Geology of Belton Reservoir Area
Leon River, Bell County, Texas

By JACK COLLIGAN*

REGIONAL GEOLOGY

Location of project. Belton Reservoir will be formed by construction of an earthen dam on the Leon River at about river mile 16.7, approximately 3 miles north of Belton. The reservoir will occupy a northern portion of Bell County and a southeastern portion of Coryell County.

Sites investigated. An extensive subsurface investigation was made of the project document site at river mile 15.5. Subsurface explorations disclosed adverse leakage and unfavorable geologic conditions, and as a result the site was abandoned. A dam site at about river mile 16.7 was investigated and found to be geologically satisfactory for development of the definite project dam.

PHYSIOGRAPHY

The Belton Reservoir will occupy a portion of the Central Texas section of the Great Plains physiographic province. The original surface of the Central Texas section was a broad plateau supported by resistant Cretaceous limestones. The plateau has been eroded by major streams and their numerous tributaries to such an extent that at the present time it appears as a maturely dissected plateau. Resistant limestones of the Edwards formation form the cap rock on the divides between the principal drainage ways and on the numerous buttes and outliers in the area.

There are numerous flat-surfaced areas between the divides, buttes, and outliers, but much of the area is of rolling or hilly character becoming moderately rugged in the southeastern portion of the reservoir. The valley slopes, in general, are moderately steep and rough, and the valleys are about one-half mile wide. The drainage of the area is to the southeast, generally consequent upon the dip-plain of the underlying Cretaceous formations.

The topography of the section within and adjacent to the lower portion of the reservoir, where the Edwards limestones are more prevalent, is moderately rough. The Edwards usually forms steep bluffs along the principal streams and the smaller creeks and drains. The numerous laterals of the main streams are deeply incised into the resistant formation. The relief of the section near the upstream portion of the reservoir is comparatively flat and featureless except for the remnants of the old plateau surface which occur as steep sloped

*Corps of Engineers, Department of the Army, Fort Worth, Texas.

buttes and outliers or as narrow ridges along the stream divides. The area is locally designated as the Walnut Prairie, so termed because it is within the outcrop of the shale and argillaceous limestones of the Walnut formation.

STRATIGRAPHY

The reservoir area and dam sites are located within the outcrop of the formations of Lower Cretaceous age. These formations are of the Trinity, Fredericksburg, and Washita groups. The aerial geology of Belton Reservoir is shown on plate 1. Data for the plate were compiled from various maps, texts, and bulletins on the geology of the region and a study of surface outcrops in the reservoir and dam site areas.

The oldest or Trinity group outcrops in the western portion of the reservoir along Cowhouse Creek, and dip eastward beneath younger beds. The group is represented by outcrops of Glen Rose limestones and Paluxy sands.

The Fredericksburg group consists of the Walnut shale, Comanche Peak limestone, and Edwards limestone. These formations outcrop throughout the dam site area and in a major portion of the reservoir area.

Strata of the Washita group outcrop over a limited portion of the reservoir area east of the Leon River. The section is composed chiefly of limestone and shale strata.

STRUCTURE

The Trinity, Fredericksburg, and Washita strata dip eastward at a rate of 30 to 40 feet per mile and the strike of these beds in Central Texas is almost north-south. The oldest formations outcrop in the upper reservoir area and dip under younger formations at a greater angle than the regional slope of the land surface. Consequently, a progressively younger series of formations is encountered southeastward from the upstream reservoir areas.

Two faults of the Balcones zone of faulting cross the Leon River Valley in the vicinity of the dam sites. One fault crosses the valley at about river mile 15.3, the other at mile 16.1. The faults have a prevailing trend to the northeast, are of normal character, and have small displacement with downthrow to the east. The displacement in each fault is about 30 feet. Investigations revealed that the faults do not extend under the dam sites nor into the reservoir area. There are no records or evidences of recent damaging earthquakes occurring in the area under consideration.

DEFINITE PROJECT SITE

SUBSURFACE INVESTIGATIONS

Previous investigations. Geological explorations at the definite project site (mile 16.7) were made in 1938 and 1946 in connection with the investigation of the project document site. The explorations consisted of drilling 13 auger borings and 5 core borings, and conducting a general geological reconnaissance of the dam site and reservoir area.

Definite project investigations. Geological investigations performed for the definite project report consisted of an extensive core drilling program to afford visual examination of the foundation materials and to determine the structural and stratigraphic conditions at the dam site. A program of water-pressure testing the core holes was conducted to determine the porosity of the foundation materials.

Fifty-seven borings were made, consisting of 35 two-inch and 5 six-inch core borings and 17 six-inch undisturbed borings. Nine of the undisturbed borings were extended by means of 8-inch auger and/or 2-inch core borings, as required. Boring locations and a geologic profile of the foundation materials adjacent to the axis of the dam are shown on plate 2. Geologic profiles of various sections of the dam site foundation are shown on plates 3 and 4 and the graphic logs of the 57 borings are shown on plates 5 to 16, inclusive.

Geology of the Dam Site

SOILS

The upland areas of the dam site are covered with a thin mantle of residual soils consisting of silts, clays, sands, gravels, and limestone materials in combination. The residual materials generally range from a few inches, near rock outcrops, to 2 or 3 feet in thickness and in upland areas occasionally attain a maximum thickness of 5 to 10 feet. On the abutment faces, which have slopes ranging from about 1 on 2 to 1 on 3, the mantle is very thin, consisting of residual clay and limestone materials. Large boulders and limestone fragments occur on the slopes between weathered outcrops. The soil mantle in the flood plain area of the dam site consists chiefly of alluvial sands, silts, and clays in various combinations. The overburden varies from 20 to 40 feet in thickness with the maximum section occurring in the vicinty of the right bank of the Leon River. A stratum of sand and/or gravel, 2 to 15 feet in thickness, underlies the overburden and rests upon a 2- to 7-foot stratum of weathered Walnut formation. Talus-like deposits composed of weathered rock fragments, boulders, and limestone boulders in a clay, sand, and gravel matrix occur along the toe of each abutment.

STRATIGRAPHY

Rock strata outcropping at and penetrated by borings at the dam site, from oldest to youngest, are those of the Walnut, Comanche Peak, and Edwards formations of the Fredericksburg group of Lower Cretaceous age.

Walnut formation. The Walnut formation underlies the alluvial deposits in the flood plain area, and underlies the Comanche Peak formation in the right and left abutments. The formation is medium hard and compact except where exposed to weathering or reached by groundwater which softens the shale strata to a depth of 2 to 7 feet below contact with alluvial materials. The formation is made up of alternating beds of argillaceous limestone and calcareous shale. The limestones are moderately hard to hard, depending on the content of argillaceous material, and range in color from light to dark gray. Numerous thin irregular partings and seams of calcareous shale occur in almost all the limestone strata. The limestones are fossiliferous and occasionally contain flakes, clusters, and crystals of pyrite. Many of the shale strata of the Walnut formation are very calcareous, and it is difficult to distinguish them from the argillaceous limestone phases of the formation. They range from light gray, where high in lime content, to dark gray or black in color and are thinly laminated where calcareous materials are absent. The shales are moderately hard, fossiliferous, and pyritic and contain numerous thin seams and nodular pieces of gray limestone. Typical Walnut shell beds occur in the lower portions of the formation. These beds are a shell agglomerate in a dark gray, calcareous, shale matrix. They are moderately hard and for the most part the shells are firmly cemented together. These beds range from a few inches to 10 feet in thickness and often are interbedded with seams of limestone or shale. The maximum thickness of Walnut penetrated by core borings was 116 feet. However, the formation attains a maximum thickness of from 165 to 185 feet in Bell County.

Comanche Peak formation. The Comanche Peak formation forms the steep slopes of both abutments, between elevations of 540 feet and 605 feet on the right abutment and elevations of 535 feet and 600 feet on the left abutment. The formation is uniformly 65 feet in thickness at the dam site and consists chiefly of chalky, nodular pieces of limestone in a matrix of limy marl or shale. The limestones are white to light gray in color and are moderately hard and occasionally fossiliferous. The formation is not distinctly bedded and the contact with the underlying Walnut is transitional. On the outcrop, the formation has a dull chalky texture. Weathering of the formation, on the outcrop or where overlain by alluvial deposits, rarely extends into the limestones more than 1 or 2 feet.

Edwards formation. The Edwards formation conformably overlies the Comanche Peak and is readily distinguishable from it by the absence of argillaceous materials, the presence of flint and chert, and the honeycombed or vuggy appearance of the limestone. Facies of the Edwards are varied, some of the strata appearing as nearly pure, fragmental, coquina-like limestone, miliolid limestone, arenaceous limestone, marly limestone, or rudistid and caprinid shell agglomerates. The formation is predominantly tan to light gray in color, is generally medium hard to hard, and is massively bedded. The Edwards outcrops above an elevation of 605 feet on the right abutment and just below an elevation of 600 feet on the left abutment. Borings at the dam site indicated the formation to be 52 feet thick. Many of the limestone strata appear porous and vuggy; however, evidence of large continuous openings, solution channels, or caves was not revealed in any of the borings. A study of outcrops in the dam site area did not reveal any evidence of cavernous condition in the limestones, although a honeycombed condition does exist on surface exposures.

STRUCTURE

Analysis of the geological profiles shown on plates 3 and 4 reveal that the dip of the primary formations is towards the east at a rate of about 35 feet per mile. The geological profiles on plates 2 and 3 show that the contact between the Comanche Peak and Edwards formation outcrops on the right abutment about 5 feet higher than on the left abutment. The profiles indicate that the main portion of the dam axis nearly parallels the strike of the primary formations.

A normal fault occurs about 2,000 feet downstream of the dam axis crossing the Leon River Valley at about river mile 16.1. It has a displacement of about 30 feet with downthrow to the east and can be traced in a northeast-southwest direction for a distance of about 1½ miles on each side of the Leon River. The line of faulting does not extend beneath the dam site nor into the reservoir area. The fault was not involved in the construction of the dam.

WEATHERING OF BEDROCK

The zone of weathering in the Edwards limestone formation is difficult to determine due to the color and composition of the beds. Solution action has in the past discolored and altered various strata in the formation giving the limestone a weathered appearance. Several borings in the spillway section indicate weathered rock to a depth of 3 to 5 feet. Weathering has penetrated the Edwards limestones from 3 to 7 feet on the right abutment. Inspection of Comanche Peak outcrops on the abutment slopes indicates that weathering has not penetrated the formation more than 2 feet. A considerable depth of weathering has occurred in the exposed Walnut formation outcrops on the abutment faces below an elevation of 540 feet and it appears that the formation cannot be classed as being resistant to weathering or erosion. Weathering of the Walnut strata underlying alluvial deposits in the floodplain area varies from 2 to 7 feet into the formation. The base of the weathered zone ranges from an elevation of 455 feet to 460 feet in the flood plain area, is at about an elevation of 470 feet near the toe of the right abutment, and at an elevation of 480 feet at the toe of the left abutment.

FOUNDATION CONDITIONS AT STRUCTURE LOCATIONS

Earth embankment. The formations beneath the earth embankment area on the right and left abutments consisting of limestone and shale strata were found to be structurally sound and satisfactory to serve as the foundation for the earth embankment. The rock formations below an elevation of 600 feet were found to be highly impervious. Borings in the Edwards formation reveal the presence of numerous small to large solution cavities and channels partly to tightly filled with marl and in some strata with porous lime deposits. The Walnut formation under the flood plain area of the embankment is structurally sound and impervious below the weathered zone. Tests performed on samples of the Walnut formation obtained at the project document site indicate that the unconfined compression strength of the shales ranged from 14.8 to 19.8 tons per square foot.

Outlet works. Two sites were investigated for the location of the outlet works. One site considered the construction of a tunnel through the right abutment. The other site considered a concrete conduit beneath the earth embankment located near the toe of the right abutment. The location of these sites is shown by sections C-C and D-D, respectively, on plate 2.

A 22-foot diameter flood-control tunnel having an intake invert elevation of 483 feet and an outlet invert elevation of 477 feet is considered adequate to pass the flood flows through the dam. Section C-C, plate 2, and boring logs on plates 14, 15, and 16 reveal that the tunnel would be cut through the Walnut formation consisting of argillaceous limestone, calcareous shale, and shell agglomerate beds. It was determined that these strata are moderately hard, impervious, and structurally sound. The results of water-pressure testing the tunnel core borings are shown in table 1.

Analysis of the conduit alignment borings reveals that the base of the weathered shale and limestone strata of the Walnut formation occurs at about an elevation of 470 feet, and that a satisfactory foundation for the conduit outlet works can be had at and below elevation 470. Approximately 40 feet of overburden including a stratum of weathered shale and limestone would have to be removed to secure satisfactory foundation rock. Additional borings at the selected outlet works site will be required for final design purposes.

Spillway. The spillway is located on the left abutment as indicated on plate 2. A 1300-foot wide, broad crested spillway having an approach channel and crest at an elevation of 631.0 feet was found to be most economical. The crest of the spillway coincides with the axis of the earth embankment extending across the spillway. From the crest, the spillway discharge channel extends downward on a 2 per cent grade to intersect natural ground at a low elevation of about 610. Thus, the spillway is within and underlain by the Edwards formation which is considered to be very resistant to erosion and weathering.

Core borings within the spillway area reveal that the Edwards limestone is porous and honeycombed, and will permit some leakage through the strata if water should be impounded above elevation 600 for a long period of time. At the downstream end of the spillway discharge channel, the Comanche Peak formation occurs beneath the overburden between approximate elevations of 600 feet and 530 feet and immediately overlies the Walnut formation. The Comanche Peak is impervious and fairly resistant to erosion but slakes down rapidly when exposed to repeated wetting and drying. The Walnut is impervious but cannot be classed as resistant to erosion, although a few hard limestone layers occur within the formation. Investigation reveals that the spillway will be in operation only during floods considerably greater than the maximum flood of record and accordingly will be used very infrequently. In view of the foregoing, it appears that the spillway foundation materials are structurally sound and that weathering and erosion of the spillway, if any, will not be detrimental to its stability.

Leakage

Leakage through alluvial and residual materials. Alluvial deposits in the flood plain at the dam site are generally of silt and clay content but contain layers of sand and gravel of varying thicknesses. Pervious strata of sand and gravel occur at the base of the alluvium and overlie a zone of weathered Walnut formation. A maximum thickness of 16 feet of sand and gravel was found in boring 6D8A-101. The pervious strata are not well sealed by overlying alluvium, and outcrops of sand and gravel occurring in the upstream flood plain may be interconnected with those at the dam site whereby water would have easy entrance to the basal pervious strata. Borings in the area also revealed that weathering has penetrated into the primary formation from 2 to 7 feet with a maximum thickness of 19 feet of partly softened and slightly weathered formation occurring in boring 6D8A6C-96. An impervious cut-off wall extending through the pervious strata and zone of weathered formation for the full width of the flood plain is necessary to prevent detrimental leakage of water beneath the earth embankment. The residual soil mantle on the face and top of the abutments is of porous character, and its removal or construction of an impervious cut-off extending into the primary formation was deemed necessary to prevent leakage.

Leakage through bedrock. Water-pressure tests were conducted in 35 two-inch core holes in the dam site area. These tests indicated that all weathered materials regardless of the characteristics of the formation with which they are associated will readily transmit water and should be removed, grouted, or cut off by a core trench to insure a water-tight foundation. The results of the water-pressure tests made on strata of the three formations at the dam site are given in table 1.

On the left abutment, water-pressure tests were conducted in 18 core holes. Considerable leakage was developed in core hole 2C-77 and of lesser amount in six other holes of which five are located in the spillway discharge area and the other beyond the spillway. Testing of the six holes revealed that the zone of leakage exists in the Edwards formation at or above an elevation of 607 feet. The maximum leakage in these holes was 19.5 gallons per minute under 20-pound pressure in boring 2C-93. Core hole 2C-77 is located on the crest of the abutment about 350 feet downstream of the axis of the dam. Top of hole is at an elevation of 626.6 feet and bottom at about an elevation of 450 feet. Testing at a pressure of 30 pounds per square inch between the elevations of 593 feet and 450 feet disclosed leakage of 23.4 gallons per minute. At 5- and 10-pound pressures between the elevations of 598 feet and 505 feet the leakage was negligible, being 0.75 gallons per minute. Between the elevations of 503 feet and 450 feet at 5-pound pressure, the leakage was 7.3 gallons per minute; thereby indicating that leakage occurs in the Walnut formation. In view of the imperviousness of the formation as revealed by tests in adjacent holes, it appears that leakage in 2C-77 was probably towards the abutment face.

Eleven core holes on the right abutment were water-pressure tested. Excessive leakage was developed in hole 2C-123 through Edwards strata and of lesser amount in five other holes. The leakage zone in these five holes was found to exist in the Edwards formation at and above an elevation of 620 feet. The maximum leakage occurred in hole 2C-118 which amounted to 34 gallons per minute under 5-pound pressure. Boring 2C-123 is located near the crest of the abutment in close proximity to the axis of the dam. Ground surface at the boring is at about an elevation of 637 feet and bottom of hole at an elevation of 474 feet. Leakage between the elevations of 615 feet and 604 feet amounted to 19 gallons per minute with no pressure applied. Between the elevations of 605 feet and 594 feet no leakage was developed under 50-pound pressure, between the elevations of 595 feet and 474 feet the leakage was about 15 gallons per minute at 50-pound pressure, and between the elevations of 555 feet to 474 feet about 0.4 gallons per minute at 10-pound pressure. The tests indicate that leakage occurred in both the Edwards and Comanche Peak formations.

In general, the tests reveal that the primary Comanche Peak and Walnut formations at the dam site are relatively impervious below an elevation of 600 feet and that some leakage will occur through the Edwards formation above this elevation. Grouting of the pervious Edwards formation is deemed inadvisable at this time. However, excavation of the spillway area will reveal the character of the porous strata and may dictate the desirability of providing a grout cut-off through the strata. Therefore, it is proposed that an item of foundation grouting be included in the estimated cost of the project to provide for such action. With respect to the leakage in 2C-77 and 2C-123, it is proposed that additional water-pressure tests be performed to determine more definitely the leakage characteristics of foundation rocks near both abutment faces and to provide adequate data for the design of any necessary cut-off walls.

Summary and Conclusions

Summary. Subsurface investigations at the definite project site, together with examination of rock outcrops, made a 225-foot section of Lower Cretaceous strata available for visual examination and revealed the composition of the formations, formational contacts, the dip and strike of the beds, and structural characteristics. Water-pressure tests performed in the core borings provided accurate data for determination of leakage characteristics of the formations. The investigations also revealed the nature and extent of alluvial and residual materials, and weathering characteristics of the rock formations.

Conclusions. Based on results of the foregoing investigations, it is concluded that:

1. The dam and reservoir sites are physiographically and geologically suitable for impounding the waters of the Leon River.
2. The dam site is free of adverse structural features.
3. Unweathered portions of the Walnut, Comanche Peak, and Edwards formations are structurally sound and will form a satisfactory foundation for the proposed structures.
4. Pervious strata occur in the alluvial deposits in the flood plain at the dam site and removal of these strata or a cut-off through them will be required to prevent leakage under an earth embankment section.
5. The residual materials on the steep slopes and tops of both abutments are pervious and should be removed to provide satisfactory foundation conditions.
6. Removal of the weathered portion of foundation rocks or a cut-off through them will be required to insure satisfactory foundation conditions.
7. Edwards strata above an elevation of 600 feet on both abutments are pervious and leakage will take place through them.
8. Comanche Peak strata at the dam site are impervious, except in localized zones on the crests of the left and right abutments. These leaky zones can be effectively grouted to prevent leakage through the foundation rocks.
9. The Edwards and Comanche Peak strata in the spillway discharge channel are erosionally resistant and will provide a protective cap over the more easily eroded Walnut strata.
10. A large amount of weathered Walnut shale and argillaceous limestone will have to be removed from a narrow bench or terrace in the area of the outlet works at the toe of the right abutment to insure satisfactory foundation conditions.
11. Shale and limestone strata of the Walnut and Comanche Peak formations should be protected against weathering when exposed during construction operations.

PROJECT DOCUMENT SITE

Subsurface Investigations

Investigation of project document site. Geological investigations of the dam site at mile 15.5 on the Leon River were made in 1938 for the purpose of determining the most feasible site for the project document dam. Field investigations included the drilling of four 2-inch core borings along proposed dam axis, and conducting a general reconnaissance of the dam site and reservoir area.

Upon authorization to prepare a definite project report on Belton Reservoir, an extensive program of core drilling and pressure testing of the project document dam site was initiated in February, 1948, to determine more definitely the suitability of the site and to obtain adequate data for design purposes. The program was cancelled only after considerable investigational work definitely established the unsuitability of the site. A total of 39 core borings were made, of which

25 were 2-inch, 10 were 6-inch, and 4 were 30-inch. Water-pressure tests were performed in 13 core borings. A grout test panel covering 40 feet of spillway length was made on the left abutment. Unconfined compression tests were made on samples of the primary formation underlying the flood plain. The location of the completed borings is shown on plate 18. Graphic logs of 12 borings which reveal the detrimental character of the foundation materials are shown on plate 19.

General Geology of Dam Site

Geologically, the project document site at river mile 15.5 and the definite project site at mile 16.7 are similar in character with the exception that the primary formations at the project document site occur at lower elevations. Thus, the information given in Geology of the Dam Site of this report is applicable, in general, to the project document site.

Two normal faults are present near the site. One is located about 1,000 feet downstream of and somewhat parallel to the proposed dam axis. The fault has a displacement of about 30 feet with downthrow to the east, and rock strata in the fault zone are badly broken and contain solution channels. The fault would not be involved in the construction of the dam. The other fault crosses the Leon River Valley at about river mile 16.1 and crosses the south divide of the reservoir about ½-mile upstream of the site. This fault also has a displacement of about 30 feet with downthrow to the east. Preliminary investigations indicated the possibility that the Edwards limestone may be considerably more leaky along the fault zone than elsewhere, requiring a grout curtain to prevent excessive losses of reservoir water through the south divide into the Nolan Creek Basin. An investigation of this fault zone was not completed prior to abandonment of the project document site.

Foundation Conditions

Foundation stability. Unconfined compression tests were performed on three samples of shale strata of the Walnut formation underlying alluvial materials in the flood plain and on one sample of the Edwards formation from the spillway area. The tests indicate compressive strengths of 14.8 to 19.8 tons per square foot for the Walnut shale and 166 tons per square foot for the Edwards limestone. Tests were not performed on samples of the Comanche Peak formation which is structurally sound and of harder quality than the Walnut formation. Data regarding the compression tests are given in table 3.

Foundation leakage. It is planned that the Belton Reservoir will ultimately be operated for the generation of hydroelectric power in addition to its present planned use for flood-control and water-conservation purposes. The proposed top of power pool of the project document plan would be at an elevation of 592 feet, which would necessitate an impervious foundation and reservoir below such elevation. Almost all strata in the Edwards formation above an elevation of 540 feet on both abutments were found to be potential leakage zones. Strata both immediately above and below the chert seam on both abutments are vuggy to cavernous. Core recovery was very poor in these strata and many cavities both open and clay filled were encountered. Water-pressure tests performed in the 2-inch core holes on both abutments indicated a large amount of leakage could be expected to take place through Edwards strata; however, the tests also showed that the areas of leakage were somewhat irregular, indicating that channeling has developed through the Edwards strata. Results of water-pressure tests at the project document site are presented in table 2. The Edwards limestone rises above the proposed power-pool elevation about a mile upstream of the dam site and is the only formation through which important leakage might take place.

Grout tests. Because of the porous condition of the rock formations at the project document site, grout tests were performed on the left abutment to determine the amount of grouting required to insure satisfactory foundation conditions. Two areas were selected for testing; one in a low saddle on the left abutment near boring 6C-31, where average leakage conditions were expected, and the other near boring 2C-61 where the worst leakage conditions were indicated by water-pressure tests.

In the saddle section, 3-inch diameter holes were drilled and grouted on 20-foot centers, covering a 40-foot panel. Intermediate holes were then drilled, pressure tested, and grouted on 10-foot centers and finally holes were drilled, tested, and grouted on 5-foot centers. These tests disclosed that an effective grout curtain could be placed at a reasonable cost in strata indicated by pressure tests to have a small or average amount of leakage through them. Location of the grout test panel and borings is shown on plate 18. A summary of the grout tests is presented in table 4.

Water-pressure tests in boring 2C-61, on the left abutment, indicated a potential leakage of more than 55 gallons per minute in 10-foot sections of the foundation rocks between an elevation of 555 feet and the ground surface (elevation 597 feet). These tests also revealed that strata from elevations of 555 feet to 523 feet are water tight. A grout test was performed in this hole by setting a packer at an elevation of 585 feet and pumping grout into the hole at water-cement mixes varying from 4 to 1 to 5/8 to 1. The hole took 452 cubic feet of grout in eight and three-quarters hours with no pressure developed in the grout lines or hole during the test. The grout test clearly indicated abnormal foundation conditions occur in this area on the order of a large fracture or cavernous condition in the limestone strata. Investigation of this condition was continued by drilling large diameter inspection holes.

Inspection holes. Four 30-inch holes were drilled along the axis of the proposed dam. Three of these holes were drilled on the left abutment in the vicinity of boring 2C-61, and the other on the right abutment as boring 30C-4, (see plate 17). The holes were drilled to make possible visual examination of the foundation rocks in place and to examine foundation conditions in the grout test area on the left abutment near 2C-61.

Boring No. 30C-1 was drilled where unusually poor foundation conditions were indicated by water-pressure and grout tests. A cavern was reached in this boring at an elevation of 580 feet, which extended downward to an elevation of 576.8 feet. The opening was partially filled with clay and grout as well as typical calcareous cavern deposits. The boring was continued from an elevation of 576.8 feet to 552 feet with a 6-inch bit and the core showed grout filled cavities from elevations of 563.2 feet to 558.3 feet, indicating the zone of grout penetration in the grout test on boring No. 2C-61. Borings 30C-2 and 30C-3 were drilled 100 feet south and west, respectively, of boring 30C-1 and reached the cavernous zone at approximately the same elevation as in boring 30C-1. The cavernous zone was explored by cleaning out cavern deposits for a distance of 100 feet southwest from 30C-1. At this point, the cavern branched to the south and west for a distance of at least 50 feet in each direction. Examination of the cavern upon completion of clearing operation revealed that numerous small solution channels and openings lead off from the main opening. These laterals were observed to extend a considerable distance from the main cavern. All observations in the areas indicate that the openings are irregular, extensive, and inter-connected, and that a large amount of leakage would take place through the strata in which solution has taken place. Smoke generated at the bottom of boring No. 30C-1 vented from both the other 30-inch borings. Views of the cavernous condition of the foundation encountered in boring 30C-1 are shown on plates 20 and 21.

A 30-inch boring (30C-4) was made on the right abutment in an area indicated to be porous or cavernous by borings 2C-62 and 2C-11 and an opening was encountered between the elevations of 572.5 feet and 570 feet. This opening was observed to be the result of fracturing or faulting of the foundation rocks. Large scale solution action was not in evidence in the fracture zone; however, a definite opening is established on an east-west line and extends at least 15 to 20 feet in each direction from the 30-inch boring. Two-inch core borings drilled in this abutment strongly indicate that porous to cavernous openings and solution channels exist in the Edwards limestone.

CONCLUSIONS

The project document site is the most favorable site topographically, but cavernous Edwards limestones occur in the abutments below the top of the proposed power pool (elevation 592 feet). Extensive explorations disclosed that serious leakage conditions exist within the Edwards limestones which could not be economically corrected by means of grouting. The existence of a fault which crosses the south reservoir divide is also considered an important source of leakage, but this condition was not fully explored. Representatives of the offices of the Chief of Engineers, Division, and District Engigineers inspected the cavernous condition of the site and reviewed the results of the subsurface investigations. The representatives concluded that the site should be abandoned because of its unfavorable geologic conditions, and suggested that investigation be made of an upstream dam site at about river mile 16.7 where geological conditions appeared to be more favorable.

TABLE 1

SUMMARY OF WATER-PRESSURE TESTS DEFINITE PROJECT SITE

Left Abutment

Core Boring No.	Section tested El. top	Section tested El. bottom	Length of core hole tested	Leakage — Gallons per minute, Pressure per sq. inch: 5	10	15	20	30	50
77	597.9	450.1	147.8	0.2				18.4	
77	592.9	450.1	142.8	2.2	8.9	7.5		23.4	
77	512.9	450.1	62.8	6.6					
77	502.9	450.1	52.8	7.3					
77	492.9	450.1	42.8	2.9					
77	482.9	450.1	32.8	1.8	3.0				
77	472.9	450.1	22.8	1.8	3.0				
77	597.9	505.1	92.8	0.6	0.8				
78	595.3	450.5	144.8					0.6	
79	594.4	445.4	149.0					0.0	
80	612.8	571.9	43.9		3.0				
80	607.0	571.9	38.1						0.0
81	594.6	444.8	149.8					0.0	
82	595.8	575.9	19.9					0.0	
83	599.6	562.2	37.4	2.9	3.7				
85	612.0	549.1	62.9					2.4	
85	607.0	549.1	57.9					1.9	
85	602.0	549.1	52.9						0.0
86	611.5	441.9	169.6				5.4		
86	601.5	441.9	159.6						0.0
87	618.4	549.1	69.3					0.6	
88	626.4	450.6	175.8						0.7
89	622.8	565.0	57.8						0.0
90	599.4	561.6	37.8						0.0
92	625.8	585.0	40.8					0.9	2.3
92	620.8	585.0	35.8						1.7
93	623.0	575.6	47.4				19.5		
93	618.0	575.6	42.4						0.1
94	615.2	527.3	87.9						0.1
115	635.0	565.4	69.6				0.3		
115	630.0	565.4	64.6						0.7
130	634.4	572.0	62.4						0.4

Flood Plain

Core Boring No.	El. top	El. bottom	Length	5	10	15	20	30	50
102	456.6	438.1	18.5					0.8	5.0
102	453.6	438.1	15.5						0.0
70**	475.1	447.1	28.0					1.0	
73**	465.0	445.2	19.8					14.9*	
105	462.0	448.1	14.5	5.5	13.8*				
105	459.8	448.1	12.3	10.5*					
105	455.8	448.1	8.3						0.0
131	484.4	436.6	47.8				0.2		

Tunnel Outlet Works

Core Boring No.	El. top	El. bottom	Length	5	10	15	20	30	50
122	596.5	473.7	122.8						0.0
123	595.1	473.7	121.4					6.7	14.9
123	579.0	474.7	105.3			4.0		7.5	
123	575.1	473.7	101.4	4.0					
123	570.1	473.7	96.4	4.0					
123	565.1	473.7	91.4	4.0					
123	555.1	473.7	81.4		0.42				
123	615.1	603.8	11.3	19.2***					
123	605.1	593.8	11.3						0.0
123	595.1	583.8	11.3	0.8					
123	585.1	573.8	11.3	0.7					
123	575.1	563.8	11.3						0.7
123	565.1	553.8	11.3	3.0					
124	594.2	467.5	126.3					0.0	
125	600.7	474.5	125.3	0.4					

TABLE 1 (Continued)

Right Abutment

Core Boring No.	Section tested El. top	Section tested El. bottom	Length of core hole tested	Leakage — Gallons per minute, Pressure per sq. inch: 5	10	15	20	30	50
112	633.5	472.1	161.4					1.0	
112	628.5	472.1	156.4						0.0
113	629.8	471.0	158.8	16.5					
113	619.8	471.0	148.8						0.1
114	629.7	473.5	156.2			0.7			
114	624.7	473.5	151.2					0.2	
117	621.2	473.3	147.9						0.0
118	631.4	473.0	158.4	34.1					
118	622.2	473.0	149.2						0.0
119	631.2	471.8	159.4					0.6	1.1
120	630.3	472.0	158.3					2.5	
120	620.3	472.0	148.3					0.2	
122	596.5	473.7	122.8						0.0

* Water leak around packer.
** Located on center line of proposed concrete conduit outlet works.
***Hole took 19.2 Gal. per min. under no pressure.

TABLE 2

SUMMARY OF WATER-PRESSURE TESTS
PROJECT DOCUMENT SITE

Right Abutment

Core Boring No.	Elevation of test section Top	Bottom	Length tested	Leakage — Gallons per minute, Pressure per square inch: 0	10	15	20	25	30
2C-11	568.8	518.6	50.2		32.3*				
2C-11	563.8	518.6	45.2						10.1
2C-11	543.8	518.6	25.2						0.0
2C-12	551.7	510.9	40.8	16.8*					
2C-12	546.2	510.9	35.3						1.6
2C-13	560.2	507.7	52.8						7.9
2C-13	536.2	507.7	28.5						7.7
2C-13	526.2	507.7	18.5						0.0
2C-14	549.5	442.0	107.2						0.8
2C-62	598.6	489.2	109.4	24.2*					
2C-62	593.6	489.2	104.4				5.7		
2C-62	558.6	489.2	69.4				2.17		
2C-62	548.6	489.2	59.4				0.15		
Left Abutment									
2C-28	559.0	517.1	41.9						0.5
2C-28	535.0	517.1	17.9		0.0				
2C-34	594.0	531.9	62.1		18.7*				
2C-34	589.0	531.9	57.1					3.56	
2C-34	579.0	531.9	47.1					2.9	
2C-35	564.1	526.6	37.5						9.7
2C-35	559.1	526.6	32.5						0.6
2C-42	575.8	535.8	40.0		44.4*				
2C-42	570.8	535.8	35.0						0.8
2C-43	590.6	531.5	59.1			29.1*			
2C-43	585.6	531.5	54.1					9.8	
2C-43	540.6	531.5	9.1						0.0
2C-61	597.0	523.3	73.7	55.0*					
2C-61	585.3	574.3	11.0	28.2*					
2C-61	575.3	523.3	52.0	27.4*					
2C-61	565.3	523.3	42.0	27.8*					
2C-61	555.3	523.3	32.0				0.51		
2C-63	596.5	517.8	78.7			45.8			
2C-63	591.5	517.8	73.7						4.2
2C-63	561.5	517.8	43.7						0.7
G-1	589.2	534.4	54.8					23.8	
G-1	587.4	534.4	53.0					1.1	

*Pump capacity on this test.

TABLE 3

SUMMARY OF UNCONFINED COMPRESSION TESTS
PROJECT DOCUMENT SITE

Core Boring No.	Elevation of sample	Depth feet *	Unconfined compression Tons/sq. foot	Type of formation
6DC-18	464.1	39.6	16.5	Walnut shale
6DC-21	461.9	30.0	14.8	Walnut shale
6DC-24	456.5	35.3	19.8	Walnut shale
6DC-31	589.1	11.4	166.1	Edwards limestone

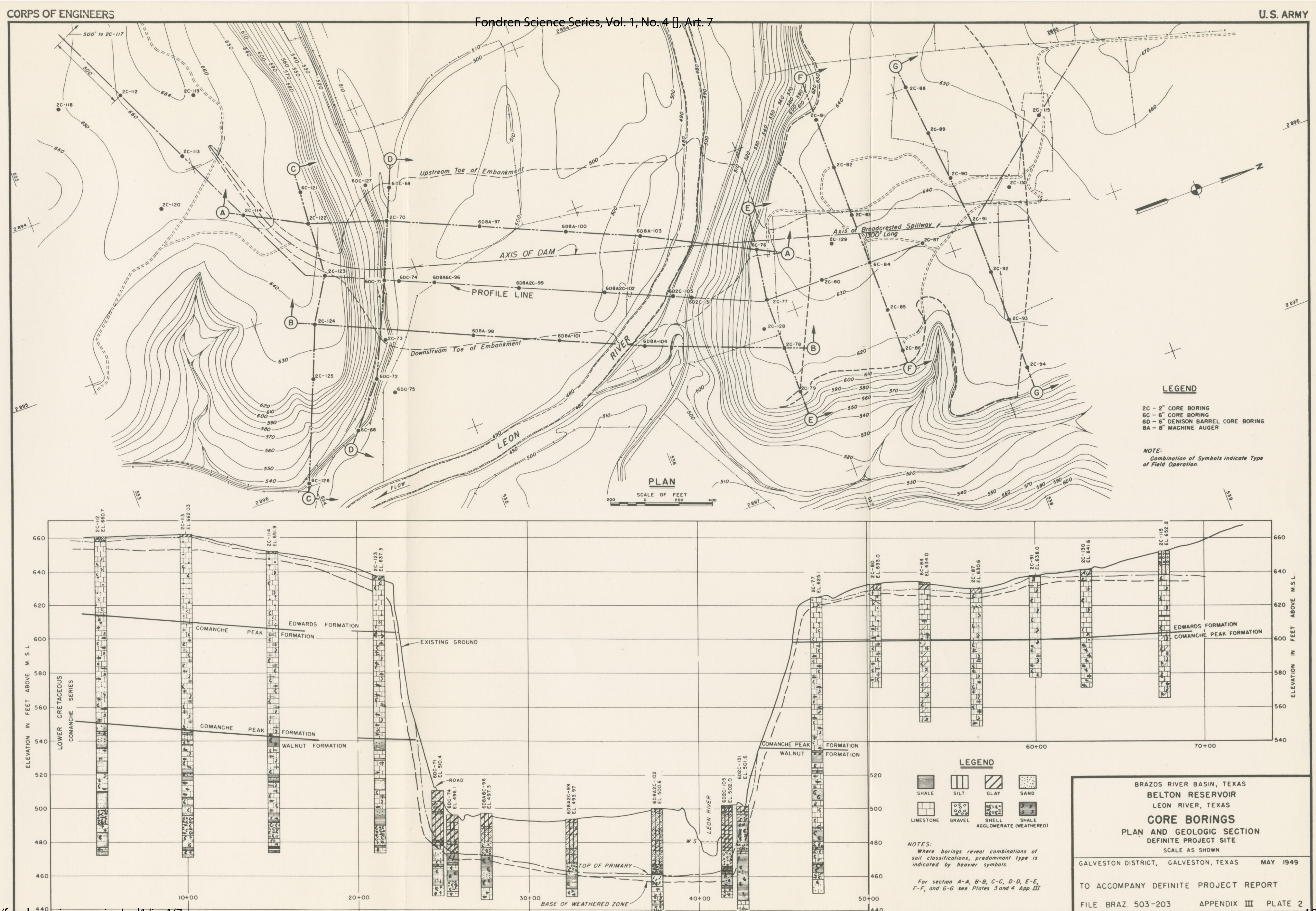
*Depth below ground surface at boring location.

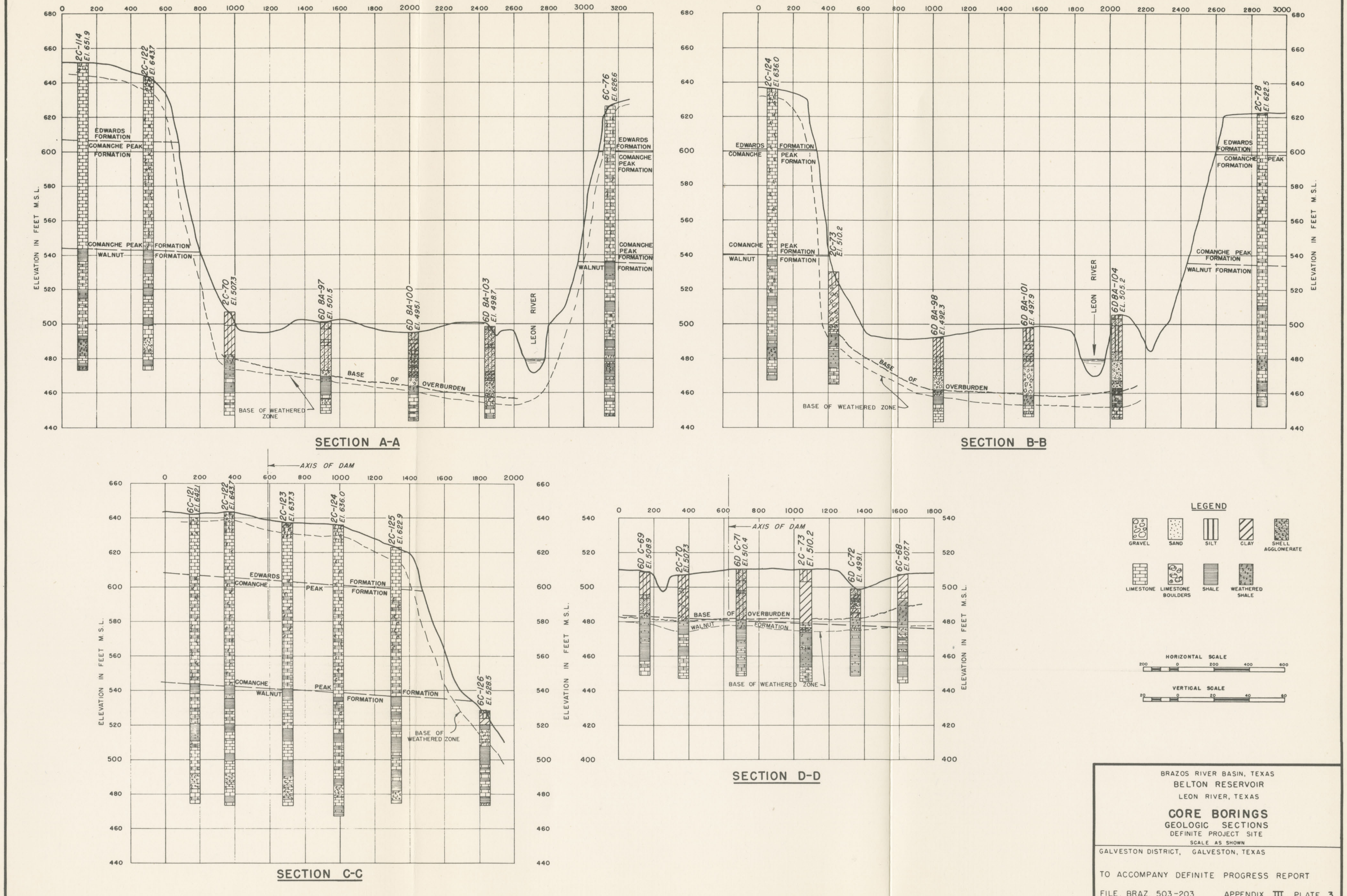
TABLE 4

SUMMARY OF GROUT TESTS
PROJECT DOCUMENT SITE

Core Boring No.	Location dam axis stationing	Elevation of test		Grout mixes water-cement	Maximum pressure lbs./sq. in.	Sacks of cement used
		From	To			
G1	70+57	589.4	534.4	2:1 to 1:1	30	8
G6	70+62	589.4	573.6	6:1	20	3
G4	70+67	588.4	571.4	6:1 to ¾:1	25	40
G7	70+72	594.8	572.5	6:1 to 1:1	20	14
G3	70+77	588.4	530.6	6:1 to 1:1	30	34
G8	70+82	594.2	572.6	6:1 to 4:1	20	2
G5	70+87	589.2	572.7	6:1	25	2
G9	70+92	593.8	577.8	6:1 to 2:1	20	21
G2	70+97	588.8	527.0	6:1 to 4:1	25	16


CORPS OF ENGINEERS
U.S. ARMY
LEGEND
LOWER CRETACEOUS AGE
Kw WASHITA GROUP (UNDIFFERENTIATED)
FREDERICKSBURG GROUP
Kecp EDWARDS-COMANCHE PEAK
Kwa WALNUT
Kt TRINITY GROUP (UNDIFFERENTIATED)
BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS
AREAL GEOLOGY
SCALE OF FEET
GALVESTON DISTRICT, GALVESTON, TEXAS MAY 1949
TO ACCOMPANY DEFINITE PROJECT REPORT
FILE: BRAZ. 503-203 APPENDIX III PLATE 1
WHITSON
MOTHER NEFF STATE PARK
LEON JUNCTION
THE GROVE
WHITEHALL
FLAT
TO GATESVILLE
ATLANTIC PIPE LINE COMPANY
MOFFAT
BLAND
OWL CREEK
MILITARY RESERVATION BOUNDARY (APPROX.)
SEATTLE
COLD SPRING
CORYELL COUNTY
BELL COUNTY
TO TEMPLE
TOP OF FLOOD CONTROL POOL EL. 631.0
TOP OF CONSERVATION POOL EL. 569.0
EAST RANGE ROAD
UNION HILL SCHOOL
TENNESSEE VALLEY
BELTON DAM SITE
CAMP HOOD
COWHOUSE CREEK
SPARTA
BROOKHAVEN
LEON RIVER
COW CREEK
CEDAR CREEK
STAMPEDE CREEK
Fault
FLOW
TO BELTON


CORPS OF ENGINEERS
U.S. ARMY
Upstream Toe of Embankment
AXIS OF DAM
PROFILE LINE
Downstream Toe of Embankment
Axis of Broadcrested Spillway 1300' Long
LEON RIVER
FLOW
PLAN
SCALE OF FEET
LEGEND
2C - 2" CORE BORING
6C - 6" CORE BORING
6D - 6" DENISON BARREL CORE BORING
8A - 8" MACHINE AUGER
NOTE: Combination of Symbols indicate Type of Field Operation.
ELEVATION IN FEET ABOVE M.S.L.
LOWER CRETACEOUS
COMANCHE SERIES
EDWARDS FORMATION
COMANCHE PEAK FORMATION
WALNUT FORMATION
EXISTING GROUND
ROAD
TOP OF PRIMARY
BASE OF WEATHERED ZONE
LEGEND
SHALE
SILT
CLAY
SAND
LIMESTONE
GRAVEL
SHELL AGGLOMERATE
SHALE (WEATHERED)
NOTES: Where borings reveal combinations of soil classifications, predominant type is indicated by heavier symbols.
For section A-A, B-B, C-C, D-D, E-E, F-F, and G-G see Plates 3 and 4 App. III
BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS
CORE BORINGS
PLAN AND GEOLOGIC SECTION
DEFINITE PROJECT SITE
SCALE AS SHOWN
GALVESTON DISTRICT, GALVESTON, TEXAS MAY 1949
TO ACCOMPANY DEFINITE PROJECT REPORT
FILE BRAZ. 503-203 APPENDIX III PLATE 2



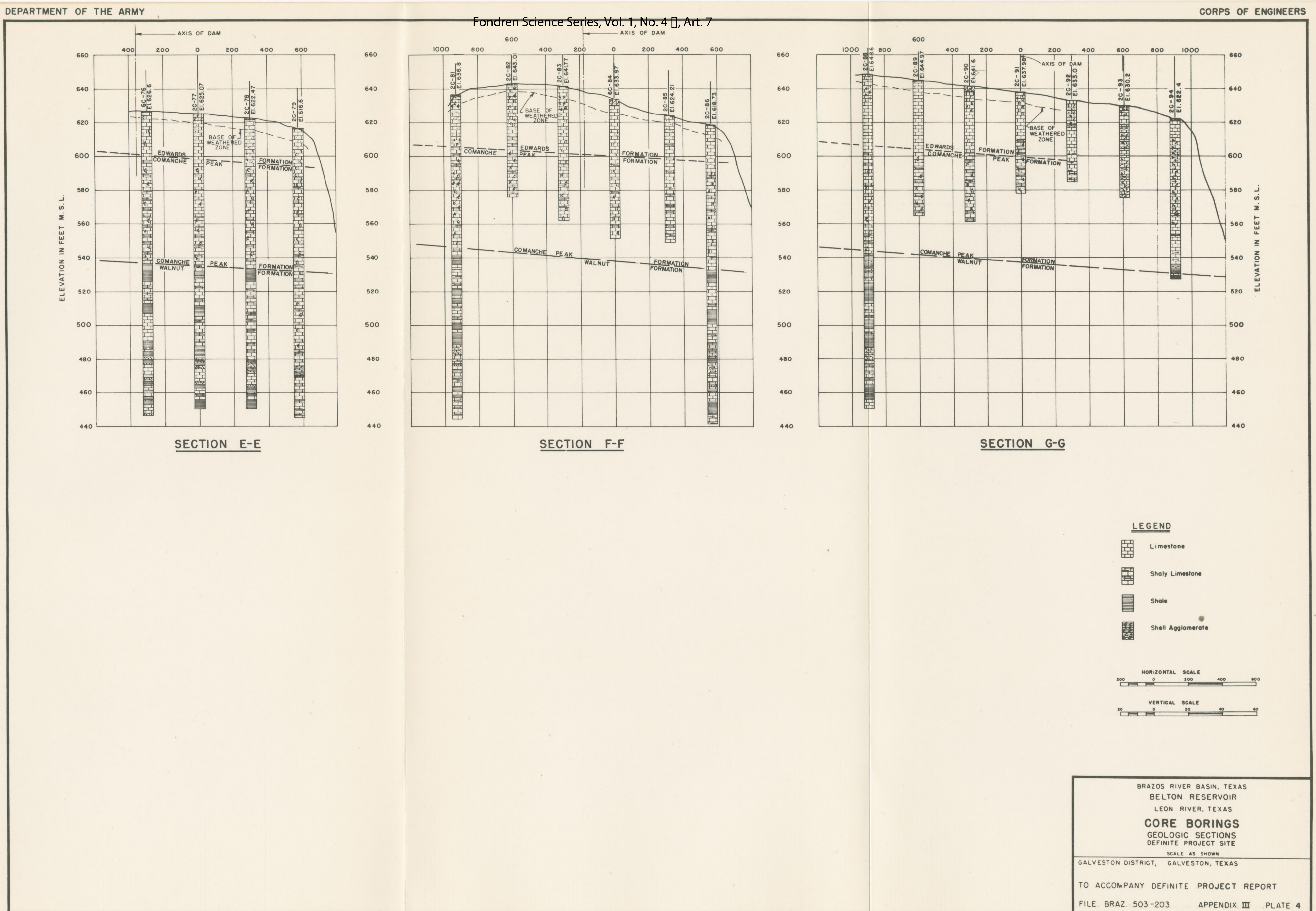
BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

CORE BORINGS
GEOLOGIC SECTIONS
DEFINITE PROJECT SITE
SCALE AS SHOWN

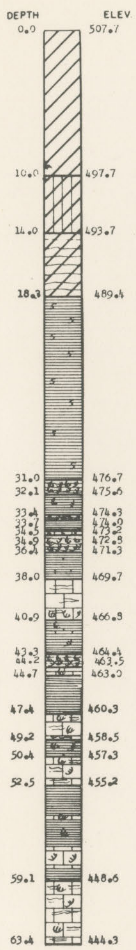
GALVESTON DISTRICT, GALVESTON, TEXAS

TO ACCOMPANY DEFINITE PROGRESS REPORT

FILE BRAZ 503-203 APPENDIX III PLATE 3


DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
AXIS OF DAM
ELEVATION IN FEET M. S. L.
BASE OF WEATHERED ZONE
EDWARDS FORMATION
COMANCHE PEAK FORMATION
WALNUT FORMATION
SECTION E-E
SECTION F-F
SECTION G-G
LEGEND
Limestone
Shaly Limestone
Shale
Shell Agglomerate
HORIZONTAL SCALE
VERTICAL SCALE
BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS
CORE BORINGS
GEOLOGIC SECTIONS
DEFINITE PROJECT SITE
SCALE AS SHOWN
GALVESTON DISTRICT, GALVESTON, TEXAS
TO ACCOMPANY DEFINITE PROJECT REPORT
FILE BRAZ 503-203
APPENDIX III
PLATE 4

6C-68



0.0' to 10.0' CLAY, brown, very hard, dry.

10.0' to 4.0' CLAY, brown, silty.

14.0' to 18.3' CLAY, shaly.
(Taken from driller's log).

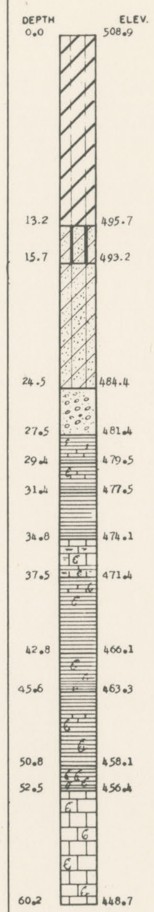
WALNUT FORMATION

18.3' to 31.0' SHALE, soft, badly weathered, yellow.

31.0' to 32.1' SHELL AGGLOMERATE, hard, white, in a matrix of hard calcareous gray shale.
32.1' to 33.4' SHALE, medium hard, calcareous, gray, with occasional fossils.
33.4' to 33.7' SHELL AGGLOMERATE, hard, white, in a matrix of hard calcareous gray shale.
33.7' to 34.5' SHALE, medium hard, very calcareous, gray.
34.5' to 34.9' LIMESTONE, hard, argillaceous, fossiliferous, light gray.
34.9' to 36.4' SHELL AGGLOMERATE, hard, white, in a matrix of hard calcareous gray shale.
36.4' to 38.0' SHALE, hard, very calcareous, gray, with large concretionary masses of hard, argillaceous, light gray limestone.
38.0' to 40.9' LIMESTONE, hard, argillaceous, light gray, with irregular tight thin partings of medium hard, calcareous gray shale becoming fossiliferous in the lower part.
40.9' to 43.3' SHALE, medium hard, slightly calcareous, fossiliferous, gray, with a hard, very argillaceous, very fossiliferous, light gray limestone band from 41.3' to 41.7'.
43.3' to 44.2' SHELL AGGLOMERATE, hard, light gray, in a matrix of hard calcareous gray shale.
44.2' to 44.7'LIMESTONE, hard, very argillaceous, fossiliferous, light gray.
44.7' to 47.4' SHALE, medium hard, slightly calcareous, gray, with occasional minor hard, calcareous phases.
47.4' to 49.2'LIMESTONE, hard, argillaceous, slightly fossiliferous, light gray, with irregular, tight thin partings of hard, calcareous, gray shale.
49.2' to 50.4'SHALE, medium hard, slightly calcareous, gray, with a very hard, slightly argillaceous, very fossiliferous light gray limestone band from 49.8' to 50.0'.
50.4' to 52.5'LIMESTONE, hard, very argillaceous, partly fossiliferous, light gray, with occasional thin bands and irregular tight thin partings of medium hard calcareous gray shale.
52.5' to 59.1'SHALE, medium hard, slightly calcareous, gray, with a very hard, slightly argillaceous, very fossiliferous light gray limestone band from 54.6' to 54.8', and with a fossiliferous gray shale phase having concretionary nodules of hard very argillaceous light gray limestone from 56.8' to 58.3'.
59.1' to 63.4'LIMESTONE, hard, argillaceous, very fossiliferous, light gray, with occasional thin bands and numerous irregular tight thin partings of medium hard, calcareous, very fossiliferous, gray shale, and with very hard, very fossiliferous, light gray limestone bands from 61.7' to 62.0' and 63.0' to 63.2'.

BOTTOM OF HOLE

6DC-69



0.0' to 13.2' CLAY, silty, gray to tan.

13.2' to 15.7' SILT, sandy, clayey, tan.

15.7' to 24.5' SAND, silty, clayey, tan, firm.

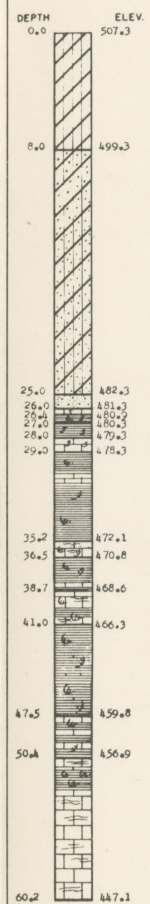
24.5' to 27.5' SAND and GRAVEL, medium grained.

WALNUT FORMATION

27.5' to 29.4'SHALE, partly softened, slightly weathered, gray, with occasional concretionary nodules of hard, very argillaceous, partly fossiliferous light gray limestone.
29.4' to 31.4'SHALE, medium hard, calcareous, gray, with numerous concretionary nodules of hard, very argillaceous, fossiliferous, light gray limestone.
31.4' to 34.8'SHALE, medium hard, slightly calcareous, gray.
34.8' to 37.5'LIMESTONE, hard, very argillaceous, partly fossiliferous, lightgray, with medium hard, slightly calcareous, gray shale bands from 35.4' to 35.8' and 36.2' to 36.7', and with very hard, very fossiliferous gray limestone bands from 35.2' to 35.4', and 35.8' to 36.2'.
37.5' to 42.8' SHALE, medium hard, slightly calcareous, gray, with very calcareous, transitional phases from 40.0' to 40.2' and 42.3' to 42.5' and with a hard, very argillaceous, fossiliferous light gray limestone band from 38.1' to 38.5'.
42.8' to 45.6'SHALE, medium hard, fossiliferous, dark gray, with a medium hard calcareous phase from 45.0' to 45.2'.
45.6' to 50.8'SHALE, medium hard, calcareous, partly fossiliferous, gray, with transitional phases and concretionary nodules of hard, partly fossiliferous, very argillaceous light gray limestone.
50.8' to 52.5'SHALE, medium hard, calcareous, very fossiliferous (bordering on shell agglomerate), gray.
52.5' to 60.2'LIMESTONE, hard, argillaceous, partly fossiliferous, light gray, with numerous irregular, very thin partings of gray calcareous shale.

BOTTOM OF HOLE

2C-70



0.0' to 8.0' CLAY, brown, silty.

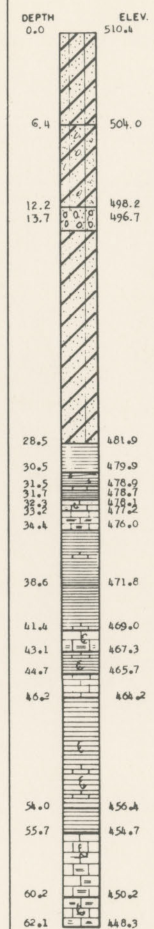
8.0' to 25.0' CLAY, light brown, silty, with some fine gravel.

25.0' to 26.0' SAND and fine gravel.
26.0' to 26.4' LIMESTONE, gray, soft, weathered.
26.4' to 27.0' SHALE, lime, and shell, weathered, soft. (Taken from driller's logs).

WALNUT FORMATION

27.0' to 28.0' SHALE, dark gray, soft, weathered, calcareous.
28.0' to 29.0'LIMESTONE, gray, soft to medium hard, argillaceous, weathered.
29.0' to 35.2'SHALE, gray, calcareous, soft to medium hard, a few fossils, limestone phase 30.5' to 31.2', weathered to 33.8'.
35.2' to 36.5'LIMESTONE, gray, medium hard, argillaceous, numerous oyster shells, thin shale seams.
36.5' to 38.7'SHALE, gray, medium hard, very calcareous, fossiliferous, thin gray limestone seams and bands of gray argillaceous limestone from 38.0' to 38.5'.
38.7' to 41.0'LIMESTONE, gray, medium hard, very argillaceous, fossiliferous, thin shale seams, band of calcareous dark gray shale from 39.9' to 40.4'.
41.0' to 47.5'SHALE, dark gray, calcareous, thin seams and nodular pieces of gray argillaceous limestone, medium hard, fossiliferous.
47.5' to 50.4' Alternating bands of dark gray calcareous shale and gray argillaceous limestone, fossiliferous, medium hard.
50.4' to 60.2'LIMESTONE, gray, hard, argillaceous, numerous thin partings of gray shale, slickensided fracture surface at 59.6'. Shell agglomerate from 51.2' to 52.5' in shale matrix.

6DC-71



0.0' to 6.4' CLAY, sandy, silty, brown.

6.4' to 12.2' CLAY, sandy, silty, gravelly, tan to brown.

12.2' to 13.7'GRAVEL, sandy, silty.

13.7' to 29.5'CLAY, silty yellow with silt nodules of lime.

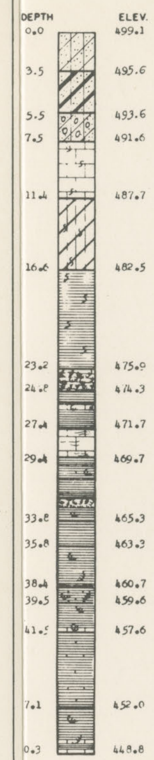
29.5' to 30.5'SHALE, badly weathered with some gravel.

WALNUT FORMATION

30.5' to 31.5'SHALE, medium hard, calcareous, weathered, light yellowish-gray.
31.5' to 31.7'LIMESTONE, very hard, slightly argillaceous, very fossiliferous, slightly weathered, light yellowish-gray.
31.7' to 32.3'SHALE, medium hard, calcareous, weathered, light yellowish-gray.
32.3' to 33.2'LIMESTONE, hard, slightly weathered, argillaceous, partly fossiliferous, with numerous irregular, tight, thin partings of medium hard, calcareous, fossiliferous, gray shale.
33.2' to 34.4'LIMESTONE, hard, argillaceous, partly fossiliferous, with numerous irregular, tight thin partings of medium hard, calcareous, fossiliferous, gray shale.
34.4' to 38.6'SHALE, medium hard, fossiliferous, calcareous, gray, with a very hard, fossiliferous, slightly argillaceous, light gray limestone band from 36.2' to 36.4'.
38.6' to 41.4'SHALE, medium hard, calcareous, gray, with fossils and numerous concretionary nodules of hard, very argillaceous, light gray limestone from 41.0' to 41.4'.
41.4' to 43.1'LIMESTONE, hard, partly fossiliferous, argillaceous, light gray, with numerous irregular, tight thin partings of medium hard, calcareous, slightly fossiliferous, gray shale in the lower part.
43.1' to 44.7'SHALE, medium hard, slightly calcareous, gray, with very hard, very fossiliferous, light gray limestone bands from 43.7' to 43.9' and 44.3' to 44.7'.
44.7' to 46.2'LIMESTONE, hard, argillaceous, fossiliferous, light gray, with numerous irregular tight thin partings of medium hard, very calcareous, gray shale.
46.2' to 54.0'SHALE, medium hard, calcareous, gray, with occasional concretionary nodules of hard, fossiliferous, argillaceous, light gray limestone, and with hard, very argillaceous, partly fossiliferous, light gray limestone phases from 52.5' to 52.8' and 53.2' to 53.7'.
54.0' to 55.7'SHALE, medium hard, calcareous, very fossiliferous, gray, with numerous concretionary nodules of hard, argillaceous, partly fossiliferous, light gray limestone.
55.7' to 60.2'LIMESTONE, hard, argillaceous, very fossiliferous, light gray, with numerous irregular tight thin partings of medium hard, very fossiliferous, calcareous, gray shale. (This limestone borders on shell agglomerate in the lower part).
60.2' to 62.1'LIMESTONE, hard, slightly argillaceous, light gray, with occasional irregular, tight, very thin partings of hard, calcareous gray shale.

BOTTOM OF HOLE

6DC-72



0.0' to 3.5' SAND, silty, clayey, firm.

3.5' to 5.5' CLAY, silty, sandy, firm, gray.

5.5' to 7.5'GRAVEL, sandy, silty, clayey.

7.5' to 11.4'LIMESTONE, hard, sugary appearance, slightly weathered, yellow, with occasional small solution cavities. Edwards boulder.

11.4' to 16.6'CLAY, very soft, shaly, yellow. (No core recovered). Weathered.

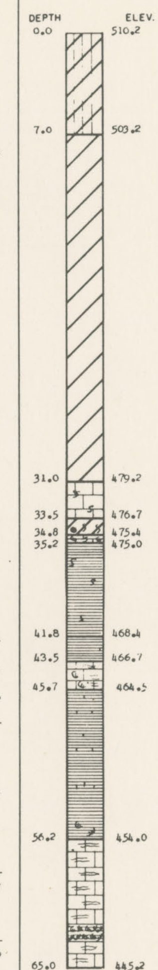
WALNUT FORMATION

16.6' to 23.2'SHALE, soft, very badly weathered, calcareous, yellow.

23.2' to 24.8'SHELL AGGLOMERATE, hard (medium hard and slightly weathered from 23.2 to 23.8'), light gray, in a matrix of medium hard, calcareous, gray shale.
24.8' to 27.4'SHALE, hard, very calcareous, light gray, with a very hard, very fossiliferous light gray limestone band from 25.8' to 26.1' and with occasional concretionary nodules of hard, argillaceous, light gray limestone.
27.4' to 29.4'LIMESTONE, hard, argillaceous, light gray, with irregular, tight, thin, partings of medium hard, calcareous gray shale becoming fossiliferous, more numerous and thicker in the lower part.
29.4' to 33.8'SHALE, medium hard to hard, very calcareous, fossiliferous, gray, with occasional large concretionary nodules of hard, very argillaceous, light gray limestone and with a shell agglomerate from 32.3' to 32.9'.
33.8' to 35.8'SHALE, medium hard, calcareous, gray.
35.8' to 38.4'SHALE, hard, very calcareous, gray, with numerous concretionary nodules of hard, argillaceous, slightly fossiliferous, light gray limestone.
38.4' to 39.5'SHALE, medium hard, calcareous, gray, with very hard, very fossiliferous, slightly argillaceous, light gray limestone bands from 38.7' to 38.8', and 39.2' to 39.5'.
39.5' to 41.5'SHALE, hard, very calcareous, gray with numerous large concretionary nodules of hard argillaceous, fossiliferous, light gray limestone and with a very hard, very fossiliferous light gray limestone band from 41.2' to 41.5'.
41.5' to 47.1'SHALE, medium hard, calcareous, gray, with occasional minor hard, very argillaceous, light gray limestone phases.
47.1' to 50.3'SHALE, medium hard, fossiliferous, calcareous, gray, with hard, fossiliferous, argillaceous, light gray limestone bands from 49.4' to 49.6' and 49.9' to 50.3'.

BOTTOM OF HOLE

2C-73



0.0' to 7.0'CLAY, brown, silty, nodular.

7.0' to 31.0'CLAY, yellow, nodular.
(Taken from driller's log)

31.0' to 33.5'LIMESTONE, hard, slightly weathered, sugary appearance, with small solution cavities. (Edwards limestone boulder).
33.5' to 34.8'CLAY, soft, weathered, yellow, with limestone gravel.

WALNUT FORMATION

34.8' to 35.2'LIMESTONE, hard, weathered, argillaceous, fossiliferous, light yellowish-gray.
35.2' to 41.8'SHALE, partly softened, slightly weathered, calcareous, gray.
41.8' to 43.5'SHALE, dark gray, medium hard, fossiliferous, calcareous.
43.5' to 45.7'LIMESTONE, gray, very argillaceous, medium hard, fossiliferous; thin, dark gray shale seams at base of section.
45.7' to 56.2'SHALE, dark gray, soft to medium hard, interbedded with numerous thin bands of gray argillaceous limestone. Shale bands 0.6' to 1.0' foot thick, limestone bands and seams 0.1' to 0.3' thick. Fossiliferous from 55.0' to 56.2'.

56.2' to 65.0'LIMESTONE, gray, medium hard, very argillaceous, numerous irregular seams and partings of dark gray calcareous shale shell agglomerate from 62.0' to 63.4', occasional masses of pyrite.

TOTAL DEPTH

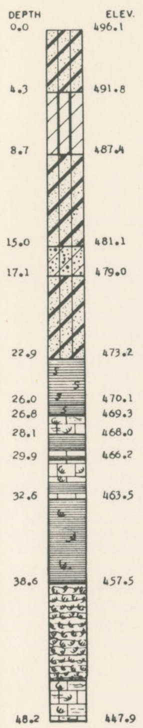
BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS
CORE BORINGS
GRAPHIC LOGS
DEFINITE PROJECT SITE

GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 5

6DC-74



0.0' to 4.3' CLAY, sandy, silty, dry and hard to plastic.

4.3' to 8.7' SILT, clayey, brown.

8.7' to 15.0' CLAY, sandy, silty, brown to gray, plastic.

15.0' to 17.1' SAND, silty, clayey.

17.1' to 22.9' CLAY, sandy, silty, plastic to stiff.

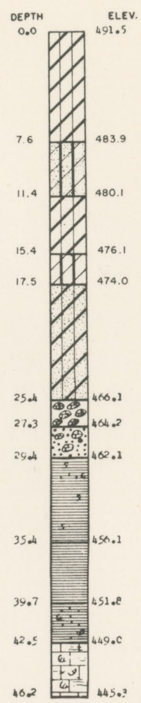
WALNUT FORMATION

22.9' to 26.0' SHALE, soft, badly weathered, calcareous, gray-brown.

26.0' to 26.8' SHALE, medium hard, slightly weathered, gray.
26.8' to 28.1' LIMESTONE, gray, medium hard, argillaceous, thin shale seams, numerous oyster shells.
28.1' to 29.9' SHALE, medium hard, gray, calcareous, limestone band from 29.4' to 29.7'.
29.9' to 32.6' LIMESTONE, gray, argillaceous, medium hard, numerous shells, band of gray calcareous shale from 31.5' to 32.1'.
32.6' to 38.6' SHALE, dark gray, medium hard, calcareous, fossiliferous, gray argillaceous limestone band from 32.1' to 32.6'.
38.6' to 45.3' SHELL AGGLOMERATE in dark gray shale matrix, medium hard, fossiliferous limestone band from 41.0' to 42.7'.

45.3' to 48.2' LIMESTONE, hard, gray, slightly argillaceous, numerous irregular seams and partings of shale, occasional shells and small masses of pyrite.

6DC-75 Pl-6.



0.0' to 7.6' CLAY, silty, plastic to stiff, brown.

7.6' to 11.4' SILT, sandy, clayey, plastic, gray-brown.

11.4' to 15.4' CLAY, silty, gray.

15.4' to 17.5' SILT, clayey, gray, plastic.

17.5' to 25.4' CLAY, sandy, silty, gray, soft.

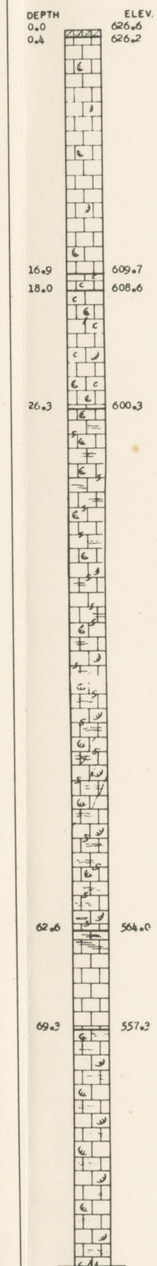
25.4' to 27.3' LIMESTONE BOULDER, hard, slightly weathered, suggary appearance, massive tan, with occasional small solution cavities partly filled with yellow marl. (Lower Edwards Formation boulder.)
27.3' to 29.4' GRAVEL, hard, sub-rounded limestone pebbles and boulders.

WALNUT FORMATION

29.4' to 35.4' SHALE, medium hard, slightly weathered, gray, with calcareous phases, and with a very hard, very fossiliferous, light gray limestone band from 30.7' to 31.0'.
35.4' to 39.7' SHALE, medium hard, gray, with a hard calcareous phase from 36.4' to 37.7'.
39.7' to 42.5' SHALE, medium hard, fossiliferous, gray, with hard, very argillaceous light gray limestone bands from 39.9' to 40.2', 40.6' to 40.8', 41.0' to 41.3', and 42.0' to 42.2'.
42.5' to 46.2' LIMESTONE, hard, very argillaceous, fossiliferous, light gray, with numerous irregular tight thin partings of calcareous gray shale.

BOTTOM OF HOLE

6C-76



0.0' to 0.4' TOPSOIL. (Taken from driller's log).

EDWARDS FORMATION

0.4' to 16.9' LIMESTONE, hard, sugary appearance, massive, variably white to tan, with small to large solution cavities partly to tightly filled with yellow marl, and with occasional fossils.

16.9' to 18.0' LIMESTONE, medium hard, very argillaceous, chalky, light grayish tan.
18.0' to 26.3' LIMESTONE, hard, slightly argillaceous, gray, with numerous flakes of chalk and concretionary masses of light gray limestone, and with occasional fossils.

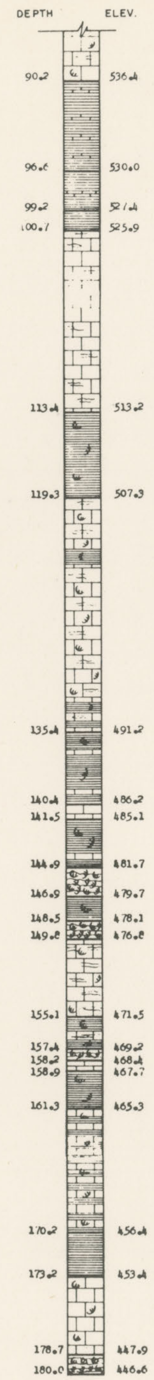
COMANCHE PEAK FORMATION

26.3' to 62.6' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight thin partings of gray calcareous shale, with occasional fossils, with occasional small masses of pyrite and pyritized fossils, and with numerous fractures having iron-stained surfaces from 49.0' to 55.3'.

62.6' to 69.3' LIMESTONE, hard, argillaceous gray, with occasional fossils and small concretionary masses of limestone, and with numerous irregular tight thick partings of dark gray calcareous shale from 62.6' to 63.3'.

69.3' to 90.2' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale, having occasional slickensided surfaces in the upper part, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

6C-76 Continued



WALNUT FORMATION

90.2' to 96.6' SHALE, calcareous, gray, medium hard, thin seams of gray limestone.

96.6' to 99.2' SHALE, soft, dark gray, core loss. Limestone band 97.7' to 98.0'.

99.2' to 100.7' SHALE, gray, very calcareous, medium hard.
100.7' to 113.4' LIMESTONE, gray, argillaceous, thin shale seams, medium hard.

113.4' to 119.3' SHALE, gray, medium hard, calcareous, fossiliferous.

119.3' to 135.4' LIMESTONE, gray, argillaceous, medium hard, numerous thin dark gray shale seams, shale bands from 122.8' to 123.8', 133.3' to 134.0', 134.6' to 135.1', fossiliferous.

135.4' to 140.4' SHALE, dark gray, medium hard, fossiliferous, calcareous, limestone bands from 136.5' to 136.9' and 139.3' to 139.6'.
140.4' to 141.5' LIMESTONE, medium hard, gray, argillaceous.
141.5' to 144.9' SHALE, dark gray, calcareous, fossiliferous, medium hard with gray limestone seam from 143.7' to 144.2'.
144.9' to 146.9' SHELL AGGLOMERATE, dark gray shale matrix, medium hard.
146.9' to 148.5' SHALE, dark gray, fossiliferous, calcareous, medium hard.
148.5' to 149.8' SHELL AGGLOMERATE, in dark gray shale matrix, medium hard.
149.8' to 155.1' LIMESTONE, gray, medium hard, argillaceous, thin shale seams, fossiliferous.

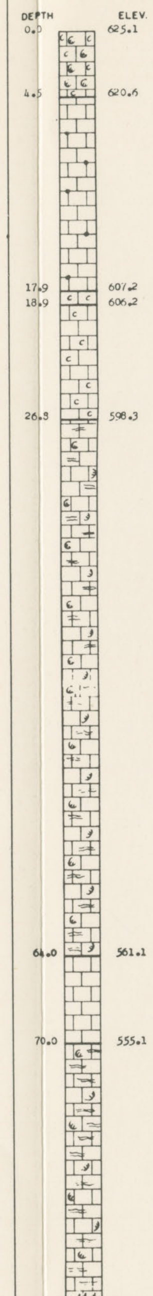
155.1' to 157.4' SHALE, dark gray, medium hard, very calcareous, fossiliferous, limestone band from 156.0' to 156.6'.
157.4' to 158.2' SHELL AGGLOMERATE in dark gray shale matrix, medium hard.
158.2' to 158.9' LIMESTONE, gray, medium hard, argillaceous.
158.9' to 161.3' SHALE, dark gray, calcareous, medium hard, fossiliferous.
161.3' to 170.2' Thin alternating bands of dark gray calcareous shale and gray argillaceous limestone, medium hard, fossiliferous.

170.2' to 173.2' SHALE, dark gray, compact, medium hard, calcareous.
173.2' to 178.7' LIMESTONE, gray, medium hard, argillaceous, fossiliferous.

178.7' to 180.0' SHELL AGGLOMERATE in dark gray shale matrix, medium hard.

TOTAL DEPTH 180.0'

2C-77



EDWARDS FORMATION

0.0' to 4.5' LIMESTONE, hard, slightly crystalline and fossiliferous, massive, light tan, with numerous flakes of chalk.
4.5' to 17.9' LIMESTONE, hard, sugary appearance, massive, tan, with solution "cavities" tightly filled with yellow marl.

17.9' to 18.9' LIMESTONE, medium hard, argillaceous, massive, somewhat chalky, gray, brown.
18.9' to 26.8' LIMESTONE, hard, slightly argillaceous, gray, with occasional concretionary masses of light gray limestone becoming very numerous in the upper part, and with numerous flakes of chalk throughout.

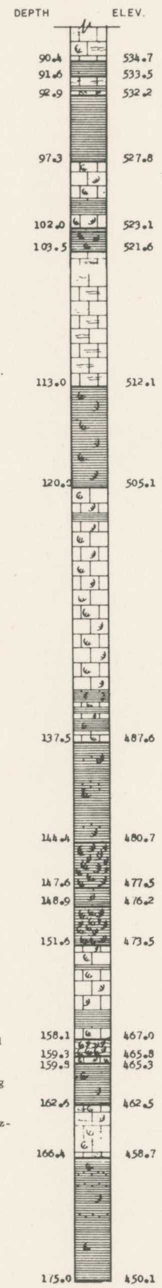
COMANCHE PEAK FORMATION

26.8' to 64.0' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

64.0' to 70.0' LIMESTONE, hard, argillaceous, massive, gray.

70.0' to 90.4' LIMESTONE, hard, slightly argillaceous, light gray (becoming gray and more argillaceous at the bottom), with numerous irregular tight thin partings of gray calcareous shale throughout and having occasional slickensided surfaces in the upper part, with occasional fossils, and with occasional masses of pyrite and pyritized fossils in the upper part.

2C-77 Continued



WALNUT FORMATION

90.4' to 91.6' SHALE, medium hard, compact, calcareous, gray.
91.6' to 92.9' LIMESTONE, medium hard, argillaceous, nodular, gray with dark gray shale band from 92.1' to 92.7'.
92.9' to 97.3' SHALE, medium hard, gray, compact, calcareous.
97.3' to 102.0' LIMESTONE, medium hard, gray, argillaceous, occasional fossils, dark gray shale band from 100.1' to 101.0'.

102.0' to 103.5' SHALE, gray, compact, medium hard, a few shells, very calcareous.

103.5' to 113.0' LIMESTONE, medium hard, gray, argillaceous, thin shale seams.

113.0' to 120.0' SHALE, gray, medium hard, fossiliferous, thin limestone seams, calcareous.

120.0' to 137.5' LIMESTONE, gray, medium hard, argillaceous, fossiliferous, bands of dark gray compact calcareous shale from 121.8' to 122.3', 134.0' to 134.8', 135.1' to 135.6' and 135.9' to 136.8'.

137.5' to 144.4' SHALE, gray, compact, medium hard, calcareous, fossiliferous with gray limestone bands from 138.5' to 138.8', 140.6' to 141.4' and 143.2' to 143.7'.

144.4' to 147.6' SHELL AGGLOMERATE, in dark gray shale matrix, medium hard.

147.6' to 148.9' SHALE, gray, medium hard, fossiliferous, calcareous.
148.9' to 151.6' SHELL AGGLOMERAGE, in dark gray shale matrix, medium hard.
151.6' to 158.4' LIMESTONE, gray, medium hard, very argillaceous, thin shale seams, fossiliferous, with dark gray shale bands from 152.9' to 153.1' and 156.2' to 157.2'.

158.1' to 159.3' SHELL AGGLOMERATE, in dark gray shale matrix, medium hard.
159.3' to 159.8' LIMESTONE, medium hard, fossiliferous, argillaceous, gray.

159.8' to 162.6' SHALE, gray, compact, medium hard, fossiliferous, calcareous.
162.6' to 166.4' LIMESTONE, gray, medium hard, fossiliferous, thin shale seams.
166.4' to 175.0' SHALE, dark gray, compact, very calcareous, hard with limestone seams from 167.4' to 167.7', 168.3' to 168.4' and 170.4' to 170.5', fossiliferous.

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

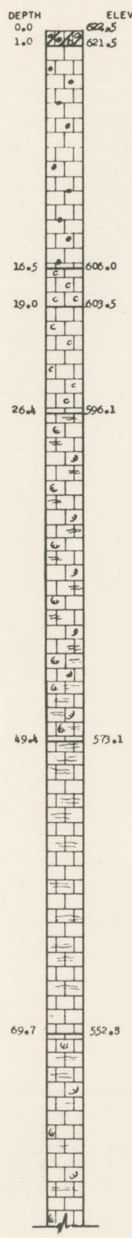
CORE BORINGS
GRAPHIC LOGS
DEFINITE PROJECT SITE

GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 6

2C-78



0.0' to 1.0'CLAY, silty and limestone gravel.
(Taken from driller's log)

EDWARDS FORMATION

1.0' to 16.5'LIMESTONE, hard, sugary appearance, massive, tan with occasional solution cavities partly to tightly filled with marl, and with a very hard dense fractured white limestone seam from 8.6' to 8.8'.

16.5' to 19.0'LIMESTONE, medium hard, argillaceous, somewhat chalky, massive, grayish-tan.
19.0' to 26.4'LIMESTONE, hard, slightly argillaceous, gray, with numerous small concretionary masses of light gray limestone in the upper part, and with flakes of chalk throughout.

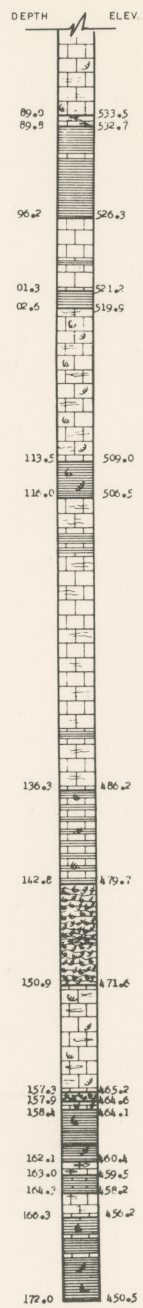
COMANCHE PEAK FORMATION

26.4' to 49.4'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

49.4' to 69.7'LIMESTONE, hard, argillaceous, massive, gray, with shaly phases, and with occasional irregular tight partings of gray calcareous shale.

69.7' to 89.0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces in the upper part, with occasional fossils, and with occasional small masses of pyrite.

2C-78 Continued



WALNUT FORMATION

89.0' to 89.8'LIMESTONE, gray, medium hard, argillaceous, shaly.
89.8' to 96.2'SHALE, gray, medium hard, compact, calcareous, band of gray limestone from 91.7' to 92.0'.

96.2' to 101.3'LIMESTONE, hard, gray, argillaceous, dark gray shale seams from 99.2' to 99.6'.

101.3' to 102.6'SHALE, gray, medium hard, calcareous.
102.6' to 113.5'LIMESTONE, gray, medium hard, argillaceous, thin shale seams, fossiliferous.

113.5' to 116.0'SHALE, gray, calcareous, medium hard, fossiliferous.

116.0' to 136.3'LIMESTONE, gray, argillaceous, thin shale seams, medium hard, shale bands from 118.4' to 119.1', 119.5' to 120.0' and 132.2' to 132.6'.

136.3' to 142.8'Alternating bands of gray calcareous shale and gray argillaceous limestone, medium hard, fossiliferous.

142.8' to 150.9'Shell agglomerate in shale matrix, medium hard, with band of gray fossiliferous shale from 146.0' to 147.2'.

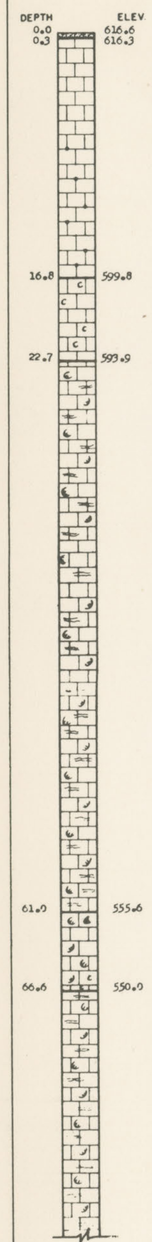
150.9' to 157.3'LIMESTONE, gray, medium hard, argillaceous, fossiliferous, thin shale seams.

157.3' to 157.9'SHELL AGGLOMERATE in dark gray shale matrix, medium hard.
157.9' to 158.4'LIMESTONE, gray, hard, fossiliferous, argillaceous.
158.4' to 162.1'SHALE, dark gray, medium hard, calcareous, fossiliferous.
162.1' to 163.0'LIMESTONE, gray, medium hard, argillaceous, thin shale seams.

163.0' to 164.3'SHALE, gray, calcareous, hard, thin limestone seams.
164.3' to 166.3'LIMESTONE, gray, medium hard, argillaceous, with thin dark gray shale seams.
166.3' to 172.0'SHALE, dark gray, calcareous, medium hard, fossiliferous with limestone bands from 167.4' to 167.6' and 168.8' to 169.0'.

172.0' TOTAL DEPTH

2C-79



0.0' to 0.3' SOIL and LIME.
(Taken from driller's log)

EDWARDS FORMATION

0.3' to 16.8'LIMESTONE, hard, sugary appearance, massive, becoming slightly argillaceous in the lower part, tan, with occasional solution cavities partly to tightly filled with yellow marl.

16.8' to 22.7'LIMESTONE, hard, slightly argillaceous, gray, with numerous small concretionary masses of light gray limestone in the upper part, and with occasional small flakes of chalk.

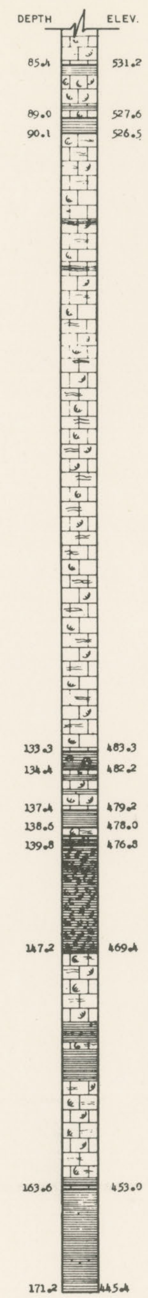
COMANCHE PEAK FORMATION

22.7' to 61.0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

61.0' to 66.6'LIMESTONE, hard, argillaceous, massive, variably light gray to gray, with occasional fossils, and with numerous flakes of chalk in the extreme lower part.

66.6' to 85.4'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces in the upper part, with occasional fossils, and with very occasional small masses of pyrite.

2C-79 Continued



WALNUT FORMATION

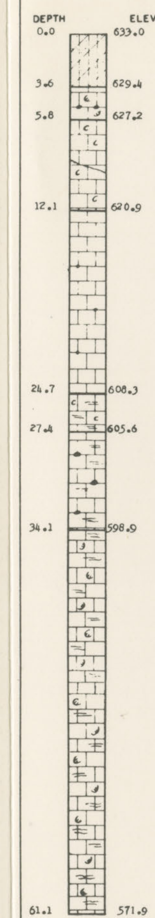
85.4' to 89.0'LIMESTONE, medium hard, argillaceous, thin shale seams, gray, occasional fossils, dark gray shale bands from 85.4'to 85.8' and 88.2' to 88.6', very calcareous.
89.0' to 90.1'SHALE, medium hard, gray calcareous, compact.
90.1' to 133.3'LIMESTONE, medium hard, gray, argillaceous, thin shale seams, occasional fossils, nodular bands of dark gray compact shale from 96.1' to 96.4' and 99.2' to 99.6'.

133.3' to 134.4'SHALE, dark gray, compact, calcareous, medium hard, with nodular pieces of limestone.
134.4' to 137.4'LIMESTONE, gray, medium hard, very argillaceous, thin shale seams, fossiliferous, dark gray calcareous shale bands from 134.7' to 135.3' and 135.7' to 136.2'.
137.4' to 138.6'SHALE, hard, compact, calcareous, dark gray.
138.6' to 139.8'LIMESTONE, gray, medium hard, argillaceous, fossiliferous, thin shale seams.
139.8' to 147.2'SHELL AGGLOMERATE in calcareous shale matrix, gray, medium hard, dark gray calcareous, fossiliferous shale bands from 139.1' to 139.8' and 142.1' to 143.1'.
147.2' to 163.6'LIMESTONE, gray, medium hard, very argillaceous, thin shale seams fossiliferous dark gray calcareous shale bands from 152.2' to 152.7', 152.8' to 153.4', 155.9' to 153.8' and 162.8' to 163.3'.

163.6' to 171.2'SHALE, medium hard, compact, gray, very calcareous, small nodular pieces of gray limestone. Limestone bands from 165.5' to 165.8' and 168.8' to 169.1'.

171.2' TOTAL DEPTH

2C-80 P1-7



0.0' to 3.6'CLAY, brown, silty.
(Taken from driller's log)

EDWARDS FORMATION

3.6' to 5.8'LIMESTONE, hard, crystalline, fossiliferous, tan, with very numerous solution cavities partly to tightly filled with hard porous, secondary lime, and with occasional calcite-lined vugs.
5.8' to 12.1'LIMESTONE, hard, somewhat sugary appearance, massive, tan, with numerous flakes and nodules of chalk, and with a vertical lime-filled fracture from 8.9' to 9.3'.
12.1' to 24.7'LIMESTONE, hard, sugary appearance, massive, tan, with numerous solution cavities partly to tightly filled with marl from 12.3' to 23.0'.

24.7' to 27.4'LIMESTONE, hard, slightly argillaceous, brownish-tan, with irregular tight thin partings of gray calcareous shale, with numerous concretionary masses of brown argillaceous limestone containing flakes and nodules of chalk in the upper part and with red-brown iron stains from 24.7' to 25.0'.
27.4' to 34.1'LIMESTONE, hard, slightly argillaceous, gray, with numerous irregular tight thin partings of gray calcareous shale, with nodules and flakes of chalk throughout, with numerous small concretionary masses of light gray limestone, and with a large calcite-lined vug from 28.6' to 28.7'.

COMANCHE PEAK FORMATION

34.1' to 61.1'LIMESTONE, hard, argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, with occasional small masses of pyrite and pyritized fossils, and with occasional small concretionary masses of light gray limestone in the lower part.

TOTAL DEPTH 61.1'

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

CORE BORINGS

GRAPHIC LOGS
DEFINITE PROJECT SITE

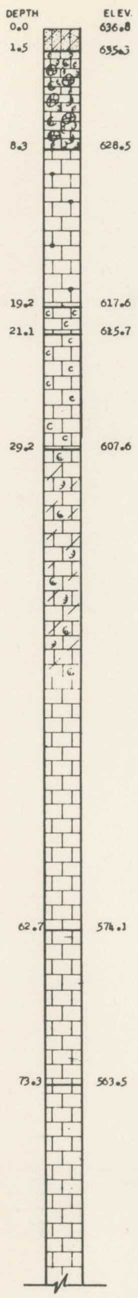
GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 7

CORPS OF ENGINEERS

U. S. ARMY



2C-81

0.0' to 1.5' Topsoil and soft rock.
(Taken from driller's log.)

EDWARDS FORMATION

1.5' to 8.3'SHELL COQUINA, hard, massive, variably white to tan, with numerous hard sugary tan limestone phases.

8.3' to 19.2'LIMESTONE, hard, massive, sugary appearance, tan, with occasional solution cavities partly to tightly filled with yellow marl.

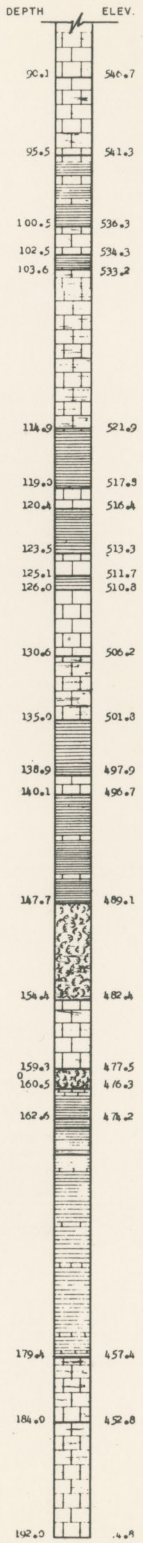
19.2' to 21.1'LIMESTONE, hard, slightly argillaceous, massive, tan, with numerous flakes of chalk.
21.1' to 29.2'LIMESTONE, hard, argillaceous, gray, with occasional small concretionary masses of light gray limestone, and with flakes of chalk throughout.

COMANCHE PEAK FORMATION

29.2' to 62.7'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous clay, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

62.7' to 73.3'LIMESTONE, medium hard, argillaceous, gray, with occasional irregular tight thin partings of gray calcareous clay.

73.3' to 90.1'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous clay having slickensided surfaces in the upper part, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.



2C-81 Continued

WALNUT FORMATION

90.1' to 95.5'LIMESTONE, hard, argillaceous, slightly fossiliferous light gray, with occasional minor shaly phases especially in basal part.

95.5' to 100.5'SHALE, variably hard and medium hard, gray with occasional minor bands and concretionary nodules of hard light gray argillaceous limestone.

100.5' to 102.5'LIMESTONE, very hard, and fossiliferous in top 0.5', becoming very argillaceous and with minor shale phases below 103.0', variably gray and light gray.
102.5' to 103.6'SHALE, variably hard and medium hard, gray.
103.6' to 114.9'LIMESTONE, variably hard and medium hard, very argillaceous with some phases bordering on very calcareous shale, light gray.

114.9' to 119.0'SHALE, hard, very calcareous, gray with occasional minor transitional phases of argillaceous light gray limestone especially in upper part.

119.0' to 120.4'LIMESTONE, hard, very argillaceous, gray.
120.4' to 123.5'SHALE, very hard, very calcareous, gray.

123.5' to 125.1'LIMESTONE, hard, slightly fossiliferous, argillaceous, light gray.

125.1' to 126.0'SHALE, hard, calcareous, gray.
126.0' to 130.6'LIMESTONE, variably argillaceous, light gray.

130.6' to 135.0'LIMESTONE, hard, extremely argillaceous, gray.

135.0' to 138.9'SHALE, alternating with limestone bands, medium hard, calcareous, gray.

138.9' to 140.1'LIMESTONE, hard, very argillaceous and fossiliferous, light gray.

140.1' to 147.7'SHALE, medium hard, gray with numerous thin bands and transitional phases of hard, argillaceous, light gray limestone.

147.7' to 154.4'SHELL AGGLOMERATE in matrix of hard, calcareous gray shale.

154.4' to 159.3'LIMESTONE, hard, slightly fossiliferous, argillaceous, light gray with numerous very thin, irregular and wavy partings of hard, calcareous, gray shale.

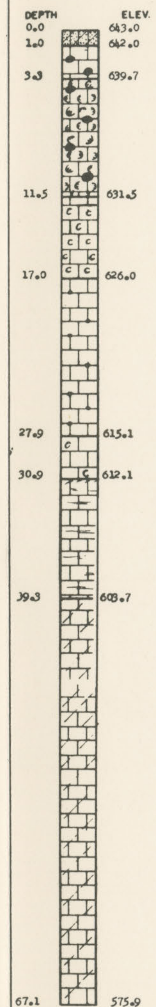
159.3' to 160.5'SHELL AGGLOMERATE, in matrix of hard, calcareous, gray shale.
160.5' to 162.6'SHALE, variably hard and medium hard, calcareous, gray with 0.5' of hard, fossiliferous limestone at top.
162.6' to 165.3'SHALE, medium hard, gray.

165.3' to 179.4'SHALE, medium hard, calcareous, gray with numerous bands of argillaceous, light gray limestone.

179.4' to 184.0'LIMESTONE, hard, argillaceous, light gray, with numerous fossiliferous partings filled with gray shale.

184.0' to 192.0'LIMESTONE, hard, light gray to white, with numerous very thin irregular partings of hard, very calcareous, gray shaly clay.

BOTTOM OF HOLE



2C-82

0.0' to 1.0' TOPSOIL.
(Taken from driller's log)

EDWARDS FORMATION

1.0' to 3.3'LIMESTONE, hard, crystalline, vuggy, brown.
3.3' to 11.5'LIMESTONE, shell coquina, hard, crystalline, massive, white, with numerous solution cavities partly to tightly filled with hard porous secondary lime and occasional calcite-lined vugs from 7.3' to 8.9', and with occasional bands of tan sugary massive limestone in the lower part.
11.5' to 17.0'LIMESTONE, hard, somewhat sugary appearance, massive, variably light tan to white, with numerous flakes and nodules of chalk.

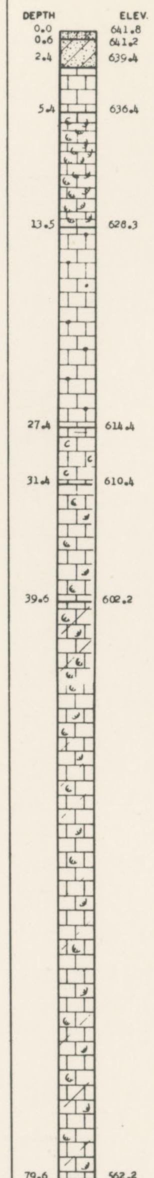
17.0' to 27.9'LIMESTONE, hard, sugary appearance, massive, tan, with numerous solution cavities partly to tightly filled with marl from 17.0' to 25.3'.

27.9' to 30.9'LIMESTONE, hard, slightly argillaceous, light brown, with occasional small concretionary masses of argillaceous brown limestone containing flakes and nodules of chalk, the concretionary masses becoming larger and more numerous at the bottom, with occasional irregular tight "hairline" partings of gray calcareous clay from 30.1' to 30.9', and with red-brown iron stains from 30.1' to 30.4'.
30.9' to 39.3'LIMESTONE, hard, slightly argillaceous, gray, with numerous flakes and nodules of chalk with occasional small concretionary masses of light gray limestone becoming numerous in the upper part.

COMANCHE PEAK FORMATION

39.3' to 67.1'LIMESTONE, hard, argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous clay, with occasional fossils, with occasional small pyrite masses and pyritized fossils, and with occasional small concretionary masses of light gray limestone in the lower part.

TOTAL DEPTH 67.1'



2C-83

0.0' to 0.6'TOPSOIL.
0.6' to 2.4'CLAY, yellow and sand.
2.4' to 5.4'LIMESTONE, soft.
(Taken from driller's log)

EDWARDS FORMATION

5.4' to 13.5'SHELL COQUINA, hard, crystalline, massive, variably white to tan.

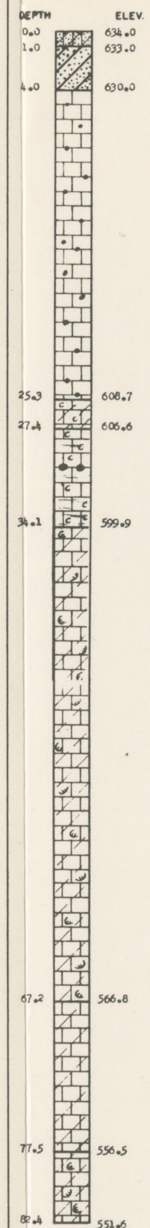
13.5' to 27.4'LIMESTONE, hard, sugary appearance, massive, tan, with small to large solution "cavities" tightly filled with yellow marl throughout.

27.4' to 31.4'LIMESTONE, hard, somewhat sugary appearance, slightly argillaceous, massive, variably tan to grayish-tan, with numerous flakes of chalk.
31.4' to 39.6'LIMESTONE, hard, slightly argillaceous, gray, with numerous flakes of chalk and concretionary masses of light gray limestone, and with occasional fossils.

COMANCHE PEAK FORMATION

39.6' to 79.6'LIMESTONE, hard, argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous clay, with occasional fossils, with occasional small masses of pyrite and pyritized fossils, and with occasional small concretionary masses of light gray limestone in the lower part.

TOTAL DEPTH 79.6'



6C-84

0.0' to 1.0' TOPSOIL.
1.0' to 4.0' CLAY and GRAVEL
(Taken from driller's log)

4.0' to 25.3'LIMESTONE, hard, sugary appearance, massive, tan, with occasional solution cavities partly to tightly filled with yellow marl.

25.3' to 27.4'LIMESTONE, hard, slightly argillaceous, grayish-tan, with numerous small pockets of grayish tan lime containing flakes of chalk, and with occasional irregular tight thin partings of gray calcareous clay.
27.4' to 34.1'LIMESTONE, hard, argillaceous, gray, with numerous concretionary masses of light gray limestone in the upper part, with numerous flakes of chalk throughout, and with a large calcite-lined vug from 29.2' to 29.4'.

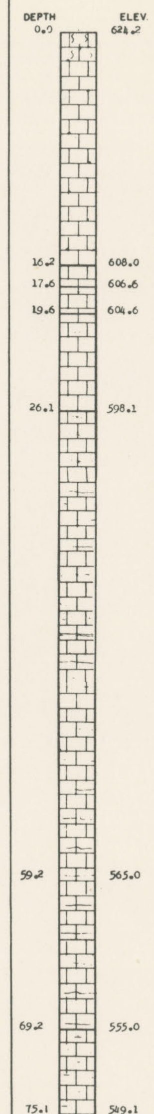
COMANCHE PEAK FORMATION

34.1' to 67.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous clay, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

67.2' to 77.5'LIMESTONE, medium hard, argillaceous, gray, with occasional irregular tight thin partings of gray calcareous clay.

77.5' to 82.4'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight, thin partings of dark gray calcareous clay having slickensided surfaces and with occasional fossils.

TOTAL DEPTH 82.4'



2C-85

EDWARDS FORMATION

0.0' to 16.2LIMESTONE, hard, sugary appearance, massive, variably white to tan, with small to large solution "cavities" tightly filled with yellow marl.

16.2' to 17.6'LIMESTONE, hard, somewhat sugary appearance, massive, tan, with numerous flakes of chalk.
17.6' to 19.6'LIMESTONE, hard, slightly argillaceous, grayish-tan, with numerous irregular tight thin partings of gray calcareous clay, and with occasional fossils.
19.6' to 26.1'LIMESTONE, hard, slightly argillaceous, gray, with numerous flakes of chalk and concretionary masses of light gray limestone, and with occasional fossils.

COMANCHE PEAK FORMATION

26.1' to 59.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous clay, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

59.2' to 69.2'LIMESTONE, hard, slightly argillaceous, gray, with numerous small concretionary masses of light gray limestone with occasional irregular tight thin partings of dark gray calcareous clay, and with occasional fossils.

69.2' to 75.1'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous clay having occasional slickensided surfaces, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

TOTAL DEPTH 75.1'

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

CORE BORINGS

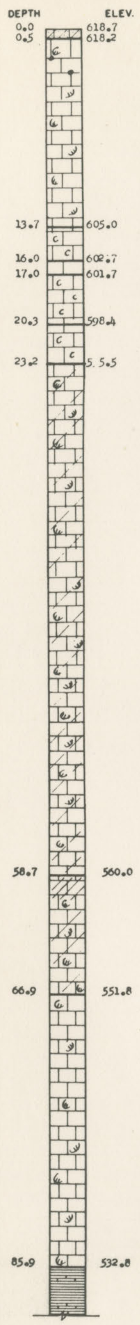
GRAPHIC LOGS
DEFINITE PROJECT SITE

GALVESTON DISTRICT, GALVESTON, TEXAS — DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 — APPENDIX III PLATE 8

2C-86



0.0' to 0.5' TOPSOIL.
(Taken from driller's log)

EDWARDS FORMATION

0.5' to 13.7' LIMESTONE, hard, sugary appearance, massive, tan, with occasional solution cavities partly to tightly filled with iron-stained marl, and with a hard, dense, fossiliferous, vuggy white limestone seam from 1.4' to 1.6'.

13.7' to 16.0' LIMESTONE, medium hard (almost soft), very argillaceous, chalky, massive, light grayish-tan.
16.0' to 17.0' LIMESTONE, medium hard to hard, argillaceous, massive, gray.
17.0' to 20.3' LIMESTONE, hard, slightly argillaceous, gray, with numerous flakes of chalk and small concretionary masses of light gray limestone.
20.3' to 23.2' LIMESTONE, hard, argillaceous, massive, gray, with occasional small flakes of chalk.

COMANCHE PEAK FORMATION

23.2' to 58.7' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous clay, with occasional fossils, with occasional small masses of pyrite and pyritized fossils.

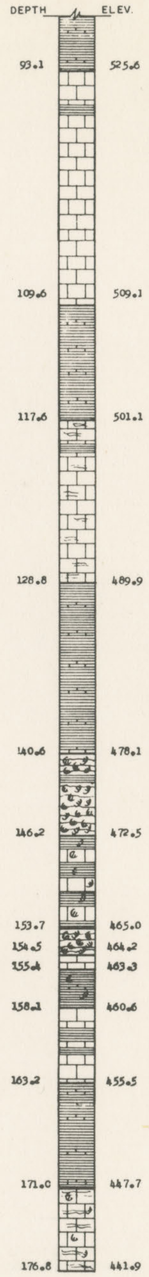
58.7' to 66.9' LIMESTONE, hard, argillaceous, light gray, with very numerous irregular tight thin partings of gray calcareous clay from 58.7' to 60.2' and becoming less numerous from 60.2' to 66.9', with occasional fossils and pyritized fossils. Note: The "contact" shown at 58.7' is transitional.

66.9' to 85.9' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous clay having slickensided surfaces in the upper part, with occasional fossils and with occasional small masses of pyrite and pyritized fossils.

WALNUT FORMATION

85.9' to 93.1' SHALE, gray, medium hard, calcareous with thin gray limestone seams.

2C-86 Continued



93.1' to 109.6' LIMESTONE, gray, medium hard, argillaceous, band of calcareous shale from 95.3' to 96.1'.

109.6' to 117.6' SHALE, dark gray, compact, medium hard, calcareous, thin limestone seams.

117.6' to 128.8' LIMESTONE, gray, medium hard, argillaceous, numerous thin seams of shale, shale band 119.2' to 119.8'.

128.8' to 140.6' SHALE, hard, gray, calcareous, with numerous wide seams of light gray argillaceous limestone.

140.6' to 146.2' SHELL AGGLOMERATE in dark gray shale matrix, medium hard, shale band 142.0' to 142.5'.

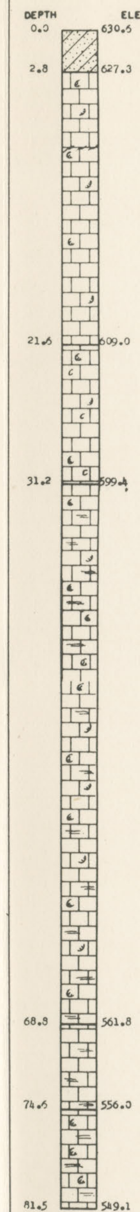
146.2' to 153.7' Alternating bands of gray calcareous shale and argillaceous limestone, medium hard, fossiliferous.

153.7' to 154.5' SHELL AGGLOMERATE in gray shale matrix, medium hard.
154.5' to 155.4' LIMESTONE, gray, argillaceous, medium hard.
155.4' to 158.1' SHALE, gray, calcareous, limestone phases, fossiliferous, hard.
158.1' to 163.2' LIMESTONE, gray, argillaceous, medium hard, shale bands from 159.6' to 160.5' and 160.8' to 161.2'.

163.2' to 171.0' SHALE, gray, hard, very calcareous, thin gray limestone seams.

171.0' to 176.8' LIMESTONE, gray, medium hard, argillaceous, fossiliferous, thin gray shale seams.

2C-87



0.0' to 2.8' CLAY, red, sandy.
(Taken from driller's log)

EDWARDS FORMATION

2.8' to 21.6' LIMESTONE, hard, sugary appearance, massive, tan, with solution cavities partly to tightly filled with yellow marl, with a hard crystalline, fossiliferous, iron-stained, tan limestone break from 3.9' to 5.1' with two thin red marl seams at 5.2' and 5.4', and with a very hard, dense, fractured white limestone from 8.0' to 8.3'.

21.6' to 31.2' LIMESTONE, hard, slightly argillaceous, gray, with numerous small concretionary masses of light gray limestone, with occasional fossils, and with numerous small flakes of chalk throughout.

COMANCHE PEAK FORMATION

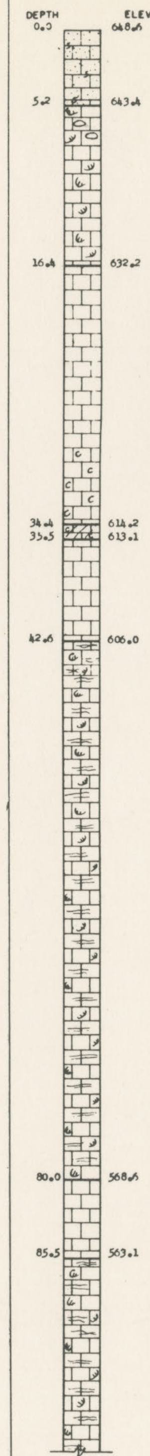
31.2' to 68.8' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

68.8' to 74.6' LIMESTONE, hard, argillaceous, massive, gray, with occasional irregular tight thin partings of gray calcareous shale in the middle part.

74.6' to 81.5' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale having occasional slickensided surfaces, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

81.5' TOTAL DEPTH

2C-88



0.0' to 5.2' LIMESTONE, very soft, weathered, sandy.
(Taken from driller's log)

EDWARDS FORMATION

5.2' to 16.4' LIMESTONE, SHELL COQUINA, hard, slightly crystalline, massive, white, with occasional small solution cavities in the upper part.

16.4' to 34.4' LIMESTONE, hard, sugary appearance, massive, tan, with occasional small solution cavities partly to tightly filled with tan marl, and with numerous flakes of chalk in the extreme lower part.

34.4' to 35.5' LIMESTONE, medium hard, argillaceous, gray, with flakes of chalk, with small concretionary masses of light gray limestone, and with occasional irregular, tight, thin partings of dark gray calcareous clay.
35.5' to 42.6' LIMESTONE, medium hard, argillaceous, massive, gray.

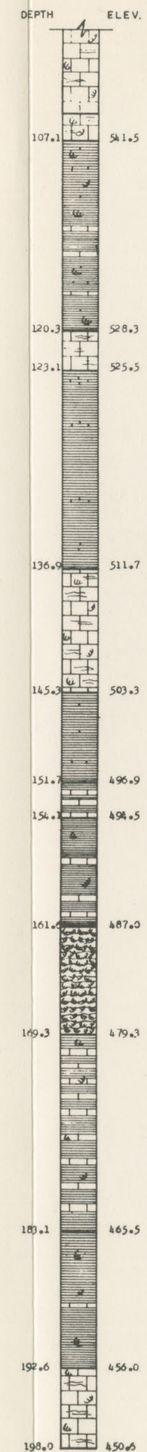
COMANCHE PEAK FORMATION

42.6' to 80.0' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous clay, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

80.0' to 85.5' LIMESTONE, medium hard, argillaceous, massive, gray.

85.5' to 105.1' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces in the upper part, with occasional fossils, and with occasional small masses of pyrite.

2C-88



CLASSIFICATION AND REMARKS

2C-88

WALNUT FORMATION

105.1' to 107.1' LIMESTONE, gray, medium hard, argillaceous, occasional fossils, thin shale seams.
107.1' to 120.3' SHALE, calcareous, gray, medium hard to hard, occasional fossils and limestone seams, band of gray argillaceous limestone from 113.0' to 113.4', 114.7' to 115.2' and 117.6' to 117.8'.

120.3' to 123.1' LIMESTONE, gray, argillaceous, medium hard, thin seams and partings of dark gray shale.
123.1' to 136.9' SHALE, hard, very argillaceous, gray, numerous nodular pieces of gray limestone, upper 5 feet borders on very argillaceous limestone.

136.9' to 145.3' LIMESTONE, gray, very argillaceous, medium hard, occasional fossils, and thin seams of gray shale.

145.3' to 151.7' SHALE, gray, calcareous, hard to medium hard, thin seams and nodular pieces of gray limestone.

151.7' to 154.1' Alternating bands of gray argillaceous limestone and dark gray calcareous shale, medium hard.
154.1' to 161.6' SHALE, dark gray, medium hard, calcareous, with bands of gray argillaceous limestone from 156.8' to 157.3', 159.6' to 159.9' and 160.6' to 160.9', fossiliferous.

161.6' to 169.3' SHELL AGGLOMERATE in dark gray, calcareous shale matrix, medium hard, fossiliferous shale band from 163.9' to 164.4'.

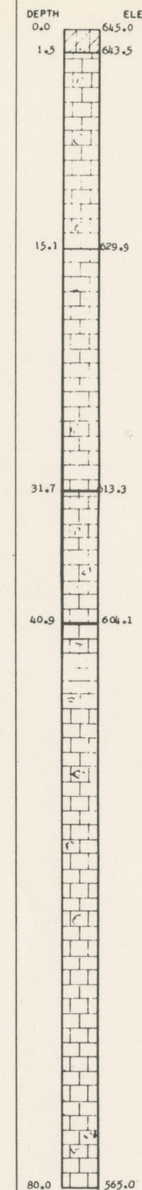
169.3' to 183.1' Alternating bands of dark gray calcareous shale and gray argillaceous limestone, medium hard, fossiliferous, shale predominant material.

183.1' to 192.6' SHALE, dark gray, calcareous, fossiliferous, medium hard to hard, bands of gray limestone from 187.9' to 188.3', grades to argillaceous limestone at base.

192.6' to 198.0' LIMESTONE, gray, medium hard, very argillaceous, occasional shells and thin seams of dark gray shale, occasional masses of pyrite.

TOTAL DEPTH

2C-89



0.0' to 1.5' TOPSOIL.
(Taken from driller's log)

EDWARDS FORMATION

1.5' to 15.1' LIMESTONE, shell coquina, hard, slightly crystalline, massive, variably white to tan, with occasional solution cavities.

15.1' to 31.7' LIMESTONE, hard, sugary appearance, massive, tan, with occasional solution cavities partly to tightly filled with yellow marl.

31.7' to 40.9' LIMESTONE, medium hard, argillaceous, gray, with occasional small concretionary masses of light gray limestone and with occasional flakes of chalk.

COMANCHE PEAK FORMATION

40.9' to 80.0' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

TOTAL DEPTH 80.0'

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

CORE BORINGS

GRAPHIC LOGS
DEFINITE PROJECT SITE

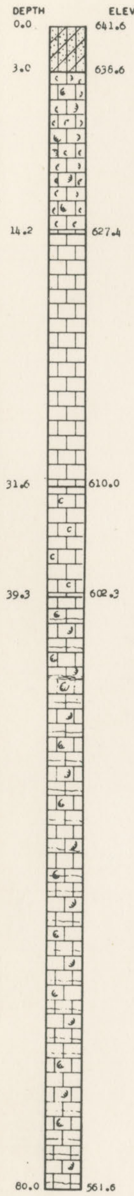
GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 9

CORPS OF ENGINEERS

U.S ARMY



2C-90

0.0' to 3.0' TOPSOIL and CLAY.
(Taken from driller's log)

EDWARDS FORMATION

3.0' to 14.2'LIMESTONE, shell coquina, very hard, massive, variably white to tan, with numerous iron-stained solution cavities partly filled with reddish-brown marl and clay.

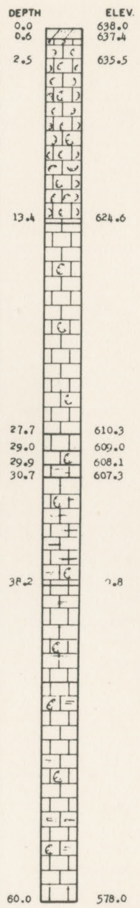
14.2' to 31.6'LIMESTONE, hard, sugary appearance, massive, tan.

31.6' to 39.3'LIMESTONE, medium hard, argillaceous, massive, gray, with occasional small concretionary masses of light gray limestone, and with occasional flakes of chalk throughout.

COMANCHE PEAK FORMATION

39.3' to 80.0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous clay, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

TOTAL DEPTH 80.0'



2C-91

0.0' to 0.6' TOPSOIL
(Taken from driller's log)

0.6' to 2.5'LIMESTONE, hard, slightly crystalline, light brown with numerous solution cavities partly filled with yellow marl.
2.5' to 13.4'LIMESTONE, shell coquina, hard, crystalline, massive, white with numerous small solution cavities tightly filled with sugary lime, and with occasional sugary tan limestone phases in the lower part.

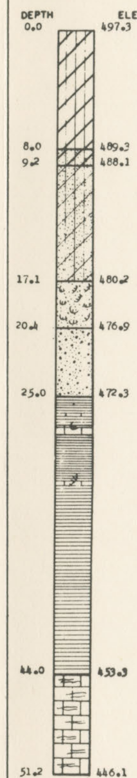
13.4' to 27.7'LIMESTONE, hard, sugary appearance, massive, tan, with occasional hard crystalline, white fossiliferous limestone phases in the upper part, and with a very hard, fractured, dense, white limestone seam from 19.3' to 19.5'.

27.7' to 29.0'LIMESTONE, hard, slightly argillaceous, fossiliferous, massive, tan, with numerous flakes of chalk.
29.0' to 29.9'LIMESTONE, hard, slightly argillaceous, massive, fossiliferous, light grayish tan, with numerous flakes of chalk.
29.9' to 30.7'LIMESTONE, hard, argillaceous, gray with numerous small concretionary masses of light gray limestone having numerous flakes of chalk, and with occasional irregular tight thin partings of dark gray calcareous shale.
30.7' to 38.2'LIMESTONE, hard, argillaceous, massive, gray.

COMANCHE PEAK FORMATION

38.2' to 60.0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight, thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

TOTAL DEPTH 60.0'



6D8A6C-96 P1-10

0.0' to 8.0'CLAY, silty, gray to dark brown, plastic.

8.0' to 9.2'CLAY, sandy, silty, brown, plastic.
9.2' to 17.1'SAND, silty, clayey, brown, firm, fine to medium grained.

17.1' to 20.4' SAND and SHELL.
(Taken from driller's log)

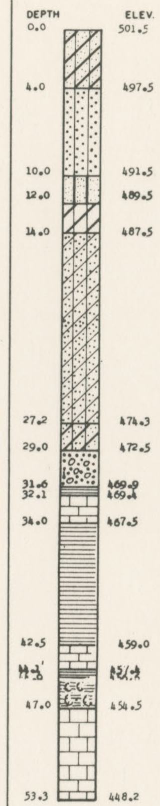
20.4' to 25.0'GRAVEL, sandy, medium fine.

WALNUT FORMATION

25.0' to 44.0'SHALE, partly softened, very slightly weathered, slightly calcareous, gray, with occasional minor, very thin, hard, very argillaceous, light gray limestone bands, and with very hard, very fossiliferous, light gray limestone bands from 27.0' to 27.5' and 30.7' to 31.0'.

44.0' to 51.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight, thin partings of hard, calcareous, gray shale.

BOTTOM OF HOLE



6D8A-97 P1-10

0.0' to 4.0'CLAY, sandy, silty.

4.0' to 10.0'SAND, silty, clayey brown to tan, medium to fine grained.

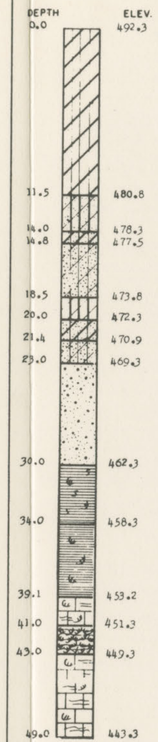
10.0' to 12.0'SILT, sandy, clayey, gray, plastic.
12.0' to 14.0'CLAY, silty, gray, plastic.

14.0' to 27.2'SAND, silty, clayey, tan, firm.

27.2' to 29.0'CLAY, sandy, silty, plastic to stiff, tan.
29.0' to 31.6' SAND and gravel.
(Taken from driller's log)
BASE OF OVERBURDEN
WALNUT FORMATION
31.6' to 32.1'SHALE, badly weathered, soft, calcareous, yellow-brown.
32.1' to 34.0'LIMESTONE, argillaceous, gray, medium hard, weathered.
34.0' to 42.5'SHALE, dark gray, soft to medium hard, variably gray to light, fossiliferous.

42.5' to 44.1'LIMESTONE, argillaceous, medium hard, fossiliferous, thin shale seams
44.1' to 44.9'SHALE, calcareous, medium hard, dark gray, fossiliferous.
44.9' to 47.0'SHELL AGGLOMERATE in shale matrix, moderately hard, gray.
47.0' to 53.3'LIMESTONE, hard, argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale having slickensided surfaces, and with occasional fossils.

TOTAL DEPTH 53.3'



6D8A-98

0.0' to 11.5'CLAY, silty, plastic, tan.

11.5' to 14.0'SILT, sandy, clayey, plastic, brown.
14.0' to 14.8'CLAY, sandy, silty, gray.
14.8' to 18.5'SAND, silty, clayey, tan, firm.
18.5' to 20.0'SILT, clayey, brown, plastic.

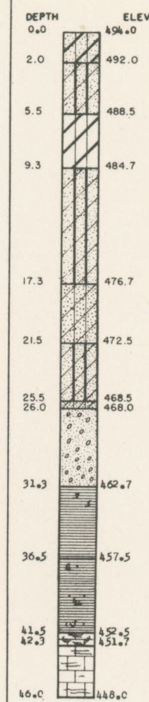
20.0' to 21.4'CLAY, sandy, silty, plastic, sand pockets.
21.4' to 23.0'SAND, silty, clayey, fine grained, wet.
23.0' to 30.0'SAND and GRAVEL, coarse grained.

TOP OF PRIMARY STRATA
WALNUT FORMATION

30.0' to 34.0'SHALE, soft to medium hard, weathered, calcareous, occasional fossils, gray.

34.0' to 39.1'SHALE, dark gray, medium hard, calcareous, fossiliferous.

39.1' to 41.0'LIMESTONE, gray, medium hard, very argillaceous, thin shale seams, occasional shells.
41.0' to 43.0'SHELL AGGLOMERATE in matrix of dark gray shale, medium hard.
43.0' to 49.0'LIMESTONE, gray, medium hard, very argillaceous, numerous irregular thin seams and partings of shale, occasional fossils.



6D8A2C-99

0.0' to 31.3'CLAY, sandy, silty, stiff.
2.0' to 5.5'SILT, sandy, clayey, stiff, gray.

5.5' to 9.3'CLAY, silty, gray, plastic to stiff.

9.3' to 17.3'SILT, sandy, clayey, tan, plastic to stiff.

17.3' to 21.5'SAND, silty, clayey, tan.

21.5' to 25.5'SILT, sandy, clayey, tan, plastic to stiff.

25.5' to 26.0'SAND, clay, silty, tan.
26.0' to 31.3'GRAVELLY SAND grading to sandy gravel below 29.5'.

WALNUT FORMATION

31.3' to 36.5'SHALE, medium hard (partly softened and slightly weathered to 32.6'), slightly calcareous, gray, with hard, very argillaceous, gray limestone bands from 34.3' to 34.4', 35.4' to 34.6', and 35.9' to 36.1'.
36.5' to 41.5'SHALE, medium hard, slightly calcareous, gray, with numerous thin, hard, fossiliferous, argilaceous, light gray limestone bands.
41.5' to 42.3'LIMESTONE, hard, slightly argillaceous, very fossiliferous (bordering on shell agglomerate), light gray, with occasional irregular, tight, thin partings of hard, calcareous, very fossiliferous, gray shale.
42.3' to 46.0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of medium hard, calcareous, gray shale.

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

CORE BORINGS

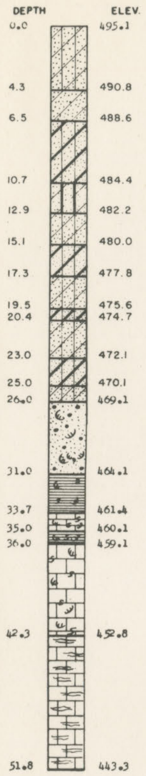
GRAPHIC LOGS
DEFINITE PROJECT SITE

GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 10

6D8A-100



0.0' to 4.3'SAND, clayey, silty, brown to gray.

4.3' to 6.5'SAND, clayey, gray, stiff.

6.5' to 10.7'CLAY, sandy, silty, gray to tan, plastic to stiff.

10.7' to 12.9'SILT, clayey, sandy, brown.

12.9' to 15.1'SAND, clayey, silty, brown, plastic.

15.1' to 17.3'CLAY, silty, sandy, brown.

17.3' to 19.5'SAND, clayey, silty, gray to tan, plastic.

19.5' to 20.4'CLAY, silty, sandy, gray.

20.4' to 23.0'SAND, clayey, silty, tan, firm.

23.0' to 25.0'CLAY, silty, sandy, gray, plastic.

25.0' to 26.0'SAND, clayey, silty, gray, plastic.

26.0' to 31.0'GRAVEL, SAND, and SHELLS, (description taken from driller's log - augered to 32.0').

WALNUT FORMATION

31.0' to 33.7'SHALE, partly softened, weathered, calcareous, fossiliferous, gray.

33.7' to 35.0'LIMESTONE, hard, very argillaceous, slightly weathered, fossiliferous, gray with irregular, tight, thin partings of calcareous gray shale.

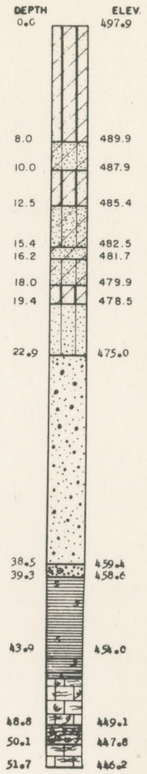
35.0' to 36.0'SHALE, medium hard, calcareous, fossiliferous, slightly weathered, gray.

36.0' to 42.3'LIMESTONE, hard, very argillaceous, slightly weathered, fossiliferous (bordering on shell agglomerate in the lower part), gray with irregular, tight, thin partings of calcareous gray shale.

42.3' to 51.8'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight, very thin partings of calcareous, gray shale.

BOTTOM OF HOLE

6D8A-101



0.0' to 8.0'SILT, clayey, sandy, brown. Stiff to hard, dry.

8.0' to 10.0'SAND, clayey, silty, brown to tan. Plastic.

10.0' to 12.5'SILT, clayey, sandy, brown. Plastic.

12.5' to 15.4'SAND, clayey, silty, tan, fine to very fine. Firm.

15.4' to 16.2'SAND, clayey, brown, fine to very fine. Plastic to firm.

16.2' to 18.0'SAND, clayey, silty, tan, plastic.

18.0' to 19.4'SILT, sandy, clayey, brown, plastic.

19.4' to 22.9'SAND, silty, brown, fine to very fine.

22.9' to 38.5'SAND and GRAVEL, (fish-tailed; description taken from driller's log). (Fine gravel).

38.5' to 39.3'GRAVEL, large limestone and chert pebbles.

WALNUT FORMATION

39.3' to 43.9'SHALE, partly softened, weathered, calcareous, gray.

43.9' to 45.4'SHALE, medium hard, slightly weathered, calcareous, gray.

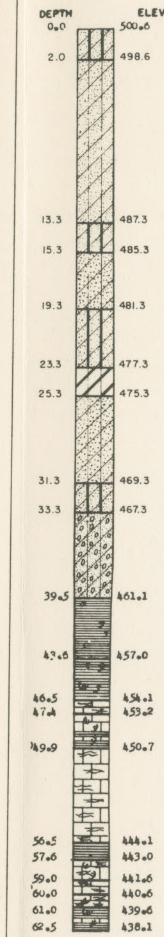
45.4' to 48.8'LIMESTONE, hard, argillaceous, fossiliferous, light gray, with numerous, irregular, tight thin partings of medium hard calcareous gray shale.

48.8' to 50.1'SHELL AGGLOMERATE, hard, light gray, in a matrix of medium hard calcareous, gray shale.

50.1' to 51.7'LIMESTONE, hard, slightly calcareous, light gray, with numerous irregular, tight very thin partings of medium hard, calcareous, gray shale.

BOTTOM OF HOLE

6D8A2C-102



0.0' to 2.0'SILT, sandy, clayey, brown, friable.

2.0' to 13.3'SAND, silty, clayey, brown.

13.3' to 15.3'SILT, clayey, sandy, brown, plastic.

15.3' to 19.3'SAND, clayey, silty, brown, very fine to fine grained.

19.3' to 23.3'SILT, sandy, clayey, tan, stiff to plastic.

23.3' to 25.3'CLAY, silty, plastic.

25.3' to 31.3'SAND, very fine to medium grained, gray-tan silty and clayey at base.

31.3' to 33.3'SILT, clayey, sandy, gray, plastic.

33.3' to 39.5'GRAVEL, sandy, silty, clayey.

WALNUT FORMATION

39.5' to 43.6'SHALE, partly softened, very slightly weathered, calcareous, gray.

43.6' to 46.5'SHALE, partly softened, very slightly weathered, gray, with occasional thin, hard, argillaceous, fossiliferous, light gray limestone bands.

46.5' to 47.4'LIMESTONE, hard, argillaceous, light gray, with numerous irregular, tight thin partings of hard, calcareous gray shale.

47.4' to 49.9'LIMESTONE, hard, slightly argillaceous, very fossiliferous, light gray with transitional phases of medium hard to hard shell agglomerate in a matrix of medium hard, calcareous gray shale from 48.6' to 49.0' and 49.3' to 49.9'.

49.9' to 56.5'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of medium hard, calcareous gray shale.

56.5' to 57.6'SHALE, hard, very calcareous, light gray, with a hard, very argillaceous, light gray limestone band from 57.3' to 57.4'.

57.6' to 59.0'LIMESTONE, hard, slightly argillaceous, light gray, partly fossiliferous, with irregular tight thin partings and masses of hard, very fossiliferous, very calcareous, gray shale.

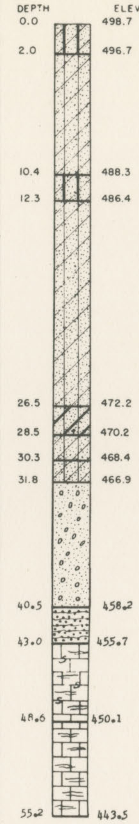
59.0' to 60.0'LIMESTONE, hard, argillaceous, light gray, with numerous, tight, thin partings of hard, very calcareous, light gray shale.

60.0' to 61.0'LIMESTONE, hard, argillaceous, fossiliferous, light gray, with numerous, irregular, tight thin partings of hard, very calcareous, light gray shale.

61.0' to 62.5'SHALE, hard, very calcareous, fossiliferous, light gray, with a very hard, very fossiliferous, very light gray limestone band from 61.6' to 62.0'.

BOTTOM OF HOLE

6D8A-103



0.0' to 2.0'SILT, sandy, clayey.

2.0' to 10.4'SAND, clayey, silty, friable, brown.

10.4' to 12.3'SILT, clayey, sandy, gray, plastic to stiff.

12.3' to 26.5'SANDY, silty, clayey, plastic to stiff, brown.

26.5' to 38.5'CLAY, sandy, silty, plastic, gray.

28.5' to 30.3'SAND, silty, clayey, tan.

30.3' to 31.8'SAND, gravell, silty, clayey, tan.

31.8' to 40.5' GRAVEL, sandy.

40.5' to 43.0'GRAVEL, limestone cobbles and gravel interbedded with reworked shale and gravel.

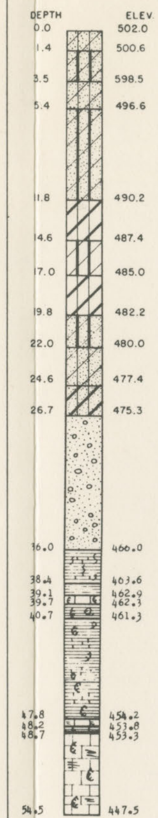
WALNUT FORMATION

43.0' to 48.6'LIMESTONE, hard, slightly weathered, very argillaceous, fossiliferous (bordering on shell agglomerate in the lower part), light gray, with ..umerous thin bands and irregular, tight, thin partings of calcareous gray shale.

48.6' to 55.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight, very thin partings of hard, calcareous, gray shale.

BOTTOM OF HOLE

6D2C-105



0.0' to 1.4'SAND, clayey, silty, gray.

1.4' to 3.5'SILT, clayey, sandy, stiff.

3.5' to 5.4'SAND, silty, clayey, tan, stiff.

5.4' to 11.8'SILT, clayey, sandy, plastic to stiff, gray.

11.8' to 14.6'CLAY, silty, stiff, brown.

14.6' to 17.0'SILT, clayey, gray.

17.0' to 19.8'CLAY, silty, plastic, gray.

19.8' to 22.0' SILT, clayey, sandy, tan-gray.

22.0' to 24.6'SAND, clayey, silty, tan.

24.6' to 26.7'CLAY, silty, sandy, plastic, gray.

26.7' to 36.0'SAND and GRAVEL, medium grained, tan.

WALNUT FORMATION

36.0' to 38.4'SHALE, partly softened, slightly weathered, calcareous, light gray, with partings of hard, very argillaceous, slightly weathered, light gray limestone.

38.4' to 39.1'SHALE, medium hard, calcareous, gray.

39.1' to 39.7'LIMESTONE, very hard, slightly argillaceous, very fossiliferous, light gray.

39.7' to 40.7'SHALE, hard, calcareous, partly fossiliferous, gray, with numerous small concretionary nodules of hard, very argillaceous, light gray limestone.

40.7' to 47.8'SHALE, medium hard, slightly calcareous, gray, with very hard, slightly argillaceous, fossiliferous, light gray limestone bands from 41.1' to 41.4', 42.8' to 43.6' and 44.4' to 44.5', and with a hard, very calcareous, gray shale phase from 47.5' to 47.8'.

47.8' to 48.2'LIMESTONE, hard, very argillaceous, gray, with numerous irregular, tight, thin partings of hard, calcareous, gray shale.

48.2' to 48.7'SHALE, medium hard, slightly calcareous, fossiliferous, gray.

48.7' to 54.5'LIMESTONE, hard, slightly argillaceous, very fossiliferous, light gray, numerous irregular tight, thin partings of hard calcareous gray shale, and with irregular bands of medium hard, calcareous, partly fossiliferous, gray shale, and with irregular areas of medium hard, calcareous, partly fossiliferous, gray shale having concretionary nodules of hard, fossiliferous, slightly argillaceous, light gray limestone from 50.3' to 51.2' and 52.6' to 53.4'.

BOTTOM OF HOLE

NOTE:
Borings Nos. 6D-106 to 6D-111 are shown in Appendix IV.
6D-104 is shown on Plate 17 Appendix III.

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

CORE BORINGS

GRAPHIC LOGS
DEFINITE PROJECT SITE

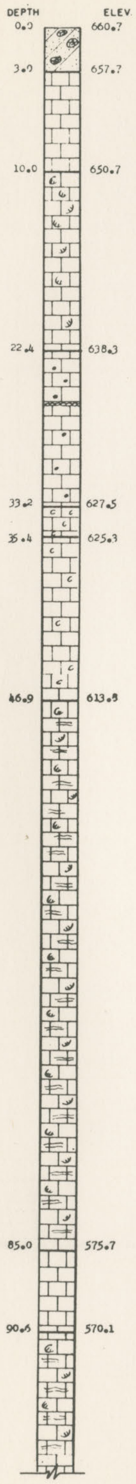
GALVESTON DISTRICT, GALVESTON, TEXAS — DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 — APPENDIX III PLATE 11

CORPS OF ENGINEERS | U. S. ARMY

2C-112



0.0' to 3.0' TOPSOIL and weathered limestone boulders.
(Taken from driller's log)

EDWARDS FORMATION

3.0' to 10.0' LIMESTONE, very hard, crystalline, massive, white, with occasional hard sugary tan limestone phases in the lower part.

10.0' to 22.4' LIMESTONE, shell coquina, hard, slightly crystalline, massive, white, with occasional hard sugary tan limestone phases in the lower part.

22.4' to 33.2' LIMESTONE, hard, sugary appearance, massive, tan, with numerous large solution cavities partly to tightly filled with yellow marl, and with a very hard, dense, brittle, fractured, light gray chert seam from 26.1' to 26.3'.

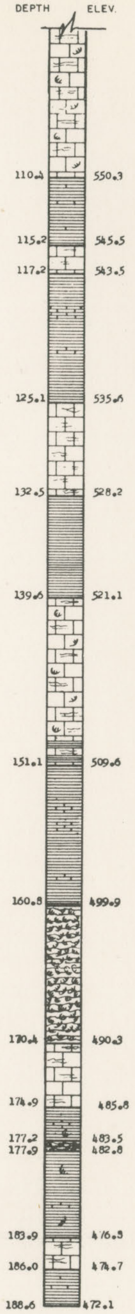
33.2' to 35.4' LIMESTONE, medium hard, argillaceous, massive, tan, with numerous flakes of chalk.
35.4' to 46.9' LIMESTONE, medium hard, argillaceous, gray, with flakes of chalk and small concretionary masses of light gray limestone.

COMANCHE PEAK FORMATION

46.9' to 85.0' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite.

85.0' to 90.6' LIMESTONE, medium hard, argillaceous, massive, gray.

90.6' to 110.4' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces in the upper part, with occasional fossils, and with occasional small masses of pyrite.



CLASSIFICATION AND REMARKS

2C-112

WALNUT FORMATION

110.4' to 115.2' SHALE, gray, medium hard, calcareous, thin limestone seams.

115.2' to 117.2' LIMESTONE, medium hard, gray, argillaceous, thin shale seams.

117.2' to 125.1' SHALE, medium hard, calcareous, dark gray with bands of gray argillaceous limestone from 119.4' to 120.4' and 122.2' to 122.6'.

125.1' to 132.5' LIMESTONE, gray, medium hard, very argillaceous, numerous thin seams of dark gray calcareous shale.

132.5' to 139.6' SHALE, compact, medium hard, calcareous, dark gray.

139.6' to 151.1' LIMESTONE, gray, argillaceous, thin shale seams, fossiliferous with shale bands from 149.4' to 149.8' and 150.4' to 150.8'.

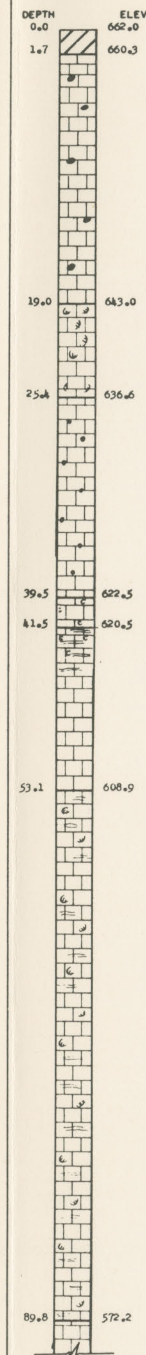
151.1' to 160.8' SHALE, very calcareous, hard, gray with limestone bands from 153.7' to 154.3', 155.0' to 155.5' and 158.6' to 159.0'.

160.8' to 170.4' SHELL AGGLOMERATE in dark gray calcareous shale matrix, medium hard.

170.4' to 174.9' LIMESTONE, gray, medium hard, argillaceous, with thin seams of shale.

174.9' to 177.2' SHALE, dark gray, fossiliferous, calcareous, medium hard, with limestone band from 175.7' to 176.2'.
177.2' to 177.9' SHELL AGGLOMERATE in dark gray calcareous shale matrix, medium hard.
177.9' to 183.9' SHALE, dark gray, medium hard, calcareous, fossiliferous with gray argillaceous limestone bands from 181.6' to 182.0'.
183.9' to 186.0' LIMESTONE, gray, medium hard, argillaceous, with thin shale seams.
186.0' to 188.6' SHALE, dark gray, compact, medium hard, thin seams and bands of gray limestone.

2C-113



0.0' to 1.7' CLAY topsoil.
(Taken from driller's log)

EDWARDS FORMATION

1.7' to 19.0' LIMESTONE, very hard, crystalline, massive, brown with numerous large and small iron-stained vugs, and with occasional large chert concretions.

19.0' to 25.4' LIMESTONE, shell coquina, hard, slightly crystalline, massive, white, with numerous large solution "cavities" tightly filled with yellow porous lime in the lower part.

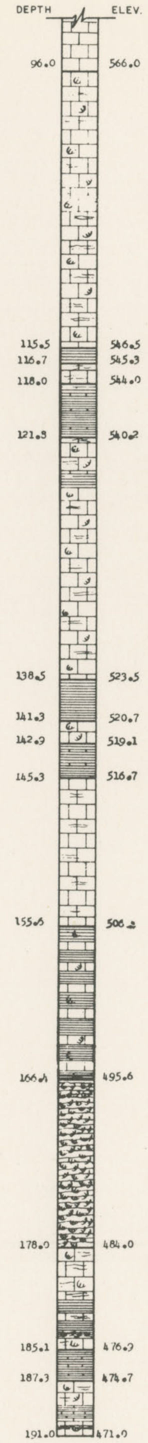
25.4' to 39.5' LIMESTONE, hard, sugary appearance, massive, tan, with numerous large solution cavities partly to tightly filled with yellow marl.

39.5' to 41.5' LIMESTONE, medium hard, argillaceous, brown, with numerous flakes of chalk.
41.5' to 53.1' LIMESTONE, medium hard, argillaceous, gray, with numerous flakes of chalk and concretionary masses of light gray limestone and occasional irregular tight, thin partings of dark gray, calcareous shale in the upper part.

COMANCHE PEAK FORMATION

53.1' to 89.8' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite.

89.8' to 96.0' LIMESTONE, medium hard, argillaceous, massive, gray.



2C-113 Continued

96.0' to 115.5' LIMESTONE, hard, slightly argillaceous, light gray with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces in the upper part, with occasional fossils and with occasional small masses of pyrite.

WALNUT FORMATION

115.5' to 116.7' SHALE, gray, medium hard, calcareous.
116.7' to 118.0' LIMESTONE, gray, medium hard, argillaceous, thin dark gray calcareous shale seams.
118.0' to 121.8' SHALE, dark gray, very calcareous, hard, with thin gray, argillaceous limestone seams.
121.8' to 138.5' LIMESTONE, gray, medium hard, very argillaceous, thin shale seams, fossiliferous; band of dark gray shale from 124.2' to 125.2'.

138.5' to 141.3' SHALE, dark gray, compact, medium hard, very calcareous.

141.3' to 142.9' LIMESTONE, gray, argillaceous, fossiliferous, medium hard.
142.9' to 145.3' SHALE, hard, dark gray, very calcareous with thin seams of gray argillaceous limestone.
145.3' to 155.6' LIMESTONE, gray, medium hard, argillaceous, thin seams of dark gray shale.

155.6' to 166.4' Alternating bands of dark gray, medium hard, calcareous shale and gray very argillaceous limestone, shale slightly predominant material, fossiliferous.

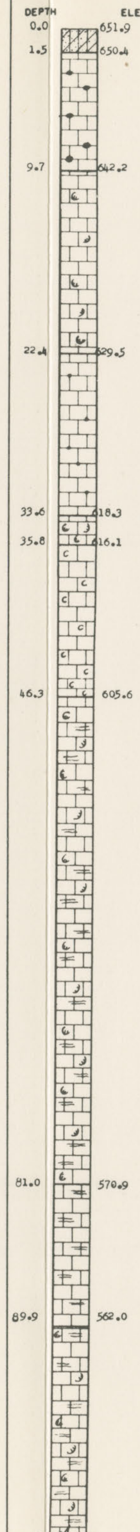
166.4' to 178.0' SHELL AGGLOMERAGE, in dark gray calcareous shale matrix, medium hard.

178.0' to 185.1' LIMESTONE, gray, calcareous, medium hard, thin shale seams, fossiliferous bands of dark gray shale from 181.6' to 182.5' and 183.1' to 183.7'. Shell agglomerate in shale matrix from 183.7' to 184.4'.

185.1' to 187.3' SHALE, dark, gray, very calcareous, with several 0.1' wide seams of gray limestone, fossiliferous.
187.3' to 191.0' LIMESTONE, gray, argillaceous, medium hard, with bands of dark gray shale from 189.1' to 189.4', 189.6' to 189.9' and 190.2' to 190.6', fossiliferous.

191.0' TOTAL DEPTH

2C-114



0.0' to 1.5' TOPSOIL.
(Taken from driller's log)

EDWARDS FORMATION

1.5' to 9.7' LIMESTONE, very hard, crystalline, variably tan to white, with occasional "pinhole" vugs, with occasional large solution "cavities" tightly filled with yellow marl from 7.0' to 8.1', and with numerous large vugs in the upper part.

9.7' to 22.4' LIMESTONE, shell coquina, hard, crystalline, massive, variably white to tan, with occasional sugary tan limestone phases in the lower part.

22.4' to 33.6' LIMESTONE, hard, massive, sugary appearance, tan, with occasional solution cavities partly to tightly filled with yellow marl.

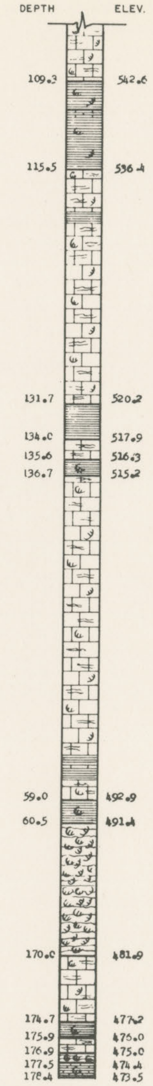
33.6' to 35.8' LIMESTONE, medium hard, slightly argillaceous, grayish brown, with occasional fossils, with falkes of chalk throughout, and with irregular tight thin partings of gray calcareous clay in the lower part.
35.8' to 46.3' LIMESTONE, medium hard, argillaceous, massive, variably light gray to gray, with occasional small concretionary masses of light gray limestone in the upper part, and with occasional flakes of chalk throughout.

COMANCHE PEAK FORMATION

46.3' to 81.0' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight, thin partings of gray calcareous shale, with occasional fossils, with occasional small masses of pyrite and pyritized fossils.

81.0' to 89.9' LIMESTONE, medium hard, argillaceous, variably light gray to gray, with numerous irregular, tight, thin partings of gray calcareous shale in the upper part.

89.9' to 109.3' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.



2C-114 Continued

WALNUT FORMATION

109.3' to 115.5' SHALE, gray, hard, very calcareous, fossiliferous. Limestone band from 111.3' to 111.5'.

115.5' to 131.7' LIMESTONE, medium hard, very argillaceous, thin shale seams, gray, fossiliferous, with dark gray shale band from 118.3' to 118.9'.

131.7' to 134.0' SHALE, gray, medium hard, very calcareous.

134.0' to 135.6' LIMESTONE, gray, medium hard, argillaceous, thin shale seams.
135.6' to 136.7' SHALE, gray, very calcareous, hard, fossiliferous.
136.7' to 159.0' LIMESTONE, gray, medium hard thin shale seams, gray, fossiliferous, argillaceous, with gray shale bands from 155.9' to 156.5' and 156.7' to 157.6'.

159.0' to 160.5' SHALE, dark gray, medium hard, fossiliferous, calcareous.
160.5' to 170.0' SHELL AGGLOMERATE in dark gray shale matrix, medium hard.

170.0' to 174.7' LIMESTONE, medium hard, gray, very argillaceous, thin shale seams, fossiliferous.

174.7' to 175.9' SHALE, dark gray, medium hard, calcareous, fossiliferous.
175.9' to 176.9' LIMESTONE, gray, medium hard, argillaceous, thin shale seams.
176.9' to 177.5' SHELL AGGLOMERATE in dark gray calcareous shale matrix.
177.5' to 178.4' SHALE, gray, hard, fossiliferous, very calcareous.

178.4' TOTAL DEPTH

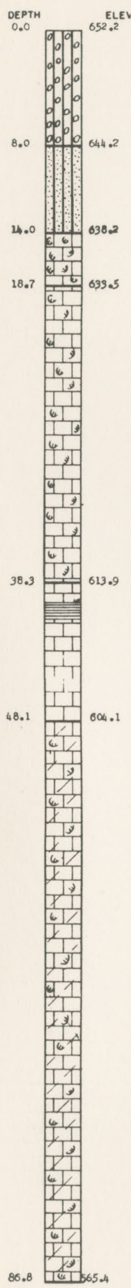
BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

CORE BORINGS
GRAPHIC LOGS
DEFINITE PROJECT SITE

GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 12



2C-115

0.0' to 8.0' SILT and boulders.

8.0' to 14.0' SILT and sand.

EDWARDS FORMATION

14.0' to 18.7' LIMESTONE, medium hard, occasionally soft and friable, slightly arenaceous, very fossiliferous (becoming a shell coquina from 17.2' to 17.8'), weathered, massive, brown, with a large, very hard, brittle, light gray chert concretion from 18.0' to 18.1'.

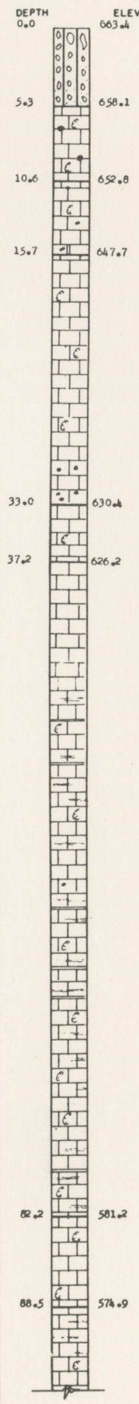
18.7' to 38.3' LIMESTONE, hard, sugary appearance, massive, tan, with occasional open solution cavities, with occasional fossiliferous crystalline white limestone phases in the extreme upper part, and with a tight vertical fracture from 31.5' to 32.3'.

38.3' to 48.1' LIMESTONE, medium hard, argillaceous, massive, gray, with numerous irregular, tight, thin partings of dark gray calcareous shale from 39.7' to 40.8', and with a transitional, almost soft, very argillaceous phase in the lower part.

COMANCHE PEAK FORMATION

48.1' to 86.8' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight, thin partings of gray calcareous clay, with occasional fossils and with occasional small masses of pyrite and pyritized fossils.

TOTAL DEPTH 86.8'



2C-117

0.0' to 5.3' SILT, boulder, and gravel. (Taken from driller's log)

EDWARDS FORMATION

5.3' to 10.6' LIMESTONE, very hard, fossiliferous, crystalline, vuggy, brown.

10.6' to 15.7' LIMESTONE, hard, fossiliferous, massive, crystalline, white, with numerous tiny vugs throughout.

15.7' to 33.0' LIMESTONE, hard, sugary appearance, massive, tan, with numerous large solution cavities partly filled with marl in the lower part.

33.0' to 37.2' LIMESTONE, medium hard, argillaceous, light brown, with numerous flakes of chalk.

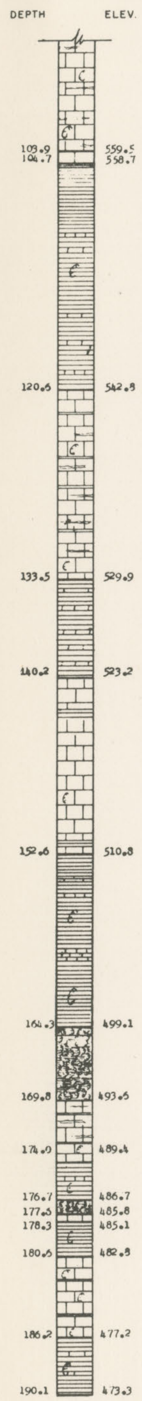
37.2' to 45.2' LIMESTONE, medium hard, argillaceous, massive, gray.

COMANCHE PEAK FORMATION

45.2' to 82.2' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale having slickensided surfaces, with occasional fossils, and with occasional small masses of pyrite.

82.2' to 88.5' LIMESTONE, medium hard, argillaceous, massive, gray.

88.5' to 103.9' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces, with occasional fossils, and with occasional small masses of pyrite.



2C-117 Pl-13 Continued

WALNUT FORMATION

103.9' to 104.7' LIMESTONE, medium hard, gray shaly.
104.7' to 120.6' SHALE, medium hard, to hard, calcareous, compact, gray limestone bands from 109.8' to 110.1', 110.7' to 111.0', 115.2' to 115.5', 117.0' to 117.3' and 119.0' to 119.5'.

120.6' to 133.5' LIMESTONE, gray, medium hard, argillaceous, thin shale seams.

133.5' to 140.2' SHALE, hard to very hard, gray, calcareous, numerous thin seams and bands of gray limestone.

140.2' to 152.6' LIMESTONE, gray, medium hard, argillaceous with bands of dark gray calcareous shale from 142.5' to 143.0', and 151.6' to 152.0'.

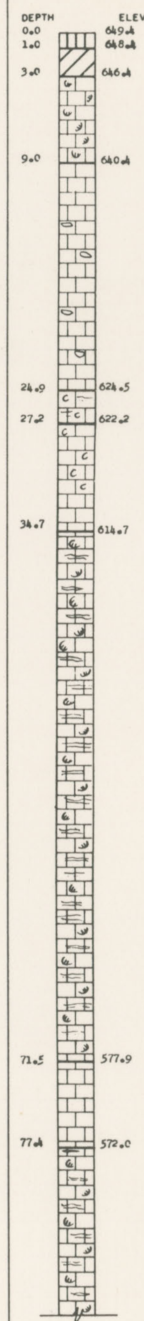
152.6' to 164.3' SHALE, gray, medium hard, very calcareous, with limestone bands from 154.1' to 154.6', 155.4' to 155.9', and 159.0' to 159.9', fossiliferous.

164.3' to 169.8' SHELL AGGLOMERATE in dark gray shale matrix, medium hard with bands of fossiliferous shale from 165.9' to 167.0' and 167.4' to 167.9'.
169.8' to 174.0' LIMESTONE, gray, argillaceous, medium hard, thin dark gray shale seams.

174.0' to 176.7' SHALE, dark gray, medium hard, fossiliferous, gray limestone band from 175.1' to 175.8'.
176.7' to 177.6' SHELL AGGLOMERATE, in dark gray shale matrix, medium hard.
177.6' to 178.3' LIMESTONE, medium hard, gray, argillaceous.
178.3' to 180.6' SHALE, hard, very calcareous, gray.
180.6' to 186.2' LIMESTONE, argillaceous, gray, medium hard, fossiliferous, shale seams.

186.2' to 190.1' SHALE, medium hard, dark gray, calcareous, thin seams of gray argillaceous limestone.

190.1' TOTAL DEPTH



2C-118

0.0' to 1.0' SILT.
1.0' to 3.0' CLAY.
(Taken from driller's log)

EDWARDS FORMATION

3.0' to 9.0' LIMESTONE, shell coquina, hard, massive, white, iron-stained.

9.0' to 24.9' LIMESTONE, hard, massive, sugary appearance, tan, with numerous large iron-stained solution cavities partly to tightly filled with yellow marl.

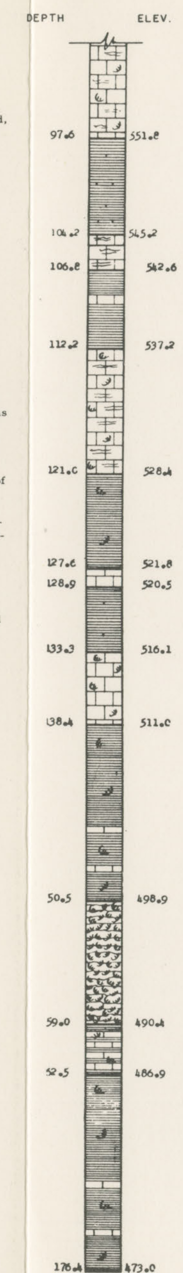
24.9' to 27.2' LIMESTONE, medium hard, argillaceous, grayish brown, with numerous small flakes of chalk, and with occasional tight irregular partings of gray calcareous shale.
27.2' to 34.7' LIMESTONE, medium hard, argillaceous, gray, with numerous flakes of chalk and large concretionary masses of light gray limestone in the extreme upper part, and with occasional small concretionary masses of light gray limestone throughout.

COMANCHE PEAK FORMATION

34.7' to 71.5' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite.

71.5' to 77.4' LIMESTONE, medium hard, argillaceous, massive, gray.

77.4' to 97.6' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces, with occasional fossils and with occasional small masses of pyrite.



2C-118 Continued

WALNUT FORMATION

97.6' to 104.2' SHALE, gray, hard, very calcareous, thin seams and nodular pieces of gray limestone.

104.2' to 106.8' LIMESTONE, gray, very argillaceous, medium hard, thin shale seams and partings.
106.8' to 112.2' SHALE, gray, medium hard, calcareous, thin seams and nodular pieces of gray limestone, band of gray argillaceous limestone from 108.5' to 109.2'.

112.2' to 121.0' LIMESTONE, gray, medium hard, argillaceous, occasional fossils, thin seams and partings of dark gray shale.

121.0' to 127.6' SHALE, dark gray, medium hard, calcareous, occasional fossils.

127.6' to 128.9' LIMESTONE, gray, medium hard, argillaceous.
128.9' to 133.3' SHALE, dark gray, occasional seams and nodular pieces of gray limestone, medium hard.

133.3' to 138.4' LIMESTONE, gray, medium hard, argillaceous, occasional fossils.

138.4' to 150.5' SHALE, dark gray, medium hard to hard, calcareous, occasional fossils; gray limestone bands from 145.4' to 145.8' and 148.0' to 148.4'.

150.5' to 159.0' SHELL AGGLOMERATE in dark gray calcareous shale matrix, medium hard.

159.0' to 162.5' Alternating bands of dark gray calcareous shale and gray argillaceous limestone, medium hard, fossiliferous.
162.5' to 176.4' SHALE, dark gray, medium hard to hard with irregular seams and nodular masses of gray limestone, bands of gray limestone from 170.0' to 170.5' and 173.4' to 173.9', fossiliferous.

TOTAL DEPTH

NOTE:
Boring 2C-116 is shown on Plate 17 Appendix III.

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS
CORE BORINGS
GRAPHIC LOGS
DEFINITE PROJECT SITE

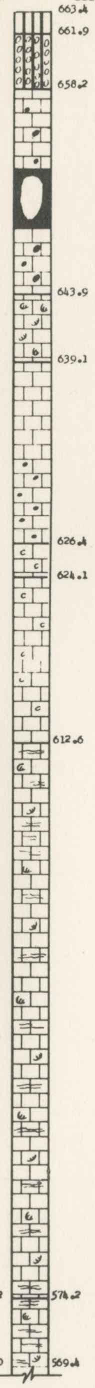
GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 13

2C-119

DEPTH ELEV.



0.0' to 1.5' SILT.
1.5' to 5.2'SILT and boulders.

EDWARDS FORMATION

5.2' to 19.5'LIMESTONE, very hard, crystalline, massive, variably tan to brown, with numerous large to small vugs lined with iron-stained calcite. Open cavity from 10.8' to 15.0'.

19.5' to 24.3'LIMESTONE, shell coquina, hard, massive, crystalline, variably white to tan.

24.3' to 37.0'LIMESTONE, hard, sugary appearance, massive, tan, with numerous large solution cavities partly to tightly filled with yellow marl from 31.1' to 37.7'.

37.0' to 39.3'LIMESTONE, hard, slightly argillaceous, tan, with numerous flakes of chalk.
39.3' to 50.8'LIMESTONE, medium hard, argillaceous, gray, with occasional concretionary masses of light gray limestone, and with occasional flakes of chalk.

COMANCHE PEAK FORMATION

50.8' to 89.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

89.2' to 94.0'LIMESTONE, medium hard, argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces, with occasional fossils, and with occasional small masses of pyrite.

2C-119 Continued

DEPTH ELEV.

94.0' to 112.8'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces, with occasional fossils, and with occasional small masses of pyrite.

WALNUT FORMATION

112.6' to 120.8'SHALE, medium hard, gray, calcareous, gray, argillaceous, limestone band from 114.4' to 115.0'.

120.8' to 126.9'Alternating bands of gray argillaceous limestone and dark gray calcareous shale, medium hard.

126.9' to 139.0'LIMESTONE, gray, medium hard, argillaceous, fossiliferous, band of dark gray shale from 138.0' to 138.5'.

139.0' to 147.2'SHALE, calcareous, dark gray, hard, fossiliferous, with numerous thin limestone seams and bands.

147.2' to 157.0'LIMESTONE, gray, medium hard, argillaceous, thin dark gray shale seams and partings.

157.0' to 165.8'SHALE, dark gray, compact, calcareous, medium hard, nodular limestone seams fossiliferous, limestone bands from 160.0' to 160.5' and 163.5' to 164.3'.

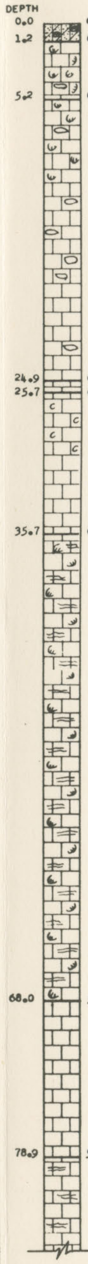
165.8' to 175.6'SHELL AGGLOMERATE, in dark gray shale matrix, medium hard to hard.

175.6' to 176.9'LIMESTONE, gray, medium hard, shaly.
176.9' to 177.8'SHELL AGGLOMERATE in dark gray shale matrix, medium hard.
177.8' to 180.9'LIMESTONE, gray, medium hard, very argillaceous, shale seams and bands.
180.9' to 182.8'SHALE, dark gray to black, compact, medium hard, thin limestone seams, fossiliferous.
182.8' to 184.3'LIMESTONE, gray, medium hard, argillaceous, fossiliferous.
184.3' to 189.0'SHALE, dark gray, calcareous, medium hard, fossiliferous.
189.0' to 190.1'LIMESTONE, gray, very argillaceous, medium hard, thin shale seams.
190.1' to 191.6'SHALE, black, compact, calcareous, medium hard, thin gray limestone bands.

191.6' TOTAL DEPTH

6C-121

DEPTH ELEV.



0.0' to 1.2'Soil and weathered limestone boulders.
(Taken from driller's log)

EDWARDS FORMATION

1.2' to 5.2'LIMESTONE, shell coquina, hard, massive, tan, with a horizontal iron-stained solution cavity at 4.2'.
5.2' to 24.9'LIMESTONE, hard, sugary appearance, massive, tan, with numerous masses of calcite and bands of shell coquina in the upper part and with numerous solution cavities partly filled with yellow marl throughout.

24.9' to 25.7'LIMESTONE, medium hard, argillaceous, massive, tan.
25.7' to 35.7'LIMESTONE, medium hard, argillaceous, gray, with numerous concretionary masses of light gray limestone and flakes of chalk in the upper part.

COMANCHE PEAK FORMATION

35.7' to 68,0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, with occasional small masses of pyrite, and with numerous irregular iron-stained fractures from 59.3' to 68.0'.

68.0' to 78.9'LIMESTONE, medium hard, argillaceous, gray, with numerous irregular tight thin partings of gray calcareous shale, and with occasional irregular iron-stained fractures.

78.9' to 98.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces, with occasional fossils and small masses of pyrite.

DEPTH ELEV. CLASSIFICATION AND REMARKS

6C-121 Continued

WALNUT FORMATION

98.2' to 104.5'SHALE, medium hard, calcareous, gray, numerous thin bands of gray limestone.

104.5' to 106.5'LIMESTONE, gray, medium hard, very argillaceous, occasional fossils, thin shale seams.
106.5' to 110.2'Alternating bands of gray argillaceous limestone and dark gray calcareous shale, medium hard to hard.
110.2' to 121.5'LIMESTONE, gray, argillaceous, medium hard, occasional fossils, thin dark gray calcareous seams and partings.

121.5' to 131.5'SHALE, gray, very calcareous, hard, with small concretionary masses of gray argillaceous limestone, occasional fossils, band of hard gray limestone 129.0' to 130.1'.

131.5' to 144.9'LIMESTONE, gray, very argillaceous, occasional fossils, numerous irregular shale seams and partings.

144.9' to 150.7'Alternating bands of gray argillaceous limestone and calcareous shale, medium hard, fossiliferous.

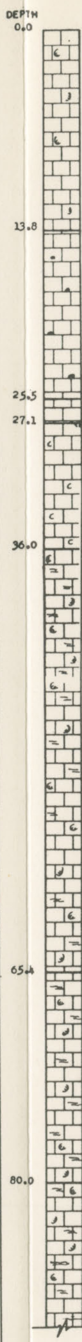
150.7' to 159.1'SHELL AGGLOMERATE in dark gray calcareous shale matrix, hard to medium hard.

159.1' to 159.9'SHALE, dark gray, calcareous, medium hard, fossiliferous.
159.9' to 167.5'LIMESTONE, gray, very argillaceous, irregular seams and partings of dark gray calcareous shale, medium hard, fossiliferous, with shell agglomerate from 164.9' to 166.8'.

TOTAL DEPTH

2C-122

DEPTH ELEV.



EDWARDS FORMATION

0.0' to 13.8'LIMESTONE, shell coquina, hard, massive, white, with occasional solution cavities tightly filled with yellow lime, and with numerous hard sugary tan limestone phases in the lower part.

13.8' to 25.5'LIMESTONE, hard, sugary appearance, massive, tan, with occasional solution cavities partly to tightly filled with yellow marl.

25.5' to 27.1'LIMESTONE, medium hard, argillaceous, massive, grayish-brown.
27.1' to 36.0'LIMESTONE, hard, argillaceous, gray, with numerous concretionary masses of light gray limestone in the upper part, and with numerous flakes of chalk throughout.

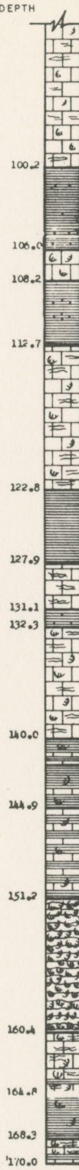
COMANCHE PEAK FORMATION

36.0' to 65.4'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, with occasional small masses of pyrite and pyritized fossils.

65.4' to 80.0'LIMESTONE, medium hard, argillaceous, gray, with numerous irregular tight thin partings of gray calcareous shale in the upper part, and with occasional fossils.

80.0' to 100.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces in the upper part, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

DEPTH ELEV CLASSIFICATION AND REMARKS



2C-122 Continued

WALNUT FORMATION

100.2' to 106.0'SHALE, very calcareous, medium hard, gray, thin seams and nodular pieces of gray argillaceous limestone.

106.0' to 108.2'LIMESTONE, gray, medium hard, very argillaceous, occasional fossils.
108.2' to 112.7'SHALE, hard, very calcareous, gray argillaceous, limestone, hard from 109.2' to 109.5' and 110.5' to 111.0'.

112.7' to 122.8'LIMESTONE, gray, medium hard, argillaceous, thin seams of dark gray shale, a few fossils.

122.8' to 127.9'SHALE, hard, very calcareous, gray, massive.

127.9' to 131.1'LIMESTONE, gray, medium hard, argillaceous, thin, dark gray shale seams.

131.1' to 132.3'SHALE, hard, very calcareous; small concretionary nodules of light gray limestone.
132.3' to 140.0'LIMESTONE, gray, medium hard, very argillaceous; a few fossils and thin shale seams.

140.0' to 144.9'SHALE, soft to medium hard, dark gray, calcareous, fossiliferous, shaly limestone bands from 140.9' to 141.2', 141.4' to 141.6' and 144.5' to 144.9'.
144.9' to 151.2'Alternating bands of dark gray to black calcareous shale and light gray argillaceous, fossiliferous limestone, medium hard.

151.2' to 160.4'SHELL AGGLOMERATE in matrix of dark gray calcareous shale, medium hard.

160.4' to 164.8'LIMESTONE, gray, medium hard, very argillaceous, thin seams of gray shale, fossiliferous, band of dark gray calcareous shale from 163.7' to 164.1'.

164.8' to 168.3'SHALE, dark gray, calcareous, medium hard, fossiliferous.

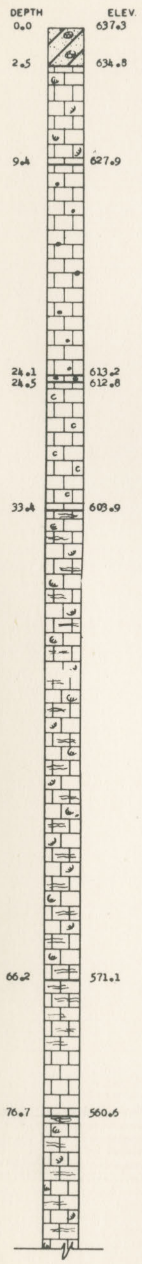
168.3' to 170.0'LIMESTONE, gray, medium hard, argillaceous, thin shale seams, fossiliferous, dark gray calcareous shale band from 169.4' to 169.7'.

NOTE:
Boring 2C-120 is shown on plate 17 App. III.

BRAZOS RIVER BASIN, TEXAS BELTON RESERVOIR LEON RIVER, TEXAS **CORE BORINGS** GRAPHIC LOGS DEFINITE PROJECT SITE
GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948
TO ACCOMPANY DEFINITE PROJECT REPORT
FILE: BRAZ. 503-203 APPENDIX III PLATE 14

2C-123

DEPTH ELEV.



0.0' to 2.5'CLAY, sandy, and limestone. (Taken from driller's log)

EDWARDS FORMATION

2.5' to 9.4'LIMESTONE, shell coquina, hard, massive, white with solution "cavities" tightly filled with hard porous lime, with numerous iron-stains in the upper part, and with occasional transitional phases of hard sugary massive tan limestone in the lower part.

9.4' to 24.1'LIMESTONE, hard, sugary appearance, massive, tan, with occasional solution cavities partly to tightly filled with yellow marl.

24.1' to 24.5'LIMESTONE, very hard, slightly crystalline, vuggy, grayish brown.

24.5' to 33.4'LIMESTONE, hard, slightly argillaceous, gray, with occasional concretionary masses of light gray limestone, and with flakes of chalk throughout.

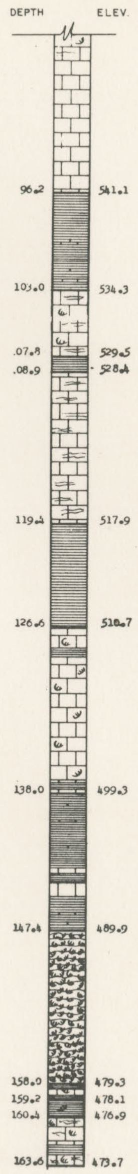
COMANCHE PEAK FORMATION

33.4' to 66.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

66.2' to 76.7'LIMESTONE, variably hard to medium hard, argillaceous, gray, with occasional irregular tight thin partings of dark gray calcareous shale in the upper part.

76.7' to 96.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces in the upper part, with occasional fossils, and with numerous small cubic pyrite crystals in the extreme upper part.

DEPTH ELEV.



2C-123 Continued

WALNUT FORMATIO

96.2' to 103.0'SHALE, gray, hard, very calcareous, occasional nodular pieces of gray limestone.

103.0' to 107.8'LIMESTONE, gray, medium hard, argillaceous, occasional shells and thin dark gray shale seams.

107.8' to 108.9'SHALE, hard, very calcareous, gray.

108.9' to 119.4'LIMESTONE, gray, very argillaceous, numerous thin seams and partings of gray shale, medium hard.

119.4' to 126.6'SHALE, very calcareous, hard, gray.

126.6' to 138.0'LIMESTONE, hard, gray, very argillaceous, occasional shells, bands of dark gray calcareous shale from 127.9' to 128.5' and 137.3' to 137.7'.

138.0' to 147.4'SHALE, hard, very calcareous, gray, numerous thin seams and nodular pieces of gray limestone, argillaceous limestone band from 143.0' to 143.3' and 144.1' to 145.1'.

147.4' to 158.0'SHELL AGGLOMERATE in matrix of dark gray calcareous shale, medium hard, shale seams.

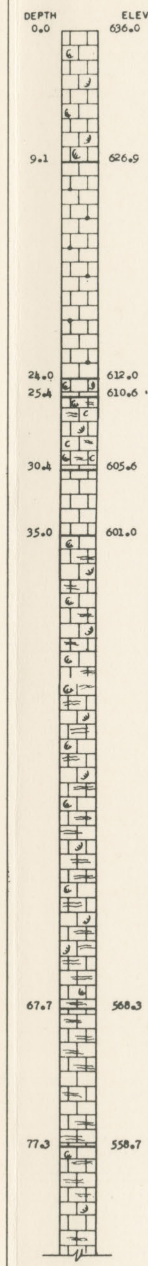
158.0' to 159.2'Thin alternating bands of gray calcareous shale and argillaceous limestone, fossiliferous, medium hard.

159.2' to 160.4'SHALE, hard, very calcareous, occasional fossils, gray.

160.4' to 163.6'LIMESTONE, gray, medium hard, argillaceous, occasional fossils, clusters of pyrite and thin shale seams. Band of dark gray calcareous shale from 162.3' to 163.0'.

2C-124

DEPTH ELEV.



EDWARDS FORMATION

0.0' to 9.1'LIMESTONE, shell coquina, hard, crystalline, massive, white, with occasional small solution "cavities" tightly filled with calcareous material, and with numerous hard sugary tan limestone phases in the lower part.

9.1' to 24.0'LIMESTONE, hard, sugary appearance, massive, tan, with occasional solution cavities partly to tightly filled with yellow-brown marl.

24.0' to 25.4'LIMESTONE, very hard, crystalline, fossiliferous, grayish-tan.

25.4' to 30.4'LIMESTONE, hard, slightly argillaceous, fossiliferous, light gray, with irregular tight thin partings of gray calcareous shale, and with numerous flakes of chalk.

30.4' to 35.0'LIMESTONE, hard, argillaceous, massive, gray.

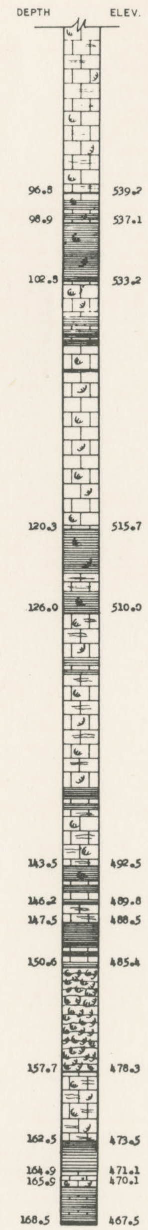
COMANCHE PEAK FORMATION

35.0' to 67.7'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

67.7' to 77.3'LIMESTONE, variably medium hard to hard, argillaceous, gray, with occasional irregular tight thick partings of gray calcareous shale.

77.3' to 96.8'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces in the upper part and with occasional fossils.

DEPTH ELEV. CLASSIFICATION AND REMARKS



2C-124 Continued

WALNUT FORMATION

96.8' to 98.9'LIMESTONE, gray, medium hard, very argillaceous, thin shale seams, fossiliferous, with shale bands from 97.2' to 97.8' and 98.1' to 98.8'.

98.9' to 102.8'SHALE, dark gray, medium hard, fossiliferous, calcareous.

102.8' to 120.3'LIMESTONE, gray, medium hard, very argillaceous, fossiliferous, dark gray calcareous shale bands from 105.3' to 106.0', 106.3' to 106.9', 107.0' to 107.3' and 109.0' to 109.3'.

120.3' to 126.0'SHALE, gray, compact, medium hard, calcareous, fossiliferous, limestone band from 123.2' to 124.5'.

126.0' to 143.5'LIMESTONE, gray, medium hard, argillaceous, thin shale seams, fossiliferous, with shale bands from 129.0' to 129.6', 129.8' to 130.2', 138.1' to 138.8' and 139.2' to 139.6'.

143.5' to 146.2'SHALE, gray, medium hard, calcareous, fossiliferous, gray limestone bands from 144.5' to 144.8' and 145.4' to 145.8'.

146.2' to 147.5'LIMESTONE, gray, argillaceous, medium hard, with thin dark gray shale seams.

147.5' to 150.6'SHALE, medium hard, gray, calcareous with limestone bands from 149.1' to 149.4' and 149.7' to 150.2'.

150.6' to 157.7'SHELL AGGLOMERATE in dark gray shale matrix, medium hard.

157.7' to 162.5'LIMESTONE, gray, medium hard, argillaceous, thin shale seams, fossiliferous

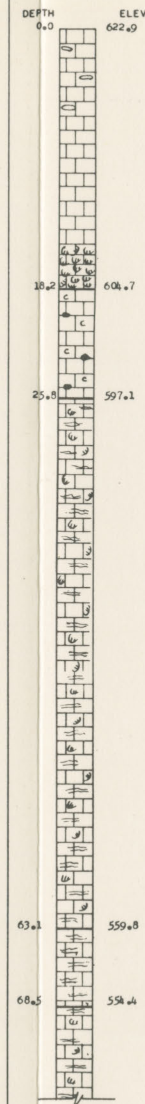
162.5' to 164.9'SHALE, dark gray, very calcareous and fossiliferous, gray limestone band from 163.7' to 163.9'.

164.9' to 165.9'LIMESTONE, gray, hard, argillaceous, fossiliferous.

165.9' to 168.5'SHALE, medium hard, gray calcareous with thin gray argillaceous limestone bands.

2C-125

DEPTH ELEV.



EDWARDS FORMATION

0.0' to 18.2'LIMESTONE, hard, sugary appearance, massive, tan, with occasional large solution cavities partly to tightly filled with yellow marl, with a very hard crystalline brown limestone phase from 1.3' to 2.0', and with a hard massive white shell coquina from 15.0' to 18.2'.

18.2' to 25.8'LIMESTONE, medium hard, argillaceous, gray, with occasional flakes of chalk, and with occasional calcite-lined vugs.

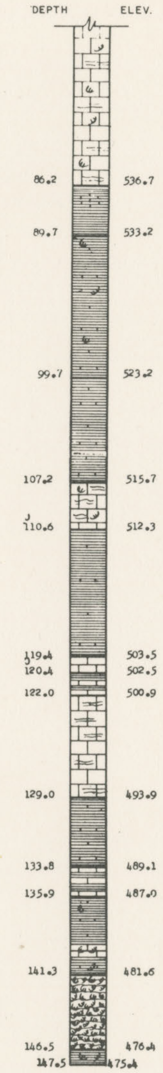
COMANCHE PEAK FORMATION

25.8' to 63.1'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite.

63.1' to 68.5'LIMESTONE, medium hard, argillaceous, somewhat shaly, gray.

68.5' to 86.2'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale, having slickensided surfaces (surfaces also iron-stained from 69.5' to 75.0'.), with occasional fossils, and with occasional small masses of pyrite.

DEPTH ELEV. CLASSIFICATION AND REMARKS



2C-125 Continued

WALNUT FORMATION

86.2' to 89.7'SHALE, hard, very calcareous, gray, gray argillaceous limestone band from 86.7' to 87.6'.

89.7' to 99.7'SHALE, dark gray, calcareous, medium hard, occasional shells and thin seams and nodular clusters of gray argillaceous limestone.

99.7' to 107.2'SHALE, very hard, very calcareous, with numerous concretionary nodules of hard very argillaceous gray limestone.

107.2' to 110.6'LIMESTONE, gray, argillaceous, medium hard, thin dark gray shale seams, occasional shells.

110.6' to 119.4'SHALE, gray, hard, very calcareous, occasional concretionary nodules of hard argillaceous limestone.

119.4' to 120.4'LIMESTONE, gray, very argillaceous, medium hard.

120.4' to 122.0'Thin alternating bands of dark gray calcareous shale and gray argillaceous limestone, medium hard.

122.0' to 129.0'LIMESTONE, gray, argillaceous, medium hard, occasional seams of dark gray shale.

129.0' to 133.8'SHALE, gray, hard, very calcareous, thin seams of gray argillaceous limestone.

133.8' to 135.9'Alternating bands of dark gray shale and gray argillaceous limestone, medium hard.

135.9' to 144.0'SHALE, dark gray, medium hard, calcareous, thin limestone seams, fossiliferous, band of gray argillaceous limestone, 139.2' to 140.0'.

141.3' to 146.5'SHELL AGGLOMERATE in matrix of dark gray shale, medium hard.

146.5' to 147.5'SHALE, dark gray, calcareous, medium hard, fossiliferous.

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

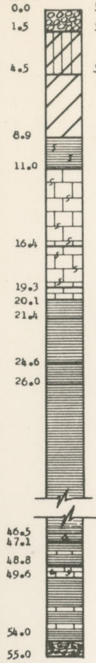
CORE BORINGS

GRAPHIC LOGS
DEFINITE PROJECT SITE

GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 15



6C-126

0.0' to 1.5' Road fill - boulders.
1.5' to 4.5' CLAY, brown, silty

4.5' to 8.9' CLAY, brown, very hard and dry.
(Taken from driller's log)

WALNUT FORMATION

8.9' to 11.0' SHALE, partly softened, badly weathered, calcareous, yellow.

11.0' to 16.4' LIMESTONE, variably hard and partly softened, badly weathered, very argillaceous, light yellowish-gray.

16.4' to 19.3' LIMESTONE, hard, slightly weathered, very argillaceous, light gray.

19.3' to 20.1' LIMESTONE, hard, very argillaceous, light gray.
20.1' to 21.4' SHALE, hard, very calcareous, gray.
21.4' to 24.6' SHALE, medium hard, calcareous, gray.
24.6' to 26.0' SHALE, hard, very calcareous, gray.
26.0' to 46.5' SHALE, hard, very calcareous, in zones borders on very argillaceous limestone light to dark gray, hard to medium hard, numerous seams and nodular pieces of gray limestone, becomes fossiliferous at base.

46.5' to 47.1' SHALE, hard, very calcareous, partly fossiliferous, gray, with concretionary nodules of hard, argillaceous, partly fossiliferous light gray limestone.
47.1' to 48.8' SHALE, medium hard, calcareous, gray, with a hard, very argillaceous, light gray limestone band from 47.7' to 47.9'.
48.8' to 49.6' LIMESTONE, hard, argillaceous, fossiliferous, light gray, with a very hard, very fossiliferous, light gray limestone band from 48.9' to 49.0'.
49.6' to 54.0' SHALE, medium hard, calcareous gray, with hard, very argillaceous, light gray limestone phases from 51.6' to 51.9' and 52.8' to 53.1'.
54.0' to 55.0' SHELL AGGLOMERATE, hard, in a matrix of hard, calcareous, gray shale.

6DC-127

0.0' to 10.6' CLAY, sandy, silty, firm.

10.6' to 12.5' GRAVEL, sandy, silty, clayey.

12.5' to 13.9' SAND, clayey, silty, firm.

13.9' to 20.2' GRAVEL, clayey, sandy, tan.

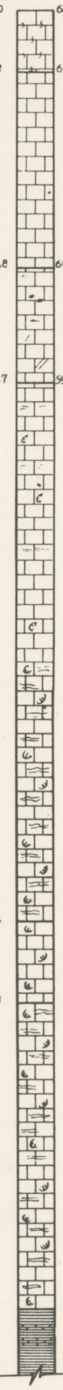
20.2' to 21.6' CLAY, sandy, silty, stiff.

WALNUT FORMATION

21.6' to 25.8' SHALE, soft, badly weathered, light yellowish-gray.

25.8' to 27.5' SHELL AGGLOMERATE, hard, partly weathered, in matrix of medium hard, calcareous, light yellowish-gray shale.
27.5' to 28.5' SHALE, probably same as above (container sample).
28.5' to 30.0' LIMESTONE, hard, very argillaceous, partly fossiliferous, light gray, with a very hard, very fossiliferous, slightly argillaceous light gray limestone seam from 28.5' to 28.7' and with a very calcareous gray shale phase from 29.4' to 29.7'.
30.0' to 34.7' SHALE, hard, calcareous, fossiliferous, light gray, with minor transitional phases of medium hard, slightly calcareous, slightly fossiliferous gray shale.
34.7' to 37.3' SHALE, medium hard, slightly calcareous, gray.
37.3' to 38.3' LIMESTONE, hard, argillaceous, partly fossiliferous, light gray, transitional to a shaly phase at the base.

38.3' to 42.0' SHALE, medium hard, slightly calcareous, becoming fossiliferous in the lower part, gray, with minor hard, very calcareous phases, and with a very hard, very fossiliferous light gray limestone band from 39.6' to 39.8'.
42.0' to 49.0' SHALE, medium hard, slightly calcareous, gray, with minor very calcareous shale phases, and with a hard, fossiliferous, argillaceous, light gray limestone band from 44.6' to 44.8'.
49.0' to 51.8' SHALE, medium hard, slightly calcareous, fossiliferous, gray, with occasional transitional phases of hard, very calcareous, slightly fossiliferous, light gray shale.
51.8' to 56.1' LIMESTONE, hard, very argillaceous, fossiliferous, light gray, with minor transitional phases of medium hard, very calcareous, very fossiliferous, gray shale.
56.1' to 65.0' LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight very thin partings of gray calcareous shale.



2C-128

0.0' to 4.2' TOPSOIL, soft, weathered limestone.
(Taken from driller's log)

EDWARDS FORMATION

4.2' to 17.8' LIMESTONE, hard, sugary appearance, massive, tan, with occasional small solution cavities partly to tightly filled with argillaceous lime.

17.8' to 25.7' LIMESTONE, hard, argillaceous gray, with numerous concretionary masses of light gray limestone, with occasional irregular thin tight partings of dark gray calcareous shale, with small flakes and nodules of chalk throughout, and with a large calcite-lined vug at 20.2'.

COMANCHE PEAK FORMATION

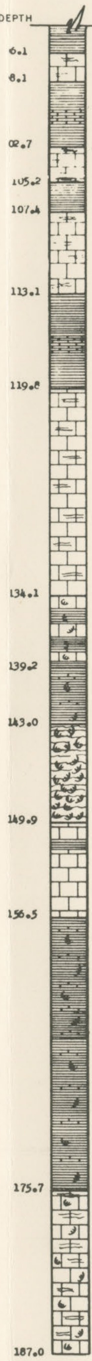
25.7' to 63.1' LIMESTONE, hard, argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale, and with occasional very small masses of pyrite and pyritized fossils.

63.1' to 68.8' LIMESTONE, hard, argillaceous, gray, with occasional concretionary masses of light gray limestone, and with occasional small masses of pyrite and pyritized fossils.

68.8' to 90.0' LIMESTONE, hard, argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having occasional slickensided surfaces in the upper part, with occasional fossils and with occasional small masses of pyrite and pyritized fossils.

WALNUT FORMATION

90.0' to 96.1' SHALE, gray, calcareous, medium hard, with limestone bands from 91.1' to 91.3' and 92.0' to 92.4'.



2C-128 Continued

96.1' to 98.1' LIMESTONE, gray, argillaceous, medium hard, thin gray shale seams.
98.1' to 102.7' SHALE, dark gray, compact, calcareous, medium hard, with band of gray limestone from 100.4' to 101.1'.

102.7' to 105.2' LIMESTONE, gray, argillaceous, medium hard, thin shale seams.

105.2' to 107.4' SHALE, very calcareous, hard, gray.
107.4' to 113.1' LIMESTONE, gray, argillaceous, medium hard, thin calcareous shale seams.

113.1' to 119.8' SHALE, very calcareous, hard, gray, limestone phase from 116.1' to 117.6'.

119.8' to 134.1' LIMESTONE, gray, argillaceous, medium hard, thin dark gray shale seams.

134.1' to 139.2' Alternating bands of gray argillaceous limestone and dark gray calcareous shale, medium hard, fossiliferous.

139.2' to 143.0' SHALE, dark gray, soft to medium hard, calcareous, fossiliferous, limestone seams.

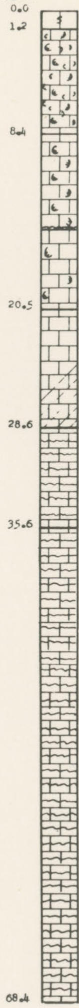
143.0' to 149.9' SHELL AGGLOMERATE in dark gray calcareous shale matrix, soft to medium hard.

149.9' to 156.5' LIMESTONE, gray, medium hard, argillaceous with soft shale bands from 151.2' to 151.7'.

156.5' to 175.7' SHALE, dark gray, very calcareous, fossiliferous, numerous bands of gray argillaceous limestone.

175.7' to 187.0' LIMESTONE, very argillaceous, medium hard, fossiliferous, numerous dark gray shale seams.

TOTAL DEPTH 187.0'



2C-129

0.0' to 1.2' TOPSOIL - weathered limestone.
(Taken from Driller's log)

EDWARDS FORMATION

1.2' to 8.4' LIMESTONE, hard, crystalline, very fossiliferous (almost shell coquina), massive, white.

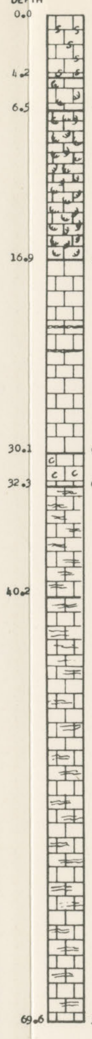
8.4' to 20.5' LIMESTONE, hard, sugary appearance, massive, tan, with occasional fossiliferous crystalline phases, and with numerous large solution cavities partly to tightly filled with yellow marl from 14.2' to 20.5', and with a large very hard gray chert nodule from 14.7' to 15.0'.

20.5' to 28.6' LIMESTONE, hard, slightly argillaceous, massive, variably tan to yellow-brown, with occasional small masses of calcite, with occasional small solution cavities tightly filled with porous marl, with numerous large concretionary masses of medium hard brown calcareous clay containing flakes and nodules of chalk from 26.9' to 27.6'.
28.6' to 35.6' LIMESTONE, hard, argillaceous, somewhat chalky, gray, with occasional irregular tight thin partings of dark gray calcareous shale with numerous concretionary masses of light gray limestone, and with very small flakes and nodules of chalk throughout.

COMANCHE PEAK FORMATION

35.6' to 68.4' LIMESTONE, hard, argillaceous, somewhat chalky, light gray, with numerous, irregular tight thin partings of dark gray calcareous shale.

TOTAL DEPTH 68.4'



2C-130

0.0' to 4.2' Topsoil-soft weathered limestone. (Taken from driller's log)

EDWARDS FORMATION

4.2' to 6.5' LIMESTONE, hard, fossiliferous crystalline, variably tan to brown, with numerous solution cavities partly to tightly filled with argillaceous lime, and with occasional small masses of calcite.

6.5' to 16.9' SHELL COQUINA, hard, crystalline massive, variably white to tan.

16.9' to 30.1' LIMESTONE, hard, slightly argillaceous, sugary appearance, massive, tan, with very hard, gray chert seams at 21.4' to 21.5' and 23.1' to 23.3'.

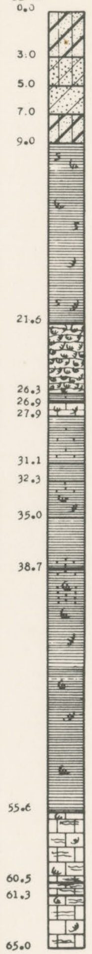
30.1' to 32.3' LIMESTONE, hard, argillaceous massive, grayish-tan, with numerous flakes and nodules of chalk.

32.3' to 40.2' LIMESTONE, hard, argillaceous, gray, with occasional irregular tight thin partings of dark gray calcareous shale, with occasional small concretionary masses of light gray limestone, and with very small flakes and nodules of chalk throughout.

COMANCHE PEAK FORMATION

40.2' to 69.6' LIMESTONE, hard, argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale, and with a small calcite lined vug at 40.9'.

TOTAL DEPTH 69.6'



6D 2C-131

0.0' to 3.0' CLAY, silty, sandy, gravelly. Brown to gray.

3.0' to 5.0' SAND, clayey, silty, brown. Plastic.

5.0' to 7.0' SAND, clayey, brown.

7.0' to 9.0' CLAY, silty, sandy, light gray.

WALNUT FORMATION

9.0' to 21.6' SHALE, soft, very badly weathered, calcareous, partly fossiliferous, yellow.

21.6' to 26.3' SHELL AGGLOMERATE, medium hard, slightly and variably weathered from 21.6' to 25.0', in a matrix of medium hard, calcareous, gray shale, and with a very hard, fossiliferous, light gray limestone band from 21.6' to 21.7'.
26.3' to 26.9' SHALE, medium hard, calcareous, gray, with a hard, very argillaceous, gray limestone phase from 26.4' to 26.7'.
26.9' to 27.9' LIMESTONE, very hard, very fossiliferous, light gray.
27.9' to 31.1' SHALE, variably medium hard to hard, calcareous, gray, with occasional hard, very argillaceous, variably gray and light gray limestone phases.
31.1' to 32.3' SHALE, medium hard, calcareous, gray.
32.3' to 35.0' SHALE, hard, very calcareous, partly fossiliferous (bordering on shell agglomerate from 33.3' to 33.9'), gray, with hard argillaceous, light gray limestone bands from 32.3' to 32.5' and 32.6' to 32.7', and with numerous concretionary nodules of hard, argillaceous, light gray limestone in the extreme lower part.
35.0' to 38.7' SHALE, medium hard, calcareous, gray, with numerous concretionary nodules of hard, argillaceous, light gray limestone in the lower part.
38.7' to 55.6' SHALE, variably medium hard and soft, slightly calcareous, gray, with very hard, very fossiliferous, light gray limestone bands from 38.7' to 38.9' and 40.8' to 41.1', and with occasional 0.1' thick, hard, very calcareous, gray limestone bands.

55.6' to 60.5' LIMESTONE, hard, slightly argillaceous, partly fossiliferous, light gray, with numerous irregular, tight, very thin partings of hard, calcareous, gray shale.

60.5' to 61.3' LIMESTONE, hard, very argillaceous, light gray, with occasional thin transitional phases of hard, very calcareous, gray shale, and with numerous irregular, tight, very thin, partings of hard, calcareous, gray shale.
61.3' to 65.0' LIMESTONE, hard, slightly argillaceous (becoming argillaceous in the lower part), partly fossiliferous, light gray, with numerous irregular tight, thin partings of hard, calcareous, gray shale.

BOTTOM OF HOLE.

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

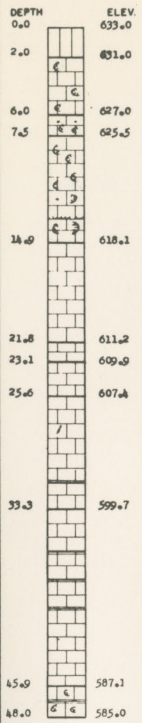
CORE BORINGS

GRAPHIC LOGS
DEFINITE PROJECT SITE

GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 16



2C-92

0.0' to 2.0'SILTY (Taken from driller's log)

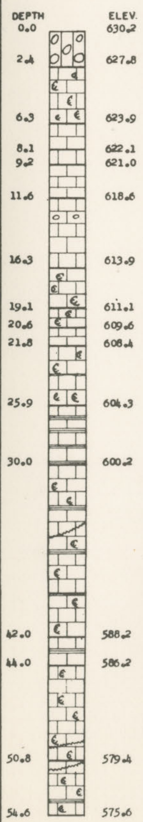
EDWARDS FORMATION

2.0' to 6.0'LIMESTONE, hard, sugary appearance, massive, partly fossiliferous, mottled white and light yellowish-tan, with occasional small solution cavities partly filled with marl.
6.0' to 7.5'LIMESTONE, hard, sugary, appearance, massive, very fossiliferous, mottled white and light yellowish-tan, with numerous "pinhole" cavities, and with a very hard, partly fossiliferous, crystalline, white limestone band from 6.5' to 6.6'.
7.5' to 14.9'LIMESTONE, hard, sugary appearance, massive, light yellowish-tan, with occasional minor, partly fossiliferous phases in the upper part, and with irregular horizontal, iron-stained, fractures at 12.6' and 13.5'.
14.9' to 21.8'LIMESTONE, hard, sugary appearance, massive, light yellowish-tan, with numerous large solution cavities partly to tightly filled with porous yellow marl.
21.8' to 23.1'LIMESTONE, hard, sugary appearance, massive, light yellowish tan.
23.1' to 25.6'LIMESTONE, hard, slightly argillaceous (becoming very argillaceous and light brown in the extreme lower part), massive, tan, with numerous flakes of chalk.
25.6' to 33.3'LIMESTONE, hard, argillaceous, gray with occasional pockets of hard, light gray limestone having numerous flakes of chalk, with numerous small concretionary nodules of hard, light gray limestone and with occasional irregular, tight, thin, partings of gray, calcareous shale.

COMANCHE PEAK FORMATION

33.3' to 45.9'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular, tight thin partings of hard, calcareous, gray shale, and with a medium hard, argillaceous, chalky white limestone band from 43.5' to 43.7'.

45.9' to 48.0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous, irregular, thick and thin, tight partings of hard, very calcareous, gray shale, with numerous fossils, and with numerous masses of pyrite and pyritized fossils.



2C-93

0.0' to 2.4'SILTY - BOULDERS (Taken from driller's log).

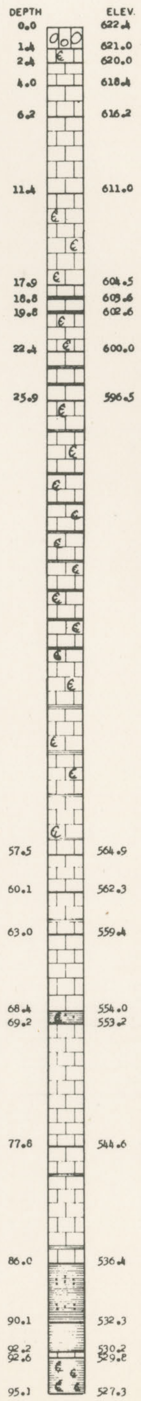
EDWARDS FORMATION

2.4' to 6.3'LIMESTONE, hard, massive, partly fossiliferous, variably white and light yellowish-tan, with occasional small masses of calcite.
6.3' to 8.1'LIMESTONE, hard, sugary, appearance, massive, variably light yellow to tan.
8.1' to 9.2'LIMESTONE, very hard, slightly crystalline, massive, variably white and tan, with very numerous, very small flakes of chalk throughout.
9.2' to 11.6'LIMESTONE, hard, sugary appearance, massive, yellowish-tan, with a large solution cavity from 9.4' to 9.6'.
11.6' to 16.3'LIMESTONE, hard, sugary appearance, massive, yellowish-tan, with occasional solution cavities partly to tightly filled with marl, with a very hard, brittle, light gray chert band from 12.2' to 12.3', and with a fractured zone having iron-stained surfaces for 12.6' to 13.9'.
16.3' to 19.1'LIMESTONE, hard, sugary appearance, massive, light yellowish-tan, with flakes of chalk and occasional fossils.
19.1' to 20.6'LIMESTONE, hard, fossiliferous, massive, light tan, with numerous very small flakes of chalk.
20.6' to 21.8'LIMESTONE, hard, slightly argillaceous, sugary appearance, massive, light yellowish-tan, with numerous flakes of chalk.
21.8' to 25.9'LIMESTONE, hard, argillaceous, gray, with occasional concretionary nodules of hard, slightly argillaceous, light gray limestone, with occasional fossils, and with occasional, irregular, tight thin partings of hard, dark gray, calcareous shale.
25.9' to 30.0'LIMESTONE, medium hard (almost hard), very argillaceous, gray, with medium hard to soft, calcareous, gray shale bands from 26.7' to 26.8', 27.0' to 27.2', 27.5' to 27.6', 28.0' to 28.8', and 29.4' to 30.0'.

COMANCHE PEAK FORMATION

30.0' to 42.0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous, irregular, tight, thin partings of hard, calcareous, gray shale, with occasional fossils, and with a fractured zone from 34.3' to 34.9'.

42.0' to 44.0'LIMESTONE, hard, argillaceous light gray, with numerous, irregular tight, thick and thin partings of hard, calcareous, gray shale, and with occasional fossils.
44.0' to 50.8'LIMESTONE, hard, slightly argillaceous, light gray, with numerous, irregular, tight, thin partings of hard calcareous, gray clay, and with occasional fossils, and with fractured zones from 49.6' to 50.0' and 50.3' to 50.6'.
50.8' to 54.6'LIMESTONE, hard, argillaceous, light gray, with numerous, irregular, tight thick and thin partings of hard, calcareous, gray shale, with occasional fossils, with occasional small concretionary nodules of hard, slightly argillaceous, light gray limestone, and with a fractured zone from 50.8' to 51.4'.



2C-94

0.0' to 1.4'SILT and boulders.
(Taken from driller's log)

EDWARDS FORMATION

1.4' to 2.4'LIMESTONE, hard, massive, partly fossiliferous, white.
2.4' to 4.0'LIMESTONE, hard, massive, somewhat sugary appearance, light yellow, with occasional solution cavities partly to tightly filled with marl.
4.0' to 6.2'LIMESTONE, hard, massive, white, with numerous, very small flakes of chalk.
6.2' to 11.4'LIMESTONE, hard, massive, sugary appearance, variably light yellow and tan, with numerous solution cavities partly to tightly filled with marl.
11.4' to 17.9'LIMESTONE, hard, slightly argillaceous, fossiliferous, variably light yellow and tan, with numerous flakes of chalk.
17.9' to 18.8'LIMESTONE, hard, argillaceous, gray, with very numerous flakes of chalk, and with tight, thick, irregular partings of hard, calcareous, gray shale.
18.8' to 19.8'LIMESTONE, hard, very argillaceous, gray, with numerous, large concretionary nodules of hard, argillaceous, gray limestone having numerous flakes of chalk, and with occasional, irregular tight, thin partings of hard, calcareous, dark gray shale.
19.8' to 22.4'LIMESTONE, hard, argillaceous, gray, with occasional fossils, with occasional small concretionary nodules of hard, argillaceous, light gray limestone, with occasional flakes of chalk, and with occasional irregular tight, thin partings of hard, calcareous, dark gray shale.

COMANCHE PEAK FORMATION

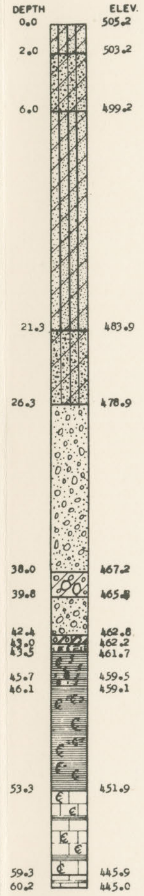
25.9' to 57.5'LIMESTONE, hard, slightly argillaceous (with transitional argillaceous phases from 37.4' to 40.4' and 47.5' to 49.5'), partly fossiliferous, light gray, with numerous, irregular, tight thin partings of hard, calcareous, gray shale, with occasional small masses of pyrite, and with numerous pockets of hard, argillaceous gray limestone having numerous small pseudomarphs of calcite after pyrite from 50.6' to 50.8'.

57.5' to 60.1'LIMESTONE, hard, argillaceous, gray, with numerous, small, concretionary nodules of hard, slightly argillaceous, light gray limestone.
60.1' to 63.0'LIMESTONE, hard, slightly argillaceous, light gray, with numerous, irregular, tight, thin partings of hard, calcareous, gray shale.
63.0' to 68.4'LIMESTONE, hard, argillaceous, light gray, with occasional, irregular, tight, thin partings of hard, calcareous, gray shale, and with occasional small concretionary nodules of hard, slightly argillaceous, light gray limestone.
68.4' to 69.2'SHALE, medium hard, calcareous, gray, with large concretionary nodules of very hard, slightly argillaceous, fossiliferous light gray limestone.
69.2' to 77.8'LIMESTONE, hard, slightly argillaceous, white, with numerous, irregular, tight, very thin partings of medium hard, calcareous, dark gray shale having slickensided surfaces, and with occasional small masses of pyrite.
77.8' to 86.0'LIMESTONE, hard, slightly argillaceous, light gray (almost white), with numerous, irregular, tight, thin partings of medium hard, calcareous, gray shale.

WALNUT FORMATION

86.0' to 90.1'SHALE, hard, very calcareous, gray, with occasional thin transitional phases of hard, very argillaceous, light gray limestone.
90.1' to 92.2'SHALE, medium hard, calcareous, gray.
92.2' to 92.6'LIMESTONE, hard, argillaceous, very fossiliferous, light gray, with occasional, irregular, tight thin partings of medium hard, calcareous, gray shale.
92.6' to 95.1'SHALE, medium hard, calcareous, gray, with occasional fossils, and with a very hard, slightly argillaceous, very fossiliferous light gray limestone band from 93.3' to 93.5'.

BOTTOM OF HOLE



6D8A6C-104

0.0' to 2.0'SILT, clayey, sandy, brown, stiff.
2.0' to 6.0'SAND, silty, clayey, brown.

6.0' to 21.3'SILT, clayey, sandy, brown, plastic to stiff.

21.3' to 26.3'SAND, clayey, silty, brown-gray, firm.

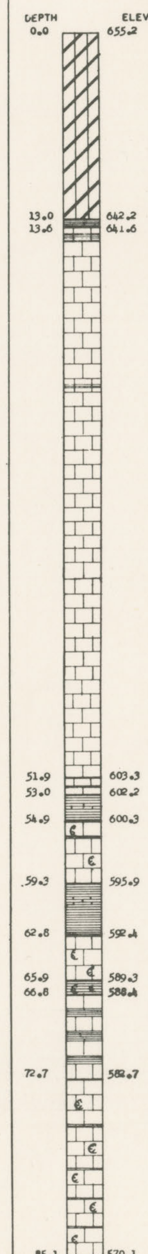
26.3' to 38.0'SAND and GRAVEL, fine grained. (Fishtailed).

38.0' to 29.8'GRAVEL, BOULDERS and BROWN CLAY, no clay recovered (description taken from driller's log).
39.8' to 42.4'SAND and GRAVEL, fine grained.
42.4' to 43.0'CLAY, soft, weathered, brown, with gravel.

WALNUT FORMATION

43.0' to 43.5'SHELL AGGLOMERATE, iron-stained, weathered, in a matrix of partly softened, weathered, yellowish-gray shale.
43.5' to 45.7'SHALE, medium hard, calcareous, weathered, partly fossiliferous, gray.
45.7' to 46.1'SHALE, medium hard, calcareous, slightly weathered, partly fossiliferous, gray, with numerous concretionary nodules of hard, light gray limestone.
46.1' to 53.3'SHALE, medium hard, slightly calcareous, gray, with occasional fossils, and with a shell agglomerate band from 52.7' to 53.0'.
53.3' to 59.3'LIMESTONE, hard, fossiliferous, argillaceous, light gray, with numerous, irregular, tight, thin partings and occasional bands of medium hard, fossiliferous, calcareous gray shale.
59.3' to 60.2'LIMESTONE, hard, slightly argillaceous, light gray, with occasional irregular, tight, thin partings of medium hard, calcareous, gray shale.

BOTTOM OF HOLE



2C-116

0.0' to 13.0'Silty clay and clay.

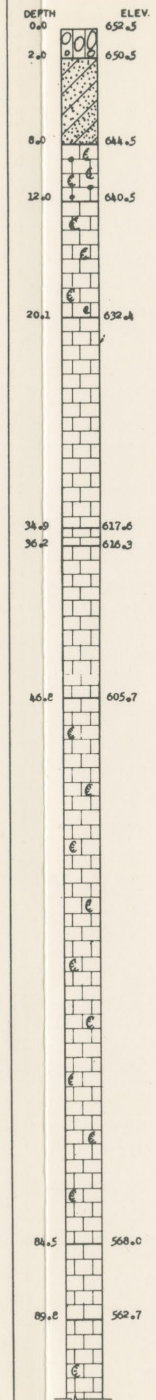
13.0' to 13.6'SHALE, gray, soft, weathered.
(Taken from driller's log)

COMANCHE PEAK FORMATION

13.6' to 51.9'LIMESTONE, medium hard (almost hard), argillaceous, light gray, with fossils throughout, with numerous irregular, tight, thick to thin partings of gray calcareous shale, having slickensided surfaces, with a few small masses of pyrite, and with medium hard, light gray to gray, calcareous shale seams from 13.6' to 14.6' and 24.5' to 24.7'.

WALNUT FORMATION

51.9' to 53.0'LIMESTONE, gray, medium to hard, argillaceous, thin dark gray shale seams.
53.0' to 54.9'SHALE, gray, hard, calcareous, with occasional small concretionary nodules of hard argillaceous light gray limestone.
54.9' to 59.3'LIMESTONE, gray, medium hard, argillaceous, fossiliferous, with numerous seams and partings of gray medium hard calcareous shale.
59.3' to 62.8'SHALE, gray, hard, calcareous, with occasional small concretionary nodules of hard argillaceous limestone.
62.8' to 65.9'LIMESTONE, gray, medium hard, argillaceous, occasional fossils, numerous thin seams and partings of calcareous fossiliferous gray shale.
65.9' to 66.8'SHALE, gray, medium hard, very calcareous, very fossiliferous, with occasional small concretionary nodules of hard, argillaceous, fossiliferous, light gray limestone.
66.8' to 72.7'Alternating thin bands and seams of gray calcareous shale and gray, hard, argillaceous limestone.
72.7' to 85.1'LIMESTONE, light gray, medium to hard, argillaceous, with numerous medium hard, very argillaceous, somewhat shaly phases with numerous fossils, with numerous irregular tight thick to thin seams and partings of very calcareous gray shale.



2C-120

0.0' to 2.0'SILT and boulders.
2.0' to 8.0'SAND and clay.
(Taken from driller's log)

EDWARDS FORMATION

8.0' to 12.0'LIMESTONE, very hard, crystalline, massive, vuggy, brown, with numerous fossils.

12.0' to 20.1'LIMESTONE, shell coquina, hard, slightly crystalline, massive, white, with occasional small solution cavities tightly filled with yellow marl.

20.1' to 34.9'LIMESTONE, hard, sugary appearance, massive, tan, with numerous large solution cavities partly to tightly filled with yellow marl.

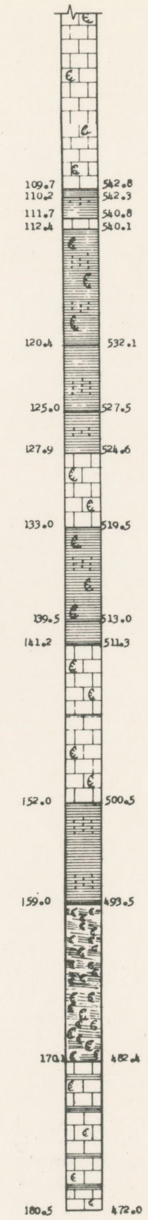
34.9' to 36.2'LIMESTONE, medium hard, argillaceous, massive, gray brown.
36.2' to 46.8'LIMESTONE, medium hard, argillaceous, massive, gray, with numerous flakes of chalk and concretionary masses of light gray limestone in the extreme upper part and with occasional flakes of chalk throughout.

COMANCHE PEAK FORMATION

46.8' to 84.5'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of gray calcareous shale, with occasional fossils, and with occasional small masses of pyrite and pyritized fossils.

84.5' to 89.8'LIMESTONE, medium hard, argillaceous, massive, gray, with occasional small concretionary masses of light gray limestone.

89.8' to 109.7'LIMESTONE, hard, slightly argillaceous, light gray, with numerous irregular tight thin partings of dark gray calcareous shale having slickensided surfaces, with occasional fossils, and with occasional small masses of pyrite.



2C-120 Continued

109.7' to 110.2'SHALE, gray, hard, very calcareous.
110.2' to 111.7'SHALE, gray, medium hard, calcareous, with thin seams of gray argillaceous limestone.
111.7' to 112.4'LIMESTONE, gray, medium hard, argillaceous.
112.4' to 120.4'SHALE, dark gray, medium hard, very calcareous, occasional fossils, with thin argillaceous limestone seam - 117.3' to 119.9'. Band of gray argillaceous limestone.
120.4' to 125.0'SHALE, dark gray, calcareous, medium hard, with very thin seams and partings of gray medium hard argillaceous limestone. Band of gray argillaceous nodular limestone from 122.9' to 124.5'.
125.0' to 127.9'SHALE, gray, hard, very calcareous, with numerous seams and partings of gray hard argillaceous limestone.
127.9' to 133.0'LIMESTONE, gray, medium hard argillaceous, occasional fossils.

133.0' to 139.5'SHALE, gray, medium hard, calcareous, occasional fossils, gray limestone band from 136.6' to 137.7'.

139.5' to 141.2'SHALE, dark gray, medium to hard, very calcareous.
141.2' to 152.0'LIMESTONE, gray, medium hard, argillaceous, occasional fossils, numerous seams and partings of gray medium hard calcareous shale.

152.0' to 159.0'SHALE, gray, medium to hard, calcareous, thin seams of argillaceous limestone.

159.0' to 170.1'SHELL AGGLOMERATE in matrix of dark gray calcareous shale, medium hard.

170.1' to 180.5'LIMESTONE, gray, medium hard, very argillaceous, numerous thin seams and bands of gray fossiliferous, calcareous shale.

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

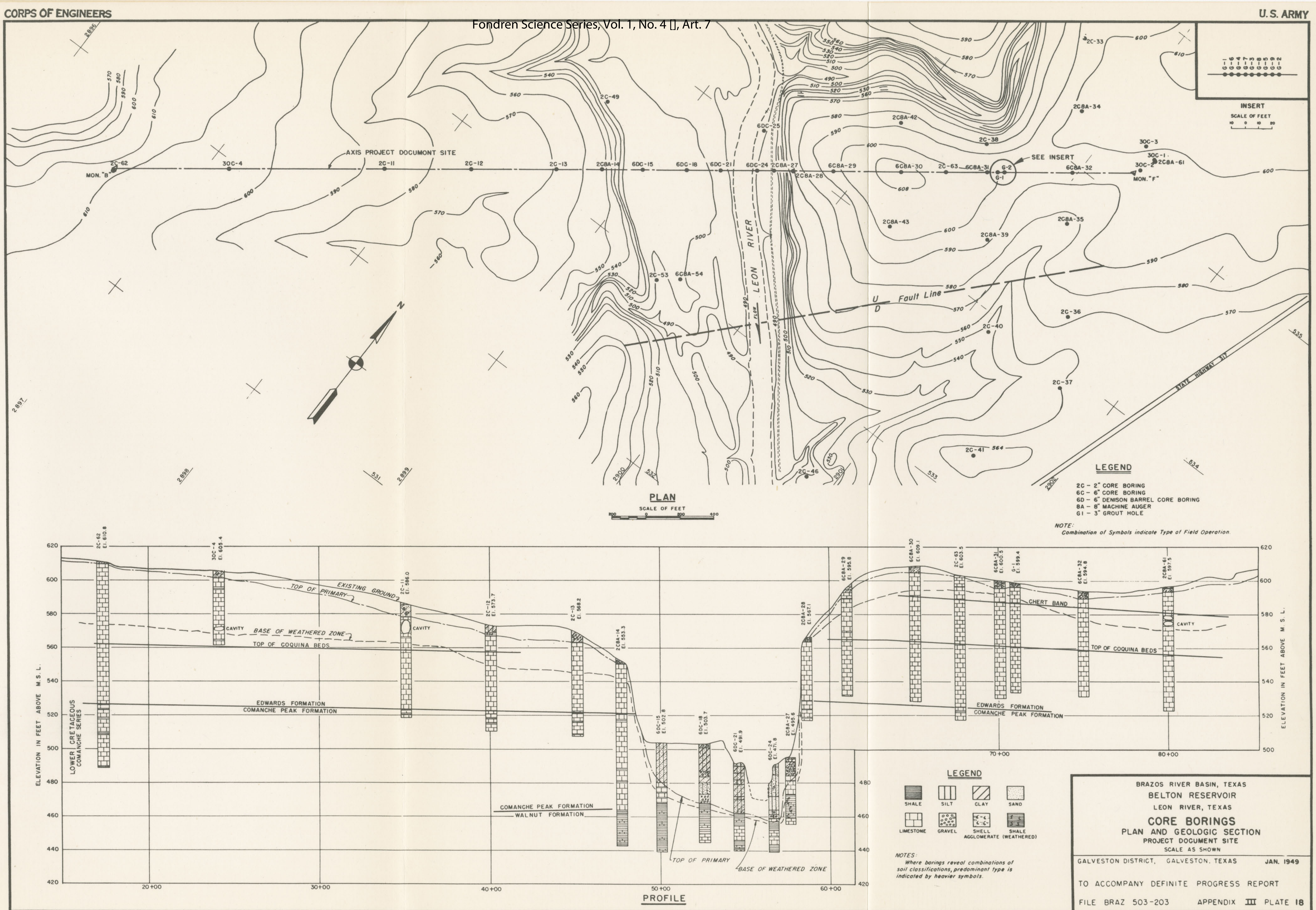
CORE BORINGS

GRAPHIC LOGS
DEFINITE PROJECT SITE
SCALE AS SHOWN

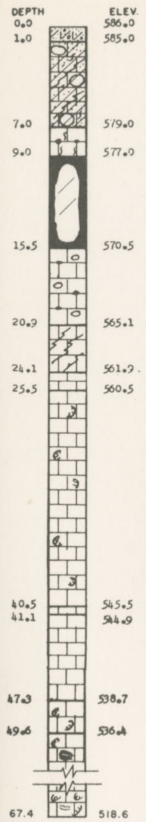
GALVESTON DISTRICT, GALVESTON, TEXAS DEC. 1948

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 17


CORPS OF ENGINEERS
U.S. ARMY
AXIS PROJECT DOCUMONT SITE
MON. "B"
MON. "F"
SEE INSERT
INSERT
SCALE OF FEET
LEON RIVER
Fault Line
STATE HIGHWAY 317
PLAN
SCALE OF FEET
LEGEND
2C - 2" CORE BORING
6C - 6" CORE BORING
6D - 6" DENISON BARREL CORE BORING
8A - 8" MACHINE AUGER
G1 - 3" GROUT HOLE
NOTE: Combination of Symbols indicate Type of Field Operation.
EXISTING GROUND
TOP OF PRIMARY
BASE OF WEATHERED ZONE
TOP OF COQUINA BEDS
CAVITY
CHERT BAND
EDWARDS FORMATION
COMANCHE PEAK FORMATION
WALNUT FORMATION
LOWER CRETACEOUS COMANCHE SERIES
ELEVATION IN FEET ABOVE M.S.L.
ELEVATION IN FEET ABOVE M. S. L.
PROFILE
LEGEND
SHALE
SILT
CLAY
SAND
LIMESTONE
GRAVEL
SHELL AGGLOMERATE
SHALE (WEATHERED)
NOTES: Where borings reveal combinations of soil classifications, predominant type is indicated by heavier symbols.
BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS
CORE BORINGS
PLAN AND GEOLOGIC SECTION
PROJECT DOCUMENT SITE
SCALE AS SHOWN
GALVESTON DISTRICT, GALVESTON, TEXAS
JAN. 1949
TO ACCOMPANY DEFINITE PROGRESS REPORT
FILE BRAZ 503-203
APPENDIX III PLATE 18

2C-11



0.0' to 1.0'Topsoil, black.
1.0' to 7.0'LIMESTONE boulders and marl, soft, weathered, broken. (From driller's report).

EDWARDS FORMATION

7.0' to 9.0'LIMESTONE, hard, massive, dense, crystalline, tan to brown, probably with occasional small gray chert concretions and numerous small vugs. Note: core loss of 1.8', weathered.
9.0' to 15.5'CAVITY. Water loss at 11.0'. (Taken from driller's logs). Probably clay filled.

15.5' to 20.9'LIMESTONE, hard, massive, dense, crystalline, tan to brown, probably with occasional small gray chert concretions and numerous small vugs.
20.9' to 24.1'LIMESTONE, moderately hard, tan, with numerous solution cavities partly to tightly filled with porous yellow calcareous material, weathered.
24.1' to 25.5'LIMESTONE, hard, crystalline, massive, dense, brown, with numerous small solution cavities tightly filled with porous calcareous material in the upper part.
25.5' to 40.5'LIMESTONE, shell coquina, massive white to tan, moderately hard, with occasional calcite crystals.
40.5' to 41.1'LIMESTONE, hard, slightly crystalline, massive, tan.
41.1' to 47.3'LIMESTONE, hard, massive, sugary appearance, tan to brown.
47.3' to 49.6'LIMESTONE, hard, massive, tan, fossiliferous, with small flakes and nodules of chalk.
49.6' to 55.8'LIMESTONE, hard, very fossiliferous, gray, with occasional paper-thin seams of dark gray shale and pockets of dark gray shale containing flakes and nodules of chalk.
55.8' to 59.8'LIMESTONE, hard, fossiliferous, gray with numerous irregular thin seams of dark gray shale and with occasional concretionary masses of light gray lime.

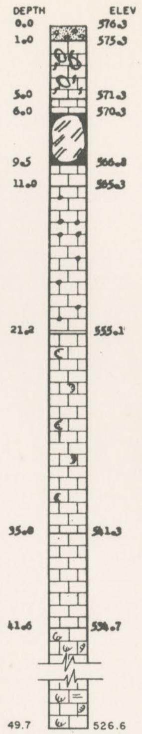
59.8' to 62.7'LIMESTONE, hard, massive, gray, with flakes and nodules of chalk throughout.

COMANCHE PEAK FORMATION

62.7' to 67.4'LIMESTONE, nodular, hard, light gray, mottled with numerous concretionary masses of gray limestone, and with numerous irregular paper-thin seams of dark gray shale.

TOTAL DEPTH 67.4'

2C8A-35 P1-19



0.0' to 1.0' Topsoil and gravel.
1.0' to 5.0'LIMESTONE boulders, weathered. (From driller's logs).

EDWARDS FORMATION

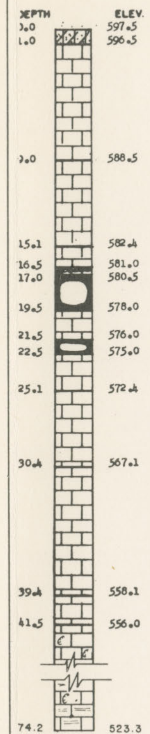
5.0' to 6.0'LIMESTONE, very hard, crystalline, brown, vuggy.
6.0' to 9.5'CAVITY. Water loss, probably clay filled.
9.5' to 11.0'LIMESTONE, soft, white, probably with a gray chert band. There is a 1.4' core loss in this run.
11.0' to 21.2'LIMESTONE, moderately hard, to soft and friable, tan to brown, siliceous, massive, with numerous small vugs and open shell casts and molds, and with very hard crystalline brown, vuggy limestone bands from 12.5' to 13.4' and 20.3' to 20.7'.

21.2' to 35.0'LIMESTONE, shell coquina, massive, tan, moderately hard, occasionally pitted with solution cavities partly filled with calcareous material.

35.0' to 41.6'LIMESTONE, hard, massive, tan to yellow, sugary appearance, with occasional solution cavities partly filled with calcareous material.
41.6' to 46.5'LIMESTONE, hard, massive, white to tan, slightly fossiliferous, with numerous small nodules and flakes of chalk in the upper part.
46.5' to 49.7'LIMESTONE, hard, massive, fossiliferous, light gray, with a few paper-thin seams of dark gray shale and pockets of dark gray shale containing small fragments of chalk in the upper part.

TOTAL DEPTH 49.7'

2C8A-61



0.0' to 1.0' TOPSOIL.
1.0' to 9.0'LIMESTONE, weathered. (From driller's report)

EDWARDS FORMATION

9.0' to 12.7'LIMESTONE, very hard, crystalline, vuggy, brown.
12.7' to 15.1'LIMESTONE, hard, somewhat platy, dense, white, with a very hard, crystalline brown limestone seam from 14.9' to 15.1'.
15.1' to 16.5'LIMESTONE, hard, slightly vuggy and fossiliferous, massive, tan.
16.5' to 17.0'CHERT, very hard, brittle, fractured, gray.
17.0' to 19.5'CAVITY.
19.5' to 21.5'LIMESTONE, hard, slightly crystalline, vuggy, brown.
21.5' to 22.5'CAVITY.
22.5' to 25.1'LIMESTONE, hard, white, with numerous solution cavities partly to tightly filled with calcareous material.
25.1' to 30.4'LIMESTONE, hard, slightly crystalline, brown, vuggy.

30.4' to 39.4'LIMESTONE, hard, massive, slightly fossiliferous, tan, with occasional small solution cavities tightly filled with calcareous material.

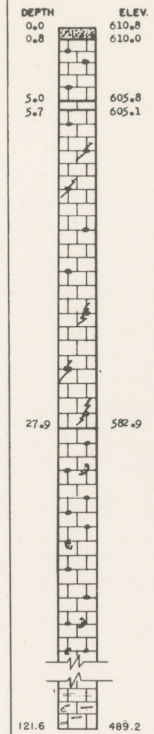
39.4' to 41.5'LIMESTONE, very hard, massive, crystalline, brown, with a few small calcite-lined vugs, slightly fossiliferous.

41.5' to 52.1'LIMESTONE, shell coquina, massive, white to tan.

52.1' to 74.2'LIMESTONE, hard to moderately hard, massive, sugary appearance, tan to brown, with occasional solution cavities partly filled with calcareous material.

TOTAL DEPTH 74.2'

2C-62



0.0' to 0.8'TOPSOIL, black.
0.8' to 5.0'LIMESTONE, weathered, broken. (From driller's report)

EDWARDS FORMATION

5.0' to 5.7'LIMESTONE, very hard, crystalline, vuggy, brown.
5.7' to 27.9'LIMESTONE, hard, massive, white, to tan, with occasional small very hard, crystalline, vuggy brown limestone breaks.

27.9' to 49.0'LIMESTONE, moderately hard to soft and friable, siliceous, tan to brown, with marly phases and with numerous small vugs and open shell casts and molds.

49.0' to 49.9'LIMESTONE, hard, massive, tan with numerous solution "cavities" tightly filled with porous yellow calcareous material.
49.9' to 61.9'LIMESTONE, shell coquina, hard, massive, white to tan, with occasional solution "cavities" tightly filled with porous yellow calcareous material in the upper part.
61.9' to 71.1'LIMESTONE, hard, massive, sugary appearance, tan to brown.

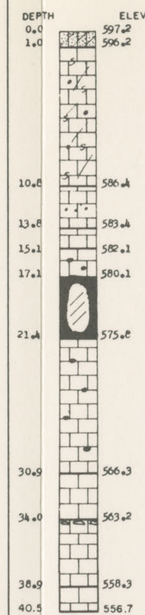
71.1' to 72.2'LIMESTONE, hard, massive, fossiliferous, tan, with numerous small flakes and nodules of chalk.
72.2' to 76.2'LIMESTONE, hard, light gray, very fossiliferous, with numerous thin seams of dark gray shale and pockets of dark gray shale containing flakes and nodules of chalk, and with a large calcite-filled vug from 74.7' to 74.8'.
76.2' to 79.5'LIMESTONE, shell coquina, light grayish-tan, hard, massive.
79.5' to 85.0'LIMESTONE, hard, slightly argillaceous, gray, with occasional thin seams of dark gray shale and concretionary mass of light gray limestone.

COMANCHE PEAK FORMATION

85.0' to 121.6'LIMESTONE, hard, light gray with numerous thin irregular seams of dark gray shale.

TOTAL DEPTH 121.6'

30C-1



0.0' to 1.0'TOPSOIL, silty clayey sand.
1.0' to 10.8'LIMESTONE, weathered, with clay or marl filled seams and fractures.

EDWARDS FORMATION

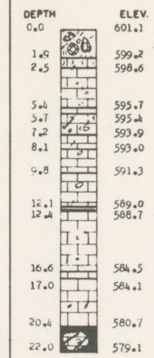
10.8' to 13.8'LIMESTONE, hard, massive, dense, tan, with a thin marly seam from 12.0' to 12.2'.
13.8' to 15.1'LIMESTONE, hard, dense, tan, with numerous solution channels.
15.1' to 17.1'LIMESTONE, very hard, massive, slightly crystalline, tan to brown, with occasional small vugs.
17.1' to 21.4'CAVITY, partially filled with clay and grout.

21.4' to 30.9'LIMESTONE, very hard, crystalline, brown, with numerous vugs lined with iron-stained calcite.

30.9' to 34.0'LIMESTONE, hard, tan with numerous large solution cavities tightly filled with porous yellow calcareous material.
34.0' to 38.9'LIMESTONE, hard, tan, slightly crystalline, with very large iron-stained, calcite-lined cavities from 34.0' to 35.0' and with numerous small to large cavities from 35.0' to 38.9'. Grout present in the cavities from 35.0' to 36.4'.
38.9' to 40.5'LIMESTONE, moderately hard to soft and friable, siliceous, marly, tan.

TOTAL DEPTH 40.5'

30C-3



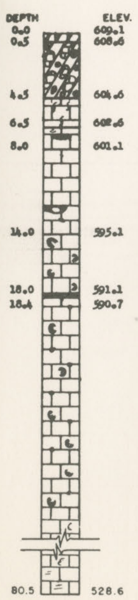
0.0' to 1.9' Topsoil, black, with limestone boulders.
1.9' to 2.5'LIMESTONE, hard, slightly crystalline, massive, tan, with thin seams of soft brown weathered marly limestone.
2.5' to 5.4'LIMESTONE, soft and friable, argillaceous, massive, light yellowish-tan.
5.4' to 5.7'LIMESTONE, hard, slightly crystalline, massive, tan.

EDWARDS FORMATION

5.7' to 7.2'LIMESTONE, hard, massive, slightly crystalline, tan, numerous large fractures.
7.2' to 8.1'LIMESTONE, very hard, crystalline, vuggy, brown, with large extensive solution channels partly clay filled.
8.1' to 9.8'LIMESTONE, moderately hard to soft and friable, somewhat platy, slightly argillaceous, marly white to tan.
9.8' to 12.1'LIMESTONE, very hard, vuggy, crystalline, brown, with large extensive solution channels partly filled with clay and soft iron-stained weathered calcareous material.
12.1' to 12.4'SHALE, white, soft, iron-stained.
12.4' to 16.6'LIMESTONE, hard, massive, dense, white to tan, with numerous fractures and with occasional marly seams.
16.6' to 17.0'LIMESTONE, very hard, coarsely crystalline, vuggy, brown.
17.0' to 20.4'LIMESTONE, hard, massive, dense, slightly crystalline, tan to brown, with numerous large extensive fractures.
20.4' to 22.0'CAVITY, clay filled.

TOTAL DEPTH 22.0'

6C8A-30



0.0' to 0.5'CLAY, silty.
0.5' to 4.5'Limestone boulders in clay matrix, weathered.

EDWARDS FORMATION

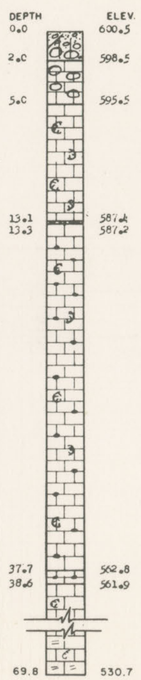
4.5' to 6.5'LIMESTONE, hard, light tan to white, dense, weathered.
6.5' to 8.0'LIMESTONE, thin, alternating layers with soft yellow and white shale or marl, limestone moderately hard. Cavity 7.0' to 7.5' solution channels.
8.0' to 14.0'LIMESTONE, tan-white, soft, crumbly, argillaceous, soft and hard banding. Calcite crystals. Core loss 4.6'. Cavity 12.0' to 12.5'.

BASE OF MAJOR WEATHERING

14.0' to 18.0'LIMESTONE, hard, dense, white to tan, fossiliferous, thin iron stained seams.
18.0' to 18.4'CHERT, very hard, brittle, fractured.
18.4' to 41.4'LIMESTONE, soft, friable, marly, seams, siliceous appearance, vuggy, tan to greenish-yellow color. Numerous fossil casts and moulds. Core has pitted surface. Band of hard solution stained honey-combed limestone 34.2' to 34.5'. Total water less 34.2'. Much core loss.
41.4' to 44.5'LIMESTONE, hard, tan to brown, granular to crystalline, slightly honeycombed and pitted, some of pits and honeycombed zones refilled with soft tan granular calcareous material.
44.5' to 56.1'LIMESTONE, shell coquina, massive moderately hard, tan to dirty white color. Impregnated with calcite crystals and masses. Ferruginous stained.
56.1' to 80.5'LIMESTONE, yellow-tan, moderately hard, dense, massive, granular to sugary appearance. Vuggy and pitted in irregular pattern. Thin soft yellow marly seams, flakes and nodules of white chalky material below 65.1'.

TOTAL DEPTH 80.5'

6C8A-31



0.0' to 2.0' Topsoil and boulders.
2.0' to 5.0' Boulders and soft weathered limestone.

EDWARDS FORMATION

5.0' to 13.1'LIMESTONE, hard, dense, white to tan, with thin iron-stained seams, fossiliferous.

13.1' to 13.3'CHERT, very hard, brittle, gray, fractured, nodular.
13.3' to 37.7'LIMESTONE, variably medium hard and soft with occasional friable, marly phases, with numerous vugs, fossil casts and molds.

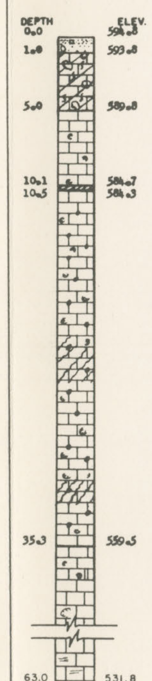
37.7' to 38.6'LIMESTONE, hard, brown, honeycombed with vugs filled with tan to orange calcareous material.
38.6' to 49.4'LIMESTONE, shell coquina, massive, moderately hard. variably tan to white, with occasional calcite crystals and iron stains.

49.4' to 65.7'LIMESTONE, massive, dense, sugary appearance, tan, hard.

65.7' to 69.8'LIMESTONE, hard, light gray with numerous paper-thin seams of dark gray shale and occasional pockets of dark gray shale containing flakes and nodules of chalk.

TOTAL DEPTH 69.8'

6C8A-32



0.0' to 1.0' Topsoil.
1.0' to 5.0'LIMESTONE boulders, weathered, in clay matrix.
(From driller's report)

EDWARDS FORMATION

5.0' to 10.1'LIMESTONE, hard, massive, tan to white, slightly fossiliferous.

10.1' to 10.5'CHERT, very hard, brittle, gray, nodular.
10.5' to 35.3'LIMESTONE, moderately hard to soft and friable, tan to brown, siliceous appearance, with numerous vugs and fossil casts and molds. Bands of very hard, brown, crystalline vuggy limestone from 21.3' to 21.6' and 25.0' to 25.2'. Fractures with iron stained surfaces from 22.0' to 24.3' and 30.6' to 32.3'.

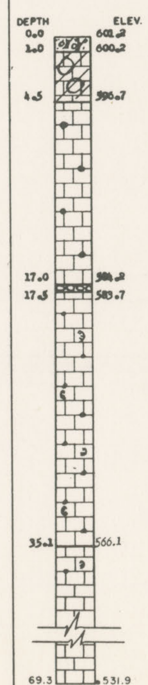
35.3' to 49.1'LIMESTONE, shell coquina, white to tan, massive, moderately hard.

49.1' to 58.1'LIMESTONE, moderately hard, massive, sugary appearance, slightly pitted surface. Bands of very hard tan slightly crystalline limestone from 53.9' to 54.0' and 54.7' to 55.0'.

58.1' to 61.6'LIMESTONE, moderately hard, massive, tan, gray, with abundant small flakes and nodules of white chalk, occasional fossils.
61.6' to 63.0'LIMESTONE, hard, variably tan to light gray, massive, fossiliferous, paper-thin seams and partings of dark gray shale, irregular pockets of dark gray shale containing small nodules of chalky material.

TOTAL DEPTH 63.0'

2C8A-34



0.0' to 1.0' Topsoil.
1.0' to 4.5'LIMESTONE boulders in clay matrix.
(From driller's report)

EDWARDS FORMATION

4.5' to 17.0'LIMESTONE, moderately hard, tan, dense, probably with occasional bands of very hard brown vuggy crystalline limestone. A core loss of 11.1' has been placed in this material. 1/3 of the water returns were lost between 12.0' and 15.0'.

17.0' to 17.5'CHERT, very hard, brittle, gray.
17.5' to 35.1'LIMESTONE, variably moderately hard to soft and friable, siliceous, brown, massive, with numerous small vugs and fossil casts and molds.

35.1' to 44.2'LIMESTONE, shell coquina, tan to white, moderately hard, massive, with occasional small calcite-lined vugs.

44.2' to 56.6'LIMESTONE, hard, massive, fossiliferous, sugary appearance, tan to yellow color. Gray, brown, very hard, brittle chert seam from 52.0' to 52.4'.

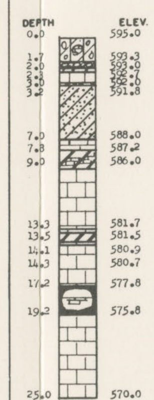
56.6' to 61.1'LIMESTONE, hard, massive, fossiliferous, tan to yellow color, with small flakes and nodules of chalk.

61.1' to 65.6'LIMESTONE, hard, massive, fossiliferous, light gray, with occasional paper-thin seams of dark gray shale and with pockets of dark gray shale containing small nodules of chalk.

65.6' to 69.3'LIMESTONE, hard, massive, gray, with occasional concretionary masses of hard light gray limestone.

TOTAL DEPTH 69.3'

30C-2



0.0' to 1.7' Clayey silt and limestone boulders. Topsoil and residual materials.
1.7' to 2.0'LIMESTONE, hard, brown, crystalline, fractured and weathered.
2.0' to 2.3'CHERT, dark gray, nodular, fractured, very hard.
2.3' to 3.0'LIMESTONE, brown, crystalline, fractured, hard.
3.0' to 3.2'MARL, soft, solution stained, honeycombed, tan.
3.2' to 7.0'MARL, soft, buff, caliche like and mealy appearanced.
7.0' to 7.8'LIMESTONE, medium hard, honeycombed, solution stained, porous.
7.8' to 9.0'CLAY and thin layers of honeycombed limestone, solution stained, porous to cavernous.

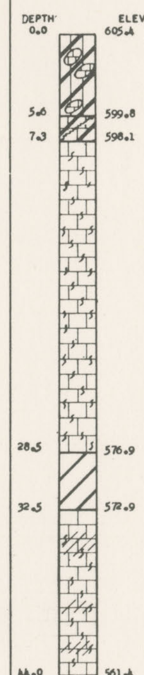
Start 30" coring

EDWARDS FORMATION

9.0' to 11.0'LIMESTONE, very hard, dense, crystalline, light brown, with numerous solution cavities from 10.4' to 11.0'.
11.0' to 13.3'LIMESTONE, massive, hard, tan, with solution channels in the lower part.
13.3' to 13.5'LIMESTONE, very hard, brittle, fractured, crystalline, brown, with numerous vugs lined with iron-stained calcite.
13.5' to 14.1'CLAY, soft, white.
14.1' to 14.3'LIMESTONE, very hard, brittle, finely crystalline, brown.
14.3' to 17.2'LIMESTONE, hard, massive, slightly crystalline, tan to brown, fossiliferous, with numerous vugs lined with iron-stained calcite.
17.2' to 19.2'CAVITY and large solution channels in coarsely crystalline, very hard, brown limestone.
19.2' to 25.0'LIMESTONE, very hard, crystalline, tan to brown, massive, with marly seams, and with occasional small solution cavities.

TOTAL DEPTH 25.0'

30C-4



0.0' to 5.6'CLAY, silty with limestone boulders.

5.6' to 7.3'CLAY and broken limestone.

7.3' to 28.5'LIMESTONE, badly weathered, soft chalky, with clay filled seams.

28.5' to 32.5' Opening partly filled with clay. Opening developed along a fracture.

32.5' Started 6" core.
32.5' to 44.0'LIMESTONE, soft, weathered, tan to light gray with clay filled seams.

TOTAL DEPTH 44.0'

BRAZOS RIVER BASIN, TEXAS
BELTON RESERVOIR
LEON RIVER, TEXAS

CORE BORINGS

GRAPHIC LOGS
PROJECT DOCUMENT SITE

GALVESTON DISTRICT, GALVESTON, TEXAS APRIL 1949

TO ACCOMPANY DEFINITE PROJECT REPORT

FILE: BRAZ. 503-203 APPENDIX III PLATE 19

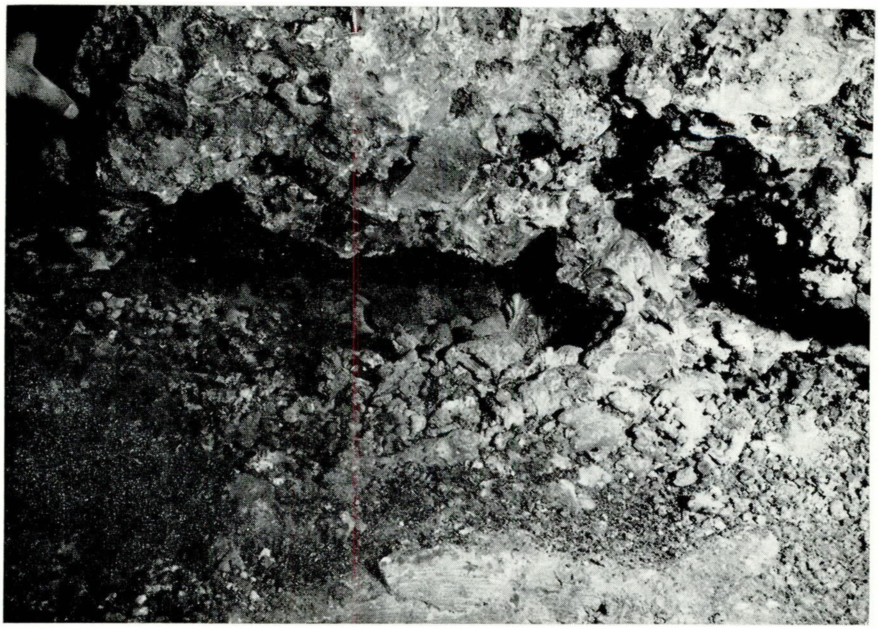


Fig. 1. Exposed cavern in wall of core boring 30C-1 at elevation 577.0 in left abutment.

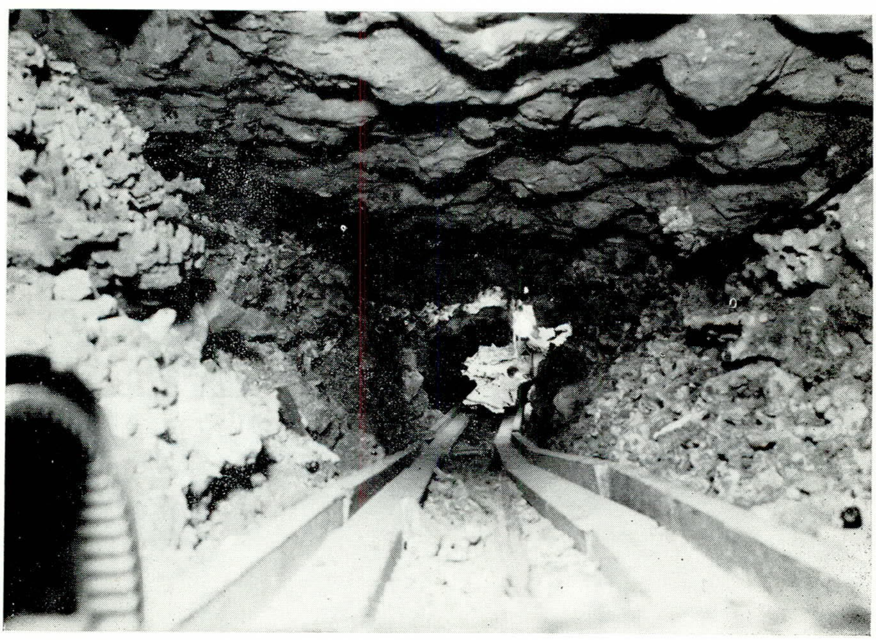


Fig. 2. Mucked-out cavern (total length about 100 feet) extending southwesterly from boring 30C-1.

BELTON RESERVOIR

Fig. 1. End of mucked-out cavern beyond which two solution channels extend approximately 50 feet.

Fig. 2. Partly mucked-out solution channel at end of mucked-out cavern.

BELTON RESERVOIR