Construction of the Missile Silo doors was the last large concrete pour for each complex. The contractor had elected to pour the doors in place which would effectively close the tops of the Missile Silos. To avoid undue delays created by closing the silos for door work, the Area Engineer scheduled a one month period for accomplishment of this work.

Another question that arose was the method of opening the Missile Silo doors. At other Areas, serious accidents had resulted when doors malfunctioned, and CEBMCO had issued strong directives on the subject of door opening procedures.

After a thorough study of all possible means for opening the doors, a procedure was approved for opening the doors using the installed hydraulic door mechanism.

Coordination with the AMF Company, who designed and installed the hydraulic opening mechanism, resulted in a procedure whereby the facility contractor now should open the doors approximately 10 inches, Appendix B, Tab 54, Page 2-99 to permit introduction of hydraulic and electric lines into the top of the silos. AMF would then attach a small hydraulic pump directly to the actuating cylinder and open one leaf of the door.

This procedure proved to be highly effective and silo doors on all complexes were opened without difficulty. Appendix B, Tab 55, Page 2-100 shows Missile Silo doors open. Appendix B, Tab 56, Page 2-101 shows method of holding Missile Silo doors open.

PART VII -- SUPPORT FACILITIES

Guided Missile Assembly Building, Acid Waste Treatment Plant and Six Way Communications Duct (DA-6134)

The Architectural Engineer was J. T. Banner and Associates.

Operations began 4 April 1960.

These facilities are all included under Contract No. DA-6134 and are interrelated to one another. It should be stated here that the G.M.A. Building was constructed within Building 7504 which is a large hanger at Ellsworth Air Force Base. The Acid Waste Treatment Plant and the Six Way Communications Duct System were constructed outside Building 7504.

The sequence of construction is as follows: At the start of the construction period, the subcontractors began mobilizing material and equipment. It was necessary to do some demolition work such as removing doors and a few partitions before any real progress could be made.

One of the first operations to be accomplished was the excavation for the Acid Waste Treatment Plant. It was necessary to dig a drain around the excavation to prevent the water draining off Building 7504 from running into the excavation.

There were fifteen electric manholes connected with this project and work began next on the excavation and forming for them.

Excavation for the acid lines from the Guided Missile Assembly Building to the Acid Waste Treatment Plant also began early in the project. Reinforcing steel and concrete forms for the basement slab in the Acid Waste Treatment Building were set concurrently, as was the installation of partitions, mesh and insulation in the Guided Missile Assembly Building.

When the necessary excavation was complete, duriron acid pipe from the GMAB to the A.W.T.P. was installed and tested. Backfill operations were then accomplished over the piping.

Next the basement slab was poured and backfill operations started. The excavation forming and concrete pouring continued. Framing was continued in the B.M.A. Building and gyp board was applied. The installation of water piping was started.

Forms were set for the wet well slab in the A.W.T.P.; installation of steam pipe was next in line; also at this time wainscoting was being applied in some areas of the G.M.A.B., and framing and the application of gyp board was continuing in this structure. The placement of concrete in the cell walls was started.

The installation of transformers was begun in the G.M.A.B. Concrete and stub-ins were placed in the communication manholes. Work was started on the ventilating system ductowrk. Conduit for power and conduit and panel boxes for telephones were installed. The taping of gyp board was started in the G.M.A. Building.

At the Acid Waste Treatment Building, masons began laying concrete blocks for the walls. In the communications duct portion of the project, progress was continuing with additional excavation, forming, placing of concrete and conduit was now placed between the manholes.

The modification pertaining to the electric power panel in the generator room was completed as was the installation of demineralized water equipment and miscellaneous piping.

These operations completed the construction of this project except for the installation of Gaseous Nitrogen piping on 21 December 1961.

Due to an incomplete design of the electrical system, numerous modifications had to be executed. Numerous changes in the nitrogen system also delayed the project, as The Martin Company was in the process of determining what type of equipment was to be installed. Final acceptance of the A.W.T. Plants was delayed due to the amount of acid required to test the plant. It was determined that the plant would be tested when the Using Service was ready to put the plant in operation and had the acid available. Therefore, the operational schooling was delayed until this time.

In the Guided Missile Assembly Building, framing and gyp board operations were continuing and the installation of heat piping was begun. Forms were built and later concrete was placed on the chemical waste tank in the A.W.T. Plant. Masons continued laying concrete blocks. The priming of walls for painting began in the G.M.A. Building.

The roof was placed on the A.W.T. Plant. Also, the installation of acid piping and the cooling tower were set in that structure. Power was cut in to the transformers in the G.M.A. Building, and fresh air ducts were installed. Work was started on the modification of the hanger doors. The communication duct portion of the project was not substantially complete.

Floor grating was set and the installation of the conduit began in the A.W.T. Plant. In the G.M.A. Building, insulation was being placed on metal ductwork, hardware was being installed on doors, the painting of walls and ceilings, and the installation of registers and grills was started. The installation of motor control boxes was being done in both the G.M.A. Building and the A.W.T. Plant.

Work started on the waste line modification. Air handling units were set and the installation of wiring and fixtures was carried on throughout the project. The modification that added the panel with the additional bus was executed.

The Nitrogen tanks were unloaded from flatcars and purged. The installation of the master fire alarm system was completed. Mixing units were placed in the acid tanks. The monorail was completed.

Re-Entry Vehicle Facilities, Building 7504

(Contract No. DA-6675)

The architectural engineer was J. T. Banner & Associates.

Construction began 23 January 1961. There was very little demolition required here except for the removal of some partitions. The Re-entry Vehicle Facilities Building was constructed within Building 7504 which is a large hanger at Ellsworth Air Force Base.

The construction work started with the layout of the partitions. Framing and erecting the partitions began soon afterward. With the erection of the partitions, electrical and telephone conduit and junction boxes were installed. At this time the gyp board was installed, and joints were taped and sanded. During these operations, steam piping for the heating unit and condensate return line were installed.

The painters applied the primer coat of paint and later the finish coats. With the installation of the heating and ventilating units, metal ducts and insulation on same, and the installation of light fixtures, the contract was complete.

A problem arose, on one building, when the plans showed a door opening of 14 feet and the existing door opening was smaller than the dimensions shown. The contractor had to remake his door to fit the existing opening.

Liquid Oxygen Facilities

(Contract No. DA-6294)

Operations began on 22 July 1960.

The sequence of construction was as follows:

Excavation and pipe laying operations began as the first part of this construction. Excavation for the footings of the building and the nitrogen tanks was completed, forms were set and the concrete was poured for the waste drain manhole and heat exchanger pad.

Next the forms were set and the concrete poured for the foundation walls. Drains were layed to toilets and backfill was placed. Concrete was placed in compressor pads. Linemen began erecting electric line to building, and after a sufficient number of poles were set, and cross arms attached, electric service was connected to the building. Water piping was layed and backfill placed. The curbs and gutters were formed and poured. Work began on the steel framework of the building and concrete was placed for paving.

The installation of conduit, outlet boxes and plumbing was next in line. Masons were now laying the necessary concrete blocks. Fire hydrants were in place and siding was attached to the building. At the railroad siding, workmen now moved LOX tanks from flatcar to the lowboy. When they arrived at building, the tanks were placed on their piers. Nitrogen tanks were installed and piping connected. Diesel engines and compressors were in place. The 350 MCM cable was installed. When the roof was installed, gas and water piping installed, electricity connected, interior painted and all metal ductwork insulated, the project was complete.

A problem arose when the supplier did not send all the necessary information on the prefab metal building. Therefore, the contractor had trouble getting the building approved. Also, the building and a number of sections had to be reworked so that it could be erected properly. The Power Electric Company failed to submit shop drawings on time. This held up completion of the distribution system.

Site E-5A (Complex 1B) Access Road

(Contract No. DA-5850)

Contractor - Summit Construction Company, Site E5A (Complex 1B) Access Road.

This road was completely built from original ground and construction began on 5 October 1959. After the right of way had been approved and the road traverse was laid out, culverts were laid at various points on the road to provide the necessary drainage.

As construction continued, stripping operations were carried on keeping ahead of the current operations. The necessary earth fill was hauled to the road, graded and compacted. The sub-base layer was placed and compacted and next the base layer of material added and compacted. The base layer was primed with armor coat. The final finish operation was the application of a 2 inch mat of bituminous pavement.

During the road building operations, numerous other activities relative to that project were being accomplished. One of these related activities was the erection of a prefabricated underpass. At both the east and west abutment, concrete piling were used, side by side, in a manner which formed a solid wall. A cap was formed and poured atop them to receive the prefabricated concrete decking. With the decking place and the wing walls poured, the construction of the bridge was complete. Fencing of the right of way was conducted concurrently during the road construction period, so as to be substantially completed at the same time as the road construction work. Guide post holes were dug and guide posts placed and temped. When these related items were accomplished, the project was complete.

Water Wells, Auxiliary Sites

(Contract No. DA-5683)

The design of each Titan site required that two water wells be drilled within the confines of the site powerhouses. Each well was to sustain a definite water production rate, so that an adequate water supply would be assured in the event that one of the two wells would fail.

Geological studies by the Omaha District indicated that water from the Black Hills flowed eastward from the hills along several beds of impervious strata which sloped downward, from ground level, in a general easterly direction and that adequate water supplies would require well depths ranging from 1800 to 3500 feet.

Contracts were issued on 26 June 1959 to M & G Drilling Company of Casper, Wyoming, for the six water wells required. M & G Drilling began preparatory work on 14 July 1959 and began actual drilling operations on Well E-2 (Site 1A) on 27 July 1959.

A typical well drilling operation, as explained below for Well E5A-A, is as follows:

Drilled 9 7/8" pilot hole; reamed to 22 inches; hole to -310.5'; set 18" OD 3/8" wall, 70.59#, Gd B., Sml, Vev end, Blk line pipe, and it cemented from -115.5' to -310.5'.

The pilot hole was then drilled to 1946.5'. An electric log and direction log were run on the pilot hole to determine probable quantity of water and plumbness. The pilot hole was then reamed to 22" from elevation ground level to -310.5'. The 18" OD, 3/8" wall, 70.59# Gd B, Smls, bevl end; blk line casing was set and cemented from ground level to elevation -310.5'. A temperature log was then run to determine effectiveness of cementing. The pilot hole was then underreamed to 24" from -1470.5' to -1758/5'. Then 228' of 8" ID, Johnson Stainless Steel well screen, 40.5' of 8 5/8" OD, Sch. 10, Stainless Steel pipe, and a 8 5/8" OD, J-55 guide and backoff nipple were installed. A Nelson lead seal and adapter were installed on the stainless steel pipe to prevent the gravel from entering the screen. The area around the screen was gravel packed with .012" to 1/8" gravel. The gravel pack was installed by using a Halliburton pump truck and blender.

The large well rig was then removed from over the hole and a small rig was moved in to bail and clean the well. After this was completed, a test pump was installed and a 24-hour pumping test was run.

Wells Number 5A-A, E2-A and E4-A are all underreamed to 24" and gravel packed around the stainless steel screen. Wells number 5A-B and E2-B are gravel packed around the stainless steel screen but not underreamed. Well number E4-B is an artesian flow and is not gravel packed. It has no screen or pump.

Some difficulty was encountered initially in Wells E-2A and E-5A, at Sites 1A and 1B respectively, in maintaining plumbness requirements in the first 1000 feet. This was true particularly at E-5A due to large boulders in gravel vein which existed 50 - 100 feet below the surface.

The underreaming of these wells also created considerable difficulty because of the large underreamed hole required in the aquifier formation. At Site 1A this was accomplished at a depth of over 3000'.

One of the biggest problems occurred at Complex 1A and Well E-2A, when, after the screen was set and the gravel packing completed, the adapter collar collapsed. This made a very difficult fishing job. It caused a five to six week delay in completion of Well E2A and the start of E2B, and eventually was the reason for the change in sequence of the completion dates of Complexes 1A and 1B.

The second wells at both Sites 1A and 1B were completed without unusual difficulties.

At Complex 1C, the first Well E4A was drilled to a depth of approximately 1800' and an artesian flow of between 3-5 gals/minute was encountered. However, when it was test pumped, only 30-35 gals/min could be produced. This was not sufficient for the requirements. The well was circulated under high pressure in order to increase the flow and also the aquifer formation was fractured but to no avail.

Therefore, it was decided to go to a greater depth in a better water bearing formation with the other well, E4B. Drilling had progressed to a depth of 3173 feet when a water vein was tapped which contained a high pressure of over 140 psi at the surface. The blow off preventer that set in the 18" casing saved the well from going wild. Water gushed at over 3000 gals/min for almost 30 days before the well was brought under control. This was accomplished by pumping very heavy mud in the hole and weighing the pressure down until solid casing could be installed and cemented in. Then this casing was perforated and a special valve installed to control the flow. This valve is set at a depth of between 600-700' and is controlled by air pressure.

After completion of the open cut excavation for the powerhouse at Site 1C, this special control valve appeared to be malfunctioning. Therefore, it was pulled, repaired and reinstalled. The cause of the malfunction was determined to be welding slag dropping in under the seals.

PART VIII -- ELECTRICAL EQUIPMENT

General

The electrical work for each complex included diesel generator sets, power distribution, motor control centers, lighting, communication raceways, grounding and alarm systems.

The Powerhouse is the heart of the complex. It houses the main electrical equipment, consisting of the following: four (1020 KW per unit at 2400/1360 Volt) diesel generator sets; 2.4 KV free standing switchgear; 1000 KVA unit substation, 2400/480 volts; Appendix B, Tab 57, Page 2-102, 2400 primary voltage motor control panels for the two 350 HP fire pump motors; the air intake (150 HP motor); water chillers and several 480 volt panels to operate necessary support equipment required in the powerhouse. Appendix B, Tab 58, Page 2-103.

The Control Center, which contains the launch and control electronic equipment, is the terminal point for control and alarm systems and equipment to be installed by the I & C contractors. The electrical installations included cable trays, lighting, air conditioning equipment and a 2400/480 volt 300 KVA substation.

The missile silos have wall mounted mercury vapor type fixtures, several large terminal boxes, thousands of feet of conduit and control wiring, various sensors and alarms, sump pumps, RP-1 pumps and LOX pumps installed. Appendix B, Tab 59, Page 2-104, shows conduit installation.

The Equipment Terminals have a 1000 KVA, 2400/480 volt substation, motor control center for pumps, air conditioning equipment and light fixtures. The Equipment Terminal electrical equipment services Missile Silos and Propellant Terminals. Appendix B, Tab 60, Page 2-105, Appendix B, Tab 61, Page 2-106, shows cable tray and conduit installation in Equipment Terminal.

The tunnels contain conduit, cable trays and shock mounted light fixtures. The ballast for the lights in the missile silo are installed in the tunnels.

All underground structures are equipped with emergency lights to be used in the event of a power failure.

Grounding

Grounding mats were installed in the Equipment Terminals, Propellant Terminals, Missile Silos, Control Center and Powerhouse. All of the grounding mats were connected in to one grounding system. Each structure had grounding plates installed in the structure walls and floors; there were connected to the grounding mats. All connections on the ground mats and cables to the grounding plates were made by thermite welds.

All air conditioning duct work was bonded with grounding straps across all flexible connections.

Problem Areas

The most perplexing problem encountered in the electrical installation was the shock mounting of the large equipment and cable trays to shock mounted floors.

The rubber cable tray shock mounts presented a minor problem. The cable trays were prefabricated and presented few problems during installation; however, after installation they would not withstand the strain of being off-set by the movement of the cable trays.

There were many modifications issued to secure proper clearance between electrical work (mainly cable trays) and mechanical work such as piping, duct work, etc.

PART IX -- MECHANICAL EQUIPMENT

General

The mechanical system consisted of a substantial amount of piping and duct work, connecting the different pieces of equipment so that they would function as designed. The various systems incorporated in the complex were:

a. Supply and Distribution System
    (1) Condenser Water Supply and Return
    (2) Chilled Water Supply and Return
    (3) Hot Water Supply and Return
    (4) Diesel Fuel Supply and Return
    (5) Diesel Lube Oil Supply and Return
    (6) Diesel Exhaust
b. Water Storage and Distribution System
c. Sewers; Sanitary, Gravity and Sewage Treatment Facilities
d. General Plumbing
e. Heating and Ventilating System
f. Air-Conditioning System
g. Fuel Oil Storage and Underground Piping
h. Gas Detection System
i. Compressed Air System
j. Blast Closure System
k. The Controls for all of the Systems

A pipe prefabrication yard was maintained in Rapid City, where the piping for all of the above systems was fabricated. Shipping the material to the right complex at proper time was accomplished smoothly and very little delay was sustained. Several modifications were issued due to design changes on the pipe supports in the Missile Silos, both for the Propellant Loading Systems and for utility piping. Modification 168 was issued to correct pipe support interference in the Missile Silos. The piping between the structures for all systems was installed in the tunnels, either under the floor or along the walls.

Heating, Ventilating and Air Conditioning System

The diesel engines (4 per Powerhouse), Appendix B, Tab 62, Page 2-107, furnish the power for electricity generation. They also provide heat for the entire complex by generating hot water from the heat recovery silencers, installed in the diesel engine exhaust system, Appendix B, Tab 63, Page 2-108, and circulating the hot water through heating coils in the air handling units located in all major structures. Appendix B, Tab 64, Page 2-109, shows the air handling units in the Control Center and Appendix B, Tab 65, Page 2-110, shows air handling unit in Equipment Terminal.

The coolant for the diesel engines is cooled by a cooling tower for each 2 engines. Appendix B, Tab 66, Page 2-111. Each Powerhouse has a lube oil and fuel oil system equipped with a clean and dirty oil tank and centrifuge for cleaning the oil. Appendix B, Tab 67, Page 2-112.

The air conditioning system is utilized for cooling electronic equipment and to circulate air throughout the complex through the same air handling units as is used for heating, by circulating chilled water through the coils in the units.

The air in the heating and air conditioning systems is carried to all structures within the complex by sheet metal ductwork from the air handling units.

Fresh air for the complex, under normal operations, is supplied by the air intake fan located in the Air Intake Structure. The complex is equipped with an auxiliary Launcher Air Filtration system which would supply fresh air to the Launcher Areas in case of emergency. The complex is also equipped with a series of blast valves, or blast closure system, which would close automatically in case of an interior or exterior explosion.

Water Supply

The water on all three complexes is supplied by two wells located in each Powerhouse. The wells were drilled and developed under Contract No. DA-5683.

Water obtained from the Titan wells contains dissolved minerals considerably in excess of the 500 ppm recommended for potable water supplies. The water is discolored, has an offensive odor and is, in some cases, moderately corrosive. To reduce the level of undesirable dissolved matter within the water, a treatment process developed by the Ionics Incorporated of Cambridge, Massachusetts was selected. The ionics treatment utilizes the fact that dissolved minerals, salt for example, splits into positive and negative ions when it dissolves.

The Ionics process consists of placing the well water between a positive and a negative plate or membrane where the ions are attracted to the charged plates and are trapped. The remaining water is thereby reduced to an acceptable level of dissolved components. The Ionics purification system is particularly adapted to the Ellsworth sites, as the system consumes power in direct proportion to the contamination removed. As the level of contamination reduction required is relatively low at Ellsworth, the system is admirably suited for its designed function.

The treated water is used in the heating and chilled water system and coolant system for the diesel engines. The treated water is stored in a 10,000 gallon concrete tank under the Powerhouse floor.

The raw water is used for sanitary purposes, fire protection and drinking. There are storage facilities for 60,000 gallons of raw water in two buried steel tanks located just outside the Powerhouse, off of Tunnel Junction No. 10.

Problem Areas

The major problem encountered in the installation of the piping was the numerous changes that were made in design. These design changes reached the contractor after the piping had been fabricated, and in many instances, after the pipe had already been installed. This caused many delays due to the necessity to remove piping already installed and the refabrication of piping which was fabricated. The delays in many instances effected other contractors who had installed their work after the original piping was installed.

Modification 168 was issued specifically to correct numerous pipe support interferences in the missile silos. Several other modifications were issued as a result of interferences or inadequate piping supports.

The contractor had the option of pneumatic-automatic or electric controls for the heating, ventilating and air conditioning system. He chose pneumatic-automatic controls, which were installed by the Minneapolis-Honeywell Company.

The diesel engines (four in each Powerhouse) were a major problem area. Trouble was encountered at Complex 1A with the thrust bearings, between the engine and the 1020 KW generator, heating. It was first thought that the engine was not properly grouted and all engines at Complex 1A and 1C were regrouted. This did not remedy the heating. Although all lube oil piping was acid pickled prior to installation, it was considered possible that dirty lube oil was not allowing proper lubrication of these bearings. The lube oil piping was removed and acid pickled a second time. This again failed to remedy the problem. A consultant from the Barnes and Reinske Company was called in and together with the Corps of Engineers' personnel remedied the situation by relieving the outer edges of the bearings to allow better lubrication of the bearing edges. This solution was used on all twelve engines.

The contractor was required by the specifications to install and test the standardized equipment furnished by others (ASC).

A trouble area developed during the testing of the ice banks. Appendix B, Tab 68, Page 2-113. The difference in design pressure between the ice banks and chilled water system would not allow proper flow to the ice banks. This caused considerable delay and additional testing, and was remedied by issuance of a modification calling for minor piping changes and revised pressure control settings.

The sump pump piping in the Equipment Terminals had to be modified. This was due to the inadequacy of designed head pressure, of the pumps to pump the material from the structure to the ground surface. The piping was modified so that the pump would discharge into a hydraulic ejector, which in turn pumped to the surface.

The fire water system was modified to provide for the release of air in the system, provisions for which were inadequate in the original design. Modification 226 provided for additional air relief valves and relocation of air relief valves installed, per original design, on the wrong side of the flow control valves. This modification also changed the spring set pressure settings, the starting time for the fire pumps to instantaneous (originally 20 seconds), and added additional pipe supports.

This high pressure artesian flowing well creates a potential hazard of flooding the powerhouse and/or the whole complex. It was noted that the sub-surface water at the elevation of just below the powerhouse was corroding the casing of both wells. Therefore, under Modification 164, the upper casing was pressure grouted on both wells.

Modification 229 was issued to add a 3-way valve for controlling the high pressure and revise the piping from the well to the raw water system.

Validation

After completing the installation of the systems, an acceptance test was run on each system component at each complex.

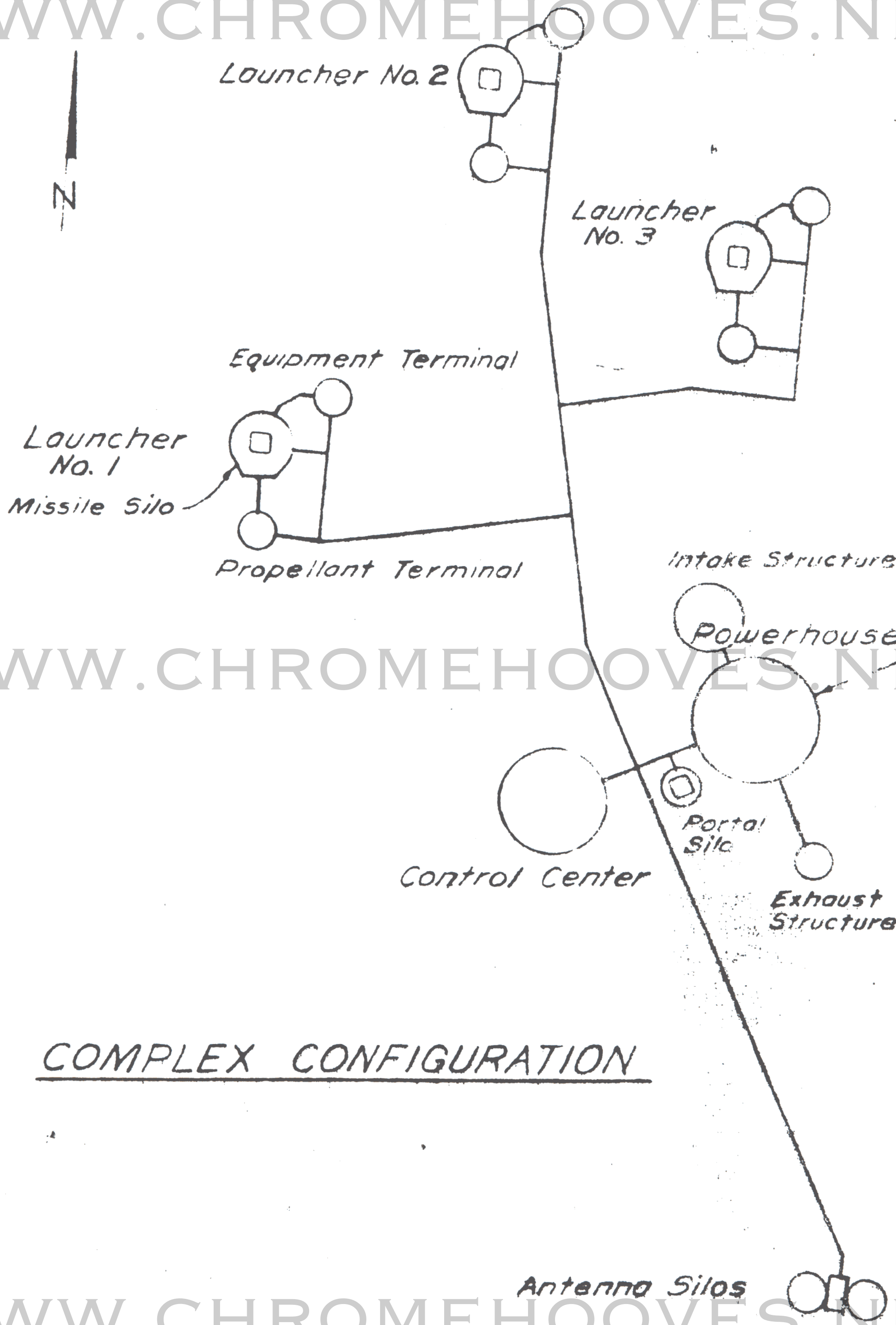
Modification 128 was issued for the validations of all systems for adequacy of design of the complete system. The validation testing was accomplished at Complex 1C only for all systems except for the water treatment equipment (Ionics Incorporated), which was also accomplished at Complex 1A. The water treatment equipment at Complex 1A and 1B were identical plants and the validation test was run at Complex 1A. Appendix B, Tab 69, Page 2-114. The water treatment equipment at Complex 1C varied from the other two complexes due to the difference in the water treated and was validated separately. Appendix B, Tab 70, Page 2-115.

The validation tests were run in accordance with the procedures set up by the Corps of Engineer, Air Force and DMJM & A. When each system was tested, it was witnessed by the representatives of the Corps of Engineers, Air Force and The Martin Company. It was then signed off as having satisfactorily passed the test procedure. During the validation testing, some systems were found to be unsatisfactory in design and others in construction or operation. Most all systems required adjustment for them to fulfill the requirements of the Air Force. Appendix B, Tab 71, Page 2-116 shows Government furnished loads banks (4 - 500 KW) used to test diesel engines and generators.

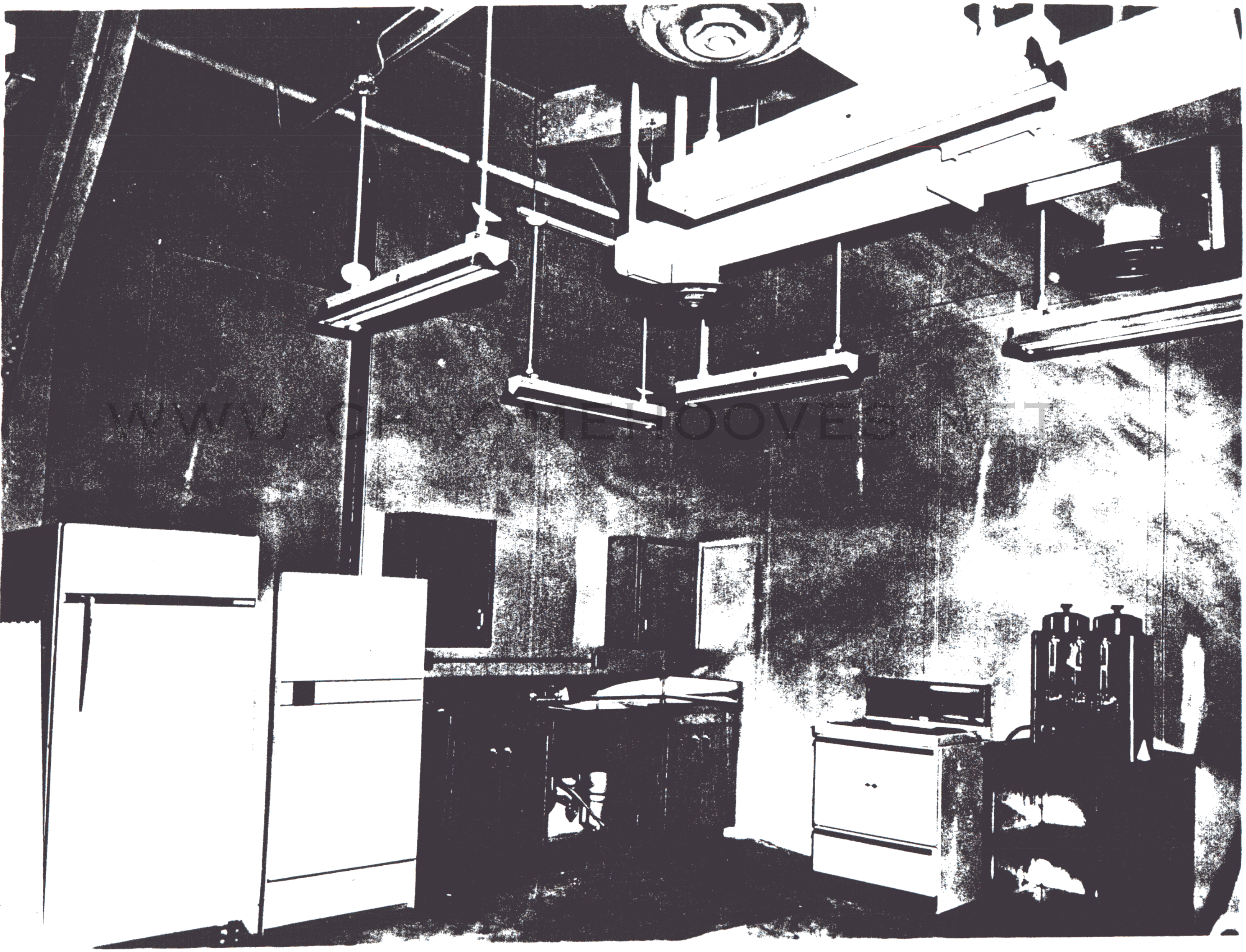
Joint occupancy during construction with the I & C contractors caused many problems. In addition to the requirement for extensive scheduling of work, joint occupancy caused many delays, which resulted in claims as well as considerable damage to installed work. The major damage was to the duct work in the Missile Silo. A modification was issued in which approximately 75 of the horizontal duct work in all nine missile silos had to be replaced. There was also damage to electrical conduit installations and fixtures, pipe insulation, painted surfaces and mechanical equipment and piping installations in all structures. The joint occupancy made it nearly impossible to affix the damage to any one contractor. As a result, the facility contractor was required to repair much of the damage, which later resulted in claims for additional compensation.

APPENDIX B

SECTION II - REFERENCES

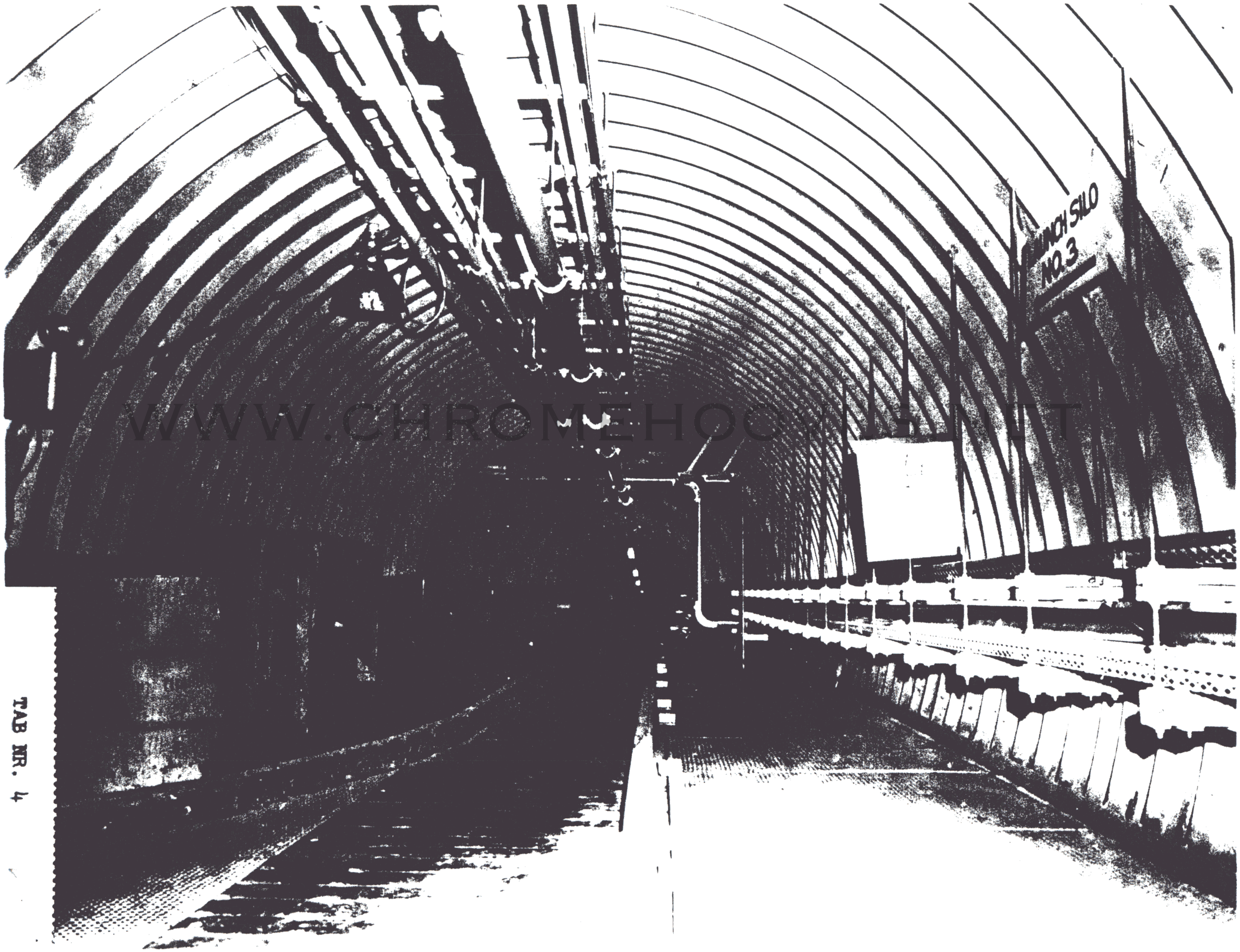


COMPLEX CONFIGURATION



TAB NR. 2
PAGE NR. 2-57

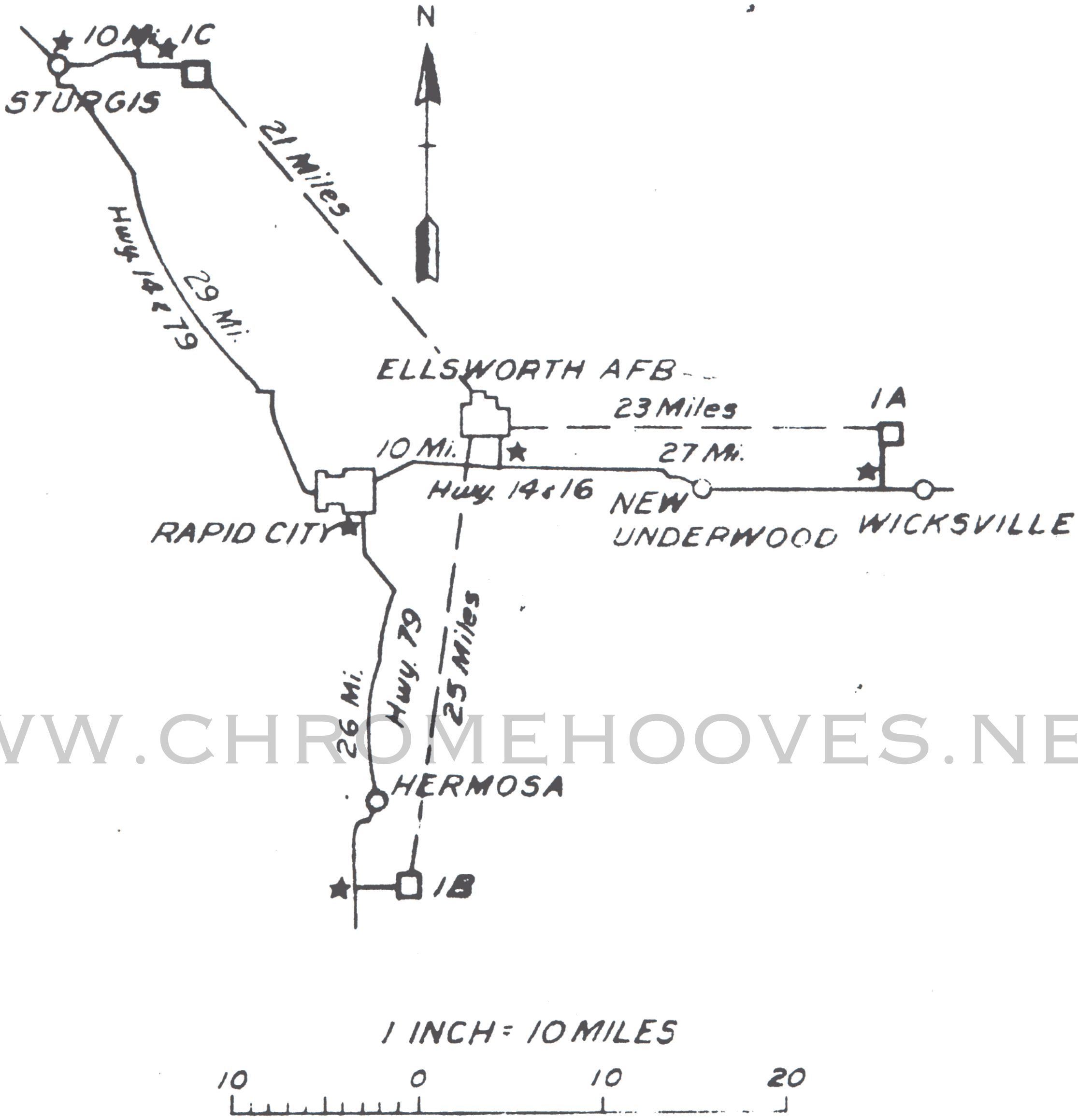
TAB NR. 3
PAGE NR. 2-58


LAUNCH SILO
NO.3

TAB NR. 5
PAGE NR. 2-60

TAB NR. 6
PAGE NR. 2-61

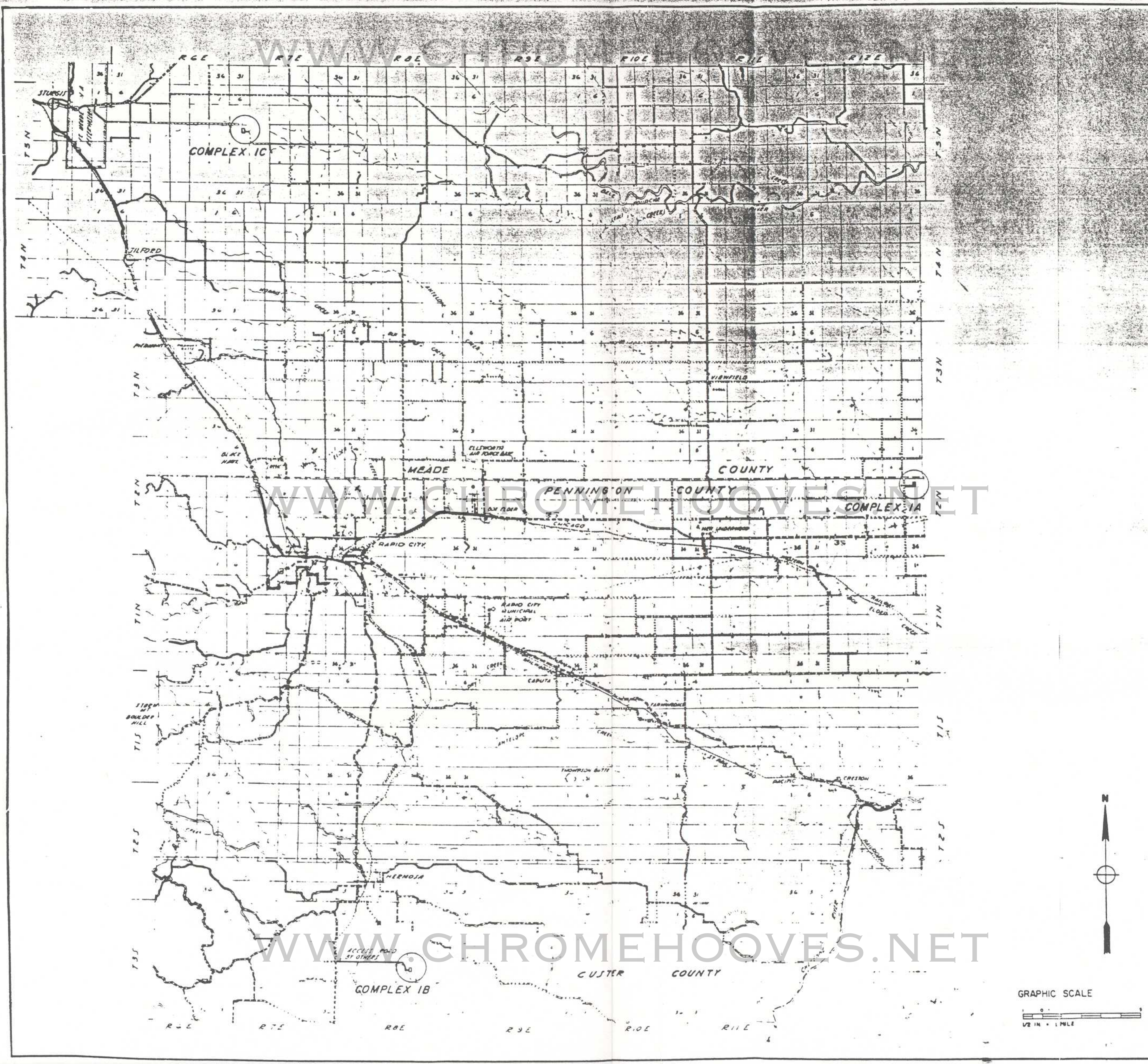
MISSILE CONSTRUCTION LOCATION MAP



Each Site is on a radius of approximately 18 nautical miles from Ellsworth Air Force Base.

— — — *Indicates Air Miles*

Fig-1



THIS DRAWING HAS BEEN REDUCED TO
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REVISION	DATE	DESCRIPTION	AGENCY	BY

DANIEL, MANN, JOHNSON & MENDENHALL AND ASSOCIATES
ARCHITECTS and ENGINEERS

DEPARTMENT OF THE AIR FORCE
AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)
INGLEWOOD, CALIFORNIA

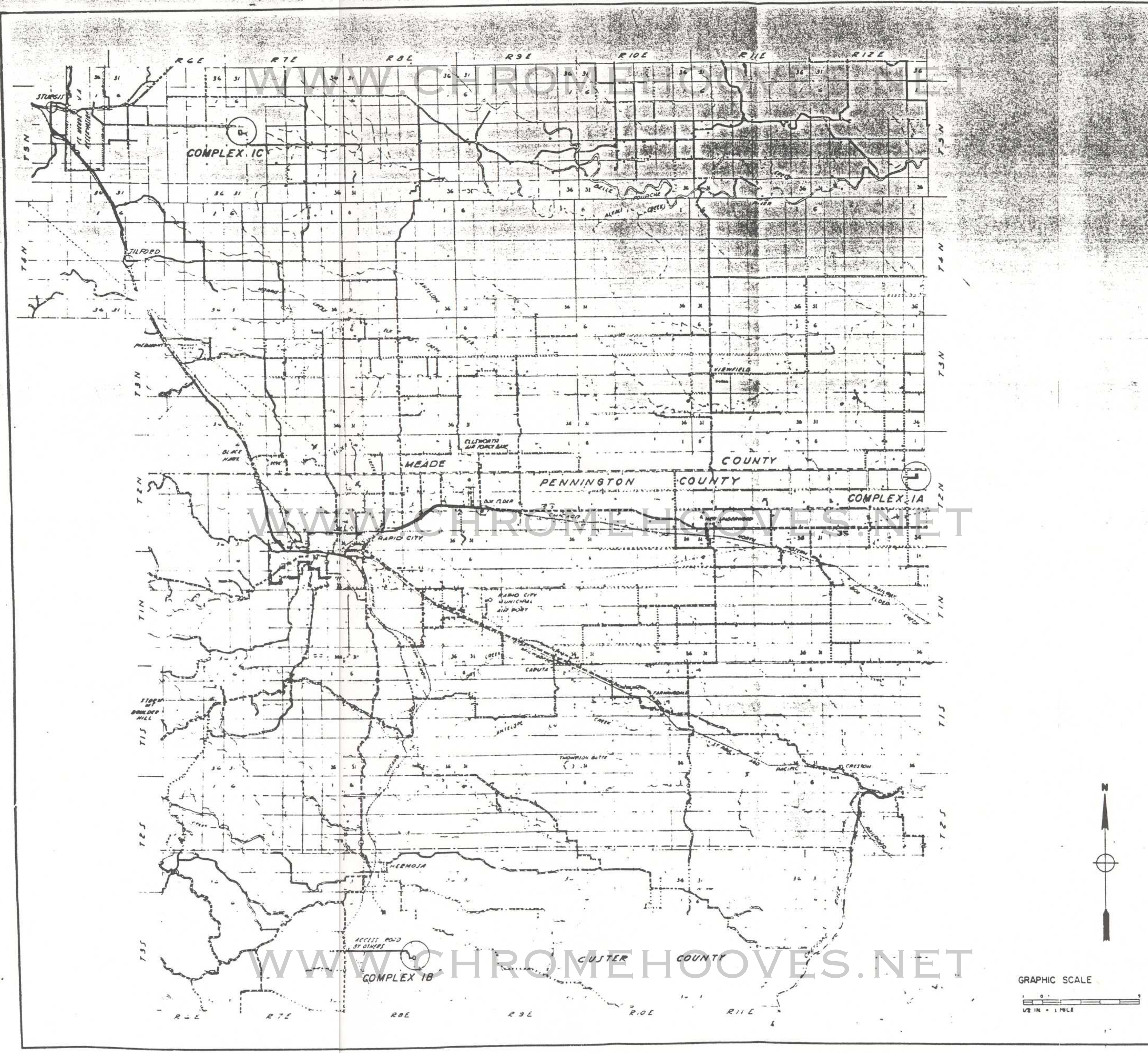
O ROSE
A-E SHEET NO. 80-C-1
E VALDERRAMA
A-E JOB NO. 353-1-1

WS-107 A-2 TECHNICAL FACILITIES
ELLSWORTH A F BASE, RAPID CITY S. DAK.
COMPLEX 1A, 1B & 1C

GENERAL
VICINITY MAP

6BI 6 0

SPECIFICATION NO. ENG-25-066-60-1
DATE 1 JULY 1959
SCALE AS NOTED
SHEET 8



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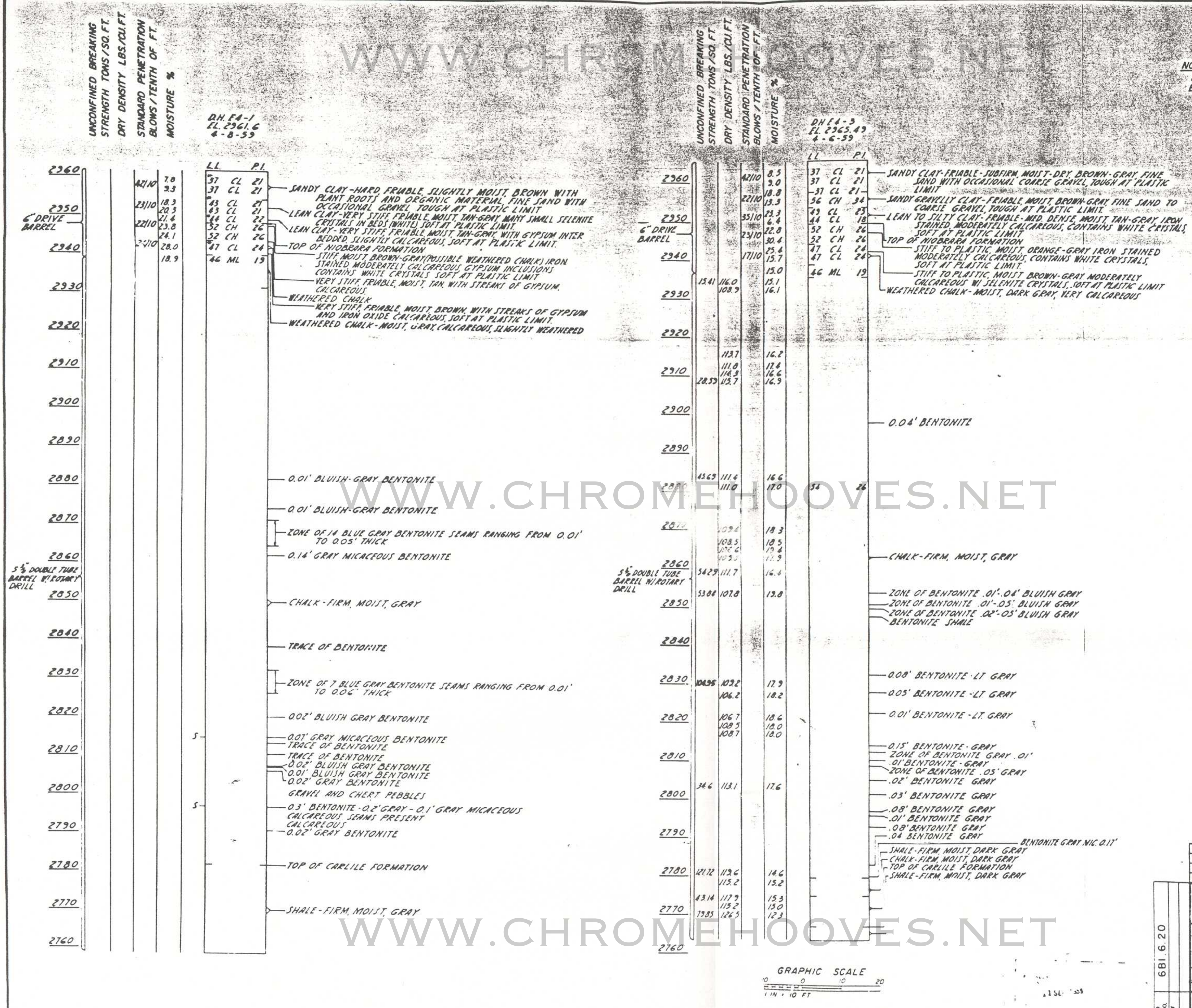
WS-107 A-2 TECHNICAL FACILITIES
ELLSWORTH A.F. BASE, RAPID CITY S. DA
COMPLEX 1A, 1B & 1C

GENERAL
VICINITY MAP

6BI 6 0

SPECIFICATION NO. ENG-25-066-60-1
DATE 1 JULY 1959
SCALE AS NOTED
SHEET 8

NOTE:
FOR LEGEND, GENERAL NOTES AND SOIL BORING LAYOUT SEE SHEET NO. 80-C-10



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ARCHITECTS and ENGINEERS

DEPARTMENT OF THE AIR FORCE
AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)
INGLEWOOD, CALIFORNIA

D. McCAULEY

A-E SHEET NO. 80-C-11

353-1-1

WS-107 A-2 TECHNICAL FACILITIES
ELLSWORTH A.F. BASE, RAPID CITY S. DAK.
COMPLEX 1A, 1B & 1C

GENERAL
COMPLEX 1C
LOG OF BORINGS

SPECIFICATION NO. ENG-25-066-60-1

DATE 1 JULY 1959

SCALE AS NOTED

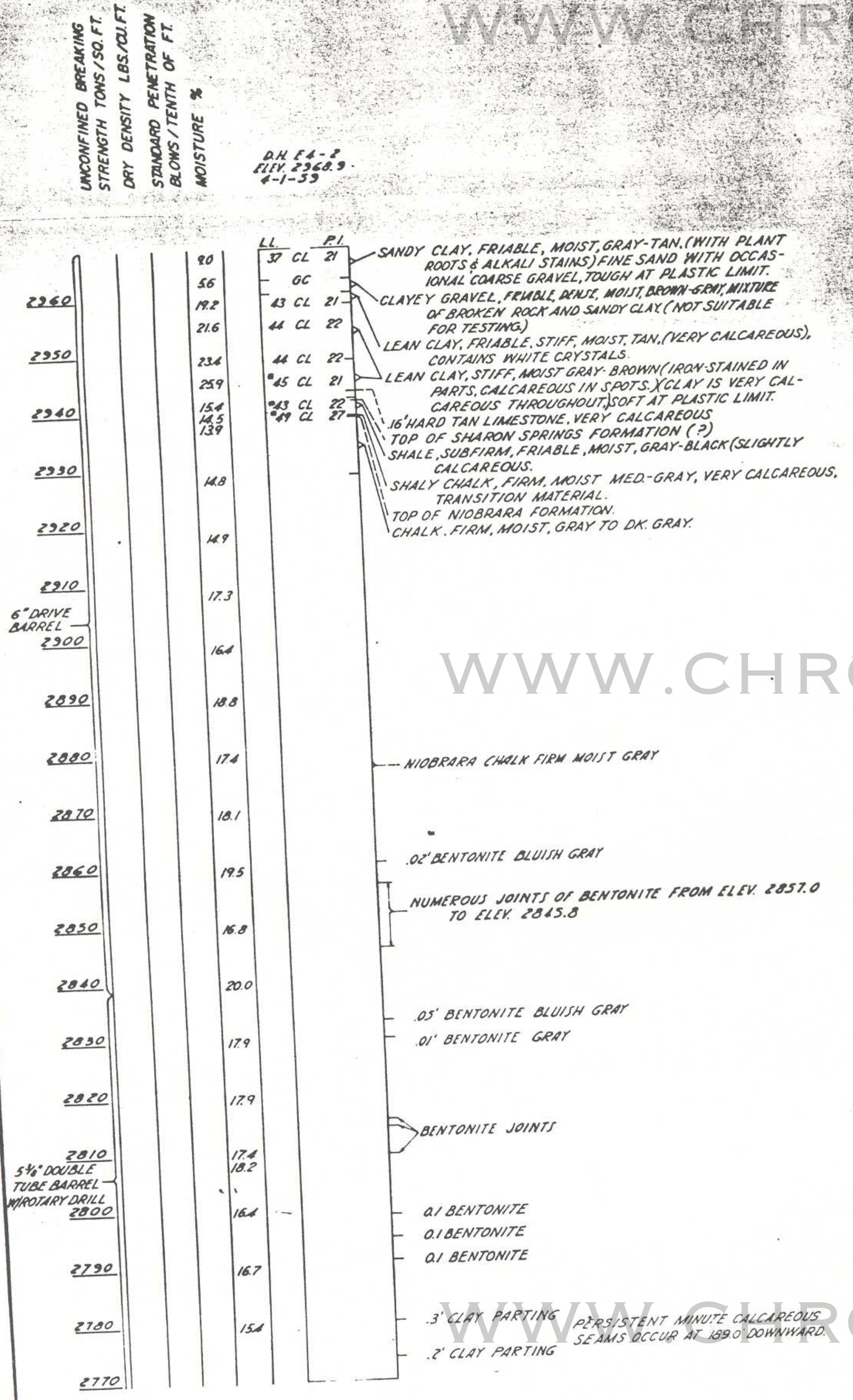
SHEET 18

6BI 6.20

AFBMD INDEX NO.

APPROVED BY

FOR



SANDY CLAY, FRIABLE, MOIST, GRAY-TAN. (WITH PLANT ROOTS & ALKALI STAINS) FINE SAND WITH OCCASIONAL COARSE GRAVEL, TOUGH AT PLASTIC LIMIT.

CLAYEY GRAVEL, FRIABLE, DENSE, MOIST, BROWN-GRAY, MIXTURE OF BROKEN ROCK AND SANDY CLAY. (NOT SUITABLE FOR TESTING.)

LEAN CLAY, FRIABLE, STIFF, MOIST, TAN, (VERY CALCAREOUS). CONTAINS WHITE CRYSTALS.

LEAN CLAY, STIFF, MOIST GRAY-BROWN (IRON-STAINED IN PARTS, CALCAREOUS IN SPOTS.)(CLAY IS VERY CALCAREOUS THROUGHOUT.) SOFT AT PLASTIC LIMIT.

.16' HARD TAN LIMESTONE, VERY CALCAREOUS

TOP OF SHARON SPRINGS FORMATION (?)

SHALE, SUBFIRM, FRIABLE, MOIST, GRAY-BLACK (SLIGHTLY CALCAREOUS.

SHALY CHALK, FIRM, MOIST MED.-GRAY, VERY CALCAREOUS, TRANSITION MATERIAL.

TOP OF NIOBRARA FORMATION.

CHALK. FIRM, MOIST, GRAY TO DK. GRAY.

NIOBRARA CHALK FIRM MOIST GRAY

.02' BENTONITE BLUISH GRAY

NUMEROUS JOINTS OF BENTONITE FROM ELEV. 2857.0 TO ELEV. 2845.8

.05' BENTONITE BLUISH GRAY

.01' BENTONITE GRAY

BENTONITE JOINTS

0.1 BENTONITE

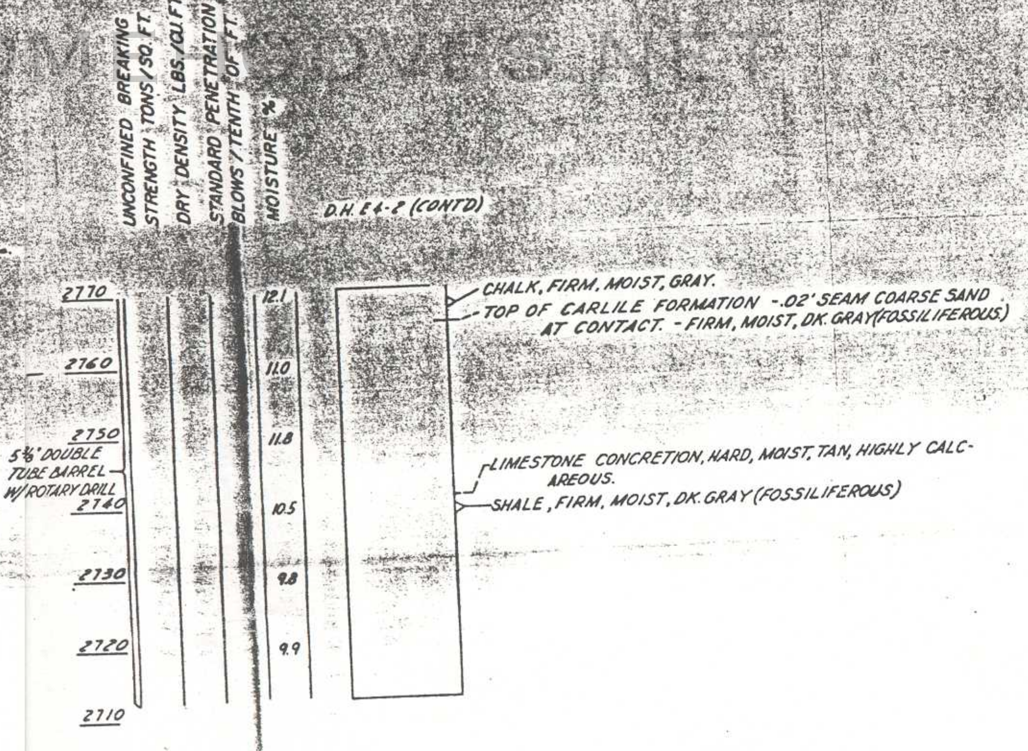
0.1 BENTONITE

0.1 BENTONITE

.3' CLAY PARTING

PERSISTENT MINUTE CALCAREOUS SEAMS OCCUR AT 189.0' DOWNWARD.

.2' CLAY PARTING

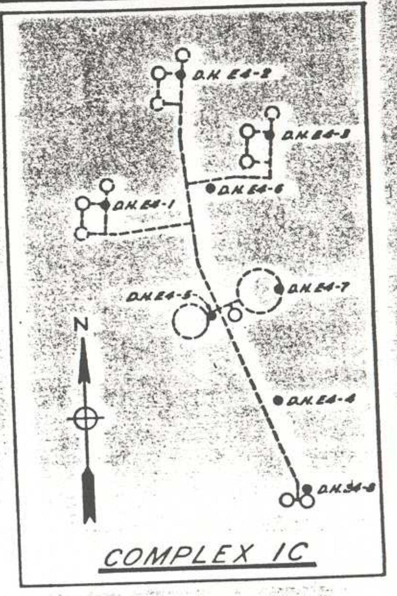


CHALK, FIRM, MOIST, GRAY.

TOP OF CARLILE FORMATION - .02' SEAM COARSE SAND AT CONTACT. - FIRM, MOIST, DK. GRAY (FOSSILIFEROUS)

LIMESTONE CONCRETION, HARD, MOIST, TAN, HIGHLY CALCAREOUS.

SHALE, FIRM, MOIST, DK. GRAY (FOSSILIFEROUS)



SOIL BORING LAYOUT

1" = 200'

DRILL HOLE NUMBER	COORDINATES	
	NORTHING	EASTING
DH E4-1	48,392	100,760
DH E4-2	48,747	100,979
DH E4-3	48,575	101,221
D.H. E4-4	47,830	101,221
DH E4-5	48,074	101,043
DH E4-6	48,430	101,053
D.H. E4-7	48,143	101,235
DH E4-8	47,578	101,236

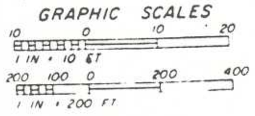
BORING LEGEND

D.H. E4-7	BORING NUMBER
EL. 2943.0	ELEVATION OF GROUND SURFACE AT TOP OF BORING.
4-4-59	DATE BORING COMMENCED.
L.L	LIQUID LIMIT
P.I.	PLASTICITY INDEX
SC	CLAYEY, GRAVELLY SAND
CL	SANDY CLAY, SILTY CLAY, OR LEAN CLAY.
CH	FAT CLAY, SANDY GRAVELLY CLAY.
ML	WEATHERED CHALK
GC	CLAYEY GRAVEL
39/10	STANDARD PENETRATION: THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2" O.D. SPLIT SAMPLER WITH A 140 POUND WEIGHT FALLING A DISTANCE OF 30 INCHES THE INDICATED TENTHS OF A FOOT. FOR EXAMPLE, THIRTY-NINE (39) BLOWS ARE REQUIRED TO DRIVE THE SAMPLER TEN-TENTHS (10/10) OF A FOOT.
W.L.	WATER LEVEL ESTABLISHED BY MEASUREMENT IN OPEN HOLE.
4-15-59	DATE WATER LEVEL WAS OBSERED.

NOTES:

1. AN ASTERISK (*) PRECEEDING THE ATTERBERG LIMITS INDICATES THAT THE TESTS WERE ACTUALLY RUN ON THAT SAMPLE. OTHERWISE, THE LIMITS WERE DETERMINED ON ANOTHER SAMPLE VISUALLY CLASSIFIED AS IDENTICAL.
2. DESCRIPTIONS TO THE RIGHT OF THE BORING PROFILE ARE SUPPLEMENTAL DATA BASED UPON LABORATORY & FIELD INSPECTION.
3. ELEVATIONS REFER TO MEAN SEA LEVEL, 1929 GENERAL ADJUSTMENT.
4. THE BORINGS WERE DRILLED WITH A 6-INCH CHURN DRILL AND A 6-INCH (NOMINAL SIZE) ROTARY DRILL, WITH BARRELS AS INDICATED AT THE FAR LEFT OF THE BORING LOG.
5. MATERIAL LISTED AS "BENTONITE" (LIGHT BLUE-GRAY, BLUISH GRAY, GRAY, LIGHT GRAY, OR COLOR UNDESCRIBED.) IS SLIGHTLY TO NONCALCAREOUS, STIFF TO PLASTIC, AND APPROACHES THE PROPERTIES OF A FAT CLAY. IT APPEARS TO BE BENTONITE.
6. THE DATE OF DRILLING THE HOLE APPEARS AT THE TOP OF THE LOG FOR EACH HOLE.
7. ABSENCE OF GROUND WATER DATA ON LOGS DOES NOT INDICATE THAT WATER WILL NOT BE ENCOUNTERED DURING CONSTRUCTION.

GRAPHIC SCALES



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ARMY CE KLOPP PRINTING CO., OMAHA

REVISION	DATE	DESCRIPTION	AGENCY	BY

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AND ASSOCIATES
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DEPARTMENT OF THE AIR FORCE
AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)
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353-1-1

WS-107 A-2 TECHNICAL FACILITIES
ELLSWORTH A.F. BASE. RAPID CITY S. DA
COMPLEX 1A, 1B & 1C

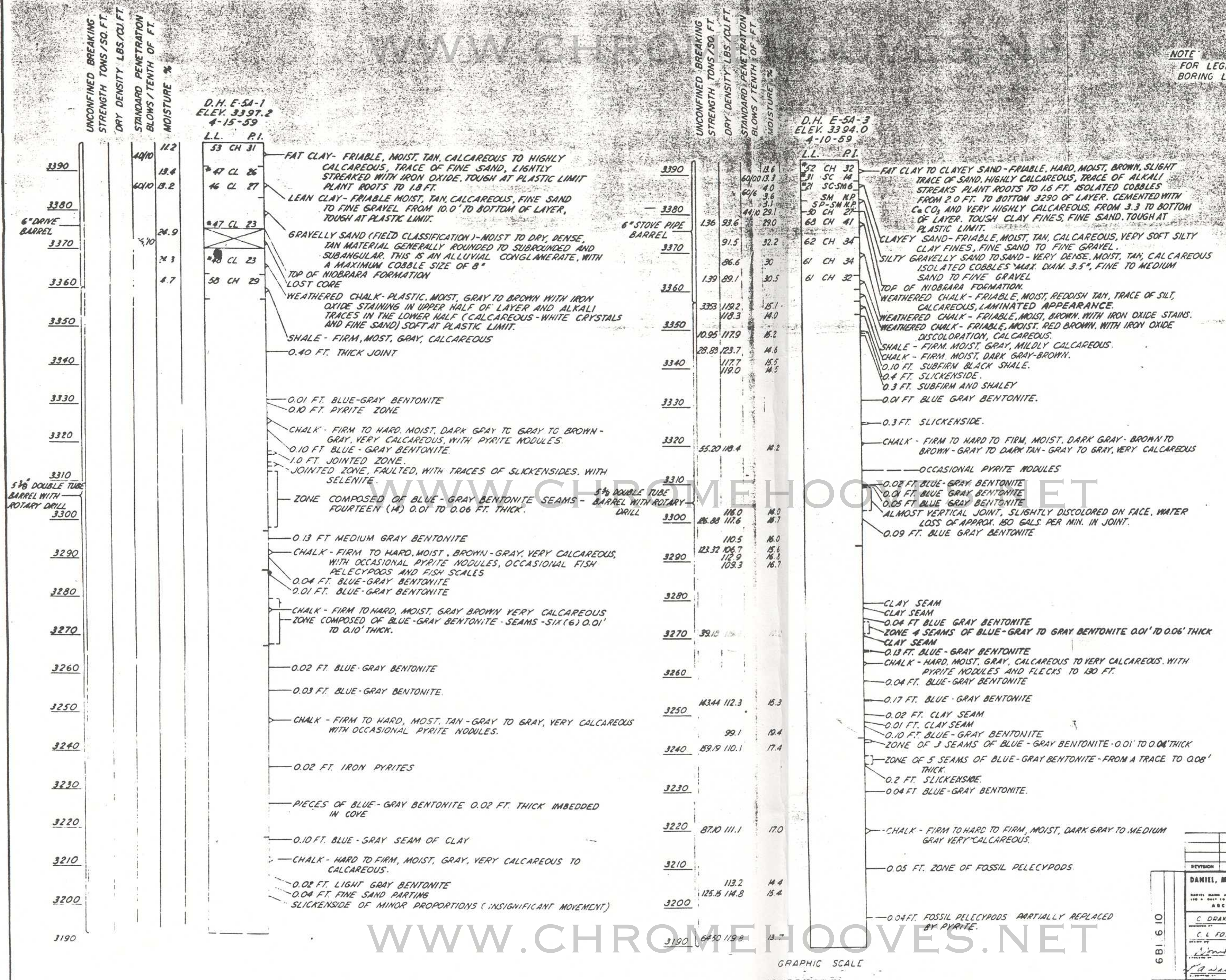
GENERAL
COMPLEX IC
LOG OF BORINGS

SPECIFICATION NO. ENG-25-066-60-1
DATE 1 JULY 1959
SCALE AS NOTED
SHEET 17

APPROVED BY
FOR

6BI.6.20

NOTE
FOR LEGEND, GENERAL NOTES AND SOIL BORING LAYOUT SEE SHEET NO 80-C-6



D.H. E-5A-1

FAT CLAY- FRIABLE, MOIST. TAN. CALCAREOUS TO HIGHLY CALCAREOUS, TRACE OF FINE SAND, LIGHTLY STREAKED WITH IRON OXIDE. TOUGH AT PLASTIC LIMIT PLANT ROOTS TO 1.8 FT.

LEAN CLAY- FRIABLE MOIST, TAN, CALCAREOUS, FINE SAND TO FINE GRAVEL FROM 10.0' TO BOTTOM OF LAYER, TOUGH AT PLASTIC LIMIT.

GRAVELLY SAND (FIELD CLASSIFICATION)-MOIST TO DRY, DENSE, TAN MATERIAL GENERALLY ROUNDED TO SUBROUNDED AND SUBANGULAR. THIS IS AN ALLUVIAL CONGLAMERATE, WITH A MAXIMUM COBBLE SIZE OF 8"

TOP OF NIOBRARA FORMATION

LOST CORE

WEATHERED CHALK- PLASTIC. MOIST, GRAY TO BROWN WITH IRON OXIDE STAINING IN UPPER HALF OF LAYER AND ALKALI TRACES IN THE LOWER HALF (CALCAREOUS-WHITE CRYSTALS AND FINE SAND) SOFT AT PLASTIC LIMIT.

SHALE - FIRM, MOST. GRAY, CALCAREOUS

0.40 FT. THICK JOINT

0.01 FT. BLUE-GRAY BENTONITE

0.10 FT. PYRITE ZONE

CHALK - FIRM TO HARD. MOIST. DARK GRAY TO GRAY TO BROWN-GRAY. VERY CALCAREOUS, WITH PYRITE NODULES.

0.10 FT BLUE - GRAY BENTONITE.

1.0 FT. JOINTED ZONE.

JOINTED ZONE, FAULTED, WITH TRACES OF SLICKENSIDES. WITH SELENITE.

ZONE COMPOSED OF BLUE - GRAY BENTONITE SEAMS - FOURTEEN (14) 0.01 TO 0.06 FT. THICK.

0.13 FT MEDIUM GRAY BENTONITE

CHALK - FIRM TO HARD. MOIST. BROWN - GRAY. VERY CALCAREOUS, WITH OCCASIONAL PYRITE NODULES, OCCASIONAL FISH PELECYPODS AND FISH SCALES

0.04 FT. BLUE-GRAY BENTONITE

0.01 FT. BLUE-GRAY BENTONITE

CHALK - FIRM TO HARD, MOIST, GRAY BROWN VERY CALCAREOUS

ZONE COMPOSED OF BLUE-GRAY BENTONITE - SEAMS - SIX (6) 0.01' TO 0.10' THICK.

0.02 FT. BLUE-GRAY BENTONITE

0.03 FT. BLUE-GRAY BENTONITE.

CHALK - FIRM TO HARD, MOST. TAN - GRAY TO GRAY, VERY CALCAREOUS WITH OCCASIONAL PYRITE NODULES.

0.02 FT. IRON PYRITES

PIECES OF BLUE - GRAY BENTONITE 0.02 FT. THICK IMBEDDED IN COVE

0.10 FT. BLUE - GRAY SEAM OF CLAY

CHALK - HARD TO FIRM, MOIST, GRAY, VERY CALCAREOUS TO CALCAREOUS.

0.02 FT. LIGHT GRAY BENTONITE

0.04 FT. FINE SAND PARTING

SLICKENSIDE OF MINOR PROPORTIONS (INSIGNIFICANT MOVEMENT)

D.H. E-5A-3

FAT CLAY TO CLAYEY SAND - FRIABLE. HARD, MOIST, BROWN, SLIGHT TRACE OF SAND. HIGHLY CALCAREOUS, TRACE OF ALKALI STREAKS PLANT ROOTS TO 1.6 FT. ISOLATED COBBLES FROM 2.0 FT. TO BOTTOM 3290 OF LAYER. CEMENTED WITH $CaCO_3$ AND VERY HIGHLY CALCAREOUS. FROM 3.3 TO BOTTOM OF LAYER. TOUGH CLAY FINES, FINE SAND. TOUGH AT PLASTIC LIMIT.

CLAYEY SAND- FRIABLE, MOIST, TAN, CALCAREOUS, VERY SOFT SILTY CLAY FINES, FINE SAND TO FINE GRAVEL.

SILTY GRAVELLY SAND TO SAND - VERY DENSE. MOIST, TAN, CALCAREOUS ISOLATED COBBLES MAX. DIAM. 3.5", FINE TO MEDIUM SAND TO FINE GRAVEL

TOP OF NIOBRARA FORMATION.

WEATHERED CHALK - FRIABLE, MOIST, REDDISH TAN, TRACE OF SILT, CALCAREOUS, LAMINATED APPEARANCE.

WEATHERED CHALK - FRIABLE, MOIST, BROWN. WITH IRON OXIDE STAINS.

WEATHERED CHALK - FRIABLE, MOIST. RED BROWN. WITH IRON OXIDE DISCOLORATION, CALCAREOUS.

SHALE - FIRM. MOIST. GRAY, MILDLY CALCAREOUS.

CHALK - FIRM. MOIST, DARK GRAY-BROWN.

0.10 FT. SUBFIRM BLACK SHALE.

0.4 FT. SLICKENSIDE.

0.3 FT. SUBFIRM AND SHALEY

0.01 FT BLUE GRAY BENTONITE.

0.3 FT. SLICKENSIDE.

CHALK - FIRM TO HARD TO FIRM, MOIST. DARK GRAY - BROWN TO BROWN - GRAY TO DARK TAN - GRAY TO GRAY, VERY CALCAREOUS

OCCASIONAL PYRITE NODULES

0.02 FT. BLUE - GRAY BENTONITE

0.01 FT. BLUE GRAY BENTONITE

0.05 FT BLUE GRAY BENTONITE

ALMOST VERTICAL JOINT, SLIGHTLY DISCOLORED ON FACE, WATER LOSS OF APPROX. 150 GALS PER MIN. IN JOINT.

0.09 FT. BLUE GRAY BENTONITE

CLAY SEAM

CLAY SEAM

0.04 FT BLUE GRAY BENTONITE

ZONE 4 SEAMS OF BLUE-GRAY TO GRAY BENTONITE 0.01' TO 0.06' THICK

CLAY SEAM

0.13 FT. BLUE - GRAY BENTONITE

CHALK - HARD, MOIST, GRAY, CALCAREOUS TO VERY CALCAREOUS. WITH PYRITE NODULES AND FLECKS TO 130 FT.

0.04 FT. BLUE-GRAY BENTONITE

0.17 FT. BLUE - GRAY BENTONITE

0.02 FT. CLAY SEAM

0.01 FT. CLAY SEAM

0.10 FT. BLUE - GRAY BENTONITE

ZONE OF 3 SEAMS OF BLUE - GRAY BENTONITE - 0.01' TO 0.04' THICK

ZONE OF 5 SEAMS OF BLUE - GRAY BENTONITE - FROM A TRACE TO 0.08' THICK.

0.2 FT. SLICKENSIDE.

0.04 FT BLUE - GRAY BENTONITE.

CHALK - FIRM TO HARD TO FIRM, MOIST, DARK GRAY TO MEDIUM GRAY VERY CALCAREOUS.

0.05 FT. ZONE OF FOSSIL PELECYPODS.

0.04 FT. FOSSIL PELECYPODS PARTIALLY REPLACED BY PYRITE.

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ARMY CE KLOPP PRINTING CO. OMAHA

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AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)

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A.E. SHEET NO 80-C-7
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WS-107 A-2 TECHNICAL FACILITIES
ELLSWORTH A.F. BASE, RAPID CITY S. DAK.
COMPLEX 1A, 1B & 1C

GENERAL
COMPLEX 1B
LOG OF BORINGS

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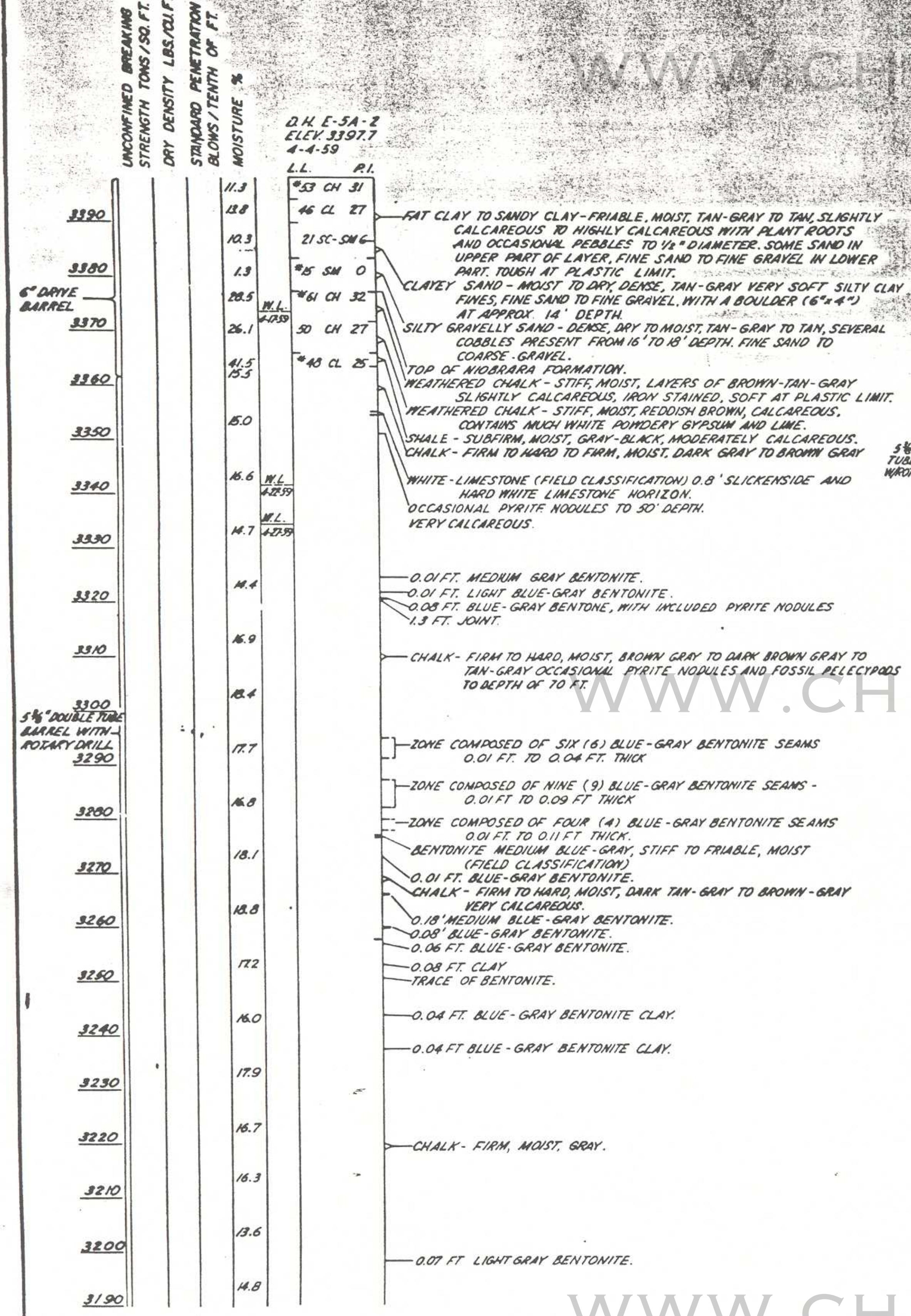
SCALE AS NOTED
SHEET 14

6BI 6 10

APPROVED BY



FAT CLAY TO SANDY CLAY - FRIABLE, MOIST, TAN-GRAY TO TAN, SLIGHTLY CALCAREOUS TO HIGHLY CALCAREOUS WITH PLANT ROOTS AND OCCASIONAL PEBBLES TO ½" DIAMETER. SOME SAND IN UPPER PART OF LAYER, FINE SAND TO FINE GRAVEL IN LOWER PART. TOUGH AT PLASTIC LIMIT.

CLAYEY SAND - MOIST TO DRY, DENSE, TAN-GRAY VERY SOFT SILTY CLAY FINES, FINE SAND TO FINE GRAVEL, WITH A BOULDER (6"x4") AT APPROX. 14' DEPTH.

SILTY GRAVELLY SAND - DENSE, DRY TO MOIST, TAN-GRAY TO TAN, SEVERAL COBBLES PRESENT FROM 16' TO 18' DEPTH. FINE SAND TO COARSE-GRAVEL.

TOP OF NIOBRARA FORMATION.

WEATHERED CHALK - STIFF, MOIST, LAYERS OF BROWN-TAN-GRAY SLIGHTLY CALCAREOUS, IRON STAINED, SOFT AT PLASTIC LIMIT.

WEATHERED CHALK - STIFF, MOIST, REDDISH BROWN, CALCAREOUS. CONTAINS MUCH WHITE POWDERY GYPSUM AND LIME.

SHALE - SUBFIRM, MOIST, GRAY-BLACK, MODERATELY CALCAREOUS.

CHALK - FIRM TO HARD TO FIRM, MOIST, DARK GRAY TO BROWN GRAY

WHITE - LIMESTONE (FIELD CLASSIFICATION) 0.8' SLICKENSIDE AND HARD WHITE LIMESTONE HORIZON.

OCCASIONAL PYRITE NODULES TO 50' DEPTH.

VERY CALCAREOUS.

0.01 FT. MEDIUM GRAY BENTONITE.

0.01 FT. LIGHT BLUE-GRAY BENTONITE.

0.08 FT. BLUE-GRAY BENTONE, WITH INCLUDED PYRITE NODULES

1.3 FT. JOINT.

CHALK - FIRM TO HARD, MOIST, BROWN GRAY TO DARK BROWN GRAY TO TAN-GRAY OCCASIONAL PYRITE NODULES AND FOSSIL PELECYPODS TO DEPTH OF 70 FT.

ZONE COMPOSED OF SIX (6) BLUE-GRAY BENTONITE SEAMS 0.01 FT. TO 0.04 FT. THICK

ZONE COMPOSED OF NINE (9) BLUE-GRAY BENTONITE SEAMS - 0.01 FT TO 0.09 FT THICK

ZONE COMPOSED OF FOUR (4) BLUE-GRAY BENTONITE SEAMS 0.01 FT. TO 0.11 FT THICK.

BENTONITE MEDIUM BLUE-GRAY, STIFF TO FRIABLE, MOIST (FIELD CLASSIFICATION)

0.01 FT. BLUE-GRAY BENTONITE.

CHALK - FIRM TO HARD, MOIST, DARK TAN-GRAY TO BROWN-GRAY VERY CALCAREOUS.

0.18' MEDIUM BLUE-GRAY BENTONITE.

0.08' BLUE-GRAY BENTONITE.

0.06 FT. BLUE-GRAY BENTONITE.

0.08 FT. CLAY

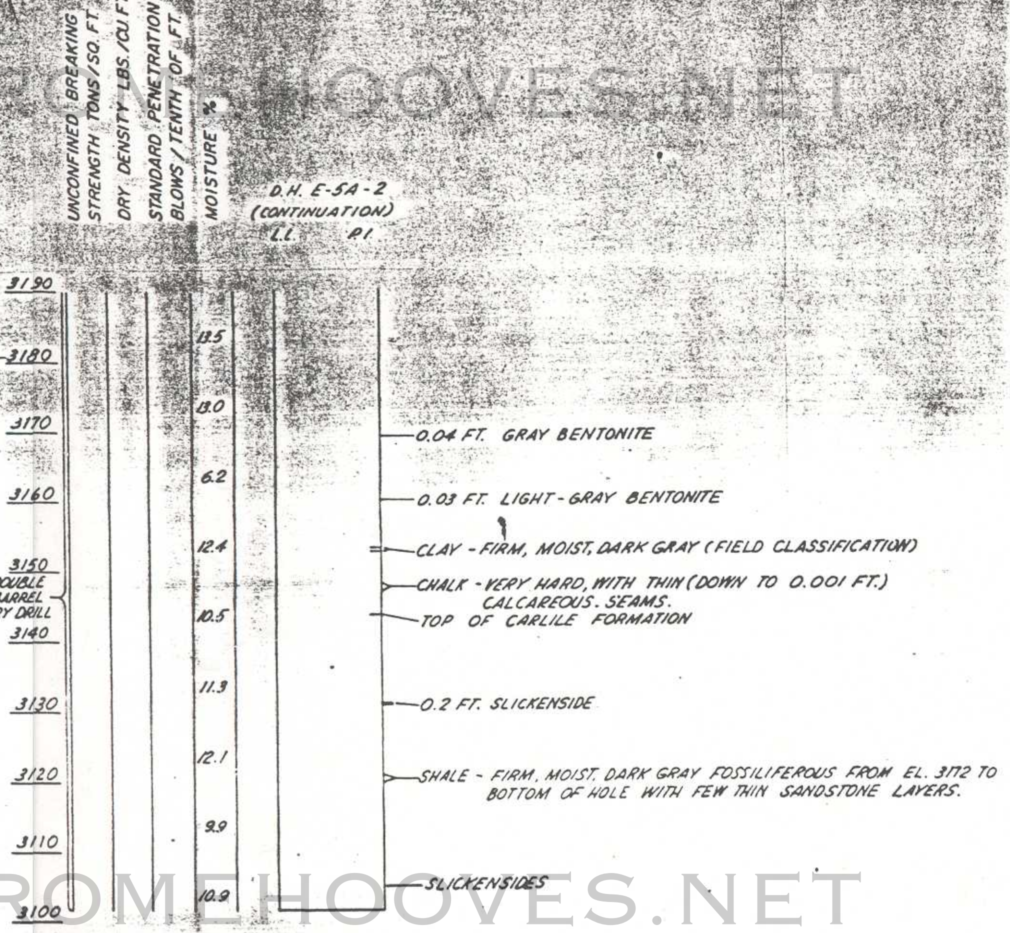
TRACE OF BENTONITE.

0.04 FT. BLUE-GRAY BENTONITE CLAY.

0.04 FT BLUE-GRAY BENTONITE CLAY.

CHALK - FIRM, MOIST, GRAY.

0.07 FT LIGHT GRAY BENTONITE.



0.04 FT. GRAY BENTONITE

0.03 FT. LIGHT-GRAY BENTONITE

CLAY - FIRM, MOIST, DARK GRAY (FIELD CLASSIFICATION)

CHALK - VERY HARD, WITH THIN (DOWN TO 0.001 FT.) CALCAREOUS. SEAMS.

TOP OF CARLILE FORMATION

0.2 FT. SLICKENSIDE

SHALE - FIRM, MOIST, DARK GRAY FOSSILIFEROUS FROM EL. 3172 TO BOTTOM OF HOLE WITH FEW THIN SANDSTONE LAYERS.

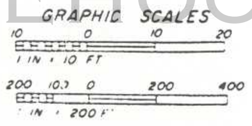
SLICKENSIDES

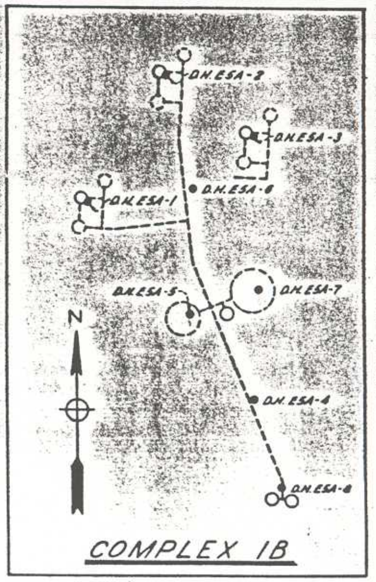
BORING LEGEND:

D.H E5A-6	BORING NUMBER
EL 3395.95	ELEVATION OF GROUND SURFACE AT TOP OF BORING.
4-20-59	DATE BORING COMMENCED.
L.L	LIQUID LIMIT
P.I.	PLASTICITY INDEX
CL	LEAN CLAY, SANDY CLAY, SHALE, WEATHERED CHALK.
CH	FAT CLAY, SHALY CHALK, WEATHERED CHALK, WEATHERED BENTONITE.
SC-SM	CLAYEY SAND.
SM	SILTY GRAVELLY SAND.
SC	CLAYEY SAND, CLAYEY GRAVELLY SAND
SP-SM	SAND. (BORDERLINE POORLY GRADED TO SILTY)
GM	SILTY SANDY GRAVEL.
W.L.	WATER LEVEL & DATE RECORDED IN OPEN HOLE (SEE NOTE 5)
39/10	STANDARD PENETRATION: THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2" O.D. SPLIT SAMPLER WITH A 140 POUND WEIGHT FALLING A DISTANCE OF 30" INCHES THE INDICATED TENTH OF A FOOT. FOR EXAMPLE: THIRTY-NINE (39) BLOWS ARE REQUIRED TO DRIVE THE SAMPLER TEN-TENTHS (10/10) OF A FOOT.

NOTES:

1. AN ASTERISK (*) PRECEEDING THE ATTERBERG LIMITS INDICATES THAT THE TEST WERE ACTUALLY RUN ON THAT SAMPLE. OTHERWISE THE LIMITS WERE DETERMINED ON ANOTHER SAMPLE VISUALLY CLASSIFIED AS IDENTICAL.
2. DESCRIPTIONS TO THE RIGHT OF THE "BORING" ARE SUPPLEMENTAL DATA BASED UPON LABORATORY & FIELD INSPECTION.
3. ELEVATIONS REFER TO MEAN SEA LEVEL, 1929 GENERAL ADJUSTMENTS.
4. THE BORINGS WERE DRILLED WITH A 6"-INCH CHURN DRILL AND A 6"-INCH (NOMINAL SIZE) ROTARY DRILL. WITH BARRELS AS INDICATED AT THE FAR LEFT OF THE BORING LOG.
5. BORINGS WERE MADE WITH ROTARY DRILL USING WATER BORING 2 WAS WASHED WITH CLEAN WATER, BAILED DRY, AND FILLED WITH CLEAN WATER. WATER LEVELS AND DATE OF OBSERVATIONS OBTAINED FROM THIS TEST ARE SHOWN ON THE LOG OF BORING D H E5A-2.
6. THE DATE OF DRILLING THE HOLE APPEARS AT THE TOP OF THE LOG FOR EACH HOLE.
7. ABSENCE OF GROUND WATER DATA ON LOGS DOES NOT INDICATE THAT WATER WILL NOT BE ENCOUNTERED DURING CONSTRUCTION.





COMPLEX 1B

SOIL BORING LAYOUT

1" = 200'

DRILL HOLE NUMBER	COORDINATES	
	NORTHING	EASTING
D.H ESA-1	30,490	90,471
D.H ESA-2	30,847	90,686
D.H ESA-3	30,677	90,930
D.H ESA-4	29,932	90,937
D.H ESA-5	30,174	90,756
D.H ESA-6	30,530	90,762
D.H ESA-7	30,245	90,948
D.H. ESA-8	29,681	91,014

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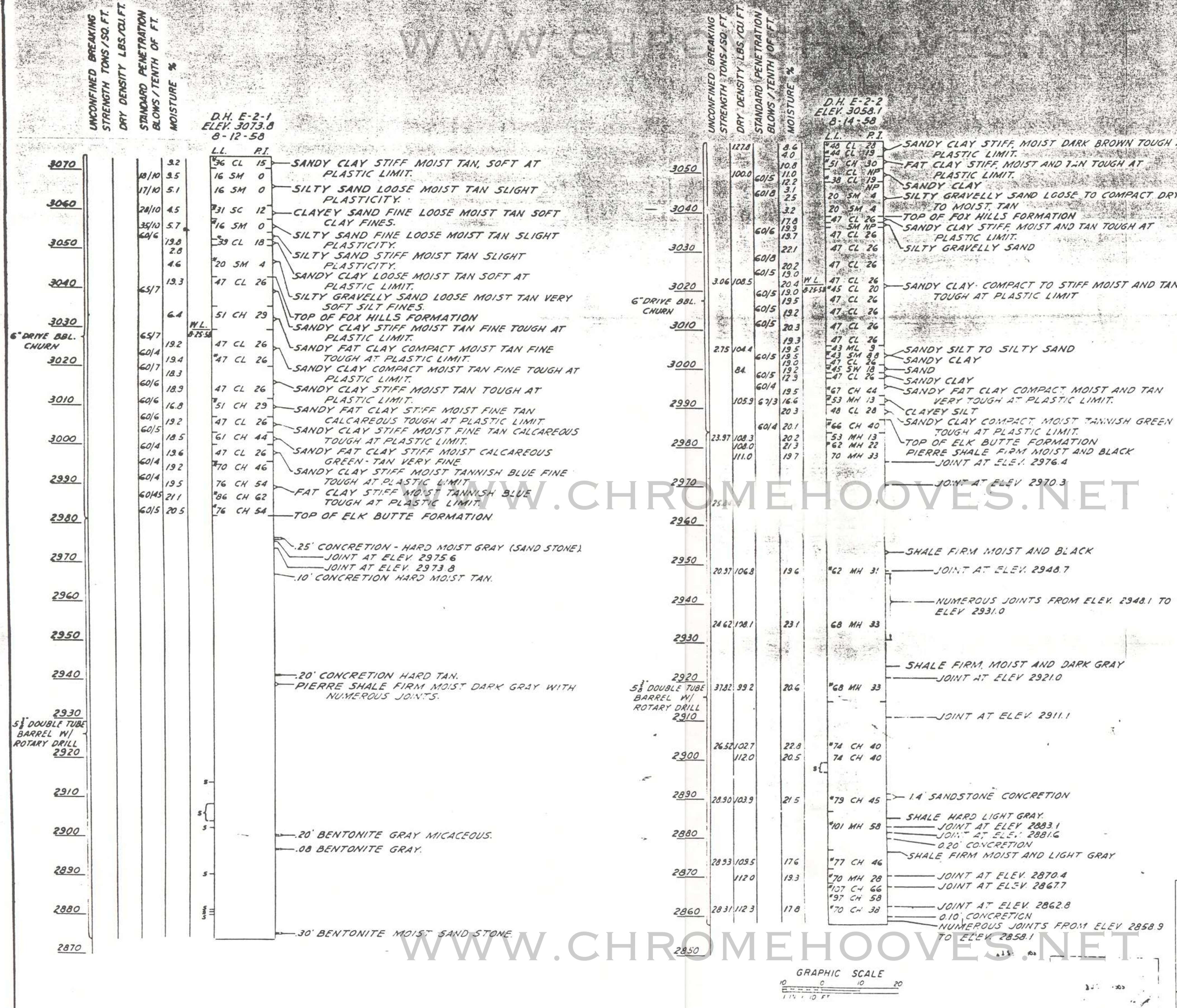
COMPLEX 1A, 1B & 1C

GENERAL
COMPLEX 1B
LOG OF BORINGS

6BI 6.10

SPECIFICATION NO. ENG-25-066-60 1
DATE 1 JULY 1959
SCALE AS NOTED
SHEET 13

NOTE:
FOR LEGEND, GENERAL NOTES AND SOIL BORING LAYOUT SEE SHEET NO. 80-C-2



D.H. E-2-1
ELEV. 3073.8
8-12-58

UNCONFINED BREAKING STRENGTH TONS/SQ.FT.	DRY DENSITY LBS/CU.FT.	STANDARD PENETRATION BLOWS/TENTH OF FT.	MOISTURE %	L.L.		P.I.
			9.2	*36	CL	15
		18/10	9.5	16	SM	0
		17/10	5.1	16	SM	0
		28/10	4.5	*31	SC	12
		35/10	5.7	*16	SM	0
		60/6	19.8	*39	CL	18
			2.8			
			4.6	*20	SM	4
			19.3	47	CL	26
		65/7				
			6.4	51	CH	29
		65/7				
			19.2	47	CL	26
		60/4	19.4	*47	CL	26
		60/7	18.3			
		60/6	18.9	47	CL	26
		60/6	16.8	*51	CH	29
		60/6	19.2	47	CL	26
		60/5	18.5	61	CH	44
		60/4	19.6	47	CL	26
		60/4	19.2	*70	CH	46
		60/4	19.5	76	CH	54
		60/45	21.1	*86	CH	62
		60/5	20.5	*76	CH	54

SANDY CLAY STIFF MOIST TAN, SOFT AT PLASTIC LIMIT.
SILTY SAND LOOSE MOIST TAN SLIGHT PLASTICITY.
CLAYEY SAND FINE LOOSE MOIST TAN SOFT CLAY FINES.
SILTY SAND FINE LOOSE MOIST TAN SLIGHT PLASTICITY.
SILTY SAND STIFF MOIST TAN SLIGHT PLASTICITY.
SANDY CLAY LOOSE MOIST TAN SOFT AT PLASTIC LIMIT.
SILTY GRAVELLY SAND LOOSE MOIST TAN VERY SOFT SILT FINES.
TOP OF FOX HILLS FORMATION
SANDY CLAY STIFF MOIST TAN FINE TOUGH AT PLASTIC LIMIT.
SANDY FAT CLAY COMPACT MOIST TAN FINE TOUGH AT PLASTIC LIMIT.
SANDY CLAY COMPACT MOIST TAN FINE TOUGH AT PLASTIC LIMIT.
SANDY CLAY STIFF MOIST TAN TOUGH AT PLASTIC LIMIT.
SANDY FAT CLAY STIFF MOIST FINE TAN CALCAREOUS TOUGH AT PLASTIC LIMIT.
SANDY CLAY STIFF MOIST FINE TAN CALCAREOUS TOUGH AT PLASTIC LIMIT.
SANDY FAT CLAY STIFF MOIST CALCAREOUS GREEN-TAN VERY FINE
SANDY CLAY STIFF MOIST TANNISH BLUE FINE TOUGH AT PLASTIC LIMIT
FAT CLAY STIFF MOIST TANNISH BLUE TOUGH AT PLASTIC LIMIT.
TOP OF ELK BUTTE FORMATION
.25' CONCRETION - HARD MOIST GRAY (SAND STONE).
JOINT AT ELEV. 2975.6
JOINT AT ELEV. 2973.8
.10' CONCRETION HARD MOIST TAN.
.20' CONCRETION HARD TAN.
PIERRE SHALE FIRM MOIST DARK GRAY WITH NUMEROUS JOINTS.
.20' BENTONITE GRAY MICACEOUS.
.08 BENTONITE GRAY.
.30' BENTONITE MOIST SAND STONE.

D.H. E-2-2
ELEV. 3058.1
8-14-58

UNCONFINED BREAKING STRENGTH TONS/SQ.FT.	DRY DENSITY LBS/CU.FT.	STANDARD PENETRATION BLOWS/TENTH OF FT.	MOISTURE %	L.L.		P.I.
	127.8		8.6	*48	CL	28
			4.0	*44	CL	19
			10.8	*51	CH	30
	100.0	60/5	11.0		CL	NP
			12.2	*38	CL	19
			3.1			NP
		60/8	2.5	20	SM	4
			3.2	20	SM	4
			17.8	*47	CL	26
		60/6	19.9		SM	NP
			19.7	47	CL	26
			22.1	47	CL	26
		60/8				
			20.2	47	CL	26
		60/5	19.0			
3.06	108.5		20.4	47	CL	26
		60/5	19.0	*45	CL	20
			19.5	47	CL	26
		60/5	19.2	47	CL	26
		60/5	20.3	47	CL	26
			19.3	47	CL	26
2.75	104.4		19.5	*43	ML	9
		60/5	19.5	*43	SM	8.8
			19.0	*47	CL	26
	84.	60/5	19.2	*45	SW	18
			12.9	*47	CL	26
		60/4				
			19.5	*67	CH	44
	105.9	67/3	16.6	*53	MH	13
			20.3	48	CL	28
		60/4	20.1	*66	CH	40
23.97	108.3		20.2	53	MH	13
	108.0		21.3	*62	MH	22
	111.0		19.7	70	MH	33
25.84						
20.37	106.8		19.6	*62	MH	31
24.62	128.1		23.1	68	MH	33
37.82	99.2		20.6	*68	MH	33
26.52	102.7		22.8	*74	CH	40
	112.0		20.5	74	CH	40
28.90	103.9		21.5	*79	CH	45
				*101	MH	58
28.93	109.5		17.6	*77	CH	46
	112.0		19.3	*70	MH	28
				*107	CH	66
				*97	CH	58
28.31	112.3		17.8	*70	CH	38

SANDY CLAY STIFF, MOIST DARK BROWN TOUGH AT PLASTIC LIMIT.
FAT CLAY STIFF, MOIST AND TAN TOUGH AT PLASTIC LIMIT.
SANDY CLAY
SILTY GRAVELLY SAND LOOSE TO COMPACT DRY TO MOIST, TAN
TOP OF FOX HILLS FORMATION
SANDY CLAY STIFF, MOIST AND TAN TOUGH AT PLASTIC LIMIT.
SILTY GRAVELLY SAND
SANDY CLAY COMPACT TO STIFF MOIST AND TAN TOUGH AT PLASTIC LIMIT
SANDY SILT TO SILTY SAND
SANDY CLAY
SAND
SANDY CLAY
SANDY FAT CLAY COMPACT MOIST AND TAN VERY TOUGH AT PLASTIC LIMIT.
CLAYEY SILT
SANDY CLAY COMPACT MOIST TANNISH GREEN TOUGH AT PLASTIC LIMIT.
TOP OF ELK BUTTE FORMATION
PIERRE SHALE FIRM MOIST AND BLACK
JOINT AT ELEV. 2976.4
JOINT AT ELEV. 2970.3
SHALE FIRM MOIST AND BLACK
JOINT AT ELEV. 2948.7
NUMEROUS JOINTS FROM ELEV. 2948.1 TO ELEV. 2931.0
SHALE FIRM, MOIST AND DARK GRAY
JOINT AT ELEV. 2921.0
JOINT AT ELEV. 2911.1
1.4' SANDSTONE CONCRETION
SHALE HARD LIGHT GRAY.
JOINT AT ELEV. 2883.1
JOINT AT ELEV. 2881.6
0.20' CONCRETION
SHALE FIRM MOIST AND LIGHT GRAY
JOINT AT ELEV. 2870.4
JOINT AT ELEV. 2867.7
JOINT AT ELEV. 2862.8
0.10' CONCRETION
NUMEROUS JOINTS FROM ELEV. 2858.9 TO ELEV. 2858.1

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REVISION	DATE	DESCRIPTION	AGENCY	BY

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DANIEL, MANN, JOHNSON & MENDENHALL
AND ASSOCIATES
ARCHITECTS and ENGINEERS

DEPARTMENT OF THE AIR FORCE
AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)

C DRAKE
J A CUNNINGHAM

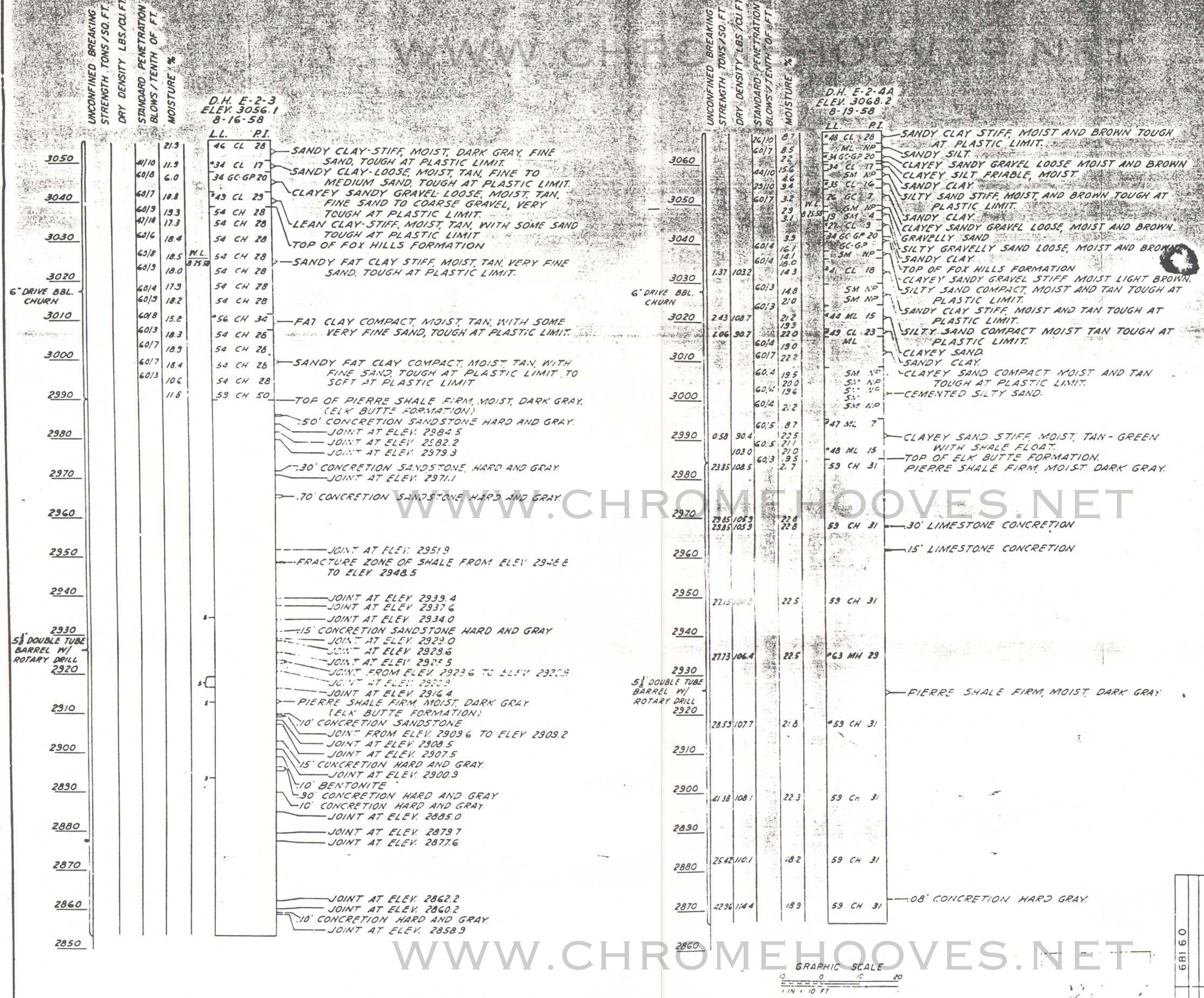
A-E SHEET NO. 80-C-4
353-1-1

WS-107 A-2 TECHNICAL FACILITIES
ELLSWORTH A.F. BASE, RAPID CITY S. DAK.
COMPLEX 1A, 1B & 1C

GENERAL
COMPLEX 1A
LOG OF BORINGS

SPECIFICATION NO. ENG-25-066-60-1
DATE 1 JULY 1959
SCALE AS NOTED
SHEET 11

NOTE
FOR LEGEND, GENERAL NOTES AND SOIL
BORING LAYOUT SEE SHEET NO. 80-C-2



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DEPARTMENT OF THE AIR FORCE
AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)

C DRAKE
J A CUNNINGHAM

80-C-3
353-1-1

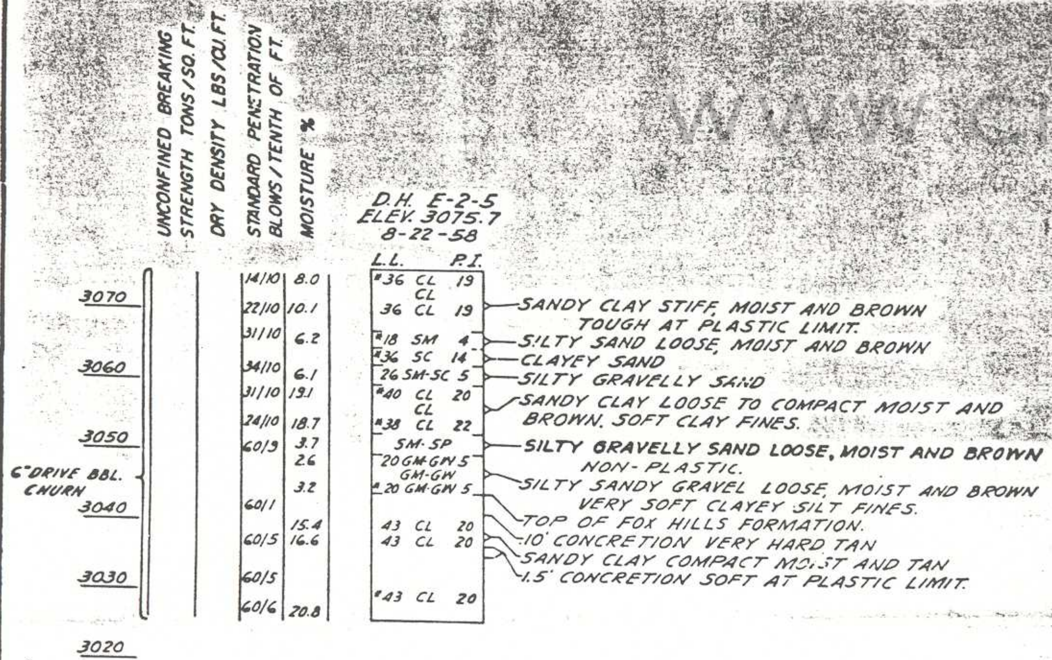
WS-107 A-2 TECHNICAL FACILITIES
ELLSWORTH A.F. BASE, RAPID CITY S. DAK.
COMPLEX 1A, 1B & 1C

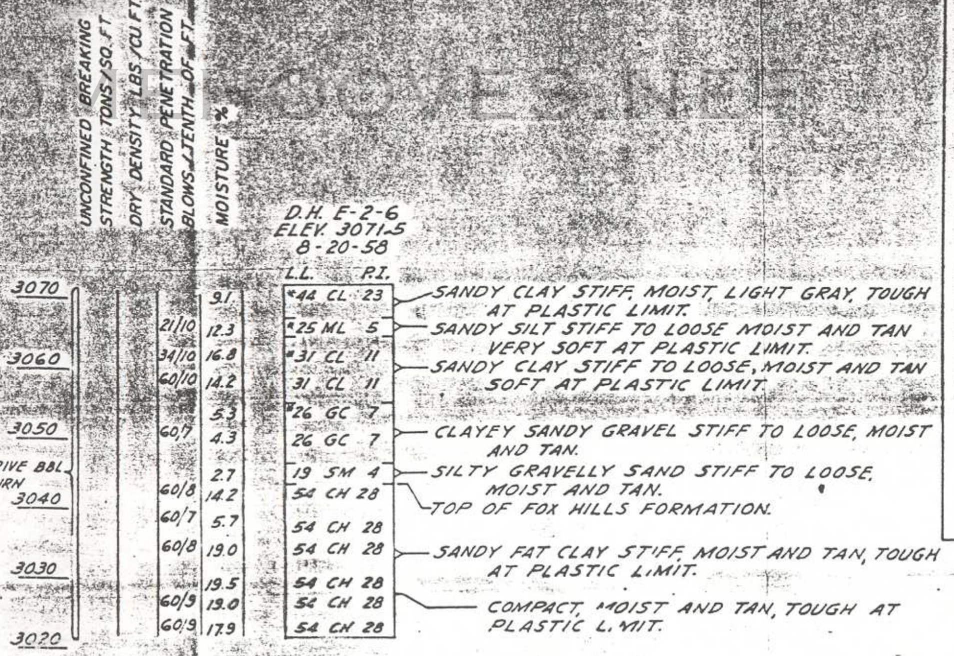
GENERAL
COMPLEX 1A
LOG OF BORINGS

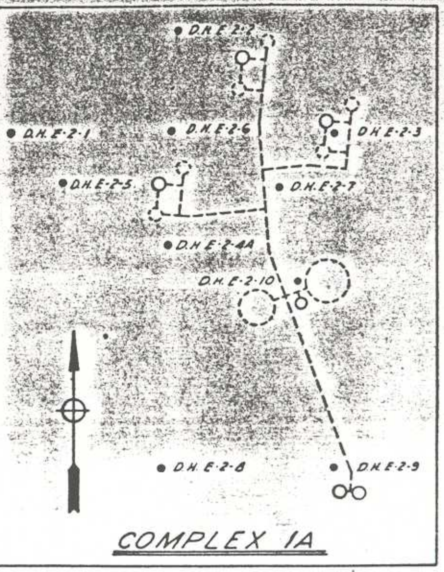
6B1 60

ENG-25-066 60-1

DATE 1 JULY 1959
SCALE AS NOTED
SHEET 10



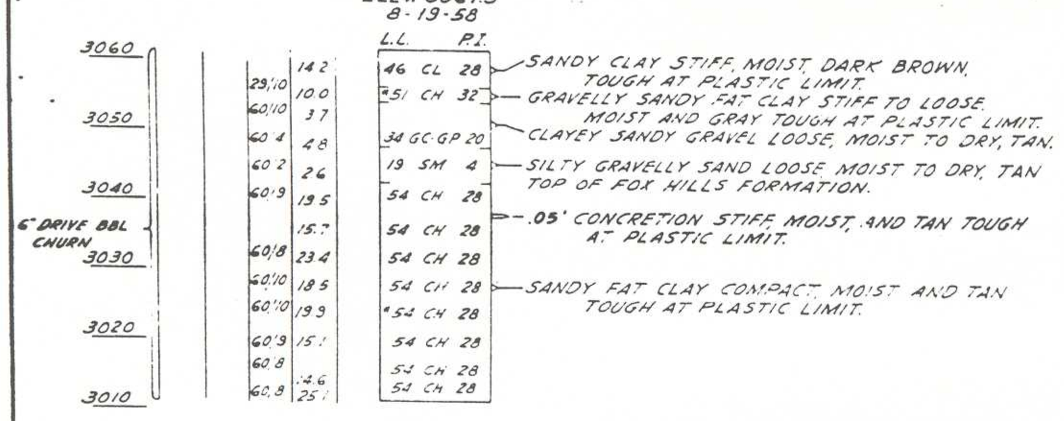




SOIL BORING LAYOUT

1" = 200'

DRILL HOLE NUMBER	COORDINATES	
	NORTHING	EASTING
D.H. E-2-1	49 622 43	101, 015 91
D.H. E-2-2	49 905 54	101, 477 30
D.H. E-2-3	49 613 64	101, 916 34
D.H. E-2-4A	49, 305.64	101, 458 05
D.H. E-2-5	49, 483 50	101, 162 65
D.H. E-2-6	49, 625. 53	101, 466. 50
D.H. E-2-7	49, 467, 65	101, 762 44
D.H. E-2-8	48, 675 86	101, 441 40
D.H. E-2-9		
D.H. E-2-10		



BORING LEGEND

D.H. E-2-5	BORING NUMBER.
E. 3075.7	ELEVATION OF GROUND SURFACE AT TOP OF BORING.
8-22-58	DATE BORING COMMENCED.
CL	SANDY CLAY.
SM	SILTY SAND, SILTY GRAVELLY SAND.
SC	CLAYEY SAND.
SM-SC	SILTY GRAVELLY SAND.
SM-SP	SILTY GRAVELLY SAND, POORLY GRADED
GM-GW	SILTY SANDY GRAVEL, WELL GRADED.
ML	SANDY SILT.
GC	CLAYEY SANDY GRAVEL
CH	FAT CLAY, SANDY FAT CLAY, GRAVELLY SANDY FAT CLAY.
GC-GP	CLAYEY SANDY GRAVEL, POORLY GRADED.
MH	CLAYEY SILT.
L.L.	LIQUID LIMIT.
P.I.	PLASTICITY INDEX.
60/3	STANDARD PENETRATION: THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2-INCH O.D. SPLIT SAMPLER WITH A 140 POUND WEIGHT FALLING 30-INCHES THE INDICATED TENTHS OF A FOOT. SIXTY (60) BLOWS ARE REQUIRED TO DRIVE THE SAMPLER 9/10 (NINE-TENTH) OF A FOOT.
S 〈	SLICKENSIDE
S {	SLICKENSIDE ZONE
8-25-58	DATE WATER LEVEL WAS OBSERVED.
W.L.	**WATER LEVEL ESTABLISHED BY MEASUREMENT IN OPEN HOLE.**

NOTES:

1- AN ASTERISK (*) PRECEEDING THE ATTERBERG LIMITS INDICATES THAT THE TESTS WERE RUN ON THAT SAMPLE, OTHERWISE THE LIMITS WERE DETERMINED ON ANOTHER SAMPLE VISUALLY CLASSIFIED AS IDENTICAL.

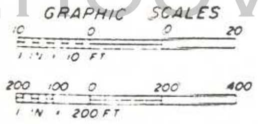
2- DESCRIPTIONS AT THE RIGHT OF BORING PROFILES IS SUPPLEMENTAL DATA BASED ON LABORATORY AND FIELD INSPECTION OF THE SAMPLE.

3- ELEVATION READINGS REFER TO MEAN SEA LEVEL, 1929 GENERAL ADJUSTMENT.

4- TYPE OF BARREL AND DRILL RIG USED FOR DRILLING THE BORING IS SHOWN AT THE LEFT OF THE LOG.

5- THE DATE OF DRILLING THE HOLE APPEARS AT THE TOP OF THE LOG FOR EACH HOLE.

6- ABSENCE OF GROUND WATER DATA ON LOGS DOES NOT INDICATE THAT WATER WILL NOT BE ENCOUNTERED DURING CONSTRUCTION.



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6BI 6.0

APPROVED BY
FOR

DATE 1 JULY 1959
SCALE AS NOTED
SHEET 9