipment connections only. Aluminum conduit optional. PVC conduit for concrete encased or under concrete slabs.

B. Conduit Fittings: Industry Standard.

C. Installation: Concealed where possible. Conduit in ground to be wrapped with Scotchrap 51 half-lapped. Supports spaced 8'-0" maximum.

SECTION 16112 - BUSDUCTS

2.01 MATERIALS:

A. General: Plug-in type, three phase, four wire, internal ground

bus, voltage as noted, full neutral.

B. Bus Bars: Aluminum or copper.

C. Short Circuit Rating: 42,000 amperes RMS symmetrical.

D. Housing: Totally enclosed.

SECTION 16114 - CABLE TRAYS

2.01 MATERIALS:

A. General: Continuous rigid aluminum ladder type.

B. Size: Three-inch clear inside depth, width to be 12 or 24 inch as noted on the drawings.

C. Rung Spacing: 6 inch.

D. Fittings: Button head fasteners on inside of tray; eight inch radius of bends.

SECTION 16120 - CONDUCTORS, 600 V AND LESS

2.01 MATERIALS:

A. Type: UL and IPCEA Standards; No. 12 minimum size; copper; 600 volts; type TW minimum; type THW or XHHW for conductors larger than No. 6. Optional use of equivalent aluminum conductors not permitted.

B. Size: As required by code for the application, plus 30% spare.

C. Color Code: Red, black, blue with white neutral and green ground for 120/208 volt system. Yellow, brown, orange, with off-white neutral and green ground for 277/480 volt system.

SECTION 16130 - BOXES AND FITTINGS

2.01 MATERIALS:

A. Outlet Boxes: Zinc-coated sheet steel, nominal 4-inch size. Cast boxes in wet locations and where required. Four inch square minimum for switch, receptacle, and single outlets. Telephone boxes to be 4-11/16 inches square by 2-1/8 inches deep.

B. Floor Boxes: Heavy-duty, cast, adjustable type, suitable for device of application. Provide carpet flanges in carpeted areas.

SECTION 16133 - CABINETS

2.01 MATERIALS:

A. Type: Code guage galvanized sheet steel; raintight where exposed to weather.

B. Fronts: One-piece galvanized sheet steel with factory paint.

C. Doors: Hinged, with catch and lock; all locks keyed alike; factory paint; door-in-door fronts.

D. Ground Bars: Copper; brazed or bolted to cabinet interior; with pressure connectors for equipment grounding.

SECTION 16134 - PANELBOARDS

2.01 MATERIALS:

A. Type: Bolted type molded case circuit breakers; multi-pole breakers to have common-trip bar and single handle; tie-handles not permitted.

B. Cabinet: Size as required; door-in-door; flush mounted in office areas; surface mounted in labs and utility areas.

C. Directories: Typewritten; on inside face of door.

SECTION 16140 - WIRING DEVICES AND PLATES

2.01 MATERIALS:

A. Snap Switches: Flush tumbler type; 15A-120/277V minimum; heavy-duty specification grade; ivory handle.

B. Receptacles: Standard NEMA configurations; ivory color where available; grounding type; special receptacles as required by the application; standard NRAO configurations where directed.

C. Plug Caps: Provide one matching plug cap for each receptacle other than duplex type.

D. Device Plates: Stainless steel with brushed satin finish to match device; one piece multi-gang where required; bushed opening for telephone or signal outlets.

SECTION 16150 - MOTORS

2.01 MATERIALS:

A. General: Furnished with equipment they are intended to operate.

B. Size: Adequate for duty to be performed.

C. Type: Suitable for application; NEMA designs.

D. Voltage Rating: NEMA standard for circuit voltage; generally 200V for 208V systems and 460V for 480V systems.

SECTION 16160 - MOTOR STARTERS

2.01 MATERIALS:

A. General: Magnetic type unless otherwise noted; NEMA Type I

general purpose enclosure unless otherwise noted.

B. Rating: Adequate for motor.

C. Overloads: Ambient temperature compensated thermal overcurrent devices in each phase.

D. Controls: As required by application; 120V from individual dry-type control transformer.

SECTION 16170 - SWITCHES AND FUSES

2.01 MATERIALS:

A. Type: Heavy-duty; fusible or non-fusible as required; raintight where exposed to weather.

B. Fuses: Dual-element, time-delay type; based on heavy service; Buss Fusetrons.

SECTION 16190 - RELAYS AND CONTACTORS

2.01 MATERIALS:

A. General: As required for electrical or mechanical control systems.

B. Type: Electro-magnetically operated, mechanically held unless other types required.

C. Contacts: Double-break, renewable, solid wiping type, self-aligning, quick-make, quick-break.

SECTION 16200 - ENGINE-GENERATOR SYSTEM

2.01 MATERIALS:

A. General: Two independent engine-generator sets with automatic start and automatic paralleling controls.

B. Fuel: Diesel.

C. Voltage: 480V grounded wye/277 V, three phase, four wire.

D. Cooling: Engine-mounted radiator with discharge to exterior.

SECTION 16301 - OUTSIDE DISTRIBUTION

2.01 MATERIALS:

A. Primary Cables: 15KV shielded aluminum cables, 19-strand, 16 No. 14 full capacity concentric wrap neutral, HM polyethelene or ethylene propylene insulation, IPCEA S-61-402 specification.

C. Duct Banks: Rigid non-metallic conduits with concrete encasement.

SECTION 16330 - PAD-MOUNT TRANSFORMERS

2.01 MATERIALS:

A. General: Pad-mount distribution type, 95 KV BIL, wye-wye, four or five legged core.

B. Voltages: Primary 12470 Grd - Y/7200 V; secondary 480 Grd - Y/277 V or 208 Grd - Y/120 V.

C. Primary Switch: Four position, load break, loop feed, internal oil switch.

D. Taps: Four 2 1/2% below; two 2 1/2% above.

E. Primary Fuses: Internal weak-link.

SECTION 16410 - ELECTRIC SERVICE

2.01 MATERIALS:

A. General: Underground secondary from pad-mount transformers or adjacent buildings.

B. Voltages: 480 Grd - Y/277 V or 208 Grd - Y/120 V; three phase, four wire.

C. Conduits: Rigid steel or PVC rigid non-metallic.

SECTION 16450 - GROUNDING

2.01 MATERIALS:

A. Equipment Grounding System: In accordance with code; provide green wire equipment ground conductor with each service, feeder, and all branch circuits.

B. Receptacles: Provide green wire bond jumpers. Mounting screw grounding of receptacles not permitted.

C. Ground Rods: Stainless steel to facilitate cathodic protection.

D. Underground Cables: 600 V insulation to facilitate cathodic protection.

E. Connections: Exothermic type welding process (Cadweld).

F. Grounding Electrode: Reinforcing rod imbedded in concrete foundation in contact with earth.

G. Supplemental Ground Field: Ground rods interconnected with insulated cables.

H. Water Piping: Bonded to grounding electrode.

I. Quiet Grounds: Separate insulated cable to grounding electrode.

J. Interconnections: All grounds interconnected.

SECTION 16460 - DRY-TYPE TRANSFORMERS

2.01 MATERIALS:

A. General: ANSI Specification 089.1; two winding type.

B. Insulation: Class B, F, or H for transformers 25 KVA or less. Class H for insulation for transformers exceeding 25 KVA.

C. Enclosures: Ventilated, except fully enclosed for transformers smaller than 15 KVA three phase and 25 KVA single phase.

D. Sound Ratings: NEMA standard, or better.

SECTION 16470 - DISTRIBUTION SWITCHBOARDS

2.01 MATERIALS:

A. General: Indoor design conforming to applicable standards of ANSI, IEEE, and NEMA.

B. Ratings: 480 Grd Y/277 V, three phase, four wire.

C. Bracing: 50,000 amperes RMS symmetrical.

D. Bus: Copper or aluminum; separate buses for phases, neutral, and ground.

E. Instruments: Voltmeter, ammeter, selector switches, watthour meter with demand register.

F. Ground Fault Protection: Only on 480Y/277 V systems, and only where required by code.

G. Overcurrent Protection: Circuit breaker units.

SECTION 16500 - LIGHTING

2.01 MATERIALS:

A. Type: Fluorescent, incandescent, or mercury vapor as required; complete with lamps, wiring, fitters, hangers, plaster rings, etc.

B. Finish: Bonderized treatment on all steel parts; baked white enamel finish or extruded aluminum.

C. Fluorescent Lampholders: Corrosion-resistant, silver-plated lamp pin contacts.

D. Fluorescent Lens: 100% acrylic conforming to ASTM D788-63; not less than nominal .125 inch thick; prismatic.

E. Incandescent Lens: Prismatic glass generally; polycarbonate diffusers on exterior or where subject to abuse.

F. Ceiling Trim: Coordinated with type of ceiling.

G. Fluorescent ballasts: UL approved; high power factor; ETL certified CBM label; "A" sound rating; premium Class P.

H. Fluorescent Lamps: Standard cool white as manufactured by General Electric, Sylvania, or Westinghouse.

I. Incandescent Lamps: Inside frosted generally; other type as required by the application.

J. Suppressors: Radio interference suppressors in each fluorescent fixture.

SECTION 16610 - LIGHTNING PROTECTION SYSTEM

2.01 MATERIALS:

A. General: Complete systems conforming to NFPA Lightning Protection Code No. 78 and UL Standard No. 96A.

B. Conductors: Copper or aluminum above ground; copper underground.

C. Air Terminals: Copper, copper-clad steel, or aluminum.

D. Grounding Electrode: Connected to grounding electrode of the building.

SECTION 16640 - CATHODIC PROTECTION SYSTEM

2.01 MATERIALS:

A. General: As required by analysis to protect the waveguide.

B. Capacities: As required by soil analysis.

SECTION 16650 - ELEVATOR WIRING

2.01 MATERIALS:

A. General: Coordinated with elevator manufacturer; including power circuits, signal circuit, and hoistway outlets for power and telephone.

SECTION 16721 - FIRE ALARM AND DETECTION SYSTEM

2.01 MATERIALS:

A. Type: Closed circuit, electrically supervised, coded, zone annunciated, continuous ringing, 24 VDC, combination manual and automatic features.

B. Manual Stations: Manual, break-glass, series, two circuit, non-coded, non-interfering, pull type, red lacquer finish, flush mounted in finished areas.

C. Bells: Vibrating, 6 inch, supervised, red lacquer finish.

D. Control Panel: Unit panel or modular type with trouble bell, meters, relays, pilot lights, etc., in wall-mounted cabinet.

E. Emergency Power: Battery standby.

F. Ionization Detectors: Pyrotronics two chamber type.

G. Annunciator: Lamp type.

H. Sprinkler Alarms: System trip and annunciation.

SECTION 16730 - CLOCKS

2.01 MATERIALS:

A. Clocks: Standard synchronous electric clocks with manual reset.

SECTION 16740 - TELEPHONE SYSTEM

2.01 MATERIALS:

A. General: Requirements to be coordinated with Mountain Bell.

B. Conduits: 3/4-inch conduit minimum.

C. Terminal Boards: 3/4-inch plywood boards.

SECTION 16901 - ELECTRICAL SYSTEM CONTROLS

2.01 MATERIALS:

A. General: Control systems to be coordinated with equipment specified and furnished under other sections of the specification.

SECTION 16920 - MOTOR CONTROL CENTERS

2.01 MATERIALS:

A. Type: Indoor, Class II, Type C.

B. Starters: Fusible combination types; as specified in Section 16160.

APPENDIX G - ANTENNA STATION LISTING AND BALANCE POINTS

EAST ARM

STATION		DIST. FROM ORIG.		
			Survey	Earthwork
Prime	Alt.	Meters	Station	Balance Point
				0+00
DE1		47	1+54.199	
DE2		93	3+05.118	
DE3	CE1	180	5+90.550	
DE4		270	8+85.825	
DE5		310	10+17.058	
DE6		350	11+48.292	
DE7	CE2	390	12+79.525	
DE8		450	14+76.375	
DE9		490	16+07.608	
BE1		560	18+37.267	
CE3		700	22+96.583	
CE4	BE2	1120	36+74.533	
CE5		1260	41+33.850	
CE6		1400	45+93.167	
CE7		1493	48+98.284	
CE8		1820	59+71.117	
CE9	AE1	2000	65+61.667	
BE3		2100	68+89.750	
BE4		3360	110+23.600	
				123+60
BE5		3780	124+01.550	
AE2		4000	131+23.333	
				131+30
				137+00
BE6		4200	137+79.500	
BE7		4480	146+98.133	
BE8		5460	179+13.350	
				190+00
BE9		5880	192+91.300	
				197+50
				212+60
AE3		7500	246+06.250	
				252+80
				260+50
				270+85
				279+00
				290+50
				300+00
				309+00
				327+00
				393+00

East Arm (Cont'd.)

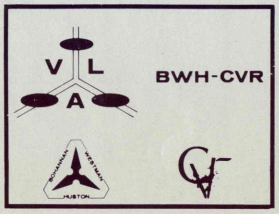
STATION		DIST. FROM ORIG.		
Prime	Alt.	Meters	Survey Station	Earthwork Balance Point
AE4		12000	393+70.000	
				412+50
				438+40
AE5		13500	442+91.250	
AE6		15000	492+12.500	
AE7		16000	524+93.333	
				532+00
				553+50
				565+00
				618+00
AE8		19500	639+76.250	
				653+10
AE9		21000	688+97.500	
				692+00

WEST ARM

STATION		DIST. FROM ORIG.		
			Survey	Earthwork
Prime	Alt.	Meters	Station	Balance Point
				0+00
DW1		35	1+14.829	
DW2	CW1	140	4+59.317	
DW3		180	5+90.550	
DW4		220	7+21.783	
DW5		260	8+53.017	
DW6		335	10+99.079	
DW7		375	12+30.313	
DW8	BW11	415	13+61.546	
DW9		455	14+92.779	
DW10		495	16+24.013	
DW11		535	17+55.246	
CW2		575	18+86.479	
CW3		747	24+50.783	
CW4		887	29+10.099	
CW5		933	30+61.018	
CW6		1353	44+38.968	
CW7	AW1	1500	49+21.250	
CW8		1587	52+06.682	
CW9		1633	53+57.601	
BW2		1680	55+11.800	
CW10		1867	61+25.316	
CW11		1960	64+30.433	
BW3		2240	73+49.067	
BW4		2660	87+27.017	
BW5		2800	91+86.333	
BW6		4060	133+20.183	
				144+60
BW7		4480	146+98.133	
BW8		4760	156+16.767	
BW9		4900	160+76.083	
				172+00
BW10		5600	183+72.666	
BW11		5880	192+91.300	
AW2		6000	196+85.000	
AW3		8000	262+46.667	
				302+00
AW4		9500	311+67.917	
				309+40
AW5		10000	328+08.333	
AW6		14500	475+72.083	
AW7		16000	524+93.333	
AW8		17000	557+74.167	
AW9		17500	574+14.583	
				652+40
				656+10
AW10		20000	656+16.667	
				673+00
				683+90
				688+10
AW11		21000	688+97.500	
				692+00

NORTH ARM

STATION		DIST. FROM ORIG.		
Prime	Alt.	Meters	Survey Station	Earthwork Balance Point
				0+00
DN1		60	1+96.850	
DN2		100	3+28.083	
DN3		170	5+57.742	
DN4		210	6+88.975	
DN5		250	8+20.208	
CN1		327	10+72.832	
DN6	CN2	410	13+45.142	
DN7		450	14+76.375	
CN3		793	26+01.701	
CN4		840	27+55.900	
CN5	BN1	980	32+15.217	
BN2		1260	41+33.850	
CN6		1633	53+57.601	
CN7		1773	58+16.917	
				78+00
BN3		2380	78+08.383	
BN4		2520	82+67.700	
BN5		2940	96+45.650	
				109+00
AN1		3500	114+82.917	
AN2		4500	147+63.750	
BN6		4900	160+76.083	
BN7		5320	174+54.033	
				255+00
				274+30
				277+50
AN3		8500	278+87.083	
				282+10
AN4		9000	295+27.500	
				297+50
				298+50
AN5		10500	344+48.750	
				414+70
				456+90
				541+80
				556+90
AN6		17500	574+14.583	
				592+95
AN7		18935	621+22.579	
				622+00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BWH-CVR