Semiannual Report for

THE CSU-CHILL RADAR FACILITY

Cooperative Agreement No. ATM-8919080

Submitted to

The National Science Foundation

Division of Atmospheric Sciences

1 October 1990

DEPARTMENT OF ATMOSPHERIC SCIENCE
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO

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1. Introduction

This report marks the first semiannual report for the CHILL National Facility since the award of the Cooperative Agreement, ATM-8919080 to Colorado State University (CSU) effective 15 April 1990. The highlights of this first six month period included the physical relocation of the CHILL radar to Greeley, CO where it will be permanently situated while in operation at CSU. At this time, save for the pending arrival of a few new waveguide parts, the CHILL radar is nearly operational in the configuration it was in during operations in Ilinois. Our immediate goal is to have the CHILL radar fully operational (with the new SUNRISE data system installed which will be described in more detail in a following section) by the end of November. The CHILL radar is planned to be part of the data collection network for the upcoming WISP experiment beginning in January 1991.

As discussed in the CSU proposal for the CHILL radar, the department of Electrical Engineering planned to add an additional faculty member in the area of multi-parameter radar if CSU successfully competed for the CHILL facility. Following through on this plan, Dr. V. Chandrasekar has joined the faculty in Electrical Engineering as an Assistant Professor. He began his duties on 15 August 1990. Prof. Chandrasekar is an expert in multiparameter radar and statistical signal processing. He will undoubtedly be a strong addition to the CHILL engineering and scientific staff.

2. Scientific Activities

Since the radar is still being installed in Greeley, CO, it was of course not possible to support any data collection efforts in the past six month period. Our scientific activities with the CSU-CHILL to date have been focussed on insuring high quality, and more versatile data collection in the future.

To insure higher quality measurements of Z_{dr}, the CHILL antenna was rotated 45° when it was reinstalled in Greeley to allow better sidelobe matches between horizontal and vertical polarizations. The antenna rotation places the feedhorn/waveguide support struts at 45° angles, hence their projections are theoretically identical between the orthogonal polarization planes of H and V. New 45° degree waveguide bends are currently on order and should arrive within ten days. Additionally, following Mueller (1984; 22nd Conference on Radar Meteorology), a calculation procedure for differential propagation

phase shift will be programmed into the SP20 signal processor to allow realtime computation of this parameter.

Near future scientific activities focus on preparation for data collection in the WISP experiment, planned for 15 January-31 March 1991. We plan to operate in a dual-Doppler mode with either the University of North Dakota 5 cm Doppler radar, or the 10 cm MILE HIGH Doppler radar to study the dynamics and microphysics in the Front Range area. We also plan experiments this coming summer pertaining to collection of dual-polarization data in electrical storms in the Front Range area by CSU scientists.

3. Educational Activities

Again, activities related to education, like the scientific activities, have focussed on planning for near-future activities. Several developments are currently underway, including plans to have realtime CHILL data available in the Weather Laboratory in the Atmospheric Science (ATS) department, as well as in the Electrical Engineering (EE) department. A SUN IPC workstation with 16 inch color monitor has been acquired for the ATS Weather Lab, on which the SUNRISE software will be installed. A T1 high speed data link, allowing 1.5 megabits per second transmission rates from CHILL to ATS, is currently being installed. A network connection will also continue to Electrical Engineering (EE) to serve the Sunrise workstations planned to be installed in the EE Remote Sensing laboratory. In the upcoming spring semester, the CHILL data will be directly integrated into AT 541, our first year graduate level weather lab course.

Two new courses in the Department of Atmospheric Science were established and offered in the past academic year that will utilize the CHILL facility at their next offerings. These courses, AT 652 (Remote Sensing) and AT 741 (Radar Meterology), taught by Profs. Stephens and Rutledge, respectively, each had enrollments exceeding 20 students.

Profs. Bringi and Chandra in the Department of Electrical Engineering have forwarded a proposal to the NSF REU (Research Experience for Undergraduates) program that would allow undergraduate engineering students in EE at CSU and Ft. Lewis College (in the CSU system) opportunities to work with the CHILL radar facility in a variety of projects. If this proposal is successul, Profs. Bringi and Chandra plan to conduct 8 senior level projects in the area of radar engineering and multi-parameter radar during the 1991 academic year.

The Department of Atmospheric Science was recently contacted by the University of Northern Colorado in Greeley with a request to possibly provide an instructor for a undergraduate level course in Radar Meteorology. After careful thought related to the duties of CHILL staff and the desire to have the CHILL facility play a strong role in education, we currently plan for Pat Kennedy, the CHILL Facility Manager, to offer this 3 hour course on the Greeley campus. The course is scheduled for two 90 minute meetings per week on the Greeley campus with an anticipated enrollment of 12 students. Since the CHILL is located within a 15 minute commute from UNC, it is anticipated that the class will pay frequent visits to the radar for "hands-on" instruction. This effort will provide Mr. Kennedy with valuable teaching experience which will be valuable in the future as we are presently considering offering a summer course on Radar Meterology at CSU during the summer of 1992. If this course is offered, both Mr. Kennedy and Prof. Rutledge will serve as instructors. The aim of this potential course would be to attract students from other academic institutions where instruction in radar meteorology is not offered, but training in the field is desirable. Also we would anticipate that professional scientists in the Boulder area would be intersted in such a course.

CHILL will host (at no cost to CHILL) two Taiwanese visitors during the period from 15 January to 15 April, 1991 in cooperation with NCAR. One of them, Mr. Salem Hwang is the newly appointed head of radar meteorology for the Central Weather Bureau in Taiwan. We will provide them office space at CHILL. They will interact with CHILL staff and participate in WISP during their stay.

4. Operational and Refurbishment Activities

The adaptation of the radar to a new home base and the installation of the Sunrise data system have precluded any research operations to date. However, several test operations are planned for the remainder of 1990.

The beam patterns of the antenna at both horizontal and vertical polarizations will be measured using a newly acquired S band signal generator driving a moveable standard horn. Permission has been secured to place the signal generator and horn atop a 160 foot high sugar plant located approximately 2 miles southwest of the radar. The horn can be oriented to transmit either horizontally or vertically polarized radiation. At each polarization, the CHILL main beam and sidelobe patterns will be mapped by recording the

received signal strength as the antenna slowly scans over the vicinity of the signal generator site. As briefly discussed in Sec. 2, the 45 degree rotation of the antenna feed supports is expected to improve the sidelobe matching between the horizontally and vertically polarized beam patterns.

A test of the complete radar system reflectivity calibration is also anticipated. Discussions with the Federal Aviation Administration (FAA) are underway to allow operation of a tethered balloon carrying a calibration sphere target. For proper illumination of this target, a balloon altitude of approximately 1000 feet is desired at a range of 4-5 miles. Tethered balloon operations at these heights will require a regulatory waiver from the FAA. If this does not prove to be feasible, then the antenna gain will be determined from the pattern tests outlined earlier, or from solar flux measurements. Finally, verification of the proper operation of the complete radar system will be achieved during test operations shortly before the mid-January start of the WISP program. Our goal is to begin WISP with the CHILL system in an established, acceptable, stable configuration.

Improvements have also been made to the data processing, radome, antenna, and auxiliary power supply systems of CHILL. An overview of the new CHILL data system is presented in Fig. 1. Most of the equipment resides in the radar trailers. Analog quadrature video (I,Q) and analog log video will be fed from the radar receiver into the new analog input card for the SP20. This input card will also generate the triggers for the radar and polarization switch and the instantaneous automatic gain control (IAGC) signal which controls the switchable attenuator in the linear receiver. The output of the SP20 will feed both the existing Microvax/Adage display system and the new Sunrise system. The existing Microvax/Adage display system will be retained to help verify the performance of the new system and to serve as a backup, in addition to offering expanded color display capabilities.

The Sunrise VME bus system will control the antenna motion and set radar operating modes through control of the SP20. The VME bus houses a 68030 processeor which will generate product files such as PPI's, CAPPI's, and randomly oriented vertical cross-sections. Also housed in the VME chassis is a Sun SPARC 1/E computer which provides a complete color workstation when connected to an external display and keyboard. This SPARC board will run the standard Sunrise user software which allows the viewing of radar products and interactive control of the radar scanning and operating modes.

An Ethernet cable will connect the VME chassis to a Sun SPARCstation IPC in the User van which is located adjacent to the radar trailer. This Ethernet is extended using remote bridging hardware and a T1 telephone line (1.5 megabits/sec) back to the CSU Atmospheric Sciences weather lab to serve the Sun SPARCstation IPC located there. The network is further extended by way of the existing CSUNET back to the engineering campus and to more remote locations via Internet. Workstations running Sunrise in the User van, at the ATS weather lab, and in EE will be able to view radar products and control the radar if authorized. Products will be available for viewing at the weather lab within seconds of when they become available at the radar. The radar Ethernet is also extended via fiber optic repeaters into the nearby CHILL office building. There it will connect to personal computers and to a future radar display color workstation.

The initial installation of the Sunrise data system is scheduled for the first week of October. After the initial installation, CHILL personnel will spend 4 to 6 weeks integrating Sunrise into the existing CHILL system. At the end of this integration period, Lassen personnel will return to solve any remaining problems. Two new interfaces to bring information into the Sunrise hardware have been designed and built by CHILL staff. One interface provides SP20 data to Sunrise, the other provides azimuth and elevation data. The plan is to use the existing SP20 software and philosophy as a base for future developements. To this end, the existing SP20 developement tools have been largely converted from the VAX to the Sun operating environment. After Sunrise is delivered, it will assume the job of SP20 software developement and real-time control of the SP20.

A new 73 foot diameter CHEMFAB radome has been installed. This radome was acquired from NCAR stock as it was intended for installation at CP-2. A replacement radome has been ordered from CHEMFAB by CSU and will be shipped to NCAR. This large radome has required changes in the inflation fan speeds. In order for the radome to withstand a 140 mph wind, the recommended high speed blower pressure setting is 9 3/4 inches of water. To obtain this value, a new variable pitch sheave was required. It was also necessary to increase the size of the blower motor from 5 hp to 7.5 hp. At present, the high speed blower is adjusted to yield a pressure of 6.4 inches of water. This is adequate for a 110 mph wind speed, and is considered to be satisfactory for the early fall season. No sheave change was necessary for the low speed blower to develop the 2.5 inch pressure that is recommended for Greeley's elevation.

The components for a third inflation fan, which is powered by a gasoline engine, are being purchased. This will provide a redundant non-electrical fan for use when the commercial power fails and the Onan standby generator engine fails to start. This is considered to be a small expenditure to provide further protection for the expensive large diameter radome.

The radome was erected on August 28, 1990, and the operation was uneventful. Based upon incidents that occurred during the installation, minor improvements to the design of the tie down rings and the entry door sealing were recommended to the radome's manufacturer (CHEMFAB). It should be noted that the tie down rings, new airlock entry doorway, and the back-draft preventers were fabricated by NCAR for this project. The costs for this fabrication, totalling approximately $20,000, were paid by CSU.

The antenna drive system has been improved by the installation of the fourth, and final, motor and amplifier board. The new system is operating well and should be more reliable than the earlier motor-generator based system. Both azimuth drive high speed gearboxes have been refurbished with new oil and grease seals. The rate of oil leakage has been substantially reduced as a result of these actions. Finally, the antenna and pedestal were cleaned and painted upon their arrival in Colorado.

Auxiliary power for the Greeley site will be available from the diesel generator that was obtained by the Water Survey from NCAR after the conclusion of the CCOPE project in Montana. This system will be used to operate the radar and to provide minimal office building power when the commercial power fails. This generator has not been used since 1981, and therefore has required the services of a diesel mechanic to restore it to operation.

In addition to these improvements and refurbishments, we have also ordered a new S band polarization switch from Raytheon. In addition to improved temperature stability of this new switch (to be delivered in six months), the new switch will be installed in series with the existing ferrite polarization switch to increase the isolation between the H and V channels. A state of the art microwave signal generator from Hewlett-Packard ($23K) has been acquired for CHILL. The lightning protection plan for CHILL consists of a series of ground rods on the antenna pedestal and trailers. Additionally, the commercial power was buried underground for a distance of 600 feet upstream of the secondary power transformer

installed at the site. A new solid state intermediate power amplifier for the high power klystron will be ordered for CHILL in the immediate future.

5. Physical Site Plan

Construction of the CSU CHILL Radar Facility office building is currently underway. Only two rather high cost bids were received for the originally proposed modular style building. As a result, the building specifications were changed to conventional frame type construction and a second bid solicitation was offered. The present contract was awarded to the Faust Construction Company of Greeley on September 12, 1990. The contract calls for the building to be completed within 90 days of the contract award, so the building should be occupied by year's end. The new building will have adequate space (approximately 2400 sq. ft.) for both the CHILL radar staff and for visiting scientists. Additional space has also been allocated for data archival and review as well as for an electronics shop. We plan to locate one of the Sunrise display's and workstation in the CHILL staff building. Site plan drawings are given in Fig. 2. The entire site will be enclosed with a security fence.

6. Appointment of the Radar Advisory Committee

As described in the CSU CHILL proposal to the NSF, we planned to establish a Radar Advisory Committee. The charge to this committee is to review the previous year's activities and radar performance, advise the Scientific Director on in-house research and enhancement activities for the coming year, review the facility educational initiatives, and advise the Facility staff on improvements in operations and capabilities. We have completed the appointment of this committee who's members are:

Dr. Jeffrey Keeler, NCAR/ATD
Dr. Dusan Zrnic, NSSL/Norman
Prof. Roger Wakimoto, UCLA
Prof. George Aunon, Head, Department of Electrical Engineering, CSU
Prof. William Cotton, Department of Atmospheric Science
Prof. Pierre Julien, Department of Civil Engineering

We plan to convene the RAC for it's initial meeting during February, 1991.

7. The following information provides a list of CHILL personnel.

Project Co-PI's

Prof. S. K. Cox, ATS

Prof. V. N. Bringi, EE

Prof. S. A. Rutledge, ATS

Staff

Prof. S. A. Rutledge, Scientific Director

Dr. Eugene Mueller, Senior Engineer

Patrick Kennedy, Facility Manager

David Brunkow, Software Engineer

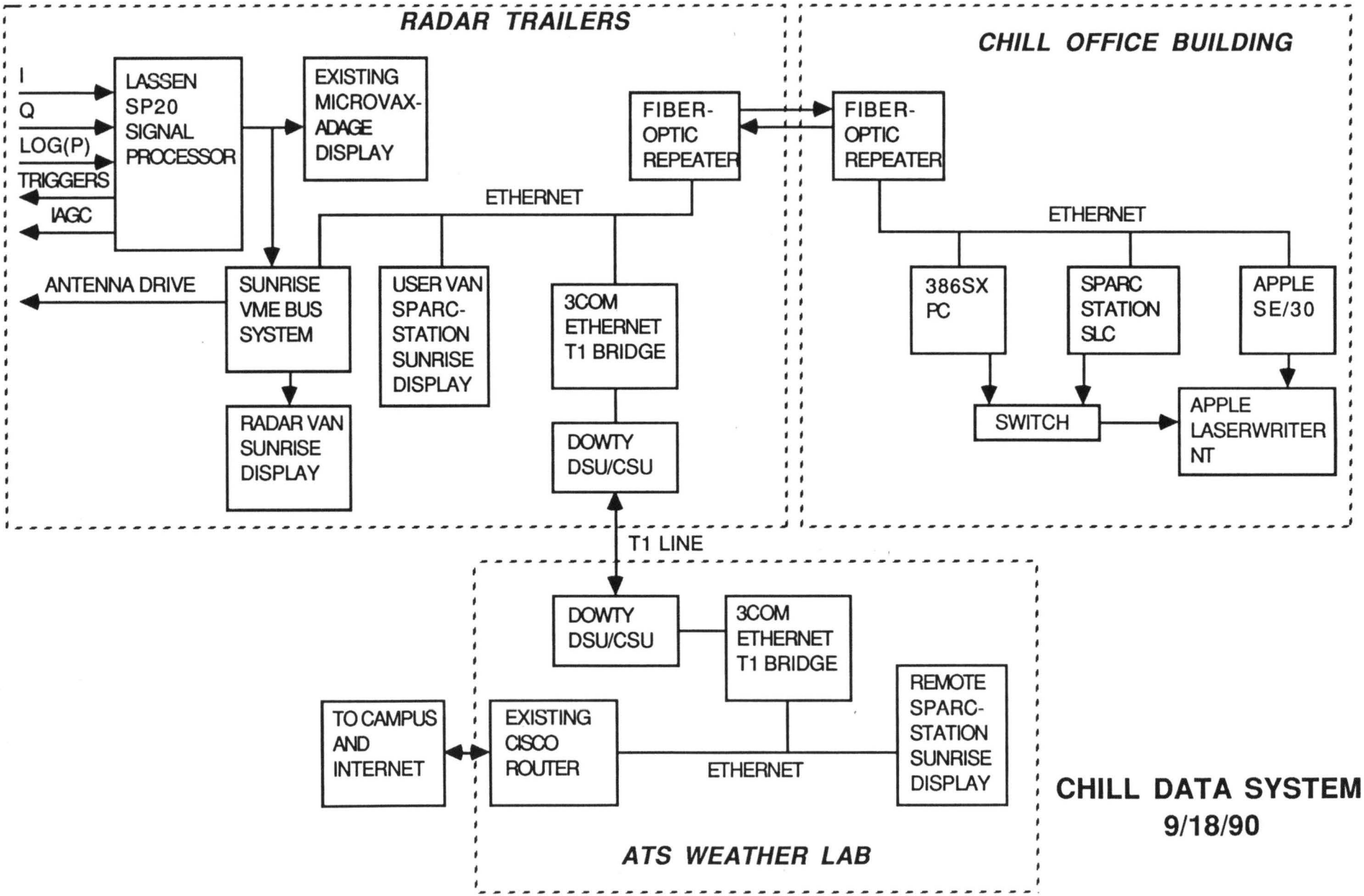
Ken Pattison, Electronic Technician

Cindy Carrick, Secretary

Figure Captions

Fig. 1. Schematic of the plan for data display and radar control.

Fig. 2. Plan drawings for the CHILL showing physical layout of the site and building presently under construction.



CHILL DATA SYSTEM
9/18/90

Figure 1

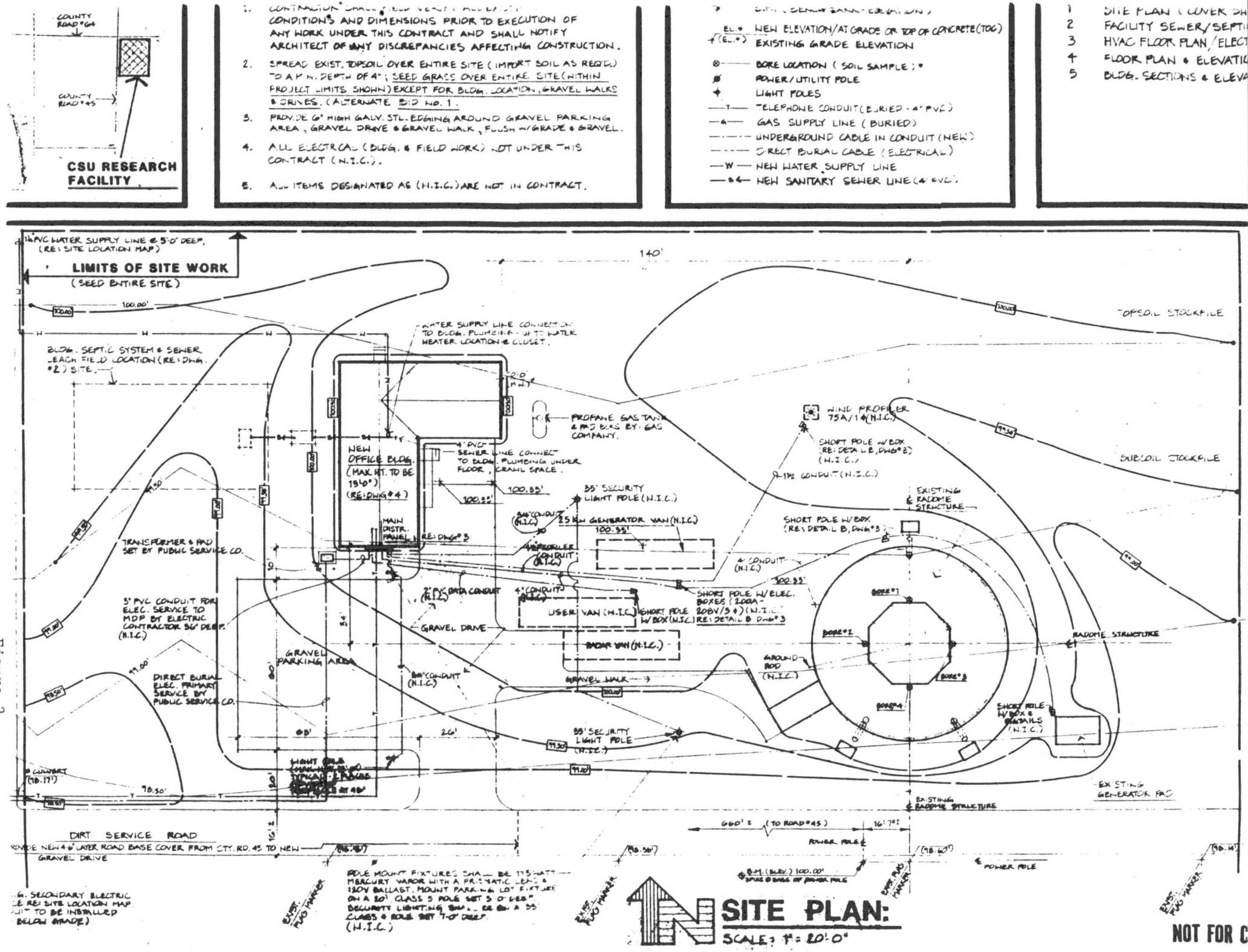
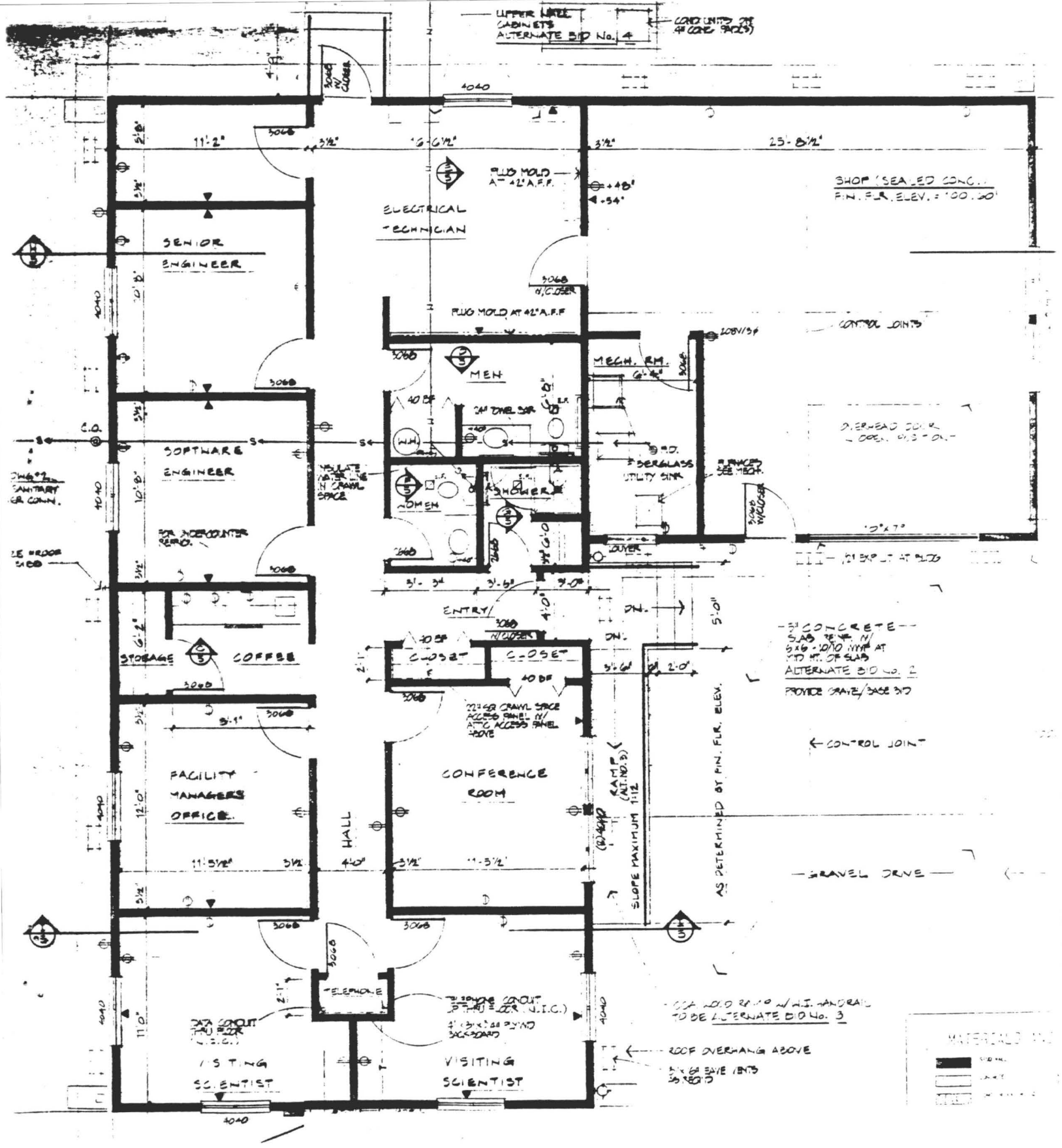
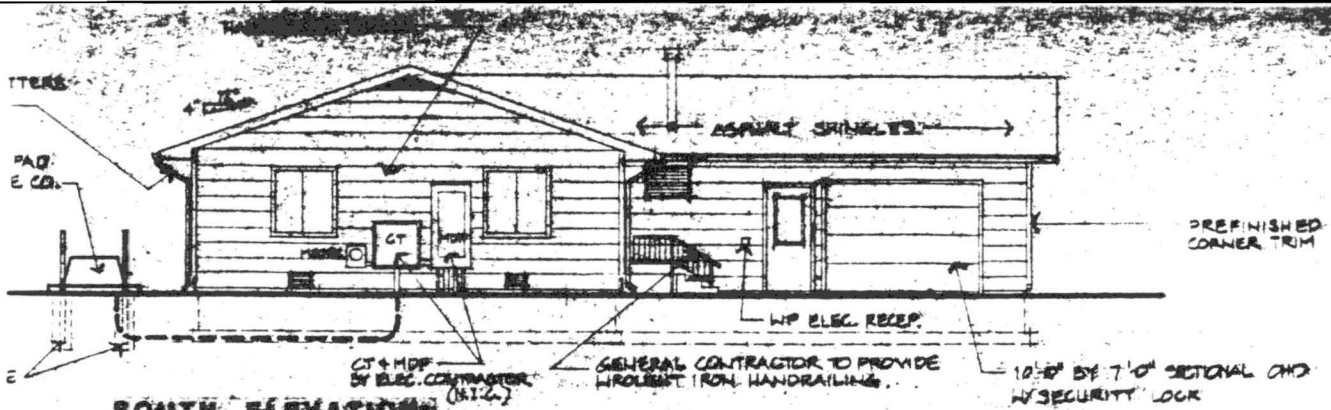
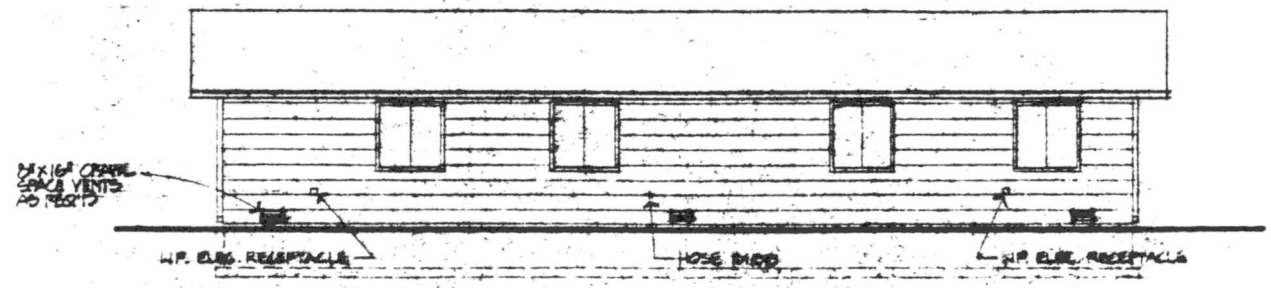

COUNTY ROAD #64
COUNTY ROAD #45
CSU RESEARCH FACILITY
1. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING CONDITIONS AND DIMENSIONS PRIOR TO EXECUTION OF ANY WORK UNDER THIS CONTRACT AND SHALL NOTIFY ARCHITECT OF ANY DISCREPANCIES AFFECTING CONSTRUCTION.
2. SPREAD EXIST. TOPSOIL OVER ENTIRE SITE (IMPORT SOIL AS REQ'D.) TO A MIN. DEPTH OF 4"; SEED GRASS OVER ENTIRE SITE (WITHIN PROJECT LIMITS SHOWN) EXCEPT FOR BLDG. LOCATION, GRAVEL WALKS & DRIVES. (ALTERNATE BID NO. 1.
3. PROVIDE 6" HIGH GALV. STL. EDGING AROUND GRAVEL PARKING AREA, GRAVEL DRIVE & GRAVEL WALK, FLUSH W/GRADE & GRAVEL.
4. ALL ELECTRICAL (BLDG. & FIELD WORK) NOT UNDER THIS CONTRACT (N.I.C.).
5. ALL ITEMS DESIGNATED AS (N.I.C.) ARE NOT IN CONTRACT.
EL. NEW ELEVATION/AT GRADE OR TOP OF CONCRETE (TOC)
(EL.) EXISTING GRADE ELEVATION
BORE LOCATION (SOIL SAMPLE)
POWER/UTILITY POLE
LIGHT POLES
TELEPHONE CONDUIT (BURIED - 4" PVC)
GAS SUPPLY LINE (BURIED)
UNDERGROUND CABLE IN CONDUIT (NEW)
DIRECT BURIAL CABLE (ELECTRICAL)
NEW WATER SUPPLY LINE
NEW SANITARY SEWER LINE (4" PVC)
1 SITE PLAN (COVER SH
2 FACILITY SEWER/SEPTI
3 HVAC FLOOR PLAN/ELECT
4 FLOOR PLAN & ELEVATIO
5 BLDG. SECTIONS & ELEVA
1½" PVC WATER SUPPLY LINE @ 5'-0" DEEP, (RE: SITE LOCATION MAP)
LIMITS OF SITE WORK
(SEED ENTIRE SITE)
140'
100.00'
TOPSOIL STOCKPILE
SUBSOIL STOCKPILE
BLDG. SEPTIC SYSTEM & SEWER LEACH FIELD LOCATION (RE: DWG. #2) SITE.
WATER SUPPLY LINE CONNECTION TO BLDG. PLUMBING - AT WATER HEATER LOCATION & CLOSET.
NEW OFFICE BLDG. (MAX. HT. TO BE 19'0") (RE: DWG #4)
4" PVC SEWER LINE CONNECT TO BLDG. PLUMBING UNDER FLOOR, CRAWL SPACE.
PROPANE GAS TANK & PAD BY GAS COMPANY.
WIND PROFILER 75A/14 (N.I.C.)
SHORT POLE W/BOX (RE: DETAIL B, DWG #3) (N.I.C.)
1½" CONDUIT (N.I.C.)
35' SECURITY LIGHT POLE (N.I.C.)
MAIN DISTR. PANEL (RE: DWG #3)
4" CONDUIT (N.I.C.)
25 KW GENERATOR VAN (N.I.C.)
TRANSFORMER & PAD SET BY PUBLIC SERVICE CO.
4" CONDUIT (N.I.C.)
EXISTING RADOME STRUCTURE
SHORT POLE W/BOX (RE: DETAIL B, DWG #3)
3" PVC CONDUIT FOR ELEC. SERVICE TO MDP BY ELECTRIC CONTRACTOR 36" DEEP. (N.I.C.)
2" PVC DATA CONDUIT (N.I.C.)
4" CONDUIT (N.I.C.)
USER VAN (N.I.C.)
SHORT POLE W/ELEC. BOXES (200A - 208V/3 ϕ) (N.I.C.)
SHORT POLE W/BOX (N.I.C.) (RE: DETAIL B DWG #3)
GRAVEL DRIVE
RADOME STRUCTURE
GRAVEL PARKING AREA
FACILITY VAN (N.I.C.)
DIRECT BURIAL ELEC. PRIMARY SERVICE BY PUBLIC SERVICE CO.
4" CONDUIT (N.I.C.)
GROUND ROD (N.I.C.)
BORE #1
BORE #2
BORE #3
BORE #4
GRAVEL WALK
SHORT POLE W/BOX & GUY WIRES (N.I.C.)
55' SECURITY LIGHT POLE (N.I.C.)
CULVERT (98.17')
98.50'
EXISTING GENERATOR PAD
EXISTING RADOME STRUCTURE
DIRT SERVICE ROAD
PROVIDE NEW 4-6" LAYER ROAD BASE COVER FROM CTY. RD. 45 TO NEW GRAVEL DRIVE
660' ± (TO ROAD #45)
16'-7"
POWER POLE
(98.60')
POWER POLE
B.M. (BLEY.) 100.00' SPIKE @ BASE OF BRONZE POLE
(98.14')
EXIST. BUG MARKER
EXIST. BUG MARKER
EXIST. BUG MARKER
EXIST. BUG MARKER
POLE MOUNT FIXTURES SHALL BE 175 WATT MERCURY VAPOR WITH A PHOTOMATIC LENS & 120V BALLAST. MOUNT PARKING LOT FIXTURE ON A 20' CLASS 5 POLE SET 5'-0" DEEP. SECURITY LIGHTING SHALL BE ON A 35' CLASS 4 POLE SET 7'-0" DEEP. (N.I.C.)
G. SECONDARY ELECTRIC E RE: SITE LOCATION MAP UIT TO BE INSTALLED BELOW GRADE)
SITE PLAN:
SCALE: 1" = 20'-0"
NOT FOR C

Figure 2

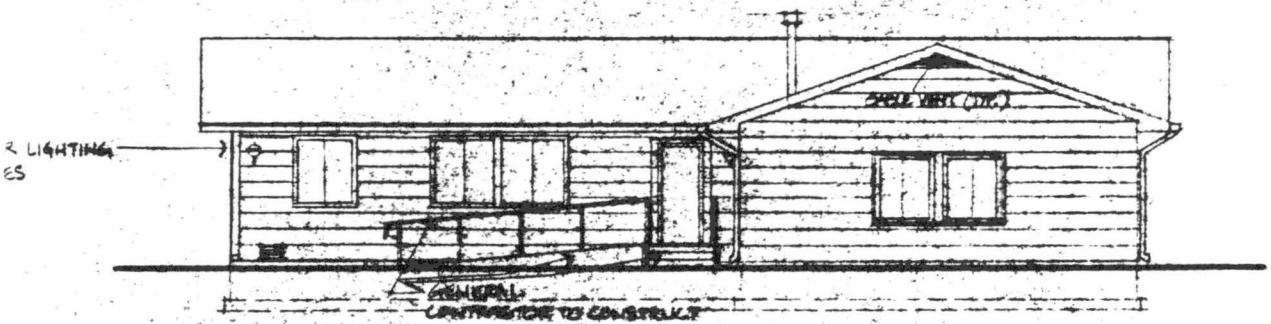

UPPER LEVEL CABINETS ALTERNATE BID No. 4
ELECTRICAL TECHNICIAN
SENIOR ENGINEER
SOFTWARE ENGINEER
FACILITY MANAGERS OFFICE
CONFERENCE ROOM
HALL
STORAGE
COFFEE
MEN
WOMEN
SHOWER
ENTRY
MECH. RM.
SHOP (SEALED CONC.)
FIN. FLR. ELEV. = 100.20
PLUG MOLD A= 42" A.F.F.
PLUG MOLD AT 42" A.F.F
FIBERGLASS UTILITY SINK
OVERHEAD DOOR
CONTROL JOINTS
GRAVEL DRIVE
SLOPE MAXIMUM 1:12
AS DETERMINED BY FIN. FLR. ELEV.
5" CONCRETE SLAB REINF. W/ 6x6 - 10/10 WWM AT MID HT. OF SLAB
ALTERNATE BID NO. 2
PROVIDE GRAVEL/BASE BID
CONTROL JOINT
ROOF OVERHANG ABOVE
VISITING SCIENTIST
DATA CONDUIT
TELEPHONE
4040
3068



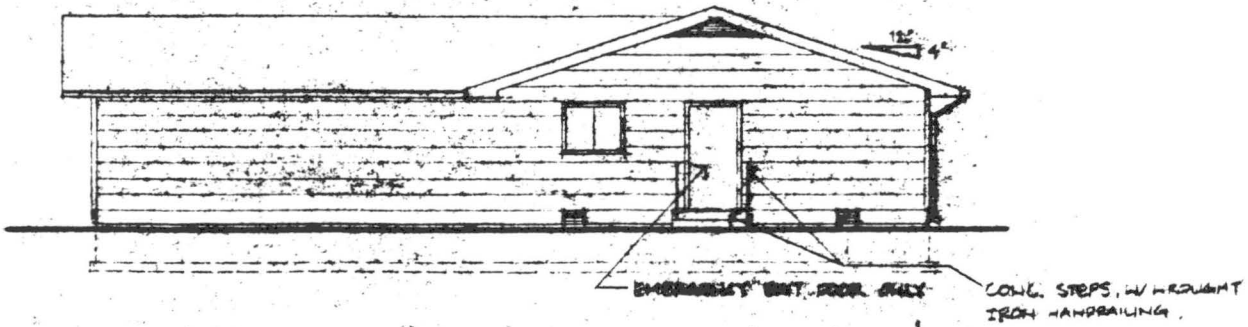
SOUTH ELEVATION
SCALE: 1/8" = 1'-0"



WEST ELEVATION
SCALE: 1/8" = 1'-0"



EAST ELEVATION
SCALE: 1/8" = 1'-0"



NORTH ELEVATION
SCALE: 1/8" = 1'-0"

FINISHING NOTES

GENERAL CONSTRUCTION NOTES