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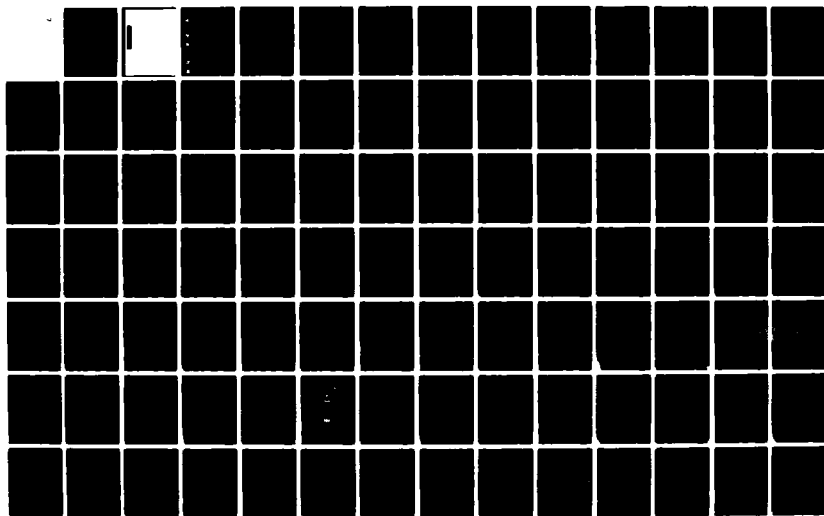
MULTIPLE-PURPOSE PROJECT KANSAS RIVER BASIN REPUBLICAN
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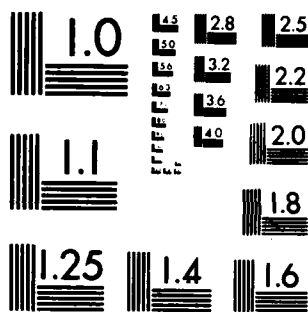
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OPERATION AND MAINTENANCE MANUAL
MILFORD DAM AND LAKE
REPUBLICAN RIVER, KANSAS
KANSAS RIVER BASIN

APPENDIX IV
CONSTRUCTION FOUNDATION REPORT

1977
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Kansas City, Missouri



OPERATION AND MAINTENANCE MANUAL
MILFORD DAM AND LAKE
REPUBLICAN RIVER, KANSAS
KANSAS RIVER BASIN

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APPENDIX IV
CONSTRUCTION FOUNDATION REPORT

CHAPTER 1

INTRODUCTION

1-01. Location and Description. Milford Dam is located 4 miles northwest of Junction City, Kansas. It is situated on the Republican River 8.3 miles above it's confluence with the Smoky Hill River which becomes the Kansas River eastward of this point. The area is served by major U.S. Highways 70 and 77 and the Union Pacific Railroad. The project consists of an earth and rock embankment stretching 6,300 feet north-south across the valley, a concrete outlet works, and a chute type uncontrolled spillway. The height of the embankment is 147 feet above the streambed. The maximum width of the embankment is 1,050 feet. Located along the right abutment is a reinforced concrete outlet works consisting of an intake control tower, a cut and cover conduit, and a stilling basin. This structure is designed to handle discharge flows up to a maximum of 26,900 cubic feet per second. Discharge flows are controlled by two hydraulically operated gates in the control tower. The spillway is located about 3,000 feet south of the embankment utilizing two large topographic draws. It is an uncontrolled, emergency, chute type spillway with a concrete sill 1,250 feet long. Full pool reservoir level is at elevation 1176.2 m.s.l. with storage capacity of 757,746 acre feet. The reservoir level at conservation pool is at elevation 1144.4 m.s.l. making a reservoir of 16,189 acres.

1-02. Construction Authority. This project was authorized by Public Law 83-780 in 1954 by the 83rd Congress of the United States. It is part of the Missouri River basin flood control plan. The project was advertised for competitive bids in the spring of 1962. Western Contracting Corporation of Sioux City, Iowa was awarded the contract for a low bid of \$13,965,840.00, and construction operations began in the fall of that year.

1-03. Purpose and Scope. The purpose of this report is to describe the construction operations, provide a record of the foundation conditions and to discuss problems encountered during construction. The report will also deal with the geological aspects of the project construction with emphasis on bedrock foundation conditions, materials utilization, and other items which have geologic relationship. The Resident Engineer was Mr. Richard Griffith and the project geologist was Mr. Steve D. Markwell.

CHAPTER 2

GEOLOGY AND PHYSIOGRAPHY

2-01. General. Milford Dam is located in the Osage Plains section of the Central Lowlands physiographic province in the middle of the Permian escarpment belt.

a. The topography of the area is in a stage of maturity to old age with broad U-shaped valleys separated by flat-topped highlands. These highlands have been appropriately named the "Flint Hills" due to the cherty limestones from which they have been carved. Rocks of Permian age crop out in the vicinity of Milford Dam. All bedrock materials encountered during construction are classified as belonging to the Chase group of the Wolfcampian series. This series has been referred to in older publications as the "Big Blue Series." It represents the oldest Permian sedimentary sequence in the state of Kansas. The Chase group, the upper bedrock division of the Wolfcampian series, consists of alternating argillaceous limestones and shales. A thickness of approximately 200 feet of bedrock strata were encountered during construction. The bedrock formations of this sequence are the Doyle shale, the Barneston limestone, the Matfield shale and the Wreford limestone. For the generalized geologic column see figure 2. A geologic map of the construction area is shown on figure 3.

b. Overburden materials in the area may be divided into three types: (1) residual soil mantle; (2) loess deposits; and (3) floodplain alluvium. Residual soils are thin, generally less than one foot thick. They are predominately organic clays and are black in color. These soils were stripped and placed in waste areas. The loess is found blanketing the higher elevations, generally above elevation 1200 m.s.l. The maximum thickness encountered is 30 feet in the vicinity of the spillway sill. It is generally classified as a lean clay, although isolated areas of silts and fat clays are also found. Loess deposits were utilized as impervious fill in the blanket and in the embankment. It is a heavy clay and is not particularly easy to work. It was generally placed in the blanket areas where moisture control was not required. Maximum thickness of the alluvium is 57 feet. The alluvial sands are generally fine grained in the upper 20 feet with coarser materials predominating below that depth at an approximate elevation of 1065 m.s.l. The more coarse materials are generally medium grained with some coarse grained sands. Gravel deposits are spotty and particles larger than 3/8-inch are absent. Clay layers in the alluvium appear to be continuous over long distances and range from 1 to 5 feet in thickness. In many instances, the clay layers are mixed with a layer of cobbles and boulders. Clays and silts are found in the terraces along the margins of the valleys. Much of this material is reworked loess transported from the higher elevations. These terrace areas produced the major portion of the impervious borrow materials utilized in the central core of the embankment.

c. Sand of the upper alluvium excavated from the downstream borrow area produced the major portion of the pervious material. A considerable portion of the random material was also obtained from this area.

2-02. Bedrock Structure. The project is located between two major structural features; the Nemaha arch to the east and the Salina basin to the west. A minor structural feature, the Abilene anticline, cuts through the upper end of the reservoir area. These features trend generally north-south; however, they are deeply buried and have little influence on the surface rocks. Regional dip is five to ten feet per mile to the northwest. Local minor undulations of a few feet commonly occur in the bedrock strata. With essentially flat lying bedrock excavation operations were relatively simple. Local geologic structure had little effect on the construction operations.

2-03. Bedrock Stratigraphy. Rock strata outcropping at the damsite, from youngest to the oldest, are described in the following paragraphs. Laboratory test data is shown in Table - 8.

a. Doyle Shale Formation. The Doyle Shale Formation represents the youngest bedrock strata in the vicinity of the dam. In the construction area, only the two lower members of this formation are present, Towanda limestone member and Holmesville shale member.

(1) Towanda Limestone Member. The Towanda limestone member is approximately 15 feet thick in the vicinity; however, it exists primarily in a cap rock condition and the thickness varies greatly. The upper 4 feet is generally a soft, friable limestone, light gray in color, clayey and thin bedded giving it a platy appearance. The full thickness of this zone is present only in areas of thick overburden. This zone is unconformable with the harder limestone zone below and in some areas it forms the greater portion of the member. Towanda limestone is easily ripped for use as a construction material. Underlying this soft upper zone is an interval of hard, gray limestone with an average thickness of 8 feet. This interval varies considerably in thickness. It is generally massive to thick bedded and contains numerous fractures. The material has an average density of 145 pounds per cubic foot and an absorption ranging from 3 to 4 percent. This zone, although discontinuous, produced the best limestone material excavated during construction with regard to hardness and durability. The lower zone of the Towanda limestone is a 3-foot thick interval of hard, medium-bedded limestone. A solution horizon is present in this interval varying from 0 to 2.7 feet thick. This horizon contains heavily weathered limestone and a soft, silty, clay.

(2) Holmesville Shale Member. The Holmesville member in this area consists of 18 feet of soft, varicolored clay shale. The upper 4 feet is yellowish brown and contains a network of hard calcareous material. The middle consists of a greenish shale with a distinct red horizon. Horizontal cleavage planes are well developed in this interval as well as vertical and high angle joints. The lower portion of this member is predominantly dark gray and soft. Two distinct limestone beds, 0.8 feet thick in this zone, form a continuous resistant horizon throughout the area. It is well exposed along the side slopes and floor of the spillway. Holmesville shale was used as shale and limestone fill.

b. Barneston Limestone Formation. The Barneston formation is about 80 feet thick. It is made up of argillaceous limestone with a few thin calcareous shale beds. The formation is divided into three members: The Fort Riley limestone, Oketo shale, and the Florence limestone. It is well exposed along the walls of the Republican river valley.

(1) Fort Riley Limestone Member is divided into five zones:

(a) Zone "A" is a moderately hard, argillaceous, limestone, tan to brown in color and medium bedded. The ledge upon exposure and weathering breaks down into a platy structure and resembles a shale. The general thickness is 15 feet. This zone is solutioned which exhibits enlarged bedding planes, stained joints, and cavities. A few thin shale seams are present in this zone and are characteristically green, laminated, and soft. In many instances these shale seams have weathered to soft clay, particularly in the lower portion of the zone. This zone is capable of transporting groundwater and considerable attention was given to it during grouting. The downstream key of the spillway sill cuts off this entire zone. The zone is above groundwater level and about 24 feet above conservation pool level.

(b) Zone "B" of the Fort Riley is the upper of two resistant beds forming one of the three "rimrock" ledges which outcrop in the area. It is generally 5 feet thick and is "pock marked" by numerous vugs. Generally, it is characterized by two thick beds separated by an open bedding plane. This horizon is capable of carrying seepage but is situated above the water table and supports no permanent springs.

(c) Zone "C" is 10 feet thick and its dark gray color makes it an excellent marker bed for correlation. It is very argillaceous, bordering on being a shale. Occasional vugs similar to the zone above are present, many of these exhibiting secondary calcite mineralization.

(d) Zone "D" is 9.5 feet thick, moderately hard, tan, pitted limestone. It is massive to thick massive to thick bedded with distinct bedding plane located 5.5 feet above the base. The density of this zone averages 140 pounds per cubic foot with an absorption ranging from 8 to 12 percent. Upon exposure, the lower 5.5 feet case hardens and the color changes to white. This results in a hard white limestone at the outcrop, gradually grading back to the original softer limestone as the cover increases. This bed is locally called the "white ledge" or "rimrock" ledge and has been quarried for cut stone building material in the state of Kansas for the last 100 years. The ledge was quarried at this project for use as riprap. The bedding plane at the base of zone "D" is also a seepage zone and has been enlarged by solutioning. It is the major spring zone of the area producing numerous small springs in the larger draws in the vicinity of the left abutment.

(e) Zone "E" marks the base of the Fort Riley member and consists of a shaly limestone with a thickness of 2 feet. It is hard and tan and contains numerous fossil fragments. Toward the outcrop the material is thin bedded and platy.

(2) Oketa Shale Member. Oketa is a dark gray, calcareous shale about 6 feet thick and is an excellent marker bed.

(3) Florence Limestone Member. The Florence limestone consists of 34 feet of argillaceous, cherty, limestone with thin calcareous shale layers in the upper part. It is tan in color with dark blue to occasionally purple chert nodules. Like the Fort Riley, the Florence has been subdivided into zones.

(a) Zone "A" is a medium bedded limestone with several calcareous shale beds. An abundance of chert is present as irregular masses in continuous horizons. The shale layers are practically unrecognizable in the unweathered state. However, like the "E" zone of the Fort Riley member, the layers become distinct when exposed to weathering.

(b) Zone "B" of this member is a massive 5-foot thick ledge which is free of chert. It is somewhat similar to the "D" zone of the Fort Riley in that it is pitted and exhibits some degree of case hardening when exposed. This ledge forms the lower rimrock of the area and like the other rimrock ledges, has an associated bedding plane at its base that is considered a seepage horizon.

(c) Zone "C" is a 10-foot zone of argillaceous limestone containing the highest percent of chert in the area. It is tan and thick to massive bedded; however, it spalls rapidly when exposed.

(d) Zone "D" is a 4-foot transitional zone between the cherty Florence limestone and the underlying shale. It consists of a soft, very argillaceous, dark gray limestone which breaks down readily upon exposure.

c. Matfield Shale Formation. Consists of two thick shale members; the Blue Springs and the Wymore, separated by the Kinney limestone member. The total thickness of 60 feet was exposed in the outlet works excavation.

(1) Blue Springs Shale Member. The Blue Springs shale is the upper member of the Matfield shale formation. The upper portion consists of alternating red and green shales. The shale is clayey and soft with the exception of a hard limestone bed, 1-foot thick, located approximately 4 feet above the base. This zone marks the upper extent of gypsum mineralization present in the form of elongated nodules and irregular masses, red in color, associated with the jointing. The lower Blue Springs consists of 12 feet of dark gray, calcareous shale moderately soft with thin, discontinuous satin spar gypsum usually associated with the numerous horizontal cleavage planes that are well developed toward the base.

(2) Kinney Limestone Member. The Kinney limestone is a hard, gray, and generally massive ledge 6.5 feet thick. Isolated gypsum masses up to 4 inches in diameter are scattered at random in this ledge. This limestone was observed in the stilling basin section of the outlet works excavation.

(3) Wymore Shale Member. The upper part (Zone A) consists of a hard calcareous weather resistant shale containing horizontal cleavage planes. The lower part (zone B) is a soft clay shale predominately green in color with a red layer and a thin purple layer. The lower portion becomes increasingly more calcareous and harder toward the base. A gypsum seam was observed, in the form of satin spar, in the lower portion. This seam is undulated slightly and showed minute displacement in one area; however, there was no indication of displacement of the adjacent materials. This seam was tight and no evidence of solutioning was observed. At the contact with the upper part, the shale had been softened by ground water and several small springs emitted from this horizon in the downstream and riverward slopes of the stilling basin excavation.

d. Wreford Limestone Formation. The upper limestone member, the Schroyer, was encountered in the lower portion of the stilling basin excavation. The two lower members of this formation; the Havensville shale and the Three Mile limestone are below required excavation. The Schroyer limestone is approximately 10 feet thick. The upper 3 feet consists of a single massive limestone ledge; hard and light gray to white in color. The remainder of the Schroyer consists of a moderately hard, dark gray, argillaceous limestone with two dark gray chert horizons in irregular masses similar to those found in the Florence limestone. Numerous gypsum nodules up to 4 inches in diameter are scattered throughout. The content of gypsum in the Schroyer is very high, far exceeding any other interval encountered. There is no particular pattern to these masses. However, a high concentration of gypsum was associated with and incorporated within the chert. With the exception of a thin, cherty, gray limestone (0.8 feet thick) the lower Schroyer becomes more argillaceous toward the base with an overall decrease in hardness. Thin satin spar gypsum seams were noted in the lower part beneath the thin limestone.

CHAPTER 3

FOUNDATION CONDITIONS AND TREATMENT

3-01. Grouting General.

a. Preliminary investigations prior to construction indicated some seepage through the abutment bedrock might be expected. During the drilling of initial borings, high or total losses of drilling fluid occurred. For a layout of the entire drilling program see figure 18 and plates No's. 13 and 14. Through a study of the bedrock cores and pressure test data, it was possible to establish the potential seepage pattern. Six core borings were pressure tested, (see table 9 Pressure Test Data.) Of these borings, 2 were drilled on the right abutment, 2 on the left abutment, and 2 in the spillway area. Examination of the drill core and comparison of pressure test data indicated a foundation leakage potential in the Fort Riley limestone more severe than those usually encountered in the Kansas City District. Seepage through open joints was found to be negligible, with the exception of areas immediately adjacent to outcrop faces or just below the top of bedrock. The major seepage was found in openings along bedding planes. Three of the four major seepage zones were directly associated with the prominent rimrock ledges previously described; the B and D zones of the Fort Riley and the B zone of the Florence. These zones are in essence enlarged bedding planes. The solution zone of the "A", upper zone of the Fort Riley, is not associated with an outcrop ledge. With a pattern established, a reasonable prediction could be made as to seepage potential of the various areas, greatly simplifying the remainder of the testing program. A test grouting program was performed by Government personnel prior to construction in 1962. A full report on the test grouting is given in Supplement A, (located in the back part of this manual). A summary of Test Grouting is shown in Table - 10. The test sections extended from station 82+20 to station 88+64 on the right abutment and from station 143+00 to station 151+00 on the left abutment. These sections were completed as a single line curtain penetrating to a depth of 125 feet to a general elevation of 1085 m.s.l. The grout curtain extended from the Towanda limestone member downward to just into the Blue Springs shale member. The grout holes were 3 inches in diameter and were drilled vertically to the desired depth. Pressure testing and the stop grouting were accomplished by setting packers in the lowest portion of the hole and resetting the packer at intervals progressively upward. Pressures were generally 1.5 - 2.0 pounds per foot of vertical depth including the column pressure. The water cement ratio of the grout mixes varied from 0.6:1 to 4:1. Primary holes were drilled on 80 foot centers. As drilling operations progressed, the spacing was reduced to 40 feet. The grout takes were not excessively high. The predicted horizontal zones showed openings to some degree.

b. Secondary holes split-spaced the primaries, reducing the hole spacing along the curtain to 20 feet. Grout placement in the secondaries, in general, showed a marked reduction. A tertiary hole series was then drilled reducing the grout hole spacing to 10 feet. The grout curtain test sections were essentially completed at this 10-foot center to center spacing although some quaternary holes were drilled along the line.

c. Angle holes. As an additional check, angle holes were drilled along the line. These were either tight or experienced negligible grout takes. To check the feasibility of the stage grouting method some holes were grouted in this manner, and it was found to be successful. For location of these sections see figure 19.

3-02. Right Abutment Grout Curtain. Initial contract grouting operations were started in February 1963. The excavation of the right abutment cutoff had been virtually completed with the foundation excavation for the conduit approximately 3 feet above grade and grouting was performed from top of bedrock. The right abutment curtain extended along the dam centerline from station 90+80, a point 80 feet riverward of the conduit centerline, across the foundation and up the cutoff slope to the top of the abutment at station 88+25, overlapping the test section. All grouting was completed by the stage method, i.e., the hole was drilled at an angle of 30 degrees (from vertical) to either a specified depth or to a zone of open conditions. The hole was then pressure tested and grouted. The hole was then deepened and the process repeated. The curtain was divided into two zones in the slope portion of the line. All drilling was accomplished with a CP 65 portable drill either mounted on a platform wagon or attached to a grouted nipple. (See photos 42 thru 44). The right abutment curtain was divided into three sections for the grouting operations. This was done on the basis of access to the work areas. For location of the grout curtain and its sections see figures 19 and 20. The grout plant was standard grouting layout equipped with a 20 cubic feet mixing vat, water meter and slush pump with a rated capacity of 50 g.p.m. at 150 pounds of pressure per square inch (see photo 47). All couplings and fittings were 1.5 inch ID. The grout tree of the header was equipped with bypass, bleeder valve and pressure gage. Gages used in most cases were 30 pound maximum gages. Pressure testing was accomplished through the header with a water meter inserted between the hole and the header in the line (see photos 42 thru 44). The grout curtain sections were completed satisfactorily and a relatively tight curtain was achieved. A summary of contract grouting is shown on Table - 11.

a. Section I.

(1) Primary holes. Section 1 included that portion of the curtain beneath the conduit foundation from its riverward extent to the toe of the cutoff slope. The primary holes were drilled on 10 foot centers and all holes were drilled to the bottom of the curtain with no indication of open conditions. These holes penetrated the lower Blue Springs shale, the Kinney limestone and the upper Wymore shale. Drilling was done with an E size bit (1-1/2-inch diameter). If anticipation of a tight zone is possible the zone of section I appeared to be that. The first open joint had been found in the foundation of the approach slab some 400 feet upstream and there was no indication that this condition was more than a very localized condition. As a check on these initial holes, a washing operation of air and water was used (see photos 42 thru 44). The wash water return from some of the holes was a dark gray color similar to the lower Blue Springs shale. This was attributed to soft shale cuttings within the holes; however, it was these holes in

particular which had significant grout "takes." Later information obtained on clay filled openings in this shale during foundation preparations lead to the assumption that washing had cleaned out the clay filling of the joints and allowed higher grout takes.

(2) Pressure test. Grouted nipples 2.0 feet in length were set and the process of grouting and pressure testing started moving riverward along this section. Initial pressures on the first holes were maintained at 1.0 psi per lineal foot of hole including the column pressure. However, as operations progressed riverward on successive holes and the grout takes increased the pressure was reduced. Free communication of grout along the line was experienced first as dark gray water and then grout appeared. For the grout takes and conditions encountered in section I, see figure 21. With consideration of possible hydraulic jacking, the unknown depth and conditions of the openings encountered, it was decided to drill the secondary series in three stages. The first stage was to a depth of 9 feet. The second stage from depths of 9 to 15 feet, and the third stage to the bottom of the grout curtain.

(3) The secondary series split the primary spacing reducing the center to center spacing along the grout line to 5 feet. Pressures were maintained at 3 psi. For the first stage, the desired low pressure was attained by gravity flow from the grout plant. The bedrock was tight. The second stage was then drilled and the grouting was accomplished with 5 psi of pressure. Again open hole conditions were encountered with communication between some holes. As a final check tertiary holes were drilled to the entire depth of the line. The bedrock was tight and the section was completed. When foundation cleanup operations reached this area, it was observed that many of the open joints contained grout as far as 50 feet upstream and downstream from the grout line. However, these were thin joints and no evidence of the relatively large grout takes was apparent. The excavation for the outlet works structure was dry and conditions are apparently tight (see photos 45 and 46). A six-inch diameter core hole was drilled through the grout line at station 90+44 and no grout was encountered, indicating that no horizontal jacking had occurred.

b. Section II

(1) Primary holes. Section II, the slope section of the grout curtain extended almost the entire length of the 1V on 1H back slope of the right abutment cutoff. Access to this section was difficult. This problem was solved by building a wooden stairway the entire length of the cut. A power winch was anchored at the top of the cut and a rubber tired platform was pulled up the slope by means of a cable. The drill was mounted to this platform and drilling operations were completed using this setup. The upper zone of section II was 7 feet in depth. The holes were drilled with an NX bit to facilitate an NX packer for grouting the lower zone. The hole size was reduced to 1-1/2 inch diameter or "E" size from that point to the bottom of the hole. Grout takes in the lower portion of the slope were negligible. However, some takes associated with the anticipated seepage zones were experienced. The upper portion of the slope did present some difficulties in the grouting operation as the A zone of the Fort Riley limestone and one zone of the Holmesville shale required slush grouting and caulking (see figure 22).

(2) Pressure test. Pressures in the upper zone of section II were generally between 2 and 5 psi. During the grouting of the lower zone pressures varied from 10 to 60 psi. The amount of grout injected in this zone was less than had been anticipated. Voids in the bedrock in this section were probably partially grouted during the early experimental grouting nearby. Section III served as an overlapping interval of the test section. The holes of this section were drilled at an angle of 30 degrees to the vertical and penetrated an area previously grouted during the early test program. The holes were drilled into the C zone of the Florence, penetrating all of the major seepage zones. Some small takes were experienced; however, the major problem was in the Towanda limestone which is at the surface. This member, with numerous open bedding planes and fractures, was difficult to grout. For details of grout sections II and III see figure 22. In general, the right abutment curtain was completed on a hole spacing of 10 feet. The grouting of section I did require a smaller interval, and in some areas section II and III were grouted with a secondary series in areas where grout takes were experienced.

3-03. Left Abutment Grout Curtain.

a. Description. The left abutment grout curtain extends from station 142+00 to station 143+78. The grouting zones are similar to those of the right abutment with the slope portion being divided into two zones. For the location of this area and its sections see figure 23. The bedrock units grouted in this area are the same units grouted in the right abutment with the exception that the backslope is at a lower elevation and the Fort Riley Zone D, the Holmesville shale, and the Towanda limestone are not present. The bench on the Blue Springs shale was grouted. This bench area designated as section I extended from the lip of the bench to the toe of the back slope of the cutoff. All holes in this area were drilled the entire zone depth and similar grouting operations were used. Pressure testing and grouting operations in section I indicated that the bedrock was relatively tight. Holes in this section penetrated the Blue Springs shale, the Kinney limestone and into the upper Wymore shale. For the conditions encountered in this section see figure 23. Section II completed the left abutment curtain extending up the backslope and overlapped the completed left abutment test section. The slope portion was grouted in two zones. The upper zone, with a depth of 7 feet, was drilled with an NX size bit to facilitate, a packer for grouting the lower zone. An "E" size of 1.5 inch diameter hole was drilled to the bottom of the curtain.

b. Grout injection in section II of the left abutment grout curtain was negligible. Some caulking of open joints was necessary on the slope; however, there were no unusual problems. The grout plant was a standard grouting layout equipped with a 20 cubic feet mixing vat, 20 cubic feet storage vat, water meter and slush pump with a rated capacity of 50 g.p.m. at 150 pounds of pressure per square inch (see photo 47). All couplings and fittings were 1.5 inch ID. The grout tree of the header was equipped with bypass, bleeder valve and pressure gage. Gages used in most cases were 30 pound maximum gages. Pressure testing was accomplished through the header with a water meter inserted between the hole and the header in the line (see photos 42 thru 44). The grout curtain sections were completed satisfactorily and a relatively tight curtain was achieved.

CHAPTER 4

OUTLET WORKS

4-01. Excavation General. The excavation of the bedrock material from the outlet works area was accomplished with an electric-powered Marion shovel with a dipper capacity of 7.5 cubic yards. Hauling equipment consisted of Euclid end dump trucks with a capacity of 30 cubic yards. A Northwest 95 crane was also employed in excavating the stilling basin area and dressing slopes. Scraper equipment was used to dig the intake channel and portions of the outlet channel. The major portion of the bedrock material excavated from this area was placed in the shale and limestone zone of the upstream blanket. Later, as the embankment progressed the material was placed in the shale and limestone fill zone of the embankment. The outlet works excavation was completed in 8 lifts with 86 shots using approximately 260,000 pounds of explosives. The rock excavation totaled approximately 535,000 cubic yards. The excavation was made in the right abutment extending 1,800 feet (from approximately 700 feet upstream of the dam centerline to 1,100 feet downstream). The excavation encountered all members of the local geologic column. The cut slopes varied from 0.5V on 1H to 1V on 1.5H. Lift diagrams are shown on figures 27 thru 31. The slopes of the cutoff and the approach channel were pre-split. The other slopes were cut by conventional blasting methods. The two blasting methods will be discussed later in the report. In the upper portion of the cutoff area the Towanda and Holmesville members were ripped with a D-9 dozer. Blasting operations were started in that area at the top of the Fort Riley member. The thin residual overburden and the outer portion of the Blue Springs shale were excavated with scrapers. The remainder of the cut required blasting.

4-02. Primary Blasting.

a. General. The primary-blast lifts were limited to a depth of 26 feet by the capacity of the rotary drill used for drilling the blast holes. This drill, a Chicago Pneumatic 705, used a rock bit 4.5 inches in diameter. The drilling rate for this equipment ranged from 200 to 300 feet per hour with an average rate of 250 feet per hour. The Contractor attempted to bottom the lifts immediately below the hard and more massive ledges. The bottom of the lifts reflected the slight dip of the bedrock. Air trac drills with a 2.5 inch diameter rock bit were also used for drilling primary blast holes. In the lifts involving the cherty Florence limestone, the rotary drill was unable to penetrate satisfactorily. Elsewhere in the primary blasting, air trac drills were used when not needed in drilling pre-split holes. The smaller diameter holes drilled with this equipment required a closer shot pattern spacing. The blasting agent used for the bulk of the excavation was ammonium nitrate with a dynamite primer. One stick of 40 percent dynamite was used in the initial blasting; later one stick of 60 percent dynamite was used. The typical loading column for primary blasting is shown on figure 4. Electric delay caps were used as detonators with a 25 mili-second delay interval. A typical shot used delays ranging from instant to number 5. Primacord was used for some shots, but this was generally only when wet conditons were encountered. The ammonium nitrate was poured and tamped into the holes generally to within four feet of the top of the hole and the remainder of the

hole was stemmed with rock dust. In wet holes, the nitrate was first put into plastic bags and then placed in the hole. This method was replaced in later shots by use of a commercially tubed nitrate called "Dynatex." Most of the shots in the stilling basin area below the flood plain level were made with a gelatine dynamite with strengths ranging from 40 to 60 percent in standard stick size. A 45 percent gelatine dynamite with a high water resistance in 4 x 8-inch sticks was used when extremely wet conditions were encountered.

b. Shot patterns and loadings varied with the bedrock conditions in the various lifts. Each shot was recorded as shown on figure 5. The blasting record listing each shot for the outlet works excavation is shown on tables 1 thru 7.

(1) Lift 1. The "A" zone of the Fort Riley limestone was shot separately in the first lift with a pattern spacing of 7 x 9 feet and a powder factor of 1.2 pounds of explosive per cubic yard of rock. This lift was "overshot" and adjustments were made in succeeding lifts. The "B" and "C" zones of the Fort Riley were shot together in one lift and, although this was a slightly harder interval than the upperlift, the powder factor was reduced to 0.9 pounds per cubic yard using a shot pattern of 9 x 12 feet. When excavated, this lift showed improvement, particularly in the reduction of overbreak in the back slope.

(2) Lift 2. The second lift included the deepest shots made during the excavation in this area involving the "D" and "E" zones of the Fort Riley, Oketo shale, and "A" and "B" zones of the Florence limestone. This lift was also shot with a powder factor of 0.9 pounds per cubic yard with a pattern of 7 x 9 feet. This pattern and loading resulted in considerable oversize material, requiring secondary breakage, chiefly from the two rimrock ledges involved. The influence of the joints in the Florence member were notable in the back slopes of this shot resulting in the formation of benches and vertical faces. This condition was not observed in the slopes that had been pre-split.

(3) Lifts 3 and 4. The remainder of the Florence limestone was shot in the third and fourth lifts. The "C" zone was very susceptible to fracture and with blasting experience gained in the left abutment cutoff (shot No. 29) the fourth lift was shot with a considerably lower powder factor of 0.65 pounds per cubic yard, on a pattern spacing of 9 x 12 feet with good breakage and back slope conditions.

(4) Lift 5. The "A" zone of the Blue Springs shale was shot in lift five (shots 68 thru 71). Because this was a soft shale material, the pattern spacing was increased to 10 x 14 feet and the powder factor reduced to 0.55 pounds per cubic yard. The depth was governed by the foundation grade and the restrictions of blasting above it, particularly in the tower area.

(5) Stilling basin.

(a) Blue Springs shale. The remaining shots involved excavation of the stilling basin. Dynamite was used in this area due to the harder limestone zones of this interval and water problems. The lower Blue Springs shale was shot in one lift. The shot pattern was reduced from the preceding lift to a spacing of 8 x 12 feet and the powder factor was increased to 0.6 pounds per cubic yard.

(b) The Kinney limestone and the extreme upper Wymore shale were shot in one lift. Because of the relative hardness of the Kinney limestone, the shot pattern spacing was further reduced to a spacing of 6 x 10 feet and the powder factor increased to 0.7 pounds per cubic yard. This lift resulted in some significant overbreaks in the side slopes of the stilling basin excavation. The remainder of the Wymore shale interval and the upper Schroyer limestone were shot in the succeeding lift with a pattern of 9 x 12 feet and a powder factor of 0.4 pounds per cubic yard. The shale interval presented no problems in excavation; however, the hard ledge in the Schroyer below had to be re-shot with the next lift.

(c) The Schroyer limestone near the base of the stilling basin excavation was shot with a pattern spacing of 6 x 8 feet with 45 percent dynamite and a powder factor of 0.8 pounds per cubic yard. Final grade was obtained with "adobe" shooting the last 2 feet of the lift. The results of this method were generally good although isolated areas required the removal of fractured limestone. These areas were few and shallow.

c. Pre-split blasting. Pre-split blasting was employed in the excavation of the cutoff area slopes and in the approach channel area adjacent to the intake tower structure. These areas are shown on figures 27 thru 31. The results obtained by this technique ranged from satisfactory to excellent.

(1) Experiments throughout the work produced only minor variations in the finished slopes. The main problem was the primary blasting. Changes in the stemming, loading and spacing of the holes in the pre-split line sometimes resulted in excessive heaving and fracturing, creating a problem of drilling shot holes for the excavation blasting. The fracturing of the primary blast area can also present problems in shooting when ammonium nitrate is used, as at this project, where blasting efficiency depends on tight shot holes. The pre-split blasting of the outlet works was done making use of experience gained in test shots made in the left abutment area. These shots were made to determine the most effective column loading and to minimize excessive heaving and fracturing. As work progressed, the center to center spacing was increased and ultimately pre-split shots and primary blasting was combined utilizing delays. This method is called "pre-split delay." It is the only change from the test shot in which the column loading was established and was employed as an economy measure.

(2) Equipment. Chicago Pneumatic, air trac drills with three-inch diameter standard rock bits were used on all pre-split drilling. The cutoff slope holes were drilled at an angle of 25 degrees from the vertical. All holes were drilled "on grade." The usual problems of angle drilling were

encountered such as maintaining proper alinement and hole depth. Specified angles, however, were "held" remarkably well. Drilling rates varied from less than 10 feet per hour to a maximum of 120 feet per hour. The overall average drilling rate was approximately 50 feet per hour.

(3) Blasting. A 30-inch center to center spacing along the pre-split line was used successfully from the first shot. This spacing was later increased to 42 inches and resulted in little difference in the finished slopes. Upon excavation it was found that "bit drift" had resulted in an average angle of 48 degrees in holes started at a 45 degree angle, or a deviation of 3 degrees. The greatest deviation was 7 degrees or a 52 degree angle. These deviations due to "bit drift" were found to begin at a depth of approximately 20 feet. Drilling errors produced occasional undercuts and overcuts; however, these were sporadic and generally within specified tolerances. Initial pre-split shots were made in the left abutment cutoff area with the number of holes held to a minimum in each shot. Standard loading consisted of one stick of 40 percent dynamite tied at the end of a branch line of Primacord cut to a length corresponding to the depth of the shot hole. Full or half sticks of 40 percent dynamite were taped at specific intervals to the Primacord completing the explosive column as shown in figure 6. After holes were blown clean, these explosive strings or "pig tails" were lowered into the hole and stemmed at the top, generally with dry rock dust, as shown in figure 6. Loading difficulties were experienced depending upon hole conditions. Water was used as a lubricant to ease loading in some holes. The branch lines were then tied to the main trunk line and detonated by an electric cap. More than one cap was sometimes placed in the trunk line. The explosive string in each hole was generally identical for an entire shot. The explosive column varied in the spacing of the individual dynamite sticks. The loading columns of these test shots are shown in figure 6. The finished slope of each test shot was identical but the heave and fracture of the primary blasting area did vary. The stemming and explosive column of each test shot were adjusted and the third shot was used as a basis for subsequent pre-splitting. Photo 4 shows a successful pre-split shot made for the second lift of the left abutment cutoff. The first shots were to a depth of 25 feet, penetrating the Fort Riley and the Oketo members. For the second lift in areas being pre-split, a work area four feet wide was required (see figure 7). These benches mark the top of each lift in the finished slopes; however, they were eliminated in the approach channel area by pre-splitting the entire lift.

d. Pre-split-delay blasting.

(1) Description. Standard pre-split loading procedures were used in pre-split-delay shooting. The difference between the two techniques is that in standard pre-splitting the pre-split row is shot prior to the loading and in some cases the drilling of the primary blast holes while in the pre-split method the pre-split row and the primary blast holes are detonated together employing delays. The pre-split holes are detonated by an instant caps connected to the trunkline Primacord, or where a great number of pre-split holes is required, instant caps are attached at each end assuring instant detonation throughout the row. The front row or face holes are also detonated instantly with the pre-split row and successive primary rows are progressively delayed toward the slope (see figure 8). At this project the

greatest delay employed between the back row and the pre-split row was a number 4 delay or 100 milliseconds. The pre-split holes were generally drilled deeper than those of the primary series as shown on figure 7. Only the portion of the slope corresponding to the depth of the primary blast holes was subjected to delayed pre-splitting. The portion of the slope below the primary blasting areas was left undisturbed as the remainder of the slope was pre-split to the desired depth. After the lift was "mucked out" primary blasting was then employed to remove the remaining material as in the standard pre-split procedure.

(2) The back row of primary blast holes was no closer than two feet above the pre-split fracture zone. This interval appeared sufficient for both types of pre-splitting. The interval was particularly critical in the pre-split-delay procedure with the possibility of this row "kicking" downward, due to fracture and lift adjacent to the pre-split fracture zone.

(3) The use of the pre-splitting technique resulted in relatively smooth slopes in the cutoff areas of the abutment for the embankment tie in (see photos 5 and 6). It also reduced the amount of cleanup required. The pre-split slopes showed improved weathering resistance over those cut by conventional blasting methods especially in the Florence member which was particularly susceptible to spalling in the conventional cuts.

4-03. Foundation. General. Initial foundation work started in the approach channel area and progressed downstream. Approximately eighty percent of the foundation bedrock beneath the structure is shale belonging to the Blue Springs and Wymore members. All shale portions of the foundation were covered with a lean concrete pad with a minimum thickness of six inches. This pad was placed within a few hours of final cleanup operations. The remaining portion of the foundation bedrock is limestones as follows: a thin ledge in the central section of the Blue Springs member, the Kinney limestone member, and the Schroyer limestone member. These limestones required no protective lean concrete pad and foundation cleanup was relatively simple with the exception of an occasional area where blast holes had been drilled too deep. For a general geologic section beneath the structure see figure 9.

4-04. Shale Foundation.

a. General. The weaker materials encountered in the foundations were the red and green clay shales of the upper Blue Springs member, and the lower Wymore. The red zones of the Blue Springs member were somewhat harder than their green counterparts. The Wymore B zone was similar to the soil zone of the Blue Springs with the exception of the extreme lower part which exhibited an increase in calcium carbonate cementation progressing toward the base of the member. This resulted in a competent shale foundation. It was within this area that the only continuous gypsum seam in the foundations was observed. This was a seam of satin spar three quarters to one inch thick which extended across the entire foundation for the O.G. section at station 4+58 downstream. The seam was tight with no evidence of ground water solution work (see photo 8). Foundation cleanup of these zones presented no problem when opened and covered with lean concrete in a reasonable time, i.e., a few hours. It was found generally that final cleanup with air only and a light water spray after cleanup produced the best results.

b. Blue Springs zone A. From station 4+25 (upstream) to 3+76 (upstream) the Blue Springs zone A predominately a green shale, forms the foundation surface for the downstream portion of the approach walls, the entire approach slab, and the upper portion of the tower key vertical surface (see photos 9 thru 11).

c. The Wymore zone B forms the foundation surface beneath the lower portion of the O.G. section from station 4+33 (downstream) to station 4+61 (downstream). It was encountered from elevation 1037 to elevation 1050 m.s.l. (see photos 12 and 13).

d. Blue Springs zone B. The extreme upper portion of the Blue Springs "B" zone formed the major portion of both vertical surfaces of the tower key at station 3+76 U.S. and 3+46 U.S. and the surface beneath the remainder of the tower and the transition section from station 3+76 U.S. to station 1+77 U.S. (see photo 14). This surface did not deteriorate as rapidly as the materials previously described and if covered in a reasonable time would not have been subjected to air slaking. However, the Contractor delayed pouring the lean concrete due to plant difficulties and the surface spalled badly. This material spalled in fragments similar in size and shape to peach seeds and several cleanup operations were required. Burlap was used to cover the surface which was kept continuously wet; however, a final air-water cleanup operation was needed immediately prior to the placement of the lean concrete pad. This material was better suited for the air-water cleanup process. Enlarged joints encountered in this zone complicated the cleanup operation. The remainder of the B zone of the Blue Springs shale is a firm, dark gray, calcareous shale. This material approaches a limestone consistency in a thin limey fossiliferous zone in the upper portion. It was the only prominent fossil zone encountered during excavation operations. This horizon formed the floor of the tower key from station 3+76 U.S. to station 3+46 U.S. and was an excellent foundation surface (see photo 15). The zone B shale forms a good firm foundation surface for the entire conduit from station 2+35 U.S. to station 3+80 D.S. Typical foundation and collar excavation is shown in photos 15 and 16. The "B" zone shale was well suited for the air-water cleanup process and could be kept in good condition indefinitely if kept continuously wet. An occasional cleavage plane was encountered and is shown on the main foundation map. Adjacent to these cleavage planes, as well as joints, drummy areas were sometimes found (see photo 18).

e. The Wymore shale zone A is the most competent shale encountered in the outlet works foundations. It forms the foundation surface beneath the O.G. section from station 4+11 D.S. to station 4+33 D.S. It is a hard, gray, calcareous shale but is susceptible to fracture. It is comparatively resistant to weathering. However, during the blasting operations, shot holes were drilled too deep in the O.G. foundation. This required considerable removal of fractured material below grade and backfilling with lean concrete. When all fractured material had been removed this zone produced an excellent foundation surface as shown on photo 19.

4-05. Limestone Foundation.

a. General. The limestone ledge in the "A" zone of the Blue Springs shale member was encountered at a general elevation of 1078 in the approach channel area. It consists of a single ledge one foot thick and forms the foundation surface for the upstream portion of the approach walls. See photo 10. The limestone is hard and generally light gray. It lies above the foundation grade downstream of station 4+25 D.S.

b. The Kinney limestone forms the foundation for the structure between stations 3+80 D.S. and 4+10 D.S. in the upper portion of the O.B. section. This is a hard, medium gray limestone and easily cleaned by air-water jetting. The Contractor experienced considerable trouble with this bed because it was undercut and was difficult to remove. Between stations 4+60 D.S. and 6+02 D.S., the Schroyer limestone forms the foundation surface for the extreme lower O.G. section, the floor of the stilling basin, stilling basin walls, and the end sill. The upper three feet is hard, white, limestone overlying seven feet of dark shaly limestone. Most of this member is found in the vertical surface of the end sill at station 6+02 D.S. This surface contained two chert layers and zones of gypsum nodules (see photos 20 and 21). The thin cherty limestone of the lower Schroyer forms the major portion of the foundation surface for the stilling basin walls and floor. This limestone is 0.8 feet thick and is hard affording an excellent foundation surface. In some areas the excavation operation broke through this ledge into the softer dark gray argillaceous material below. This generally was due to the Contractor's attempt to divert water to a sump in the upstream riverward corner.

c. The Schroyer limestone formed a good foundation surface. Cleanup operations were simple. An occasional blast hole was drilled too close to grade, and fractured rock was removed from small areas. (See photos 22 and 23.)

4-06. Foundation Jointing.

a. General. Extensive bedrock jointing was encountered during foundation preparation beneath the upstream portion of the structure. Each individual joint and fracture was mapped as to strike, condition, and seepage as shown on figures 10 thru 13 and on figures 33 thru 39. Three sets of joint trends were recognized. The major trend was N70°E and the minor trend varied from N40°W to N50°W. A third set trends N85°E and parallels the outcrop face (see figure 10). The third trend reflects the mechanical adjustment of the bedrock zone adjacent to the outcrop face due to the erosion of the river valley. All joints were vertical in the foundation and ranged from tight to open several inches. Seepage from the joints was minimal and was generally confined to the upstream sections below elevation 1075.

b. Approach channel. The Blue Springs shale zone A in the approach channel area exhibited good joint development. All three trends were present. A detailed map of this area is shown in figure 11. The joints were generally tight or filled with a soft clay. The major exception was an open joint which extended from station 4+22 U.S. to station 1+52 U.S., paralleling the south approach wall. This joint extended through the approach slab foundation, the upstream vertical key surface, and through the remainder of the tower area and beneath the conduit. The joint had been enlarged by ground water to an average width of 4 inches and extended down into the top of the "B" zone below, where it had a one quarter-inch opening in the floor of the tower key. Water was seeping from the upstream portion and the joint faces were water marked indicating a prolonged period of ground water movement. Adjacent drummy shale was removed and the walls were shaped back into a "V" notch. The "notch," when cleaned, measured approximately 2 feet wide and 3 feet deep (see photos 24 and 25). In the floor of the tower key, joints trending N85°E were concentrated in the south half and ranged from tight to open (up to one-half inch). Water seepage from these joints was small. One fracture trending N70°E was traceable. It extended from the downstream wall of the key into the approach channel area (see figure 12).

c. Tower and transition. The joints of the tower and transition areas were similar to those in the approach channel and were treated in the same manner (see photos 26 and 27). Open joints ranged from 1 to 2.5 feet deep. Original joint openings ranged from tight to open several inches. Some were completely open and some were partially filled with soft clay and large gypsum nodules. For a detailed map of these joints and their relationship to the structure see figures 11 thru 13 and figures 32 thru 39.

d. Conduit. Joints of the lower Blue Springs "B" zone beneath the conduit generally trend N85°E. These were open about one-half inch and produced occasional small amounts of seepage in the foundation floor particularly in the collar excavations. The foundation was dry in the vicinity of the grout curtain with no seepage noted for 50 feet on either side of the dam axis. Grout filling was observed in many of the joint openings in this area. Downstream of the dam axis, the major joints trend N60°E. The Kinney limestone exhibited joints of the minor trend (N40° to 50°W). The foundation area, however, was located far enough landward that the enlarged weathered joints of this member occurring in the riverward area were not present. In the upper portion of the Wymore shale zone B some joints of the minor trend were encountered. This horizon showed some evidence of groundwater work but no seepage was experienced in the foundation area. Jointing in the Schroyer limestone was poorly developed. Only a few joints of the minor trend were found and were traced only a short distance.

CHAPTER 5

SPILLWAY

5-01. Excavation General. The spillway is formed by a rock cut located 3,000 feet south of the embankment. It is an uncontrolled emergency chute type with a concrete sill. It is 1,250 feet wide at the crest and 4,800 feet in length. The depth of this excavation varies from 0 to 54 feet. The side slopes vary from 1V on 1.5H in rock, to 1V on 3H in the overburden. The centerline of the concrete sill is located at dam station 24+00 as shown in figure 14. The slab is 50 feet wide and 3 feet thick, extending across the spillway and up both slopes to elevation 1206. This slab is secured with grouted anchors, shale protection slabs, return walls, and 48-inch riprap is placed upstream and downstream from it. The spillway cut required excavation of 4,365,000 cubic yards of material consisting of 2,090,000 cubic yards of overburden and 2,265,000 cubic yards of rock. After first stripping the vegetation, which involved the removal of approximately four to six inches of the top soil, the clay overburden was excavated by means of 40 cubic yard scrapers. This excavation method continued through the top of bedrock into the upper Towanda limestone. A 60,000 pound ripper was also used. The bedrock excavated was used for shale and limestone fill. The better quality Towanda limestone was excavated separately and used as rock fill adjacent to the tower and stilling basin, in the Towanda limestone fill beneath the riprap and as bedding material. These materials were produced from the hard limestone zone in the middle section of the Towanda member (see photos 40 and 41). Towanda limestone of marginal quality was utilized as slope surfacing in the protective layer of the downstream slope of the embankment. The bulk of the blasted bedrock material in the spillway was excavated by an electric powered Marion shovel with a 7.5 cubic yard dipper. The shovel had an average loading time of 20 cubic yards per minute (see photo 39). Euclid end dumps with a capacity of 30 cubic yards were loaded by this shovel in about two minutes. The average hauling distance to the embankment was 6,00 feet and required about 15 minutes per round trip including dumping. This equipment is shown in photo 40. Excavation of the spillway was scheduled to meet the fill requirements of the embankment with the exception of the crest slab area which received priority to coincide with concrete scheduling. The excavation was generally completed to grade in a single operation except where the utilization of Towanda limestone only, was required. Excavation of the key trenches beneath the sill was completed by a backhoe. The loess blanket covering bedrock in the spillway was a lean clay with a typical moisture content of 19 percent. It was used as impervious fill in the upstream blanket and in the embankment core.

5-02. Blasting.

a. General. Blasting of the Towanda and Holmesville was, in general, completed in one lift to the spillway flow line. The lift varied in depth from 8 to 20 feet with a blasting pattern of 11 x 14 feet. Ammonium nitrate was the blasting agent, using one stick of 40 to 60 percent gelatine dynamite as a primer. Primacord was used particularly when wet conditions existed. During periods of rain, wet holes were loaded with Gelamite (4 x 6 inch of 45% gelatine dynamite). Shot records cannot be found or none were kept.

b. The loading column was varied with the anticipated utilization of materials. In areas being shot for shale and limestone, the Contractor used a straight loading column of dynamite primer; 2 pounds of ammonium nitrate per lineal foot and 5 feet of stemming (usually rock dust). In areas where the Towanda limestone was utilized separately, deck loading was employed using Primacord with 8 pounds of ammonium nitrate in the Holmesville, rock dust decking to the base of the better Towanda, and 21 pounds of nitrate with a stemming interval of 5 feet at the top. Breakage differences between the two loading systems was not apparent and the decking procedure resulted in eliminating only the shale heaves into the limestone sections above. For an illustration of the loading columns see figure 17. In blasting for the material that was to be crushed for bedding, the lift penetrated only to the base of the hard limestone zone or middle zone of the Towanda member. The lift was approximately 8 feet deep and was drilled with a pattern spacing of 7 feet x 11 feet. The excavation of the spillway bedrock involved approximately 175 shots. The powder factor was approximately 0.29 pounds of explosive per cubic yard of rock.

c. Blasting of the sill keys in the spillway involved the lower Holmesville shale member and upper Fort Riley limestone member. Prior to the excavation all vertical wall surfaces were line drilled. This was accomplished by air trac drills and a tractor mounted drill using 3 inch diameter rock bits and a rotary drill using a 4 inch diameter bit. Holes were drilled on one foot centers. After the completion of line drilling, holes were drilled for the trench blasting.

d. Blast holes (3 inch diameter) were drilled along the center line equidistant between the line drilled rows with a center to center spacing of two feet. A typical leading column for these holes is shown in figure 17, with two sticks of dynamite in the Fort Riley limestone and one stick of dynamite in the Holmesville shale.

e. Best results were obtained when shots were held to no more than 6 holes using electric caps with instant to number 5 delays. Upon completion of the excavation, the side walls were cleaned and the Holmesville portion of these walls was protected with "gunite" and wire mesh.

f. Final grading of the floor was comparatively simple with the exception of areas where the upper hard limestone bed in the lower Holmesville protruded above the foundation grade. The bulk of the grading was accomplished with blade equipment.

g. Cleanup of the sill foundation was accomplished with air jets and was reasonably successful (see photos 29 thru 31). The slope section foundation cleanup was complicated by two factors; the Holmesville shale was excavated too close to grade and the foundations were left exposed an entire winter without adequate protection against freezing. Cold weather halted operations in this area at the end of the second construction season and the slope foundation already below the specified grade were subjected to freeze and thaw cycles until the next spring when operations were resumed. This resulted in considerable over excavation and high costs for labor and backfill concrete.

h. Slope foundations in shale were "stair-stepped" on horizontal cleavage planes in the Holmesville member. The final cleanup was accomplished with air-water jets, which resulted in good foundation surfaces (see photo 32). The Towanda limestone in the south slope presented no unusual problems; however, on the north slope during the excavation blasting, this member was badly fractured. All fractured rock was removed resulting in considerable over excavation. The limestone was "stair-stepped" on the numerous well developed bedding planes. It was cleaned with the air-water jets and good to excellent foundation surfaces were obtained (see photo 33). Lean concrete was also used to backfill over excavation on the north slope.

5-03. Spillway Sill.

a. General. A typical cross section of the concrete sill is shown in figure 15. To prevent possible undercutting of the structure during spillway flows, two keys, 3 feet in width, were constructed beneath the slab as shown in photo 28. The upstream key extended downward just into the underlying Fort Riley limestone. The downstream key extended 18 feet below the slab to elevation 1158. Both keys extend up the slope portion of the slab to the ends of the crest structure.

b. The downstream key penetrated the Fort Riley zone "A" to its base on the north end and three feet above the base on the south end due to the local dip of the bedrock. The upstream key penetrated the Fort Riley an average depth of one foot.

c. Protection. In order to protect the Holmesville shale which is exposed nine feet above the flow line, concrete protection slabs were placed along the side slopes to the top of the Holmesville shale for a distance of 50 feet upstream and downstream of the main slab. These slabs were also keyed in to the top of the Fort Riley at the same general depth of the upstream key of the main crest slab. The keys were 2 feet thick and afford the Holmesville protection below flow line.

5-04. Spillway Sill Foundation. The lower Holmesville shale is the foundation for the crest slab. See foundation map plan and profile spillway, figures 40 and 41. The middle green zone in the south end and the two limestone beds of this member are the foundation toward the north end. For details of the foundation conditions beneath the main sill slab see spillway sill plan and profiles. Foundation of the upper slopes of the sill are Towanda limestone of relatively good quality. Riprap up to elevation 1085 on the north slope and 1083 on the south slope as well as the concrete slabs rest on the upper Holmesville shale.

5-05. Grouted Anchors.

a. Initial installation. After the lean concrete pad had been placed on the shale surfaces of the foundation, grouted anchors were installed. These anchors were installed by drilling a 6-inch diameter hole to a depth of 18 feet below the crest slab with a rotary drill (see photo 34). The holes were then cleaned with a combination of air and water, and filled with grout. Many holes lost grout into open solution channels of the Fort Riley "A" zone (see photo 35).

b. Testing. When the hole was filled with grout, number 10 reinforcing steel bars ("J" bars) were inserted and vibrated into position by placing a concrete vibrator against the bar. Additional grout was added when necessary. The anchor holes in the slope sections were drilled at an angle of 30 degrees to the vertical varying in length from 12 to 24 feet. The drilling of these holes was accomplished with air trac drills. For an illustration of the relationship of the anchors and slab see figure 15.

c. Deep anchors. Two rows of grouted anchors were placed through the concrete protection slab keys at an angle of 30 degrees to the vertical. This operation was difficult, requiring angle drilling of a hole large enough to pass the neck of the anchor through the key and into the shale below. This was accomplished by drilling two six-inch diameter holes "piggy back" into the key and then drilling out the wall section between the holes. These oversize holes were then backfilled with concrete after the anchors had been placed into the key wall (see photos 36 and 37).

5-06. Riprap. Additional slope protection is afforded by a 48-inch layer of riprap extending 50 feet upstream from the upstream protection slabs and 425 feet downstream from the downstream slab. A detail of the riprap is shown in figure 16.

CHAPTER 6

RELIEF WELLS

6-01. General. Along the downstream toe of the embankment, a total of 73 relief wells were installed for control of underseepage. These wells are designed to produce an artesian flow as the pressure builds in the alluvial foundation of the embankment. A series of collector and header ditches carry the flow from the toe of the embankment to the downstream borrow pits.

6-02. Well Design. The well consists of an eight-inch ID wood screen and riser of treated Douglas fir. The screen section consists of wood staves banded with galvanized wire with milled 3/16-inch slots in offset pairs constructed with open area of 25 to 30 square inches per lineal foot. The joints connecting the various sections are of the mortise-male type held together by brass screws. The riser is of similar construction without the slotted openings. The screen generally extends from two feet above the bottom of the well to a point approximately two feet below the top of the sand aquifer. The riser then extends from this point to the well header. The screen is encased within a gravel pack with a minimum of six inches of gravel between the screen and the foundation sands. The gravel pack extends from the bottom of the well, two feet below the screen to a point at least two feet above the screen near the top of the aquifer. Above the gravel pack around the riser section is a one-foot thick layer of concrete sand and gravel pack. The purpose of this layer is to relieve pressure in the upper layers of material too fine for the gravel pack, and to prevent the concrete in the collar above this layer from penetrating. A concrete collar was placed around the riser to a point just below the metal well header. The well header consists of a corrugated metal tee with an outfall and a riser extension. The outfall extension discharges into the collector ditch just above the flow line. Both the riser and the outfall extension openings are protected by galvanized flap gates (see figure 24).

6-03. Well Installation.

a. Drilling equipment. Well construction began with drilling a 24-inch diameter hole with a Mayhew reverse rotary drill rig. A 24-inch diameter cone shape fishtail bit was utilized with a drill string of eight-inch ID sections ten feet in length. This equipment is shown on photos 48 and 49. As drilling progressed, continuous samples were taken by sampling the discharge water and the hole was logged. A typical log is shown in figure 25.

b. Drilling. The wells were drilled to bedrock with the exception of the partial penetration wells designed to go only to a specified elevation, and wells between station 124+00 and station 135+00 which could not be drilled to bedrock due to a boulder and cobble layer.

c. The boulder and cobble layer created many drilling problems with larger cobbles plugging the bit. The wells were bottomed out upon refusal on a large boulder. As the drilling progressed to station 107+00, the layer appeared to be mostly cobbles with a few small boulders. At this point penetration to bedrock was accomplished. At station 116+00 the layer appeared

to be relatively level at about elevation 1040. In most cases a two to five foot interval of sand separated this layer from bedrock. The bedrock elevation varied from 1048 to 1028. The wells terminated on the Wymore shale member from station 92+50 to station 93+50 and from station 128+00 to station 140+00 on each end of the well line. From station 107+00 to 128+00 the Schroyer limestone member formed the bedrock surface. For a profile along the well lines, see figure 26.

d. Well placement. The wells were drilled on a center to center spacing of 75 feet from station 122+00 to station 92+50 and on a spacing of 50 feet from station 122+00 to station 140+00. In the latter area, every third well was a partial penetration well drilled to approximate elevation 1052. Upon encountering bedrock, the drilling tools were removed and a 24-inch ID temporary casing was placed in the hole to a depth approximately two feet below the top of the gravel pack elevation. This required about 17 feet of casing. The elevation on the top of the casing was noted and all subsequent work on the well was referenced from that point. The depth of the hole was then checked and the lengths of screen and riser sections were established.

e. Screen and riser sections were made up and the spiders (spacers) were attached. These were generally placed five feet below the bottom of the screen and three feet above the top of the screen. The bottom plug was driven into the bottom of the screen and secured with nails. The joints were secured with screws. Wood bracers and heavy gage wire were used to reinforce the joints (see photos 50 thru 53).

f. Gravel pack material was tremied into the hole to a depth of two feet above the bottom. The screen-riser assembly was then picked up by a crane and placed into the well and set on the gravel pack. The braces were removed as the assembly was lowered into the well. A third spider of heavy metal was placed around the top of the riser. This spider or collar was adjusted to fit tightly within the temporary casing. This helped to hold down the wood riser which tended to float. It also assured the centering of the riser during succeeding work operations. A heavy chain was then used to insure against slippage of the setup. The gravel pack was placed through a five-inch diameter aluminum tremie pipe. A hopper above the pipe was fed by conveyor belt. The conveyor was approximately 30 feet long, powered by a small gasoline engine. The hopper end (or feed end) of the conveyor was mounted on rubber tired wheels. A garden hose was placed in the tremie hopper and continually introduced water into the tremie pipe. The gravel pack material was shoveled by laborers into the conveyor belt hopper which in turn carried the material to the tremie pipe. When the tremie pipe was filled completely, it was lifted slightly and the material began slipping en masse into the hole. About 40 feet of gravel pack was placed in less than an hour. The well was bailed and the screen was cleaned out. The prescribed chemicals were then mixed in a tub with water and poured into the well. The bailer was then used to mix the solution by slowly raising it from the bottom to the top of the well. The well was then left undisturbed for a period of 48 hours. At the end of this period, the Contractor developed the well; however, the actual time varied with the Contractor's schedule and weather conditions. Generally the well was developed within a period of 60 hours after the chemicals were placed. A six-inch Western Roller turbine pump driven by an 8-cylinder

automobile engine was used for development. The bottom of the drop pipe was set at a depth of 24 feet which placed it generally six feet into the screen. The pump had a maximum rating of 500 g.p.m. with 50 feet of head. The static water level was measured with an M-scope, the line of this instrument was set for a drawdown of seven feet. The development was then begun by overpumping. In the large producing wells maximum drawdown was not attained. During the overpumping operation the water usually began clearing after one hour of "surging"; however, the wells continued to draw in fine sand for some time. Development time ranged from two to six hours. When the water in a jar sample was free of sand, the developing operation was considered complete. The drawdown was noted and an estimate of the final pumping rate was made (see photo 53). Once the well was developed, a sand-gravel pack mix was tremied into the well. This was brought up to an elevation generally corresponding with the bottom of the alluvial blanket. A concrete collar was placed above the sand-gravel pack to the specified elevation. Two methods of concrete placement were used. In some wells the water was pumped from the top of the sand gravel by hand with a pitcher pump and the concrete placed. In others the tremie method was used. The sand-gravel and the concrete backfill were brought up in increments of two feet and the temporary casing was pulled in the same intervals by a crane, taking care to keep the bottom of the temporary casing at least two feet below the backfill material. With the well backfilled, a check was made for the presence of fine sand drawn into the well by the developing operation. This generally ranged from a few tenths to two feet. It was removed by bailing prior to the pump test.

6-04. Pump Testing.

a. Testing. The same pump used for developing the wells was used for the pump test. The static water level was measured at each well along the well line and the pump test started. The initial drawdown was measured with an M-scope and timed with a stop watch. Continuous readings of the water level were taken on the well being tested and the adjacent well during the test. The pumping rate was measured using a 4-3/8-inch circular orifice on a six-inch ID discharge pipe. At the end of four hours the test was completed, the pump was shut off and the recovery of the water level was noted.

b. Results. In general, the wells were good producers with yields up to 200 g.p.m. per foot of drawdown. The partial penetrating wells did not produce as much as the deeper wells. For a profile along the well line see figure 26 and Plates 23 and 24.

CHAPTER 7

7-01. (a) Instrumentation consists of the following: Eleven Alinement monuments were installed in a line on 50-foot centers along range 1+75 Downstream. Five strong Motion Accelerographs were installed; one on the left abutment, one in the intake tower, one on the crest of the dam, one on the downstream slope, and one at the downstream toe. Seventy-three pressure relief wells were installed along the downstream toe. Three foundation settlement gauges and 7 crest settlement monuments were installed. Sixty-three piezometers, were installed. All are the open tube type. All but 5 have their tips in the foundation sands. The 5 remaining have their tips in the impervious clay core. Since installation, 61 of the piezometers have been continuously monitored. Extrapolation of data indicate the seepage control measures have maintained piezometric levels well below the design limits. The piezometers along the downstream toe are located midway between the pressure relief wells to aid in evaluation of the relief well's performance. They have their tips in the foundation sands and just below the base of the natural blanket. With the exception of two areas, the relief wells have been effective in holding the seepage pressures to levels only slightly higher than the elevation of the well discharge pipe. These relatively high pressures are near piezometer P-11B at station 110+90 and piezometer P-30B at station 133+80. On 3 October 1973, the record high pool was at El 1158.3, piezometer P-11B had a pressure head of 4.6 feet above the flow line of the relief well drainage ditch and piezometer P-30 had 4 feet. A small sand boil developed near P-11B. The boil was brought under control by constructing a sandbag channel block downstream of the boil, raising the water level in the ditch. Since the top of the relief well screens near the boil area is 18 feet below the ground surface, the presence of a shallow pervious zone could explain the higher pore pressure and thus the sand boil. In order to repair the high pressure area and relief well drainage ditch, a \$35,000 contract (DACW-41-76-0045) was awarded to Bayer Construction Company in April 1976 when the pool was near multipurpose level (El 1144.4) and the pore pressures were lower in the repair area. From approximate stations 108+00 to 116+00 the ditch was deepened and lined with a 6-inch layer of pervious material and a 30-inch diameter, perforated corrugated metal pipe, wrapped with plastic filter cloth was installed. Connections were made to the outfall pipes of relief wells 20 thru 30. The pipe was covered with a minimum of 6-inches of sand followed by a minimum of 12 inches of impervious clay. To date (May 1978) the buried collector pipe appears to be working satisfactorily. Pore pressures and water flows from the wells are normal but high pool levels have not occurred since the repairs have been completed. See plates 24, 25 and 26, and Periodic General Inspection Report No. 5, (April 1974).

7-01. (b) Settlement Plates. Readings of the settlement plates thru April 1974 indicate the foundation settlement is essentially complete, 0.05 foot to 0.1 foot. The two valid readings to date (April 1974) of the crest settlement monuments indicate embankment settlement of 0.1 foot to 0.2 foot.

FIGURES

FIGURES

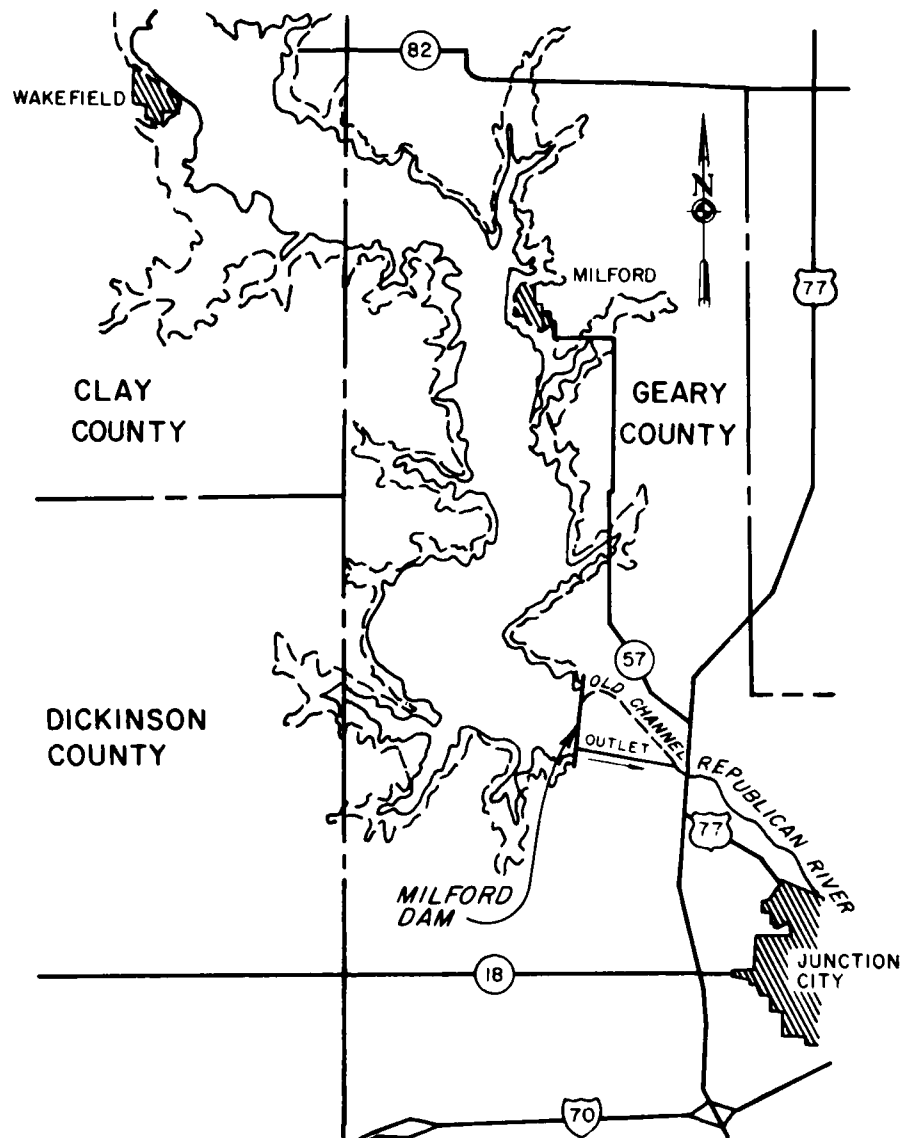


FIGURE 1

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

LOCATION

In 1 sheet

Sheet No. 1

Not to scale

CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

FILE NO. B-1-1921

APRIL 1977

FIGURE 1

[illegible]

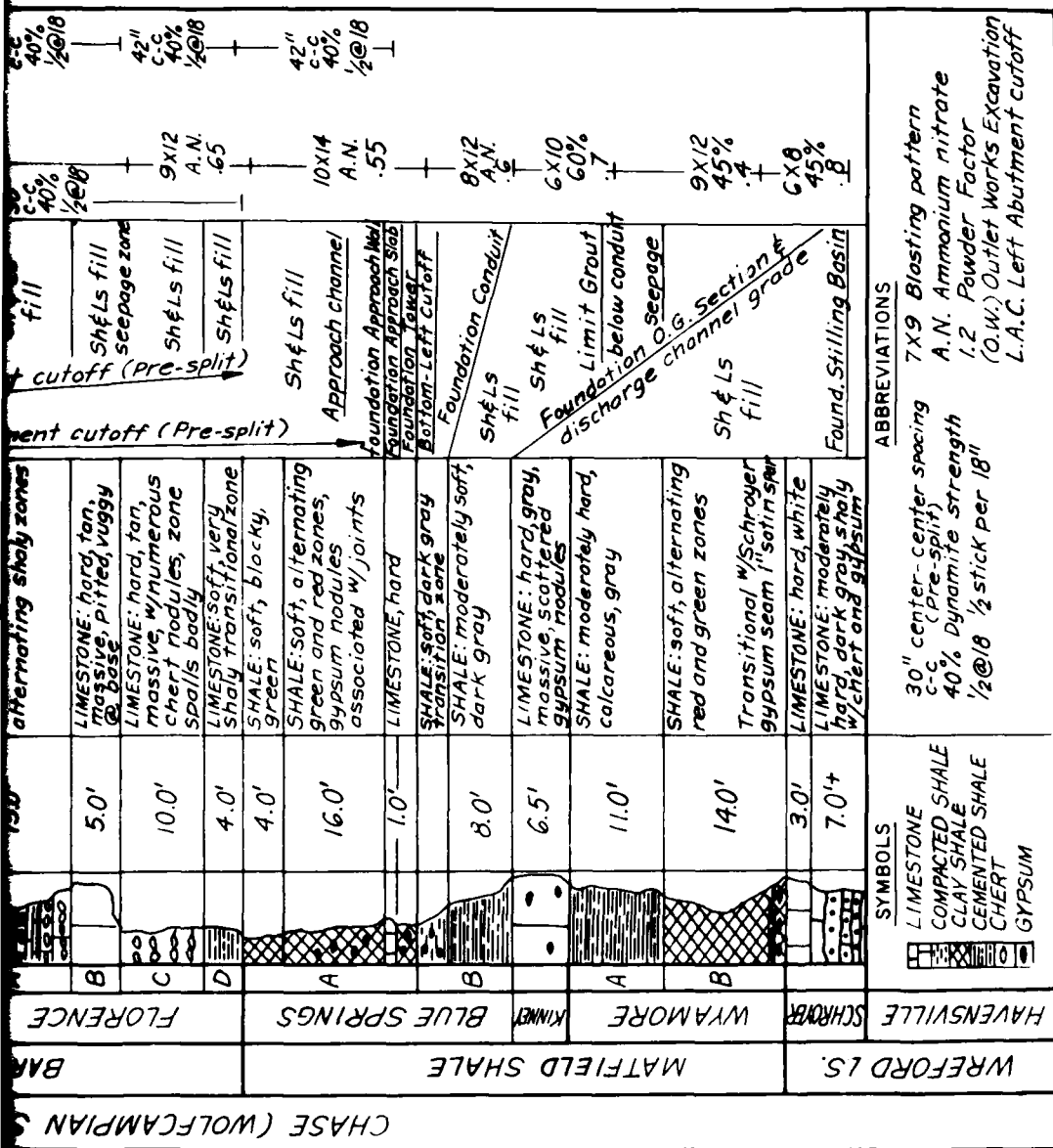


FIGURE 2

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

**GEOLOGIC COLUMN AND
UTILIZATION SUMMARY**

Sheet No. 1

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

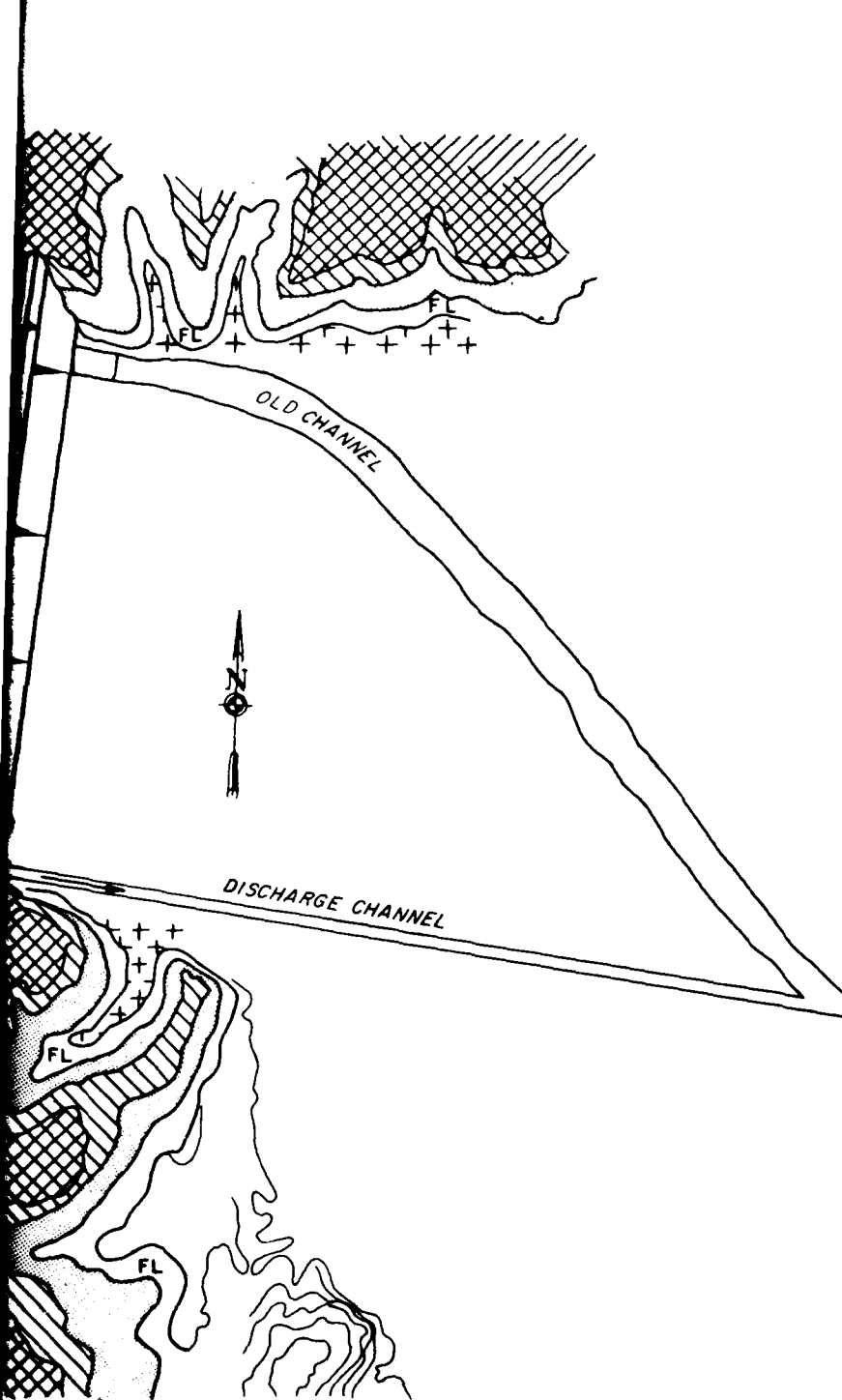
FILE NO. B-1-1922

APRIL 1977

Not to scale



FIGURE 3



LEGEND

TOWANDA LS	-----	
HOLMESVILLE SH	-----	
FORT RILEY LS	-----	
FLORENCE LS	-----	
BLUE SPRINGS SH	-----	

REPUBLICAN RIVER, KANSAS **MILFORD LAKE** FOUNDATION REPORT

GEOLOGIC MAP OF CONSTRUCTION AREA

In 1 sheet

Sheet No. 1

Not to scale

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 KANSAS CITY DISTRICT

FILE NO. B-1-1923

APRIL 1977

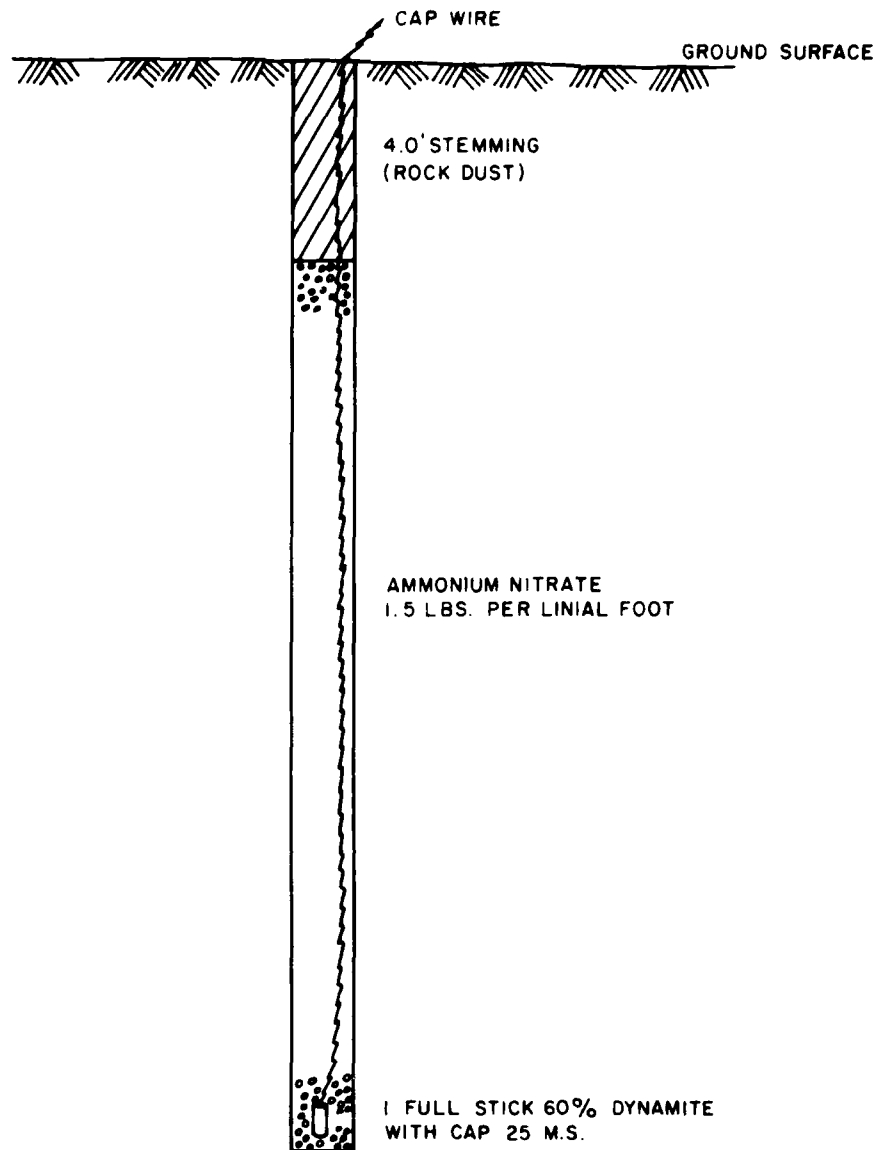


FIGURE 4

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

TYPICAL LOADING COLUMN
OUTLET WORKS EXCAVATION

In 1 sheet

Sheet No. 1

Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1924

APRIL 1977

FIGURE 4

SHOT RECORD

SHOT NO: 28
 *DATE: 10-27-62
 *TIME: 1730

*PROJECT: Milford Dam
 *CONTRACTOR: Western Contracting Corporation SUB: _____
 *PURPOSE OF BLAST: Outlet Works

DRILLING DATA

*LOCATION: Outlet Works *STA: 1+15 ds TO 4+70 ds
 *RN: 0+25 L TO 0+25 R
 SURFACE ELEV: 1168
 BOTTOM ELEV: 1153
 GEOL FMTNS: Fort Riley zones A-B-C
 VOL: 1 240 xw 50 xh 15 - 6600 CY
 *DRILL TYPE: Air Trac-Rotary DRILL ANGLE: V
 *HOLE DIA: 3 1/2" 4 1/2" SLOPE (FREE FACE): _____
 *NO OF HOLES: 146 *DEPTH: 15 *PATTERN: 7 X 9' 9X12'

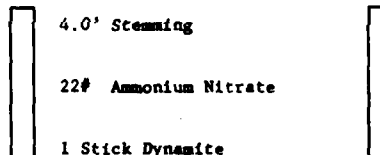
EXPLOSIVE DATA

*TRADE
 *TOTAL AMT: 1 1700 LBS NAME: Dynamite *STN: 40 % *Size: Standard
 2 70 LBS Dynamite 60 % Standard
 3 3150 LBS Ammonium Nitrate Bulk
 4 _____ LBS _____
 POWER FACTOR: 1 0.26 LB/CY 2 0.01 LB/CY 3 0.48 LB/CY 4 _____ LB/CY
 TOTAL: 0.75 LB/CY

DETONATORS:

*TYPE: Electric Delay 25MS *PRIMACORD? No
 *PERIODS: 1 1 2 3 4 5 6 7 8 9 10 11 12 13 14
30 29 29 29 29 _____

*LOADING DIAGRAM:



RESULTS

EXCAVATION METHOD: Electric power Marion Shovel w/ 7 1/2 cy dipper
 QUANTITY OF ROCK PRODUCED: _____
 *FRAGMENTATION: Poor; considerable oversize
 PRE-SPLIT RESULTS: _____

COMMENTS

Conditions vary w/ toward middle of shot, holes "rifled."

*FURNISHED BY CONTRACTOR
 1000 Form 100
 10 April 61

SIGNED _____
 INSPECTOR OR CONTRACTOR

FIGURE 5

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

SHOT RECORD

In 1 sheet Sheet No. 1 Not to scale

CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

FILE NO. B-1-1925

APRIL 1977

FIGURE 5

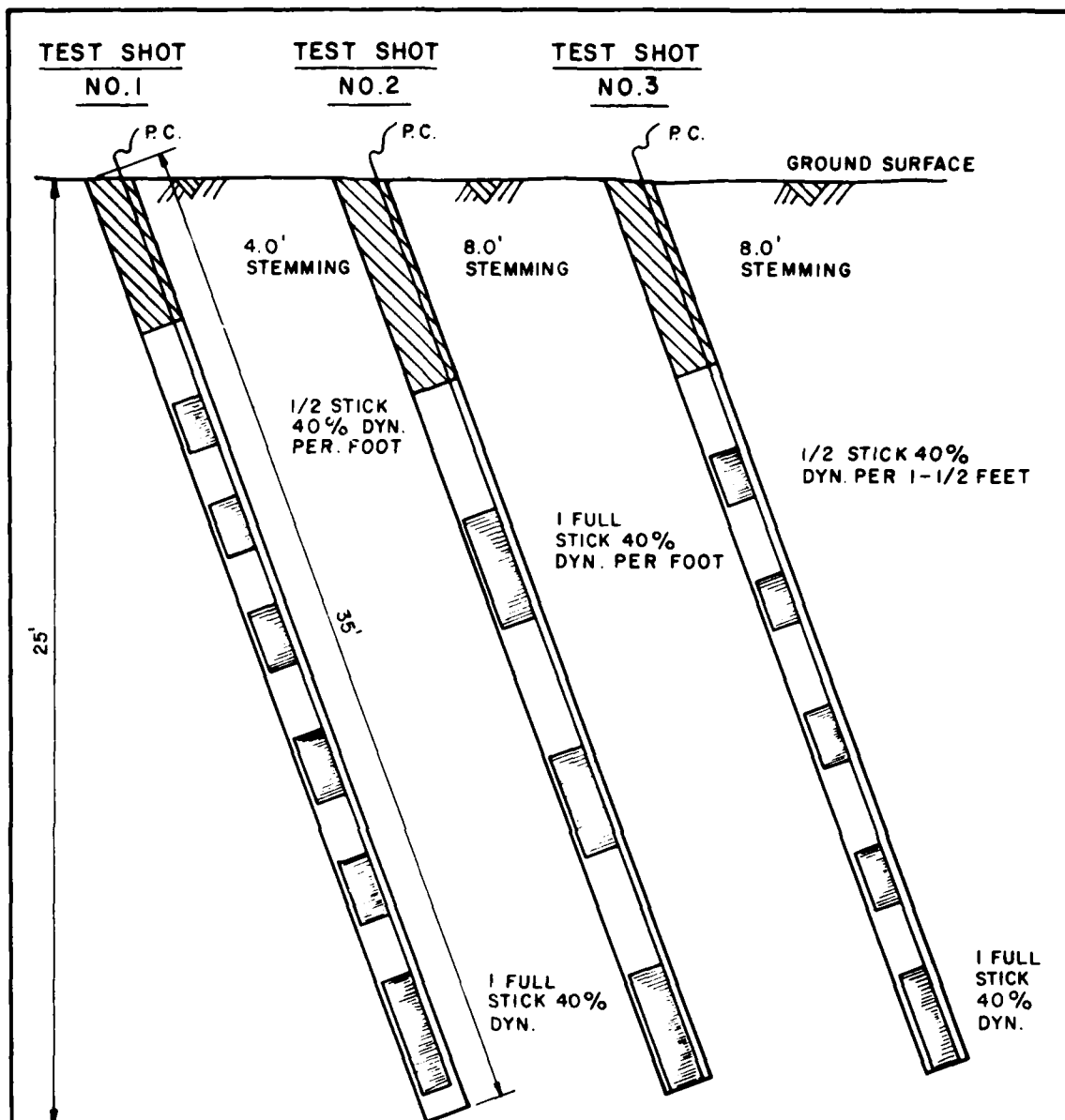


FIGURE 6

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

PRE-SPLIT TEST SHOTS

In 1 sheet

Sheet No. 1

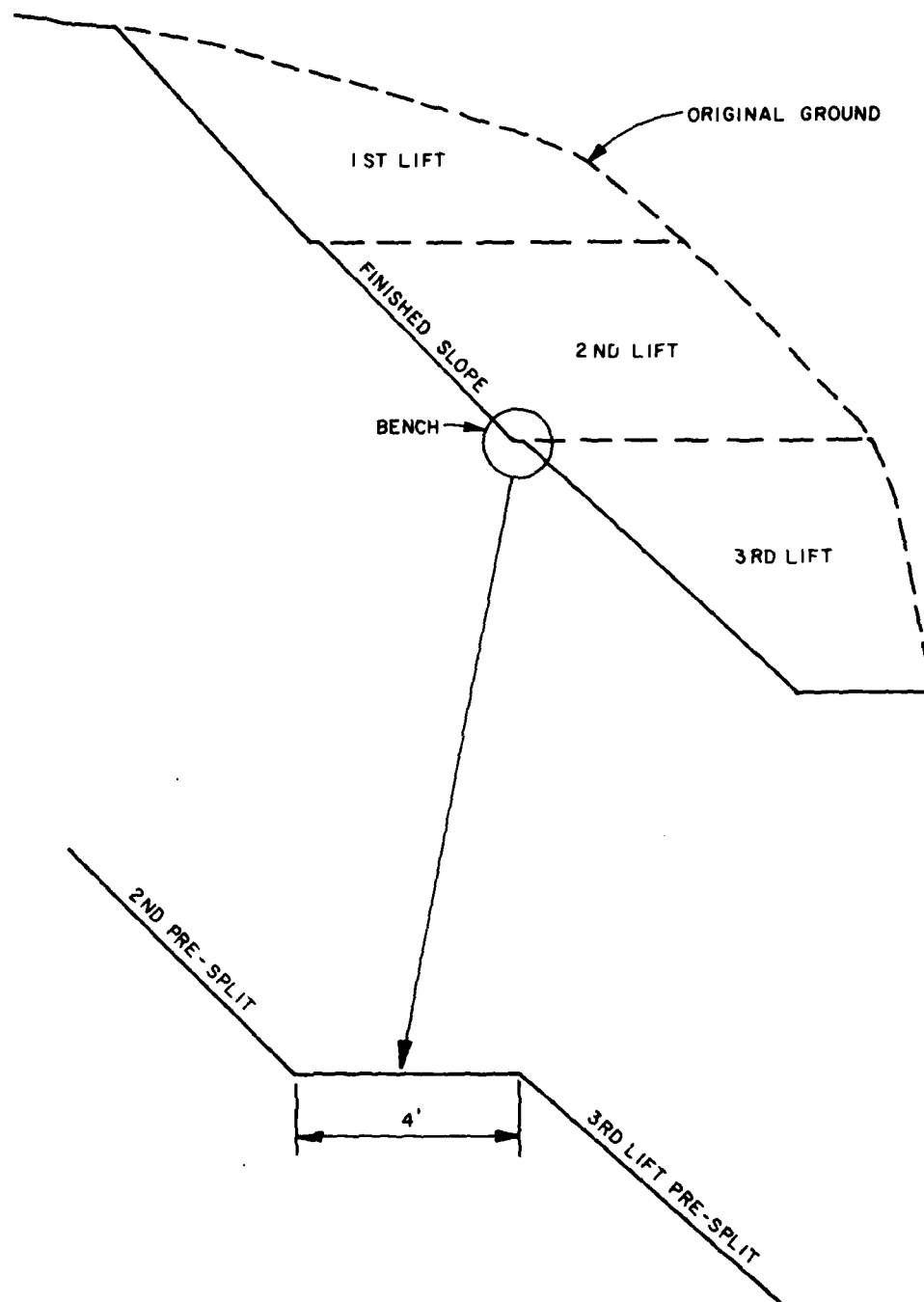
Not to scale

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 KANSAS CITY DISTRICT

FILE NO. B-1-1926

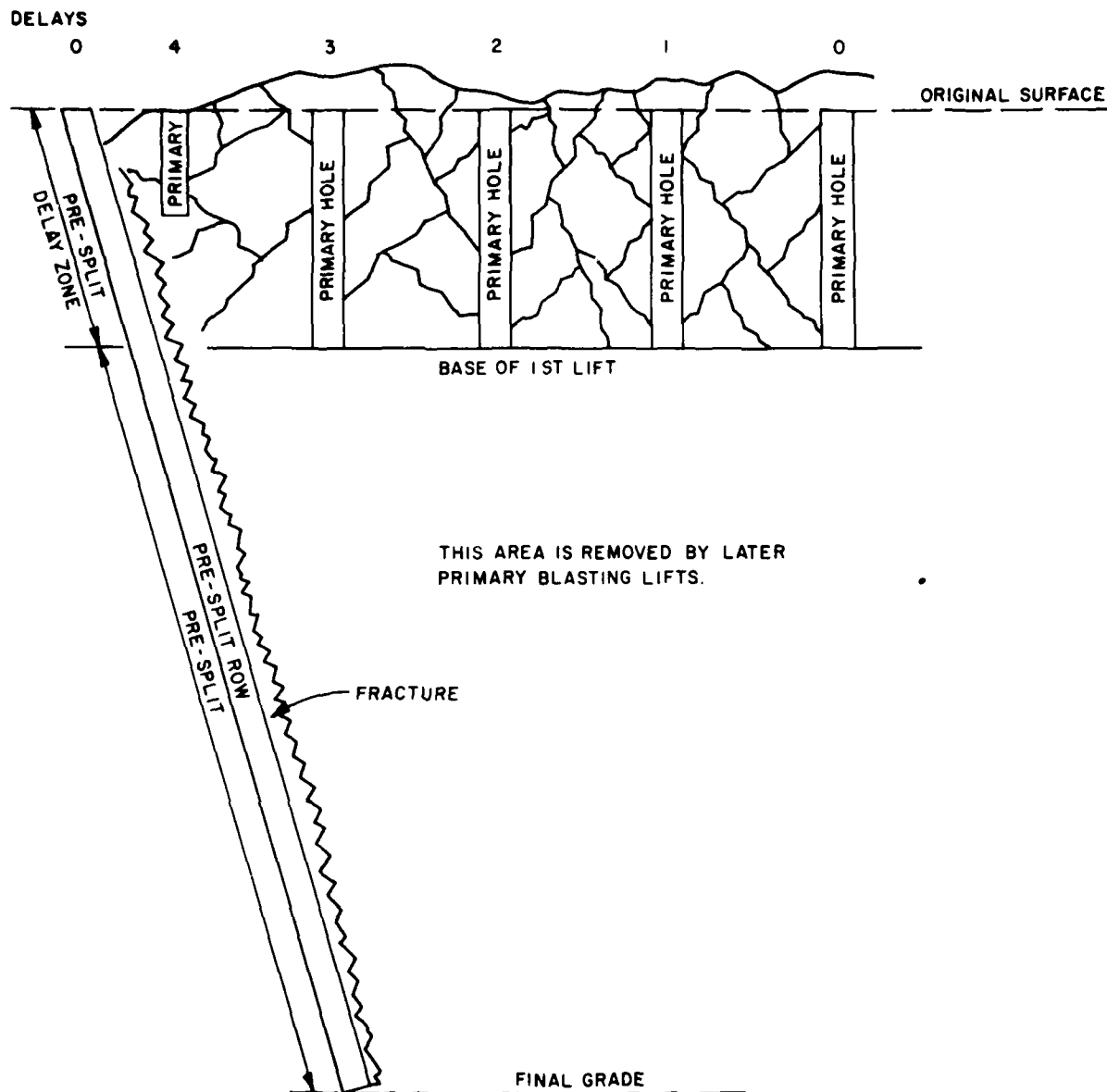
APRIL 1977

FIGURE 6



TYPICAL BENCHES MARKING
PRE-SPLIT LIFTS

FIGURE 7



PRE-SPLIT DELAY BLASTING

FIGURE 8

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

**TYPICAL BENCHES MARKING
 WITH PRE-SPLIT LIFTS
 PRE-SPLIT DELAY BLASTING**

In 1 sheet

Sheet No. 1

Not to scale

CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

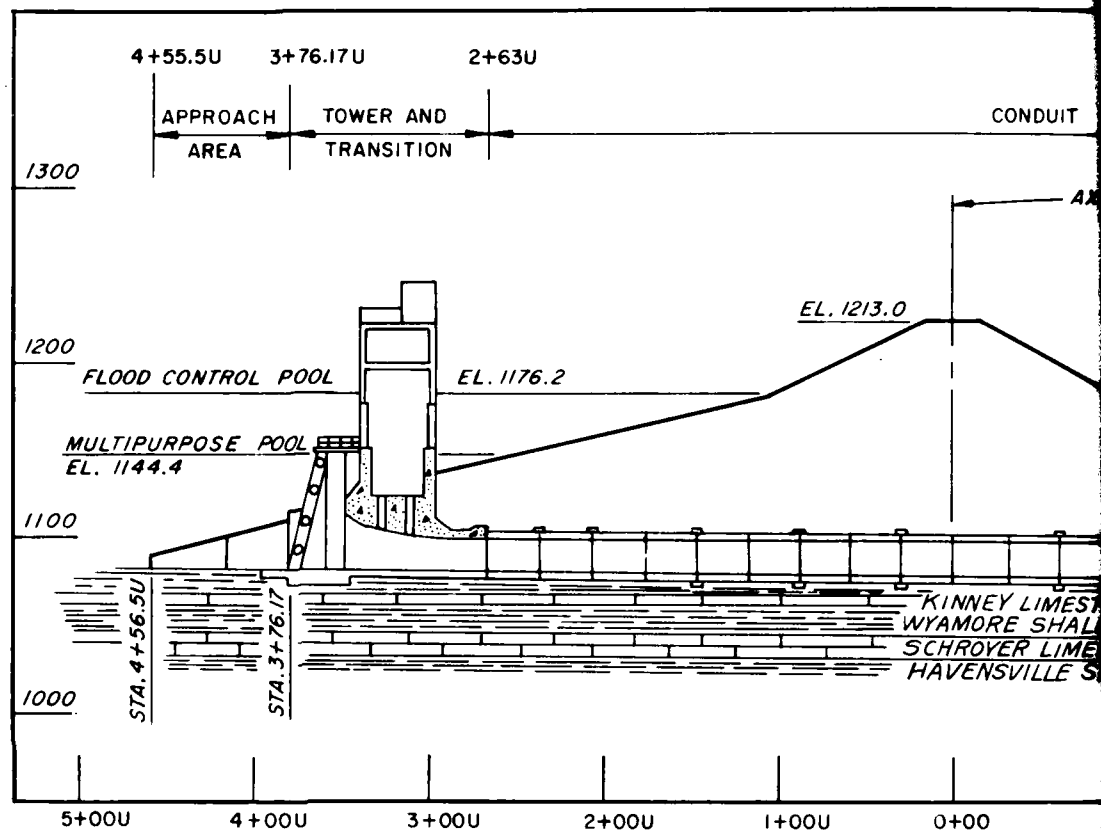
FILE NO. B-1-1927

APRIL 1977

FIGURE 7

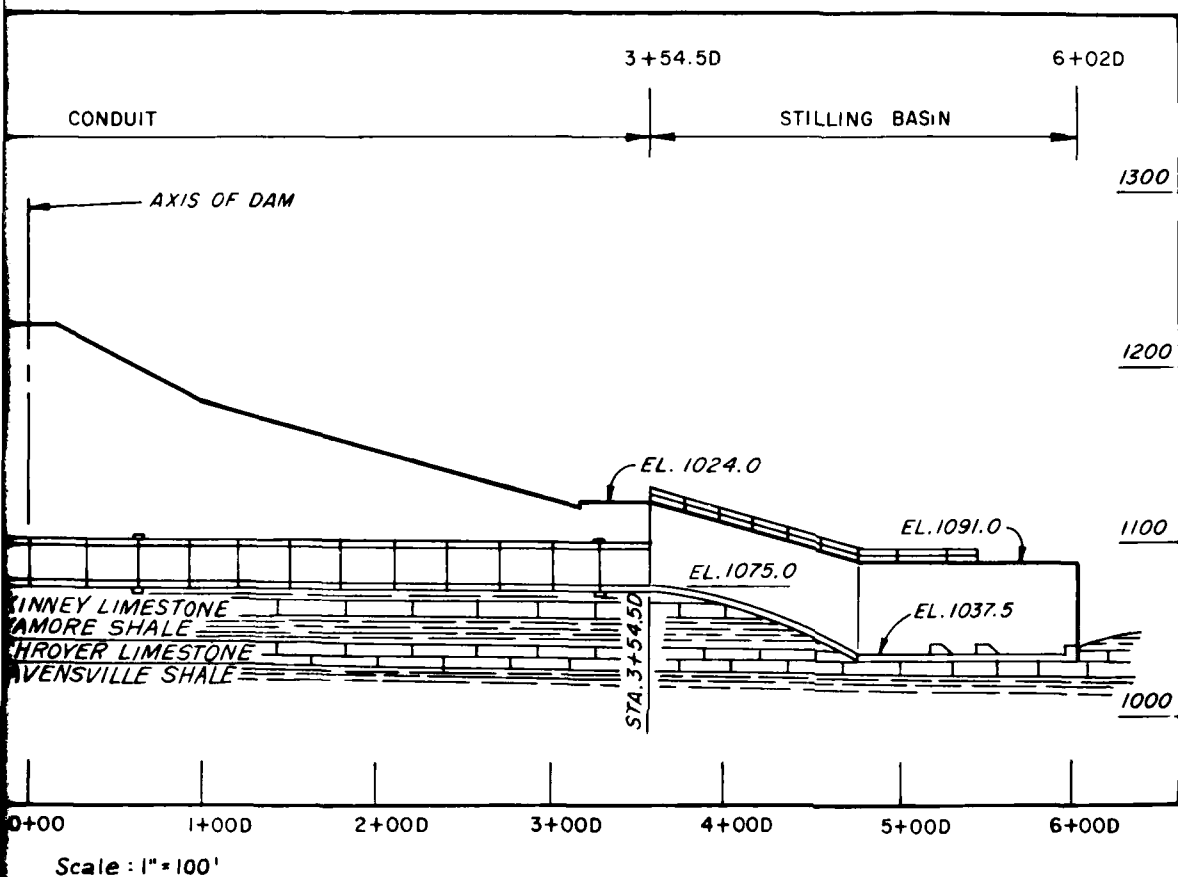
2

EL. IN FT. ABOVE M.S.L.



Scale: 1" = 1'

FIGURE



Scale: 1"=100'

FIGURE 9

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

OUTLET WORKS SECTION

In 1 sheet

Sheet No. 1

Scale: as shown

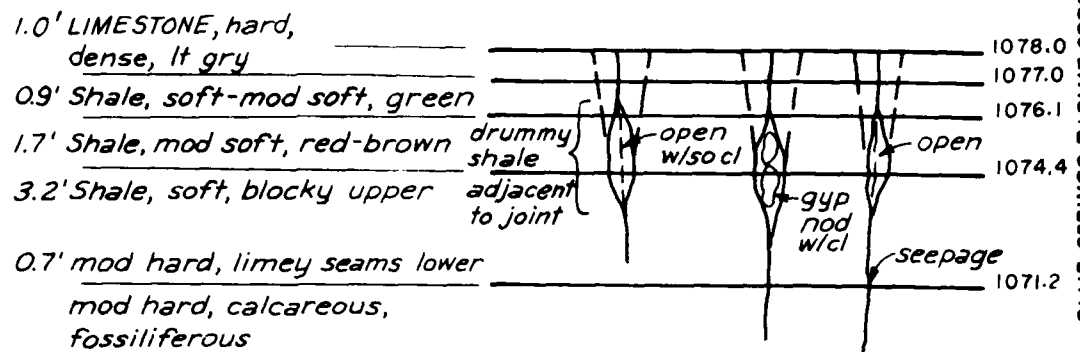
CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

FILE NO. B-1-1928

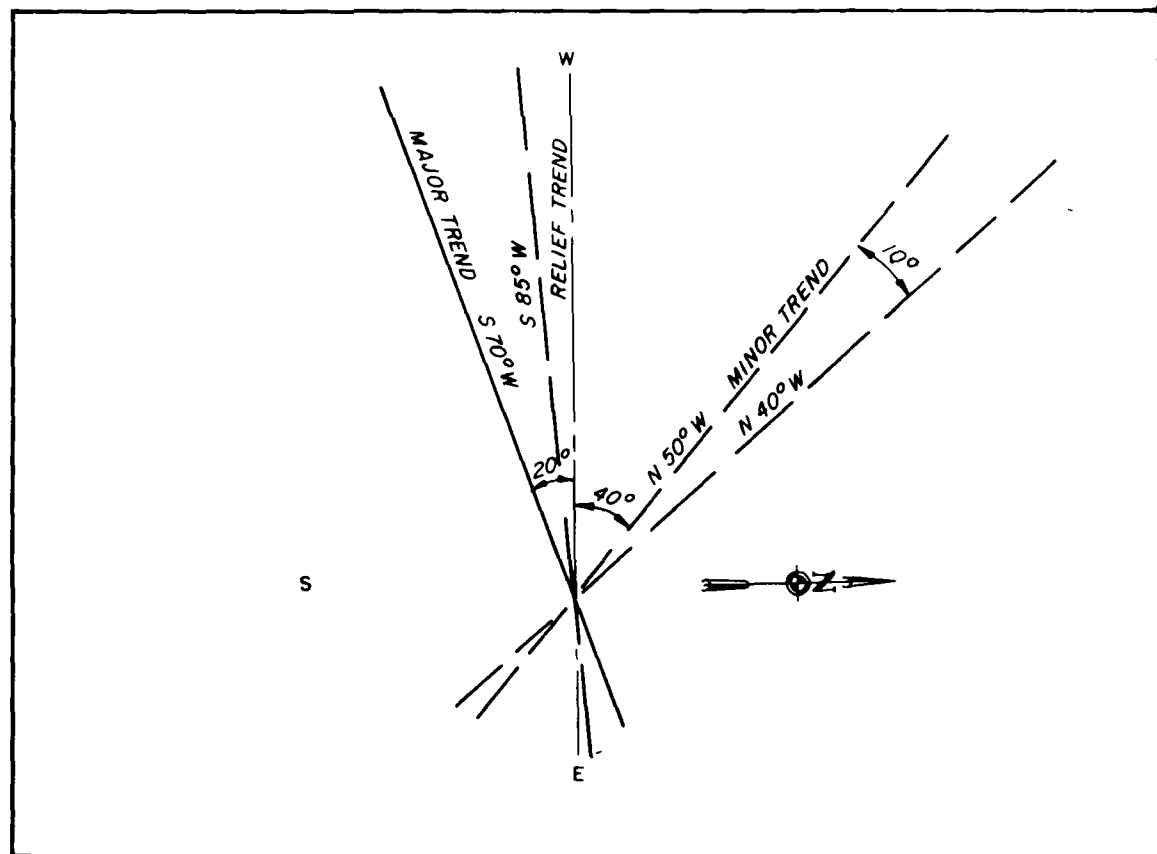
APRIL 1977

FIGURE

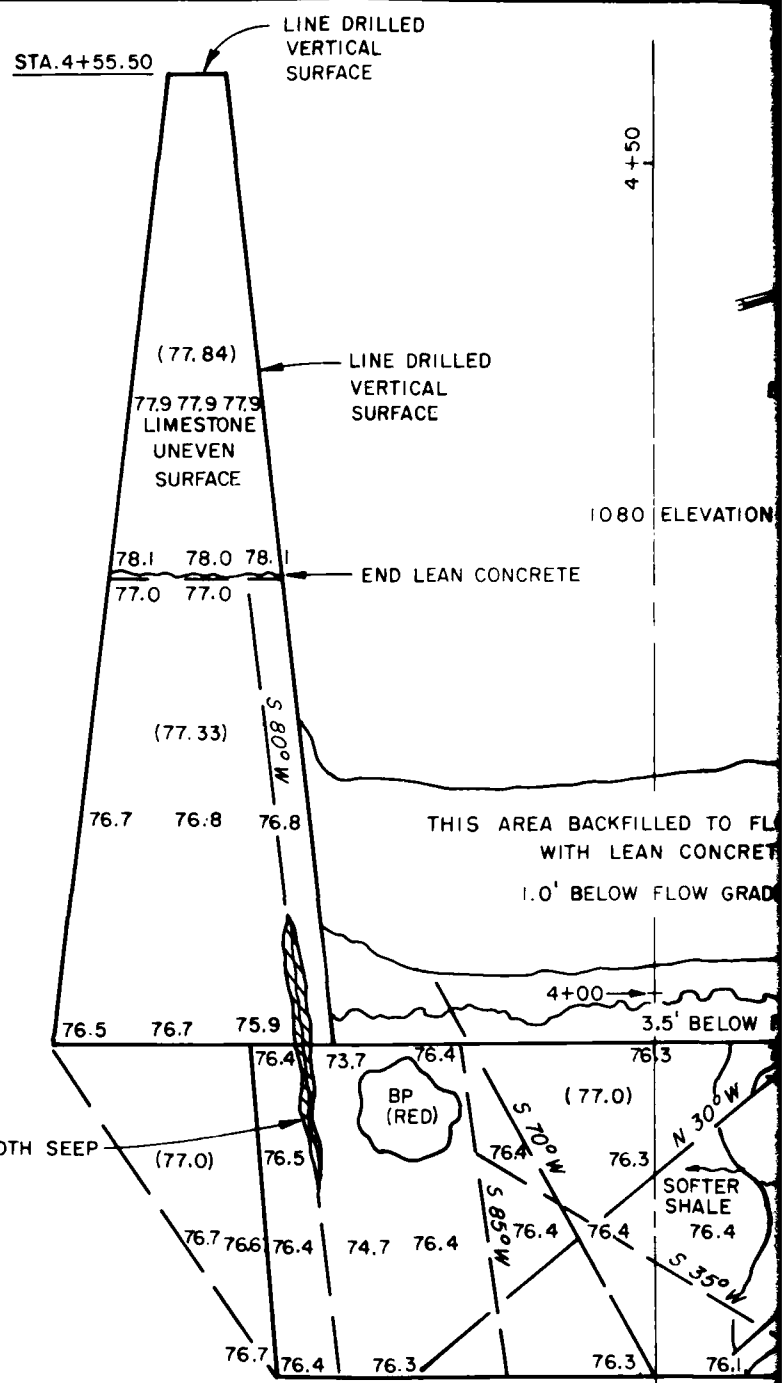
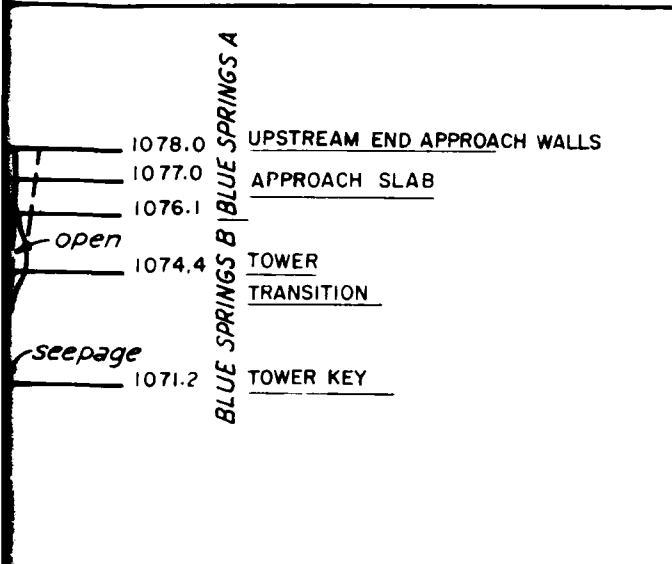
2



JOINT CONDITIONS



JOINT SYSTEM
FIGURE 10



REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

**JOINT SYSTEM AND CONDITIONS
 APPROACH AREA FOUNDATIONS**

In 1 sheet

Sheet No. 1

Not to scale

CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

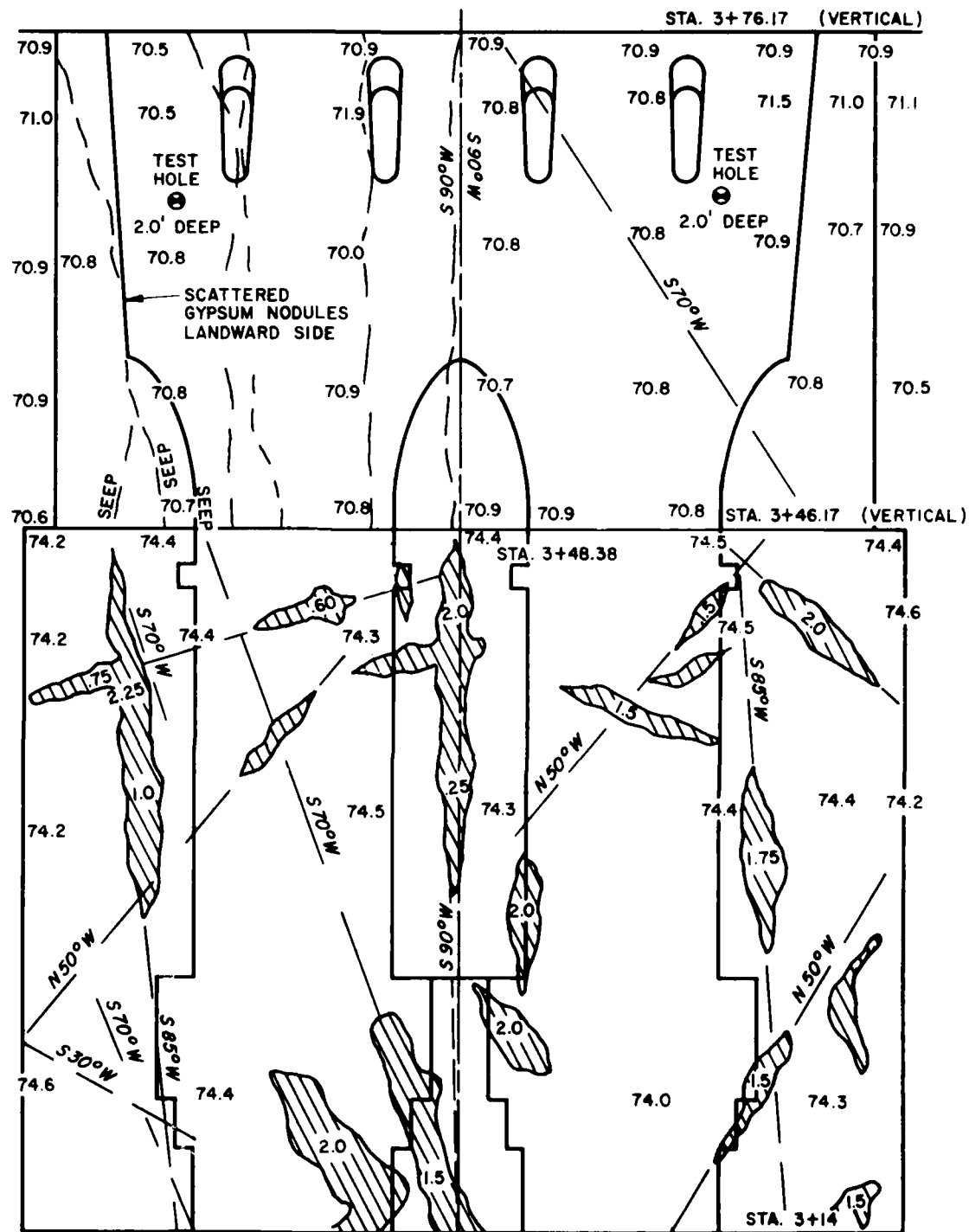
FILE NO. B-1-1929

APRIL 1977

NOTE:
 THEORETICAL ELEVATIONS IN

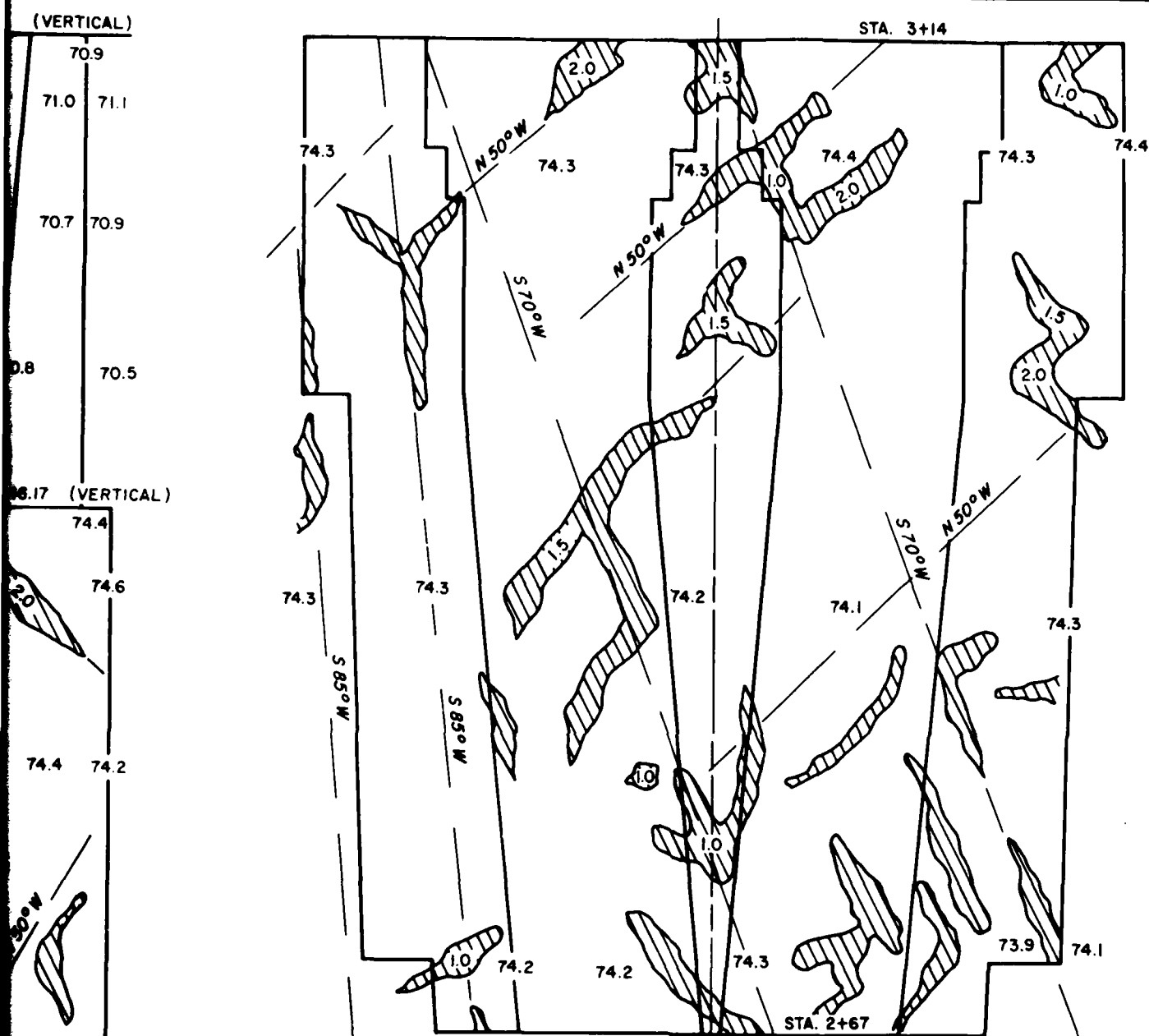
APPROACH AREA

FIGURE



TOWER FOUNDATIONS

FIGURE 12



TRANSITION FOUNDATIONS

FIGURE 13

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

TOWER AND TRANSITION FOUNDATIONS

In 1 sheet

Sheet No. 1

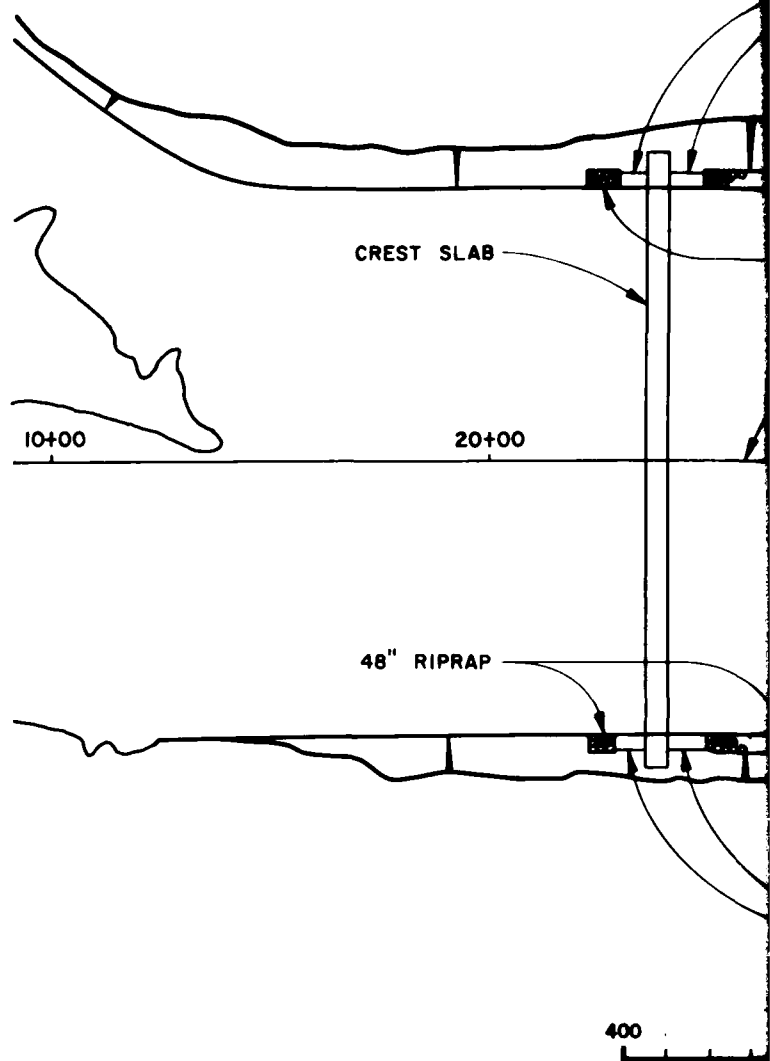
Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1930

APRIL 1977

FIGURE 12a



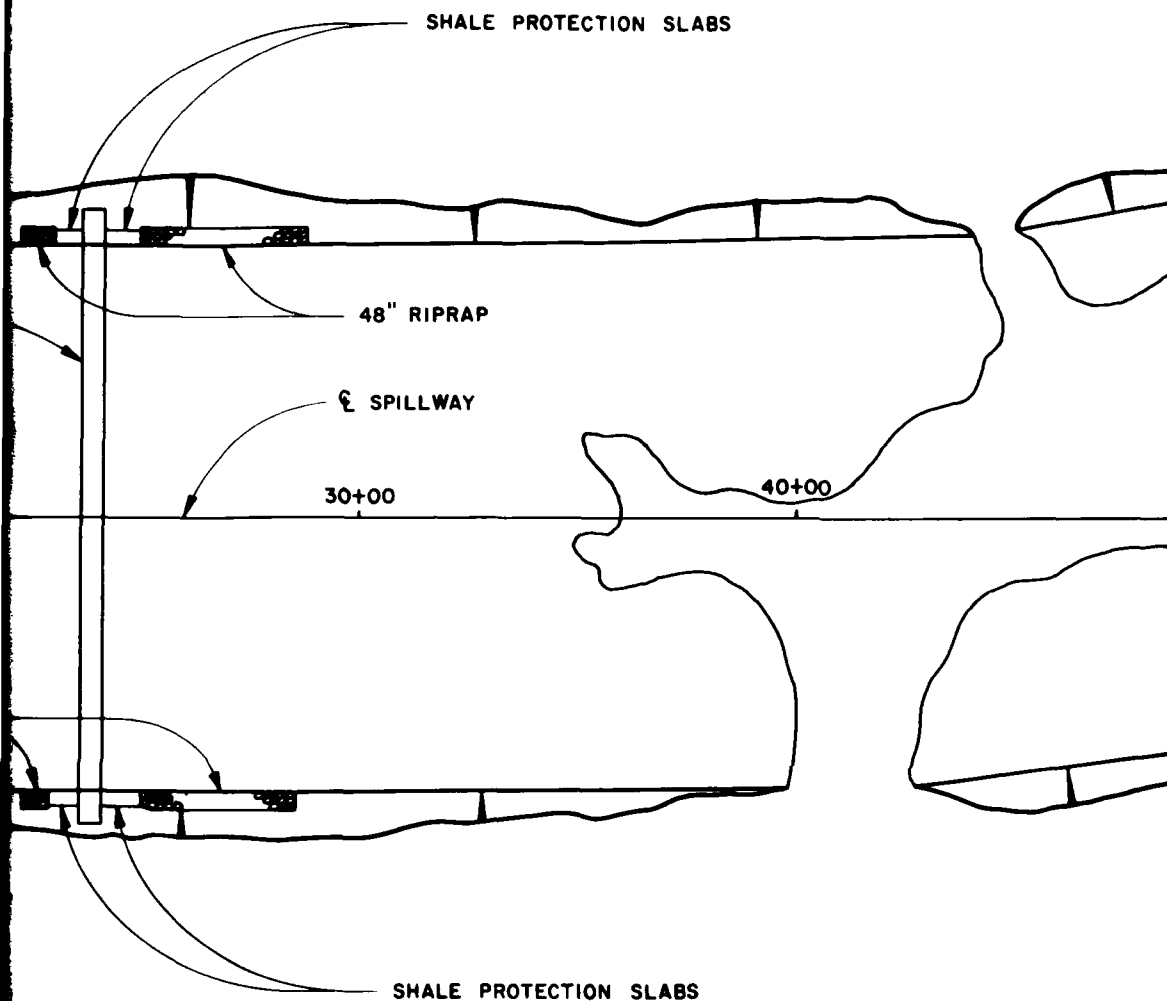


FIGURE 14



REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

SPILLWAY PLAN

In 1 sheet

Sheet No. 1

Scale: as shown

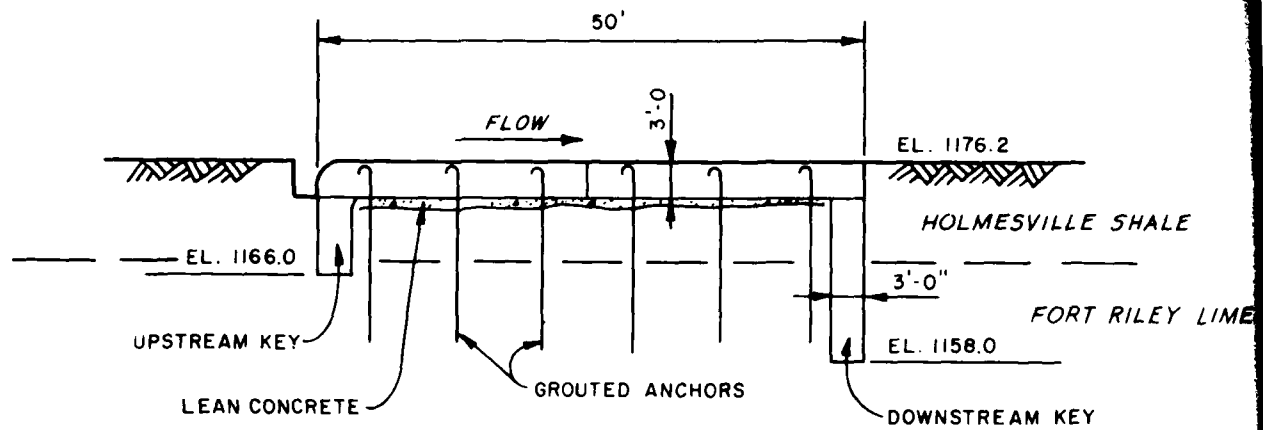
CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

FILE NO. B-1-1931

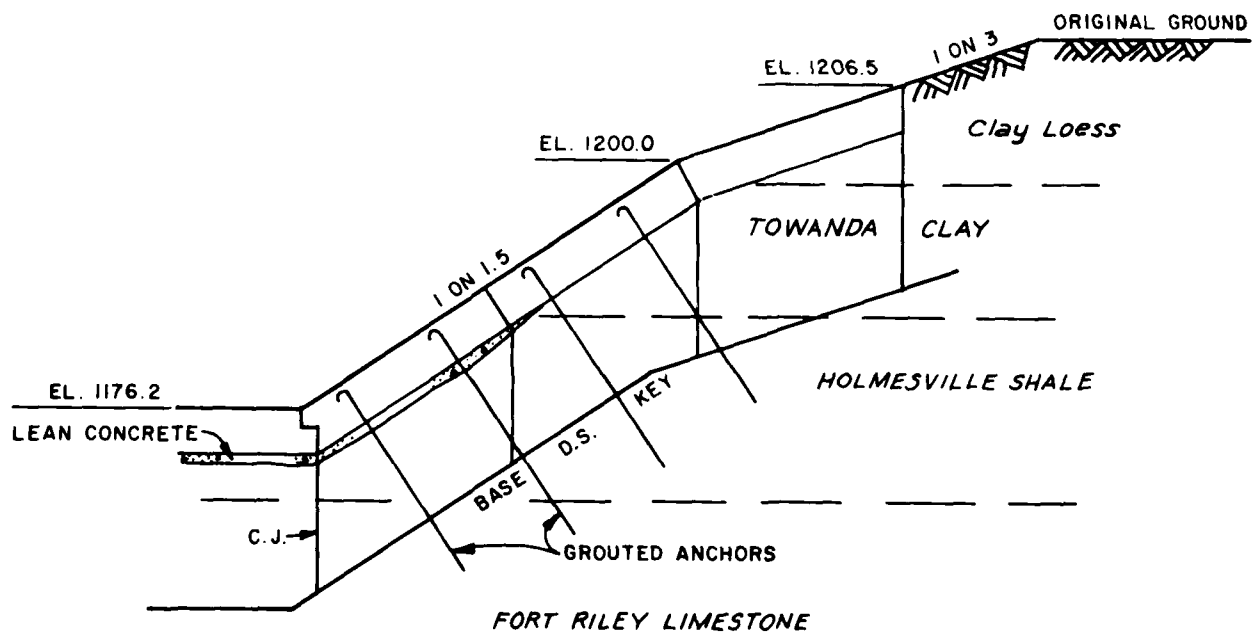
APRIL 1977

FIGURE

2



TYPICAL SECTION
SPILLWAY SILL



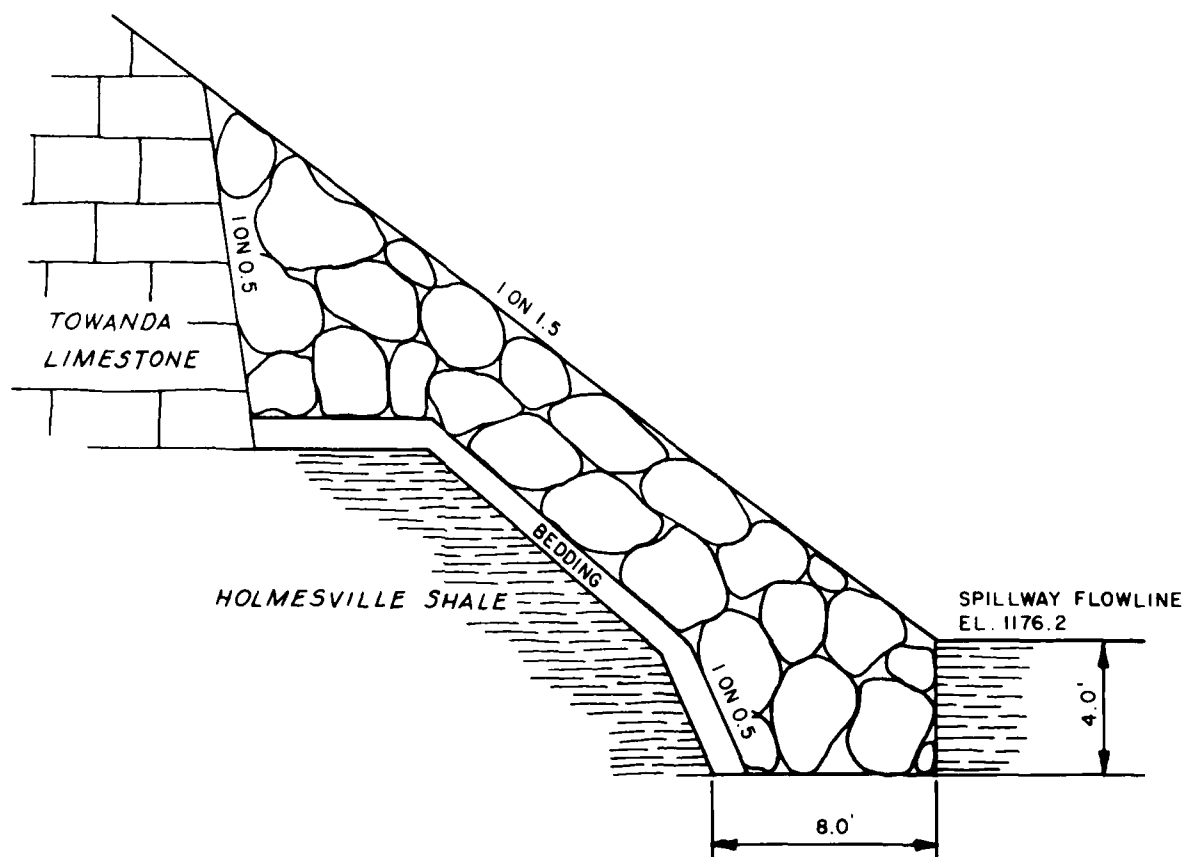
SLOPE SECTION
SPILLWAY SILL

FIGURE 15

E SHALE
T RILEY LIMESTONE

ORIGINAL GROUND

SS



SPILLWAY 48" RIPRAP

FIGURE 16

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

**SPILLWAY SILL AND
SPILLWAY RIPRAP**

In 1 sheet

Sheet No. 1

Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1932

APRIL 1977

FIGURE 15 & 16

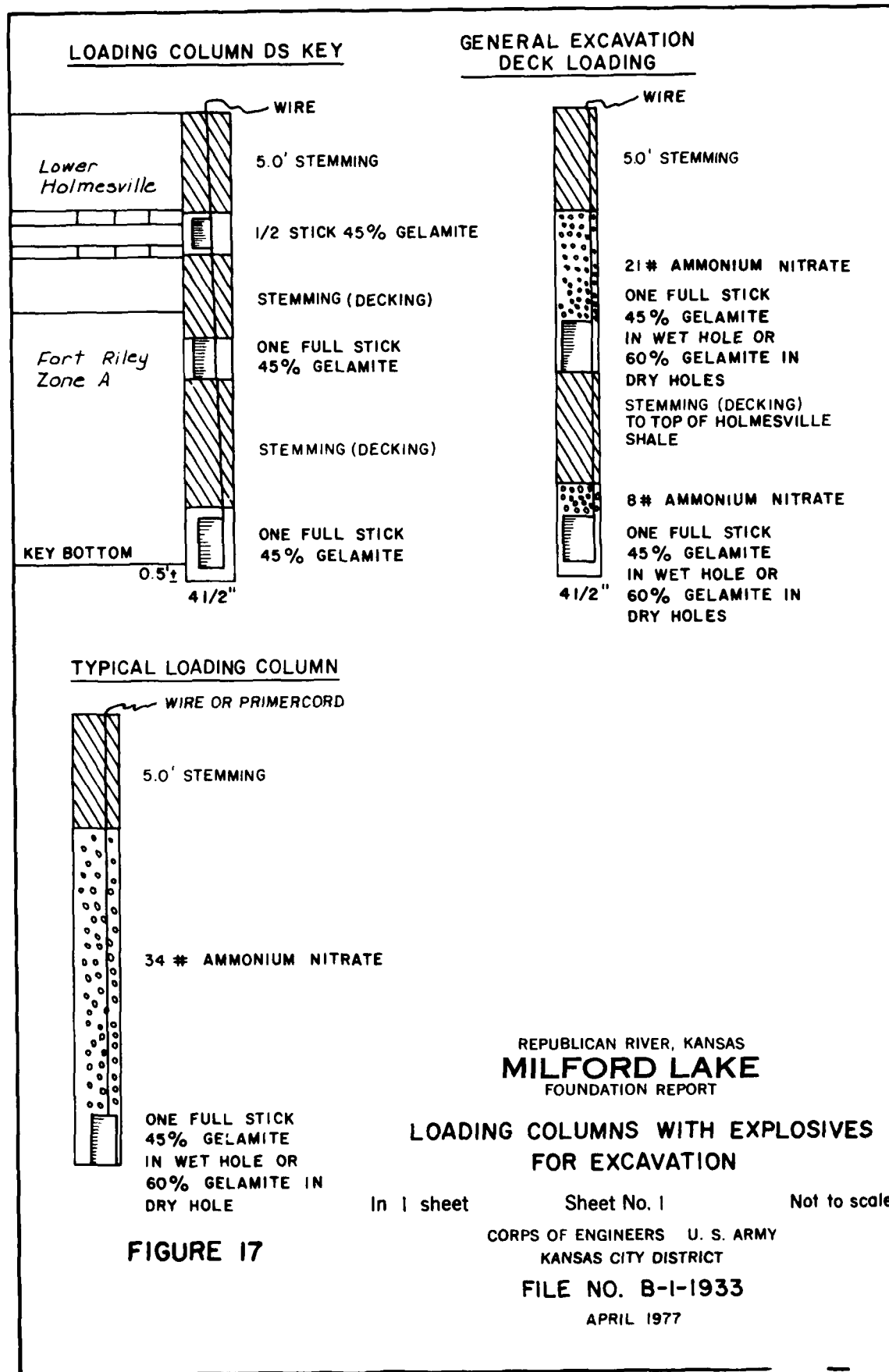
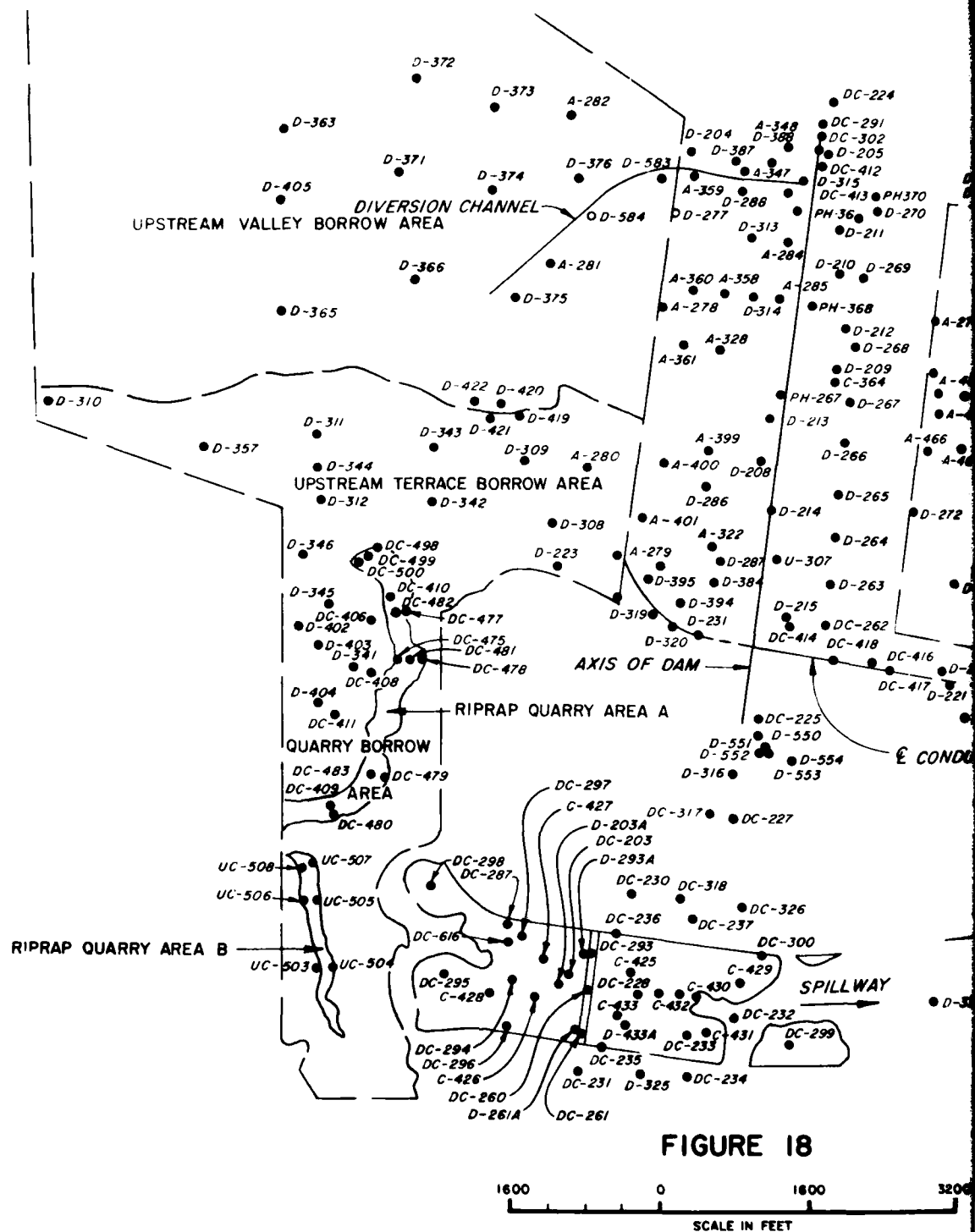
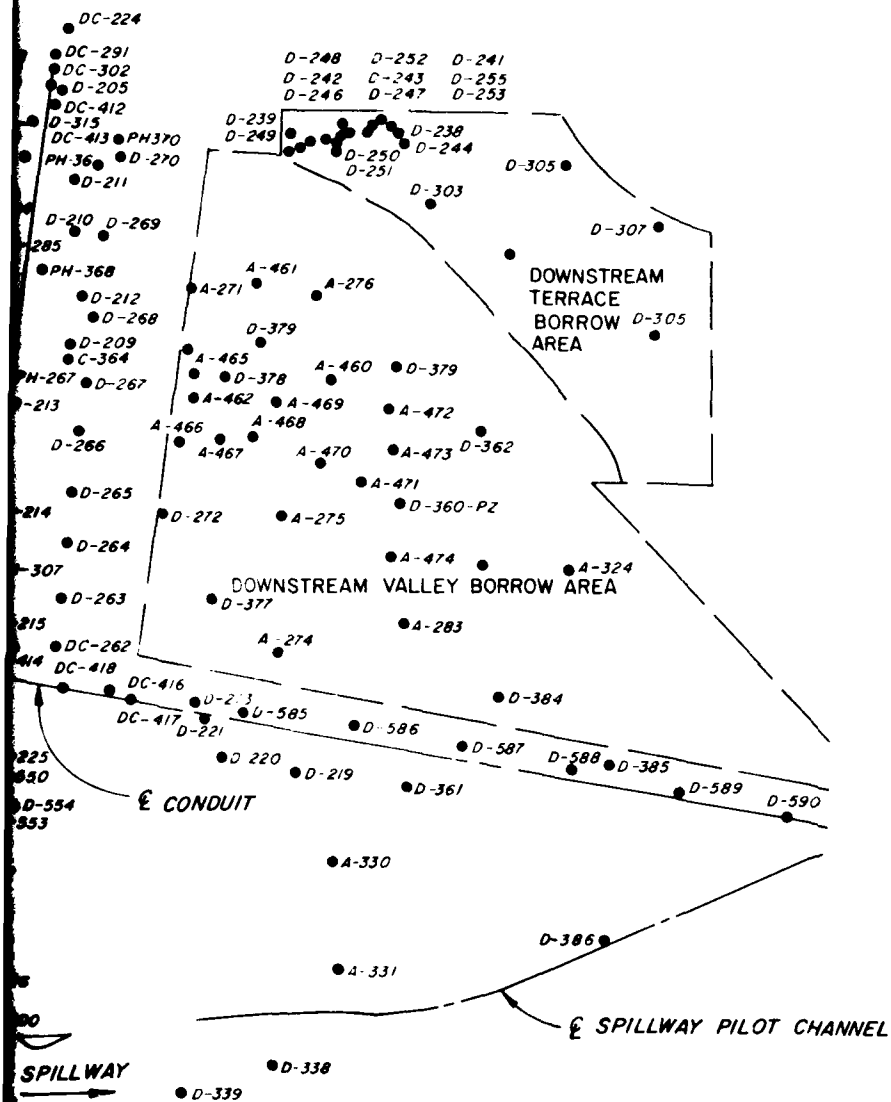


FIGURE 17

FIGURE 17





LEGEND

A = AUGER HOLE
 C = CORE HOLE
 D = DRIVE HOLE
 PH = PROBE HOLE
 U = UNDISTURBED SAMPLING

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

PLAN OF UNDERGROUND EXPLORATIONS

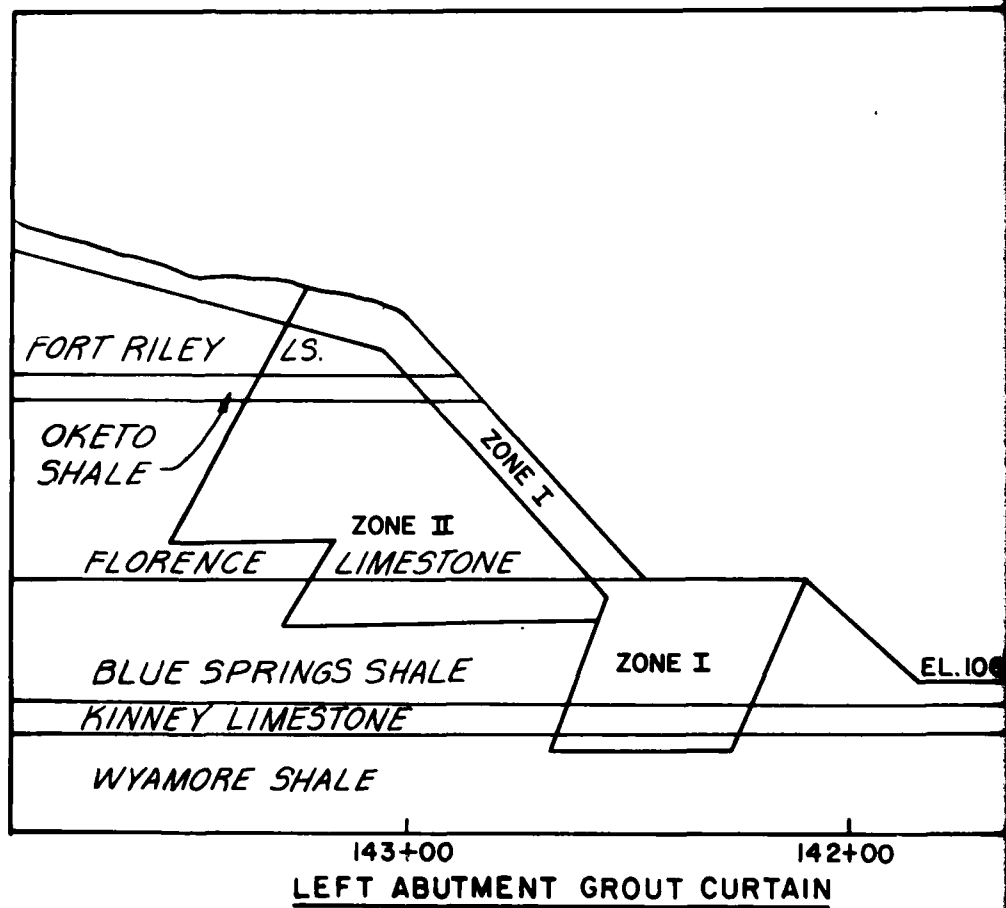
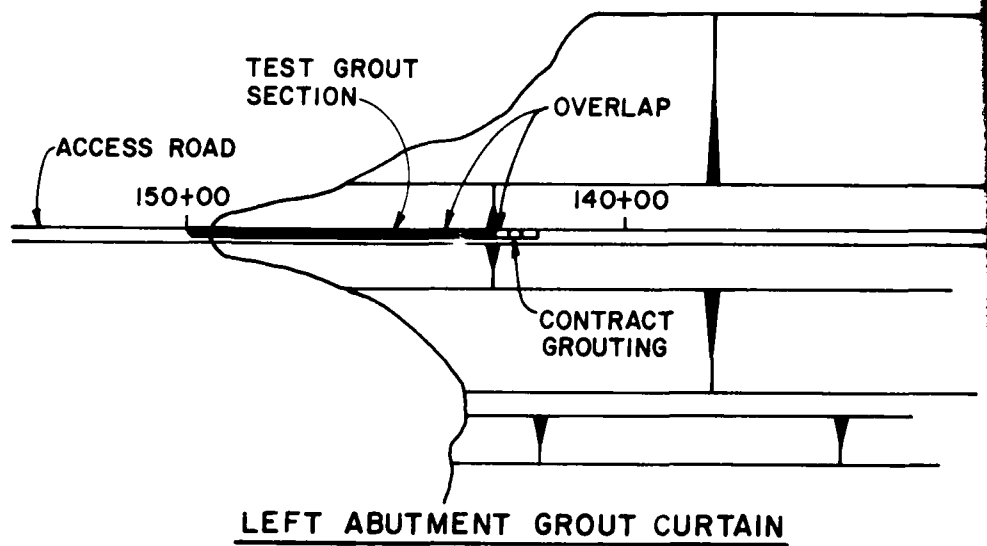
In 1 sheet Sheet No. 1 Scale as shown

CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

FILE NO. B-1-1934

APRIL 1977

FIGURE



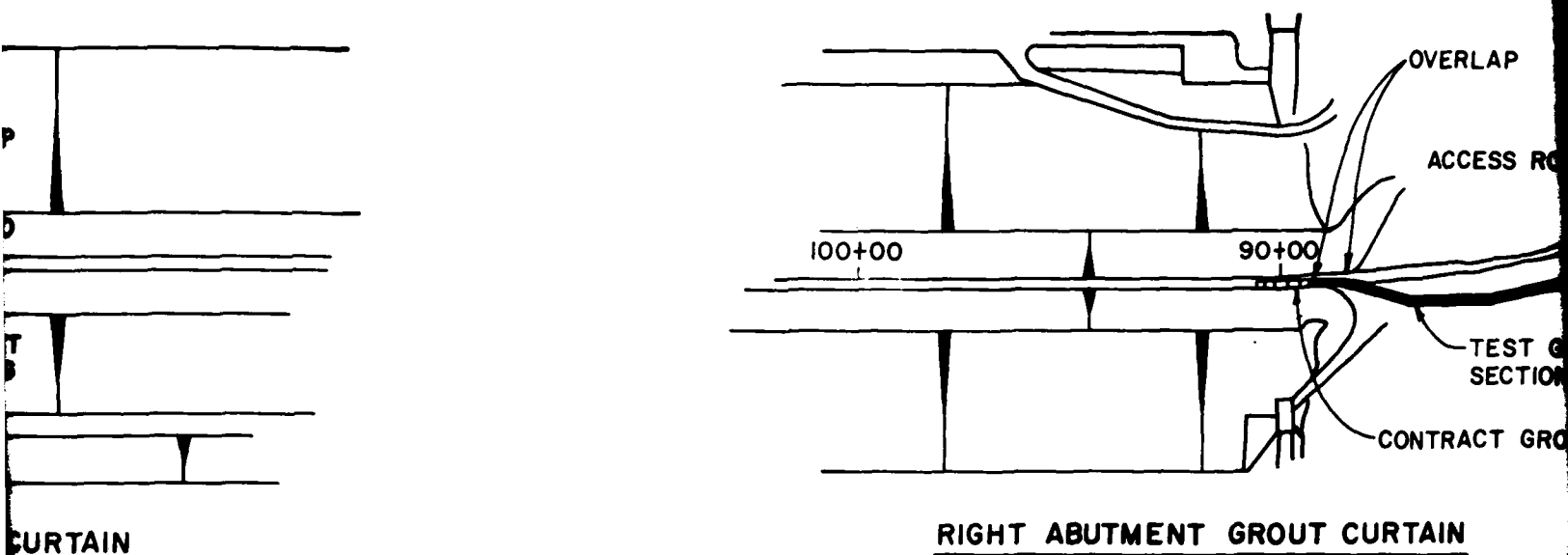


FIGURE 19

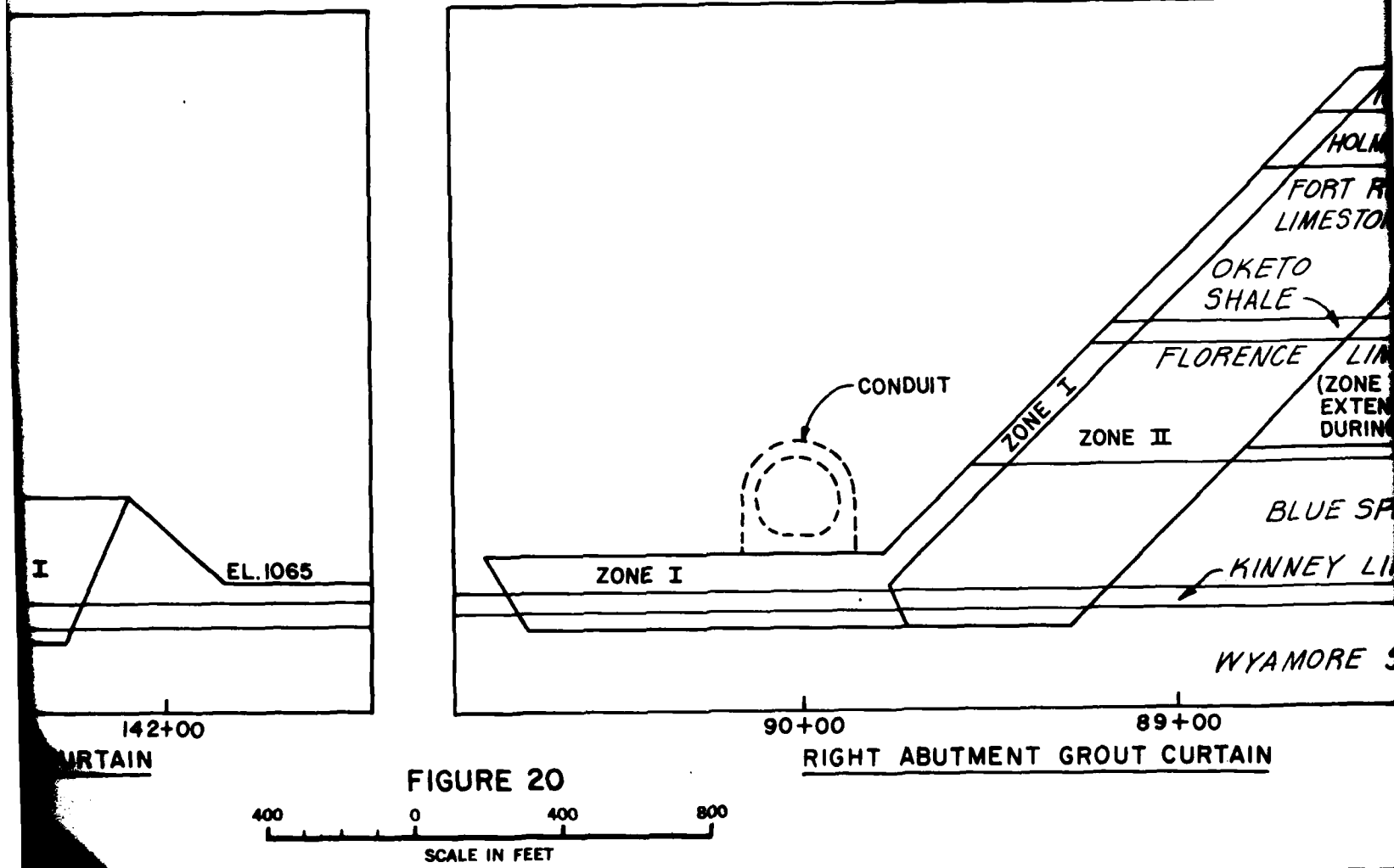
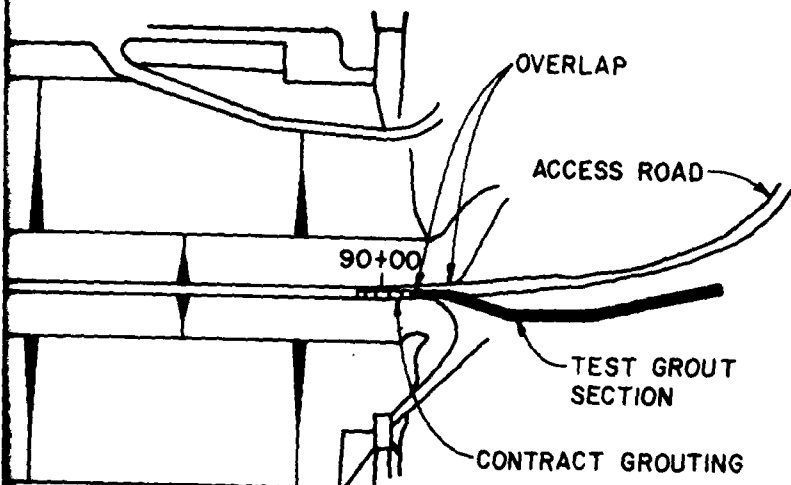
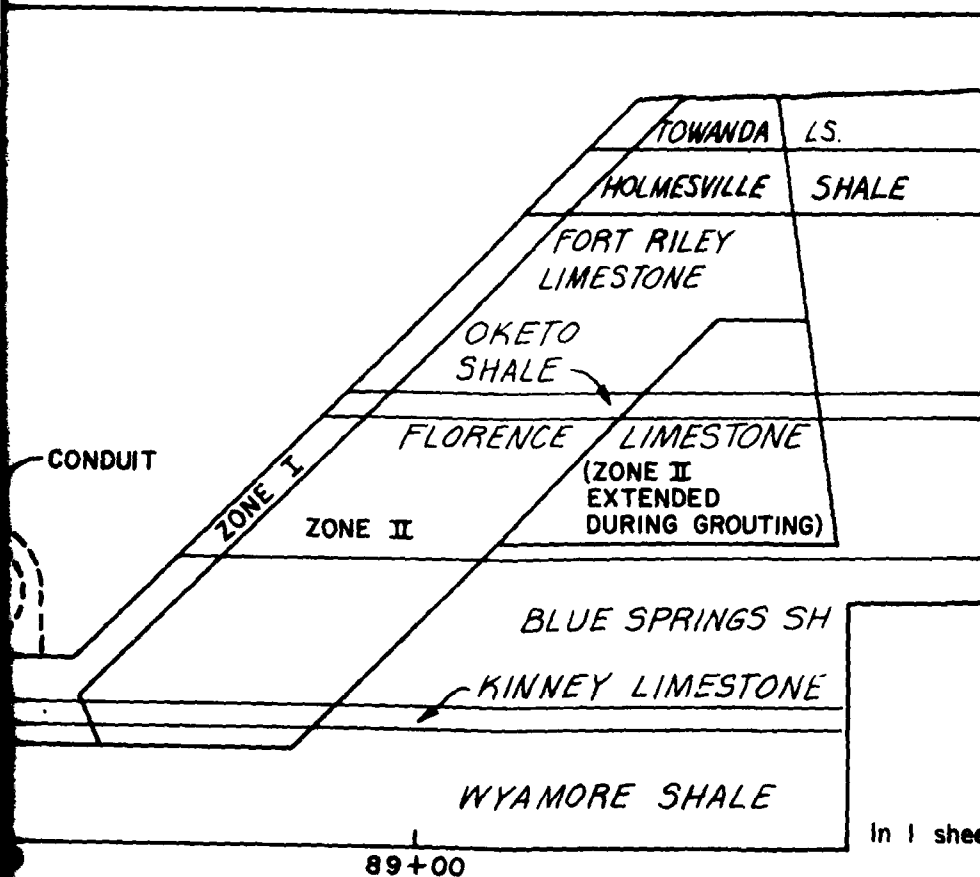


FIGURE 20



RIGHT ABUTMENT GROUT CURTAIN



LEFT ABUTMENT GROUT CURTAIN

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

**LEFT AND RIGHT ABUTMENT
 GROUT CURTAINS**

(LOOKING DOWNSTREAM)

Sheet No. 1

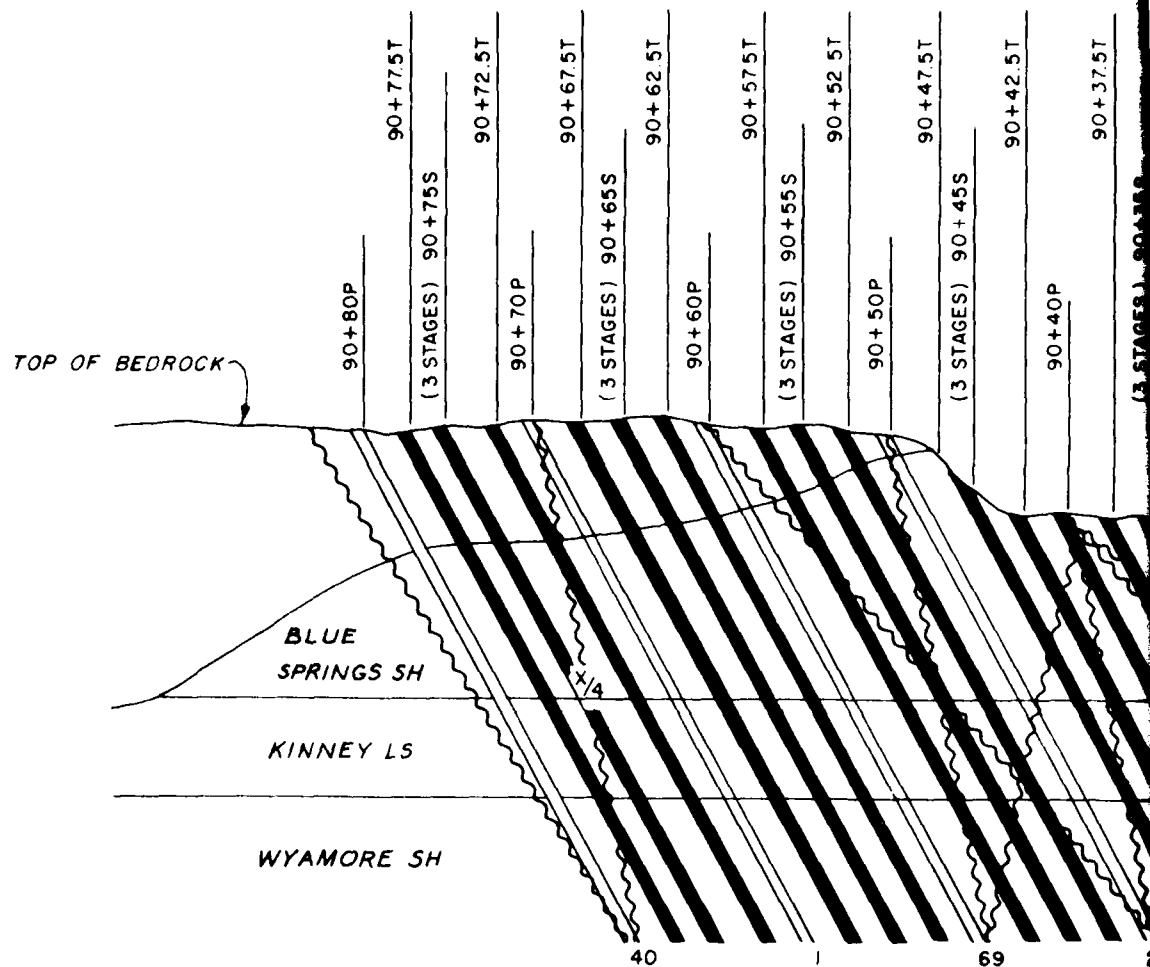
Scale: as shown

In 1 sheet

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 KANSAS CITY DISTRICT

FILE NO. B-1-1935

APRIL 1977



LEGEND

NO PRESSURE TEST ———— X

PRESSURE TEST 28 GPM / 116 BAGS PLACED ——— 28/116

OPEN ZONE ————

TIGHT ————

PRIMARY COMMUNICATION ————

SECONDARY COMMUNICATION ————

NOTE:

GROUT FIGURES @ BOTTOM OF HOLE = TAKE DEPTH UNKNOWN.

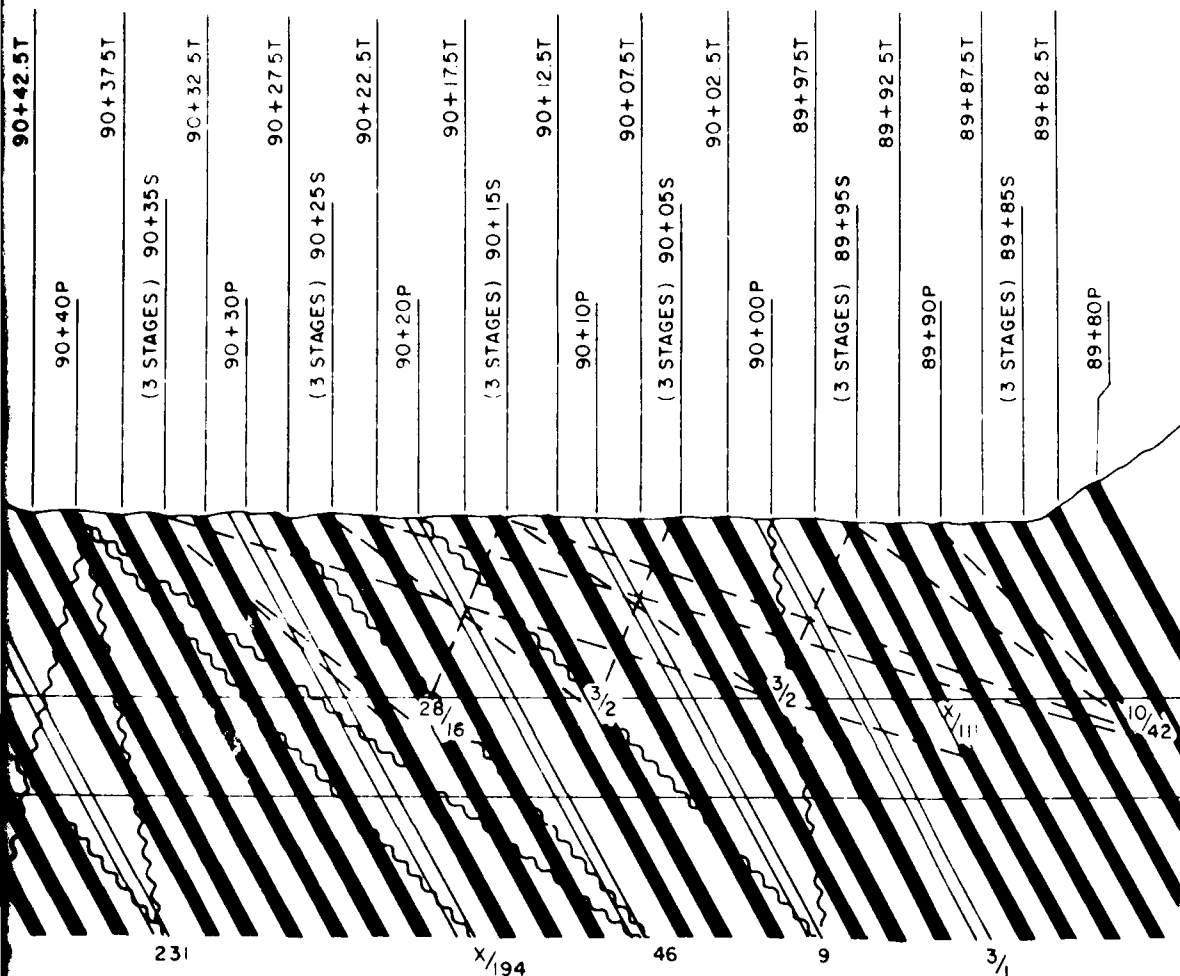


FIGURE 21

SECTION I			
11	PRIMARY	308.8'	591 SACKS
10	SECONDARY	298.3'	177 SACKS
20	TERTIARY	572.9'	0 SACKS

REPUBLICAN RIVER, KANSAS
MILFORD LAKE

FOUNDATION REPORT

GROUT LINE
RIGHT ABUTMENT
SECTION I

In 1 sheet

Sheet No. 1

Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1936

APRIL 1977

(LOOKING DOWNSTREAM)

FIGURE

2

ELEVATION IN FEET ABOVE MEAN SEA LEVEL

TOP OF DAM

LEGEND

PRESSURE TEST G.P.M. ———— 5
 GROUT PLACED, BAGS ———— 2 TIGHT
 SURFACE FLOW ————
 100% DRILL WATER LOSS ———— ◆
 TEMPORARY WATER LOSS ———— ◇
 PARTIAL WATER LOSS ———— ○
 GROUT PLACEMENT NOT PINPOINTED ————
 BAGS PLACED IN INTERVAL ———— (2)
 PRIMARY HOLE ———— P
 SECONDARY HOLE ———— S

1200

1180

1160

1140

1120

1100

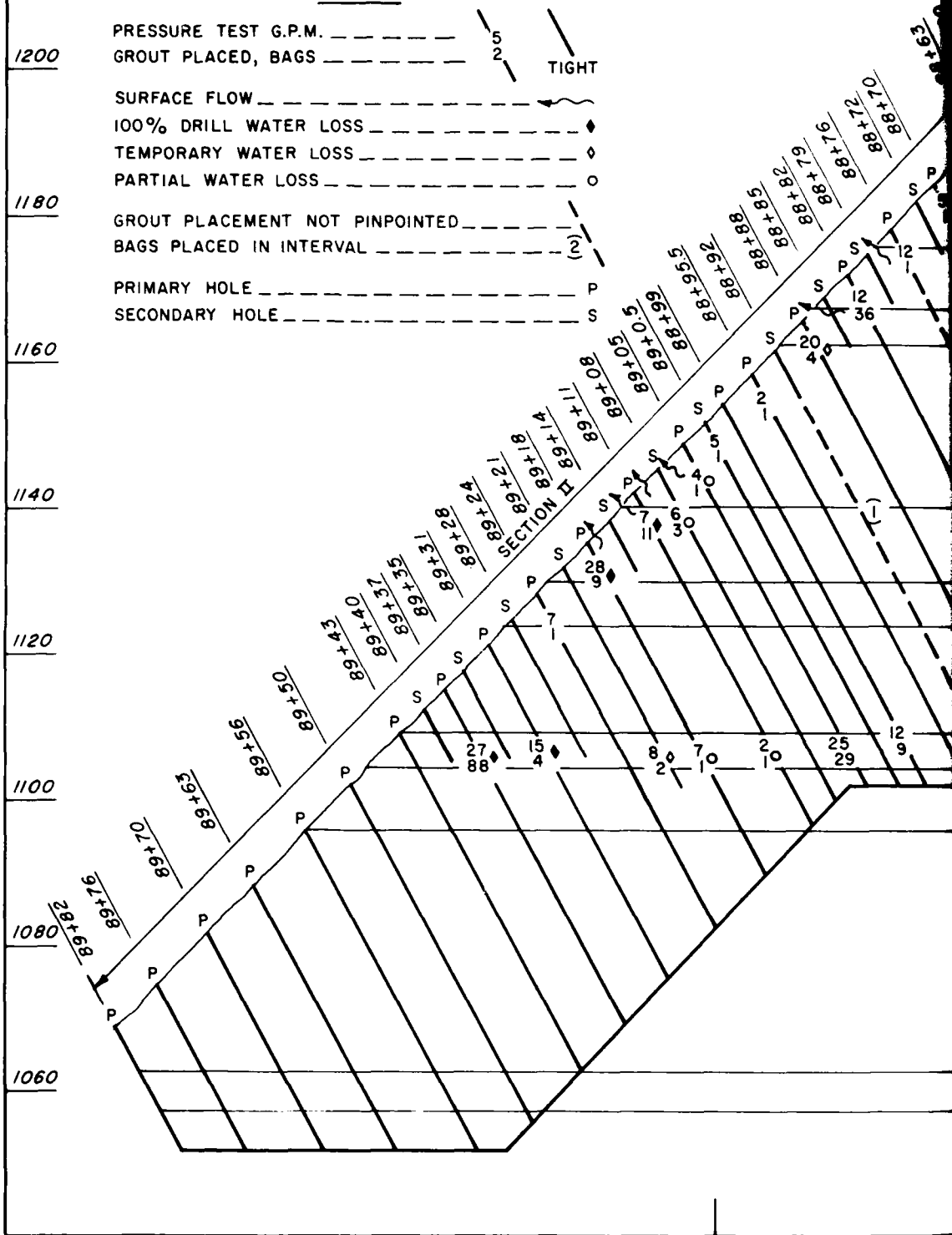
1080

1060

SECTION II

19 PRIMARY 903.6' 201 SACKS
 11 SECONDARY 283.8' 7 SACKS

89+00



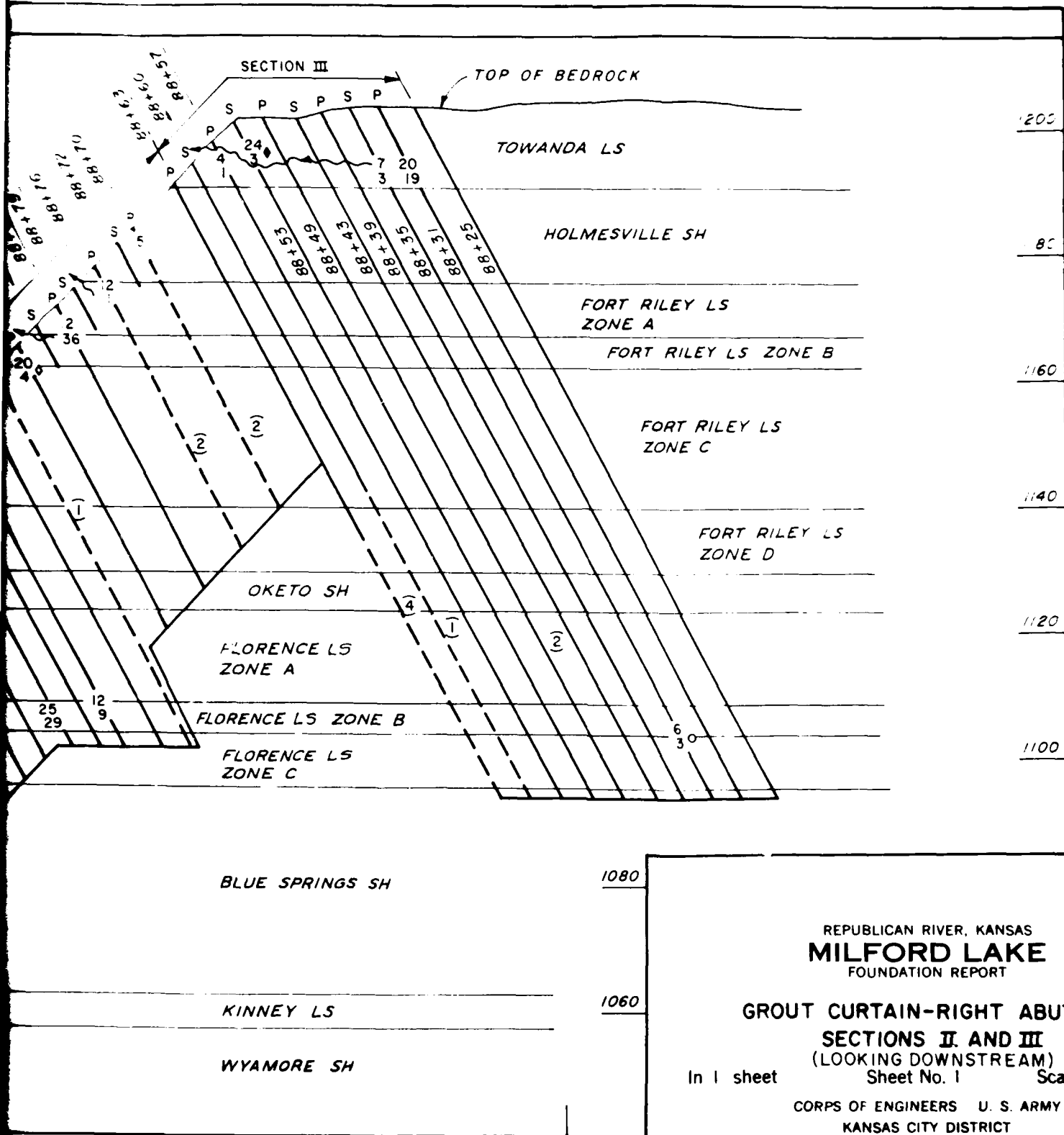


FIGURE 22

SECTION III

5 PRIMARY	559.6'	7 SACKS
4 SECONDARY	483'	7 SACKS

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

GROUT CURTAIN-RIGHT ABUTMENT
SECTIONS II AND III
(LOOKING DOWNSTREAM)

In 1 sheet

Sheet No. 1

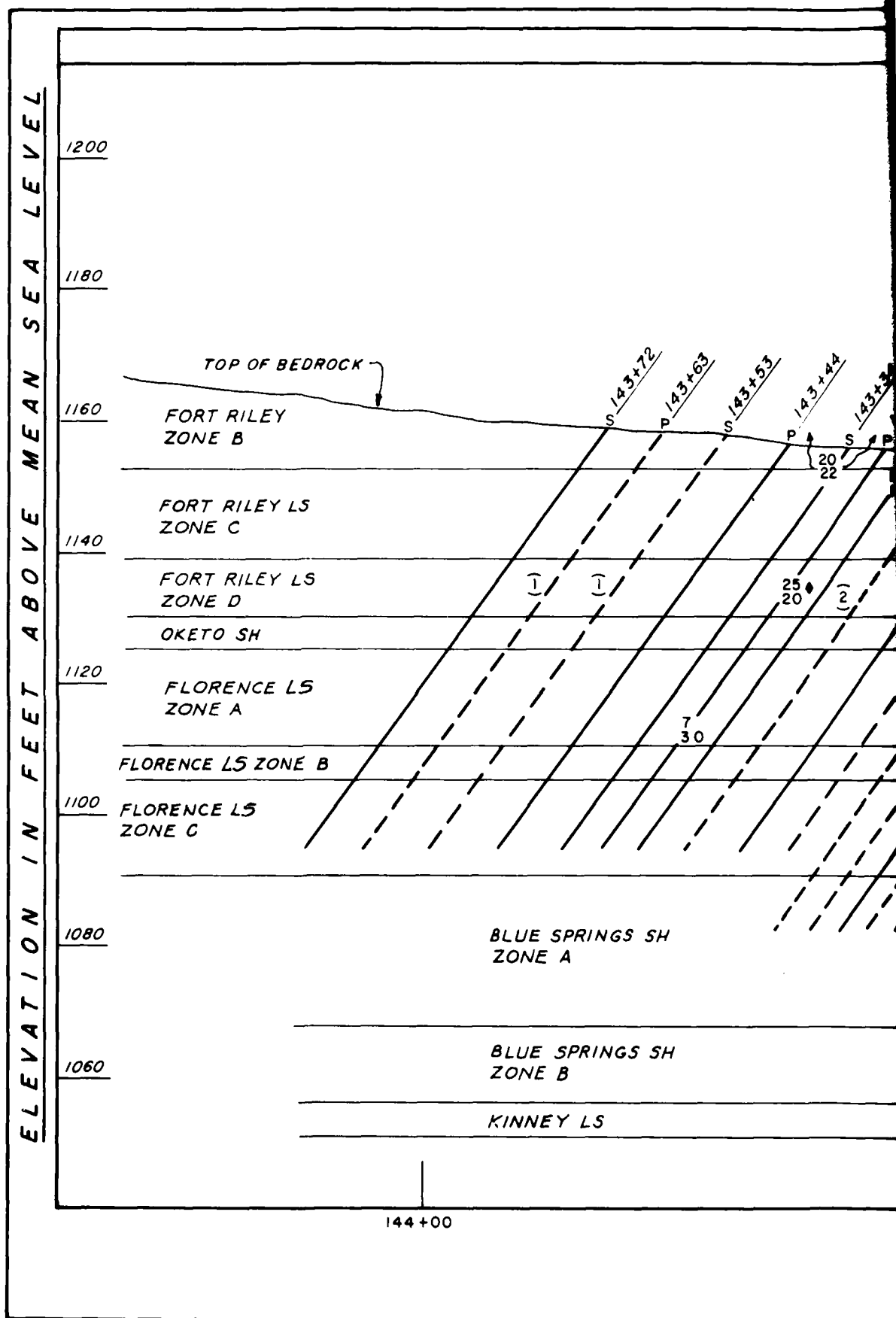
Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1937

APRIL 1977

FIGURE 22



TOP OF DAM

1200

In

1180

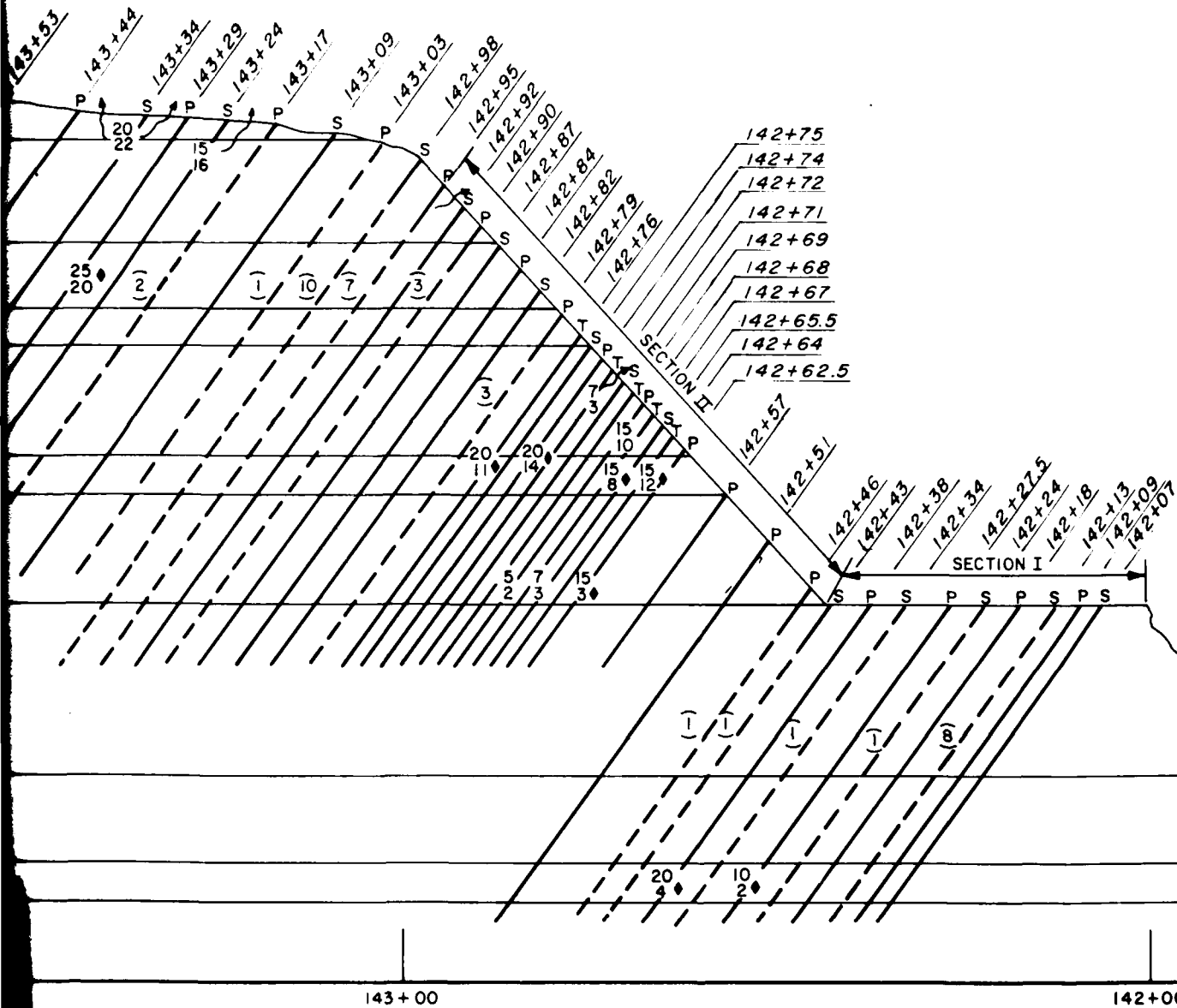


FIGURE 23

NOTE:
FOR

2

OF DAM

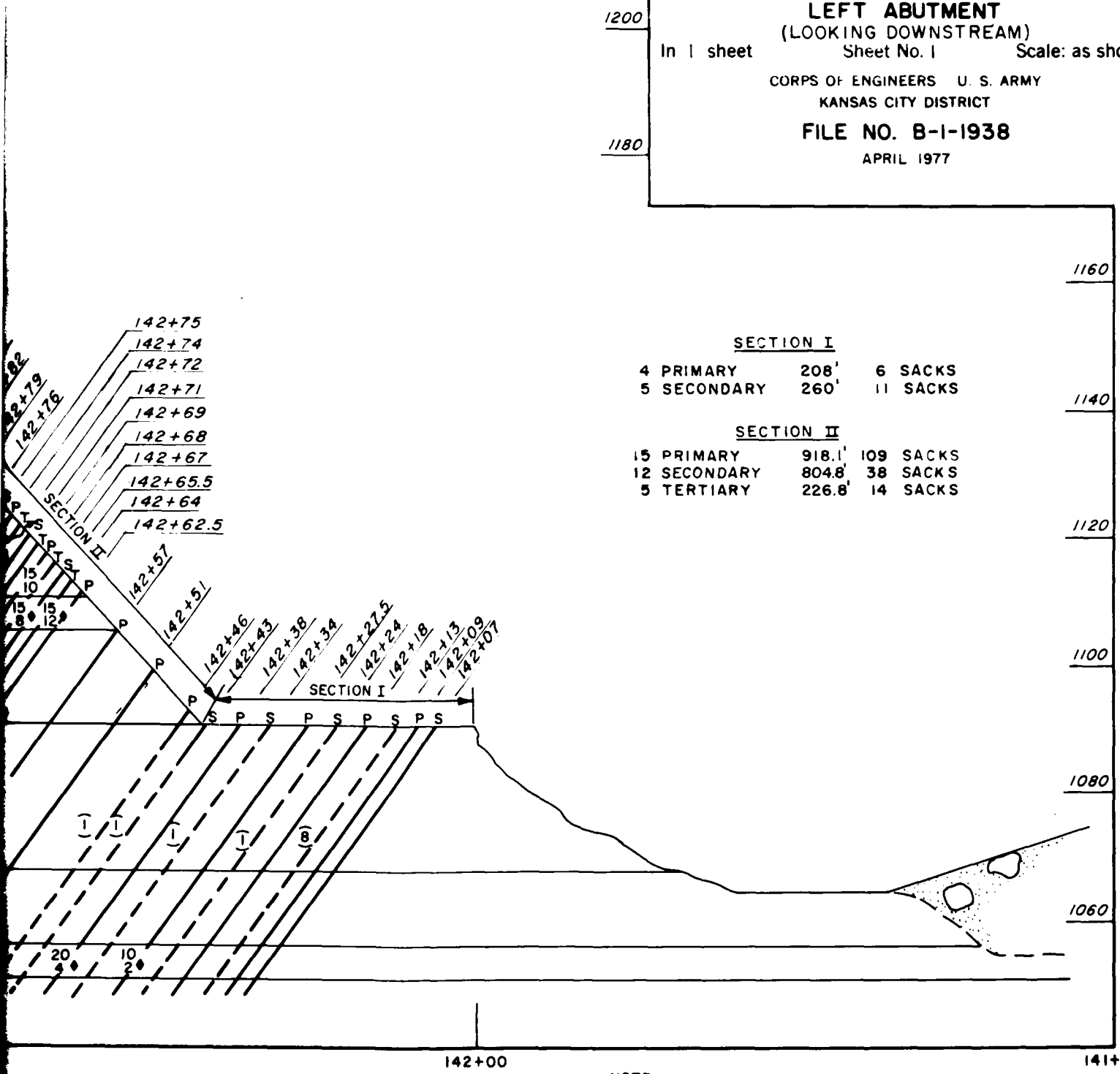
REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

GROUT CURTAIN
LEFT ABUTMENT
(LOOKING DOWNSTREAM)

In 1 sheet Sheet No. 1 Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1938
APRIL 1977



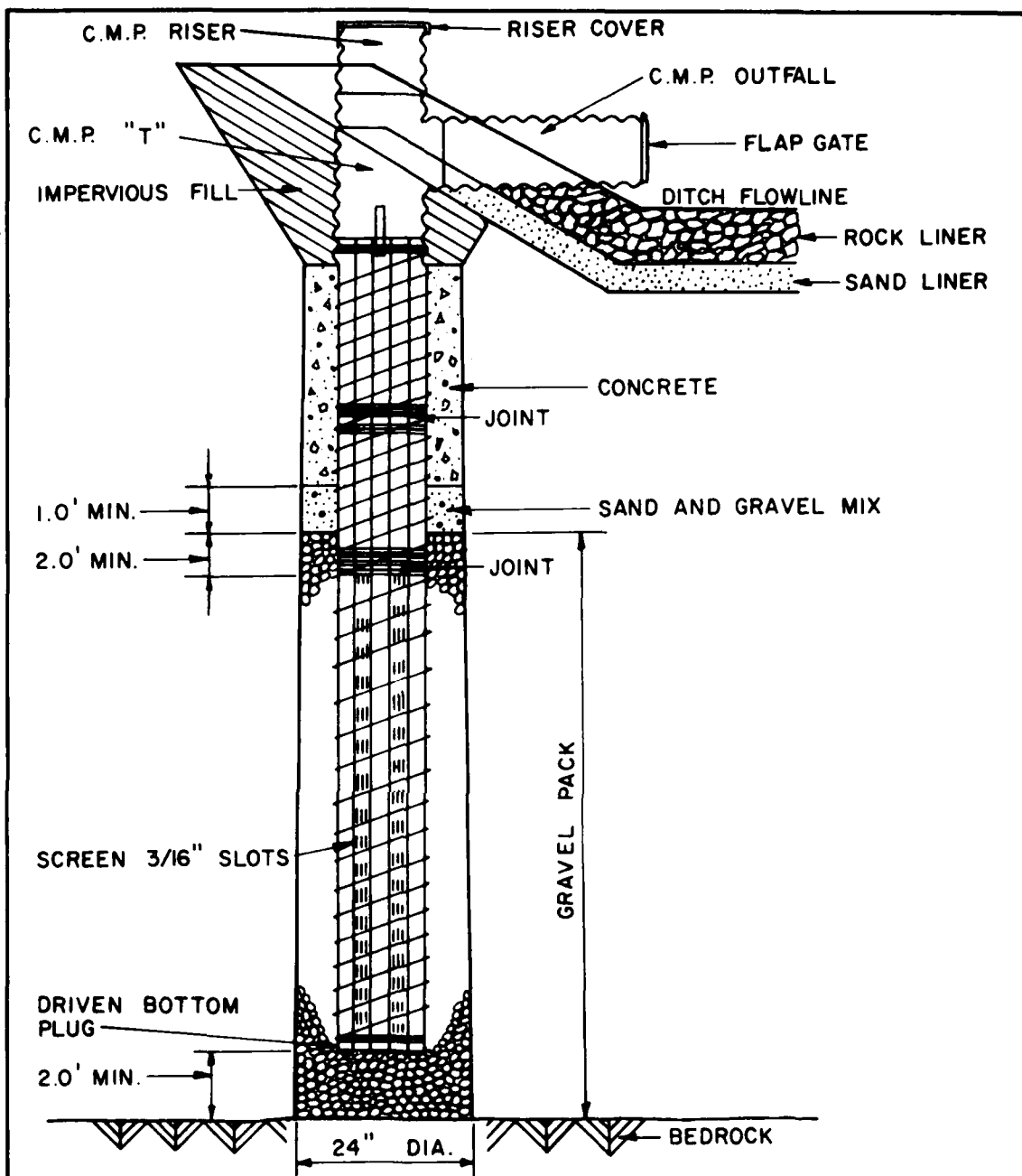


FIGURE 24

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

WELL DETAIL

In 1 sheet

Sheet No. 1

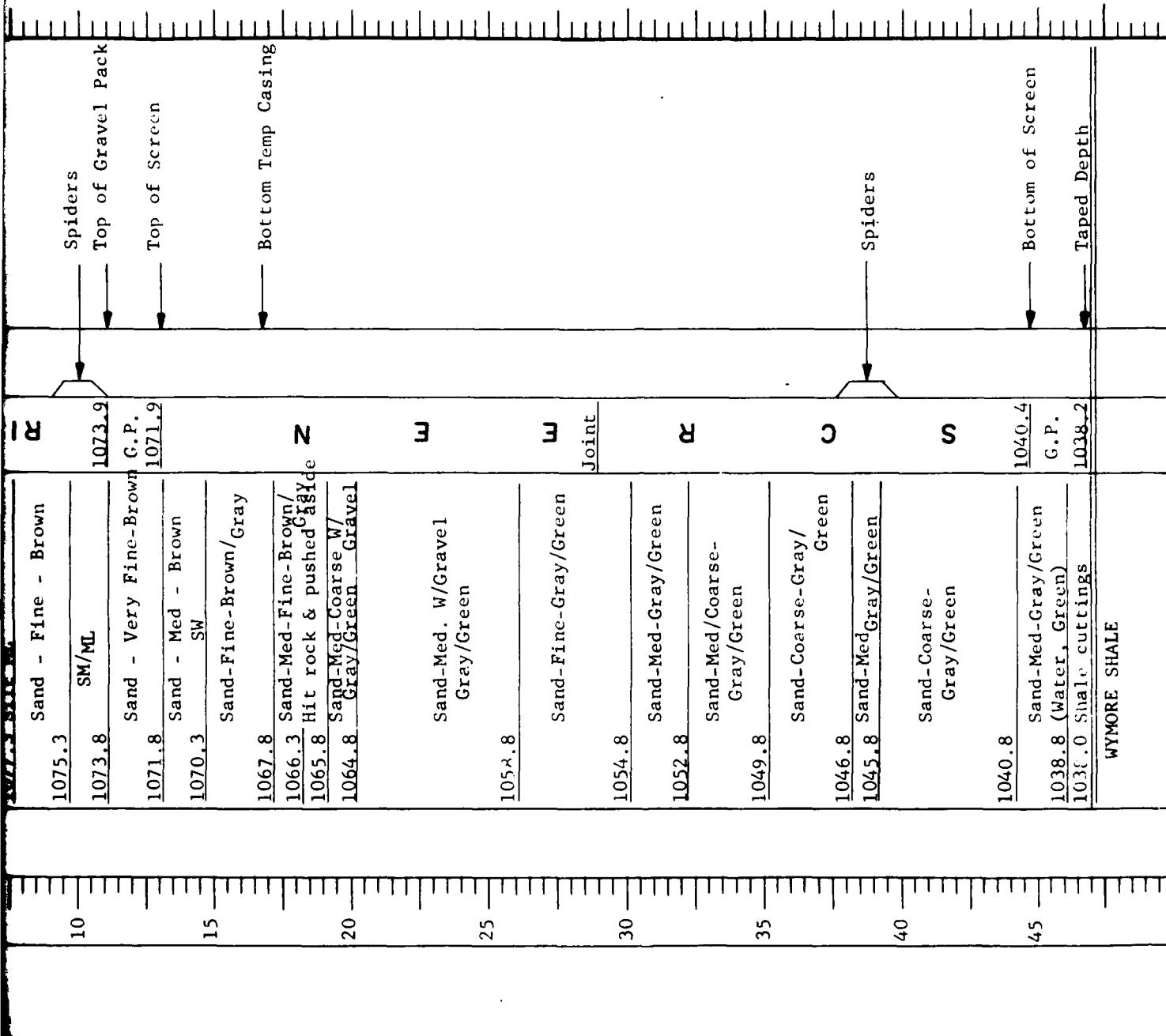
Not to scale

CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

FILE NO. B-1-1939

APRIL 1977

DRILLING LOG		DIVISION		INSTALLATION		SHEET OF SHEETS	
1. PROJECT		Missouri River		10. SIZE AND TYPE OF BIT		24"	
2. LOCATION (Coordinates or Station)		Milford Dam		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)		MSL	
3. DRILLING AGENCY		Construction Dewatering Inc.		12. MANUFACTURER'S DESIGNATION OF DRILL			
4. HOLE NO. (As shown on drawing title and file number)		Well #50		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN		DISTURBED CONTINUOUS	
5. NAME OF DRILLER				14. TOTAL NUMBER CORE BOXES			
6. DIRECTION OF HOLE		☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		16. DATE HOLE		STARTED 4-10-65 COMPLETED 4-10-65	
7. THICKNESS OF OVERBURDEN		46.2		17. ELEVATION TOP OF HOLE		1085.0	
8. DEPTH DRILLED INTO ROCK		0		18. TOTAL CORE RECOVERY FOR BORING		%	
9. TOTAL DEPTH OF HOLE		46.2		19. SIGNATURE OF INSPECTOR		Markwell	
ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)	
5			N. C.			Drilled with 24" reverse rotary. Change in materials were classified by sampling discharge water with a #30 screen.	
10			1078.8 Sand - Fine - Brown				
			1077.8 Sand - Fine - Brown				
			1077.3 Silt ML				
			1075.3 Sand - Fine - Brown				
			SM/ML				
			1073.8 Sand - Very Fine-Brown				
			1071.8 Sand - Med - Brown				
			1070.3 SW				
15			Sand-Fine-Brown/Gray				
			1067.8				
						Spiders	
						Top of Gravel Pack	
						Top of Screen	



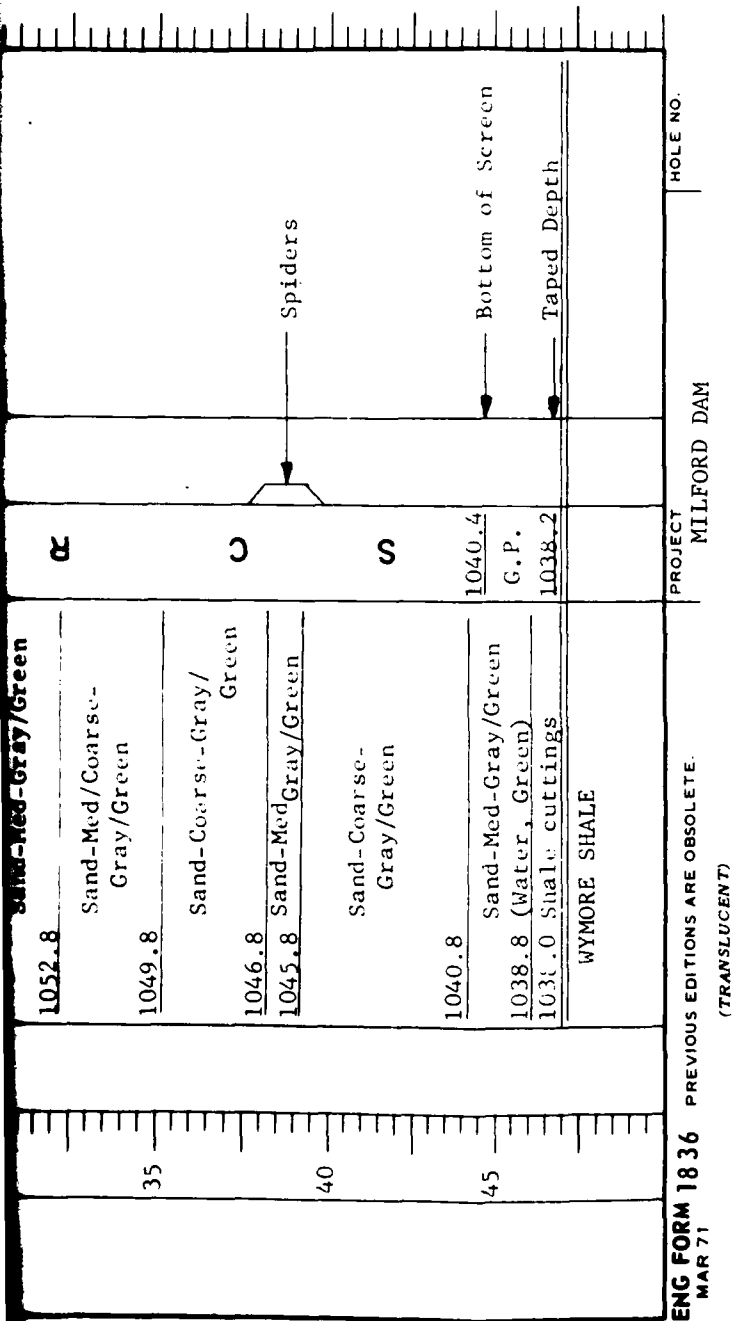


FIGURE 25

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

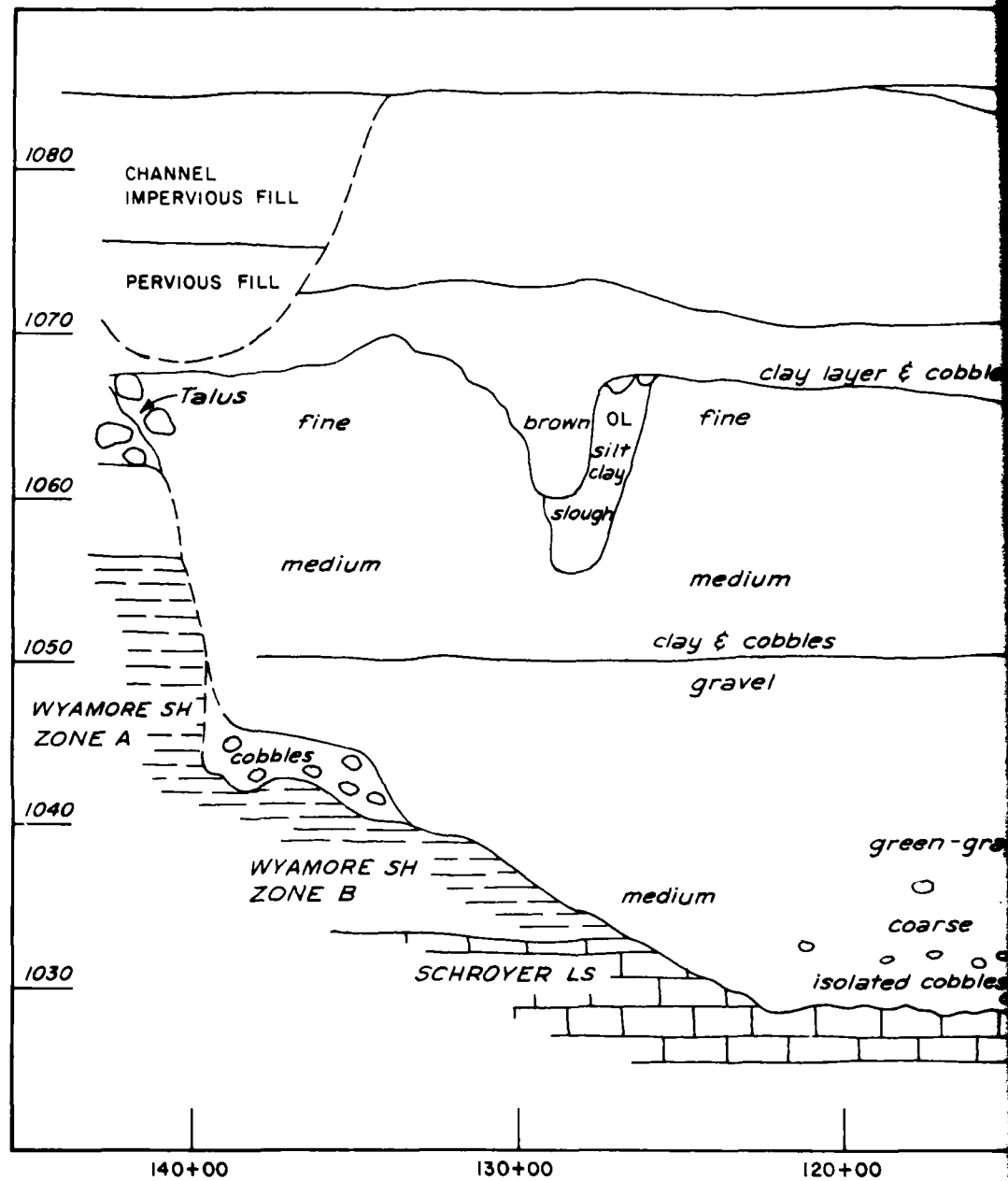
DRILLING LOG
WELL NO. 50

In 1 sheet Sheet No. 1 Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

• FILE NO. B-1-1940
APRIL 1977

ELEVATION IN FEET ABOVE MEAN SEA LEVEL



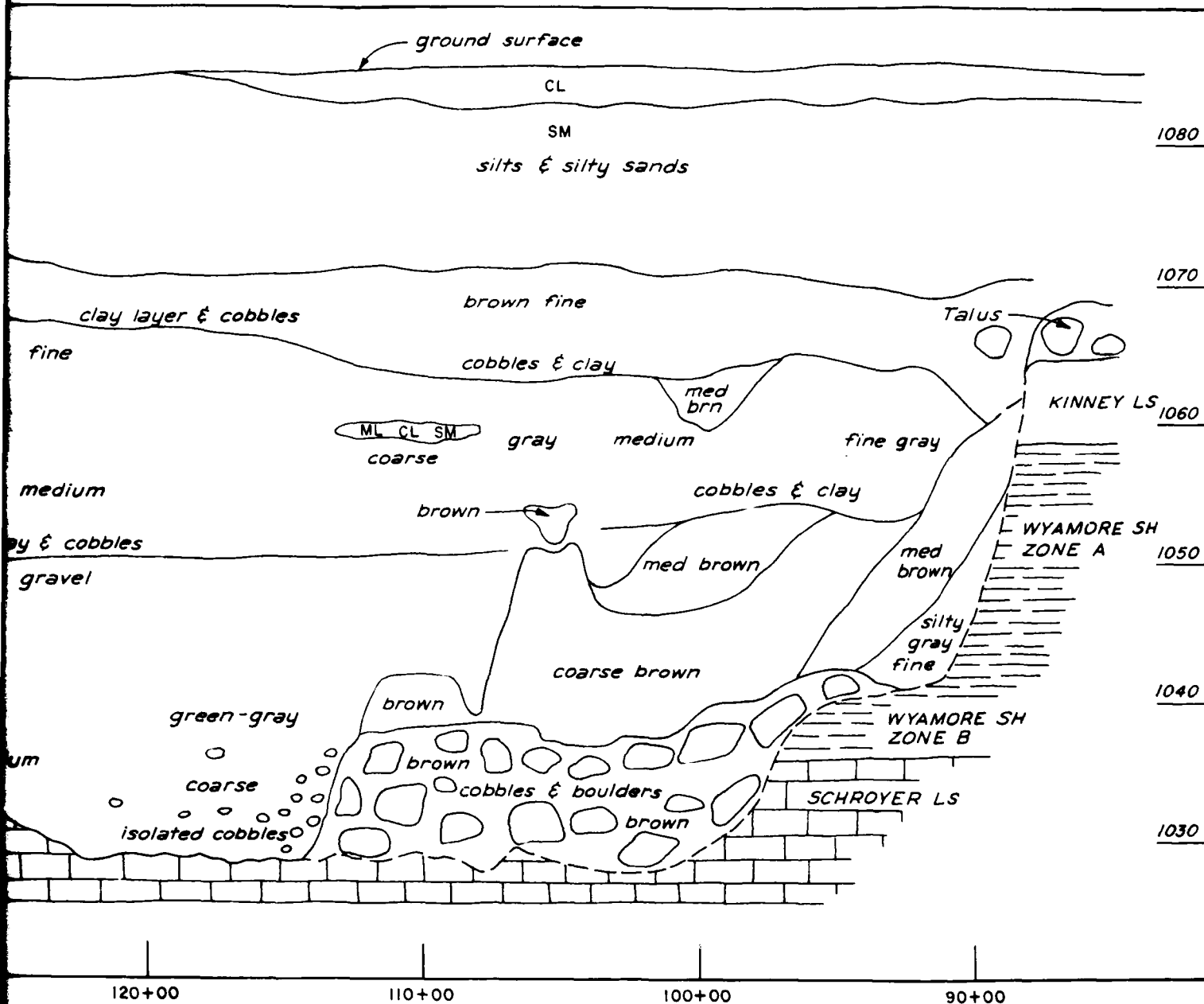


FIGURE 26

NOTE:
FOR LOCATION OF RELIEF WELLS
SEE PLATES NOS. 23 & 24

REPUBLICAN RIVER, KAN
MILFORD LA
FOUNDATION REPORT

PROFILE ALONG RELIEF
(RANGE 4+12 DOWNS)

In 1 sheet Sheet No. 1

CORPS OF ENGINEERS U.
KANSAS CITY DISTRICT

FILE NO. B-1-18

APRIL 1977

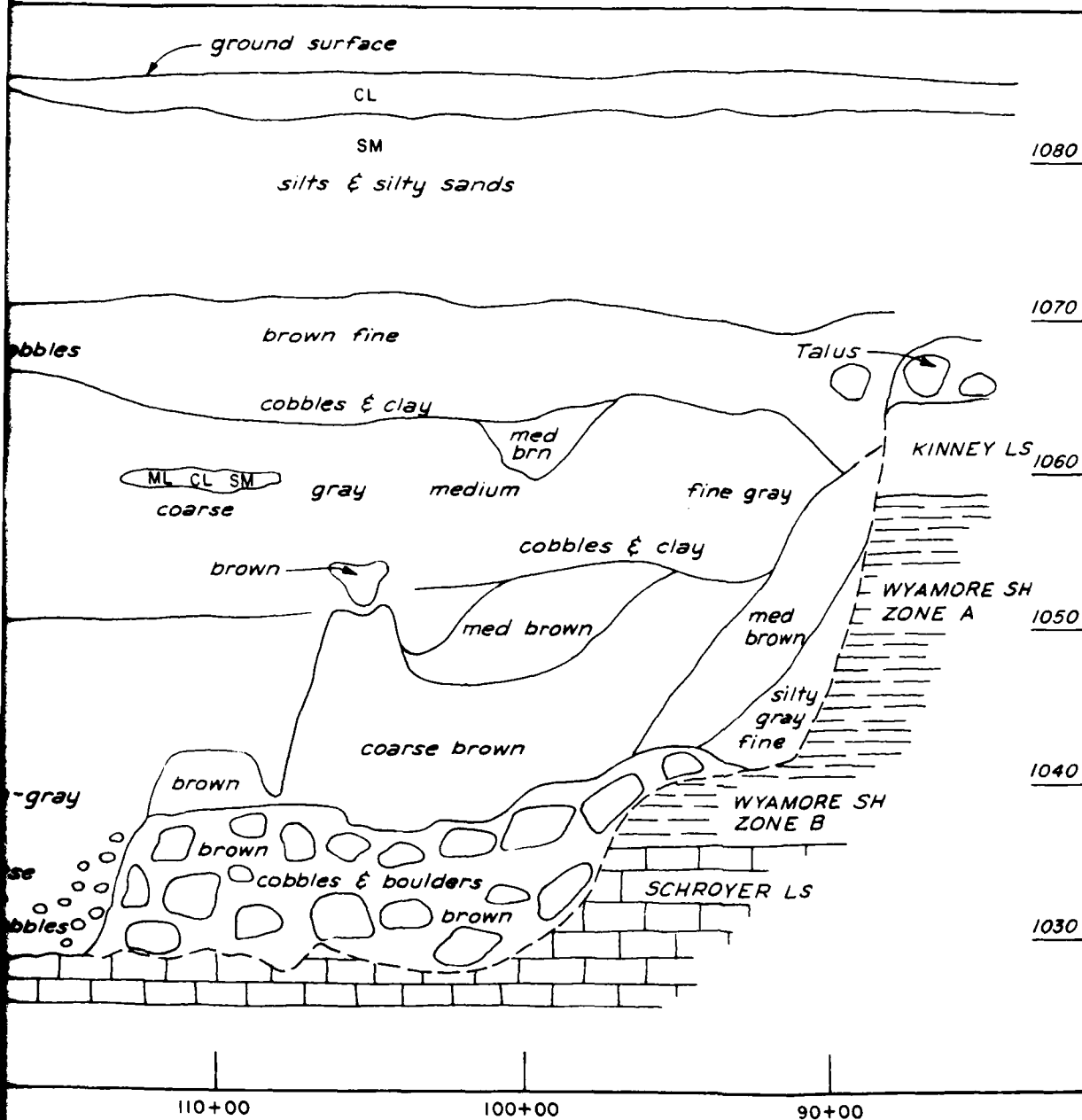


FIGURE 26

NOTE:
FOR LOCATION OF RELIEF WELLS
SEE PLATES NOS. 23 & 24

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

PROFILE ALONG RELIEF WELL LINE
(RANGE 4+12 DOWNSTREAM)

In 1 sheet

Sheet No. 1

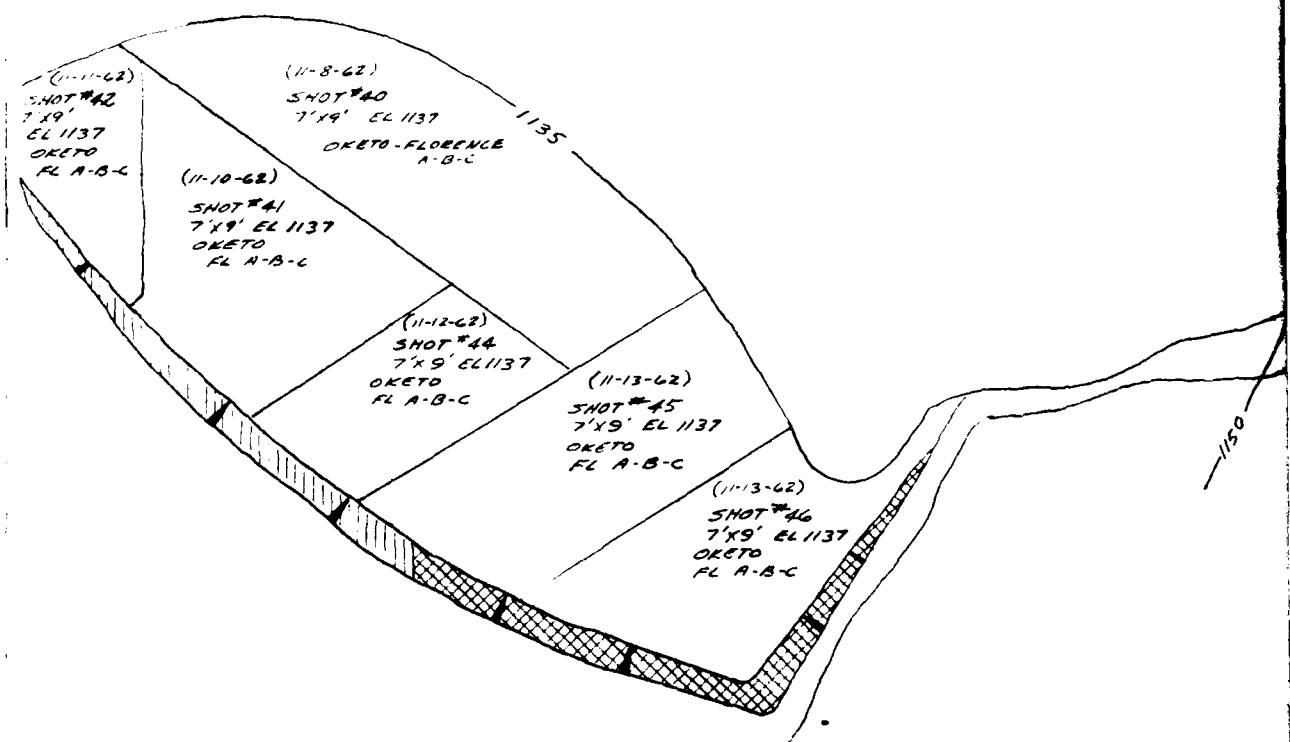
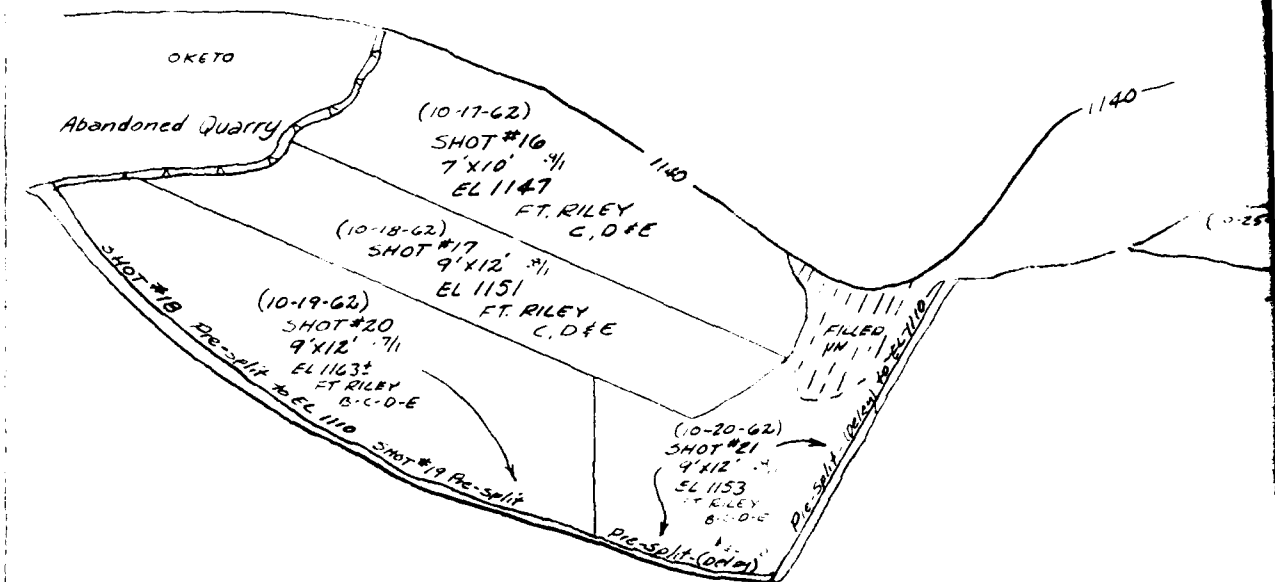
Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1941

APRIL 1977

FIGURE 26



MILFORD DAM OUTLET WORKS BLASTING PLAN
1st LIFT
Scale 1" = 40 feet

REPUBLICAN RIVER KANSAS
MILFORD LAKE
FOUNDATION REPORT

OUTLET WORKS
BLASTING PLAN
1ST AND 2ND LIFTS

in 1 sheet

Sheet No. 1

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1942

APRIL 1977

MILFORD DAM OUTLET WORKS BLASTING PLAN
2nd LIFT
Scale 1" = 10 feet

Scale 10 feet

LEGEND

-  Ripped or Daged
-  Pre-Split Slope
-  Pre-Split Delay
-  Primary Blasting

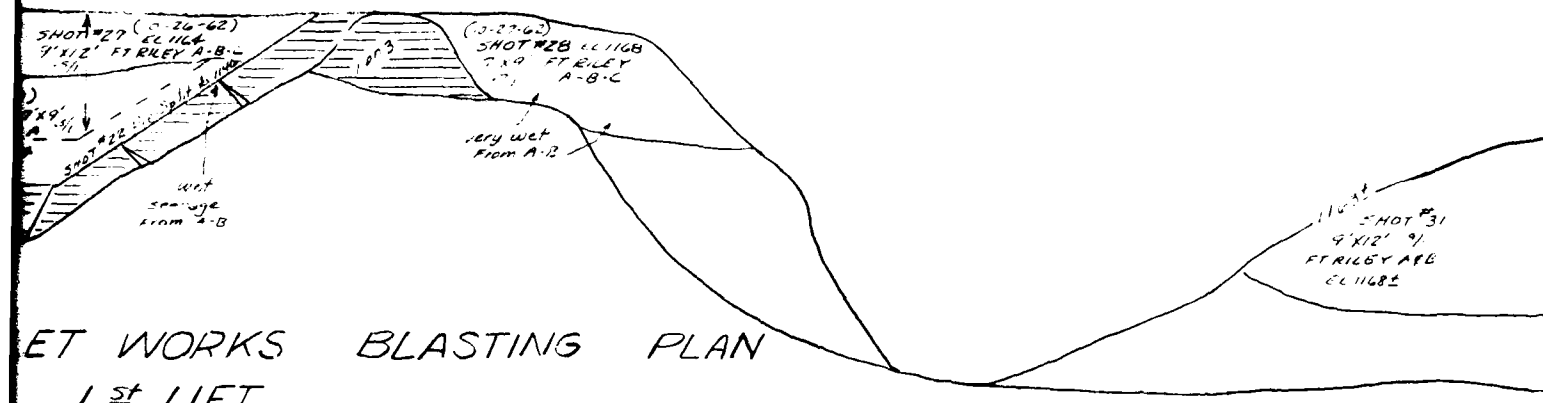


FIGURE 27

REPUBLICAN RIVER, KANSAS MILFORD LAKE FOUNDATION REPORT

OUTLET WORKS BLASTING PLAN 1ST AND 2ND LIFTS

In 1 sheet Sheet No. 1 Scale: as shown
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. B-1-1942
APRIL 1977

LEGEND

-  Ripped or Daged
-  Pre-Split Slope
-  Pre-Split Delay
-  Primary Blasting

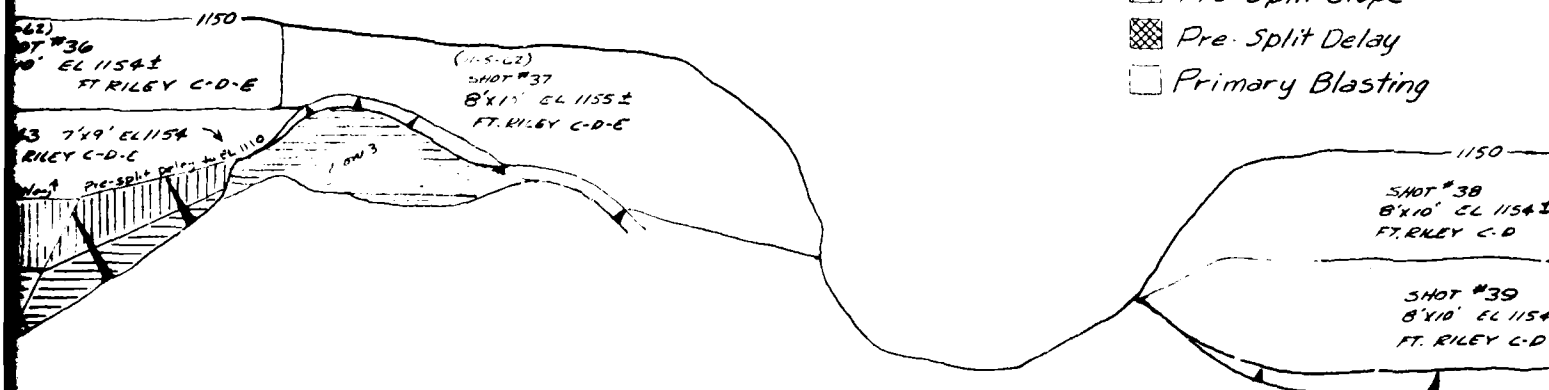


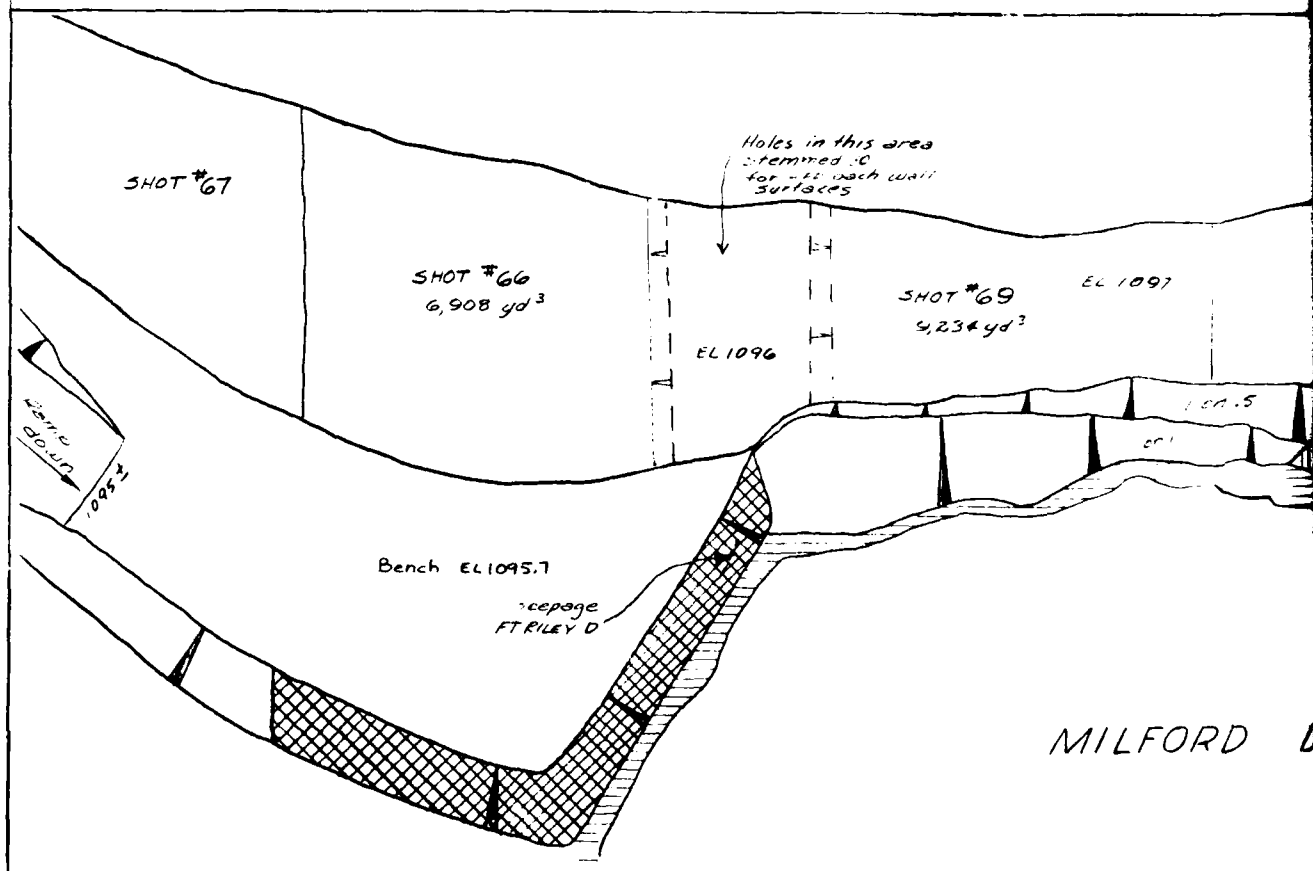
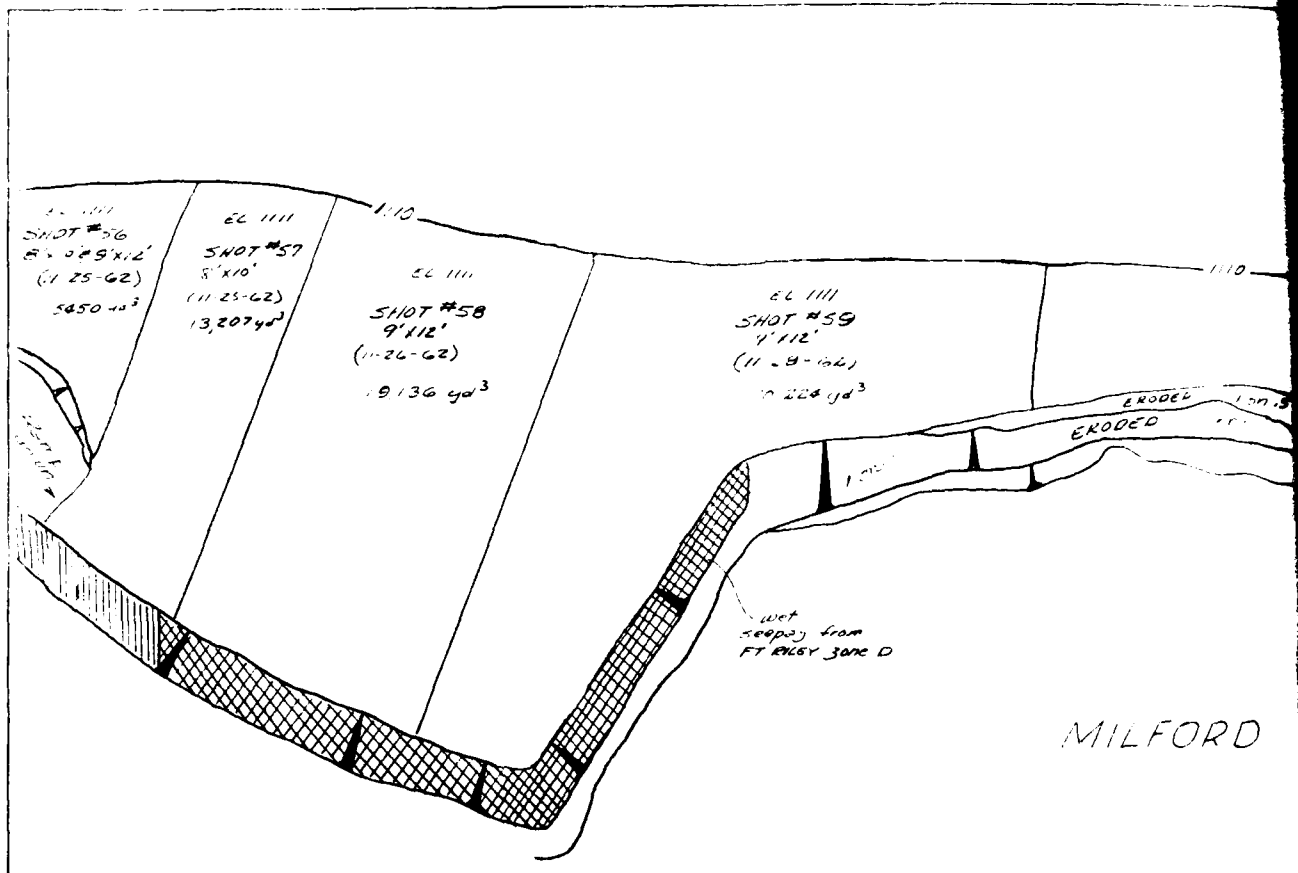
FIGURE 28

FIGURES 27 & 28

OUTLET WORKS BLASTING PLAN

2nd LIFT

Scale 10 feet



Scale 10 feet

LEGEND

-  Ripped or Dozed
-  Pre-Split Slope
-  Pre-Split Delay
-  Primary Blasting

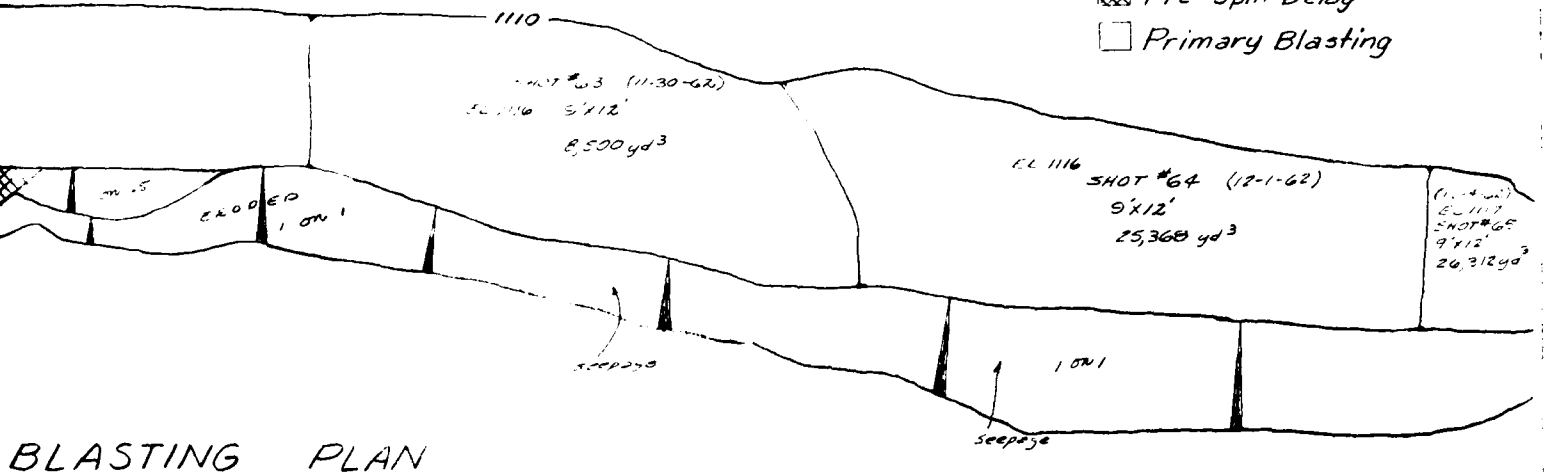


FIGURE 29

REPUBLICAN RIVER KANSAS MILFORD LAKE FOUNDATION REPORT

OUTLET WORKS BLASTING PLAN 3RD, 4TH AND 5TH LIFTS

In sheet

Sheet No. 1

Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1943

APRIL 1977

LEGEND

-  Ripped or Dozed
-  Pre-Split Slope
-  Pre-Split Delay
-  Primary Blasting

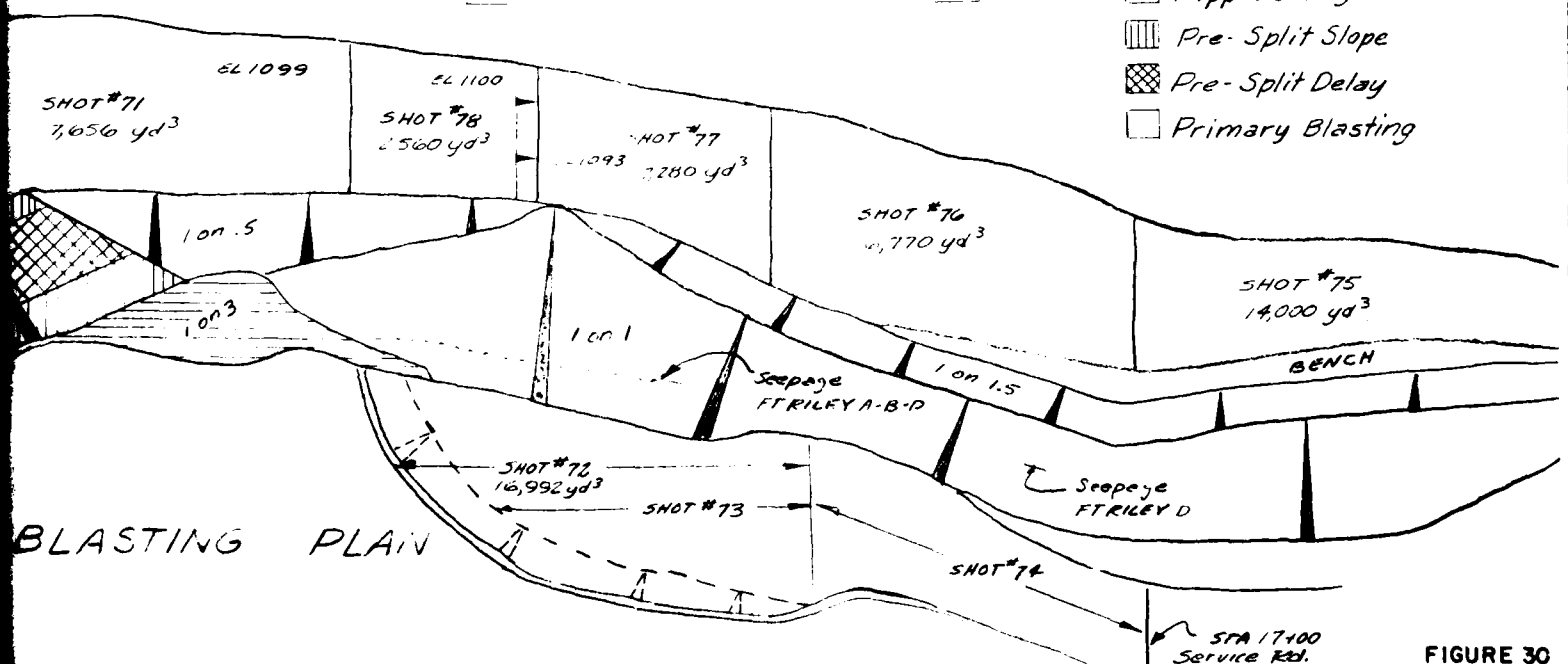
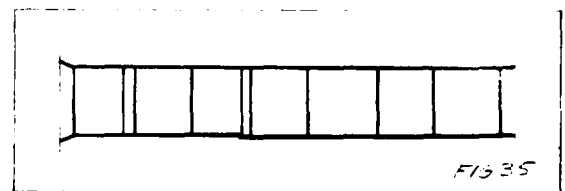
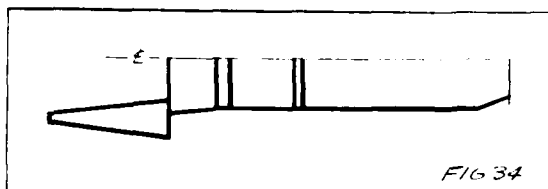
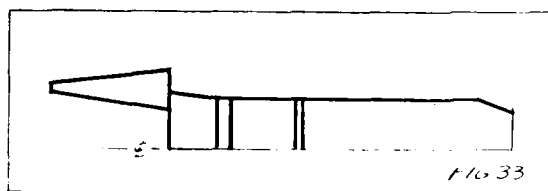
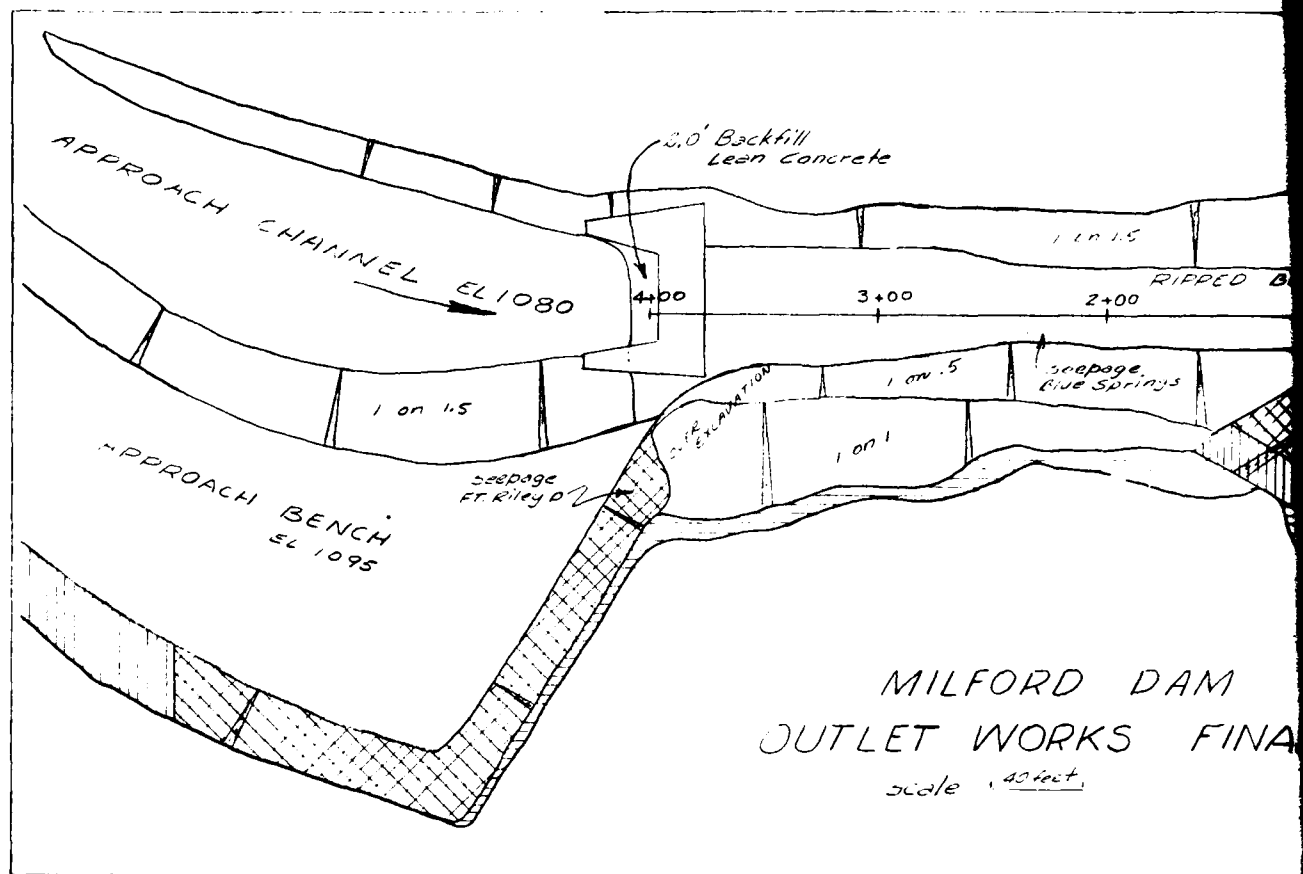


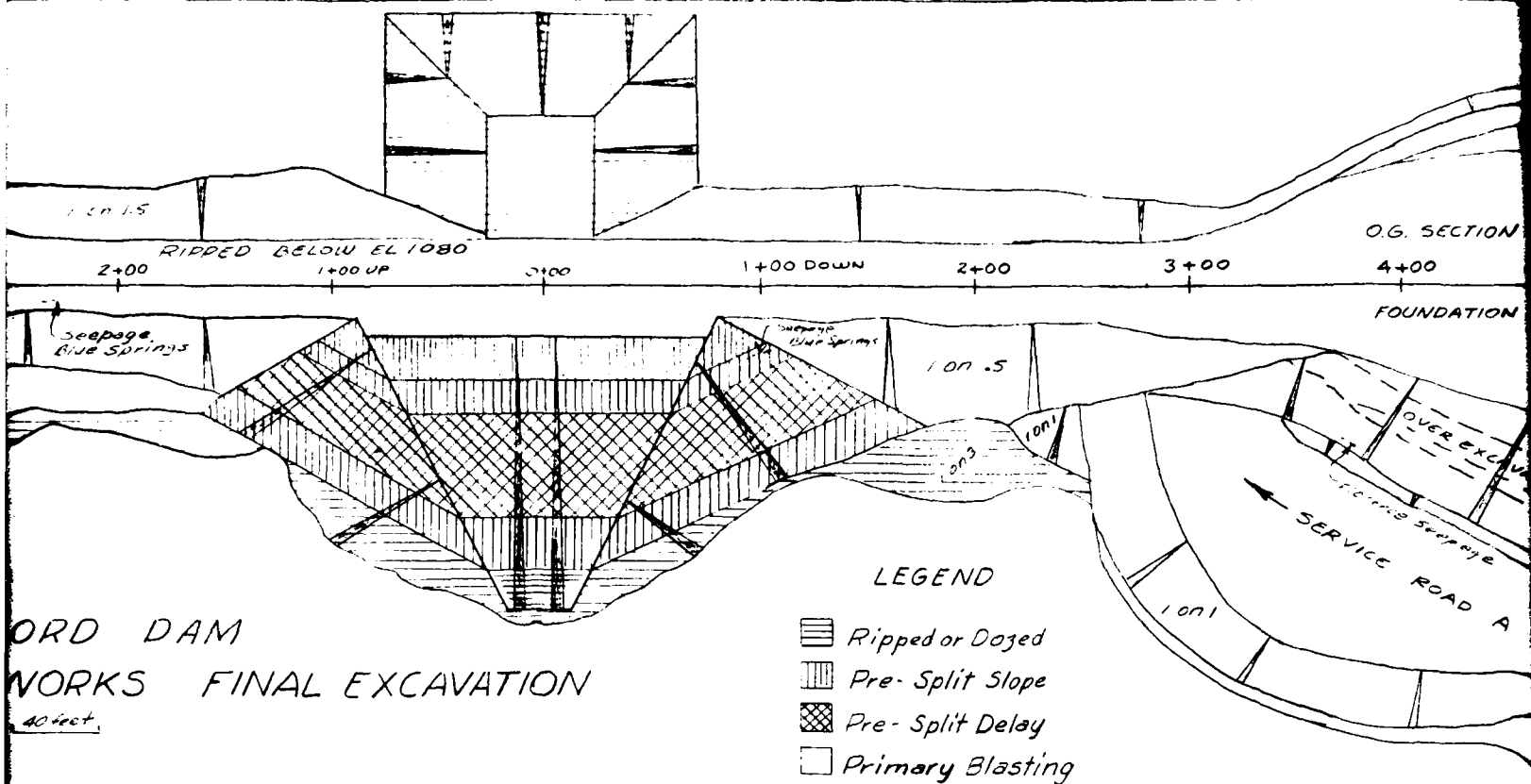
FIGURE 30

FIGURES 29 & 30



MILFORD DAM

FOUNDATION



REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

OUTLET WORKS
 FINAL EXCAVATION PLAN
 INDEX OF FOUNDATION MAPS

In 1 sheet

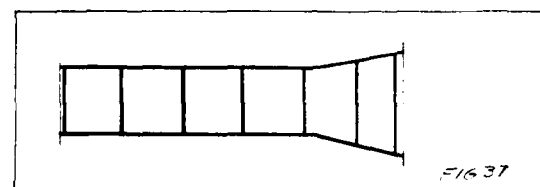
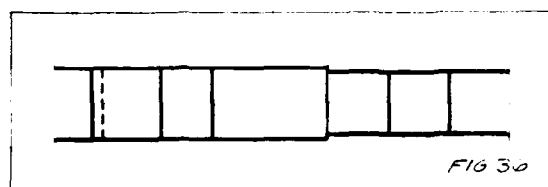
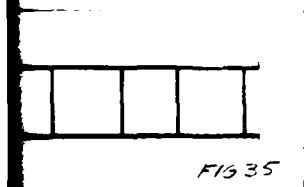
Sheet No. 1

Scale as shown

CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

FILE NO. B-1-1944

APRIL 1977



FOUNDATION MAP OUTLET WORKS INDEX SHEET FOR FIGURES 33 TH

no Scale

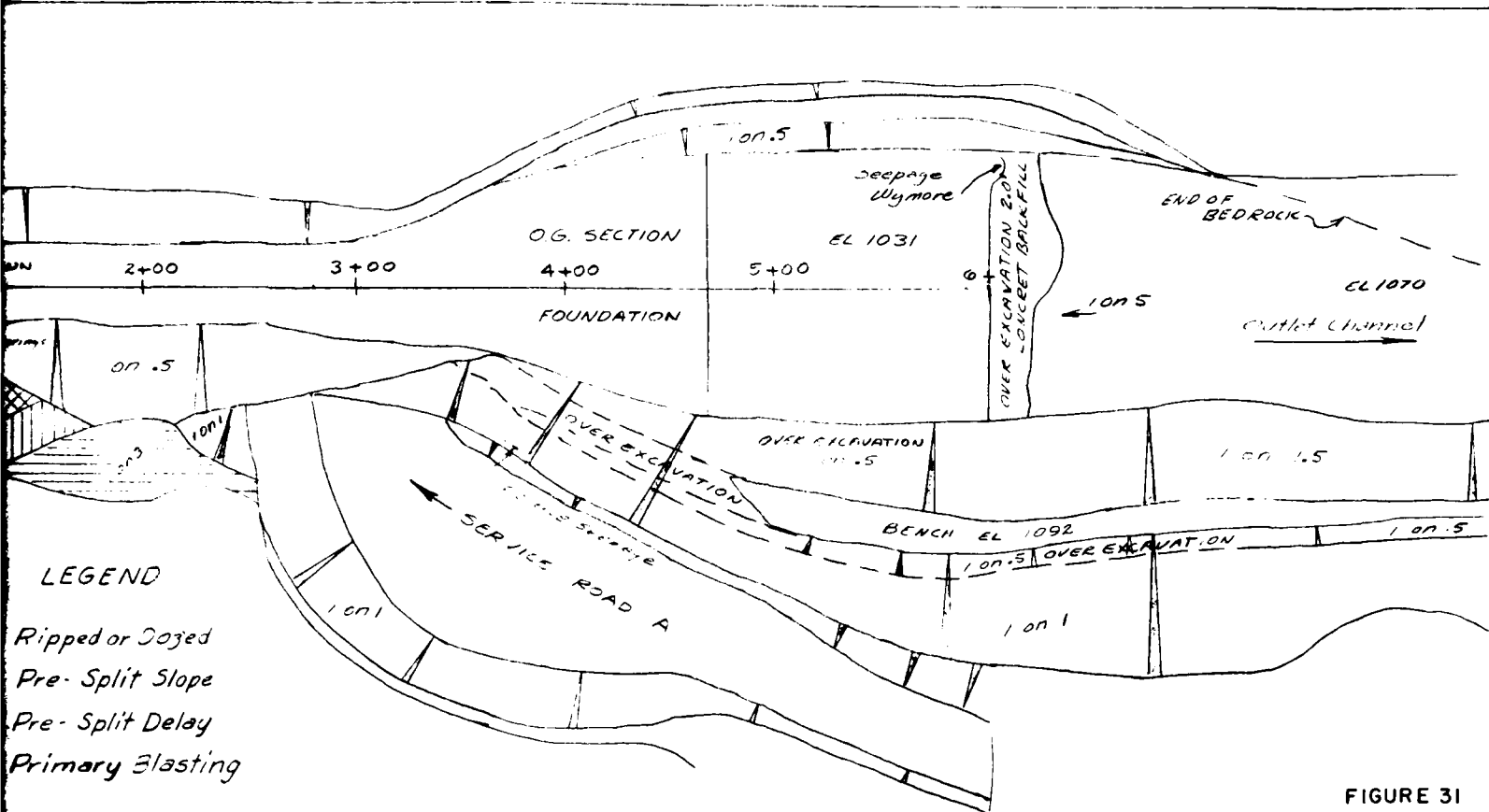


FIGURE 31

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT

OUTLET WORKS
 FINAL EXCAVATION PLAN
 INDEX OF FOUNDATION MAPS

In 1 sheet

Sheet No

Scale as shown

CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT

FILE NO. B-1-1944

APRIL 1977

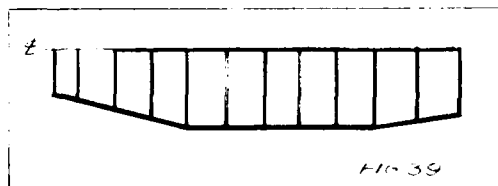
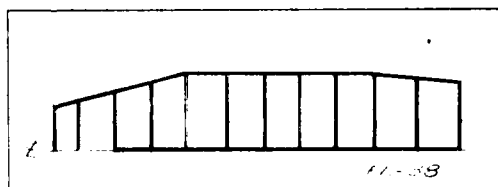
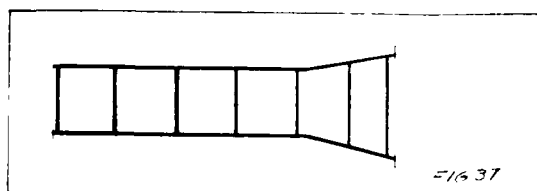
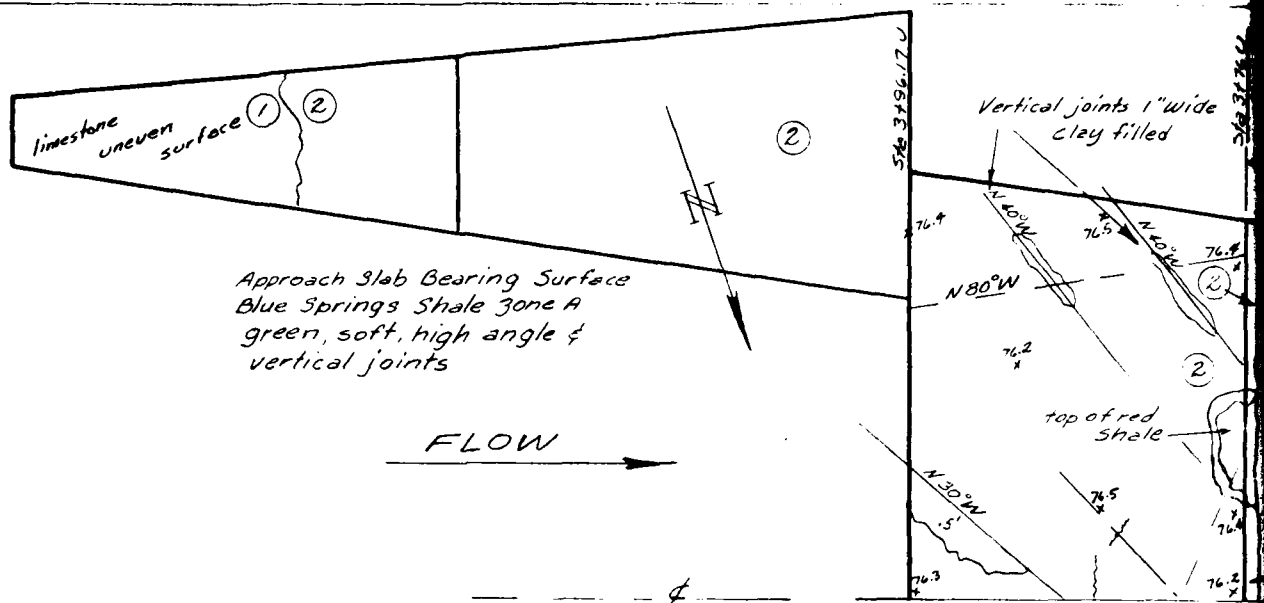


FIGURE 32

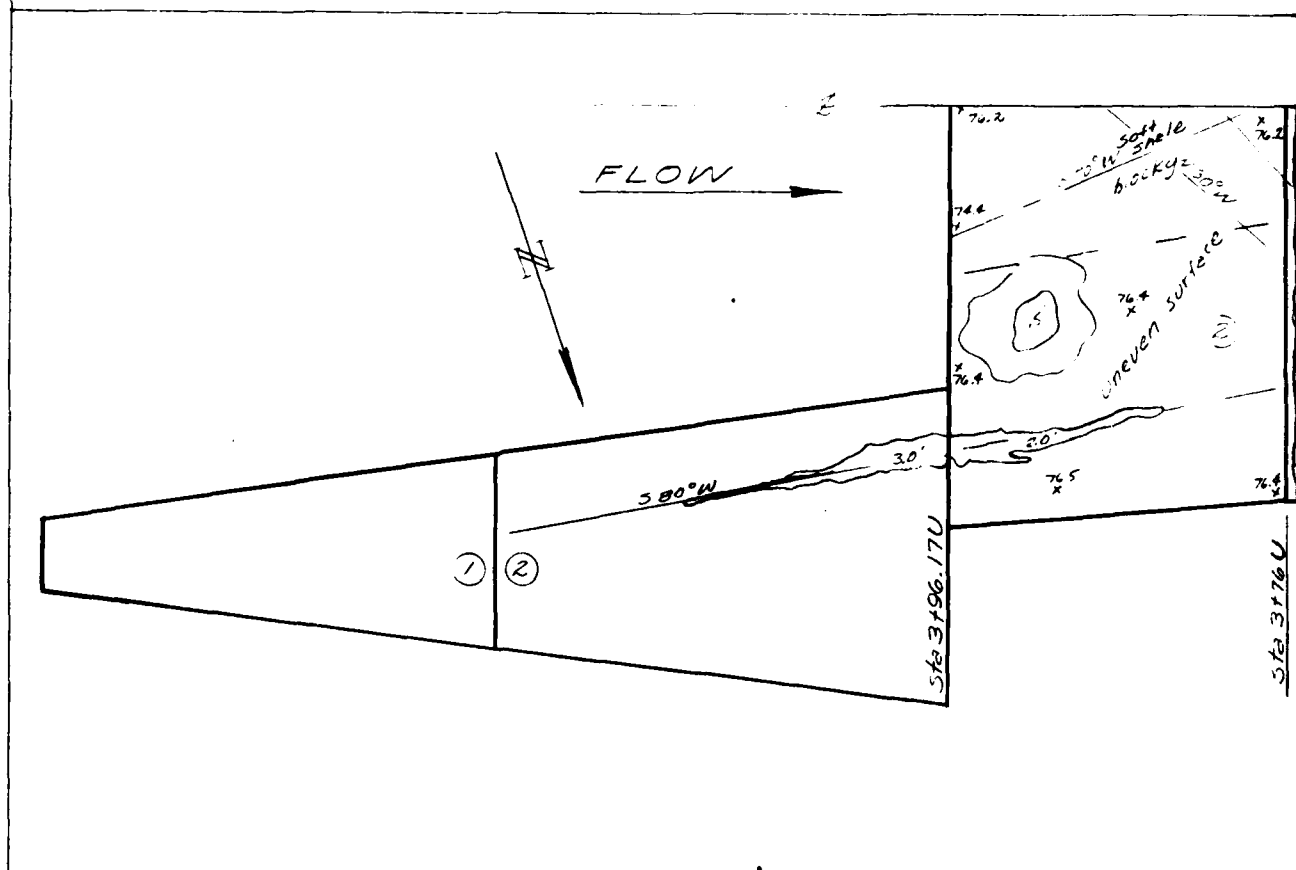
FIGURES 31 & 32

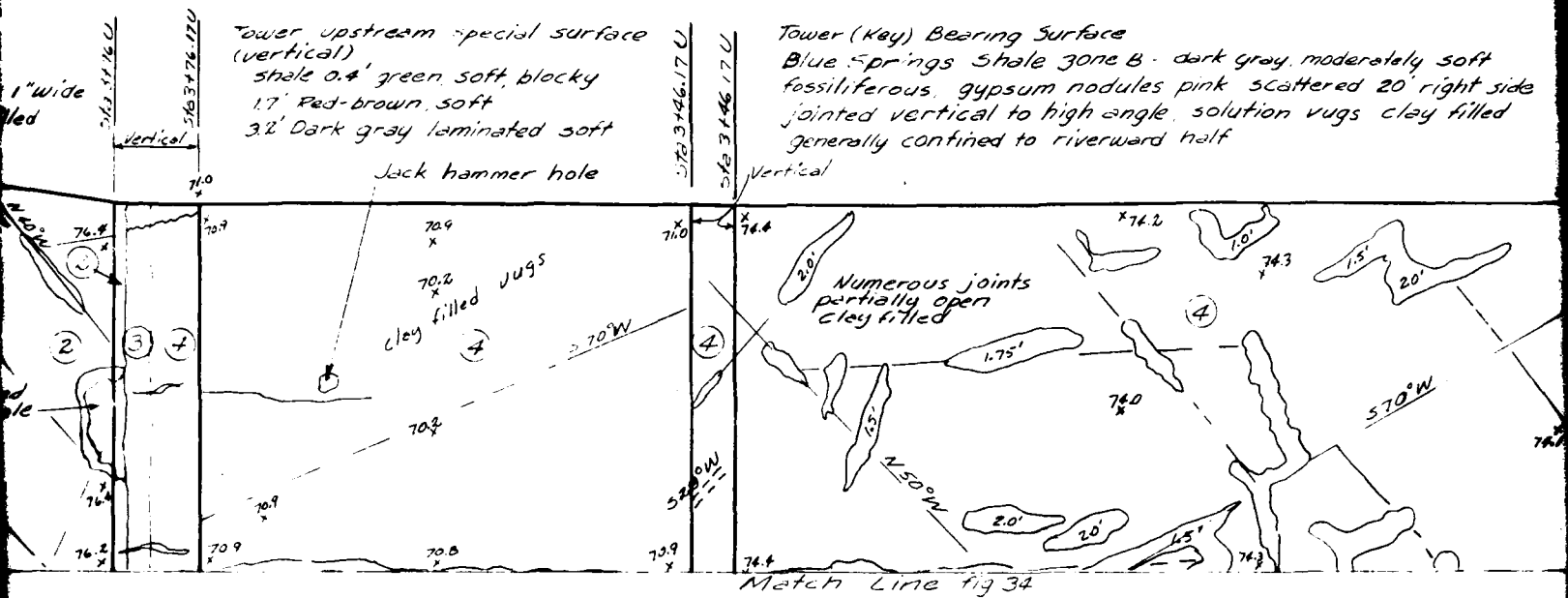
INDEX SHEET FOR FIGURES 33 THRU 39



LEGEND

- | | | |
|--|--|----------------------------------|
| ① Limestone Blue Springs zone A | ④ Dark gray calcareous shale Blue Springs zone B | ⑦ Hard gray limestone Kinney |
| ② Green clay shale Blue Springs zone A | ⑤ soft shale Blue Springs zone B | ⑧ Soft shale Blue Springs zone B |
| ③ Red clay shale Blue Springs zone A | ⑥ Hard gray limestone Kinney | ⑨ Hard gray limestone Kinney |

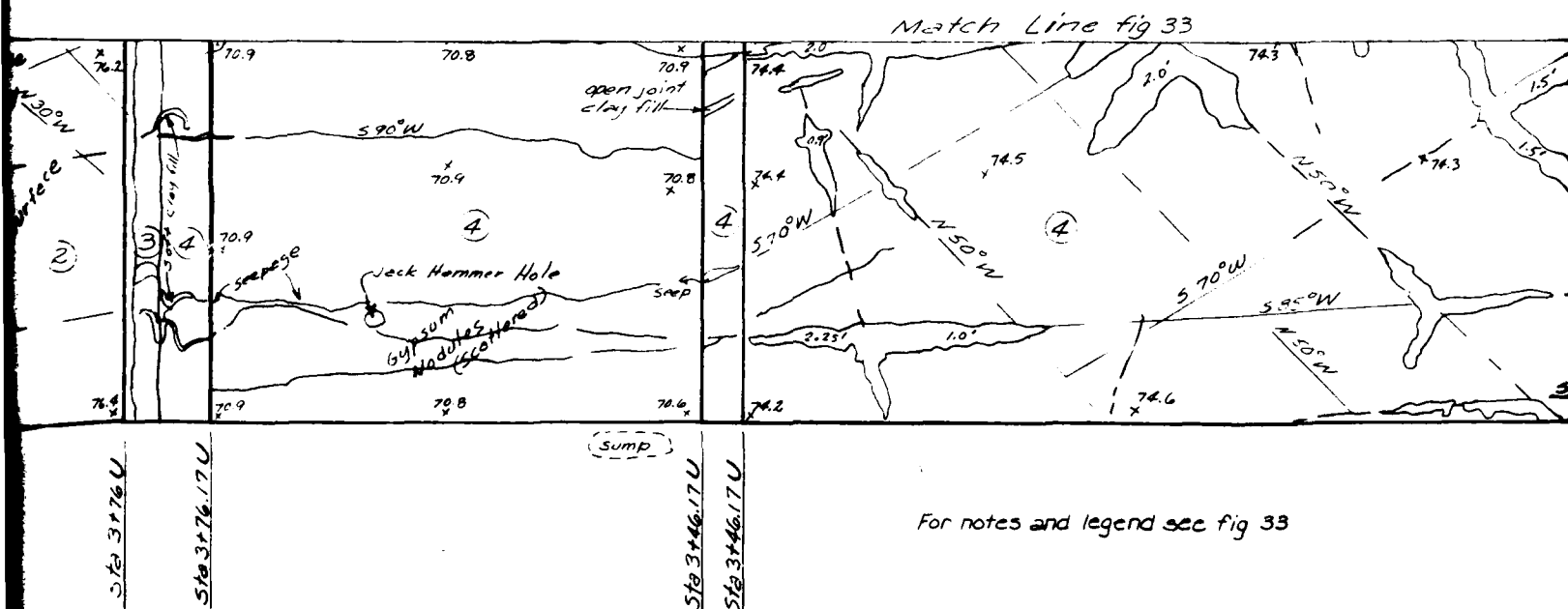




- ⑦ Hard calcareous shale Wumore zone A
- ⑧ Soft dark shale Wyniore zone B
- ⑨ Hard white upper Schroyer limestone
- ⑩ Dark argillaceous limestone upper Schroyer
- ⑪ Dark very argillaceous limestone lower Schroyer
- ⑫ Hard thin cherty limestone lower Schroyer

MILFORD DAM FOUNDATION

Scale 1" = 6'



MILFORD DAM FOUNDATION MAP OUTLET WORKS

2 Scale 1" = 6'

Tower (Key) Bearing Surface

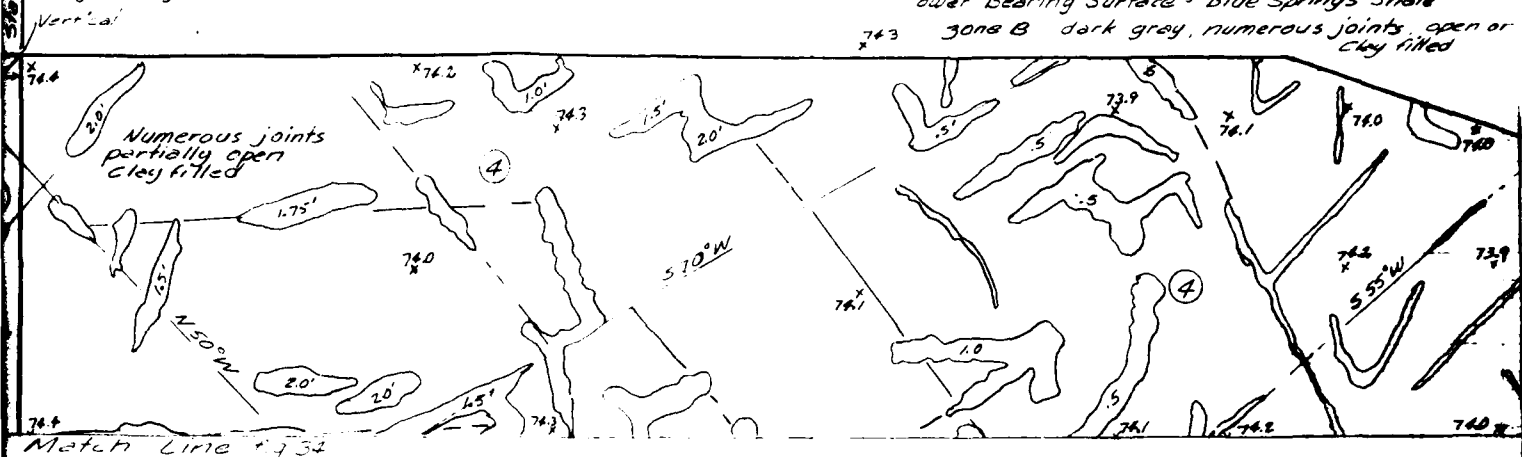
Blue Springs Shale zone B - dark gray moderately soft
fossiliferous gypsum nodules pink scattered 20' right side
jointed vertical to high angle solution vugs clay filled
generally confined to riverward half

Tower downstream special surface (vertical)

23' shale, dark gray, laminated, soft
0.7' shale, calcareous, laminae
excavated, cleaned and grouted

Tower Bearing Surface - Blue Springs shale

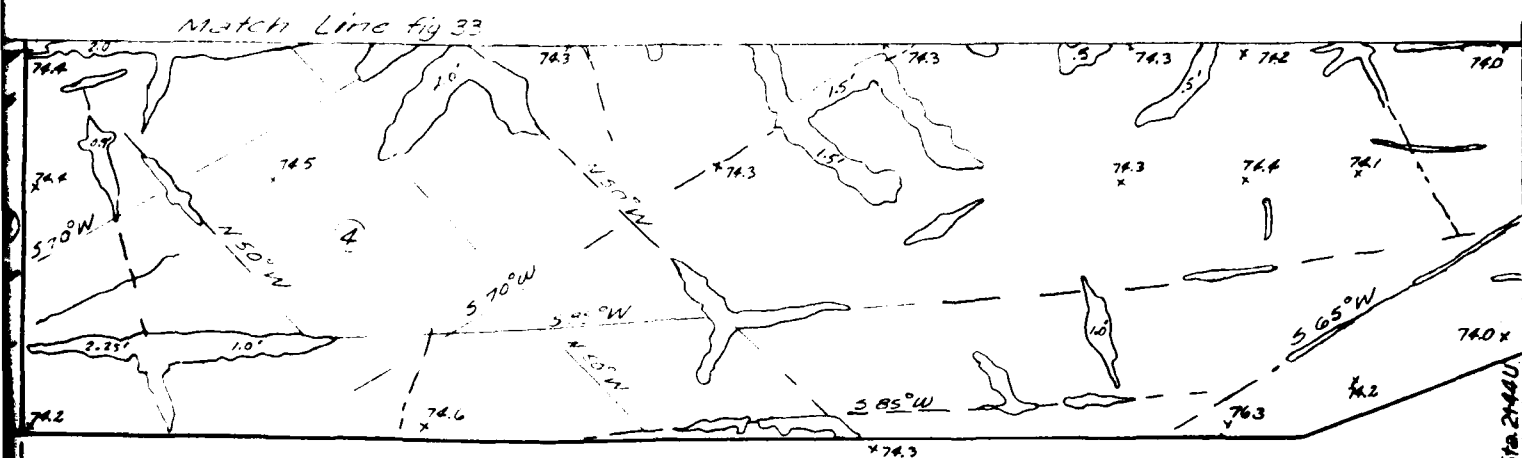
zone B dark gray, numerous joints, open or
clay filled



MILFORD DAM FOUNDATION MAP OUTLET WORKS

Scale 1 inch = 60 feet

FIGURE 33



For notes and legend see fig 33

MILFORD LAKE

FOUNDATION REPORT
OUTLET WORKS
FOUNDATION MAP OF
LEFT AND RIGHT HALVES
STA. 4+55 UPSTREAM
TO STA. 2+44 UPSTREAM

Sheet No. 1

Scale: as shown

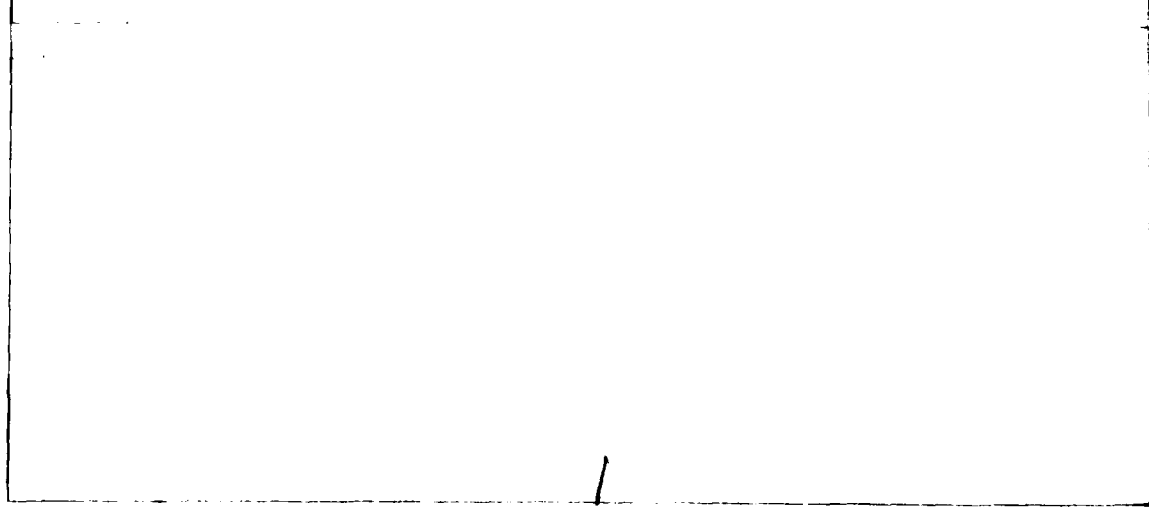
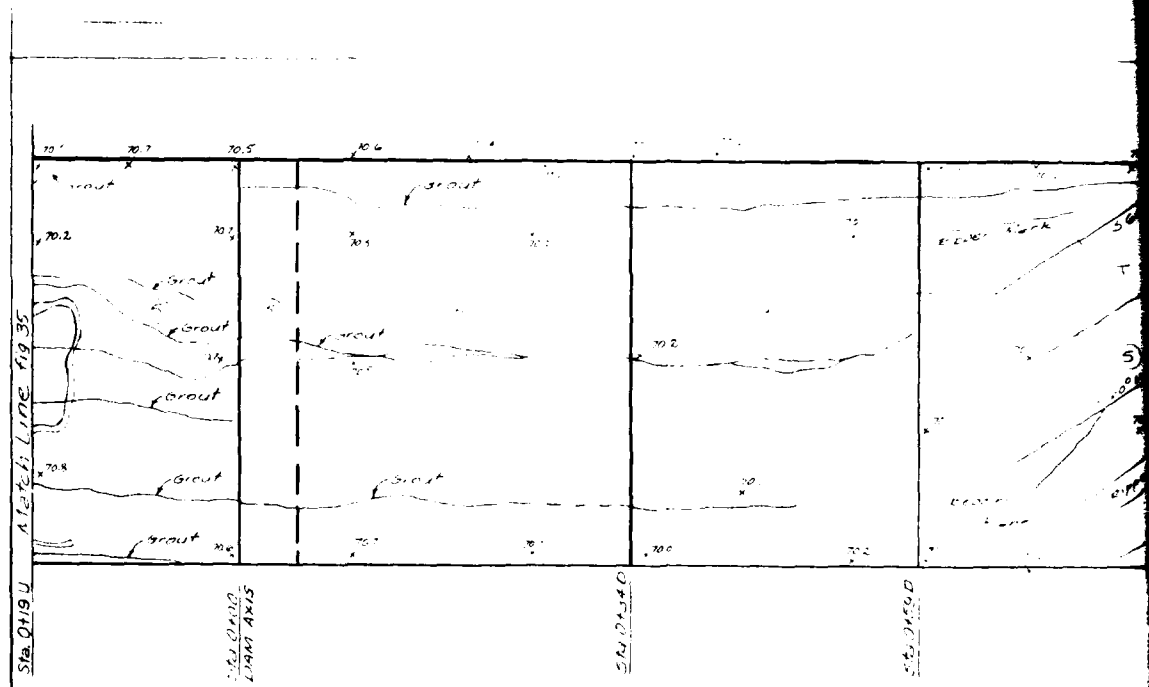
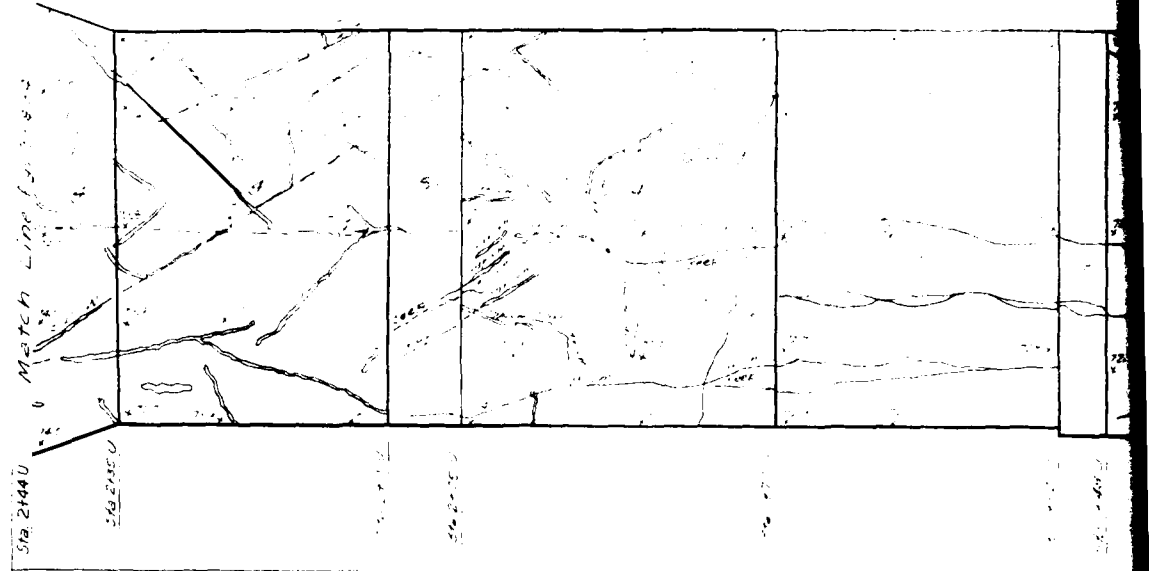
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1946

APRIL 1977

FIGURE 34

FIGURES 33 & 34



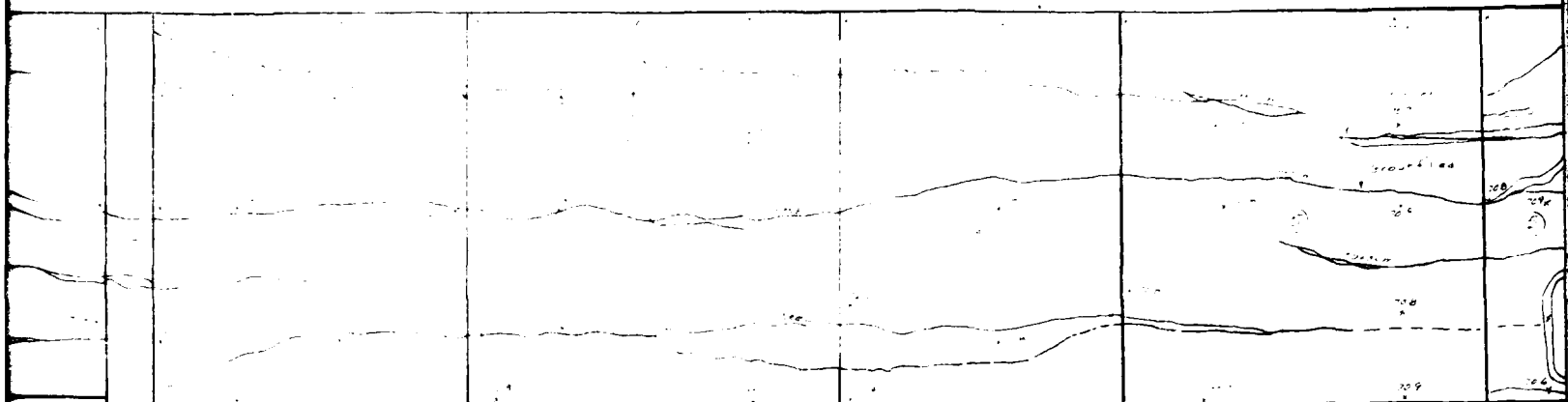


FIGURE 35

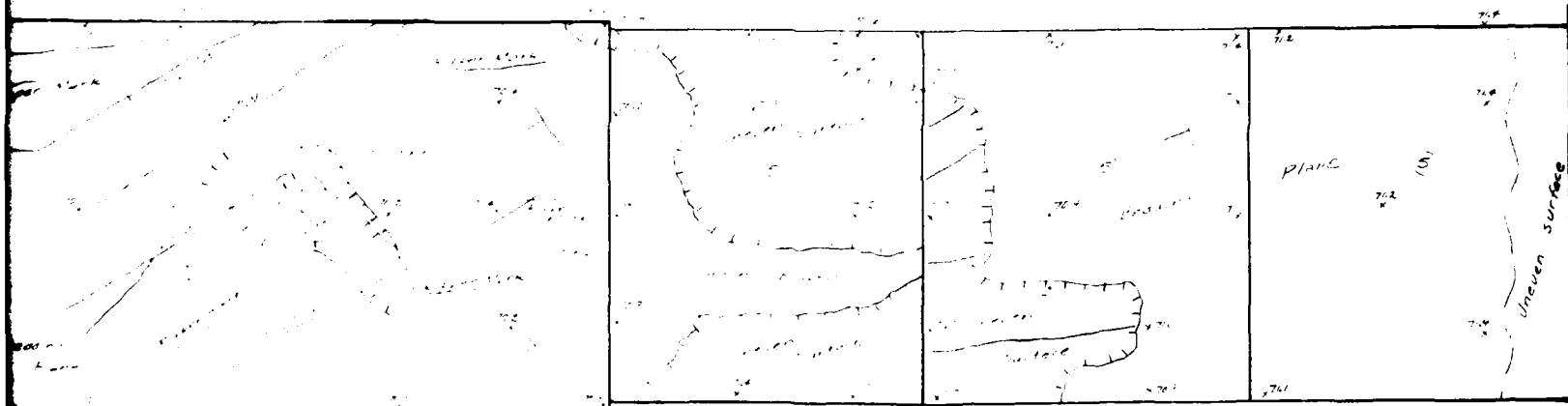
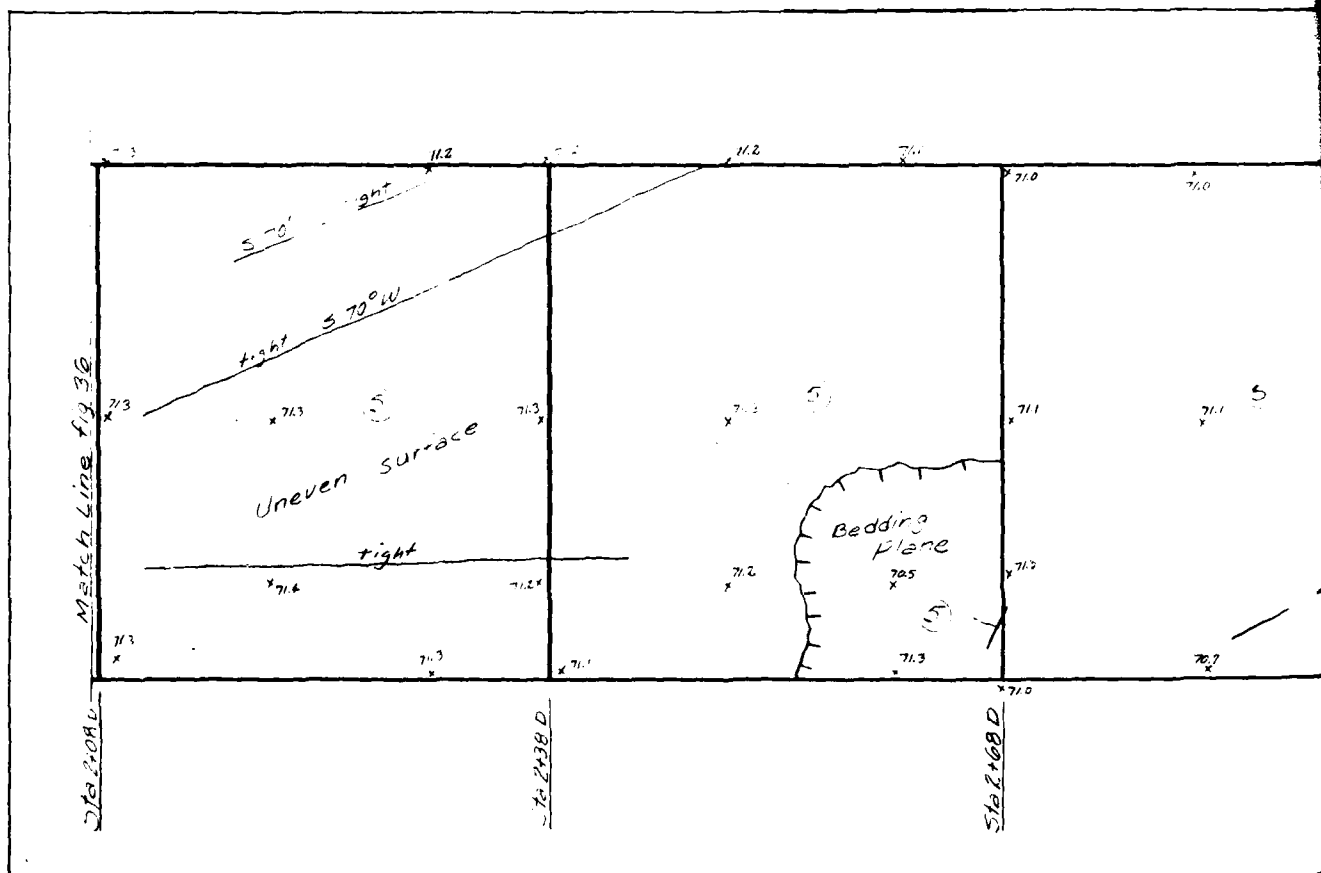


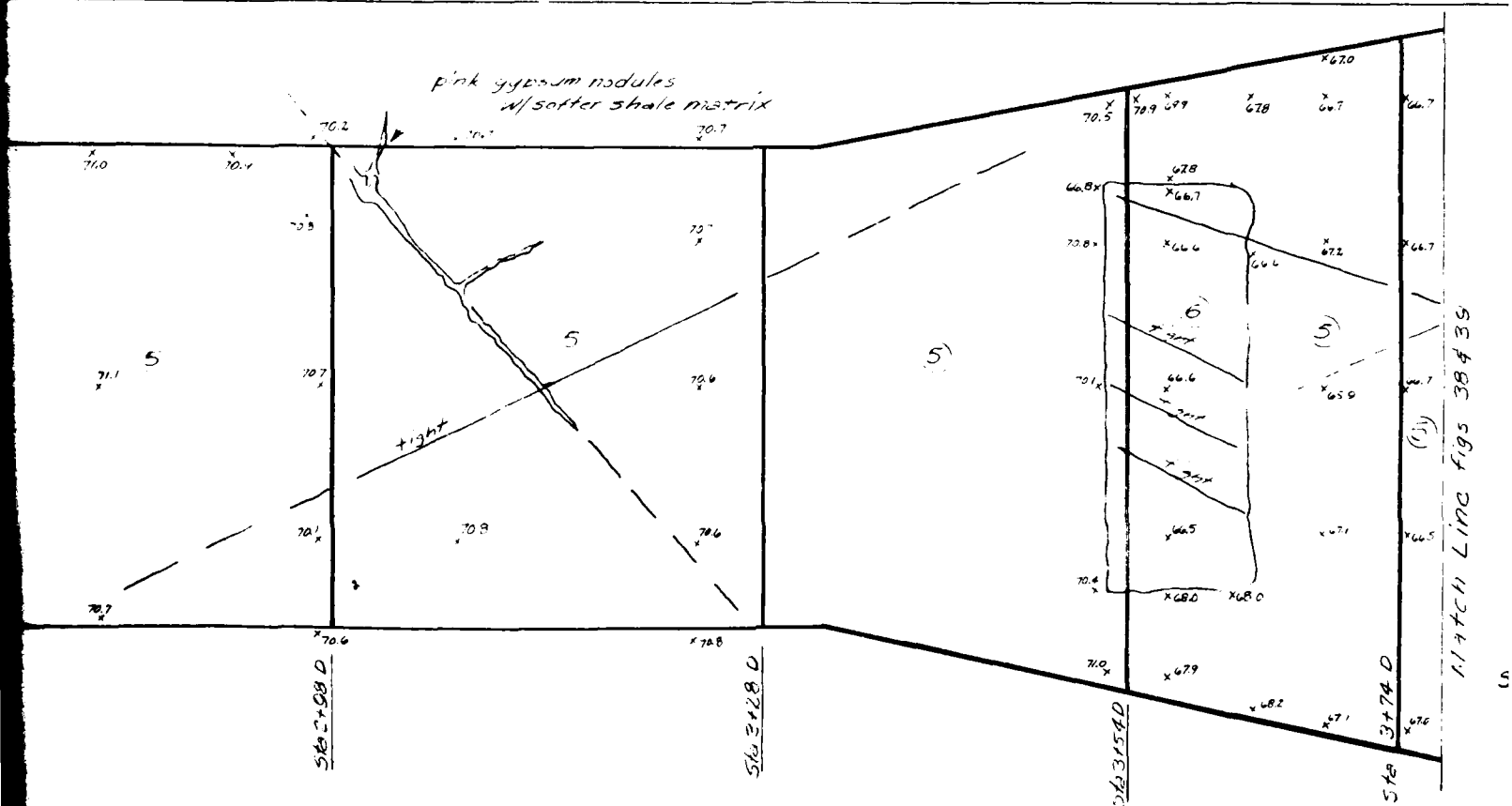
FIGURE 36

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT
 OUTLET WORKS
 FOUNDATION MAP
 STA. 2+44 UPSTREAM
 TO STA. 2+08 DOWNSTREAM
 Sheet No. 1
 CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT
 FILE NO. B-1-1946
 APRIL 1977

In 1 sheet

Scale: as shown





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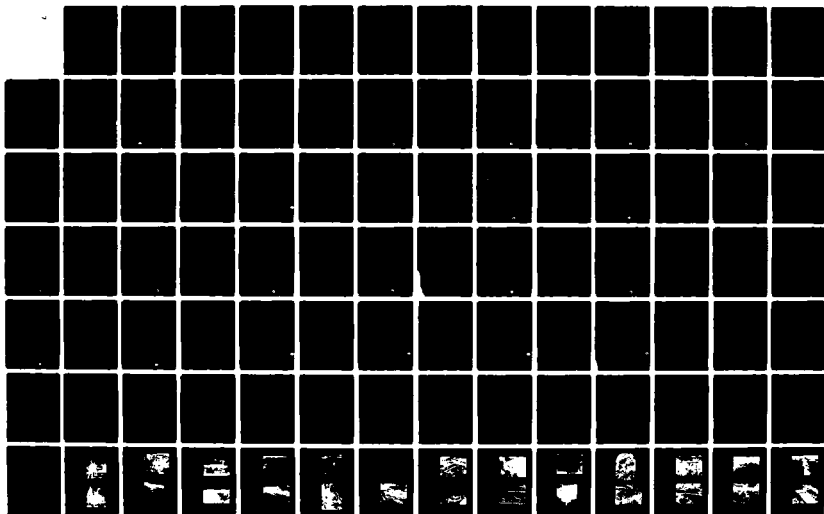
MULTIPLE-PURPOSE PROJECT KANSAS RIVER BASIN REPUBLICAN
RIVER KANSAS MILFO. (U) CORPS OF ENGINEERS KANSAS CITY
MO KANSAS CITY DISTRICT S D MARKWELL ET AL. OCT 83

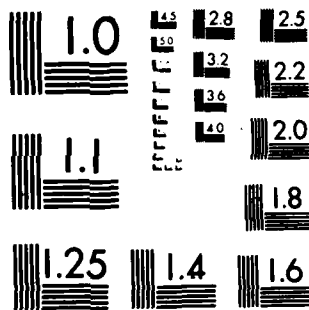
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UNCLASSIFIED

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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963 A



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APRIL 1977

Sheet No. 1

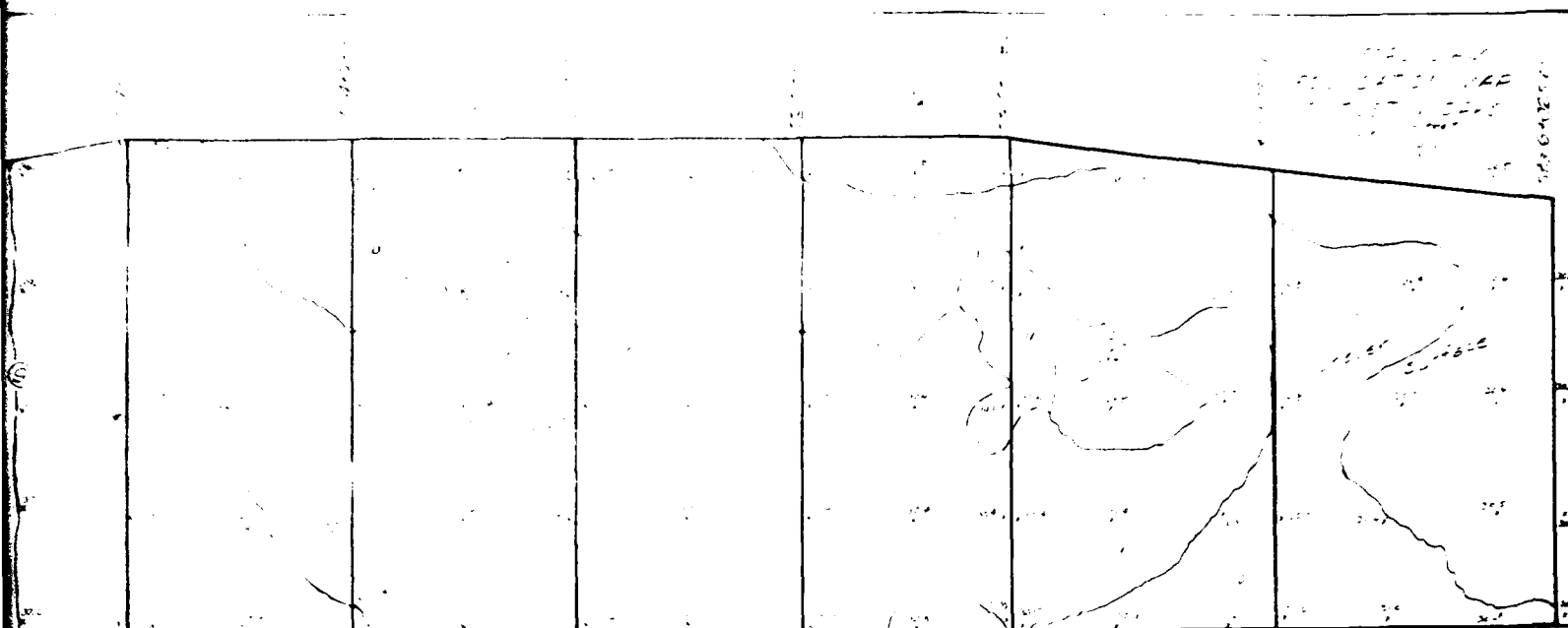
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CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1947

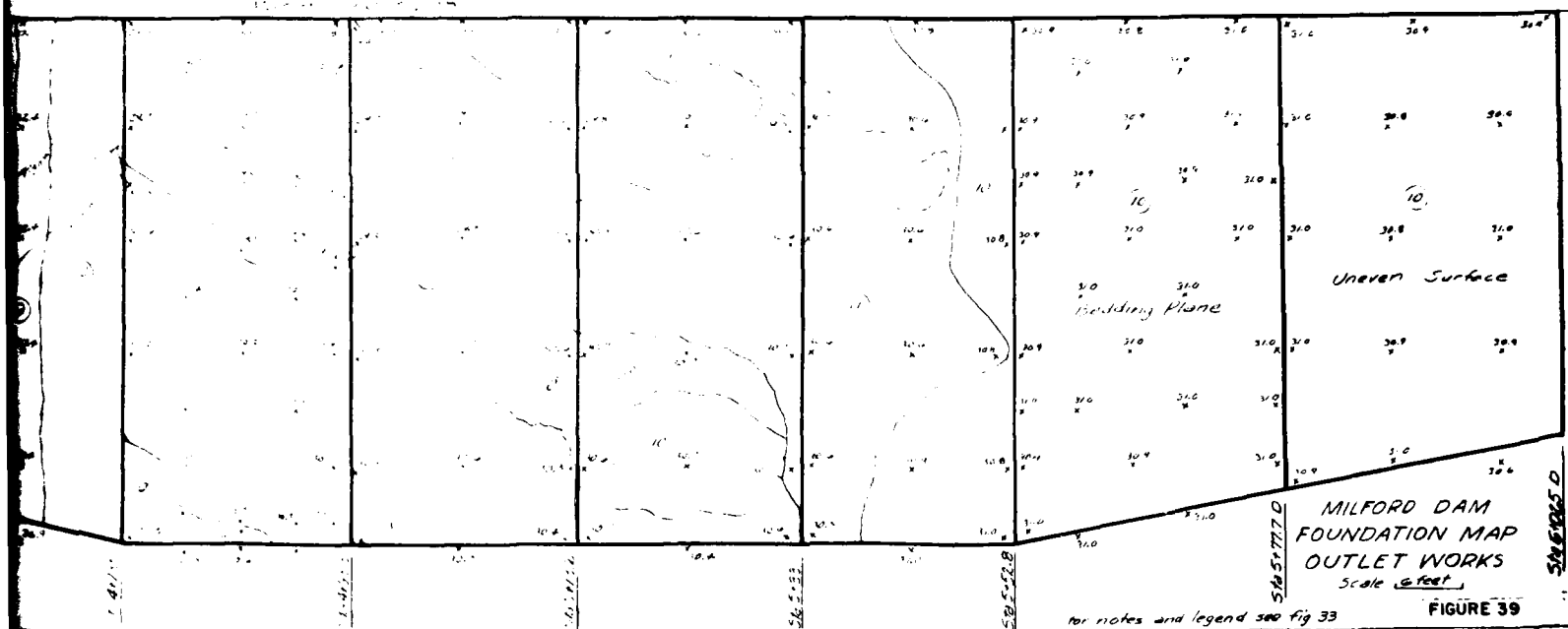
APRIL 1977

FIGURE 37



for notes and legend see fig 33

FIGURE 38



for notes and legend see fig 33

FIGURE 39

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
 FOUNDATION REPORT
 OUTLET WORKS
 FOUNDATION MAP OF
 LEFT AND RIGHT HALVES
 STA. 3+77 DOWNSTREAM
 TO STA. 6+02.5 DOWNSTREAM

In 1 sheet

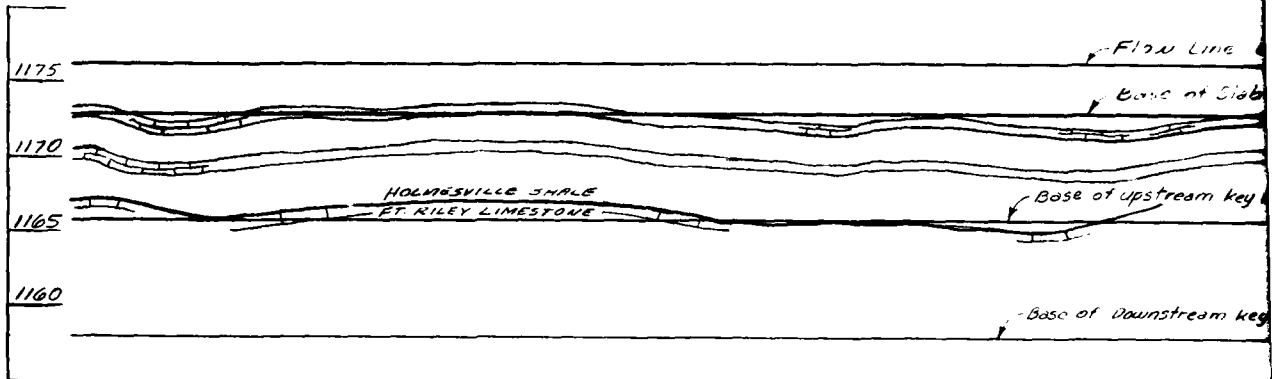
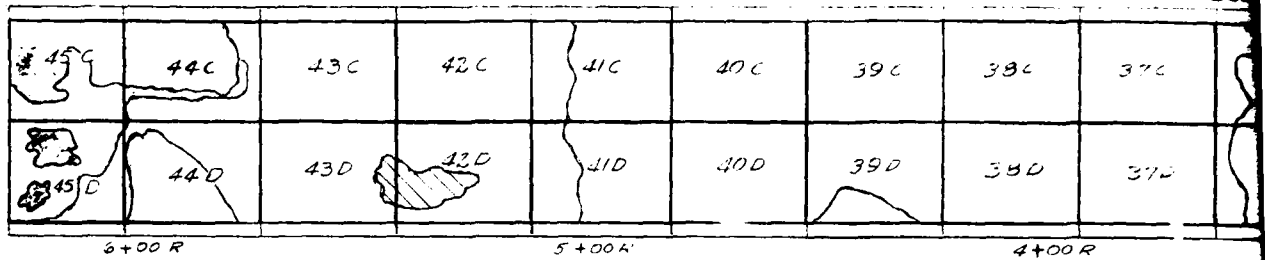
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CORPS OF ENGINEERS U. S. ARMY
 KANSAS CITY DISTRICT
 FILE NO. B-1-1948
 APRIL 1977

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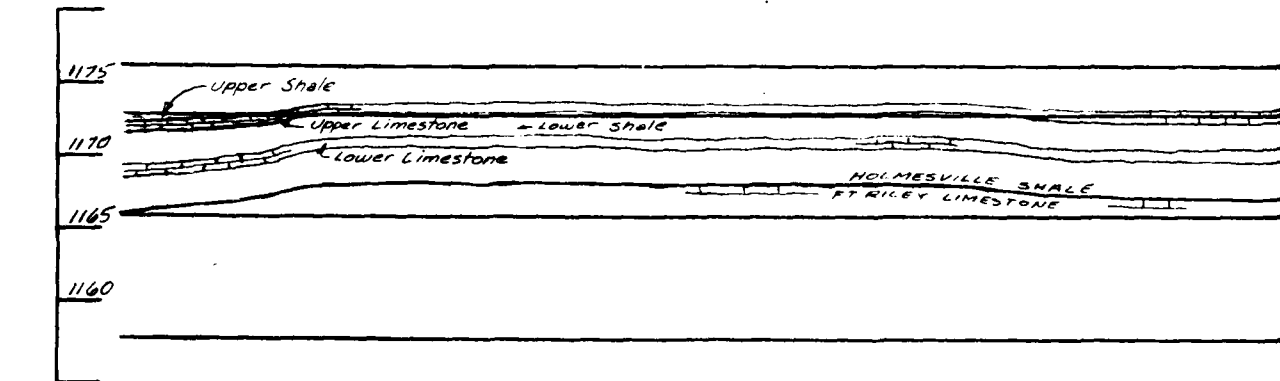
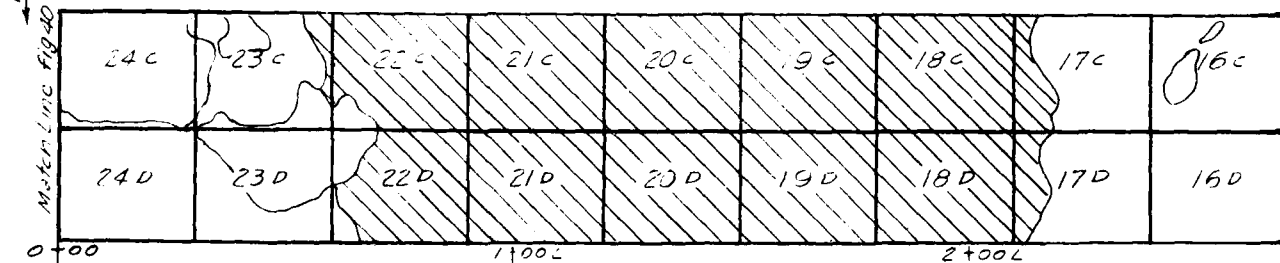
FOUNDATION



GEOLOGIC PROFILE LOOKING UPST

Spillway

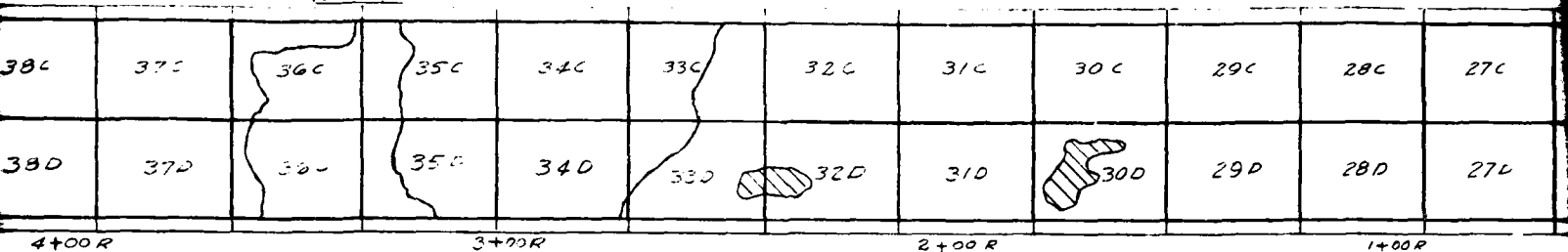
FOUNDATION



GEOLOGIC PR LOOKING

FOUNDATION MAP SPILLWAY CREST SLAB

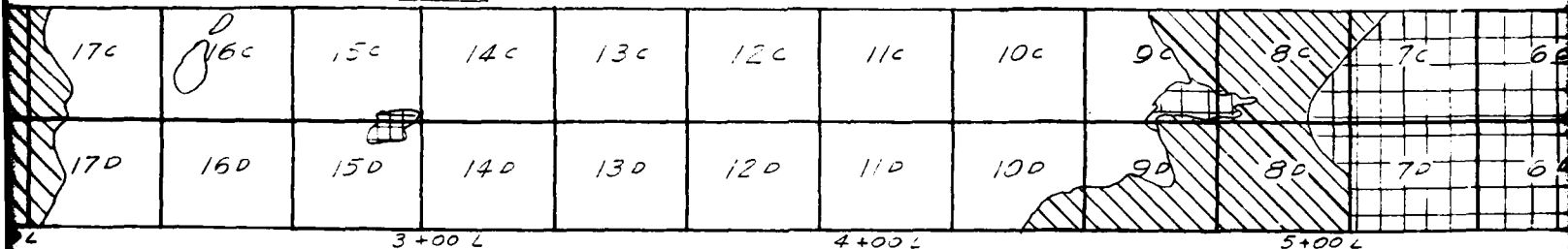
Scale 1/20 feet



GEOLOGIC PROFILE SPILLWAY CREST LOOKING UPSTREAM

FOUNDATION MAP SPILLWAY CREST SLAB

Scale 1/20 feet



GEOLOGIC PROFILE SPILLWAY CREST LOOKING UPSTREAM

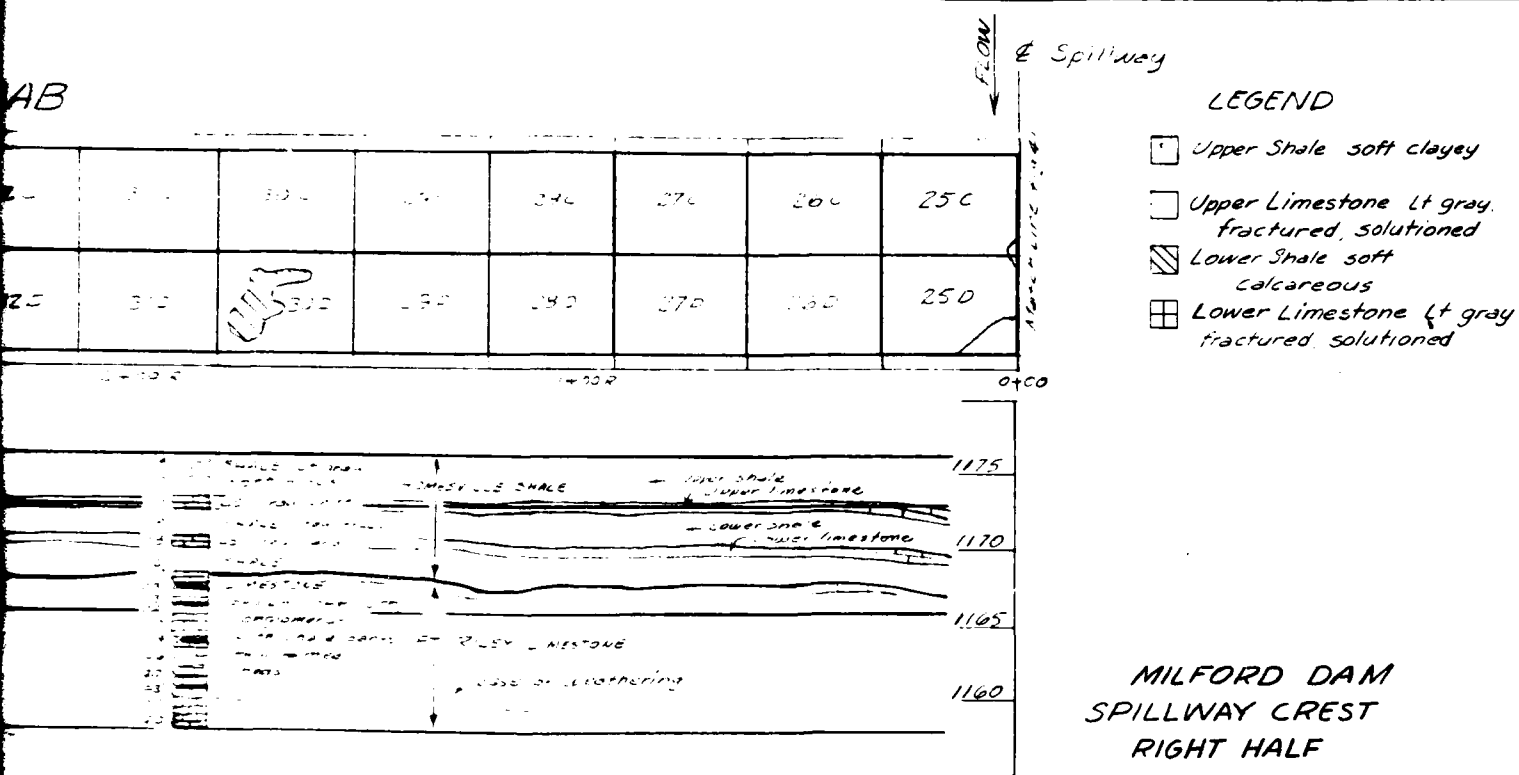


FIGURE 40

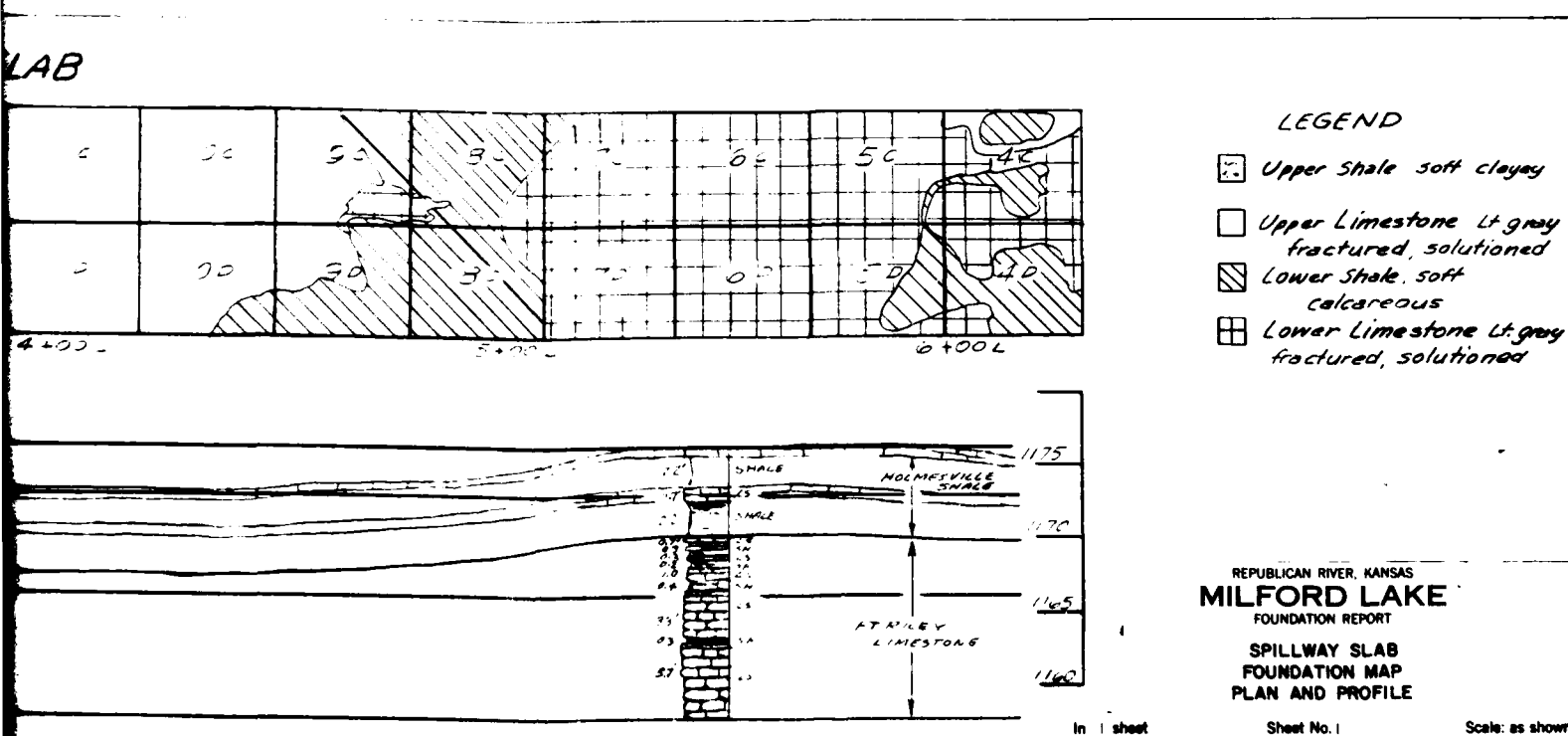


FIGURE 41

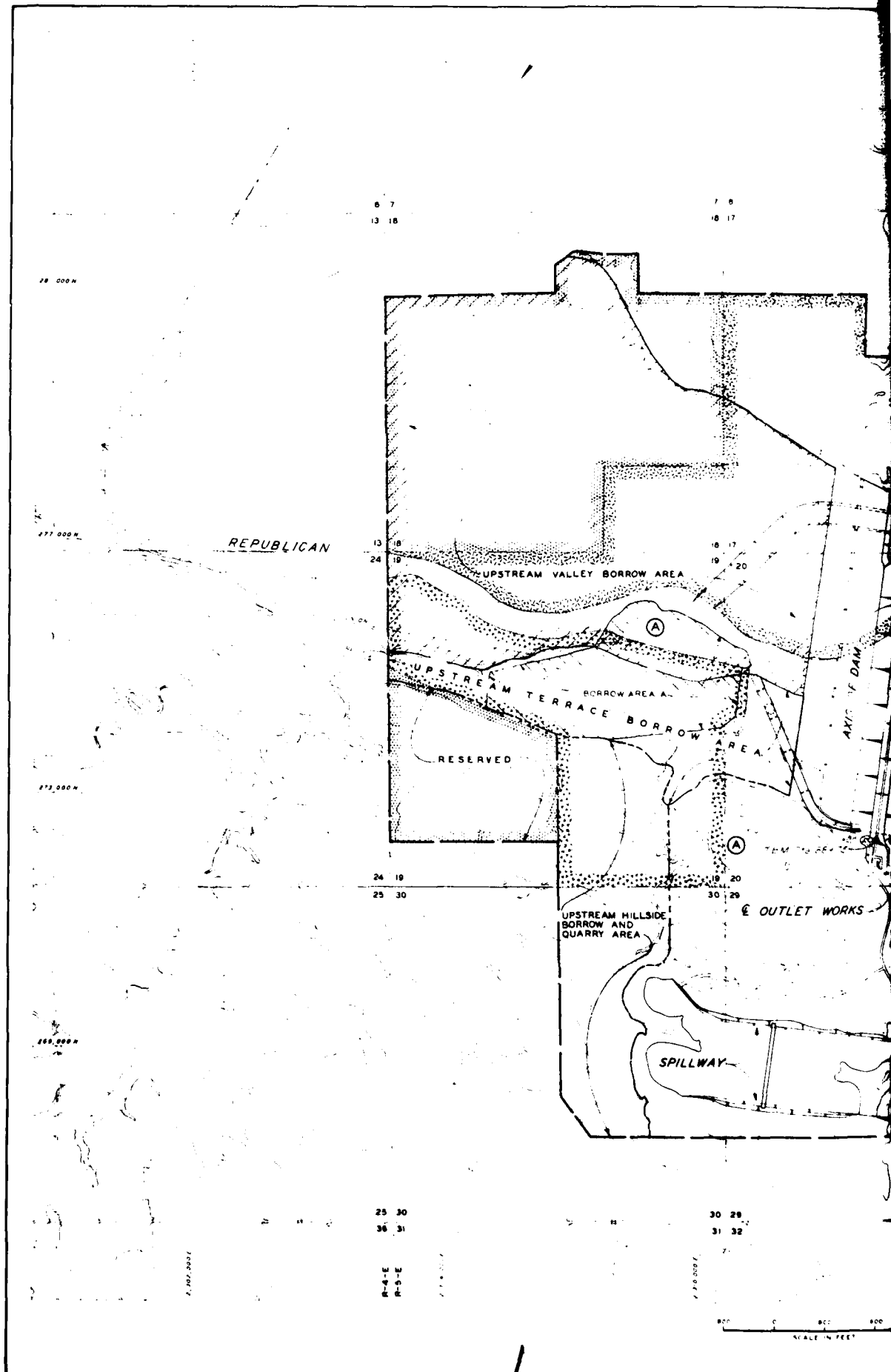
REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT
SPILLWAY SLAB
FOUNDATION MAP
PLAN AND PROFILE

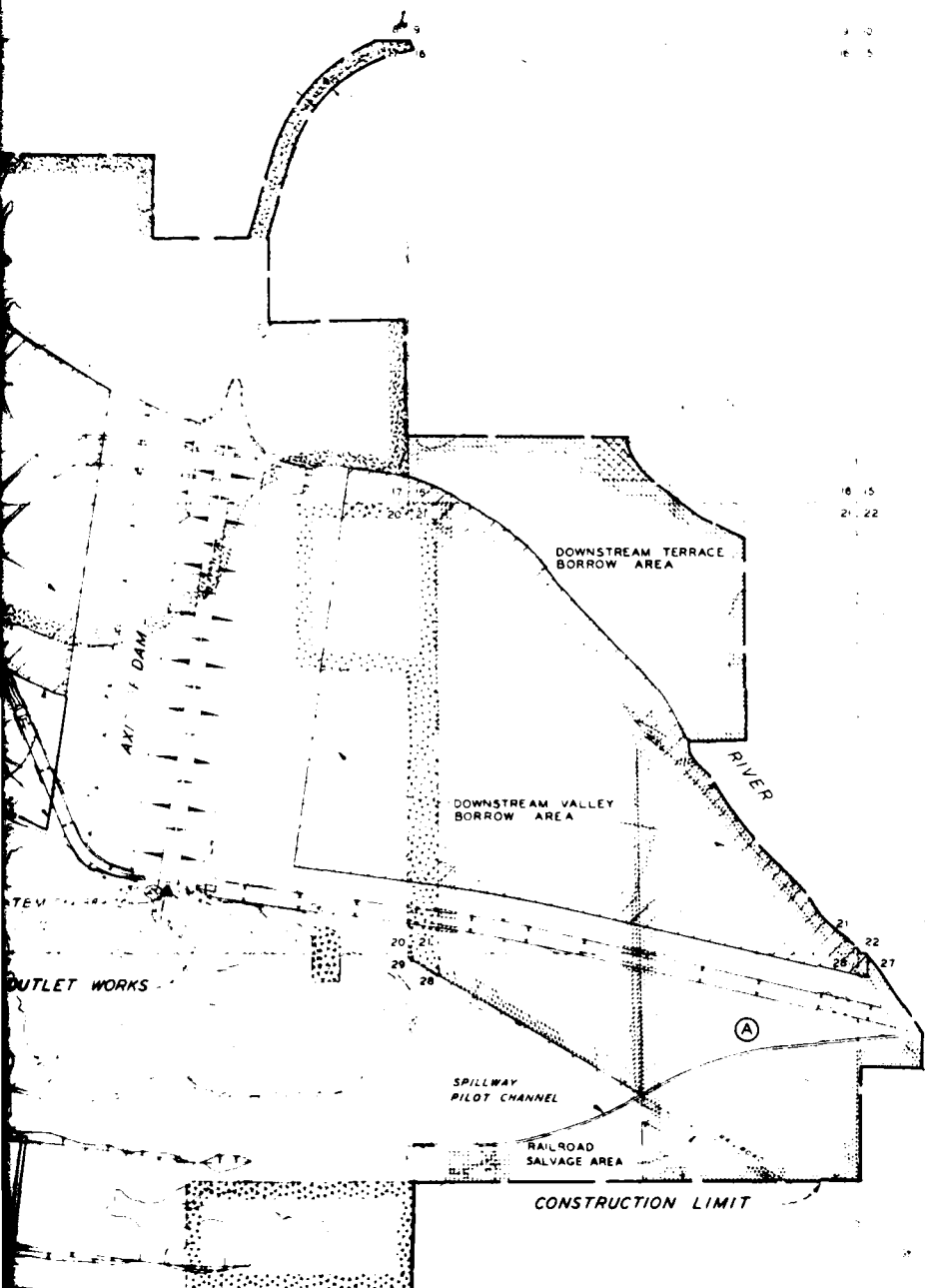
Sheet No. 1
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. B-1-1949
APRIL 1977

Scale: as shown

DRAWINGS

DRAWINGS





RIGHT-OF-WAY CODE

NOT AVAILABLE UNTIL JUNE 1, 1962	[Pattern]
NOT AVAILABLE UNTIL JUNE 20, 1962	[Pattern]
NOT AVAILABLE UNTIL JULY 1, 1962	[Pattern]
NOT AVAILABLE UNTIL JULY 15, 1962	[Pattern]
NOT AVAILABLE UNTIL DECEMBER 31, 1962	[Pattern]
CROPS RESERVED UNTIL JULY 15, 1962	[Pattern]

RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA 23 028 CIVENG 62 739

SYMBOL	DESCRIPTION	REVISIONS

**REPUBLICAN RIVER, KANSAS
MILFORD DAM**

GENERAL PLAN

In 141 sheets U. S. ARMY ENGINEER DISTRICT KANSAS CITY

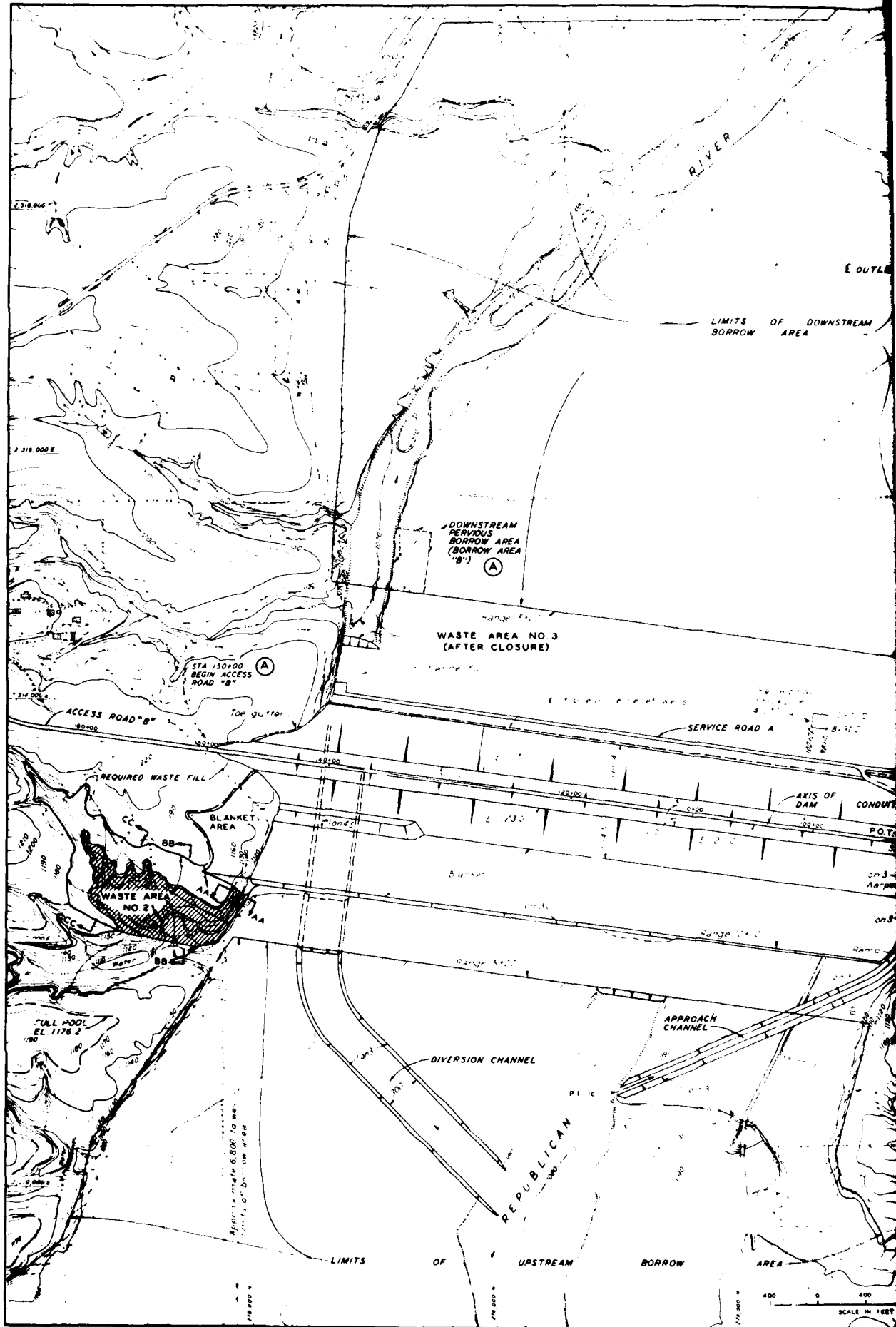
Sheet No. 3

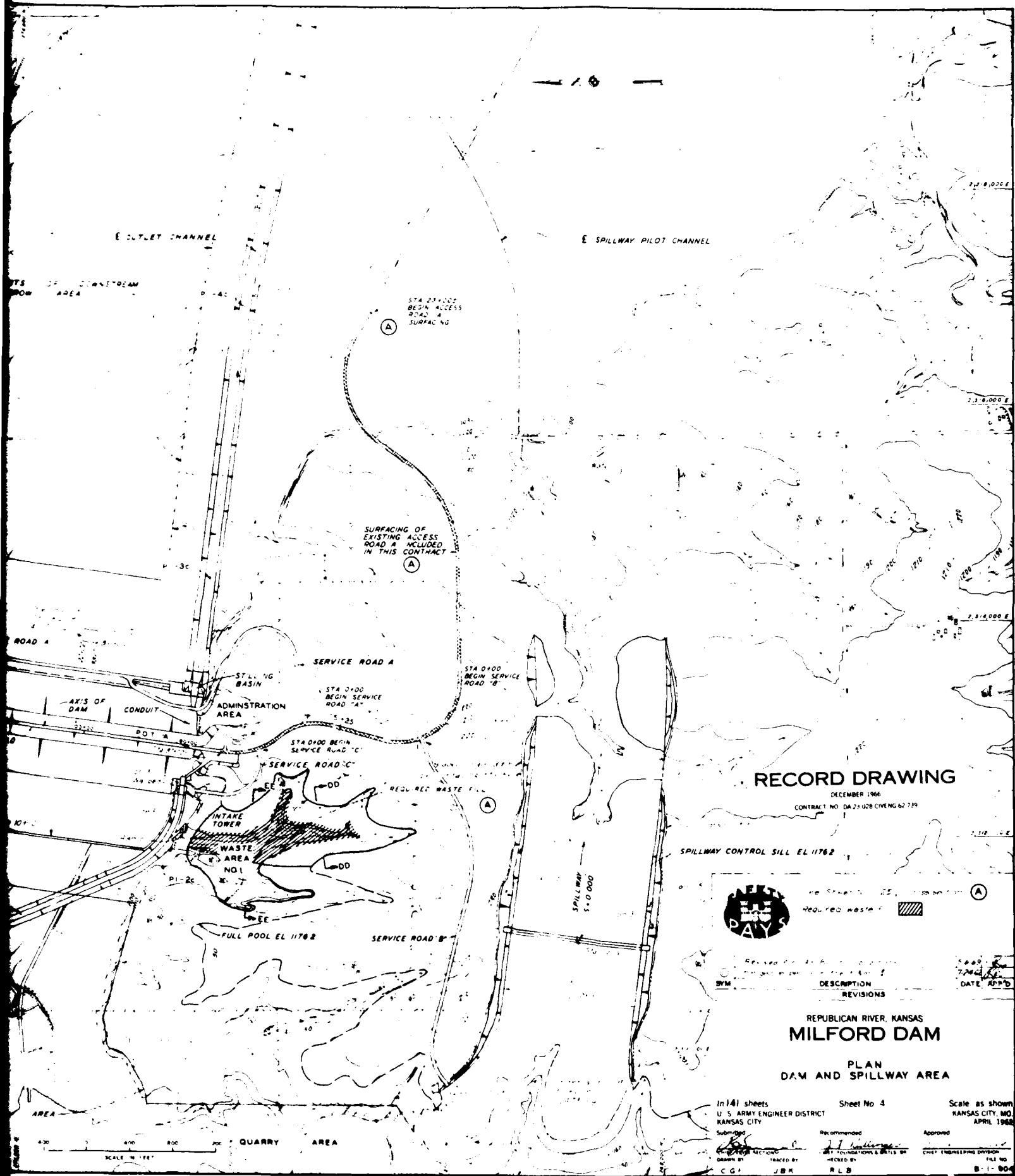
Scale: as shown KANSAS CITY, MO. APRIL 1962

Submitted: *Carl Block*
CHIEF, STRUCTURAL SECTION
DRAWN BY: J.A.M. TRACED BY: C.E.W.

Recommended: *H. J. Scales*
CHIEF, DESIGN BRANCH
CHECKED BY: M.M.R.

Approved: *James L. Ford*
CHIEF, ENGINEERING DIVISION
FILE NO. 8-1-903





RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA 24 028 CIVENG 62 739

SPILLWAY CONTROL SILL EL 1176.2



REVISIONS
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REPUBLICAN RIVER, KANSAS
MILFORD DAM
PLAN
DAM AND SPILLWAY AREA

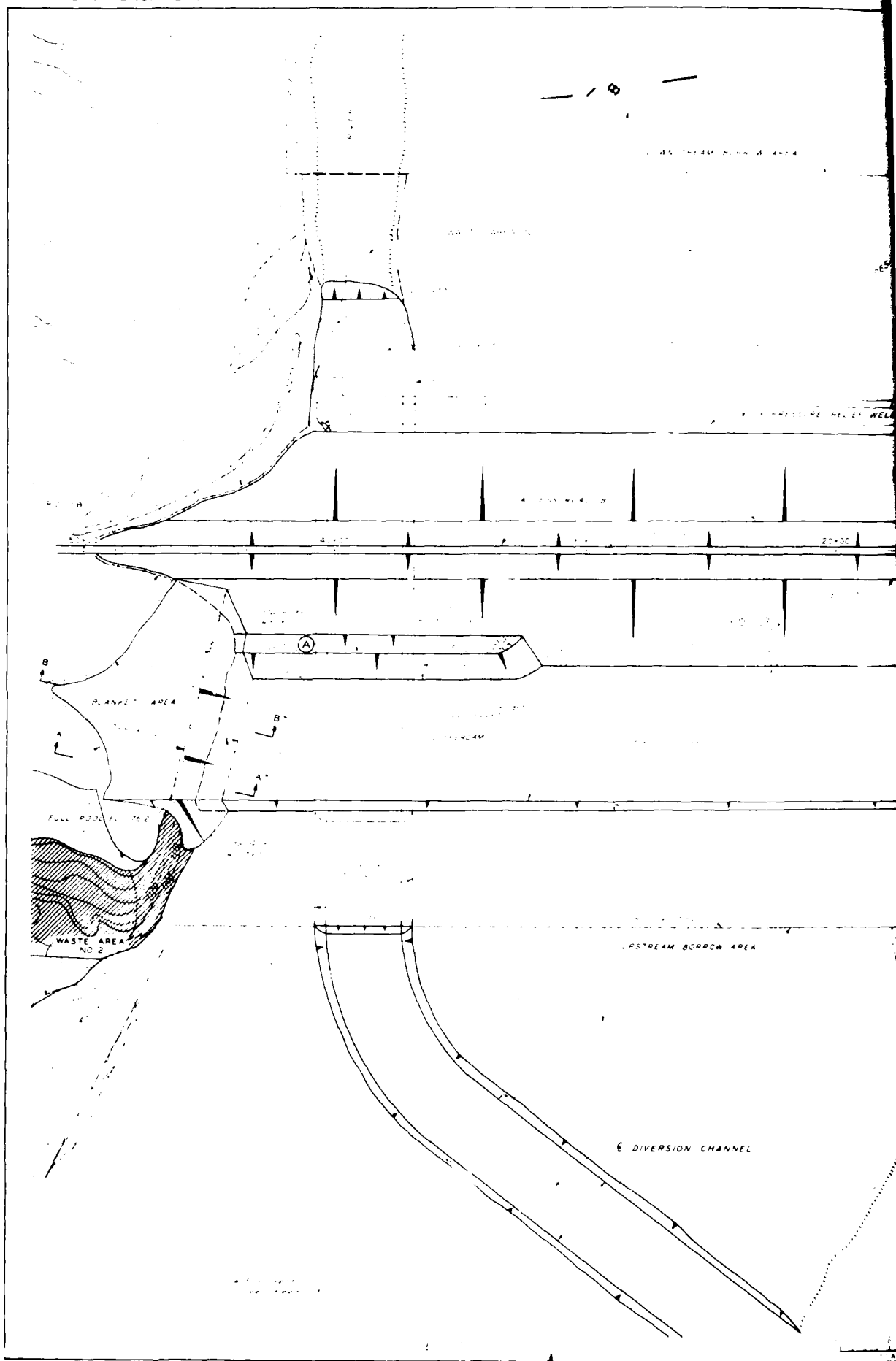
In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 4

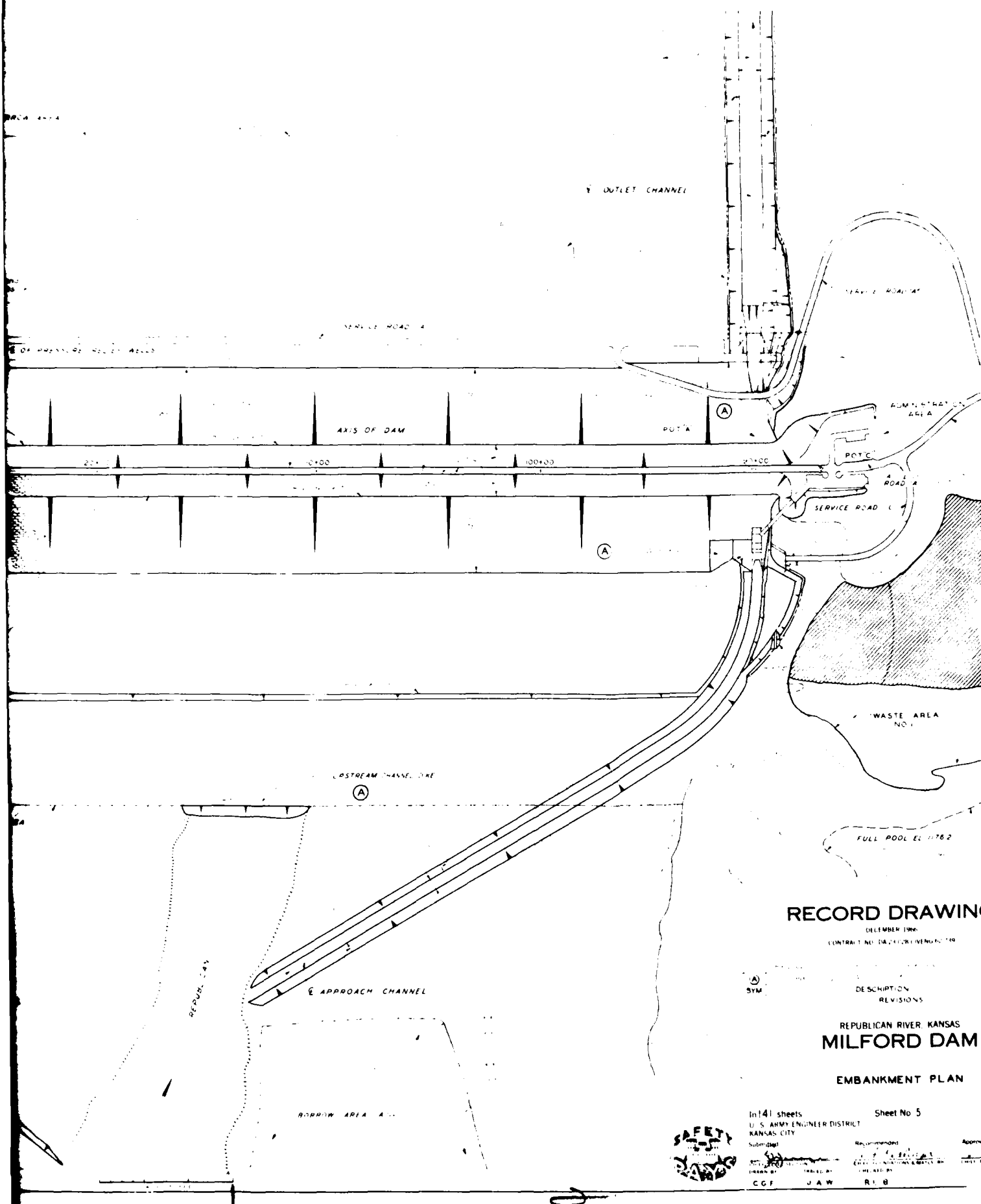
Scale as shown
KANSAS CITY, MO.
APRIL 1966

Submitted by: [Signature]
Checked by: [Signature]
Designed by: [Signature]
Traced by: [Signature]
Reviewed by: [Signature]
Approved by: [Signature]

CHIEF ENGINEERING DIVISION
FILE NO.
B-1-1-904



ARCH 4574



RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA-21-207-ENV-149

(A)
SYM

DESCRIPTION
REVISIONS

DATE APPD

REPUBLICAN RIVER, KANSAS
MILFORD DAM

EMBANKMENT PLAN

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No 5

Scale as shown
KANSAS CITY, MO
APRIL 1962

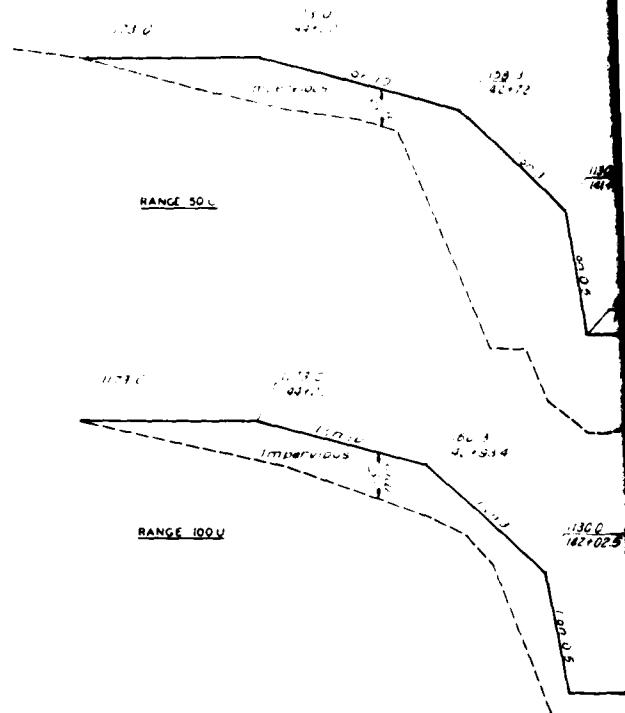


Submitted by
Checked by
Designed by
Drawn by
Reviewed by
Approved by

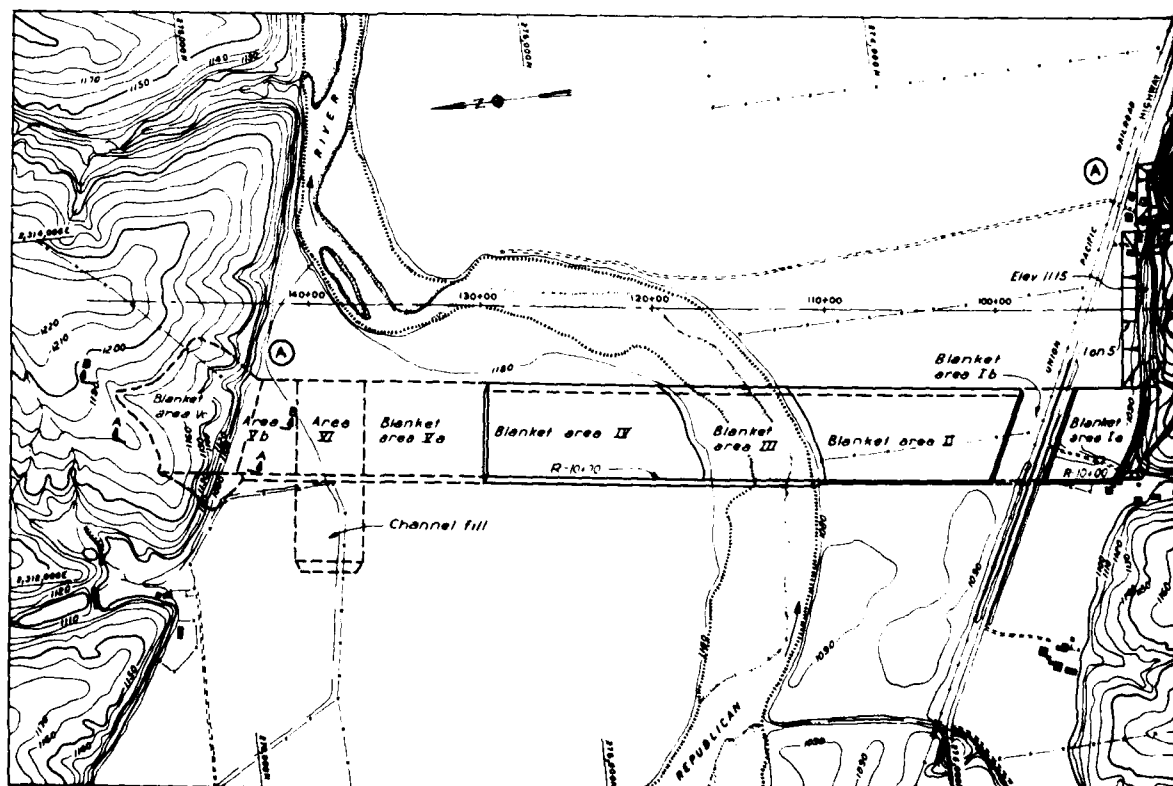
CGF JAW RLB

Approved
THREE ENGINEERING DIVISION
FREE NO
B-1-908

PLATE NO.



IMPERVIOUS BLANKET LEFT ABUTMENT



SCHEDULE III - EMBANKMENT, BLANKET & REQUIRED EXCAVATION

SCHEDULING

Right Abutment Area And Blanket Areas

Dates that right abutment area and blanket areas Ia, II, III and IV are available to Stage III Contractor are given in the specifications.

- (A) The Schedule II Contractor may place the impervious blanket in area IV prior to first stage diversion. Immediately after first stage diversion, the impervious blanket shall be completed for area II.
- (A) Schedule III Contractor shall construct blanket areas Ia and Ib complete, and finish construction of areas III and IV to the extent shale and limestone are available from required other works excavation.
- Schedule II Contractor shall complete the upstream blanket in all blanket areas after Schedule III blanket operation is completed.
- Blanket area IV and upstream channel fill in diversion channel are to be placed at the time of closure. Areas Ib and Ic may be deferred until this time.
- Blanket area Ib shall be made only after the railroad right-of-way is available for date railroad right-of-way is available, see specifications.
- (A) Schedule III work areas are shown shaded.

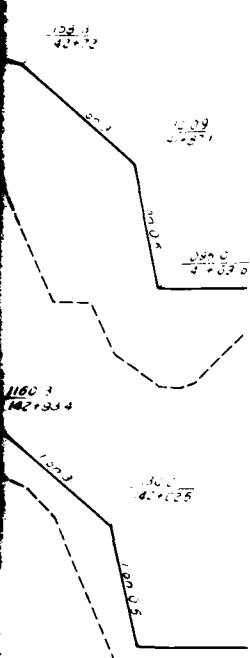
SPILLWAY

Spillway schedules not shown, see Sheet No 109

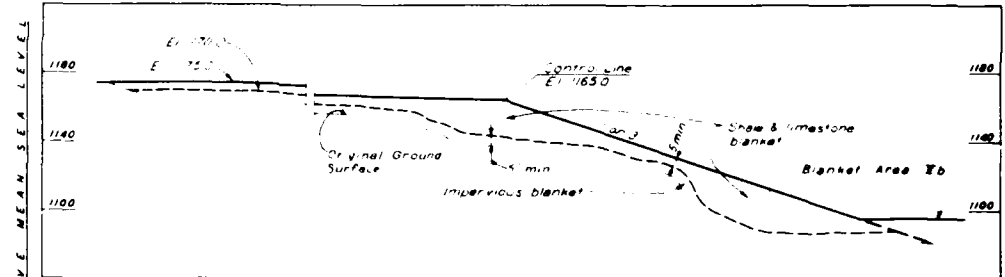
GENERAL NOTES

The area use schedule is furnished as general information to the Contractor; it is not intended to imply that the Contractors mentioned and others may not perform other work in the designated areas or shall not perform work or have access to other areas within which work is required under the specifications.

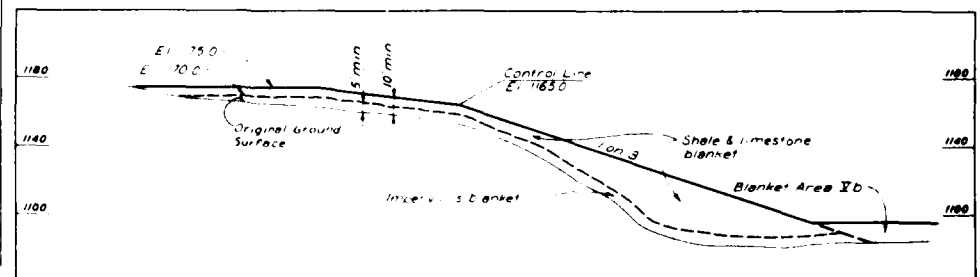
Schedule II Contractor shall request construction areas as covered in the specifications.



ABUTMENT



SECTION B-B



SECTION A-A

SECTIONS THRU BLANKET AREA IC

REPUBLICAN RIVER, KANSAS
MILFORD DAM

SCHEDULED WORK AREAS

RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA 23 028 CIVNG 62 739

In 14 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 6

Scale: as shown
KANSAS CITY, MO
APRIL 1966

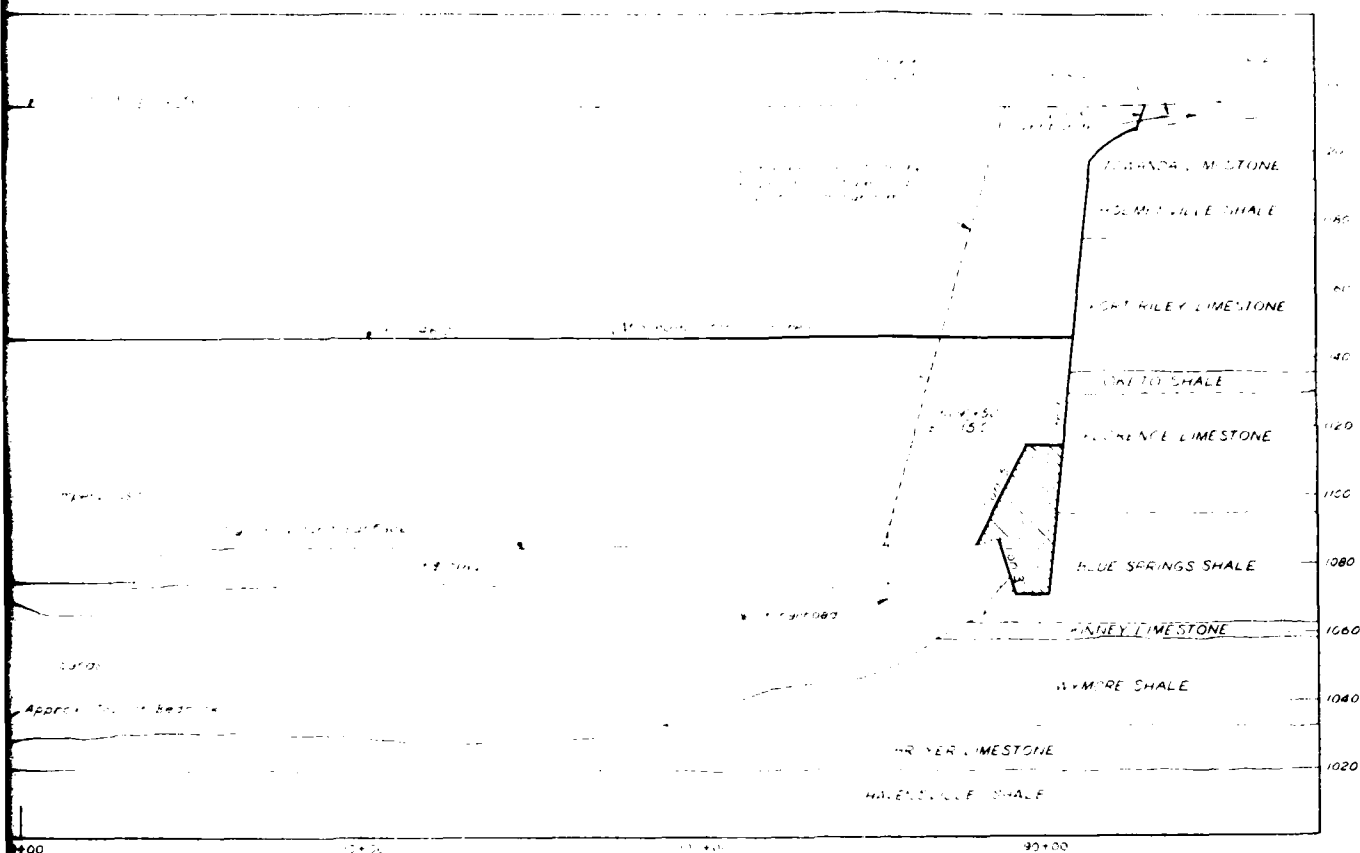


Revised for As Built Conditions		3449	6
Changed as per Amendment No. 1		22462	15
SYN	DESCRIPTION	DATE	APP'D
	REVISIONS		

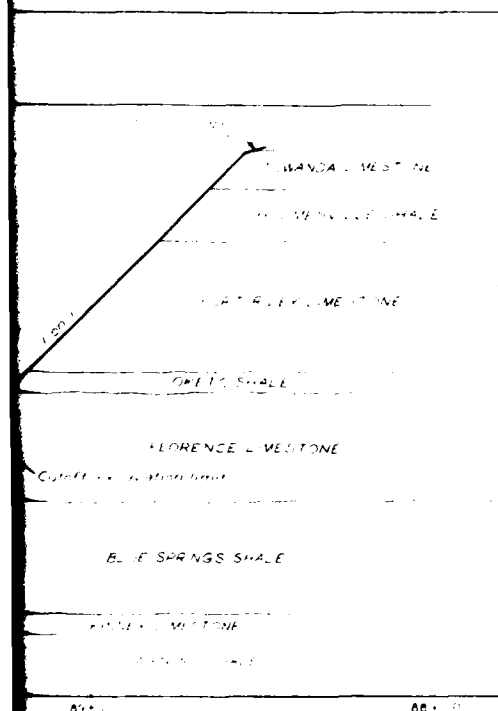
Submitted by: [Signature]
Checked by: [Signature]
Reviewed by: [Signature]
Approved by: [Signature]
C.G.P. C.E.R. R.L.B.

Approved: [Signature]
Chief Engineer District
P.L.B.
B-1-66

PLATE NO.



PROFILE - ALONG DAM AXIS



NOTES:
 1. Excavation plan shown
 2. Sheet No. 3
 3. Grading details, see Sheet No. 4
 4. Foundation details, see Sheet No. 5
 5. Foundation details, see Sheet No. 6

RECORD DRAWING

DECEMBER 1966
 CONTRACT NO. DA-23-028-CYENG-62-730

Rev. see for As-Built Conditions
 Changed as per Amendment No. 1
 SYM DESCRIPTION REVISIONS

5669
 72462
 DATE APP'D

REPUBLICAN RIVER, KANSAS MILFORD DAM

PROFILES DAM AXIS

In 41 sheets
 U. S. ARMY ENGINEER DISTRICT
 KANSAS CITY

Sheet No. 7

Scale: as shown
 KANSAS CITY, MO
 APRIL 1962



Submitted by
 Checked by
 C. G.

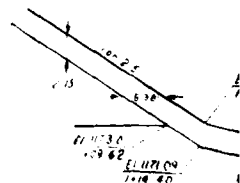
Recommended by
 Checked by
 R. L. B.

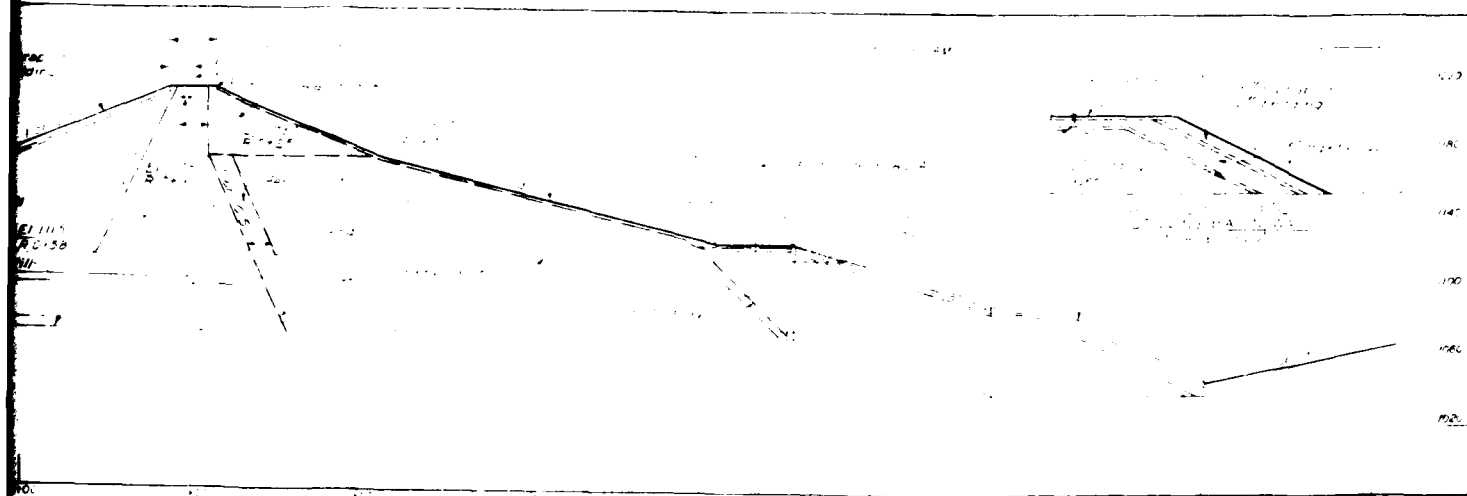
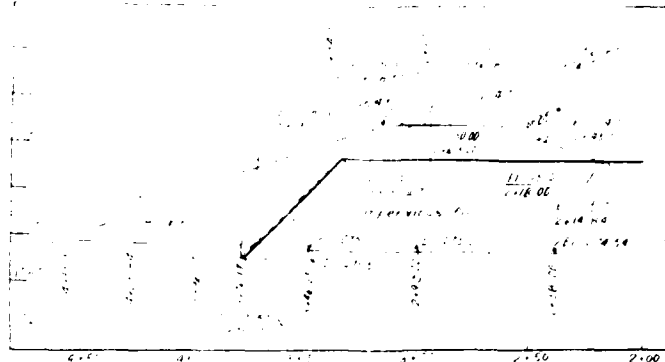
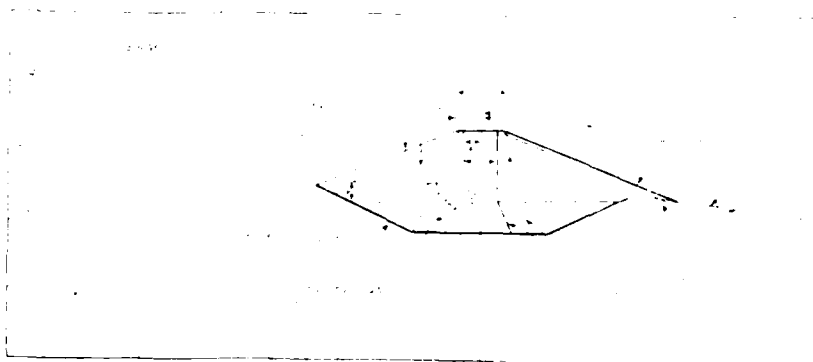
Approved by
 Checked by
 S-1 907

PLATE NO. 5

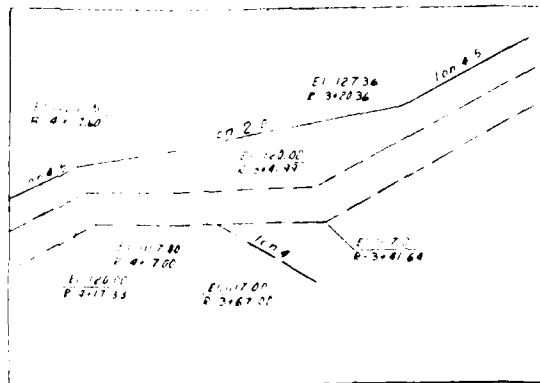
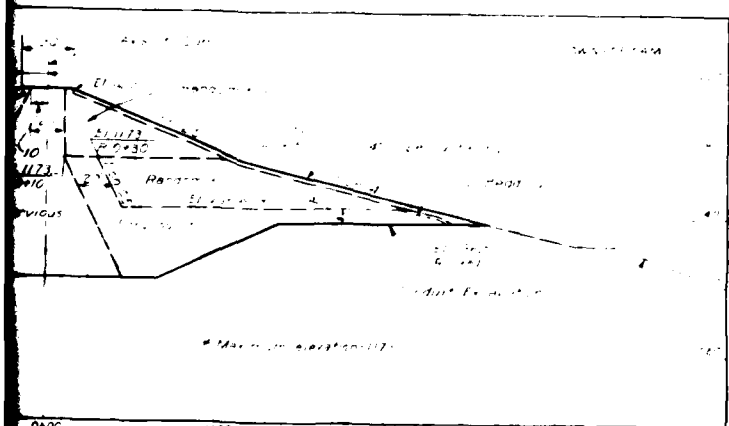
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STA 89+50
TYPICAL SECTION STA 89+0 TO STA 89+82.5





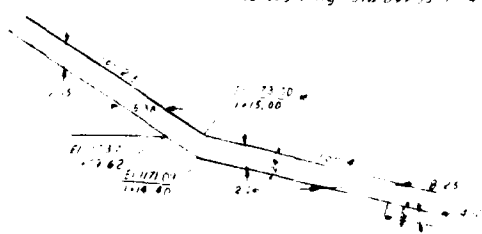
TYPICAL CONDUIT SECTION
STA 89+35 TO STA 89+50



NOTES:
for top of dam surfacing
detail, see Sheet No. 12.
for vertical curve
data, see Sheet No. 13

STA 89+50
STA 89+50 TO STA 89+60

* Distances apply between vertical
curves only. Sta 89+35 to Sta 89+50



Revised for "As Built" conditions
Changed as per Amendment No. 1
SYN. DESCRIPTION REVISIONS

5649
7462
DATE APR 1962

REPUBLICAN RIVER, KANSAS
MILFORD DAM

EMBANKMENT SECTIONS

RECORD DRAWING

DECEMBER 1960
CONTRACT NO. DA-23-028 CHENG 62 739

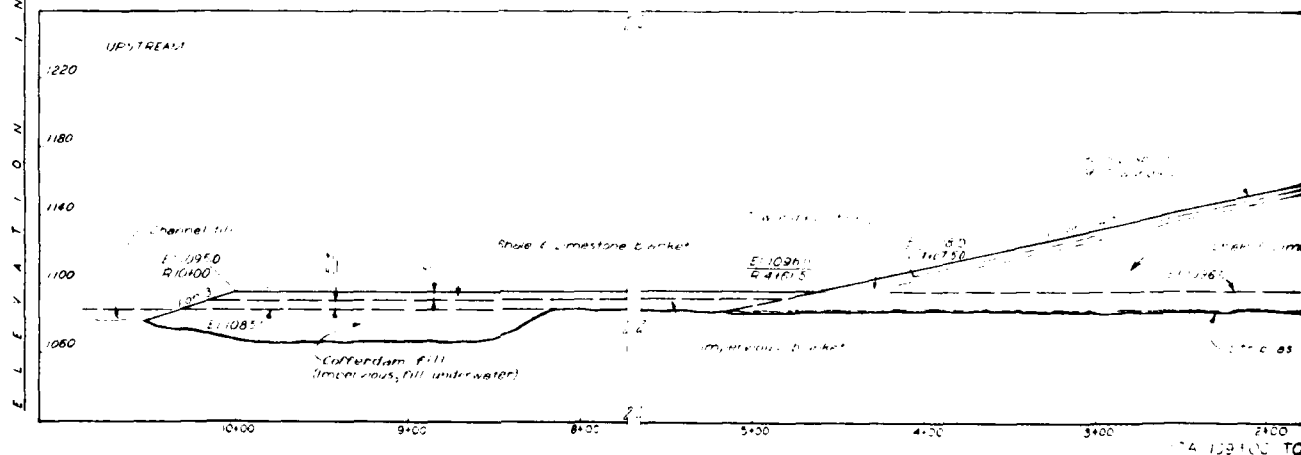
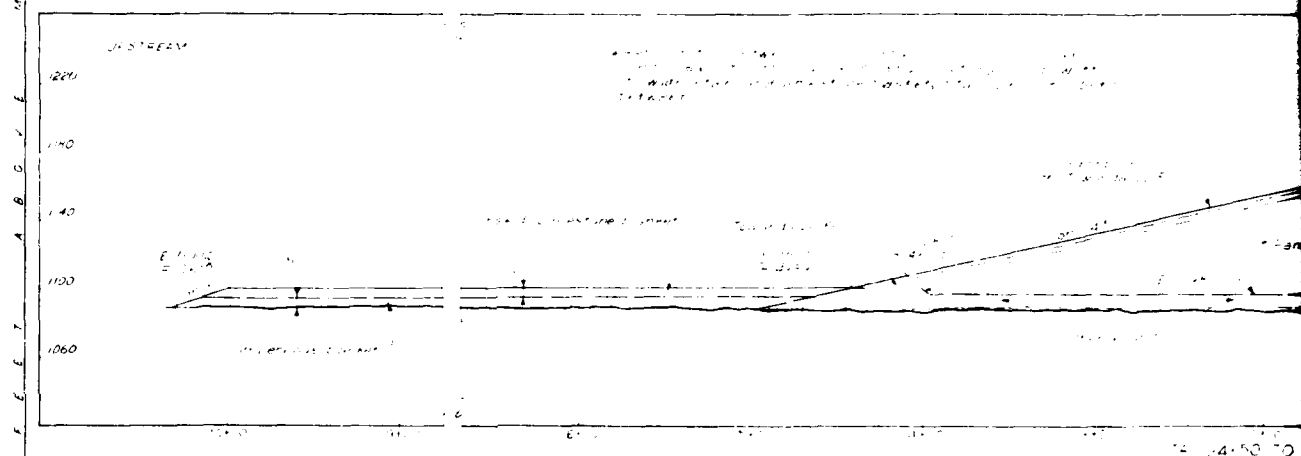
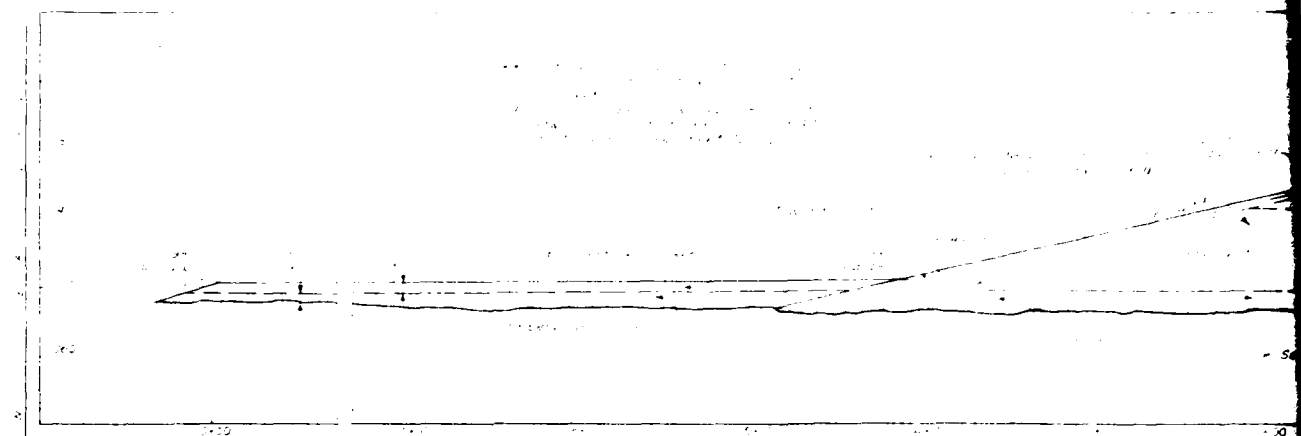


In 14 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY
DRAWN BY
CHECKED BY
C.G.F.

Sheet No. 8
Recommended
J. F. Kellerman
CHIEF FOUNDATIONS & EMBLE. BR.
CHECKED BY
R. C. B.

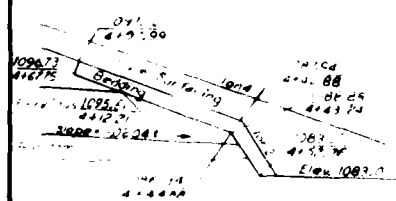
Scale: as shown
KANSAS CITY, MO
APRIL 1962
APPROVED
CHIEF ENGINEERING DIVISION
FILE NO.
8-1-808

PLATE NO. 6

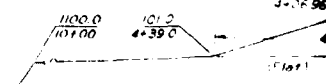


NOTES

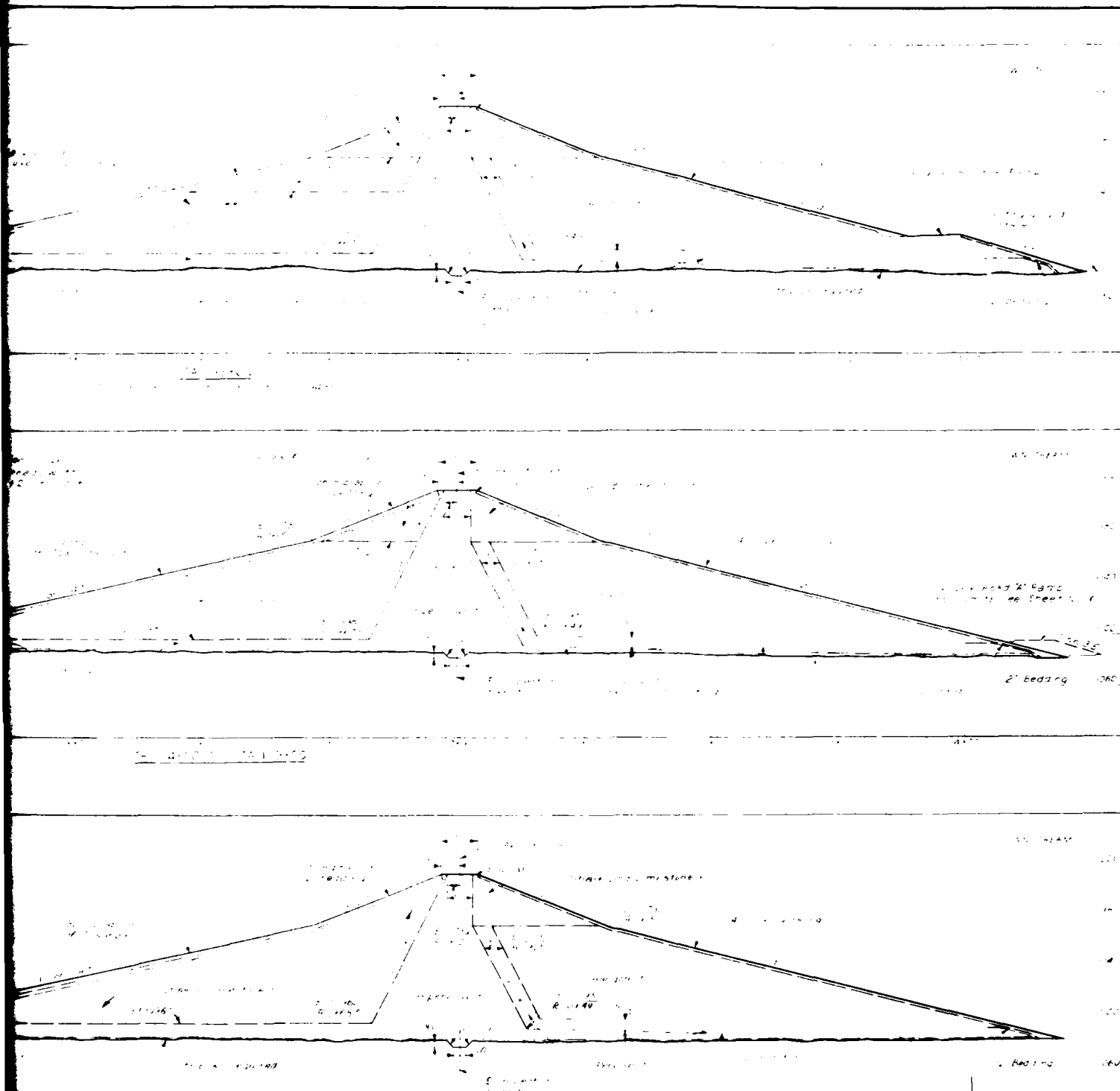
- (1) Shale limestone fill shall utilize the shale limestone from required excavation. Top of this zone shall be approximately level between transition limits and will form the downstream of the upstream random fill zone. A transition between fill and limestone shall be indicated.
- (2) For top of random fill details see Sheet No. 12.
- (3) Upstream pile jet transitions shall be indicated with a transition.



STA. 96+50 TO STA. 109+50
STA. 121+50 TO STA. 140+30



STA. 94+



STA 100+00 TO STA 101+00

STA 101+00 TO STA 102+00

STA 102+00 TO STA 103+00

SYMBOL	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions		
	Changed as per Amendment No. 1		

REPUBLICAN RIVER, KANSAS MILFORD DAM

EMBANKMENT SECTIONS

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY
Sheet No. 9
Scale: as shown
KANSAS CITY, MO
APRIL 1962

Recommended
J. J. Kistner
Approved
[Signature]
CHIEF ENGINEERING DIVISION
FILE NO.
B-1-908

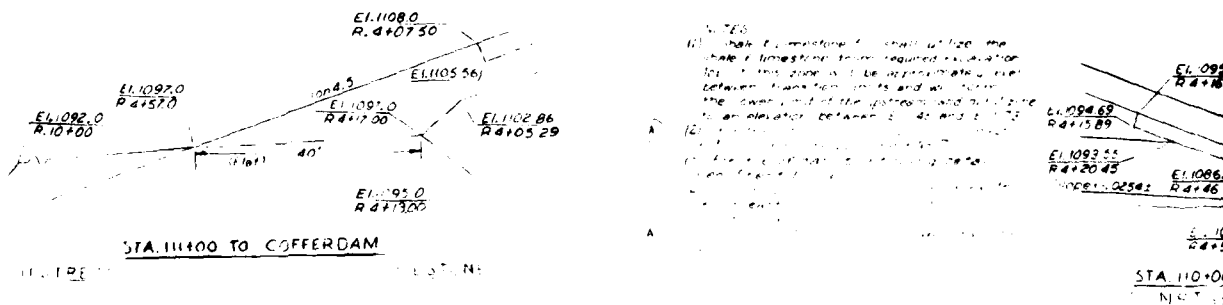
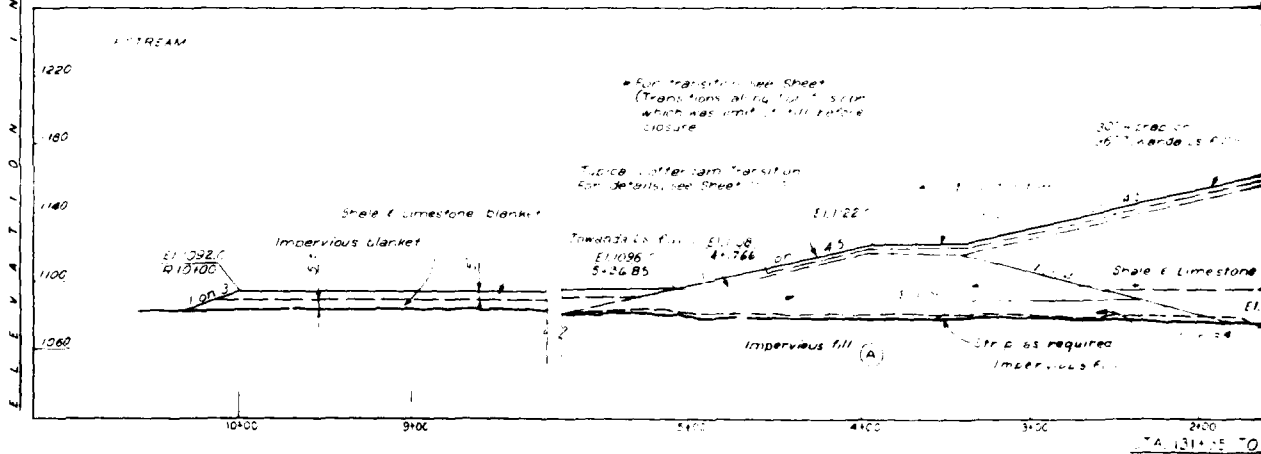
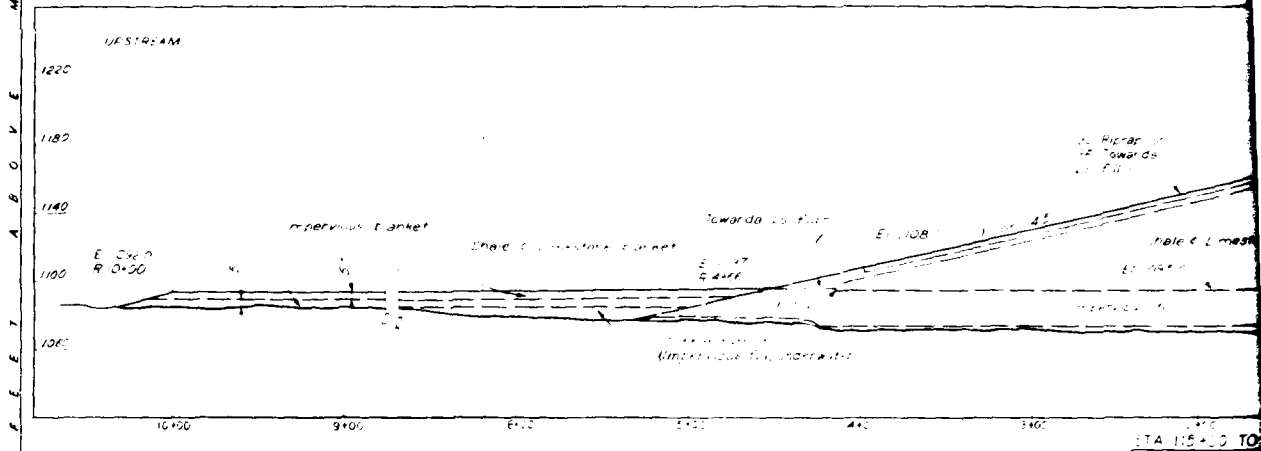
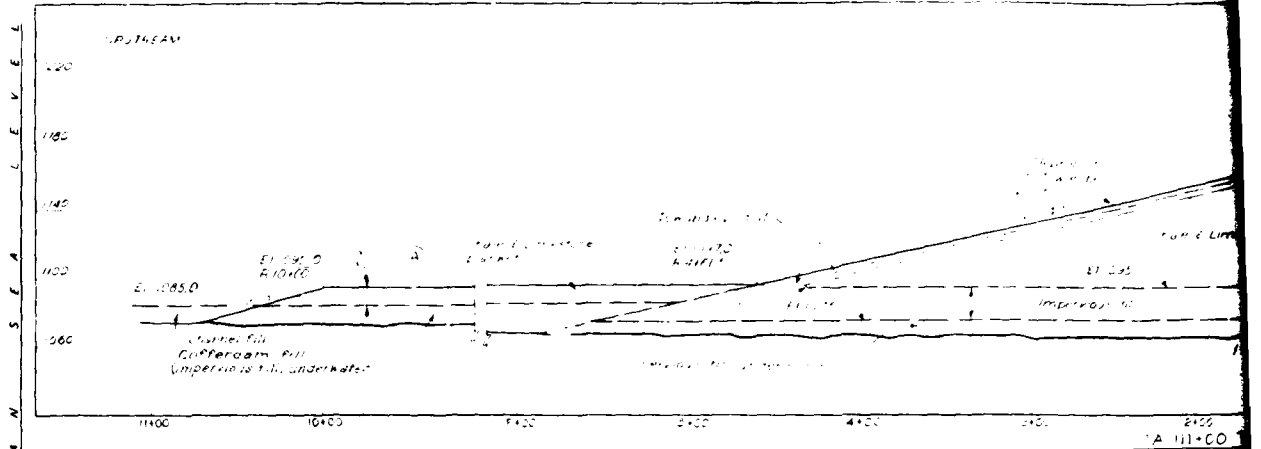
DESIGNED BY
CCS
CHECKED BY
JRP
DRAWN BY
A. B.

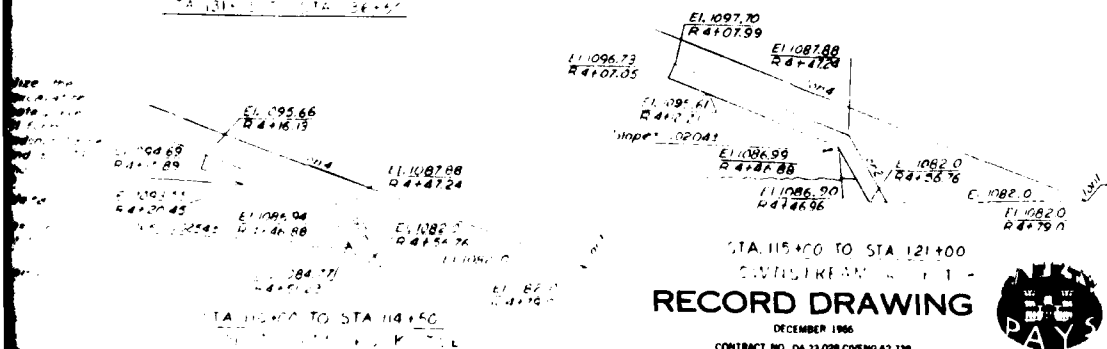
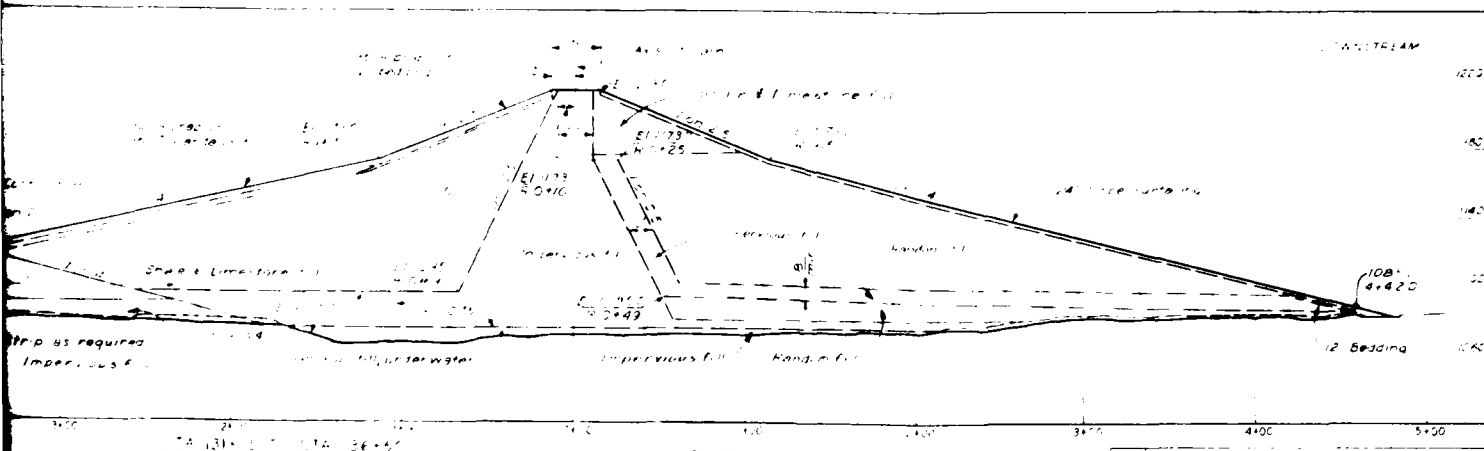
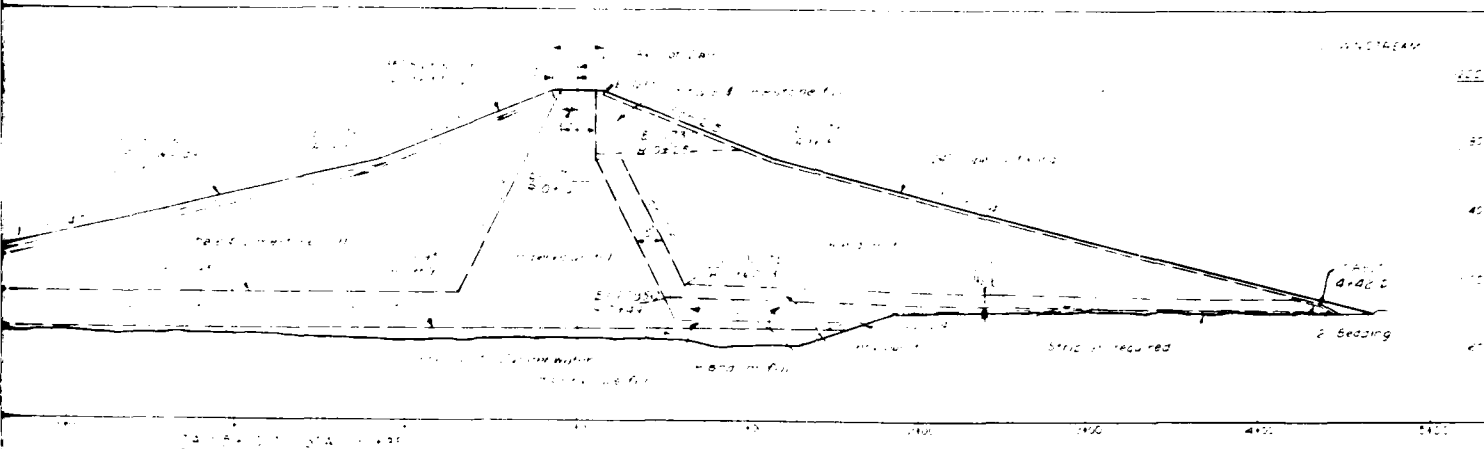
RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA 23-028 CIVENG 62 739







Revised for AS Built conditions		4-29-89
(A) changed as per Amendment No. 12		7266
SYM	DESCRIPTION	DATE
REVISIONS		

EMBANKMENT SECTIONS

Scale as shown
KANSAS CITY, MO
APRIL 1962

DECEMBER 1966

CONTRACT NO DA 23-020-CIVENG 62 739

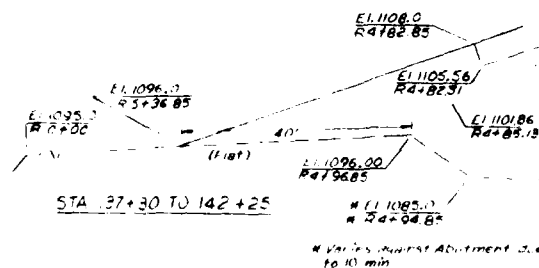
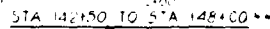


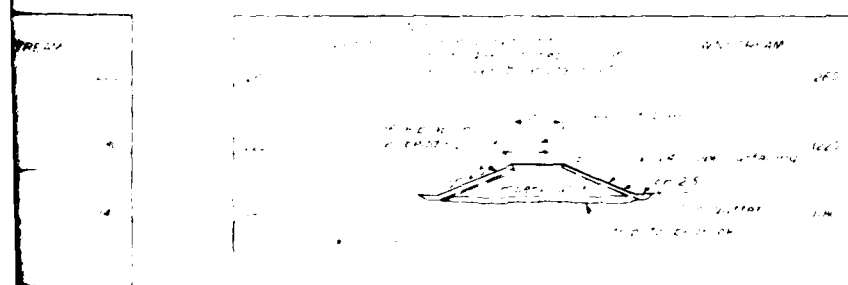
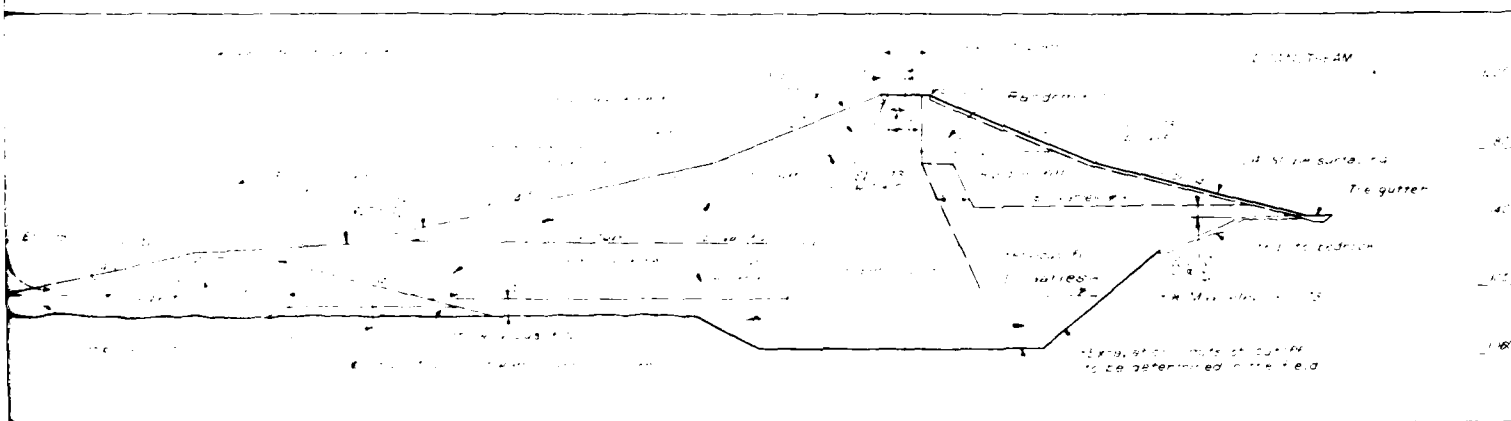
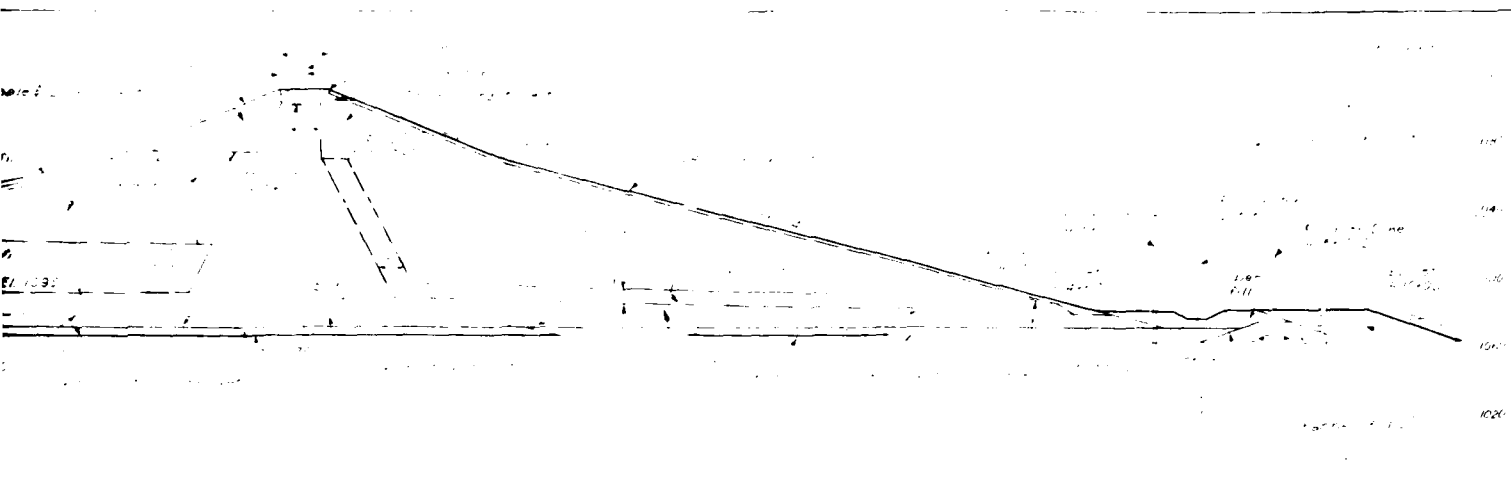
Submitted 
(HISTORICAL SECTION)
DRAWN BY CCF TRACED BY JRP

Recommended
J. F. Hollinger
CHECKED BY
1 2

Approved _____

 CHIEF ENGINEERING DIVISION
 FILE NO
 8-1-810





NOTE:
 1. For details of line work and details, see sheet No. 12.
 2. For details of line work and details, see sheet No. 13.
 3. For details of line work and details, see sheet No. 14.

RECORD DRAWING

DECEMBER 1966
 CONTRACT NO. DA 23-028-CHENG 42 739

SYMBOL	DESCRIPTION	REVISIONS
1	SYMBOL	REVISIONS

REPUBLICAN RIVER, KANSAS MILFORD DAM

EMBANKMENT SECTIONS

In 41 sheets
 U. S. ARMY ENGINEER DISTRICT
 KANSAS CITY

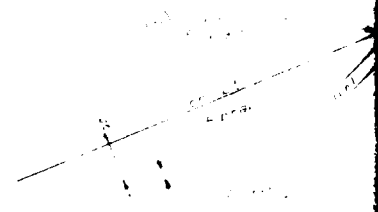
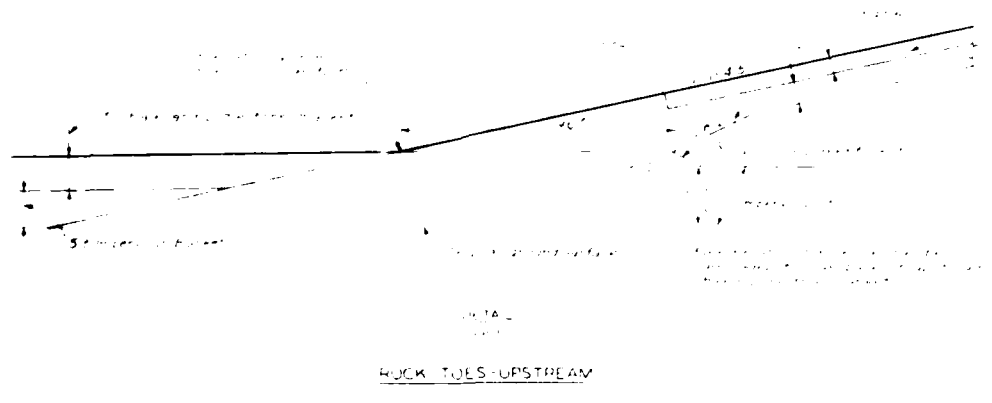
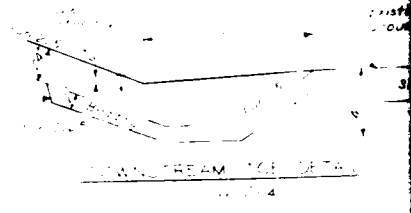
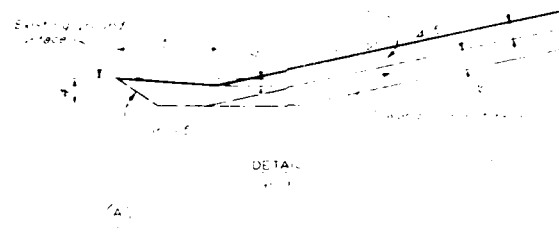
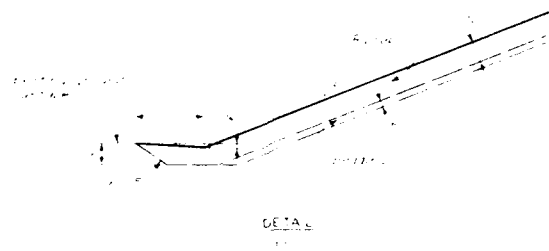
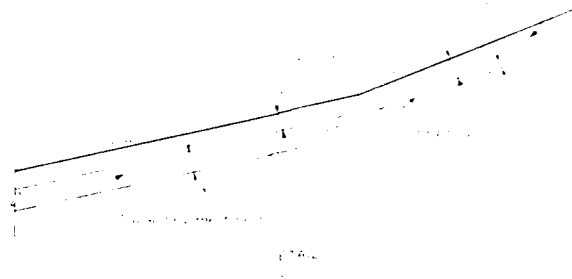
Sheet No. 11

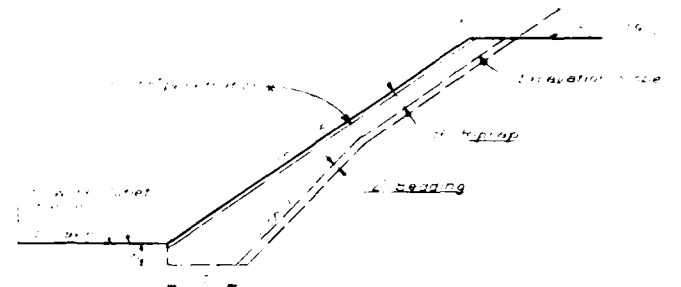
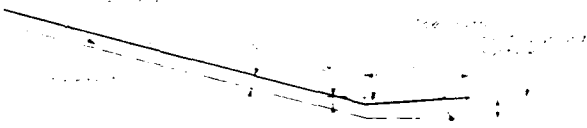
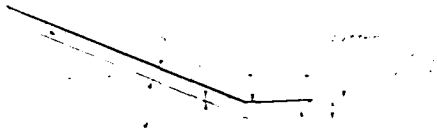
Scale as shown
 KANSAS CITY, MO
 APRIL 1962

Submitted by: *[Signature]*
 Checked by: *[Signature]*
 Drawn by: CGF
 Traced by: JRP

Approved: *[Signature]*
 Chief Engineer's Office
 FILE NO. 1-1-011







RIGHT BANK PILOT CHANNEL
TOE CHANNEL RIPRAP DETAILS
Scale 1/2" = 1'-0"

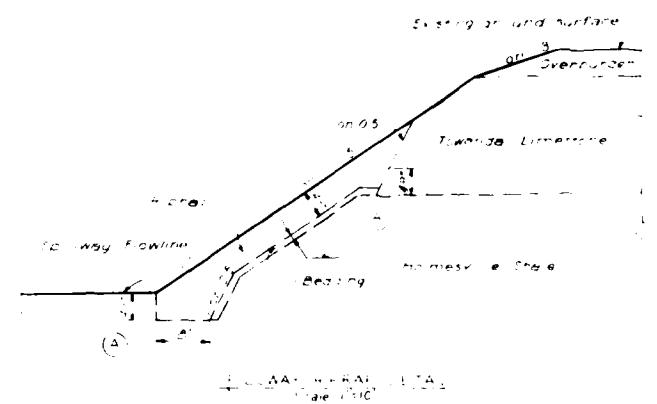
* TO BE USED IN CONJUNCTION WITH SHEET 11

DOWNSTREAM TOE DETAIL
Scale 1/2" = 1'-0"

DOWNSTREAM TOE DETAIL
Scale 1/2" = 1'-0"



ROCK TOES-DOWNSTREAM



LEFT BANK RIPRAP DETAIL
Scale 1/2" = 1'-0"

RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA-23-028-CHENG-62 738

SYMBOL	DESCRIPTION	DATE	APPROVED
①	Revised for As Built conditions	5-6-67	
②	Change as per Amendment No. 118	7-24-67	
③	REVISIONS		

REPUBLICAN RIVER, KANSAS MILFORD DAM

RIPRAP AND SLOPE PROTECTION DETAILS

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 12

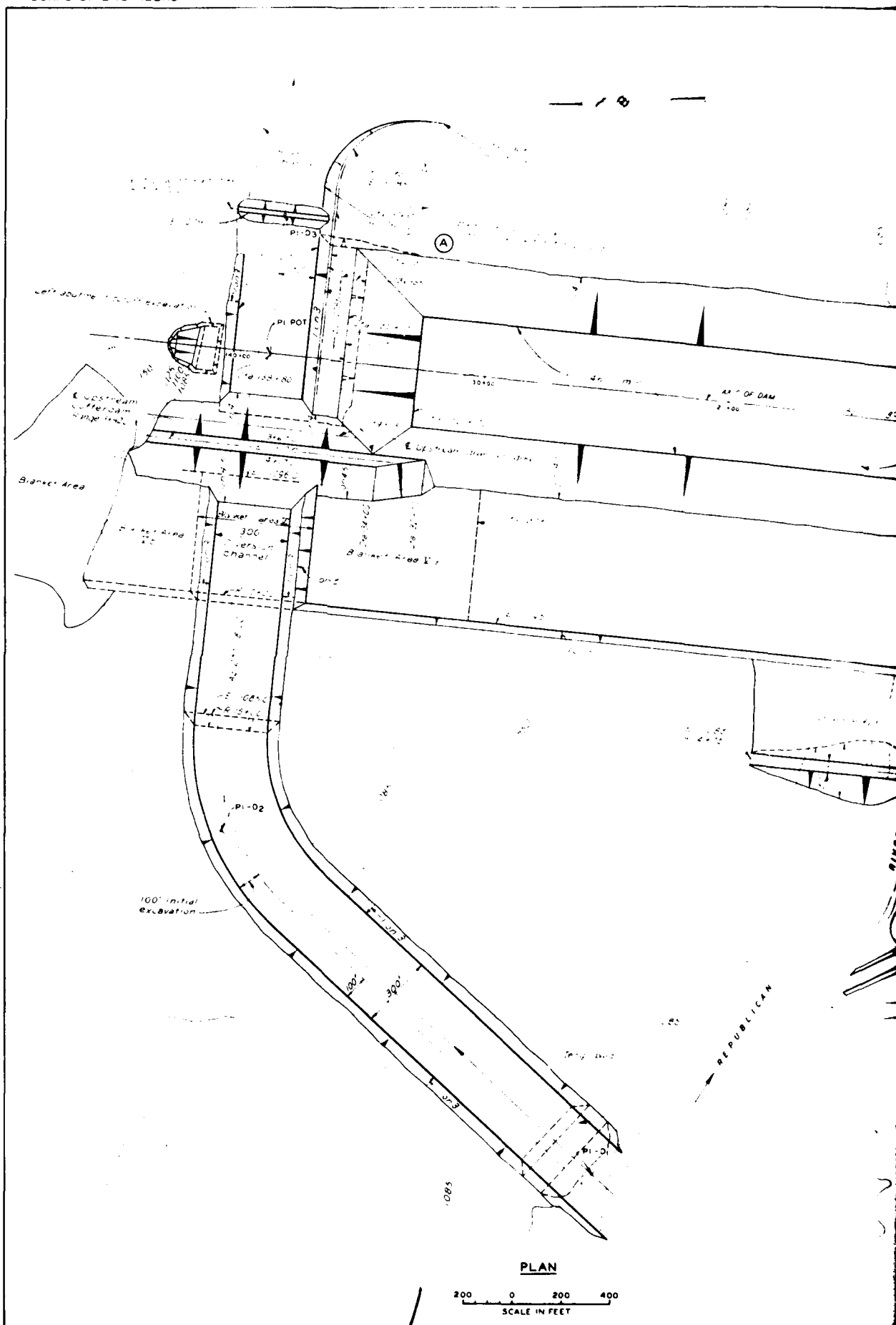
Scale: as shown
KANSAS CITY, MO.
APRIL 1966

Submitted by: *[Signature]*
Checked by: J.R.P.
CGP

Recommended by: *[Signature]*
Checked by: R.L.B.
R.L.B.

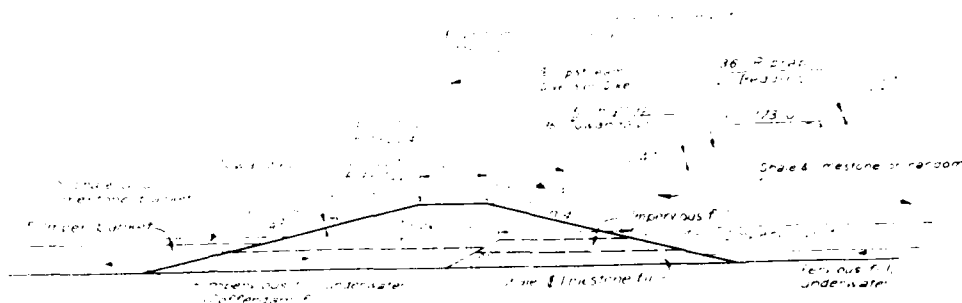
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FILE NO. B-1-100





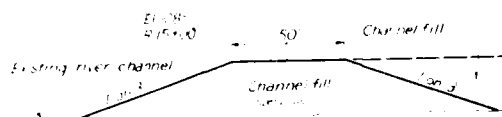
UPSTREAM

DOWNSTREAM



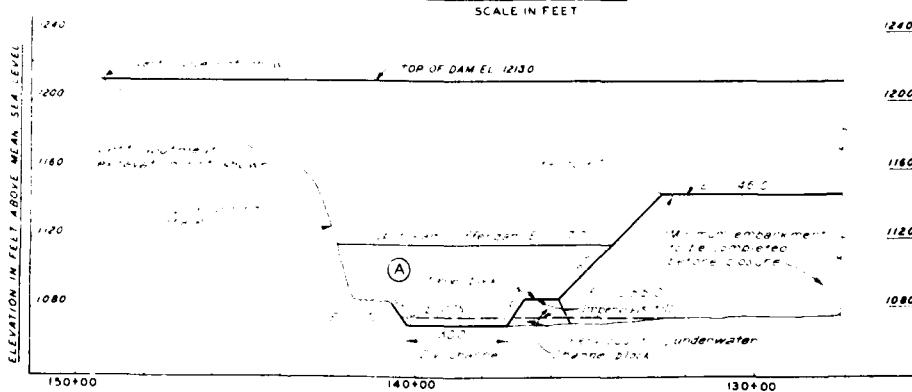
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UPSTREAM COFFERDAM

SCALE IN FEET
50 0 50 100

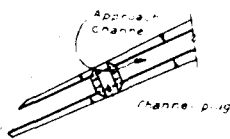


TYPICAL SECTION
UPSTREAM CHANNEL DIKE

SCALE IN FEET
30 0 30 60



PROFILE



1. The channel plug is to be constructed of concrete and is to be placed in the center of the channel. The approach channel is to be constructed of stone and is to be placed on either side of the plug. The existing river channel is to be filled with stone and is to be placed on either side of the plug.

RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA 23 028 CVENG 62 739

Revised for As Built conditions	3469
Revised as per Amendment No. 1	2462
SYN	DATE
DESCRIPTION	REVISIONS

REPUBLICAN RIVER, KANSAS MILFORD DAM

DIVERSION AND CLOSURE

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 13

Scale as shown
KANSAS CITY, MO.
APRIL 1962

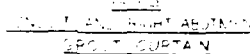
Submitted by: *[Signature]*
Checked by: CCF
Traced by: PFM
Recommended by: *[Signature]*
Checked by: RLB
Approved by: *[Signature]*
Checked by: *[Signature]*
FILE NO. 8-1-813

PLATE NO. 11

A hand-drawn diagram of a ship's hull cross-section. The hull is shown in profile, with a dashed line indicating the waterline. The hull is divided into sections labeled "100 ft" and "50 ft". A vertical line is labeled "100 ft" and another "50 ft". The diagram is labeled "Circular line" and "100 ft".

VOTES

- * Grouting done by stage method.
- * Summary holes drilled on 100' spacing and locations of all intermediate holes determined by the split spacing method.
- * Grout holes drilled at an angle of 30° from vertical into their respective abutments unless otherwise directed.
- * Grouting under the conduit done after preliminary excavation.
- * Grout hole spacing measured on a horizontal plane and numbered by dam axis stationing at collar of hole.
- * * Grouting and grouting accomplished in two zones with stages as specified, but modified in the field.
- * For excavation details of abutments and conduit, see sheet No. 19.
- * For description of geologic formations, see Sheet No. 12's.
- * * Grout curtain extended as necessary to tie with existing grout curtain as constructed by others.
- * Only primary grout holes are shown on profiles.



PLAN

CONDUIT AND RIGHT ABUTMENT

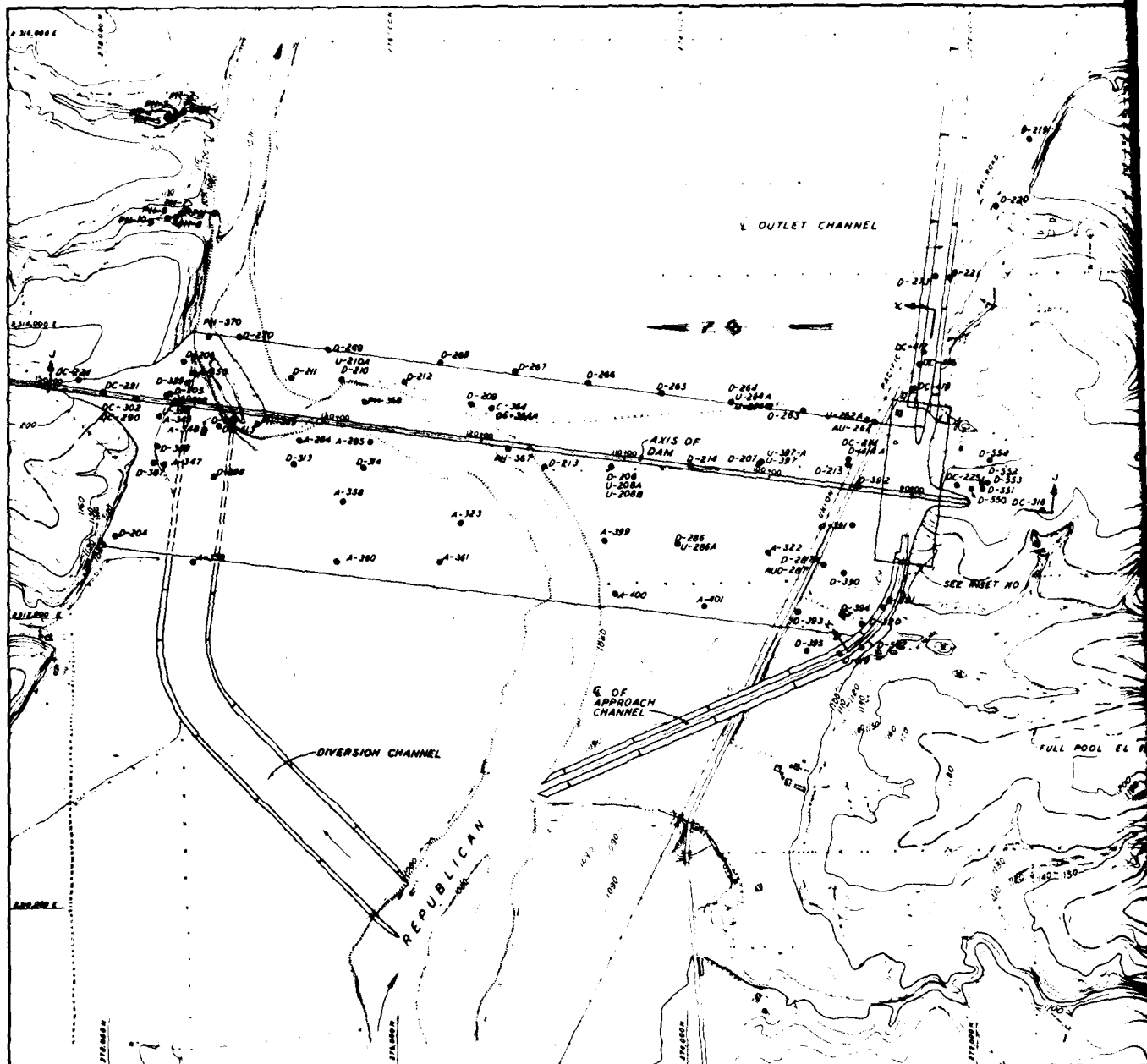
GROUT CURTAIN

40 0 40 80

SCALE IN FEET

PLATE NO.

CORPS OF ENGINEERS



400 0 400 800 1200
SCALE IN FEET

LOCATION-REFERENCE TO DAM AXIS

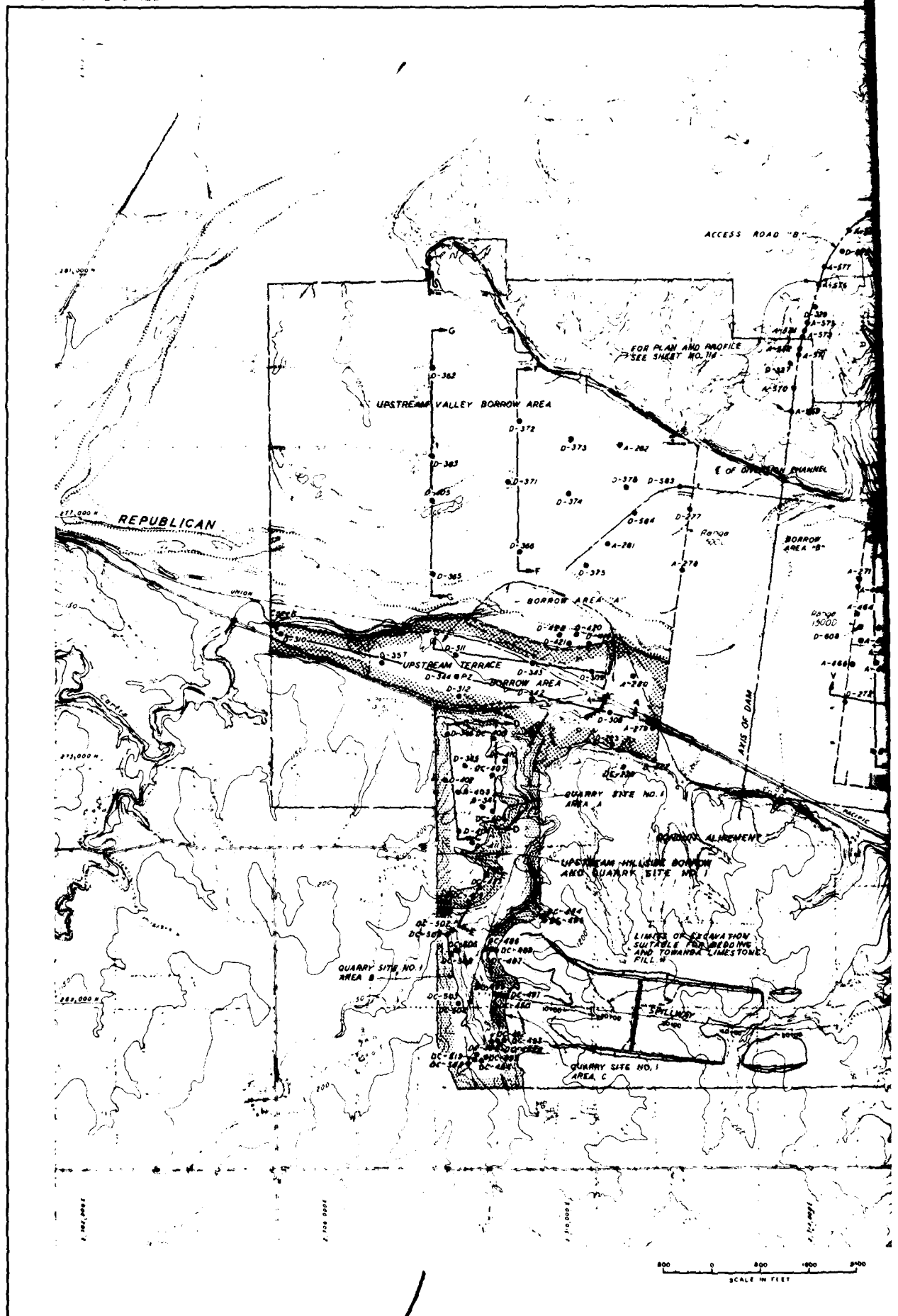
BORING NO.	STATION	RANGE
U-434	90+86	4+85 D
U-435	91+74	5+02 D
U-436	103+93	4+83 D
U-437	100+00	4+60 D
U-438	106+30	4+60 D
U-439	110+20	4+70 D
U-440	116+13	4+90 D
U-441	119+80	4+85 D
U-442	120+02	4+90 D
U-443	123+02	5+00 D
U-444	126+10	4+85 D
U-445	133+00	4+80 D
U-446	130+30	4+90 D
U-447	112+30	4+00 D
U-448	134+80	5+00 D
U-449	120+20	5+00 D
U-450	123+83	5+03 D
U-451	117+25	5+00 D
U-452	118+25	4+85 D
U-453	111+40	4+65 D
U-454	108+20	4+70 D
U-455	94+70	4+80 D
PH-617	113+00	4+20 U
PH-618	115+00	4+20 U
PH-619	117+00	4+20 U
PH-620	120+80	1+60 U
PH-621	120+80	0+20 U
PH-622	120+80	1+30 D
PH-623	135+40	2+40 D
PH-624	137+20	2+40 D
PH-625	139+00	2+40 D

* These borings are not shown. Logs are available for inspection at the Kansas City District Office.

NO. 8

MOLE NC
C 15

PLATE NO. 13



1. Five samples of
 2. Core # 1
 3. Test at 1000 psi power
 4. Auger # 1 to 10 diameter
 5. and started sample # 1
 6. Auger # 11 to 10 power
 7. Auger # 1 to 10 diameter
 8. Probe hole

For plan of borings in vicinity of axis of dam and spillway, see Sheet No. 123
For cross sections in borrow areas see Sheet Nos. 126, 127 & 128
For profile of access road "B" see Sheets Nos. 114 & 115
For plan of borings in Quarry Site No. 1, see Sheet No. 134
* Bedding and Towanda Limestone fill production is restricted to the lower Towanda Limestone with in the limits as shown
For the geology of the spillway area, see Sheet No. 130
For plan of explorations in embankment and structure areas, see Sheet No. 123
For profiles and logs of borings, see Sheet Nos. 114, 115, 126, 127, 128 & 134
* Aggregate may be produced from the section of Borrow Area "A" adjacent to the river however the operation must be so regulated as to comply with section 4, paragraph 13b (6) in the specifications

DECEMBER 1966
CONTRACT NO DA-23-028-CRNG-62 739

(A) Added borings A-480 thru A-474, D-808. Added
Borrow Area "B" limits. Extended limits. Borrow Area "A"
 SYM DESCRIPTION DATE

REPUBLICAN RIVER, KANSAS
MILFORD DAM
PLAN OF EXPLORATIONS
BORROW AND QUARRY AREAS

in 141 sheets
U S ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 124

Scale: as shown
KANSAS CITY,
APRIL 1

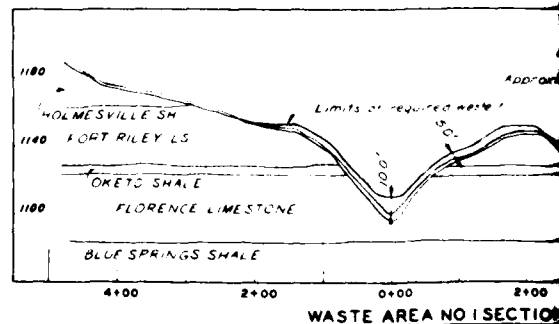
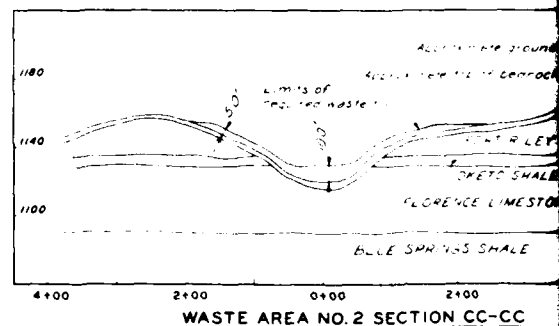
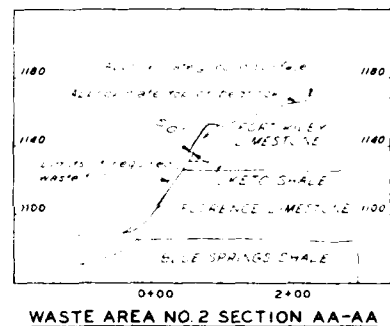
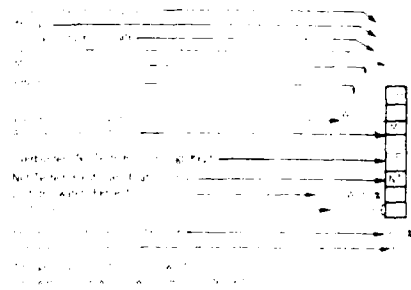
Submitted *Robert J. Kelly* Recommended *J. F. Redlinger* Approved *James S. ...*
CHIEF, GEOLOGY SECTION CHIEF, FOUNDATIONS & MOILS OF CHIEF, ENGINEERING SECTION
DRAWN BY TRACED BY CHECKED BY
JKS JAP CRG

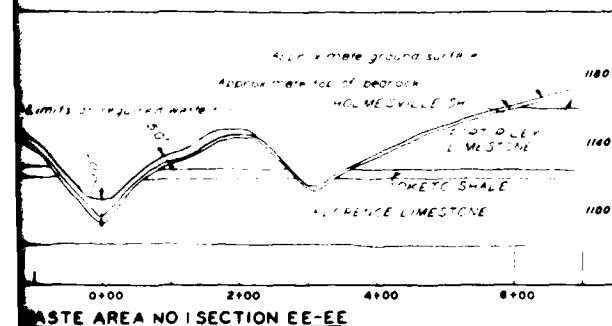
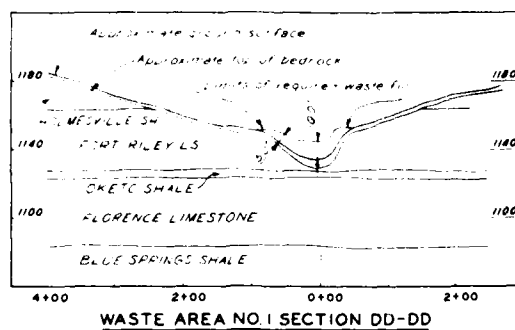
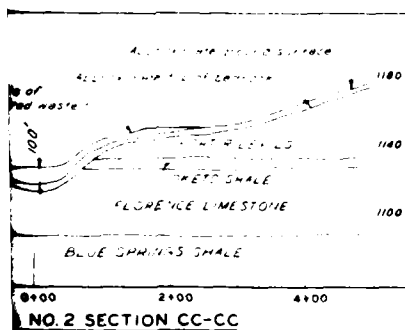
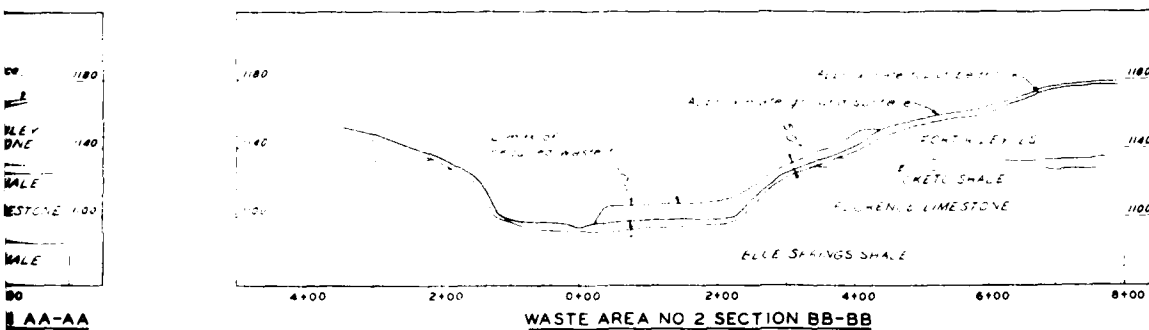
GENERAL GEOLOGIC COLUMN

SYSTEM	FORMATION	MEMBER	UNIT	AVERAGE THICKNESS	SYMBOL	GENERAL DESCRIPTION
QUATERNARY	WISCONSINIAN TERRACE & RECENT ALLUVIUM			2-4'		Thin, poorly sorted, silty sand and gravel, with some pebbles of sandstone and limestone, locally containing the remains of the Floodplain.
				10'		Thin, silty, clay, sand, and gravel, with some pebbles of sandstone and limestone, locally containing the remains of the Floodplain.
PERMIAN	DOYLE SHALE	DOYLE SHALE	Do	2-24'		Shale, massive, soft, greenish-gray.
		TOWANDA LIMESTONE	To	35'		Limestone, thin-bedded, hard, dense, silty, shaly, gray, and greenish-gray.
		HOLMESVILLE SHALE	Ho	55'		Shale, laminated, soft, with discontinuous limestone beds toward the base, green, and red.
	PORT RILEY LIMESTONE		FRa	40'		Limestone, thin-bedded, contains thin shale part near the top, moderately hard, argillaceous, dense, wuggy, grayish-brown.
			FRb	10'		Limestone, medium-bedded, moderately hard, argillaceous, slightly wuggy, light gray.
			FRc	90'		Limestone, thin-bedded, moderately hard, dense, argillaceous, light and dark gray.
			FRd	90'		Limestone, massive, hard, dense, solution-pitted, tan, thin-bedded.
			FRe	25'		Limestone, massive, hard, fine grain.
	BARNESTON LIMESTONE	OREO SHALE	O	55'		Shale, massive, calcareous, moderately hard, dark gray.
	FLORENCE LIMESTONE		FLa	150'		Limestone, thin to medium bedded, hard, dense, cherty, contains occasional shaly zone, gray and tan.
			FLb	100'		Limestone, massive, hard, dense, wuggy, tan.
			FLc	105'		Limestone, thin-bedded, hard, dense, cherty, tan and gray.
			FLd	40'		Limestone, thin to medium bedded, dense, shaly at base, gray.
MATFIELD SHALE	BLUE SPRINGS SHALE		BSa	200'		Shale, massive, soft, calcareous with limestone bed near base, red and green.
			BSb	110'		Shale, fissile, moderately hard, calcareous, slightly mineralized with gypsum, dark gray.
	HOLMESVILLE SHALE		Hi	55'		Limestone, thin-bedded, hard, dense, argillaceous, gray.
			Hiy	100'		Shale, laminated, moderately hard, calcareous, dark gray.
	WYOMING SHALE		Wy	140'		Shale, massive, soft, calcareous, scattered limestone nodules and slight gypsum mineralization, greenish-gray and red.
WYOMING LIMESTONE	WYOMING LIMESTONE		Sc	105'		Limestone, medium to thick bedded, hard, dense, shaly and cherty.
			Ha	155'		Shale, massive to laminated, soft to moderately hard, generally dark gray to black, contains argillaceous limestone beds.

* "Massive" (as used in reference to shales): Of homogeneous structure without stratification, as defined in Vol. 178 of the Glossary of "Geology and Related Sciences" published by the American Geological Institute.

** "Massive" (as used in reference to limestone): Made up of beds over 2 feet thick.





RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA 23-028 OVENG-62 739

SYMBOL	DESCRIPTION	DATE	APPROVED
Revised for As Built conditions			
Changed as per Amendment No.			
REVISIONS			

REPUBLICAN RIVER, KANSAS
MILFORD DAM

GEOLOGIC COLUMN AND LEGEND
FOR EXPLORATIONS, PROFILES
WASTE AREAS NOS. 1 AND 2.

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

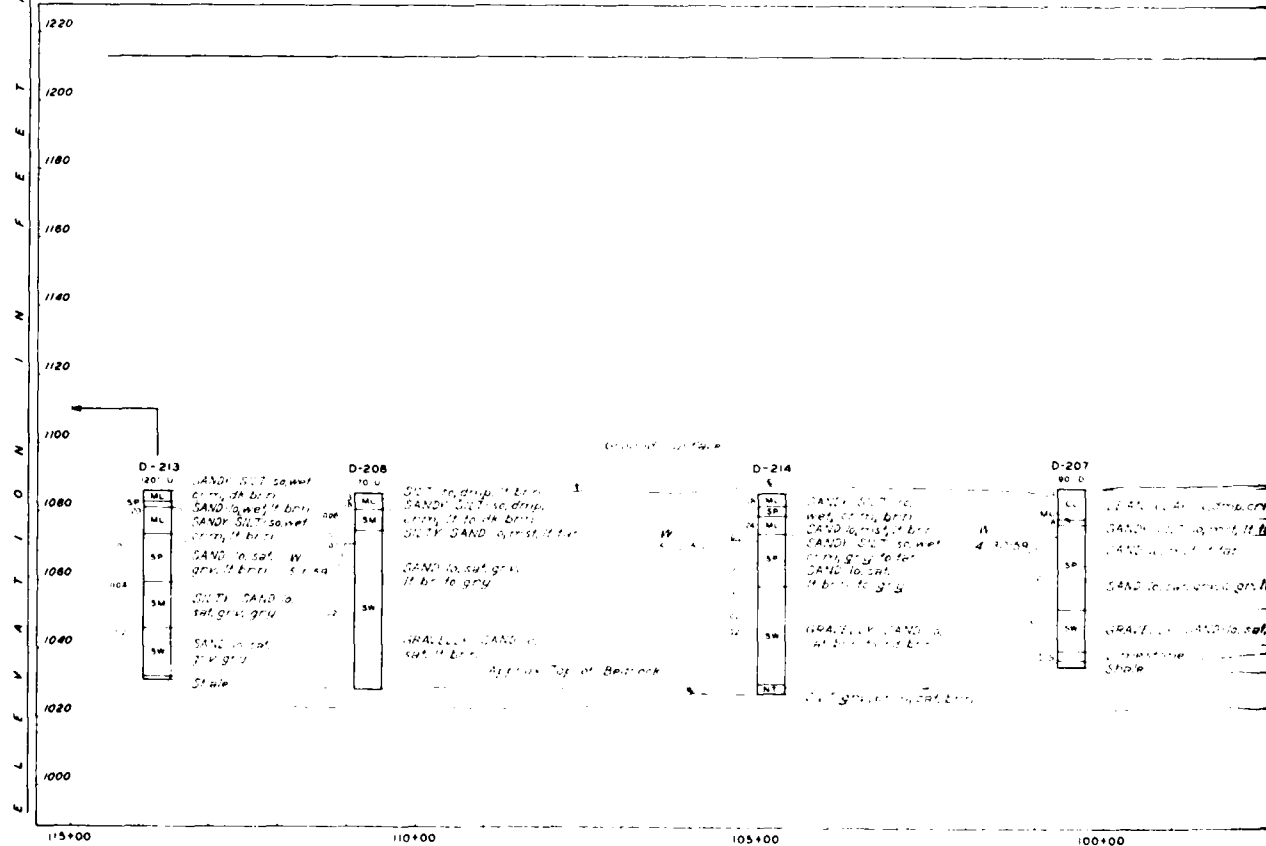
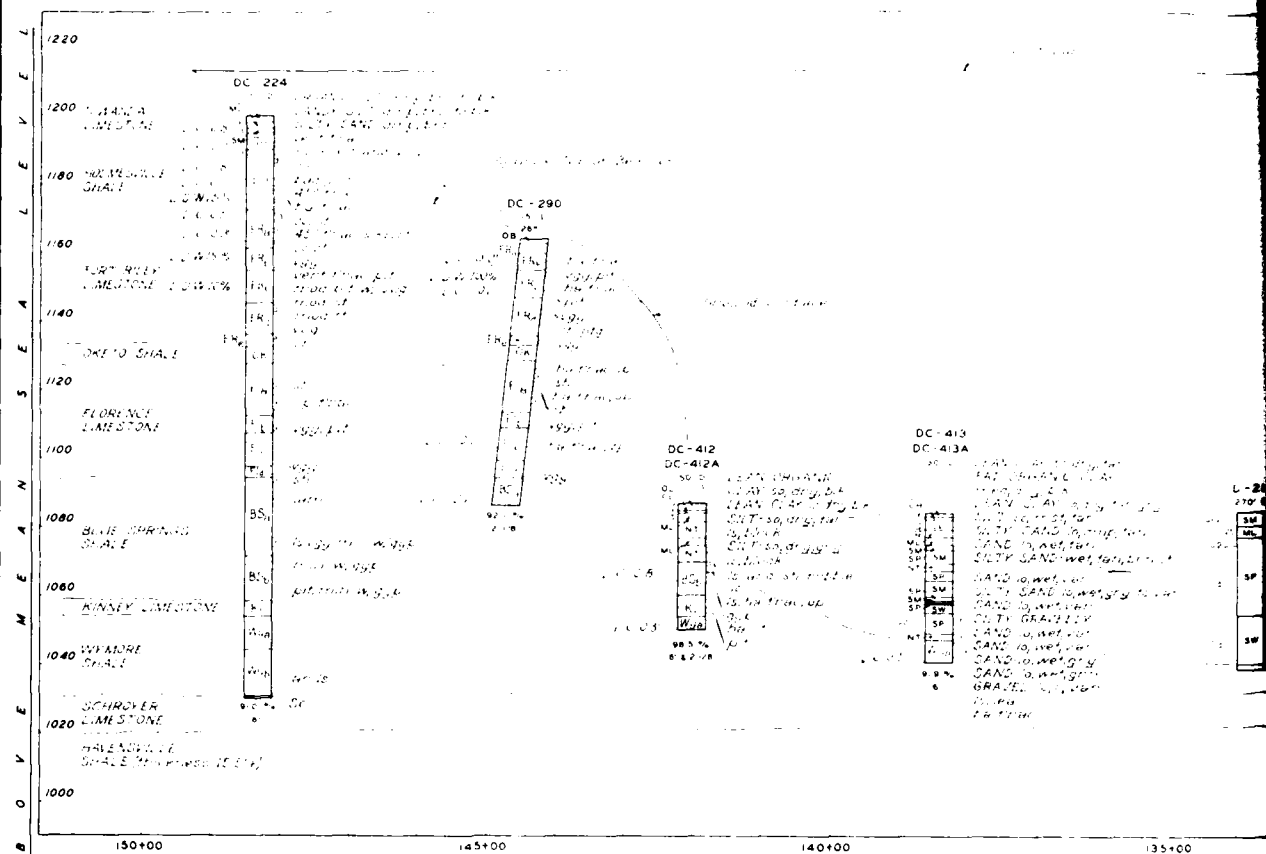
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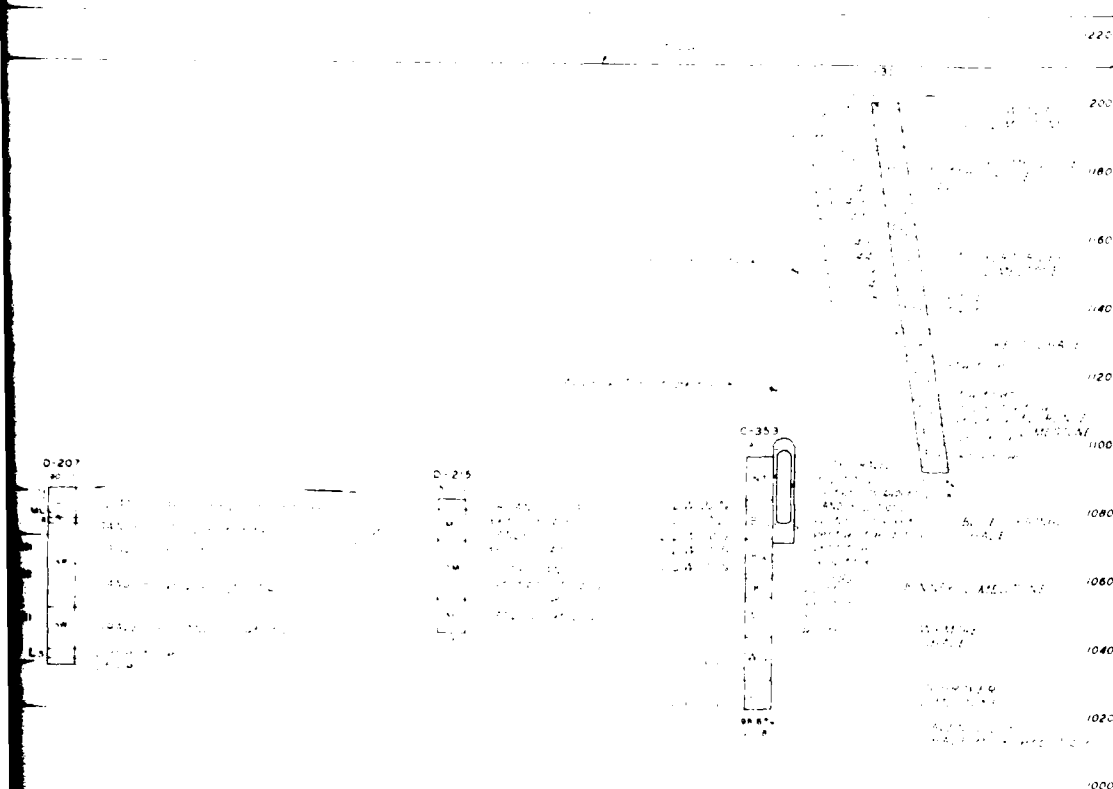
Scale: as shown
KANSAS CITY, MO
APRIL 1962

Submitted by *[Signature]* Recommended by *[Signature]* Approved by *[Signature]*
CHIEF, GEOLOGY SECTION CHIEF, FOUNDATIONS & MATERIALS CHIEF, ENGINEERING DIVISION
DRAWN BY J.R.S. TRACED BY R.P.M. CHECKED BY C.R.G. FILE NO. B-1-1088



CORPS OF ENGINEERS





RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA 23 028 (WING 62 739)

SYMBOL	DESCRIPTION	DATE, APP'D
	REVISIONS	

REPUBLICAN RIVER, KANSAS
MILFORD DAM

LOGS OF EXPLORATIONS
DAM AXIS PROFILE J-J

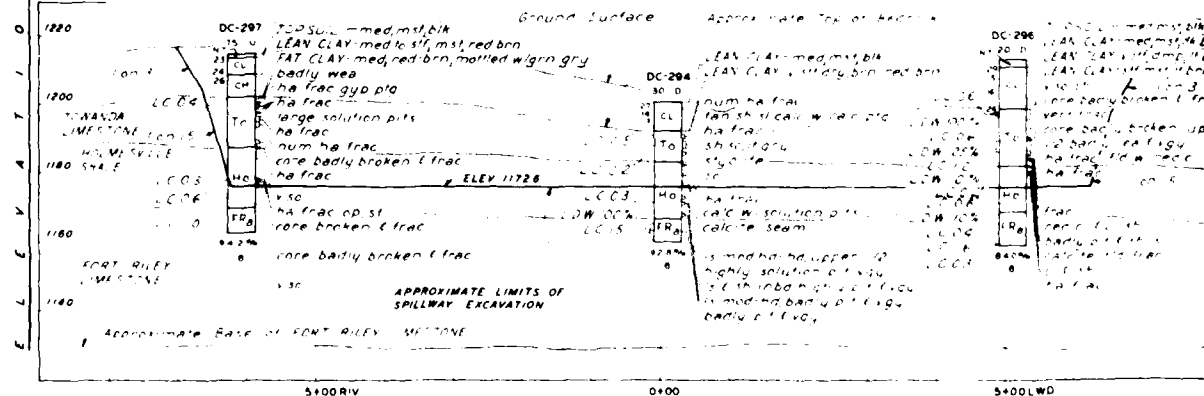
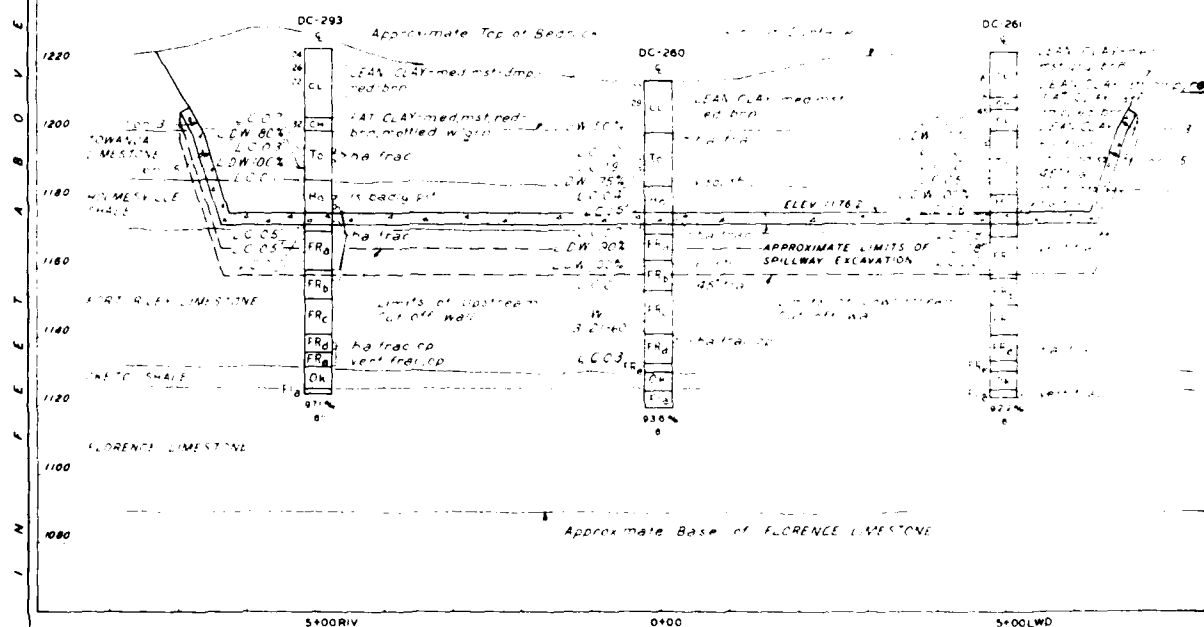
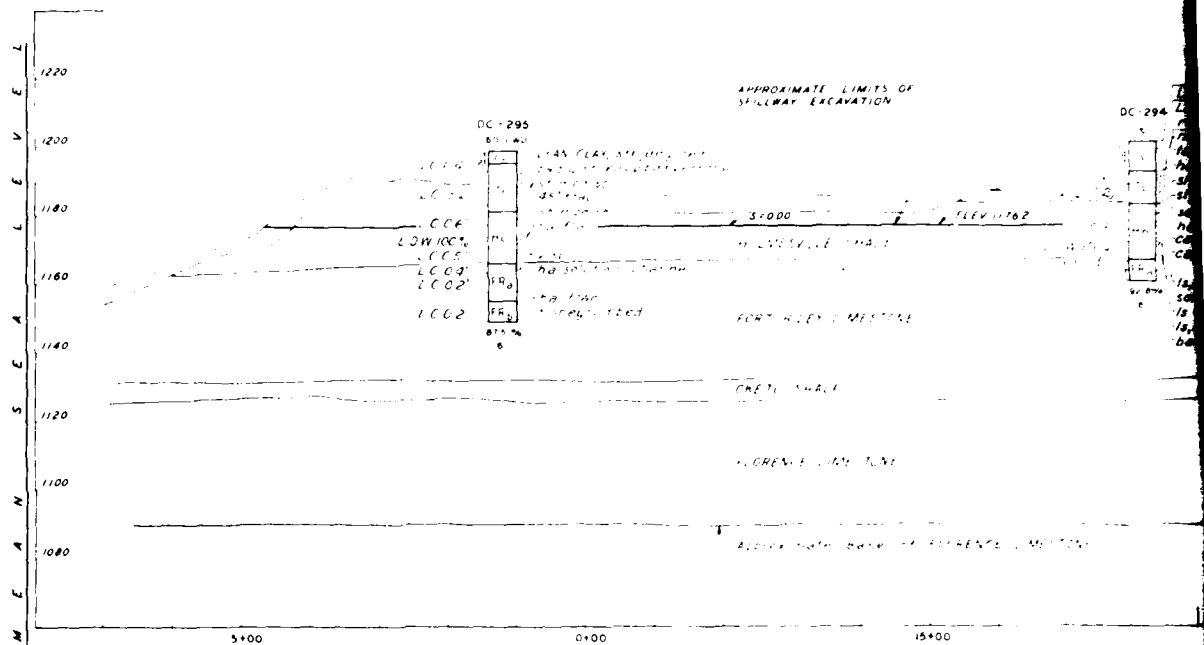
In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

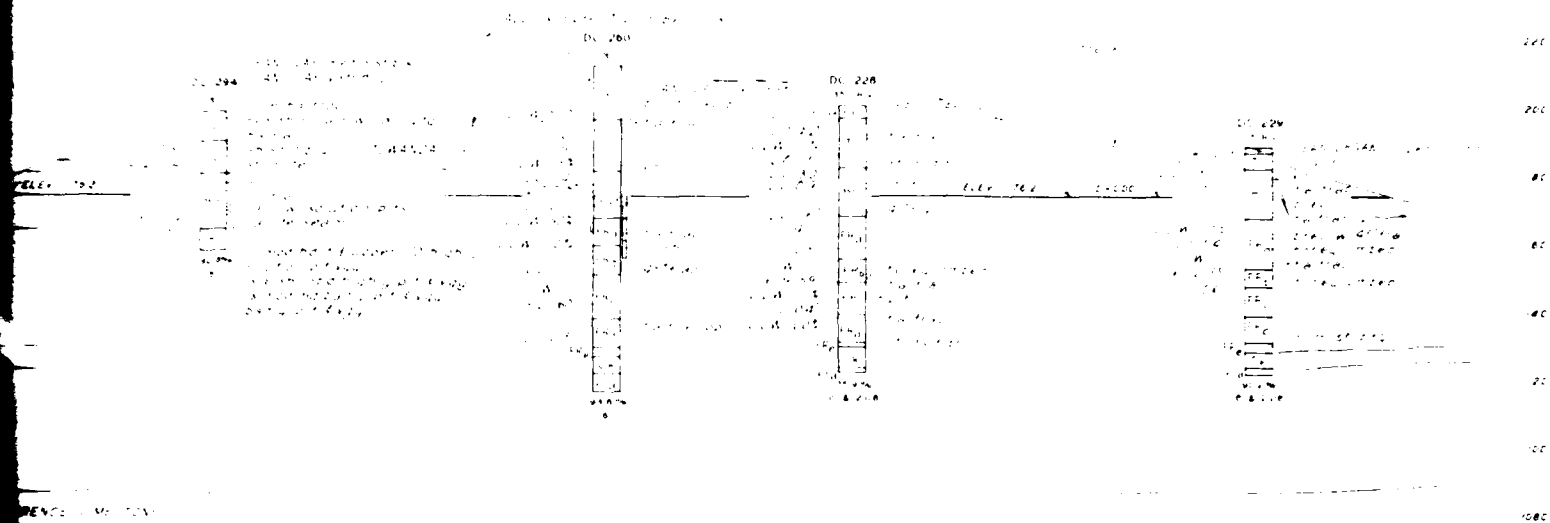
Sheet No 129

Scale as shown
KANSAS CITY, MO.
APRIL 1962

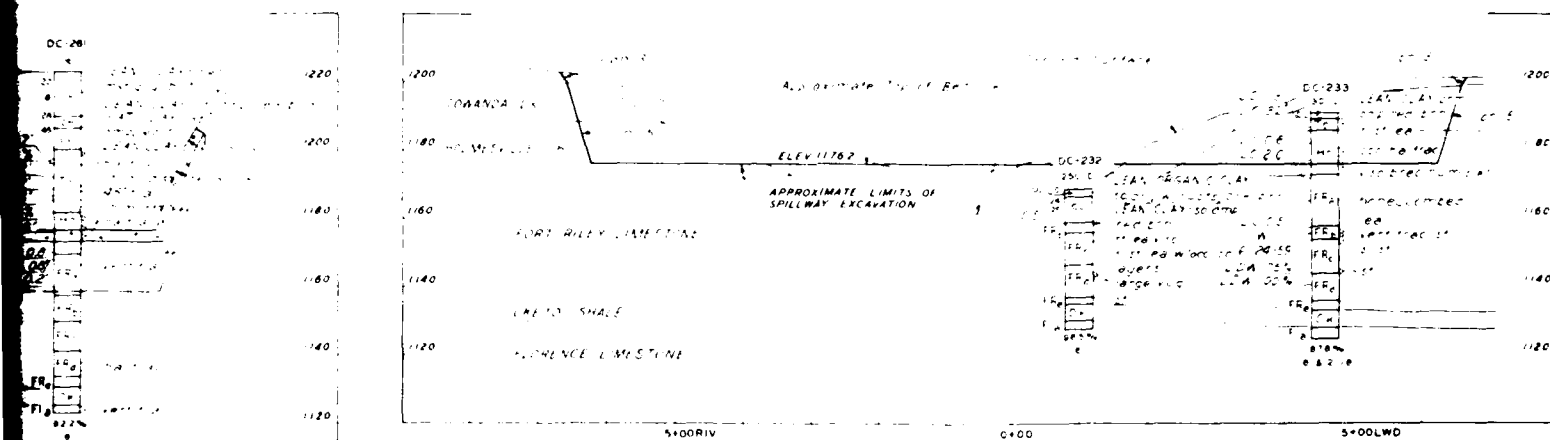
Submitted	Recommended	Approved
By: <i>[Signature]</i>	By: <i>[Signature]</i>	By: <i>[Signature]</i>
Checked by: J. K. S.	Checked by: J. A. W.	Checked by: C. S. S.

FILE NO. B-1-1029





PROFILE O-O ALONG CENTERLINE OF SPILLWAY



CROSS SECTION R-R SPILLWAY STA 36+00

NOTES:
 1. Explorations of profile cross sections and borings see Sheet No. 12.
 2. The legend of explorations and Generalized Geologic Column see Sheet No. 13.
 3. Additional logs of borings to be made are shown on Sheet No. 14.
 4. For later profile cross sections and logs of borings see Sheet No. 15, 16, 17, 18, and 19.

RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA 23-028-CVING 62-739

SYMBOLS:
 A - changes as per Amendment No. 1
 SYM - DESCRIPTION
 REVISIONS

 REPUBLICAN RIVER, KANSAS
 MILFORD DAM

 LOGS OF EXPLORATIONS
 SPILLWAY

 In 141 sheets
 U. S. ARMY ENGINEER DISTRICT
 KANSAS CITY

Sheet No 130

 Scale as shown
 KANSAS CITY, MO
 APRIL 1962

 Submitted by
 J. H. S.
 Checked by
 C. E. W.

 Recommended by
 J. H. S.
 Checked by
 C. E. W.

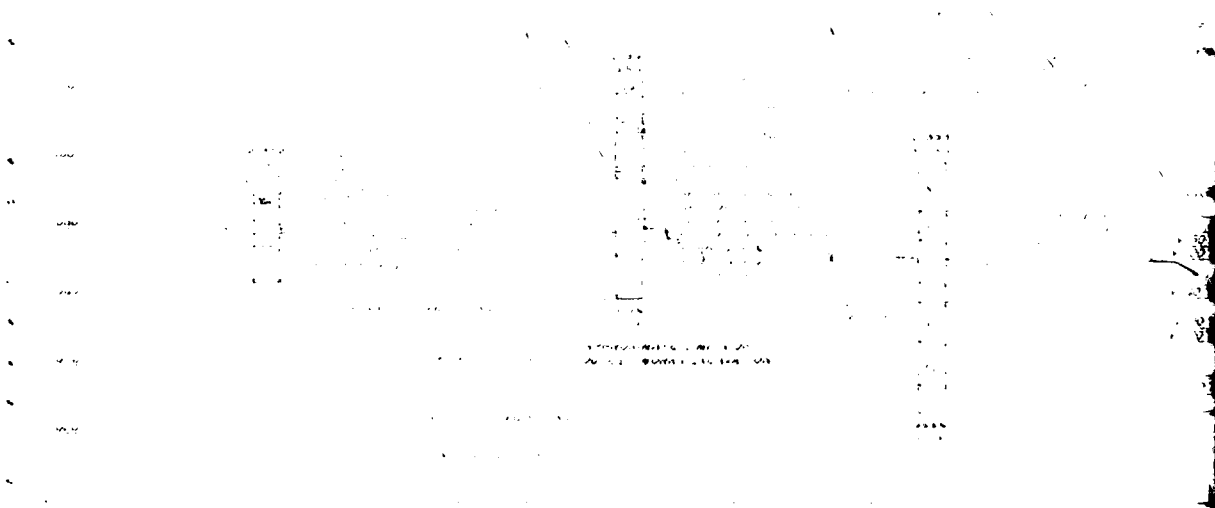
 Approved by
 J. H. S.
 Checked by
 C. E. W.

B-1-1030

PLATE NO. 17

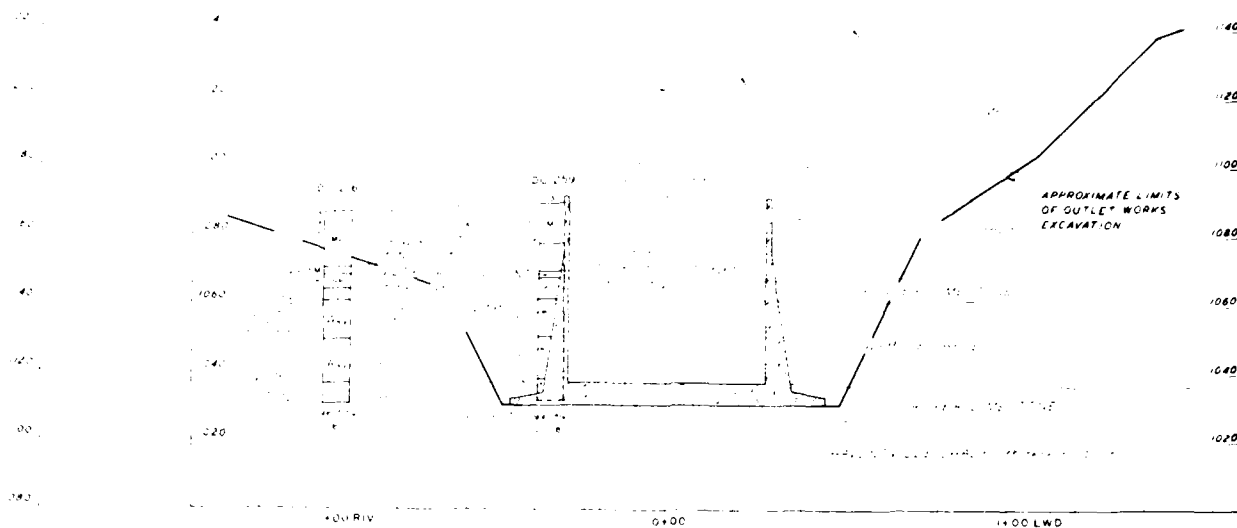


CONCRETE CROSS SECTION AT MIDSPAN

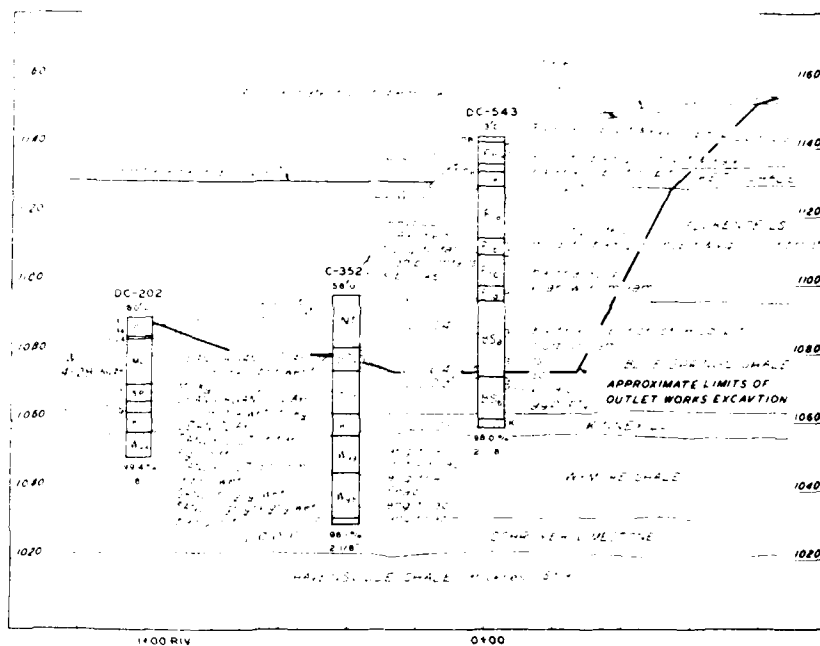


PROFILE NO. ALONG CENTERLINE OF OUTLET WORKS

1

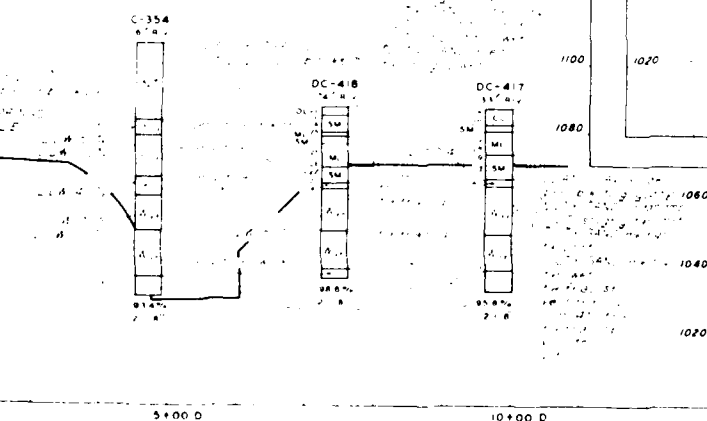


STILLING BASIN CROSS-SECTION N-N STA 5+40 D



INTAKE TOWER CROSS-SECTION L-L STA 3+10 U

And a 25' x 25' sign in the street works
and a sign on streets. Vol 13, p 138
and a sign of navigation and Generalized
and a sign on street No 125
and a sign of traffic and cross section see Sheet No 23



OF OUTLET WORKS

Revised for As Built conditions		1669
Changed as per Amendment No. 1		1667
SYM	DESCRIPTION	DATE APR
REVISIONS		

REPUBLICAN RIVER, KANSAS
MILFORD DAM

LOGS OF EXPLORATIONS
OUTLET WORKS

RECORD DRAWING

DECEMBER 1966
CONTRACT NO DA 23 028 CIVING 62 719



In 141 sheets
1. S ARMY ENGINEER DISTRICT
KANSAS CITY

Submitted

 CHIEF GEOLOGY SECTION
 DRAWN BY _____ TRACED BY _____
 JVS BEM

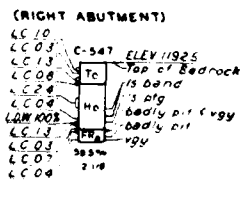
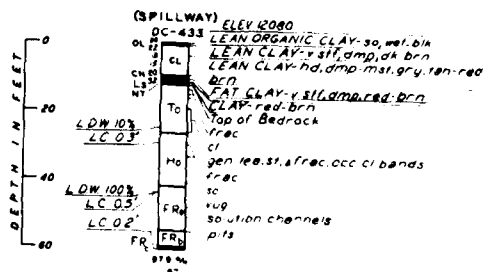
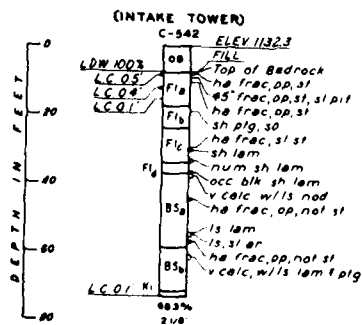
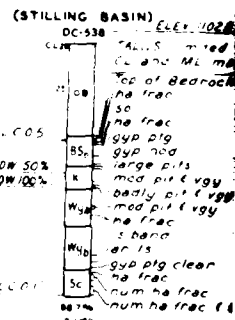
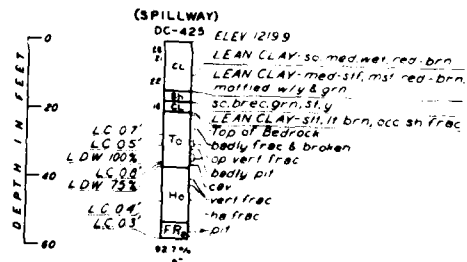
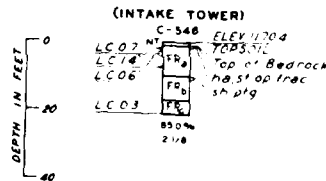
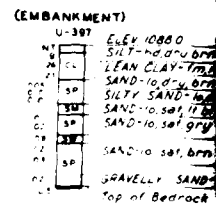
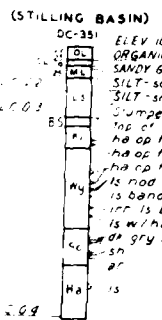
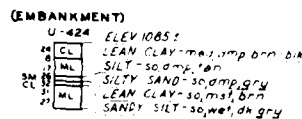
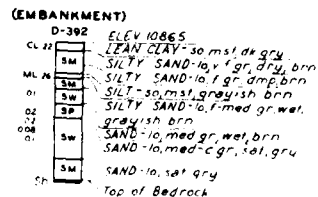
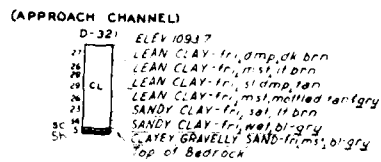
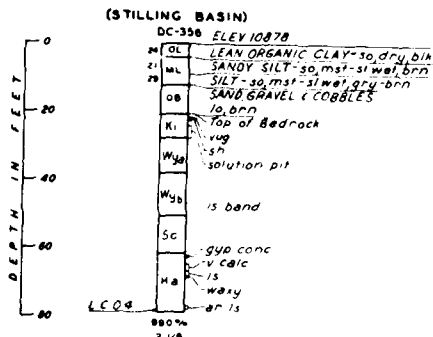
Sheet No. 131

Recommended
✓ + *Redhange*
✓ / FOUNDATIONS & MATHS BR
CHECKED BY
C.B.G.

Approved _____
 Chief Engineering Division
 FILE # _____
 B-1-M

Scale: as shown
KANSAS CITY, MO
APRIL 1961

PLATE NO.

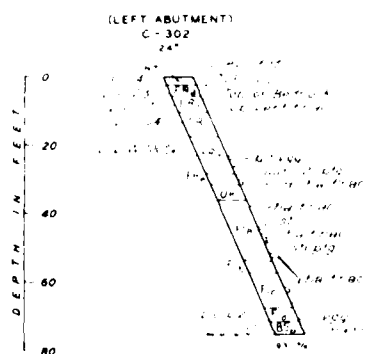
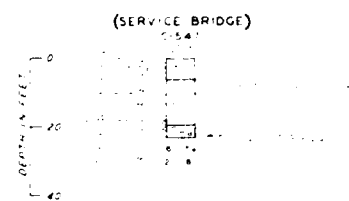




SYM	Revised for	Amendment No.	DATE	APP'D
	Changed as per			
	DESCRIPTION			
	REVISIONS			

DECEMBER 1956

Approved
Samuel L. Taylor
CHIEF ENGINEERING DIVISION
FILE NO
D-1-1030



For a complete list of drawings see Sheet No. 26
For a complete list of sections and Generalized Geologic
Columns see Sheet No. 25
For other profiles, cross sections, and logs of borings
see Sheet Nos. 23, 29 thru 32, and 34

DECEMBER 1969

CONTRACT NO. DA-23-028-CVENG-62 739

(A) SYM	Drawing No. <u>W. A. 1000</u> Changed as per Amendment No. <u>1</u> DESCRIPTION REVISIONS	409 1960 DATE APP

In 141 sheets
U S ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No 133

Scale as shown
KANSAS CITY, MO
APR 22 1962

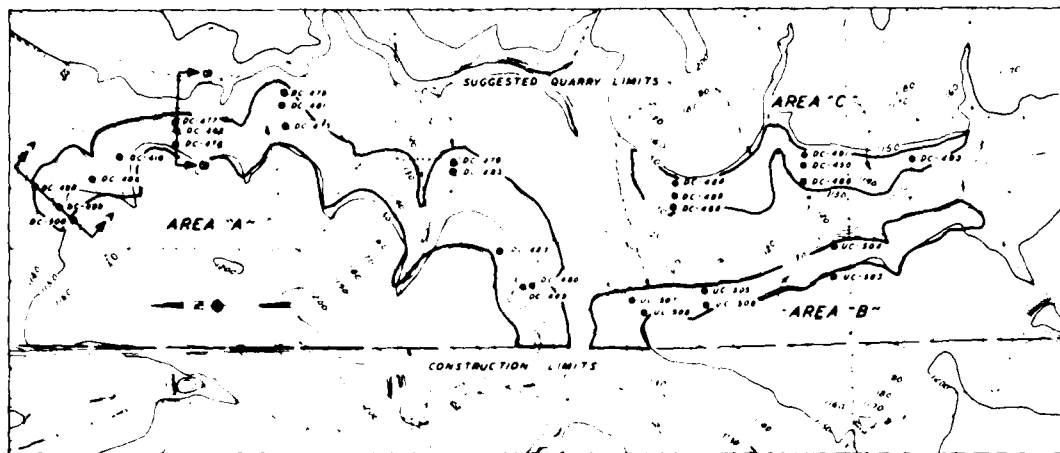


Submitted
A. Triantafyllidis
CHIEF, GEOLOGY SECTION
DRAWN BY TRACED BY
JBS JAW

Recommended
J. J. Redding
FRIES FOUNDATIONS & MATL
CHECKED BY
CRG

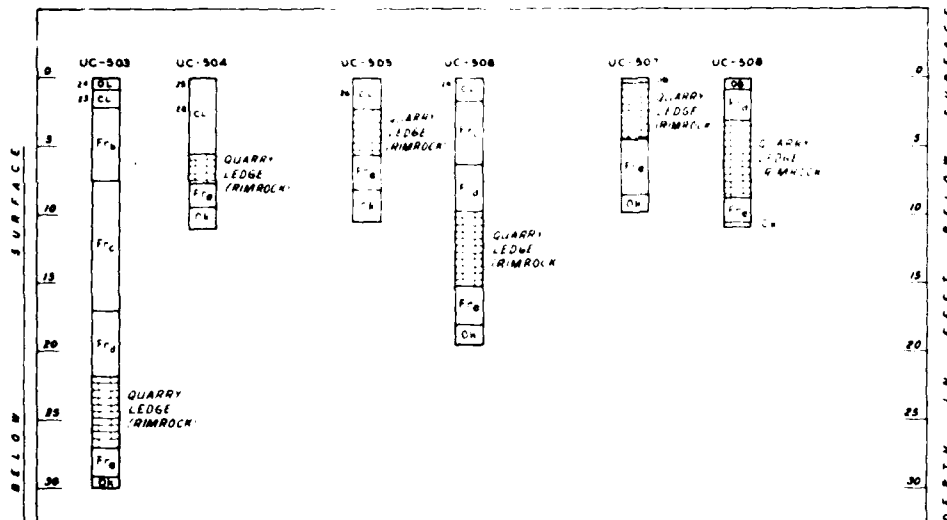
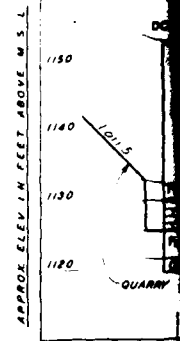
Approved _____
CHIEF ENGINEERING DIVISION
FILE NO.

8-1-1933

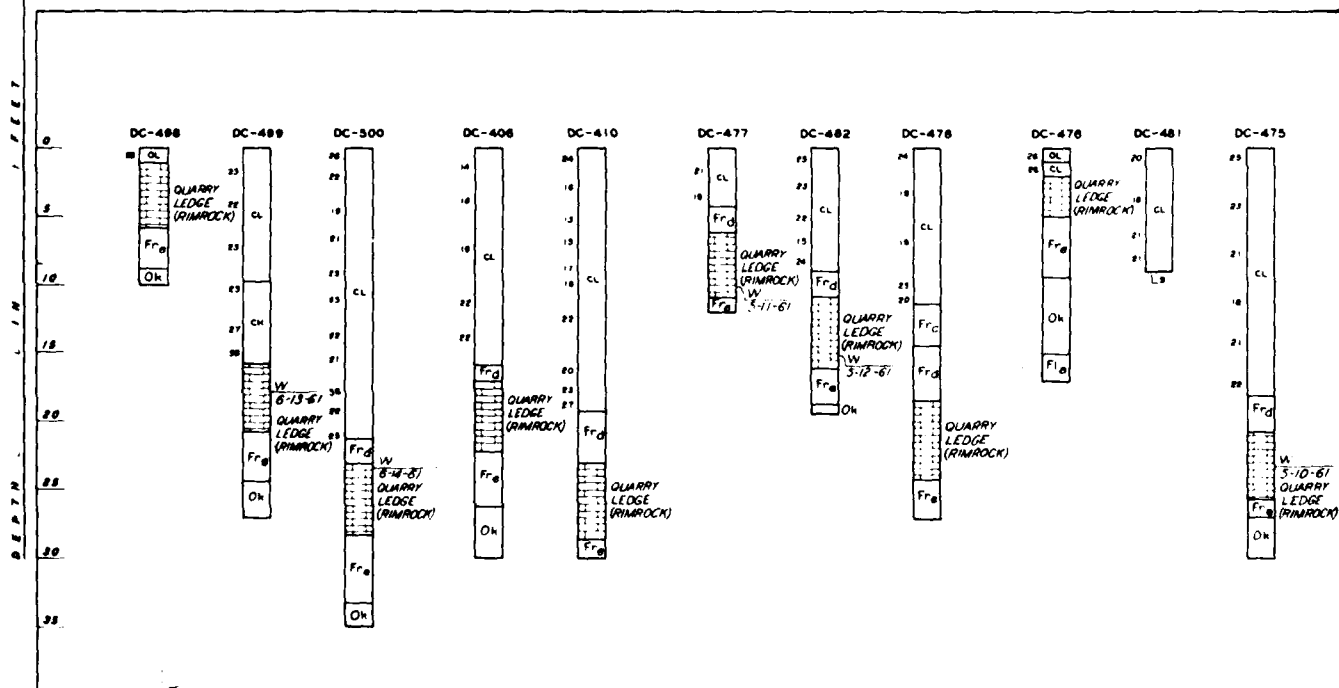


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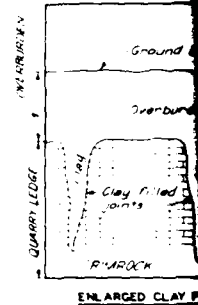
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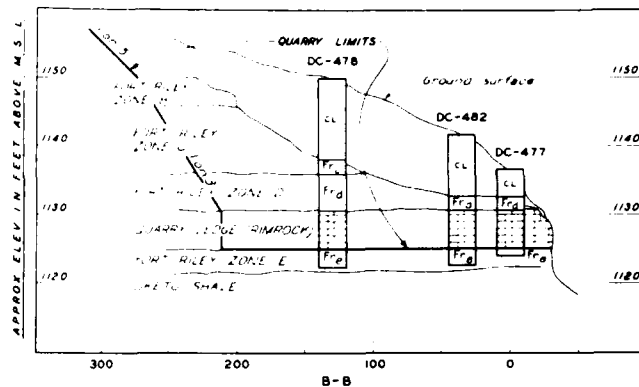
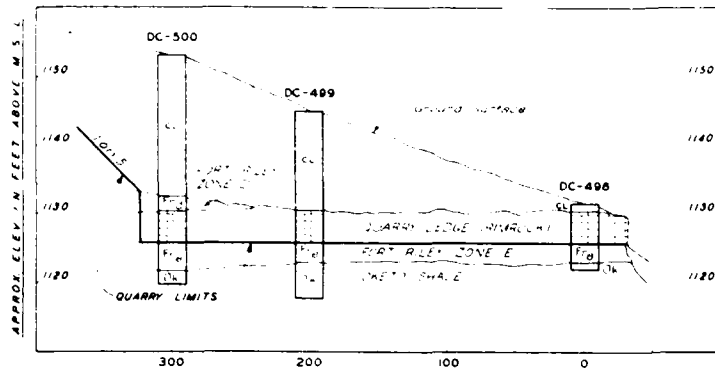


DETACHED BORINGS AREA "B"

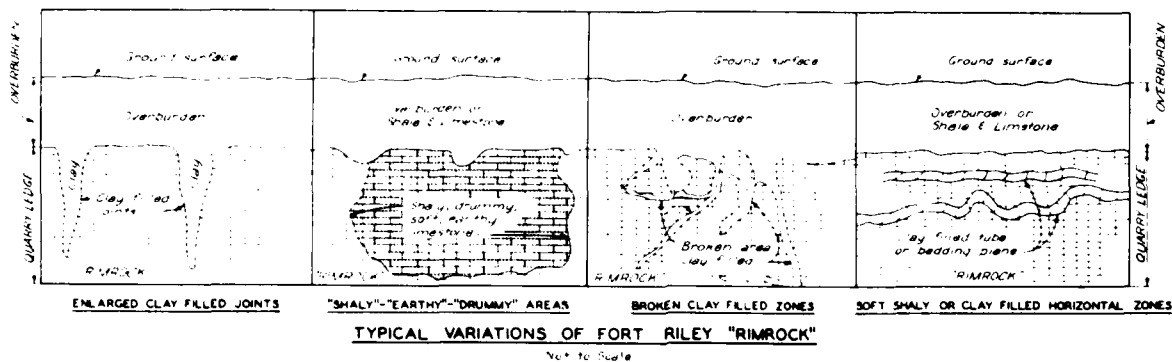


DETACHED BORINGS AREA "A"





TYPICAL CROSS-SECTIONS



TYPICAL VARIATIONS OF FORT RILEY "RIMROCK"

Not to Scale

NOTE

This section designated as rimrock and quarry ledge is also known locally as Buildingstone Ledge, White Ledge, Walker Ledge, or Junction City Limestone. Additional information on this ledge may be found in the following references: State Geological Survey of Kansas Bulletin 39 page 77, "The Geology of Riley and Geary Counties and State Geological Survey of Kansas Bulletin 89 page 44 "The Kansas Rock Column".

Limits as shown are suggested working limits for quarry operations and are subject to change depending upon quality of materials encountered.

The variations shown are diagrammatic variations which may be encountered.

The Quarry Ledge or Rimrock as shown is the lower 55' of the C zone of the Fort Riley Limestone.

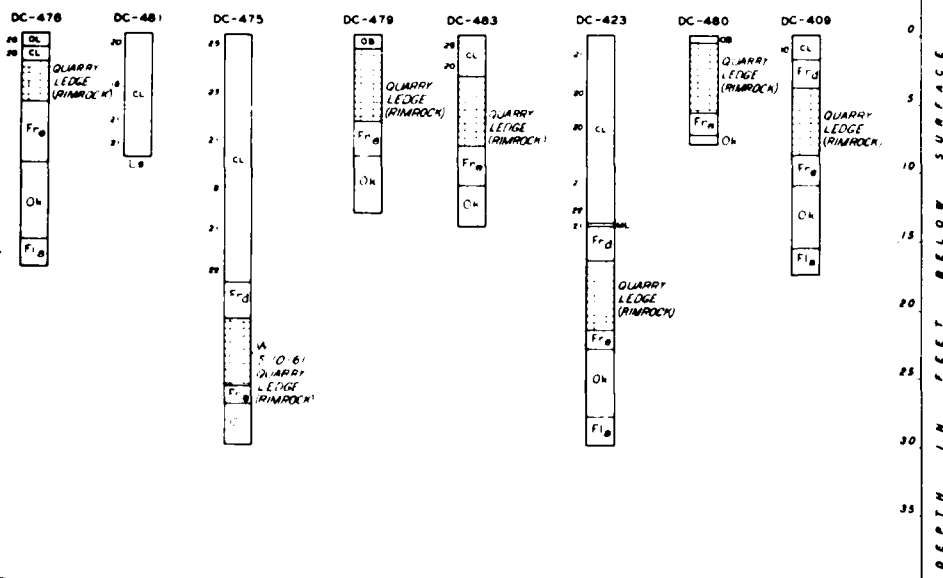
For location of the Quarry Site with reference to dam axis, see Sheet No. 124.

For general geologic description of bedrock zones and explanation of symbols, see Sheet No. 125.

Detailed logs of borings are available for inspection in the Kansas City, Corps of Engineers District Office.

Area-A to be used by Schedule II Contractor for production of riprap. Area-B Schedule II Contractor will remove overburden and rock material for the Schedule III Contractor.

Area-C this area will be utilized for the production of riprap only by approval of the contracting officer.



AREA "A"

RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA-33-009-CVENG-42-739

	Revised for 'As Built' conditions	5-6-68	
(A)	Changed as per Amendment No. 1	5-6-68	
SYM	DESCRIPTION	DATE	APPD.
REVISIONS			

REVISIONS

REPUBLICAN RIVER, KANSAS
MILFORD DAM

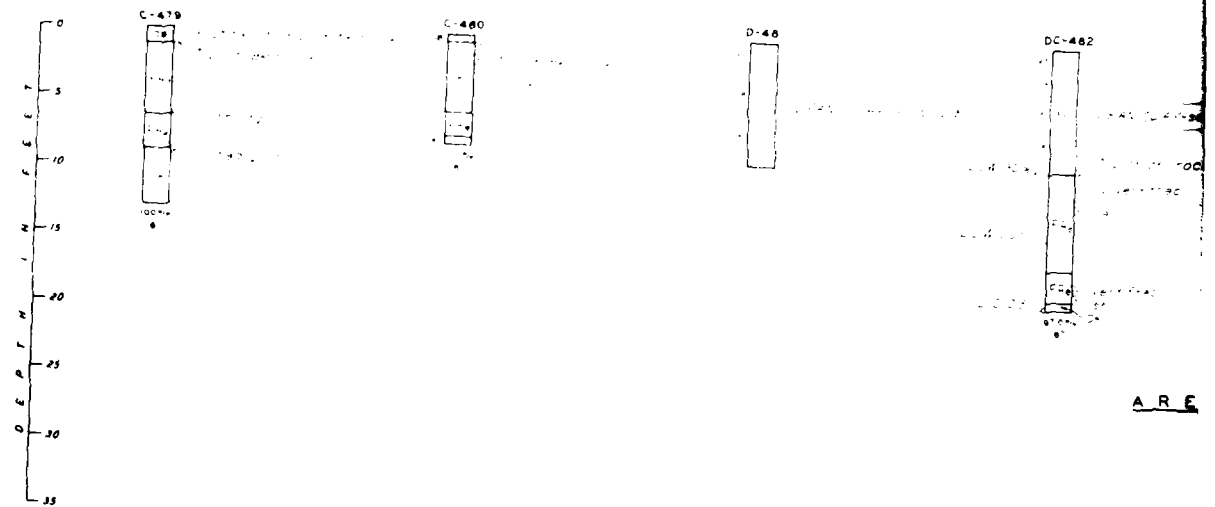
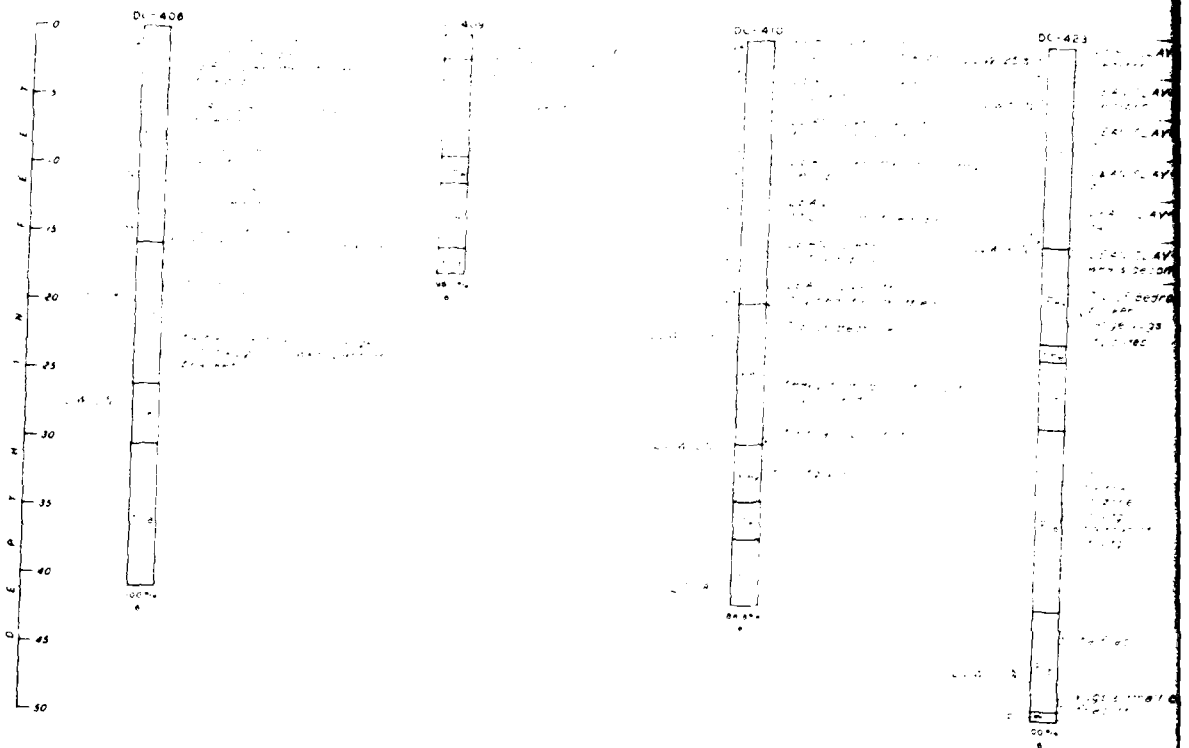
QUARRY SITE NO. 1

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

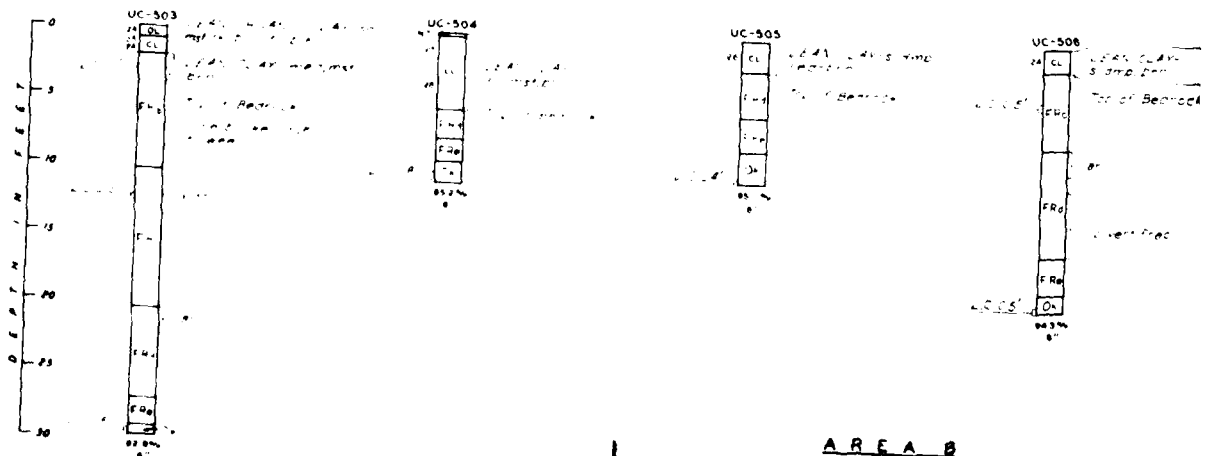
Sheet No. 134

Scale: as shown
KANSAS CITY, MO
APRIL 1967Submitted
Checked by
S.D.M.Recommended
Checked by
J.R.P.Approved
Checked by
C.R.G.FILE NO.
B-1-1034

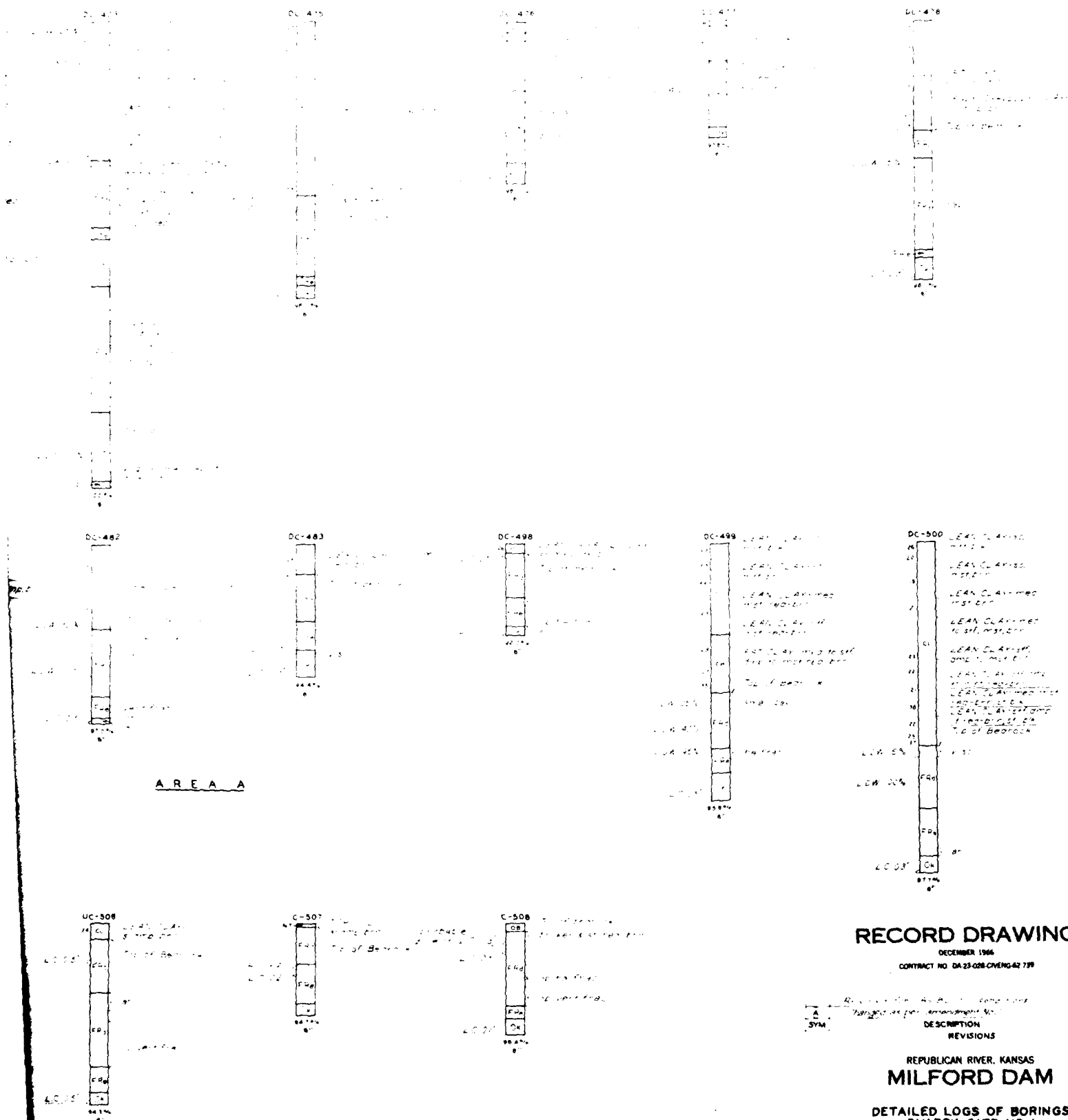
CORPS OF ENGINEERS



ARE



AREA B



RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA-23-028-CVENG-42779

REVISIONS

REPUBLICAN RIVER, KANSAS
MILFORD DAM

DETAILED LOGS OF BORINGS
QUARRY SITE NO. 1

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

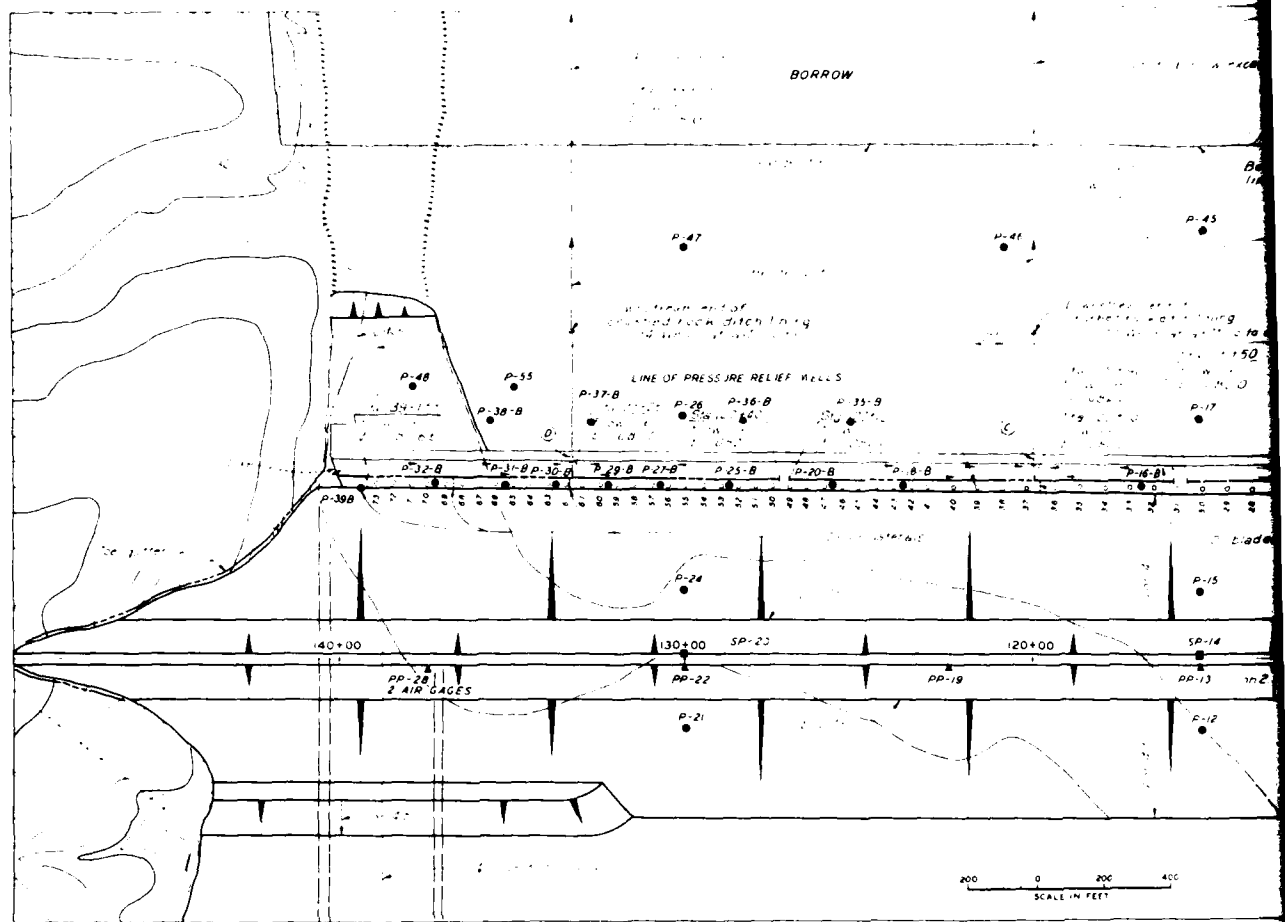
Sheet No. 135

Scale: as shown
KANSAS CITY, MO.
MAY 1968

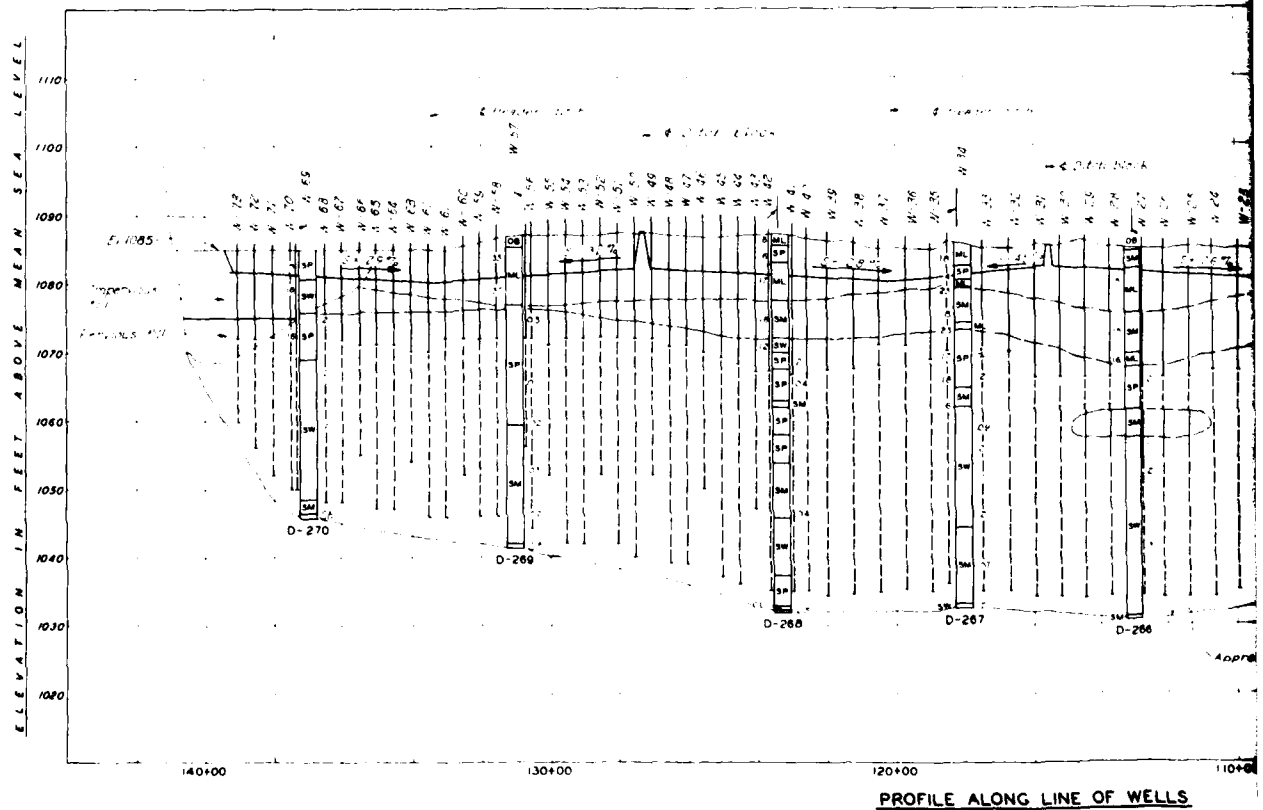


Submitted by: *[Signature]*
Checked by: *[Signature]*
Traced by: *[Signature]*
HRL RFM CRG

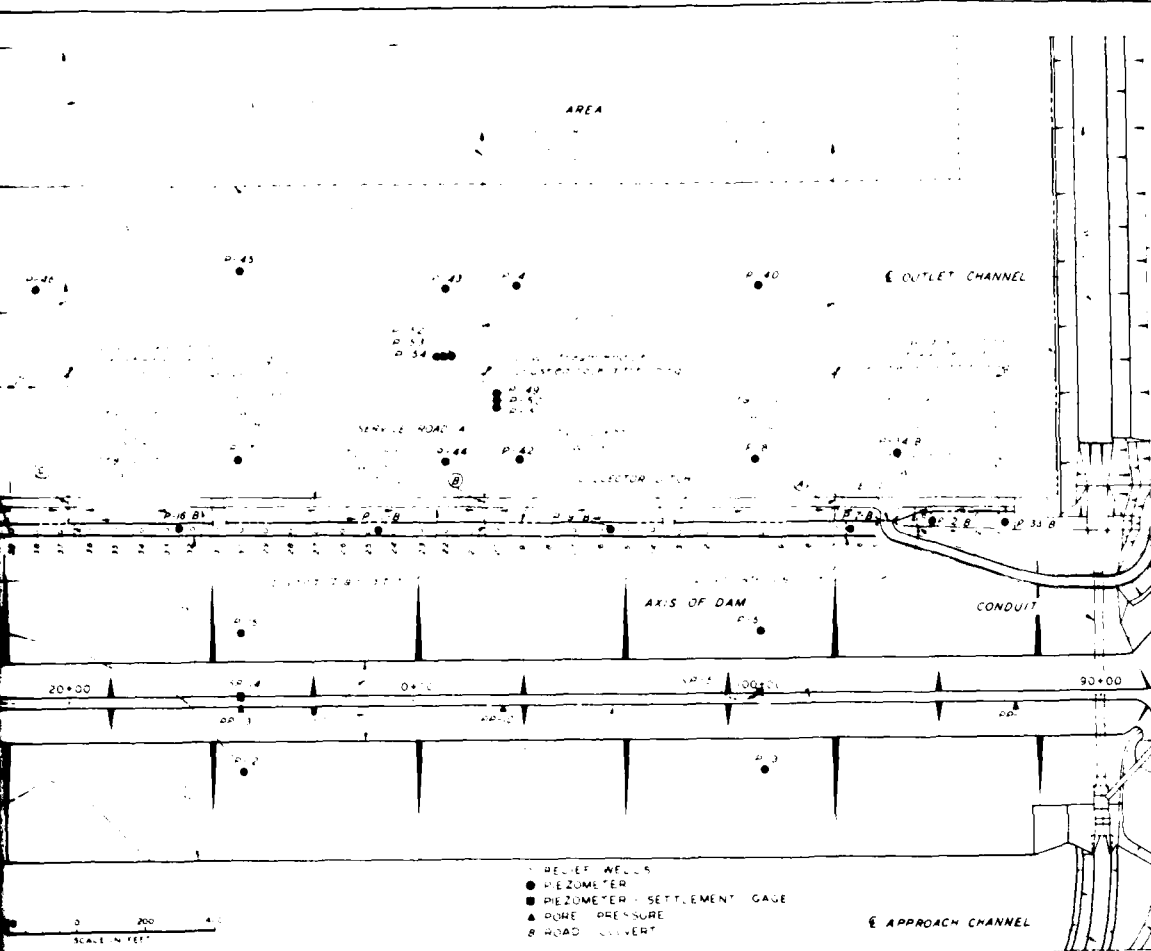
PLATE NO. 2



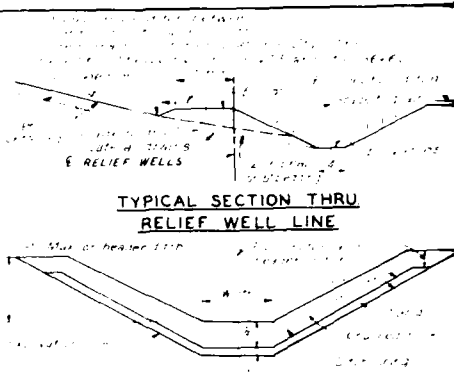
PLAN OF RELIEF WELLS AND OBSERVATION DEVICES



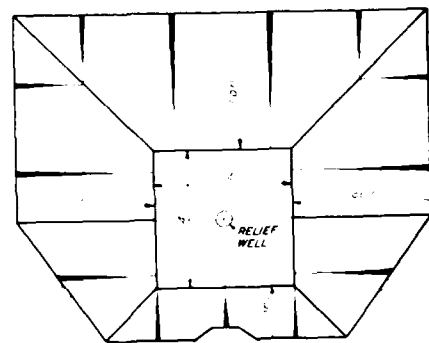
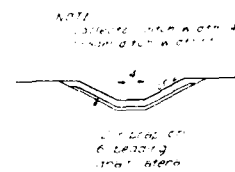
PROFILE ALONG LINE OF WELLS



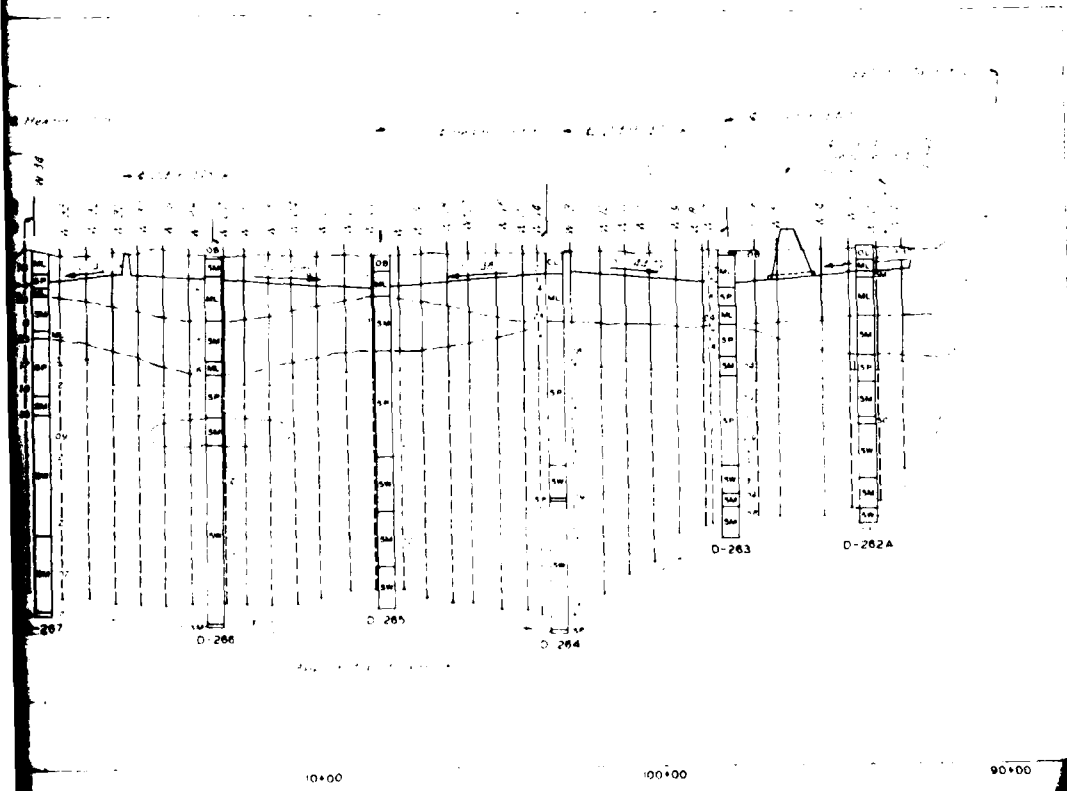
WELLS AND OBSERVATION DEVICES



TYPICAL DITCH SECTION



TYPICAL PLAN EXCAVATION AND BACKFILL



ALONG LINE OF WELLS

RECORD DRAWING

DECEMBER 1966
CONTRACT NO. DA 23 028 CIVENG 62 739

REVISIONS	DATE
1. Revised to show the location of the wells and observation devices as shown on the plan view.	12/1/66
2. Revised to show the location of the wells and observation devices as shown on the plan view.	12/1/66

REPUBLICAN RIVER, KANSAS MILFORD DAM

RELIEF WELLS PLAN AND PROFILE

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 16

Scale: as shown
KANSAS CITY, MO
APRIL 1966

Recommended
Checked by
Traced by
CGF WDT RLE

Approved
Only Engineering Division
8-1-66

PLATE NO.

PLAN-TYPICAL COLLECTOR AND HEADER DITCH SYSTEM

DETAIL OF RELIEF WELL

DETAIL OF WOOD SCREEN WITH BOTTOM PLUG

SECTION A-A
DETAIL - RISER COVER

END

SIDE

DETAIL OF OUTFALL FLAGGATE

JOINT BETWEEN WOOD AND C.M. PIPE

GUARD POST DETAIL

RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA 23-028-CWENG-62 739

SYMBOLS
B
A
SYM
DESCRIPTION
REVISIONS

DATE APP'D

REPUBLICAN RIVER, KANSAS MILFORD DAM

RELIEF WELLS SCHEDULE AND DETAILS

In 141 sheets
U.S. ARMY ENGINEER DISTRICT
KANSAS CITY

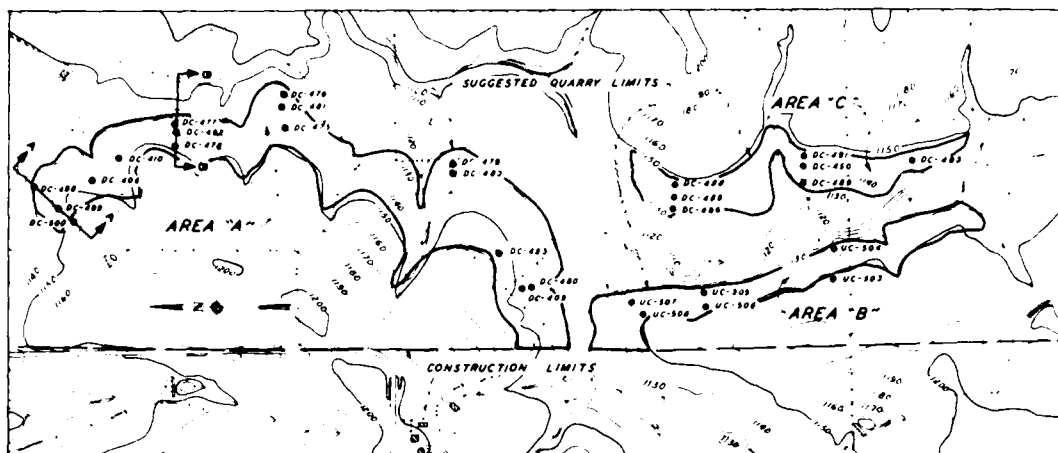
Sheet No. 1

Scale: as shown
KANSAS CITY, MO
APRIL 1962

Submitted by: J. J. Bellinger
Checked by: JAW
Recommended by: J. J. Bellinger
Checked by: RLB
Approved by: [Signature]
Chief Engineer's Division
FILE NO.
B-1-017

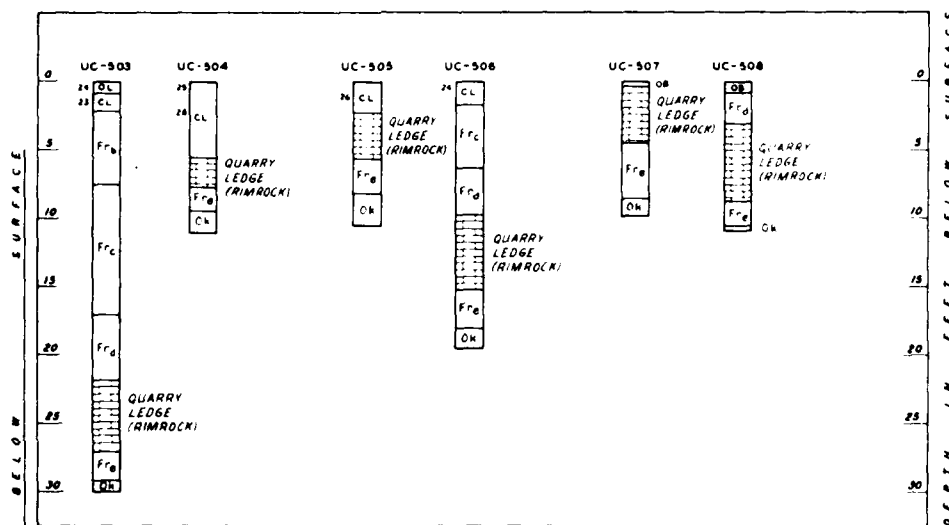


ADDER DITCH SYSTEM

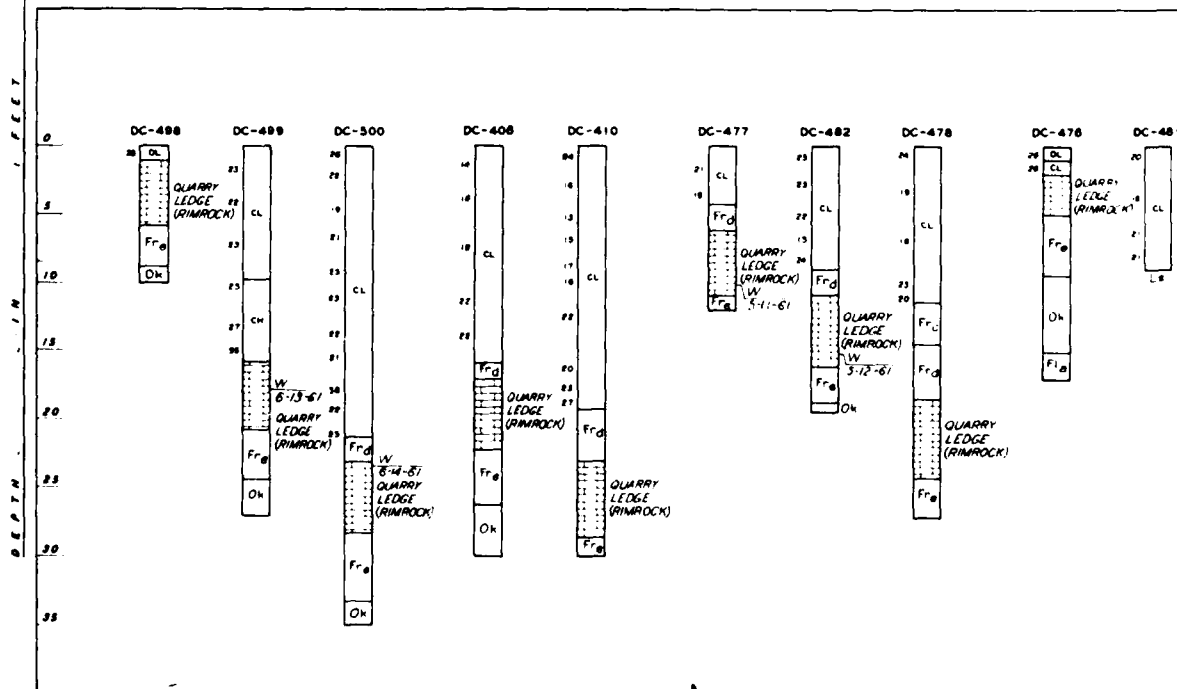


QUARRY SITE NO. 1

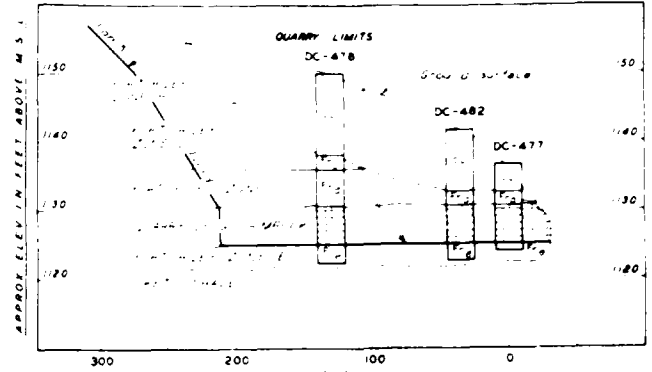
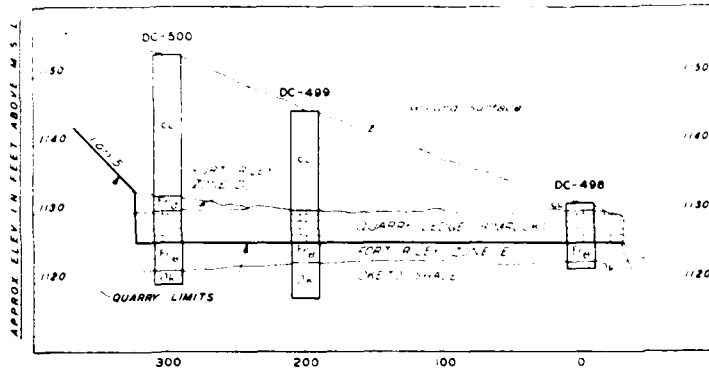
Scale 1" = 400'



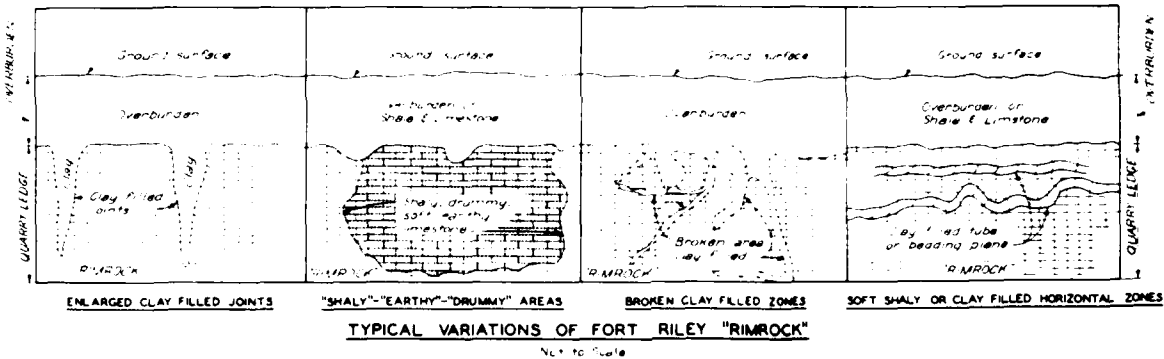
DETACHED BORINGS AREA "B"



DETACHED BORINGS AREA "A"



TYPICAL CROSS-SECTIONS



NOTE: That section designated as rimrock and quarry ledge is also known locally as Buildingstone Ledge, White Ledge, Walker Ledge, or Junction City Limestone. Additional information on this ledge may be found in the following references: State Geological Survey of Kansas Bulletin 39, page 77; The Geology of Riley and Geary Counties and State Geological Survey of Kansas Bulletin 88, page 44; The Kansas Rock Column.

Limits as shown are suggested working limits for quarry operations and are subject to change depending upon quality of materials encountered.

The variations shown are diagrammatic variations which may be encountered.

The Quarry Ledge or Rimrock as shown is the lower 55' of the D zone of the Fort Riley Limestone.

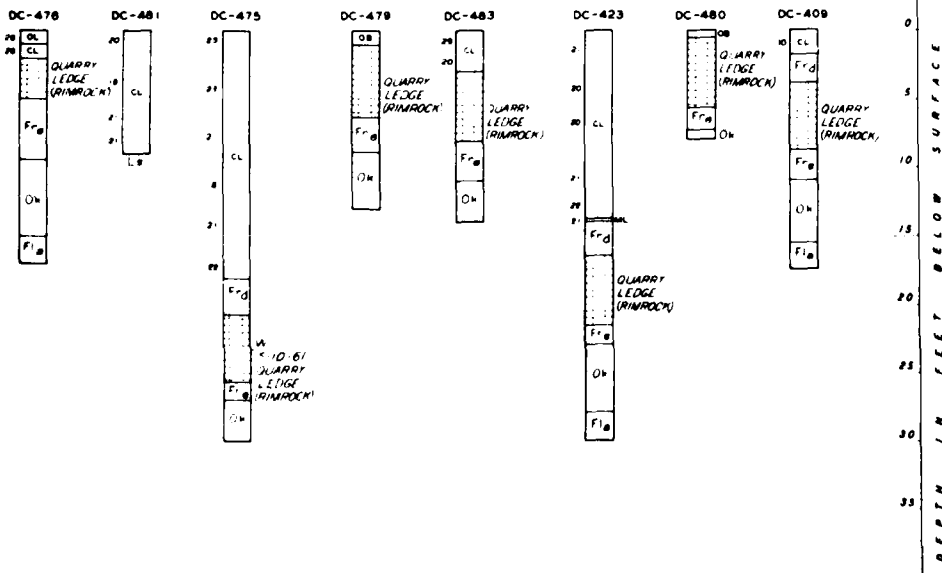
For location of the Quarry Site with reference to dam axis, see Sheet No. 124.

For general geologic description of bedrock zones and explanation of symbols, see Sheet No. 125.

Detailed logs of borings are available for inspection in the Kansas City, Corps of Engineers District Office.

Area A to be used by Schedule II Contractor for production of riprap. Area B Schedule II Contractor will remove overburden and rock material for the Schedule III Contractor.

Area C this area will be utilized for the production of riprap only by approval of the contracting officer.



RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA-33-085-CHENG-42-710

	Revised for As Built conditions	5-6-67	5-6-67
(A)	Changed as per Amendment No. 1	7-6-67	7-6-67
SYM	DESCRIPTION	DATE	APP'D
REVISIONS			

REPUBLICAN RIVER, KANSAS
MILFORD DAM

QUARRY SITE NO. 1

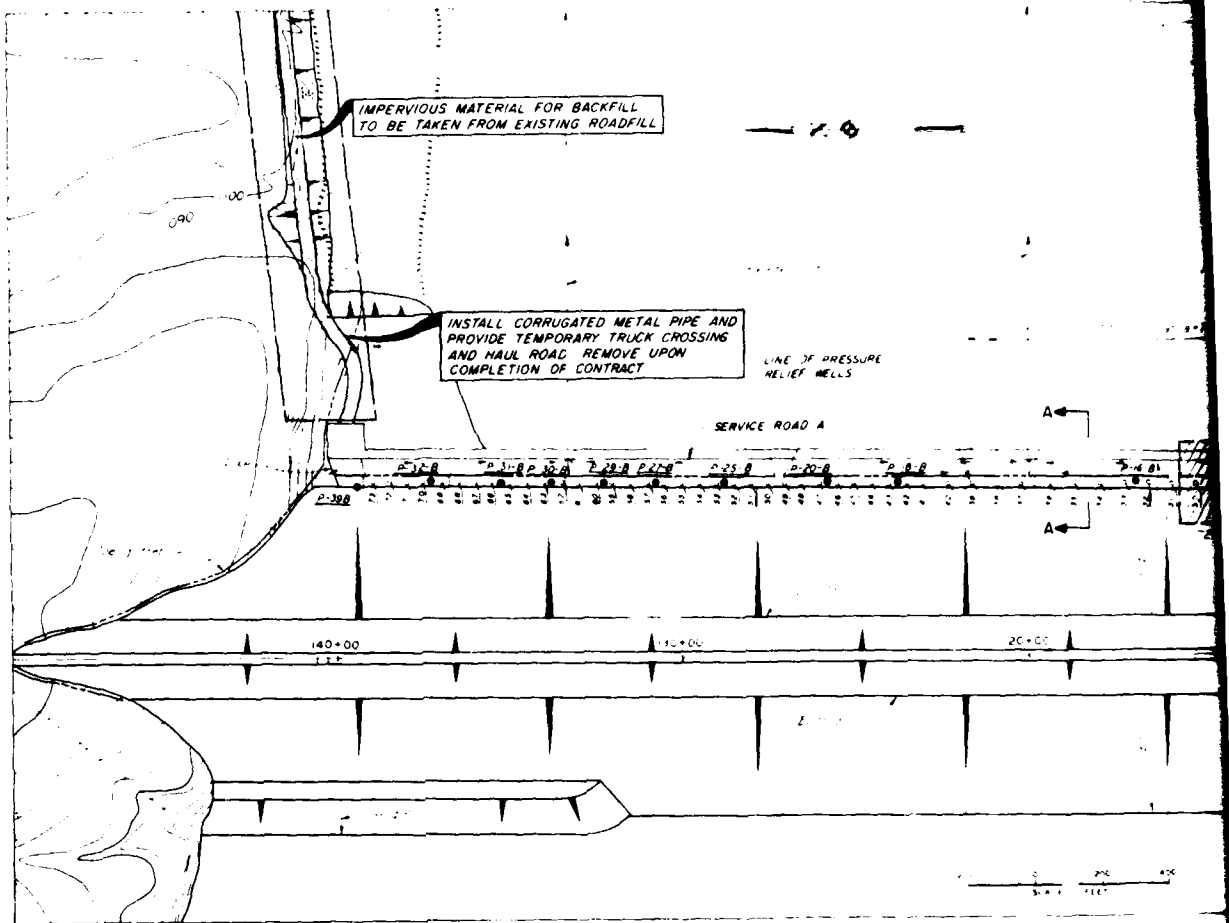
In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 134

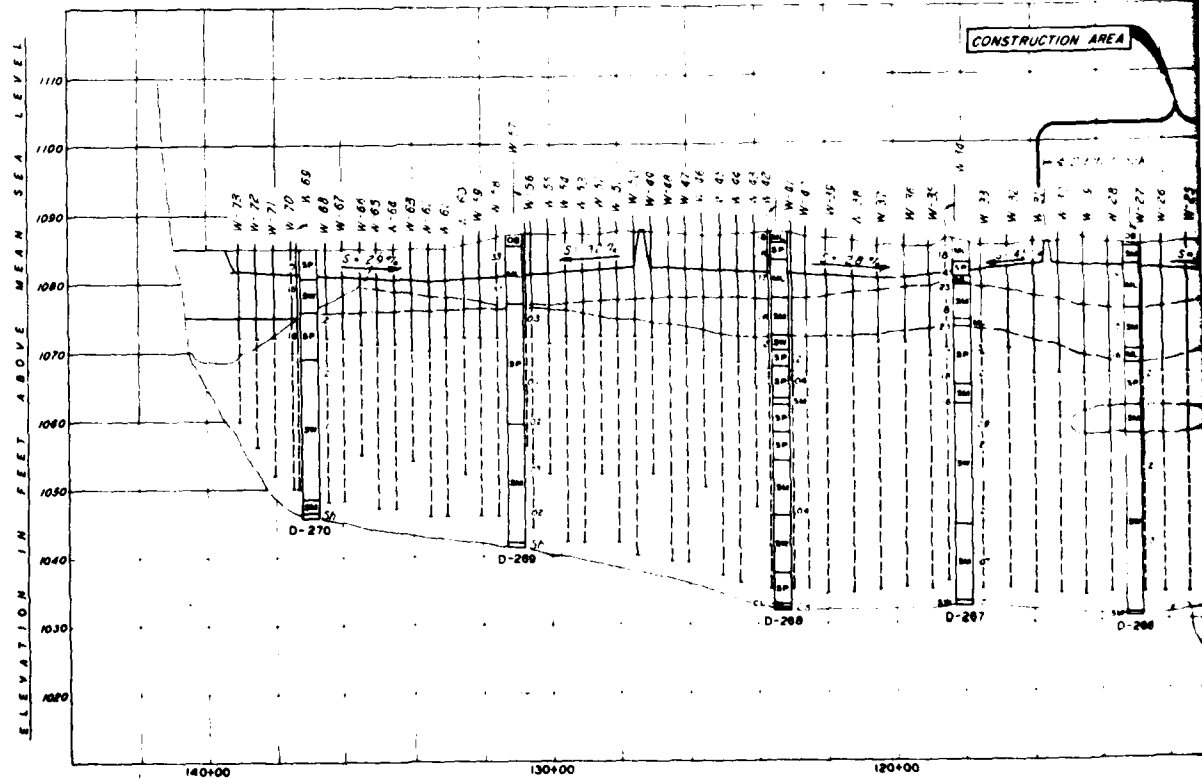
Scale: as shown
KANSAS CITY, MO
APRIL 1962

Submitted by: [Signature]
Checked by: J.R.P.
Traced by: C.R.G.
Approved: [Signature]
PAID NO. 8-1-1034

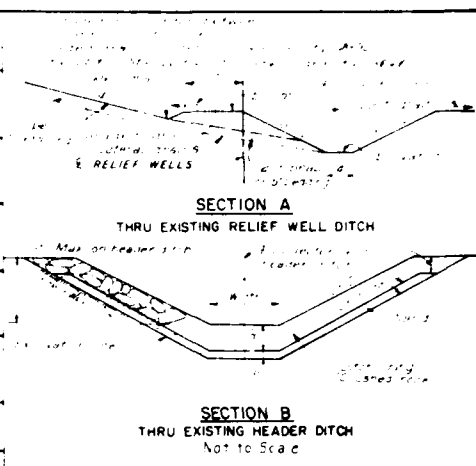
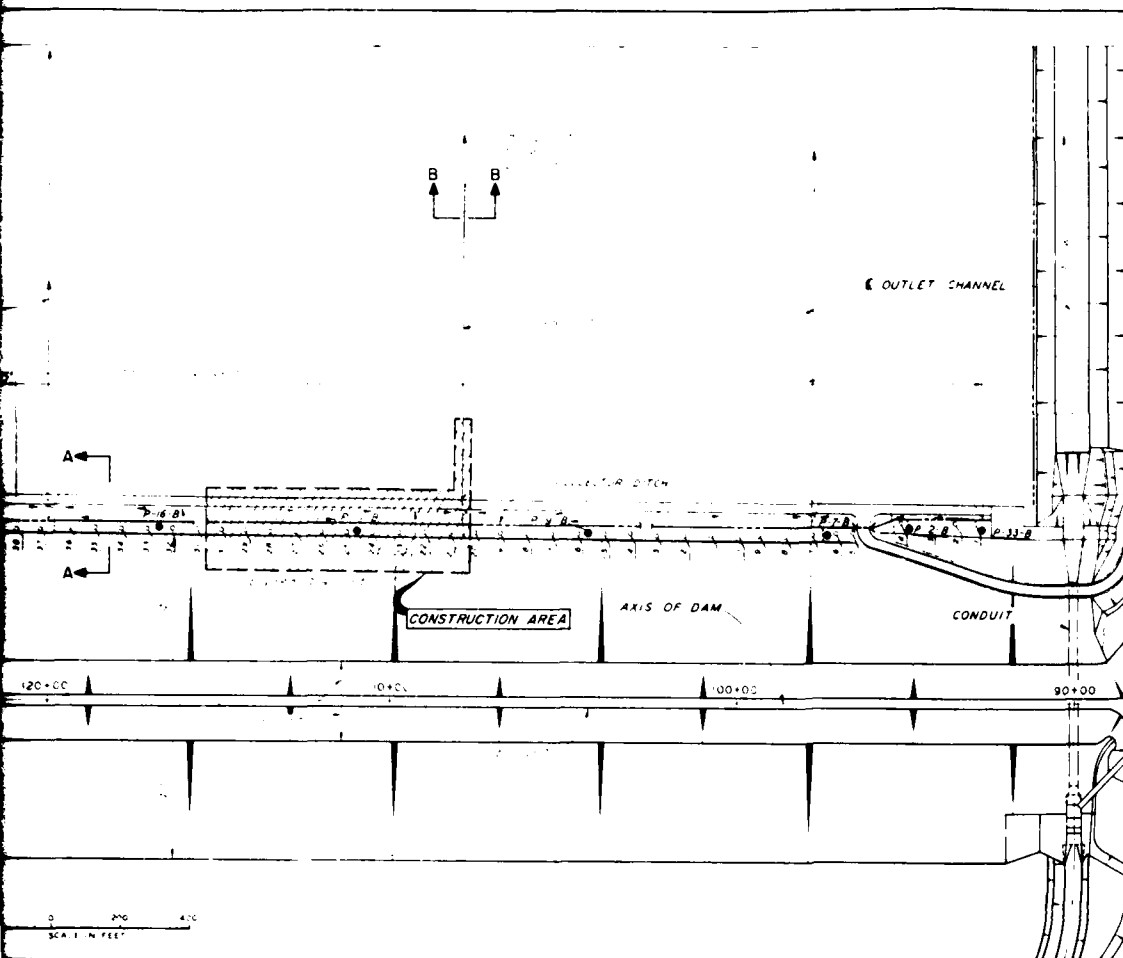
PLATE NO. 21



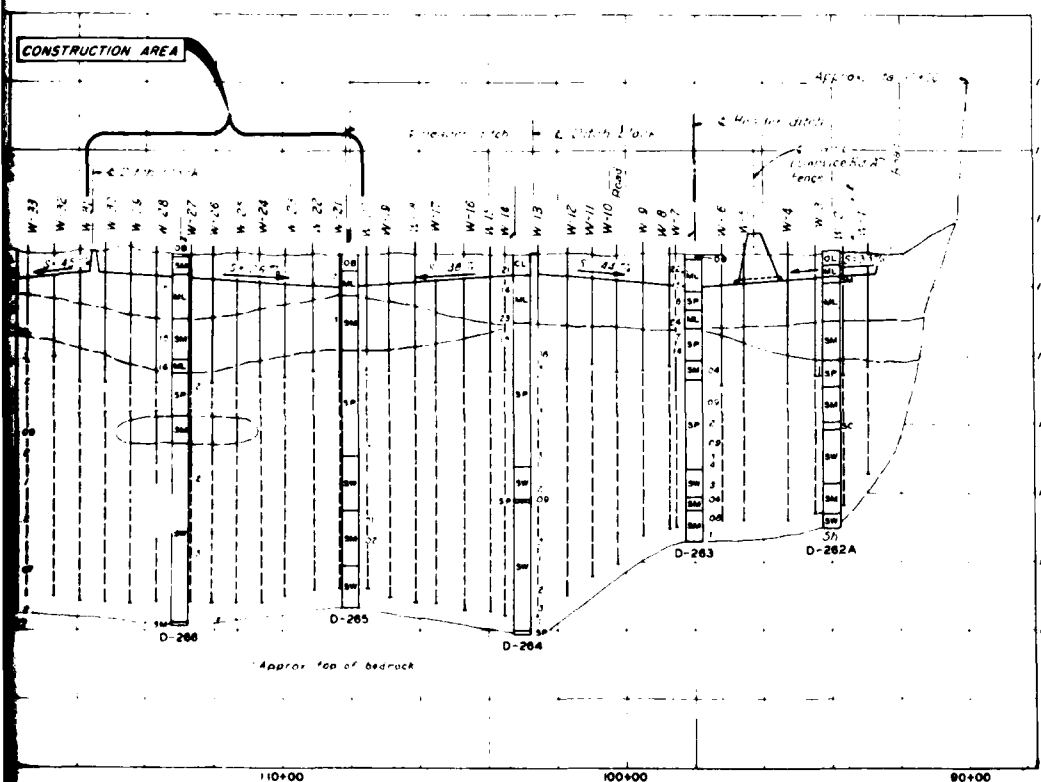
PLAN OF RELIEF WELLS AND OBSERVATION



PROFILE ALONG LINE OF WELLS



WELLS AND OBSERVATION DEVICES



RECORD DRAWING

SEPTEMBER 1976
CONTRACT NO. DACW41-76-C-0122

Revised for 'As Built' conditions
SYN. DESCRIPTION REVISIONS

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
RELIEF WELL COLLECTOR SYSTEM

EXISTING RELIEF WELLS
PLAN AND PROFILE

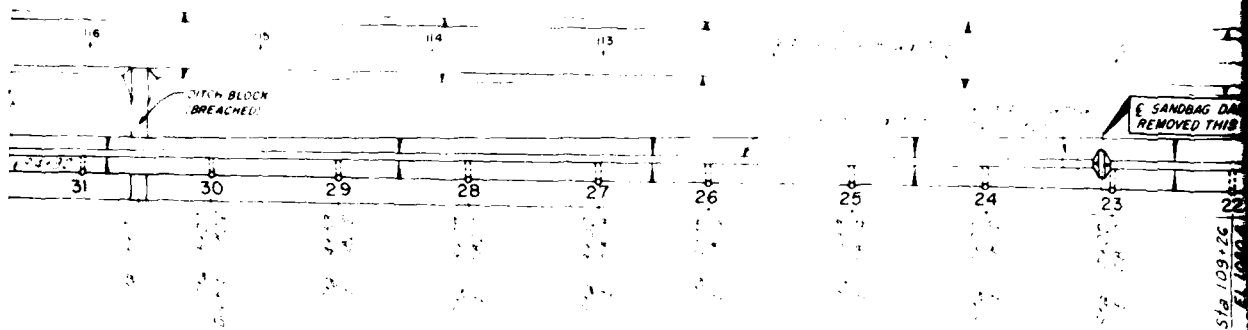
Draw No 3
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
Submitted by: [Signature]
CHECKED BY: WWS
DESIGNED BY: JLE
DRAWN BY: R&D

Recommended by: [Signature]
CHECKED BY: [Signature]
DESIGNED BY: [Signature]
DRAWN BY: [Signature]

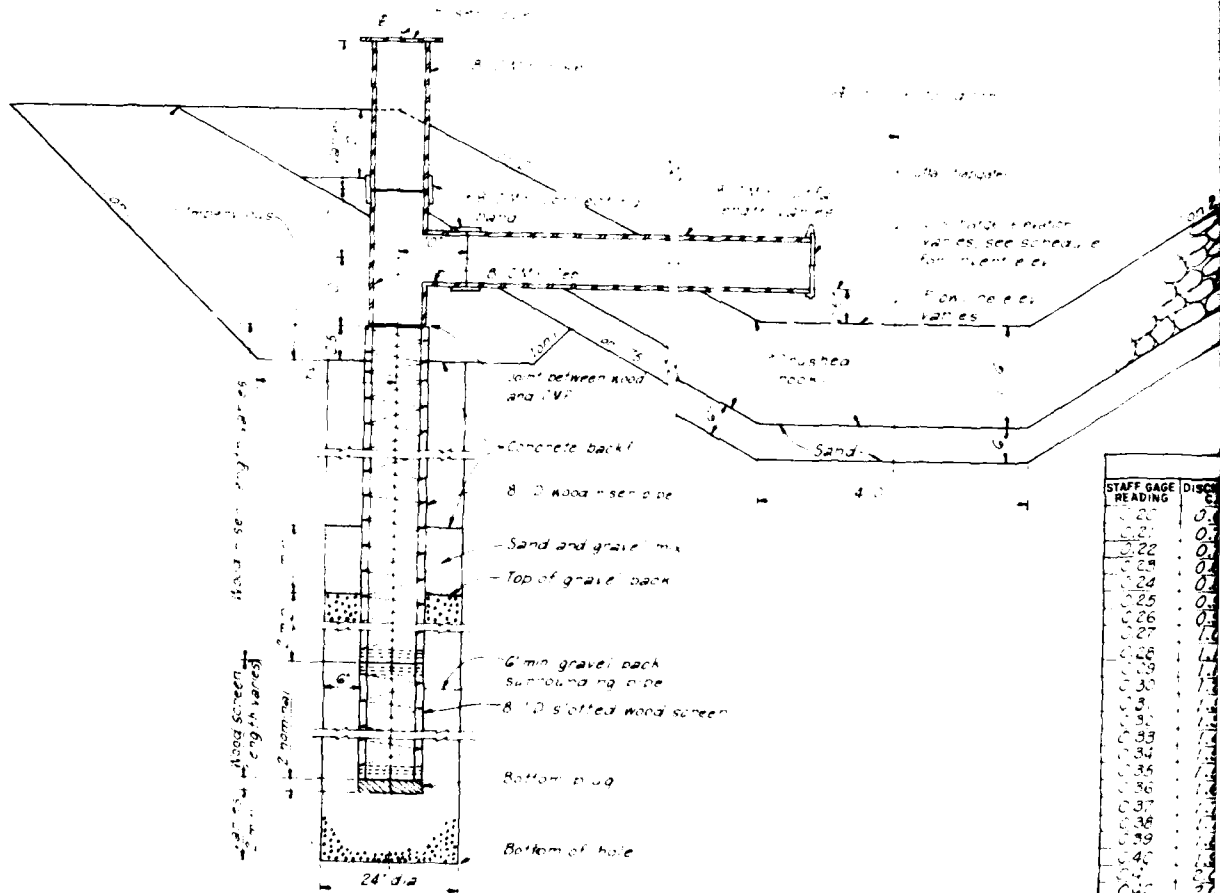
Scale as shown
U.S. ARMY
MARCH 1976

8-1-1873
PLATE NO. 26

2

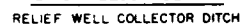
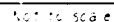


EXISTING RELIEF WELL COLLECTOR SYSTEM



DETAIL OF EXISTING RELIEF WELL AND COLLECTOR DITCH
Not to scale

STAFF GAGE READING	DISCH.
0.20	0.0
0.21	0.0
0.22	0.0
0.23	0.0
0.24	0.0
0.25	0.0
0.26	0.0
0.27	0.0
0.28	0.0
0.29	0.0
0.30	0.0
0.31	0.0
0.32	0.0
0.33	0.0
0.34	0.0
0.35	0.0
0.36	0.0
0.37	0.0
0.38	0.0
0.39	0.0
0.40	0.0
0.41	0.0
0.42	0.0



Note
Unshaded area to be constructed
in 5 contract



GALLONS GPM	STAFF GAGE READING	DISCHARGE CFS	GALLONS GPM
135.0	0.89	6.68	2,998.0
130.0	0.90	6.80	3,051.8
125.0	0.91	6.92	3,105.7
120.0	0.92	7.03	3,159.7
115.0	0.93	7.15	3,213.9
110.0	0.94	7.27	3,268.0
105.0	0.95	7.39	3,322.2
100.0	0.96	7.51	3,376.5
95.0	0.97	7.63	3,430.3
90.0	0.98	7.75	3,478.2
85.0	0.99	7.88	3,536.5
80.0	1.00	8.00	3,590.0

RECORD DRAWING

SEPTEMBER 1976

CONTRACT NO. DACW41 76-C-0122

SYM

Revised for 'As Built' conditions

DESCRIPTION
REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

RELIEF WELL COLLECTOR SYSTEM

RELIEF WELLS 20 THRU 30

PLAN AND DETAILS

12/

DO

Dwg No 4

Scale

SEPTEMBER 1976
CONTRACT NO DACW41 76-C-0122

SYM

MILFORD LAKE

RELIEF WELLS 20 THRU 30
PLAN AND DETAILS

Dwg No 4
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Submitted
See 1 enclosure
 CHIEF DATA & FOUNDATIONS SECT
 COMPILED BY WWB DRAWN BY JLE

Recommended
CHIEF FOUNDATIONS & HEALS
CHECKED BY
RGO

Chief Engineering Division
FILE NO
B-1-187

Scale as shown
U S ARMY
MARCH 1976

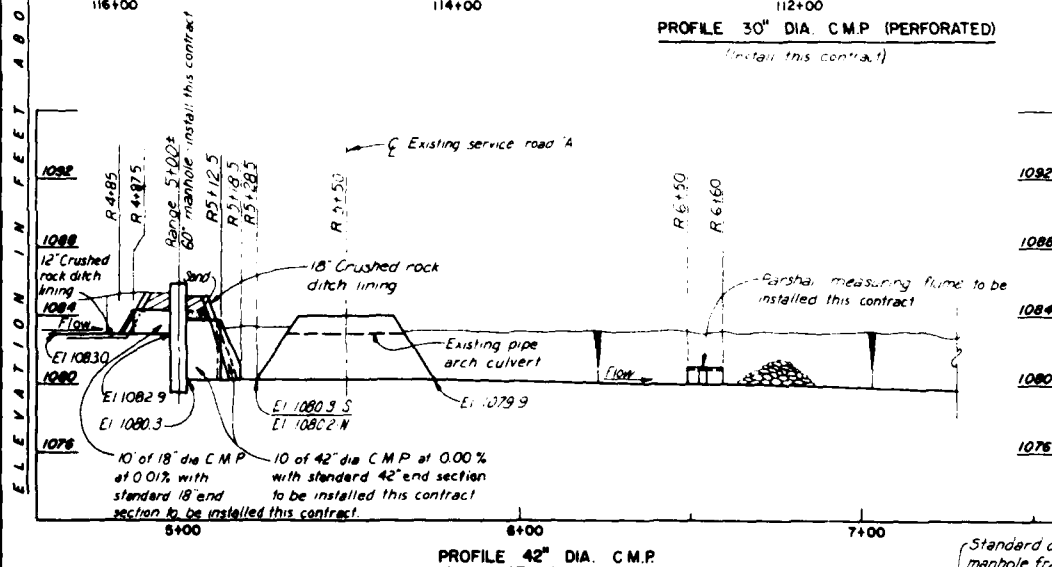
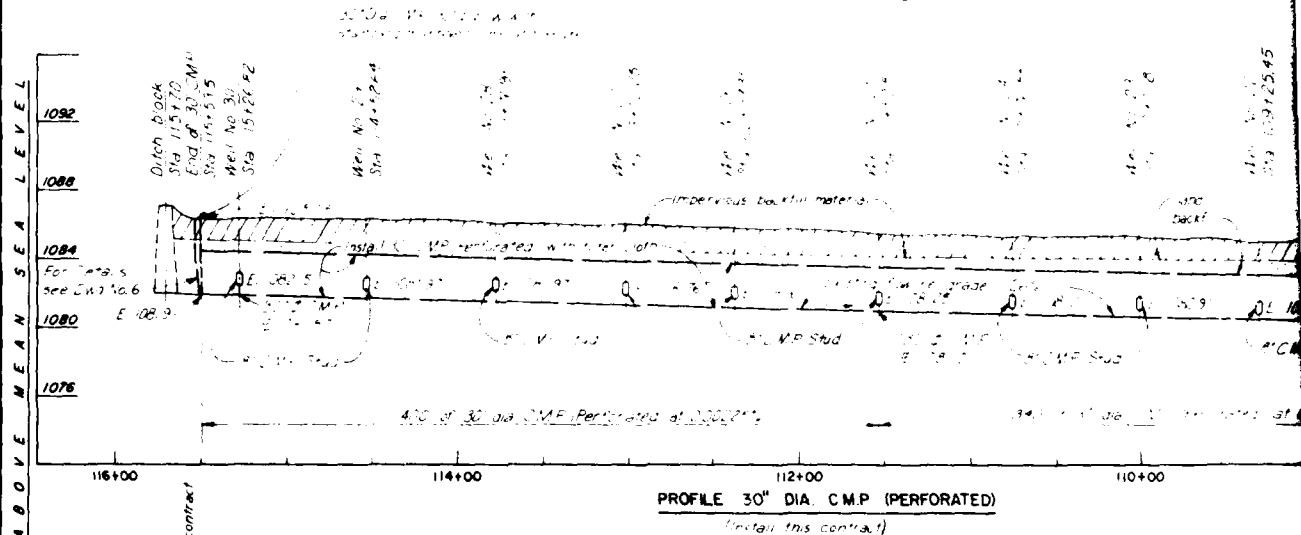
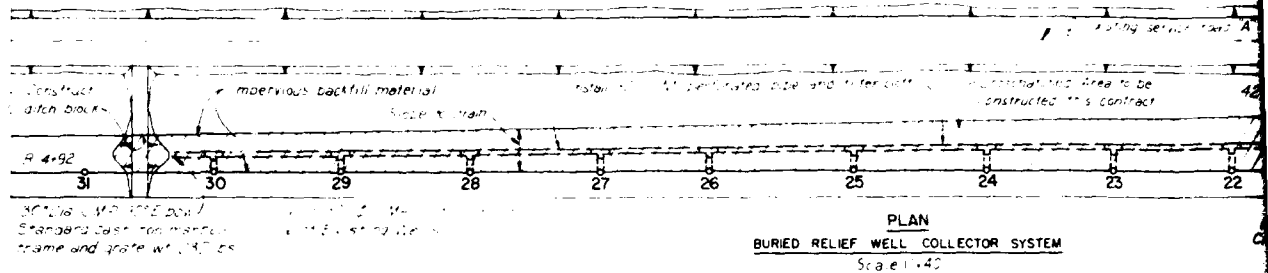
PLATE NO. 27

PLATE NO. 27

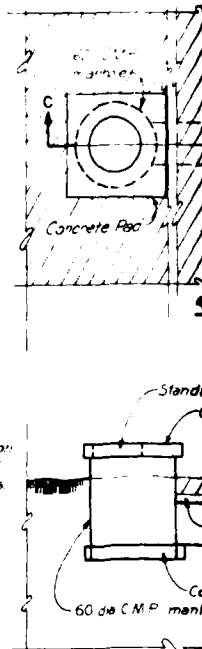
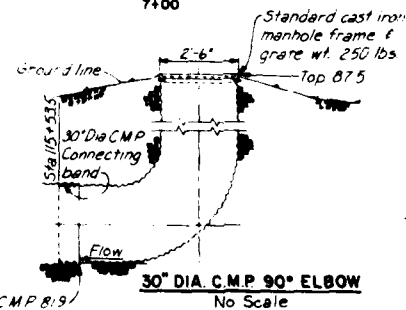
8-1-107

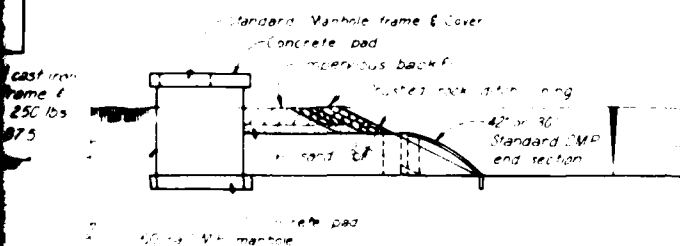
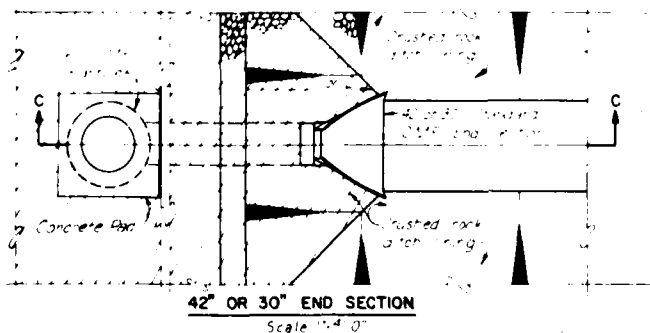
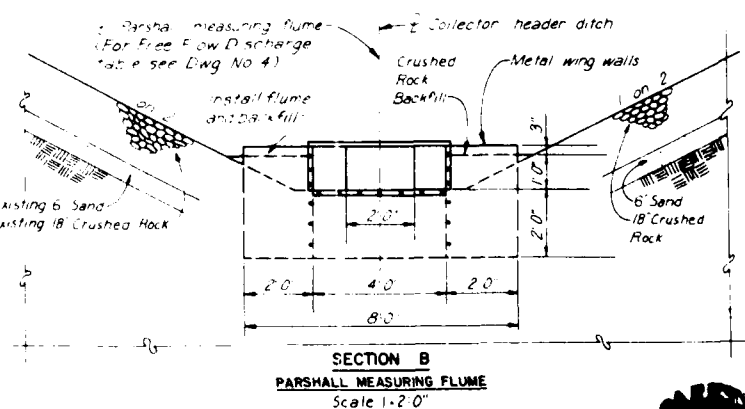
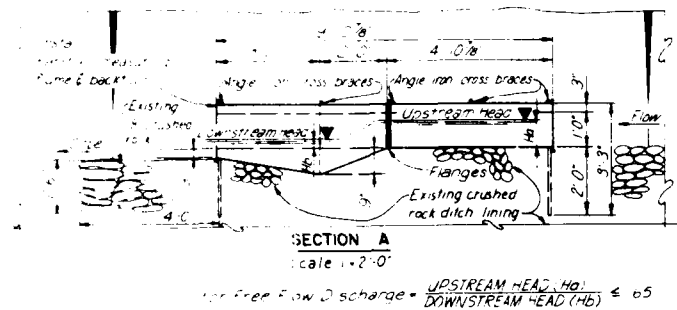
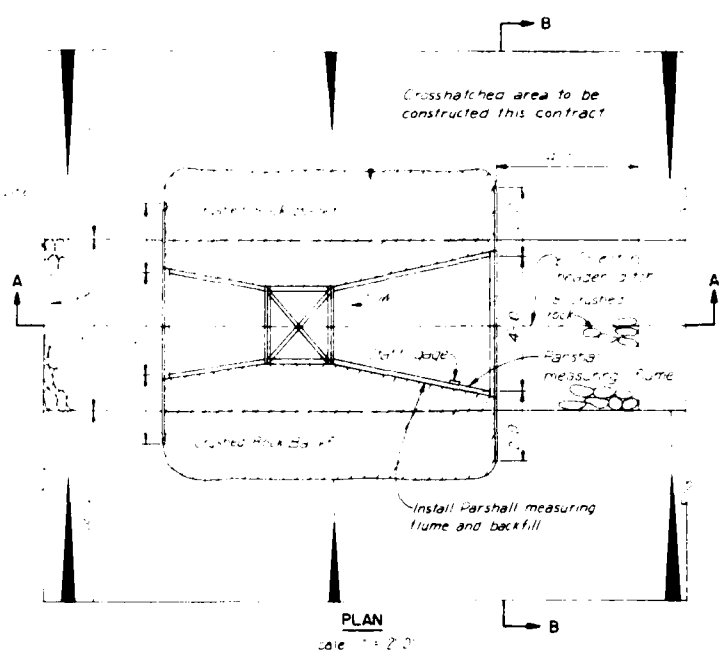
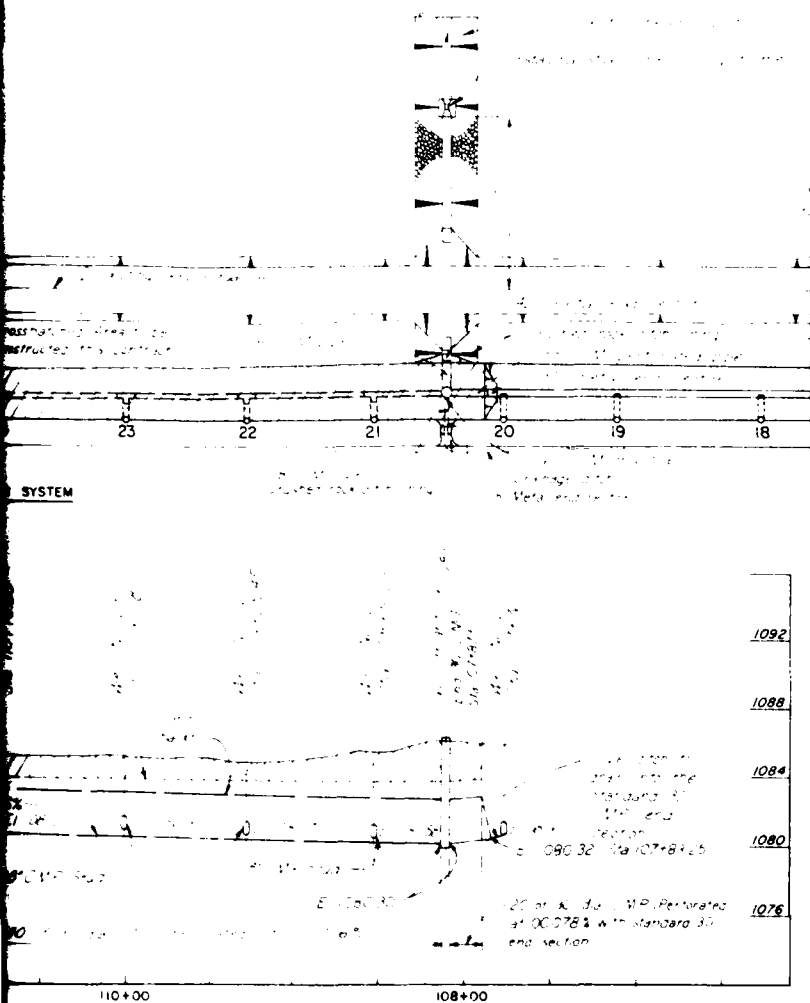
8-1-107

PLATE NO. 27



MATERIALS QUANTITY SCHEDULE	
QUANTITY	ITEM
800 L/FT	3' Wide Poly-Filter-X-Cloth
2 Cu Yds	Reinforce Concrete (Manhole)
50 Cu Yds	Excavation material
1,000 Cu Yds	Impervious backfill
600 Cu Yds	Sand backfill
20 Cu Yds	Crushed rock (Ditch lining)
10 L/FT	18" C.M.P.
760 L/FT	30" C.M.P. (Perforated)
10 L/FT	42" C.M.P.





RECORD DRAWING

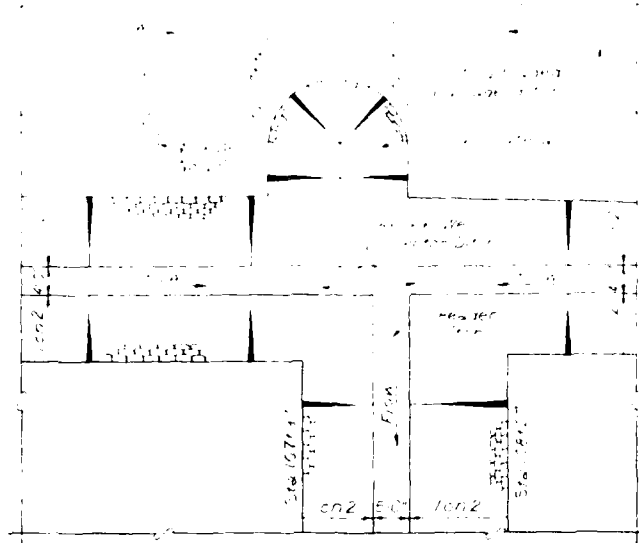
SEPTEMBER 1976
CONTRACT NO. DACW4176-C-0122

Dwg. No. 5
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
SUBMITTED
CHECKED BY
WWS
JLE
R.G.D.

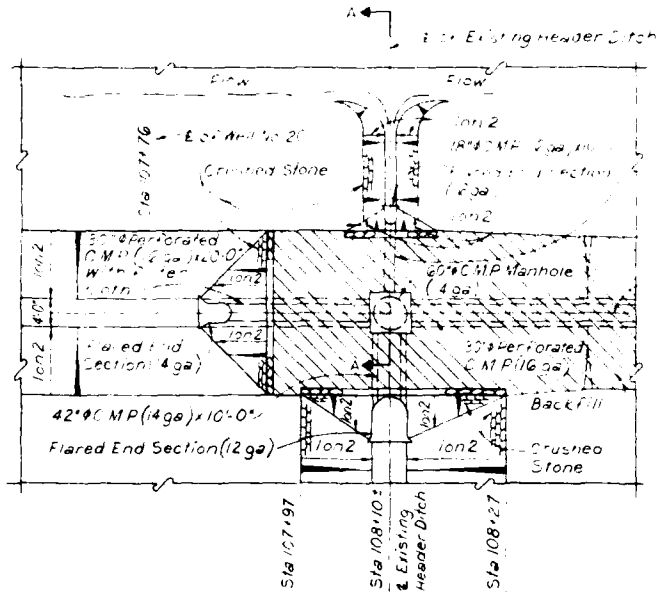
Recommended
CHECKED BY
R.G.D.

Scale as shown
U.S. ARMY
MARCH 1976
FILE NO.
8-1-1875

PLATE NO. 28

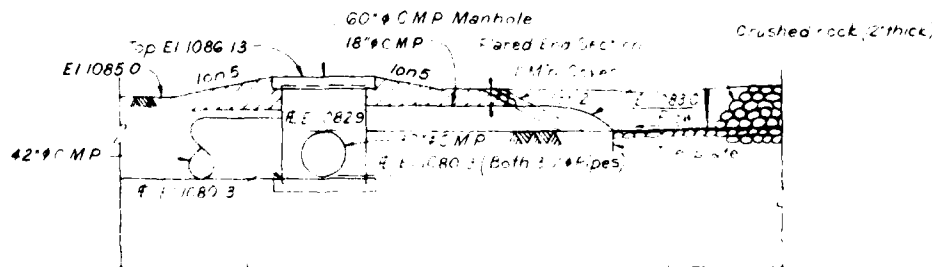


EXISTING PLAN



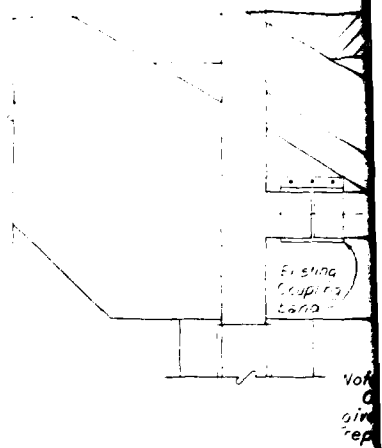
FINISHED PLAN
VICINITY OF MANHOLE

Scale 1"=10'



SECTION A

Scale 1/4"=10'



Manhole Frame Cover
Material: 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal

3" x 2" x 2" x 2"
Altered Equal

3" x 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal

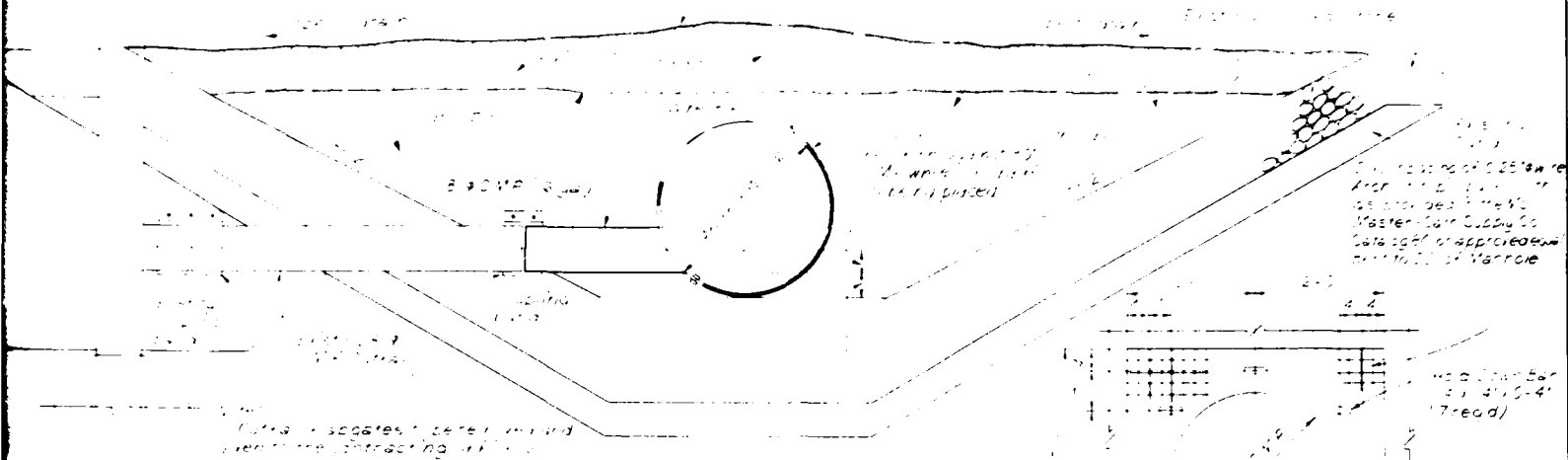
2" x 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal

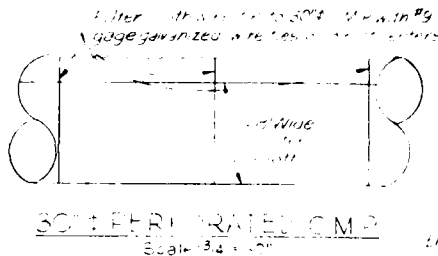
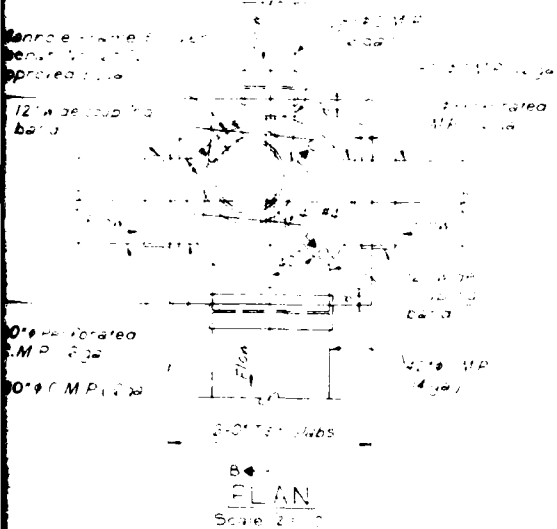
2" x 2" x 2" x 2"
Altered Equal

2" x 2" x 2" x 2"
Altered Equal



RELIEF WELL COLLECTOR SYSTEM INSTALLATION DETAIL

Scale 1" = 10'



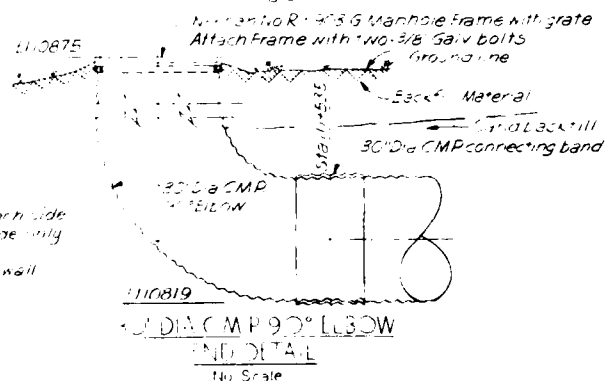
30" PERFORATED CMP

Scale 1/4" = 1"

1. The manhole shall be constructed of 30" dia. concrete pipe with a minimum wall thickness of 4" and a minimum strength of 4000 psi. The manhole shall be installed in the center of the well collector system. The manhole shall be installed in the center of the well collector system. The manhole shall be installed in the center of the well collector system.

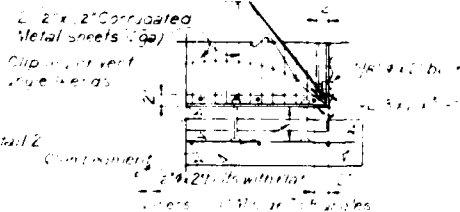
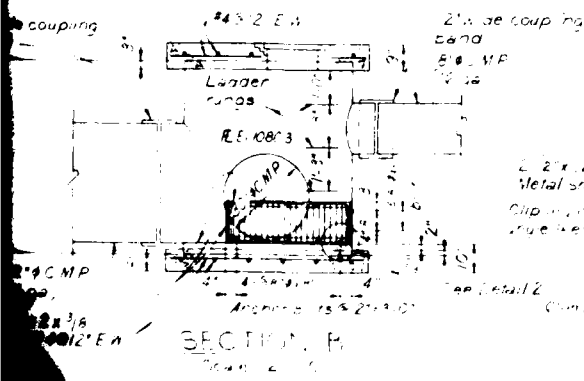
ELEVATION C

Scale 1" = 10'



LADDER RUNG DETAIL

Scale 1" = 10'



SECTION B

Scale 1" = 10'

RECORD DRAWING

SEPTEMBER 1976
CONTRACT NO. DACW4176 C-0122

Revised for "As Built" conditions
DESCRIPTION
REVISIONS

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
RELIEF WELL COLLECTOR SYSTEM

STRUCTURAL DETAILS

Day No 6
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
Submitted
Checked by
RCD

Recommended
Checked by
HEF

Approved
Chief Engineering Officer
FILE NO
B-1-1876

PLATE NO. 29

TABLES

TABLES

MILFORD DAM

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION Surface El	Bottom El	EXPLOSIVE COLUMN Lbs 60% Dyn	Lbs 40% Dyn	Lbs 40% Dyn
1	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+00 to 142+40	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	214	1147	1135	1 S 40% A.N. 4 Stem	0	260
2	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+40 to 142+80	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
3	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+80 to 142+120	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
4	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+120 to 142+160	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
5	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+160 to 142+200	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
6	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+200 to 142+240	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
7	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+240 to 142+280	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
8	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+280 to 142+320	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
9	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+320 to 142+360	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
10	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+360 to 142+400	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
11	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+400 to 142+440	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
12	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+440 to 142+480	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
13	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+480 to 142+520	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
14	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+520 to 142+560	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
15	9-10-62	Pre Split Back Slope	1st Lift	Sta 142+560 to 142+600	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 1	69	1151	1135	1 S 40% A.N. 4 Stem	0	260

MILFORD DAM

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION Surface El	Bottom El	EXPLOSIVE COLUMN Lbs 60% Dyn	Lbs 40% Dyn	Lbs 40% Dyn
16	10-10-62	Approach Bench	1st Lift	Sta 5+00 to 5+10 U	Air Trac	3 1/2	12	7 X 9	Vertical	None	214	1147	1135	1 S 40% A.N. 4 Stem	0	260
17	10-10-62	Approach Bench	1st Lift	Sta 5+10 to 5+20 U	Air Trac	3 1/2	12	7 X 9	Vertical	None	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
18	10-10-62	Pre Split	1st Lift	Sta 5+20 to 5+30 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	69	1151	1135	1 S 40% A.N. 4 Stem	0	260
19	10-10-62	Approach Bench	1st Lift	Sta 5+30 to 5+40 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	19	1160	1135	1 S 40% A.N. 4 Stem	0	260
20	10-10-62	Approach Bench	1st Lift	Sta 5+40 to 5+50 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	106	1155	1135	1 S 40% A.N. 4 Stem	0	260
21	10-10-62	Approach Bench	1st Lift	Sta 5+50 to 5+60 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	86	1155	1135	1 S 40% A.N. 4 Stem	0	260
22	10-10-62	Approach Bench	1st Lift	Sta 5+60 to 5+70 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	59 Pre Split	1155	1135	1 S 40% A.N. 4 Stem	0	260
23	10-10-62	Approach Bench	1st Lift	Sta 5+70 to 5+80 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	47	1174	1135	1 S 40% A.N. 4 Stem	0	260
24	10-10-62	Approach Bench	1st Lift	Sta 5+80 to 5+90 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	43	1174	1135	1 S 40% A.N. 4 Stem	0	260
25	10-10-62	Approach Bench	1st Lift	Sta 5+90 to 6+00 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	164	1164	1135	1 S 40% A.N. 4 Stem	0	260
26	10-10-62	Approach Bench	1st Lift	Sta 6+00 to 6+10 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	60	1164	1135	1 S 40% A.N. 4 Stem	0	260
27	10-10-62	Approach Bench	1st Lift	Sta 6+10 to 6+20 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	63	1164	1135	1 S 40% A.N. 4 Stem	0	260
28	10-10-62	Approach Bench	1st Lift	Sta 6+20 to 6+30 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	66	1164	1135	1 S 40% A.N. 4 Stem	0	260
29	10-10-62	Approach Bench	1st Lift	Sta 6+30 to 6+40 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	146	1168	1135	1 S 40% A.N. 4 Stem	0	260
30	10-10-62	Approach Bench	1st Lift	Sta 6+40 to 6+50 U	Air Trac	3 1/2	12	7 X 9	Vertical	1 on 0.5	1108	1108	1135	1 S 40% A.N. 4 Stem	0	260

MILFORD DAM

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION		EXPLOSIVE COLUMN Lbs 60% Dyn	Lbs 40% Dyn	Lbs 40% Dyn	
												Surface El	Bottom El				
31	10-10-62	Exposed 1 on 1 Slope Above Sifting Basin and Outlet	1st Lift	Sta 7+00-8+50 D	Rotary	4 1/2	18	9 X 12	Vertical	1 on 1	293	1173	1155	1 S 60% A.N. 4 Stem	150	600	8.0
32	11-1-62	R Abut. Cutoff & U.S. 5 Slope		Sta 0+70-1+00 U	Rotary	4 1/2	14	8 X 10	Vertical	1 on 0.5	150	1154	1140	1 S 40% A.N. 4 Stem	0	400	3.0
33	11-2-62	Exposed Slope 1 on 1 Above Outlet Channel		Sta 10+00-10+50 D	Rotary	4 1/2	18	7 X 9	Vertical	1 on 1	78	1173	1155	1 S 40% A.N. 4 Stem	0	50	2.0
34	11-2-62	Exposed 1 on 1 U.S. 1 on Sand		Sta 2+00-4+00 U	Air Trac	3 1/2	18	7 X 9	Vertical	1 on 1	78	1153	1135	1 S 40% A.N. 4 Stem	0	50	2.0
35	11-3-62	D 1 on Sand 1 on 1 Service Road Slope	2nd Lift	Sta 2+00-4+00 D	Air Trac	3 1/2	15	7 X 9	Vertical	1 on 0.5	None	None	None	1 S 60% A.N. 4 Stem	100	200	3.0
36	11-4-62	R Abut. Cutoff		Sta 0+70-2+00 D	Air Trac	3 1/2	15	8 X 10	Vertical	1 on 1	146	1154	1135	1 S 60% A.N. 4 Stem	100	200	3.0
37	11-5-62	D 1 on 5		Sta 2+00-5+00 D	Air Trac	3 1/2	14	8 X 10	Vertical	1 on 0.5	245	1155	1140	1 S 60% A.N. 4 Stem	100	200	3.0
38	11-6-62	Outlet Channel		Sta 5+00-3+00 D	Air Trac	3 1/2	12	8 X 10	Vertical	None	251	1154	1140	1 S 60% A.N. 4 Stem	100	400	3.0
39	11-7-62	Exposed 1 on 1 Above Outlet Channel	3rd Lift	Sta 5+00-9+50 D	Air Trac	3 1/2	12	8 X 10	Vertical	1 on 1	306	1155	1140	1 S 60% A.N. 4 Stem	150	1000	4.0
40	11-8-62	Approach Bench		Sta 5+00-9+00 U	Air Trac	3 1/2	26	7 X 9	Vertical	None	188	1137	1111	1 S 40% A.N. 4 Stem	0	100	14.0
41	11-10-62	Approach Bench		Sta 7+00-9+00 U	Air Trac	3 1/2	26	7 X 9	Vertical	None	187	1137	1111	1 S 40% A.N. 4 Stem	0	300	13.0
42	11-11-62	Approach Bench		Sta 7+00-9+00 U	Air Trac	3 1/2	20	7 X 9	Vertical	1 on 0.5	15	1154	1140	1 S 40% A.N. 4 Stem	0	150	0
43	11-11-62	R Abut. Cutoff Pre Split Delay	4th Lift	Sta 1+00-1+00 D	Air Trac	3 1/2	12	42 C to C 7 X 9	Vertical	None	180	1158	1140	1 S 40% A.N. 4 Stem	0	150	3.0
44	11-12-62	Approach Bench		Sta 5+50-6+00 U	Air Trac	3 1/2	26	7 X 9	Vertical	None	129	1137	1111	1 S 40% A.N. 4 Stem	0	150	0
45	11-13-62	Approach Bench	2nd Lift	Sta 5+00-5+50 U	Air Trac	3 1/2	26	7 X 9	Vertical	None	105	1137	1111	1 S 40% A.N. 4 Stem	0	50	7.0

MILFORD DAM BLASTING RECORD TABLE 1

[illegible]

MILFORD DAM BLASTING RECORD -- TABLE 2

EXPLOSIVE COLUMN						LOADING		CAPS DELAYS		PRIMA	RESULTS	METHOD OF EXCAV.	UTILIZATION	GEOLOGIC F.M.	REMARKS	
Lbs 40's Dyn	Lbs 40's Dyn	Lbs A-4	Total Explos.	Ext. to Rock	Lbs Yd	1	2	3	4	5						CORD
S-8 A.N. 4 Stem		75	75	75							No	Size Gradation Good	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley D.E	
S-8 A.N. 4 Stem		75	75	75							No	Size Gradation Good	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley C.D. Fort Riley B.C.D.E	
S-8 A.N. 4 Stem		75	75	75							No	Good Fracture			Fort Riley B.C.D.E Dk E To Florence A.B.C	
S-8 A.N. 4 Stem		75	75	75							No	Undulating Good	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley B.C.D.E Dk E To Florence A.B.C	Ramp elev. varies from 1095 ft. to 1100
S-8 A.N. 4 Stem		75	75	75							No	Good Fracture	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley B.C.D.E Pre Sp. In This Florence	Top soil holes need to shoot this shot. Primaries
S-8 A.N. 4 Stem		75	75	75							No	Good Fracture	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley B.C.D.E Pre Sp. In This Florence	1st major pre-spill delay shot. Contractor desired to shoot this as a delay. production blasting request denied.
S-8 A.N. 4 Stem		75	75	75							No	Good Fracture			Fort Riley A.B.C	Contractor desired to shoot this as a delay. production blasting request denied.
S-8 A.N. 4 Stem		75	75	75							No	Size Gradation Good	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley A	
S-8 A.N. 4 Stem		75	75	75							No	Size Gradation Good	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley A	
S-8 A.N. 4 Stem		75	75	75							No	Size Gradation Good	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley A.B.C	
S-8 A.N. 4 Stem		75	75	75							No	Size Gradation Good	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley A.B.C	
S-8 A.N. 4 Stem		75	75	75							No	Over-size Back Break	Marker Shove	S. Sh. and L.S. Blanket II	Fort Riley A.B.C	Middle of shot excess fines, water door breakage
S-8 A.N. 4 Stem		75	75	75							No	Over-shot Line	Marker Shove	S. Sh. and L.S. Blanket II	Florence C.D.	Shot damaged drilling left at top of cut.
S-8 A.N. 4 Stem		75	75	75							No	Size Gradation Good	Marker Shove	S. Sh. and L.S. Blanket II	Dk E To Florence A.B.C	

MILFORD DAM BLASTING RECORD - TABLE 3

EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	LOADING			Lbs Yd	CAPS DELAYS					PRIMA CORD	RESULTS	METHOD OF EXCAV	UTILIZATION	GEOLOGIC F.M.	REMARKS
			Lbs A.N.	Total Explos.	Est Yd Rock		1	2	3	4	5						
TS 80%																	
A.N. - 4 Stem	150	500	9,400	10,150	21.76	5	174	28	28	30	33	0	No	Gradation Size OK	Marion Shovel	Sh and Ls Blanket	F R B C
TS 40%																	
A.N. - 4 Stem	0	400	5,800	7,100	N/A	4	NR	NR	NR	NR	NR	NR	No	Good size Gradation	Marion Shovel	" "	F R C D
TS 40%																	
A.N. - 4 Stem	0	30	2,500	2,550	1.26	8	NR	NR	NR	NR	NR	NR	Yes	Oversize	Marion Shovel	U.S. Sh and Ls Blanket	F R B C
TS 40%																	
A.N. - 4 Stem	0	30	2,500	2,550	1.26	18	NR	NH	NR	NR	NR	NH	Yes	Size Gradation Good Slope Fair	Marion Shovel	U.S. Sh and Ls Blanket	F R B C
TS 80%																	
A.N. - 4 Stem	100	200	3,100	3,400	6.14	52	55	24	24	24	24	0	No	Size Gradation Good	Marion Shovel	U.S. Sh and Ls Blanket	F R C D
TS 80%																	
A.N. - 4 Stem	100	200	3,100	3,400	10.04	51	NR	NR	NR	NR	NH	NH	No	Some Oversize	Marion Shovel	U.S. Sh and Ls Blanket	F R C D
TS 80%																	
A.N. - 4 Stem	100	800	5,800	7,900	4.78	60	NR	NR	NR	NR	NR	NR	No	Same Oversize	Marion Shovel	U.S. Sh and Ls Blanket	F R C D
TS 80%																	
A.N. - 4 Stem	150	300	4,300	5,650	13.664	40	100	50	50	50	56	0	No	Gradation and Size Good	Marion Shovel	U.S. Sh and Ls Blanket	F R C D
TS 40%																	
A.N. - 4 Stem	0	100	14,100	14,200	11.280	28	NR	NR	NR	NR	NR	NR	No	Gradation and Size Good	Marion Shovel	Sh and Ls Fill Embankment	Florence A B F R E OKETO
TS 40%																	
A.N. - 4 Stem	0	300	13,400	13,700	11.220	27	50	34	34	34	34	0	No	Gradation and Size Good	Marion Shovel	Sh and Ls Fill Embankment	Florence A B F R E OKETO
TS 40%																	
A.N. - 4 Stem	0	100	500	615	6.97	36	3	4	4	4	4	0	No	Good Gradation Size Slope Results Good	D 9 Marion Shovel	Sh and Ls Fill Embankment	Florence A B Florence A
TS 40%																	
A.N. - 4 Stem	0	150	3,000	3,150	4.480	71	30	32	32	32	32	0	Yes See Remarks	Good Size and Gradation	Marion Shovel	Sh and Ls Fill Embankment	Florence A B
TS 40%																	
A.N. - 4 Stem	0	150	9,800	9,950	9.300	10	30	30	30	30	30	0	No	Good Size and Gradation	Marion Shovel	Sh and Ls Fill Embankment	Florence A B
TS 40%																	
A.N. - 4 Stem	0	52	4,440	4,492	6.801	18	21	21	21	19	17	27	No	Good Size and Gradation	Marion Shovel	Sh and Ls Fill Embankment	Florence A B

REPUBLICAN RIVER KANSAS
MILFORD LAKE
FOUNDATION REPORT

BLASTING RECORD
TABLES 1, 2 AND 3

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 8-1-1950
APRIL 1977

yr sheet

Sheet No 1

No. 10 25010

2

TABLES 1, 2 &

MILFORD DAM

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION Surface El	Bottom El	EXPLOSIVE COLUMN Lbs	60% Dyn Lbs	40% Dyn Lbs	Lbs
46	11-13-62	Approach Bench	1st Lift	Sta 4+50-5+00 U	Air Trac	3 1/2	26	8 X 10	Vertical	None	86	1137 +		1 S 60% A.N. - 4 Stem	0		
47	11-14-62	Approach Area		Sta 4+00-4+50 U	Air Trac	3 1/2	24	8 X 10	Vertical	1 on 1	93			1 S 60% A.N. - 4 Stem	0		
48	11-15-62	Tower Area		Sta 2+00-4+00 U	Air Trac	3 1/2	24	8 X 10	Vertical	1 on 0.5				1 S 40% A.N. - 4 Stem	0		50
49	11-16-62	R Abut. Cutoff	2nd Lift	Sta 2+70 U	Air Trac	3 1/2	26	8 X 10	Vertical	None		1135 +	1111 +	1 S 40% A.N. - 4 Stem	0		
50	11-18-62	R Abut. Cutoff		Sta 2+50 D	Air Trac	3 1/2	26	8 X 10	Vertical	None	208			1 S 40% A.N. - 4 Stem	0		104
51	11-19-62	1 on 0.5		Sta 2+50-5+00 D	Air Trac	3 1/2	26	8 X 10	Vertical	1 on 0.5	179	1140 +	1114 +	1 S 40% A.N. - 4 Stem	0		90
52	11-20-62	Slope Above	3rd Lift	Sta 2+50-6+00 D	Air Trac	3 1/2	26	7 X 9	Vertical	1 on 1	208	1142 +	1116 +	1 S 40% A.N. - 4 Stem	0		104
53	11-21-62	Stilling Basin		Sta 4+00-7+50 D	Air Trac	3 1/2	26	7 X 9	Vertical	1 on 1	240			1 S 40% A.N. - 4 Stem	0		120
54	11-23-62	and Outlet		Sta 5+00-7+50 D	Air Trac	3 1/2	26	7 X 9	Vertical	1 on 1	266	1143 +	1117 +	1 S 40% A.N. - 4 Stem	0		133
55	11-24-62	Channel	4th Lift	Sta 7+50-10+50 D	Air Trac	3 1/2	26	7 X 9	Vertical	1 on 1	90			1 S 40% A.N. - 4 Stem	0		45
56	11-25-62	Approach Bench		Sta 7+50-8+50 U	Air Trac Rotary	4 1/2	16	8 X 10	Vertical	None	109	1111 +	1095 +	1 S 40% A.N. - 4 Stem	0		54
57	11-25-62			Sta 6+50-7+50 U	Air Trac	3 1/2	16	8 X 10	Vertical	None	281			1 S 40% A.N. - 4 Stem	0		140
58	11-26-62	Final Grade	5th Lift	Sta 5+00-6+50 U	Air Trac	3 1/2	16	9 X 12	Vertical	None	299			1 S 40% A.N. - 4 Stem	0		149
59	11-28-62	Tower		Sta 5+00-7+50 U	Air Trac	3 1/2	16	9 X 12	Vertical	1 on 0.5	316			1 S 40% A.N. - 4 Stem	0		158
60	11-28-62	R Abut. Cutoff Pre-Split		Cutoff Slope	Air Trac	3 1/2	16	42 C to C	45°	1 on 1	67	1114 +	1098 +	1 S 18 4 Stem	0		100

MILFORD DAM

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION Surface El	Bottom El	EXPLOSIVE COLUMN Lbs	60% Dyn Lbs	40% Dyn Lbs	Lbs
62	11-29-62	Cutoff	6th Lift	Sta 2+50 U-2+50 D	Air Trac	3 1/2	16	9 X 12	Vertical	None	399	1114 +	2+50 D	1 Stick 40% A.N. - 4 Stem	0		800
63	11-30-62	1 on 0.5-1 on 1 Above Stilling Basin		Sta 2+50 D-5+25 D	Air Trac	3 1/2	16	9 X 12	Vertical	1 on 1	293	1116	1100	1 Stick 40% A.N. - 4 Stem	0		950
64	12-4-62	1 on 1 Above Outlet		Sta 5+25-7+50 U	Air Trac	3 1/2	24	9 X 12	Vertical	1 on 1	254	1117	1083 Final For Bench 10+50 D	1 Stick 40% A.N. - 4 Stem	0		600
65	12-4-62	Approach Channel	7th Lift	Sta 7+00-10+00 U	Air Trac	3 1/2	24	9 X 12	Vertical	1 on 1	286	10+50 D		1 Stick 40% A.N. - 4 Stem	0		300
66	12-5-62			Sta 4+50 U-6+00 U	Air Trac Rotary	4 1/2	12	7 X 9	Vertical	1 on 1.5	157	1095 +	8+00 U	1 Stick 40% A.N. - 4 Stem	0		300
67	12-6-62	Final Grade Right Abutment Pre-Split		Sta 6+00-5+00 U	Air Trac Rotary	4 1/2	16	10 X 14	Vertical	1 on 1.5	170	1086		1 Stick 40% A.N. - 4 Stem	0		300
68	12-13-62		8th Lift	Cutoff Slopes	Air Trac	3 1/2	(24)	48 C to C	45°	1 on 1	57	1087	1080	1 Stick 40% 18 1 Stick 60% A.N. - 4 Stem	0		200
69	12-14-62	Approach Wall		Sta 3+00 U	Rotary	4 1/2	13	10 X 14	Vertical	1 on 0.5	137	1086		1 Stick 60% A.N. - 4 Stem	250		0
70	12-15-62	Conduit Outside Slope		Sta 3+00 U	Air Trac Rotary	4 1/2	17	10 X 14	Vertical	1 on 1	123	1087	250 D	1 Stick 60% A.N. - 4 Stem	100		300
71	12-16-62		9th Lift	Sta 2+50 D	Air Trac Rotary	3 1/2	17	10 X 14	Vertical	1 on 1	87	1087		1 Stick 60% A.N. - 4 Stem	100		1250
72	12-13-62			Sta 11+50	Air Trac Rotary	4 1/2	18	9 X 12	Vertical	1 on 1	236	1163 +	1150	1 Stick 40% A.N. - 4 Stem	0		1160
73	12-13-62	Service Road "A" Final		Sta 20+00 D	Air Trac Rotary	3 1/2	22	9 X 12	Vertical	1 on 1	150	1150	1128	1 Stick 40% A.N. - 4 Stem	0		300
74	12-20-62		10th Lift	Sta 17+00-20+00	Air Trac Rotary	4 1/2	20	9 X 12	Vertical	1 on 1	175	9+00 D	Final Grade 5+00 D	1 Stick 40% A.N. - 4 Stem	0		1350
75	12-20-62	1 on 1.5 Slope		Sta 7+00 D-8+00 D	Air Trac Rotary	4 1/2	10	10 X 12	Vertical	1 on 1.5	126	1083	1073	1 Stick 40% A.N. - 4 Stem	0		200

MILFORD DAM

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION Surface El	Bottom El	EXPLOSIVE COLUMN Lbs	60% Dyn Lbs	40% Dyn Lbs	Lbs
76	12-27-62	1 on 1.5 Slope	11th Lift	Sta 7+00-5+00 D	Air Trac Rotary	3 1/2	20	9 X 12	Vertical	1 on 1.5	80	1083	1073	1 S 40% A.N. - 4 Stem	0		400
77	12-28-62	Stilling Basin Outlet		Sta 5+00-4+00 D	Air Trac Rotary	3 1/2	20	9 X 12	Vertical	1 on 1.5	91			1 S 40% A.N. - 4 Stem	0		600
78	12-29-62	Tower Key		Sta 2+50-4+00 D	Air Trac Rotary	4 1/2	20	9 X 12	Vertical	None	82	1100	1130	1 S 40% A.N. - 4 Stem	0		800
79	12-29-62		12th Lift														
80	2-20-63	Tower Key		Sta 3+46-3+76 D	Air Trac Rotary	3 1/2	5.0	5 X 5	Vertical	Vertical	57	1079	1072	4 S Dyn. 2 Stem	0		125
81	4-11-63	Discharge Channel		Sta 7+25-8+10 D	Rotary	4 1/2	12	4 X 8	Vertical	1 on 1.5	123			1 S 40% A.N. - 4 Stem	0		100
82	4-12-63	Discharge Channel	13th Lift	Sta 6+65-7+50 D	Rotary	4 1/2	12	8 X 10	Vertical	1 on 1.5	80	1082 +	1070 +	1 S 40% or 60% A.N. - 4 Stem	500		250
83	4-12-63	Discharge Channel		Sta 6+65-7+25 D	Rotary	4 1/2	12	8 X 12	Vertical		38			1 S 80% A.N. - 4 Stem	50		0
84	4-13-63	Discharge Channel		Sta 6+65-7+25 D	Rotary	4 1/2	12	10 X 15	Vertical	1 on 1.5	48			1 S 40% or 60% A.N. - 4 Stem	1000		100
85	—	Stilling Basin	14th Lift	Sta 6+02-4+50 D	Rotary	4 1/2	11	6 X 8	Vertical	1 on 0.5	100			8 Sticks - 6 Stem	300		100
86	—	Stilling Basin		Sta 6+02-4+50 D	Rotary	4 1/2	10	6 X 8	Vertical	1 on 0.5	175	1067 +	1057 +	24 Sticks - 40% 6 Stem	0		7200
87	—	Stilling Basin		Sta 6+02-7+27 D	Rotary	4 1/2	10	6 X 9	Vertical	1 on 0.5	153			Same as above	1400		300
88	4-17-63	Stilling Basin	15th Lift	Sta 6+02-7+27 D	Rotary	4 1/2	10	6 X 10	Vertical	1 on 0.5	53			Same as above	500		100
89	4-18-63	Stilling Basin		Sta 4+70-6+02 D	Rotary	4 1/2	10	6 X 10	Vertical	1 on 0.5	63	1057 +	1045 +	Same as above	800		100
90	4-19-63	Stilling Basin		Sta 4+00-4+73 D	Rotary	4 1/2	10	6 X 10	Vertical	1 on 0.5	55			Same as above	0		7500

[illegible]

PUSH/PULL COLUMN	Lbs	60% Dyn		Lbs	45% Dyn		LOADING			CAPS - DELAYS						PRIMA CORD
		Lbs	A N		Total Exptoe	Est Yd Rck	Lbs	Yd	0	1	2	3	4	5		
Stack 40% - LN - 4 Stem	0	800	1,065 D T	15,065	25,536	62	132	52	45	45	65	0	No			
Stack 40% - LN - 4 Stem	0	950	13,750	15,065	25,536	62	132	52	45	45	65	0	No			
Stack 40% - LN - 4 Stem	0	800	8,400	10,635	26,956	47	108	48	47	40	50	0	No			
Stack 40% - LN - 4 Stem	0	600	655 D T	8,155	25,368	36	112	38	42	32	40	0	No			
Stack 40% - LN - 4 Stem	0	300	6,900	14,900	26,312	57	124	29	34	38	61	0	No			
Stack 40% - LN - 4 Stem	0	300	250 D T	6,900	6,508	10	37	35	23	62	0	0	No			
Stack 40% - LN - 4 Stem	0	300	6,350	7,800	22,706	65	25	27	33	32	50	0	No			
Stack 40% - LN - 4 Stem	0	300	6,850	7,890									No			
Stack 40% 18 Stack 80% - LN - 4 Stem	0	200	0	2,000			1	0	0	0	0	0	Yes			
Stack 80% - LN - 4 Stem	250	0	250	6,500	9,284		NR	NR	NR	NR	NR	NR	No			
Stack 80% - LN - 4 Stem	100	300	7,000	7,400	10,842	50	NR	NR	NR	NR	NR	NR	No			
Stack 85% - LN - 4 Stem	100	250	3,500	4,850	7,656	62	NR	NR	NR	NR	NR	NR	No			
Stack 40% - LN - 4 Stem	0	1,180	11,420	12,600	16,992	63	119	24	30	25	38	0	No			
Stack 40% - LN - 4 Stem	0	300	6,850	7,150	13,200	60	37	25	25	44	0	No				
Stack 40% - LN - 4 Stem	0	350	6,600	7,950	14,000	50	NR	NR	NR	NR	NR	NR	No			
Stack 40% - LN - 4 Stem	0	200	6,900	7,100	14,000	50	17	26	22	20	41	0	No			

TESTIVE COLUMN	Lbs 65% Dyn	Lbs 40% Dyn	LOADING			Est Yd Rock	Lbs Yd	CAPS - DELAYS					PRIMA CORD
			Lbs A N	Total Explos				1	2	3	4	5	
15-4 Stem	0	800	2 500	3 300	6 770	49	0	30	15	15	20	0	No
15-4 Stem	0	800	3 300	3 900	7 280	53	0	30	20	15	26	0	No
15-4 Stem	0	800	100	900	2 560	35	12	20	0	0	0	0	No
15-4 Stem	0	125	0	125	280	4	0	0	20	27	0	0	No
15-4 Stem	0	100	1 200	1 300	1 722	7	NR	NR	NR	NR	NR	NR	No
15-4 Stem	500	250	1 248	1 998	2 800	7	37	21	22	0	0	0	
15-4 Stem	50	0	700	750	1 596	5	10	10	18	0	0	0	
15-4 Stem	1 000	0	1 500	2 800			1	22	25	0	0	0	1 000
15-4 Stem	300	100	0	400	1 700	2	40	30	30	0	0	0	No
15-4 Stem	0	2 200	0	2 200	2 975	7	1	2	2	2	0	0	1 800
15-4 Stem	1 400	300	0	1 700	3 080	5	23	15	14	18	0	0	2 700
15-4 Stem	500	100	0	600	1 166	6	9	12	13	13	3	0	500
15-4 Stem	800	100	0	900	1 386	6	16	14	16	17	0	0	Yes
15-4 Stem	0	2 500	0	2 500	2 Shots	X	2	1	3	1	1	0	2 000

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. 8-1-1951
APRIL 1977

MILFORD DAM

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION		EXPLOSIVE COLUMN Lbs 60% Dyn Lbs 40% Dyn	Lbs
												Surface E	Bottom E		
91	4.26.63	Shoring Bay	5th Lift	Sta 4+30 4+73 D	Rotary	4"	11.0	8 X 8	Vertical	1 on 0.5	52			5 Sticks 1 Stem	200
92	4.23.63			Sta 4+73 92 D	Rotary	4"	11.0	8 X 12	Vertical	1 on 0.5	103			10 Sticks 6 Stem	400
93	4.23.63			Sta 4+73 5+92 D	Rotary	4"	12.0	8 X 11	Vertical	1 on 0.5	83	1045 +	1020 +	10 Sticks 6 Stem	250
94	4.24.63			Sta 5+00 6+00 D	Rotary	4"	10.5	8 X 8	Vertical	1 on 0.5	53			10 Sticks 6 Stem	100
95	4.25.63			Sta 4+73 5+92 D	Rotary	4"	10.0	8 X 8	Vertical	1 on 0.4	83			10 Sticks 6 Stem	200
96	5.1.63			Sta 4+73 5+00 D	Rotary	4"	6.0	5 X 5	Vertical	1 on 0.5	30	1035 +	1029 +	6 Sticks 1 Stem	100
97	5.4.63			Sta 5+20 5+00 D	Rotary	4"	2.0	1 X 1	Vertical	Vertical	447		Shoring Basin 1021 + Grade	1 Stick 1 Mud Stem	50
98	5.7.63			Sta 5+20 5+60 D	Rotary	4"	2.0	1 X 1	Vertical	Vertical	715	1033 +		1 Stick 1 Mud Stem	50
99	5.9.63			Sta 5+60 6+00 D	Rotary	4"	2.0	1 X 1	Vertical	Vertical	647			1 Stick 1 Mud Stem	400
100	5.16.63	END		Sta 6+00 D	Air Trac	2 1/2"	10.0	36 C 10 C	Vertical	Vertical	30	1044 +	1034 +	1 Stick per foot	50
101	5.27.63	SILL		Sta 5+99 D	Air Trac	2 1/2"	10.0	36 C 10 C	Vertical	Vertical	30	1044 +	1034 +	1 Stick per foot	250
102	5.27.63	Quarry			Air Trac	2 1/2"	4.5	8 X 12	Vertical	Vertical	120	1132 +	1128 +	6 Sticks 3 Stem	400
103	5.28.63	Area			Air Trac	2 1/2"	4.5	8 X 12	Vertical	Vertical	365	1132 +	1128 +	2 Sticks 2 Stem 1 Stick 60%	300
104	5.29.63	A			Rotary	4"	12.0	11 X 16	Vertical	Vertical	87	1140 +	1128 +	A.M. 4 Stem	100

OUTLET WORKS
QUARRY

Milford Dam Test Data on Bedrock Strata — Table 8

Bedrock Unit	Rock Type	Unconfined Compression tons/ft ²				Dry Weight lbs/ft ³		Moisture Content % dry wt		Wetting-Drying			Modulus of Elasticity (Tan) (PSI)*				
		No. Tests	Avg.	Max.	Min.	No. Tests	Avg.	No. Tests	Avg.	No. Tests	% loss	Average		No. Tests	Avg.	Max.	Min.
												Cycles					
Towanda Limestone	Ls	4	122	318	21	6	122	6	15	3	33	14	4	4.0	11.0	0.4	
	Sh	1	5			2	106	2	23	1	100	1	1	0.1			
Holmesville Shale	Ls	1	33			1	143	1	6	0			1	7.0			
	Sh	18	25	110	1	23	124	23	13	16	100	1	18	0.4	2.0	0.01	
Ft. Riley Limestone Zone A	Ls	17	111	288	25	19	123	19	14	5	60	9	17	4.0	10.0	0.5	
	Sh	3	29	68	7	4	128	4	13	1	100	1	3	3.0	6.0	0.1	
Zone B	Ls	11	150	456	4	12	131	12	11	0			11	7.0	19.0	2.0	
Zone C	Ls	25	333	545	135	25	146	25	6	4	0	20	25	6.0	14.0	0.2	
Zone D	Ls	20	127	244	55	21	122	21	13	2	50	15	20	5.0	14.0	0.04	
Zone E	Ls	3	127	162	95	3	144	3	6	0			3	3.0	4.0	0.1	
Oketo Shale	Sh	15	253	390	131	15	152	15	4	0			15	4.0	7.0	2.0	
Florence Limestone	Ls	1	229			1	141	1	6	0			1	7.0			
	Ls	1	131			1	132	1	10	0			1	5.0			
	Ls	1	84			1	121	1	14	0			1	3.0			
	Ls	0				0		0		0			0				
Blue Springs Shale Zone A	Sh	2	47	74	20	3	139	3	9	4	100	2	2	0.9	1.0	0.7	
	Sh	4	70	172	19	4	139	4	9	4	100	2	4	1.5	3.0	0.1	
Kinney Limestone	Ls	4	338	444	188	4	148	4	5	0			4	8.0	14.0	3.0	
	Sh	6	160	289	44	8	137	8	8	6	100	3	5	3.0	6.0	1.0	

*Note: All modulus of elasticity values are x10⁵.

MILFORD DAM. PRESSURE TEST DATA - TABLE 9

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-235	Spillway	1215.8	1199.3	1195.8 - 1190.8	Towanda Ls.	26	5	2.2
				1190.8 - 1185.8	Towanda Ls.	30	5	5.1
				1185.8 - 1180.8	Towanda Ls. and Holmesville Sh.	35	3	7.0
				1180.8 - 1175.8	Holmesville Sh.	40	1	0.0
				1175.8 - 1170.8	Holmesville Sh.	45	5	0.5
				1170.8 - 1165.8	Holmesville Sh. and Ft. Riley Ls.	51	3	4.5
				1165.8 - 1160.8	Ft. Riley Ls. (Zone A)	55	3	5.0
				1163.8 - 1158.8	Ft. Riley Ls. (Zone A)	58	2	8.1
				1158.8 - 1153.8	Ft. Riley Ls. (Zones A & B)	62	5	0.1
				1153.8 - 1148.8	Ft. Riley Ls. (Zone B)	67	5	0.6
				1148.8 - 1143.8	Ft. Riley Ls. (Zone C)	No Test		

*Water used recorded in GPM per foot of section tested.

Table - 9 (1-7)

MILFORD DAM. PRESSURE TEST DATA - TABLE 9 (CONTINUED) Sheet 2 of 7

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-235	Spillway	1215.8	1199.3	1143.8 - 1138.8	Ft. Riley Ls. (Zones C & D)	77	5	7.0
				1138.8 - 1133.8	Ft. Riley Ls. (Zone D)	82	5	7.5
				1133.8 - 1128.8	Ft. Riley Ls. (Zones D & E) and Oketo Sh.	88	5	6.1
DC-236	Spillway	1229.3	1201.4	1201.3 - 1196.3	Gage Sh. and Towanda Ls.	28	5	1.3
				1196.8 - 1191.8	Towanda Ls.	33	5	0.6
				1191.8 - 1186.8	Towanda Ls.	38	5	6.5
				1186.8 - 1181.8	Towanda Ls. and Holmesville Sh.	43	5	3.9
				1181.8 - 1176.8	Holmesville Sh.	48	5	0.7

Table - 9 (2-7)

MILFORD DAM. PRESSURE TEST DATA - TABLE 9 (CONTINUED) Sheet 3 of 7

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-236	Spillway	1229.3	1201.4	1176.8 - 1171.8	Holmesville Sh.	53	3.5	9.6
				1171.8 - 1166.8	Holmesville Sh. and Ft. Riley Ls. (Zone A)	58	4	9.2
				1166.8 - 1161.8	Ft. Riley Ls. (Zone A)	63	5	7.2
				1161.8 - 1156.8	Ft. Riley Ls. (Zone A)	68	4	7.0
				1156.8 - 1151.8	Ft. Riley Ls. (Zone B)	73	2	10.9
				1151.8 - 1146.8	Ft. Riley Ls. (Zones B & C)	78	5	0.9
				1146.8 - 1141.8	Ft. Riley Ls. (Zone C)	83	5	2.3
				1141.8 - 1136.8	Ft. Riley Ls. (Zone D)	88	2	10.0
				1136.8 - 1131.8	Ft. Riley Ls. (Zones D & E) and Oketo Sh.	92.5	2	7.0

Table - 9 (3-7)

MILFORD DAM. PRESSURE TEST DATA - TABLE 9 (CONTINUED)

Sheet 4 of 7

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-289 (Angle boring 45° from vertical)	Right Abutment	1200.7	1199.0	1179.5 - 1176.0	Holmesville Sh.	21	5	4.1
				1176.0 - 1172.5	Holmesville Sh.	25	5	4.7
				1172.5 - 1169.0	Ft. Riley Ls. (Zone A)	28	5	4.2
				1169.0 - 1165.5	Ft. Riley Ls. (Zones A & B)	32	5	4.0
DC-290 (Angle boring 26° from vertical)	Left Abutment	1163.7	1162.2	1156.5 - 1154.7	Ft. Riley Ls. (Zone B)	8	5	7.8
				1147.5 - 1145.7	Ft. Riley Ls. (Zones C & D)	18	5	4.4
				1138.5 - 1136.7	Ft. Riley Ls. (Zone D)	28	5	8.3
				1129.5 - 1127.7	Oketo Sh. and Florence Ls.	38	5	0.3
				1120.6 - 1118.8	Florence Ls. (Zone A)	48	5	0.3
				1111.5 - 1109.7	Florence Ls. (Zone B)	58	5	12.6

Table - 9 (4-7)

MILFORD DAM. PRESSURE TEST DATA - TABLE 9 (CONTINUED)

Sheet 5 of 7

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-290 (Angle boring 26° from vertical)	Left Abutment	1163.7	1162.2	1102.6 - 1100.8	Florence Ls. (Zone C)	68	5	1.1
				1093.7 - 1091.9	Blue Springs Sh.	78	5	1.1
DC-301 (Angle boring 32° from vertical)	Right Abutment	1201.7	1200.2	1197.5 - 1189.2	Towanda Ls.	7	5	1.5
				1187.7 - 1181.3	Holmesville Sh.	14	5	1.7
				1181.4 - 1172.3	Holmesville Sh. & Ft. Riley Ls. (Zone A)	24	5	2.0
				1172.5 - 1168.3	Ft. Riley Ls. (Zone A)	34	5	4.7
				1168.3 - 1156.2	Ft. Riley Ls. (Zone B)	34	5	0.8
				1156.8 - 1149.6	Ft. Riley Ls. (Zones B & C)	46	5	2.7
				1149.6 - 1142.7	Ft. Riley Ls. (Zones C & D)	53	5	2.9

Table - 9 (5-7)

MILFORD DAM. PRESSURE TEST DATA - TABLE 9 (CONTINUED) Sheet 6 of 7

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER# USED (GPM)
DC-301 (Angle boring 320 from vertical)	Right Abutment	1201.7	1200.2	1143.2 - 1135.6	Ft. Riley Ls. (Zones D & E)	60	5	2.7
				1138.0 - 1133.7	Ft. Riley Ls. (Zones D & E)	65	5	0
				1133.7 - 1129.5	Oketo Sh.	69	5	1.3
				1129.5 - 1125.2	Florence Ls. (Zone A)	74	5	1.6
				1125.2 - 1121.1	Florence Ls. (Zone A)	78	5	1.8
				1121.1 - 1111.0	Florence Ls. (Zones A & B)	82	5	1.1
				1111.0 - 1102.4	Florence Ls. (Zones B & C)	93	5	2.8
				1102.4 - 1094.0	Florence Ls. (Zone D) and Blue Springs Sh.	99	5	0.0

Table - 9 (6-7)

MILEFORD DAM. PRESSURE TEST DATA - TABLE 9 (CONTINUED) Sheet 7 of 7

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-302 (Angle boring 24° from vertical)	Left Abutment	1162.3	1160.5	1156.8 - 1155.0	Ft. Riley Ls. (Zone B)	6	5	0.9
				1148.7 - 1146.3	Ft. Riley Ls. (Zone C)	16	5	4.6
				1138.5 - 1136.8	Ft. Riley Ls. (Zone D)	26	5	1.5
				1129.4 - 1127.6	Oketo Sh.	36	5	10.9
				1120.3 - 1118.5	Florence Ls. (Zone A)	46	5	11.1
				1111.2 - 1109.3	Florence Ls. (Zone A)	56	5	11.5
				1102.1 - 1100.3	Florence Ls. (Zone C)	66	5	2.7

Table - 9 (7-7)

MILFORD DAM, Summary of Test Grouting - TABLE 10
Feb-Nov 1962

Right Abutment Sta 82+20 to Sta 88+64

	<u>Lineal feet Drilled</u>	<u>Sacks of Cement injected</u>
18 Primary holes	2,180	3,825
17 Secondary holes	2,051	959
34 Tertiary holes	4,094	1,382
16 Quaternary holes	1,374	231
<u>11 Angle holes</u>	<u>1,369</u>	<u>290.5</u>
96 total	11,068*	6,687.5
	7,876 (Net)	0.849 sack/lineal ft.

*Includes 676 lineal feet of overburden and 2,516 lineal feet of horizons not grouted, (Ft. Riley zones C and E and Oketo Shale and Blue Springs Shale).

Left Abutment Sta 143+00 to Sta 151+00

	<u>Lineal feet Drilled</u>	<u>Sacks of Cement injected</u>
21 Primary holes	2,255	3,846
20 Secondary holes	2,160	1,824
40 Tertiary holes	4,278	984
34 Quaternary holes	1,366	184
2 Quinary holes	47	4
<u>5 Angle holes</u>	<u>602</u>	<u>47.75</u>
122 total	10,708*	6,889.75
	6,942 (Net)	0.992 sacks/lineal ft.

*Includes 874 lineal feet of overburden and 2,892 lineal feet of horizons not grouted, (Ft. Riley zones C and E and Oketo Shale and Blue Springs Shale).

MILFORD DAM. Summary of Contract Grouting - TABLE 11
Feb-Nov 1963

Right Abutment Sta 88+25 to Sta 90+80

	<u>Lineal feet Drilled</u>	<u>Sacks of Cement injected</u>
35 Primary holes	1,812.1	799
25 Secondary holes	1,065.1	197
<u>20 Tertiary holes</u>	<u>572.9</u>	<u>0</u>
80 total	3,450.1	996
		0.289 sacks/lineal ft.

Left Abutment Sta 142+07 to Sta 143+72

19 Primary holes	1,126.1	115
17 Secondary holes	1,064.8	49
<u>5 Tertiary holes</u>	<u>226.8</u>	<u>14</u>
41 total	2,417.7	178
		0.074 sacks/lineal ft.

PHOTOGRAPHS

PHOTOGRAPHS

1. Milford Dam,
October 1962,
Neg. No.
294-P4-3.
Laborers making
up "pig tails"
for pre-split
blasting.



2. Milford Dam,
October 1962,
Neg. No.
294-P4-2.
Loading 45°
angle holes for
pre-split
blasting.





3. Milford Dam, October 1962, Neg. No. 294-P4-5.
Test shot results for pre-split blasting.



4. Milford Dam,
October 1962,
Neg. No.
294-P4-4.
Pre-split
fracture with
primary
drilling in
progress.



5. Milford Dam, November 1962, Neg. No. 294-P4-1.
Pre-split back slope first lift left abutment
cutoff.



6. Milford Dam, November 1962, Neg. No. 294-P3-16.
Pre-split right abutment cutoff.



7. Milford Dam, November 1962, Neg. No. 294-P3-15.
Profile of pre-split slope, left abutment cutoff.



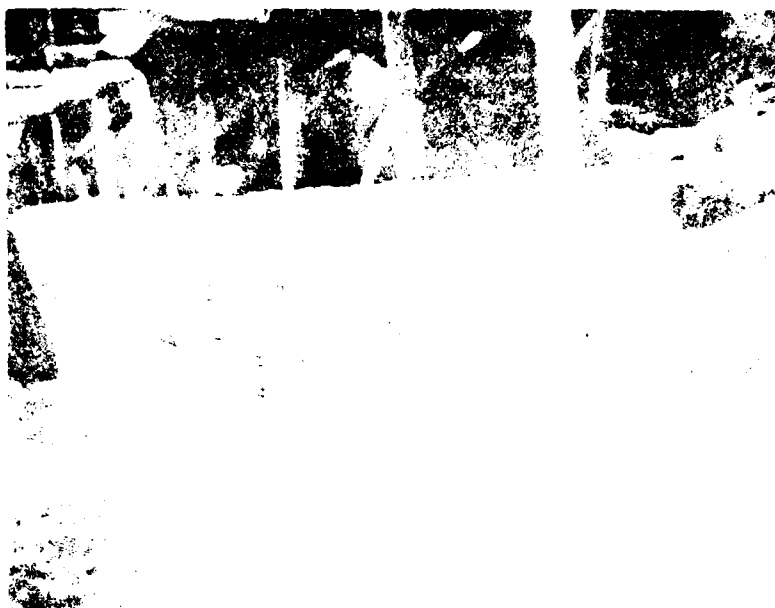
8. Milford Dam, November 1962, Neg. No. 294-P1-13.
Gypsum seam in lower Wymore.



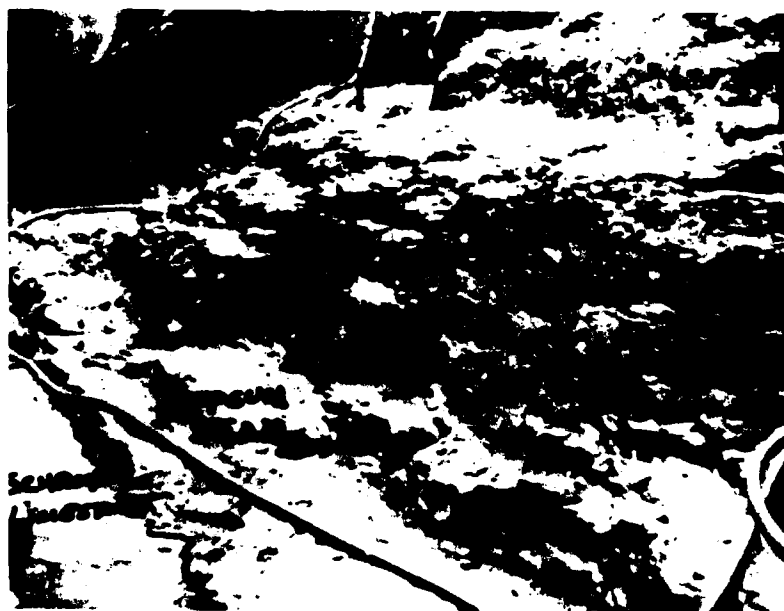
9. Milford Dam,
November 1962,
Neg. No.
294-P3-2.
Approach slab
foundation
Blue Springs
shale zone
"A" station
3+96U to
station 3+76U.



10. Milford Dam,
November 1962,
Neg. No.
294-P1-14.
Foundation of
south approach
wall, station
4+55U to
station 3+96U.



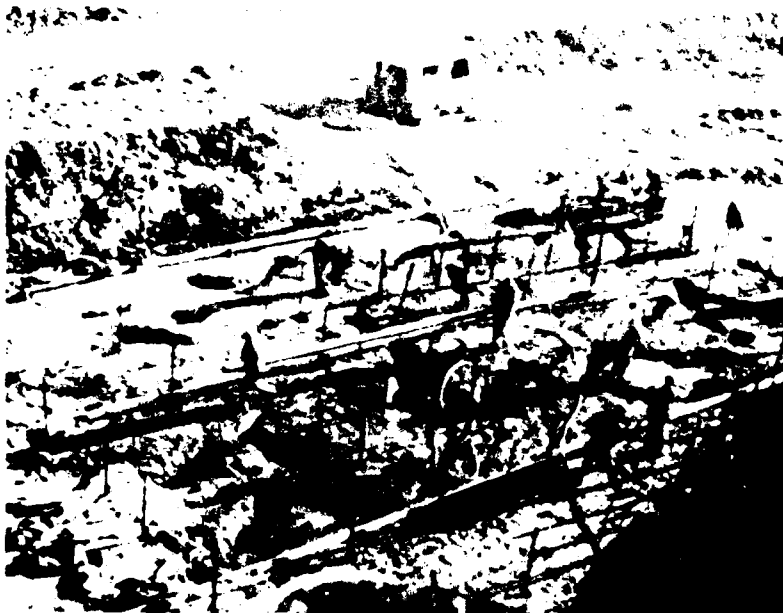
11. Milford Dam, November 1962, Neg. No. 294-P3-1.
Tower key vertical surface at station 3+76U.



12. Milford Dam, November 1962, Neg. No. 294-P1-10.
O.G. station foundation from station 4+50D to
station 4+75D, landward side, Wymore shale zone
"B".



13. Milford Dam, November 1962, Neg. No. 294-P1-11.
O.G. section foundation from station 4+50D to
station 4+75D, landward side, Wymore shale zone
"B".



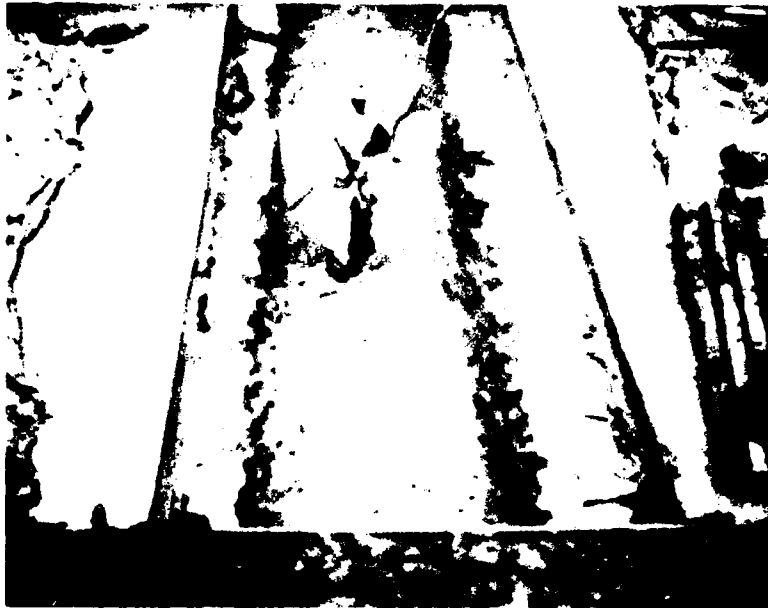
14. Milford Dam, November 1962, Neg. No. 294-P2-13.
Tower foundation station 3+14U to station 2+63U.



15. Milford Dam, November 1962, Neg. No. 294-P2-14.
Tower key foundation station 3+76U to station
3+46U Blue Springs shale zone "B".



16. Milford Dam, November 1962, Neg. No. 294-P2-16.
Typical conduit foundation in Blue Springs shale
zone "B".



17. Milford Dam, November 1962, Neg. No. 294-P2-15.
Conduit collar excavation in Blue Springs shale
zone "B".



18. Milford Dam,
November 1962,
Neg. No.
294-P3-3.
Typical cleavage
plane encountered
in the "B" zone
of the Blue
Springs shale.



19. Milford Dam,
November 1962,
Neg. No.
294-P2-2.
Foundation for
O.G. section in
Wymore shale
zone "A".



20. Milford Dam, November 1962, Neg. No. 294-P2-4.
End sill vertical surface at station 6+02D,
Schroyer limestone, upper section of surface is
protected with gunite (Wymore shale).



21. Milford Dam, November 1962, Neg. No. 294-P2-3.
Closeup of end sill vertical surface. Line drill
holes are 3 inch OD. White masses are gypsum.



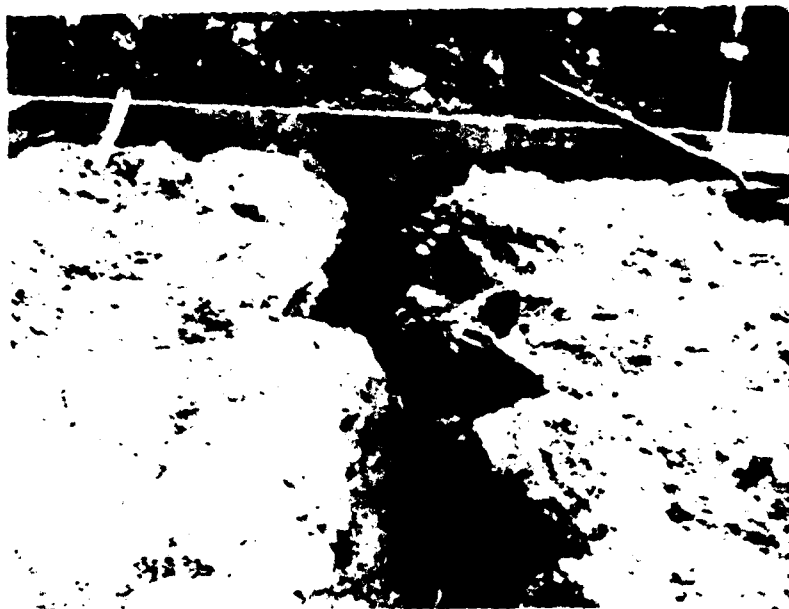
22. Milford Dam, November 1962, Neg. No. 294-P1-2.
Stilling basin foundation from station 4+73D to
station 4+93D, Schroyer limestone.



23. Milford Dam, November 1962, Neg. No. 294-P1-1.
Stilling basin foundation, station 5+52D to
station 5+77D, Schroyer limestone.



24. Milford Dam, November 1962, Neg. No. 294-P2-12.
Workman deroofing joint opening under approach
slab foundation.



25. Milford Dam, November 1962, Neg. No. 294-P2-11.
Joint in approach slab foundation after clean-up,
Blue Springs shale zone "A".



26. Milford Dam, March 1963, Neg. No. 294-P2-9.
Looking down on tower area from top of cut. The
dark depressions are joint openings after clean-up

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MULTIPLE-PURPOSE PROJECT KANSAS RIVER BASIN REPUBLICAN
RIVER KANSAS MILFO. (U) CORPS OF ENGINEERS KANSAS CITY
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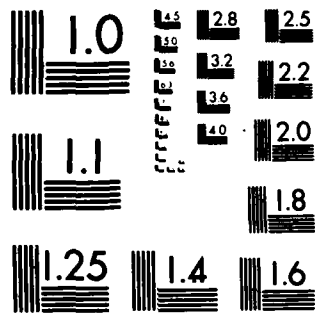
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



27. Milford Dam, March 1963, Neg. No. 294-P2-10.
Tower area showing joint depressions after
cleanup.



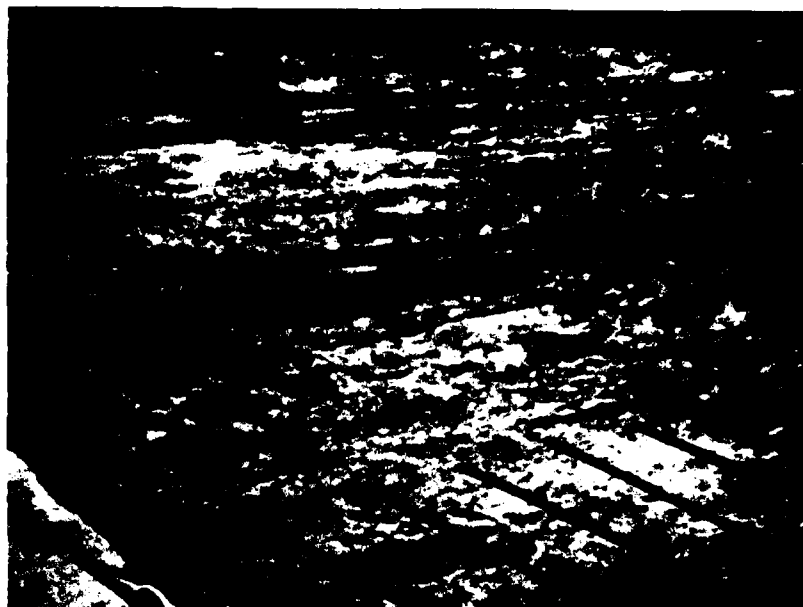
28. Milford Dam,
March 1963,
Neg. No.
294-P1-16.
Sill key
(upstream)
excavation.
Note wire mesh
on vertical walls
in foreground,
workman is
spraying gunite
in background.



29. Milford Dam, March 1963, Neg. No. 294-P2-1.
Typical foundation for crest slab in lower
Holmesville shale.



30. Milford Dam, April 1963, Neg. No. 294-P1-5.
Typical foundation for crest slab.



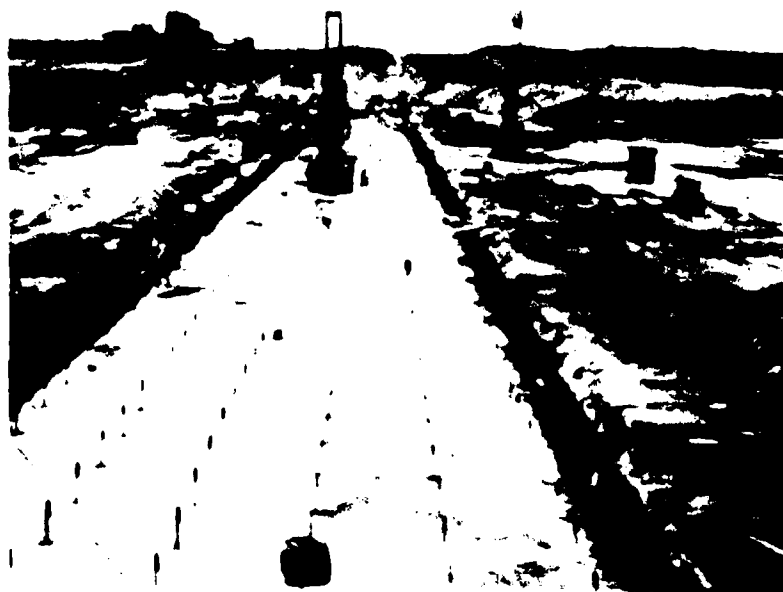
31. Milford Dam, April 1963, Neg. No. 294-P1-6.
Typical foundation for crest slab.



32. Milford Dam, April 1963, Neg. No. 294-P1-7.
Slope foundation for crest slab in Holmesville
shale.



33. Milford Dam, April 1963, Neg. No. 294-P2-5.
Slope foundation for crest slab in Towanda limestone. Note grouted anchors. Screeds are set for backfill concrete due to overexcavation.



34. Milford Dam, May 1963, Neg. No. 294-P2-6.
Work in progress in sill area. Grouted anchors are set through lean slab in foreground while rotary drills anchor holes in background.



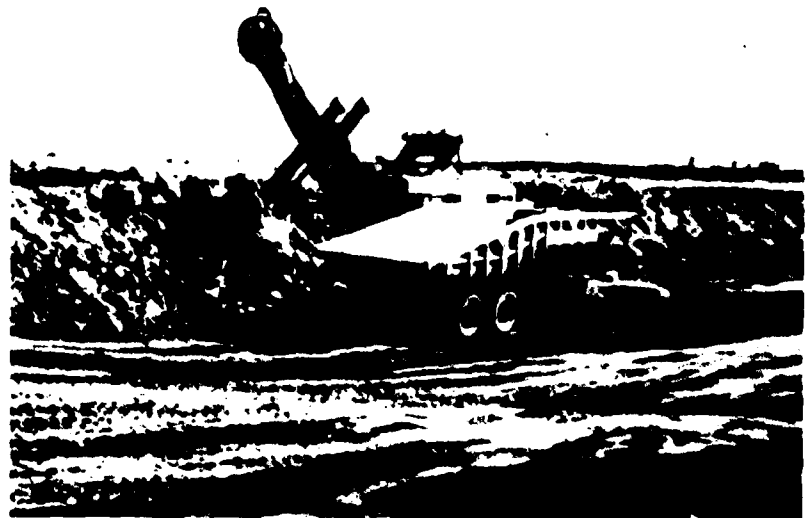
35. Milford Dam,
May 1963,
Neg. No.
294-P3-10.
Placing
grouted anchors
through lean
concrete pad
in crest slab
area.



36. Milford Dam,
May 1963,
Neg. No.
294-P3-9.
Air track
drills drilling
angle holes for
anchors in key
for shale pro-
tection slab.



37. Milford Dam, June 1963, Neg. No. 294-P1-12.
Shale protection slab key excavation with grouted
anchors in place.



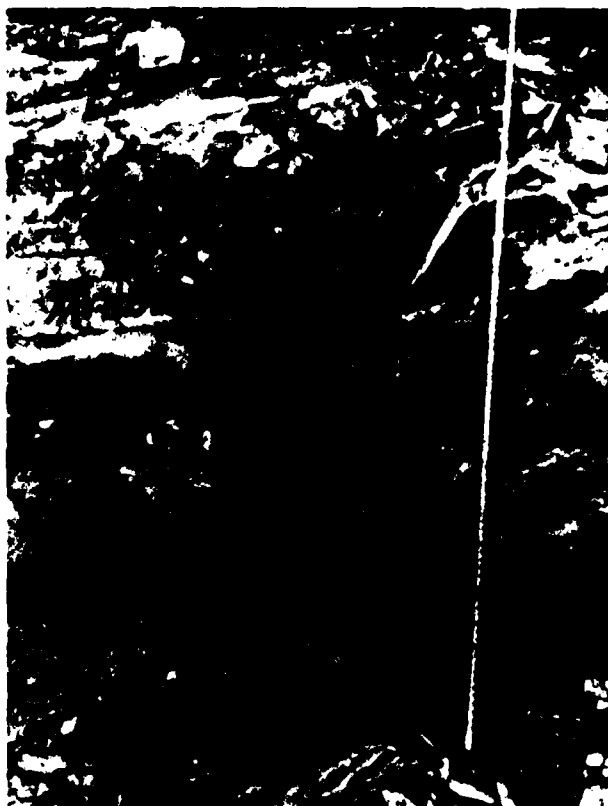
38. Milford Dam, June 1963, Neg. No. 294-P2-7.
Electric powered Marion shovel excavating spillway
rock in 80 cubic yard end dump truck.



39. Milford Dam, June 1963, Neg. No. 294-P2-8.
Hauling equipment used for rock excavation. The front truck was the type primarily used with a capacity of 30 cubic yards. The truck in the rear has a capacity of 80 cubic yards.



40. Milford Dam, July 1963, Neg. No. 294-P1-3.
The middle zone of the Towanda limestone which produced the better quality rock from the spillway excavation.



41. Milford Dam,
July 1963,
Neg. No.
294-P1-4.
The two lower
zones of the
Towanda lime-
stone. Note
the clay
filled solu-
tioned zone.



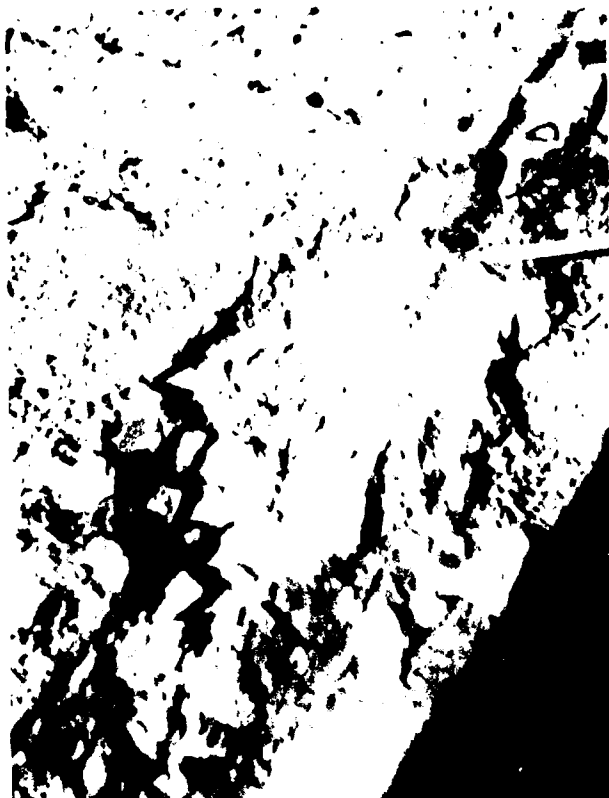
42. Milford Dam,
July 1963,
Neg. No.
294-P3-7.
Drilling
grout hole
with CP 65
drill.



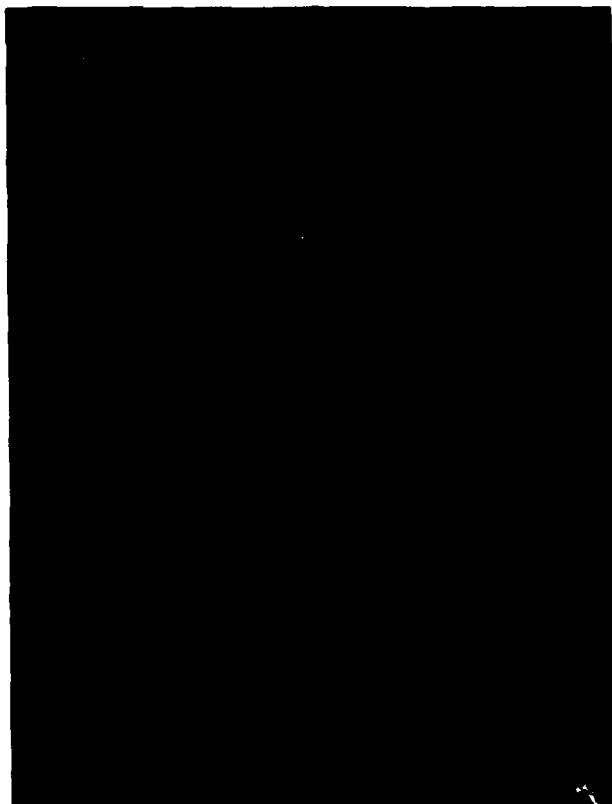
43. Milford Dam,
July 1963,
Neg. No.
294-P3-6.
Pressure hole.



44. Milford Dam,
July 1963,
Neg. No.
294-P3-8.
Washing grout
hole with
air-water.



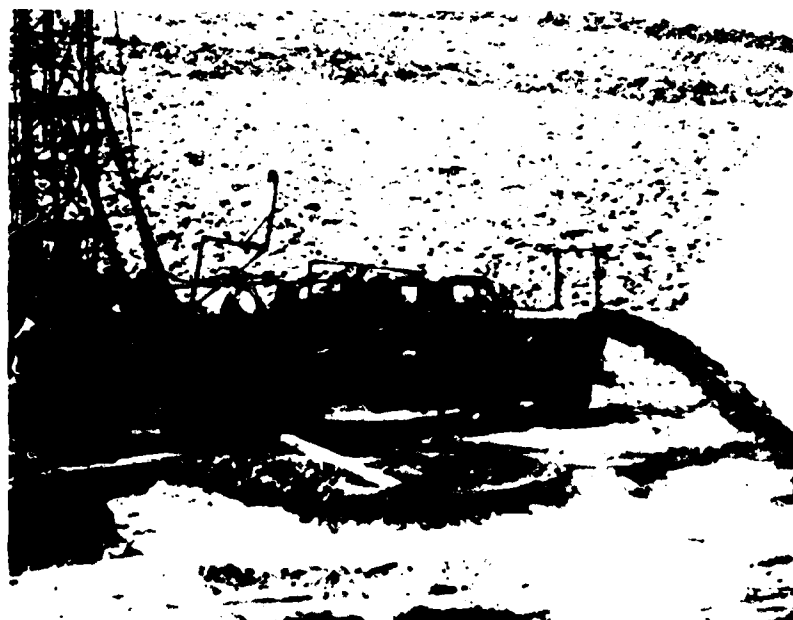
45. Milford Dam,
July 1963,
Neg. No.
294-P3-5.
Grout filled
joint at
station 0+46U
in conduit
foundation.



46. Milford Dam,
July 1963,
Neg. No.
294-P3-4.
Grout filled
joint at
station 0+46U
in conduit
foundation.



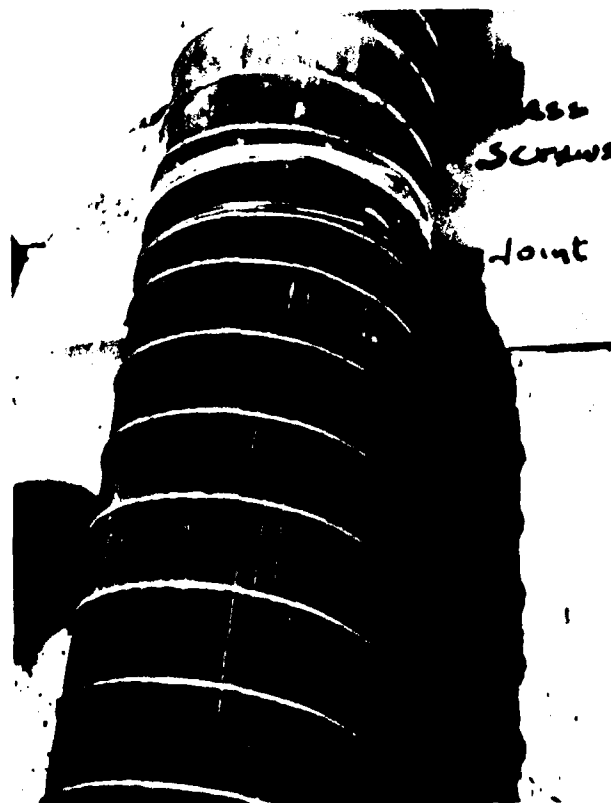
47. Milford Dam, July 1963, Neg. No. 294-P1-15
Grout plant used in grouting operations.



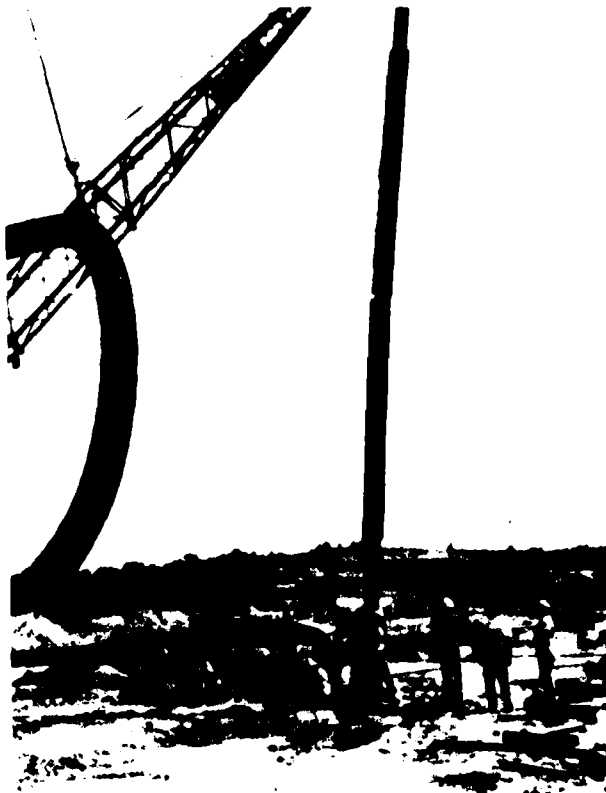
48. Milford Dam, July 1963, Neg. No. 294-P1-8.
Reverse rotary drill rig used to drill relief
wells.



49. Milford Dam, July 1963, Neg. No. 294-P1-9.
Drill bit (24" dia.) used during reverse rotary
drilling.



50. Milford Dam,
August 1963,
Neg. No.
294-P3-12.
Close-up of
screen and riser
joint in wood
section.



51. Milford Dam,
August 1963,
Neg. No.
294-P3-11.
Placement of
screen and
riser into
well by crane.



52. Milford Dam,
August 1963,
Neg. No.
294-P3-13.
Completed
makeup of wood
screen and
riser. Note
positions.



53. Milford Dam,
August 1963,
Neg. No.
294-P3-14.
Pump being
used to
develop
relief well
by over-
pumping.

SUPPLEMENT A

SUPPLEMENT A

SUPPLEMENT A

INSTALLATION OF ABUTMENT GROUT CURTAINS, MILFORD DAMSITE

A-01. General. In accordance with authorization from O.C.E., experimental drilling and grouting operations were initiated by hired labor crews 1 February 1962 on the right abutment of Milford damsite. The objectives were as follows: (1) To determine whether installation of a satisfactory grout curtain could be accomplished by means of vertical holes instead of angle holes. (2) To determine whether grout holes of NX size could be more economically drilled by use of air as the drilling fluid. (3) To determine which type of drill bit could perform the drilling with the greatest economy. All vertical holes were drilled and grouted in accordance with the "stop" method, in which each hole is drilled to full depth and then pressure tested and grouted by means of packer settings made at successively shallow depths in the hole until the highest zone encountered in the hole has been grouted. On completion of the grouting of any vertical hole in this manner, the hole was immediately backfilled with suitably heavy grout. No casing was used except in holes drilled thru the sand that overlies the landward 360 feet of the left abutment experimental grout curtain. All holes were of standard NX size. A total of 16 angle holes, all inclined at an angle of 20 degrees with the vertical, were drilled for the purpose of ascertaining the effectiveness of the vertical-hole type of grouting. Pressures used in the pressure testing and the grouting were generally (but not always) in the range of 1.5 and 2.0 pounds per foot of vertical depth. This includes so-called column pressure. Generally, the gate pressure at the grout header would register as many pounds as the distance in feet between the ground surface and the bottom of the inflated packer. When grout, "takes" were very rapid, there was no attempt made to maintain what would constitute a maximum allowable pressure. Higher pressures, up to 3.0 pounds per foot of vertical depth, were often applied when the grout injection rate appeared to be much lower than the grout injection rate that had been indicated as probable by the pressure testing. Final grouting pressures were generally in the high range unless a very large volume of grout had been injected, in which case the possibility of "jacking" the rock was taken into careful account, for the greater the volume of grout injected, the greater the danger of "jacking."

A-02. Spacing of Grout Holes Because the "stop" method of grouting was employed, hole-to-hole communication of water or grout was carefully avoided. Primary holes were drilled and grouted at 80-foot intervals, and then a second set of primary holes was drilled and grouted at intervals midway between the initial set of primary holes. Thus the primary holes, though actually drilled at 80-foot intervals, were finally spaced at 40-foot intervals along the two experimental grout curtains. The secondary holes were spaced in exactly the same manner as were the primary holes, except in cases involving the possibility of interference with contractors' operations in the immediate area. In such cases, the drilling and grouting sequence was altered to avoid interference.

Tertiary holes were also drilled and grouted at 80-foot intervals initially, and were not drilled at 40-foot intervals until the last "pass" of tertiary holes was being made after three grouted holes intervened between successive tertiary holes along the line.

A-03. Location. The left abutment grout curtain is located between Stations 143+00 and 151+00 on the dam axis. The right abutment grout curtain is located along a line that originates at a point on Station 82+20 of the dam axis and extends, in succession, to the following five points:

<u>Dam Axis</u> <u>Station</u>	<u>Range</u>
84+60	Centerline of dam
85+62.23	0+63.0' Upstream
87+02.04	0+62.85' Upstream
88+04.42	Centerline of dam
88+64.42	Centerline of dam

A-04. Bedrock stratigraphy. --Bedrock in both abutments consists of a sequence of limestone and shale beds, all of Permian age, and in descending order are as follows:

a. Towanda limestone member. --The Towanda is a hard, dense, thin-bedded limestone about 15 feet thick. Solutioning and softening due to weathering has opened the bedding planes and joints in the limestone and appreciably reduced the strength of several thin interbedded shale layers.

b. Holmesville shale member. --The Holmesville is 13 to 18 feet thick, soft, laminated, and interbedded with thin discontinuous limestones toward the base. A solution zone is generally present within five feet of the base.

c. Fort Riley limestone member. --The Fort Riley member is about 38 feet thick at the damsite and consists of thin-bedded to massive, argillaceous and shaly limestone. It has been subdivided on the basis of lithology into five zones in descending order as follows:

(1) Zone A. --Zone A, the upper zone, consists of approximately 13 feet, of thin-bedded, moderately hard, dense, argillaceous and shaly limestone.

(2) Zone B. --Zone B is medium-bedded, moderately hard, argillaceous, light gray limestone about 6 feet thick. It contains scattered vugs or solution pits.

(3) Zone C. --Zone C is limestone about 9 feet thick, thin-bedded, moderately hard, dense, argillaceous, and light to dark gray.

(4) Zone D. --Zone D is a hard, dense, massively bedded limestone. It is characteristically solution pitted. Zone D is approximately 8 feet thick and forms a conspicuous outcrop called the "rimrock" along the valley walls at the damsite.

(5) Zone E. --Zone E is the basal member of the Fort Riley and is a massive limestone ranging in thickness from less than a foot to 4 feet. It is hard, fine-grained and dark gray.

d. Oketo shale member. --The Oketo member is moderately hard, calcareous, massive, dark gray shale which ranges in thickness from 4.5 to 6.8 feet. It is the most competent shale at the damsite and shows unusually high resistance to weathering and slaking.

e. Florence limestone member. --The Florence member consists generally of about 36 feet of hard, cherty, thin to medium bedded limestone. It has been subdivided on the basis of lithology into four zones in descending order as follows:

(1) Zone A. --Zone A is a hard limestone, thin to medium bedded, dense, very cherty (nodular), gray and tan colored. It is about 15 feet thick.

(2) Zone B. --Zone B, about 5.5 feet thick, is a massive, hard, dense, tan limestone containing numerous small vugs or solution pits.

(3) Zone C. --Zone C is about 11 feet thick, is a thin-bedded, hard, dense, cherty limestone of tan and gray color.

(4) Zone D. --Zone D is about 4.5 feet thick. It is limestone, thin to medium bedded, dense and gray. It becomes very shaly at its base.

f. Blue Springs shale member. --The Blue Springs shale is about 33 feet thick and has been subdivided on the basis of lithology into two zones. The upper zone (A) is about 20 feet thick and consists of soft, calcareous, red and green shale. It contains a limestone bed about 1 foot thick near its base. The lower zone (B) is about 13 feet thick and consists of a fissile, moderately hard, calcareous, dark gray shale. Zone B contains an occasional nodule and a few thin seams of gypsum. The gypsum amounts are so minor that solutioning of them should not materially affect foundations.

A-05. Sequence of operations, right abutment. --Drilling and grouting began on 1 February 1963 and was completed on 3 July 1963 by means of a Failing 1500 "S" type rotary drill employing air as the drilling fluid. An NX hole was drilled to full depth by means of fishtail and rock bit. The hole was then grouted by the "stop" method of grouting, which consists in drilling a hole to full depth, then pressure testing and grouting the lowest zone present; then, with successively shallower settings of an inflatable packer, pressure testing and grouting each groutable horizon of the hole until the uppermost groutable horizon has been grouted. The grouted hole is then backfilled, this being done by means of a tremie pipe unless the grout present in the hole is at a level above the 20-foot depth, in which case the backfill grout is merely squirted into the top of the hole by means of the grout delivery line.

Four other holes, spaced at 40-foot intervals, were then successively drilled and grouted in the above-indicated manner, with each hole being completed (pressure-tested, grouted and backfilled) prior to the start of any nearby hole. The five completed holes were then tentatively designated as "primary," pending the performance of holes to be drilled midway between them.

A secondary hole and two tertiary holes adjacent to it were completed next, so as to provide as soon as possible a grouted section of line that could be tested for tightness by means of a test hole angled at 20 degrees. Accordingly, the section of line between Stations 83+80 and 84+20, having five vertical grout holes at 10-foot intervals, was ready for testing.

The five holes had taken a total of 418 sacks of cement (grout), but it was not known whether there existed sufficient communication between open horizontal bedding planes and vertical joints so as to allow free movement of grout to vertical joints not encountered by the drill.

An angle hole of NX size, inclined riverward at an angle of 20° with the vertical, was drilled to full depth (127.0 feet) with a Longyear Model 44 rotary drill. This hole, experimental hole 83+60, was then pressure tested and grouted by the "stop" method of grouting. In four successive settings of the packer, it was proved that the lower four of the then-supposed five groutable zones encountered in the hole were tight. The lower half of the Florence limestone, the upper half of the Florence limestone, and the "D" and "B" zones of the Fort Riley limestone proved to be tight. The "A" zone of the Fort Riley limestone could not be satisfactorily pressure tested. Since the base of the Towanda limestone is 10 feet above spillway crest elevation, grouting was not considered necessary. After testing the first 20-degree angle hole, it was decided to bring more of the grout line to a 10-foot-spacing as soon as possible, and, with additional 20-degree angle holes, verify what the first angle hole had indicated: that vertically drilled holes might prove to be a satisfactory means of delivering the grout to the vertical joints. Accordingly, nine more holes were drilled and grouted, as above, and generally in the order dictated by the necessity for avoiding conflict with the access road Contractor.

Thus the next nine holes to be completed were drilled and grouted in what appears to be aimless order: tertiary, primary, tertiary, primary, etc. At this point in the operation, with 18 vertical holes drilled and grouted, enough of the grout line had been completed with 10-foot-spaced holes so as to provide a grouted section for additional testing by means of a second 20-degree angle hole. However, Contractor's operations in the area prevented drilling of the planned angle hole. Accordingly, the second angle hole was drilled elsewhere (at Station 83+68). This hole (angle hole 83+65) was drilled to depth 50 feet with air as the drilling fluid. It could not be drilled deeper by such means, and water was then used as the drilling fluid in advancing the hole to full depth, through the Florence limestone and into the Blue Springs shale.

The second angle hole gave results similar to those of the first angle hole, proving tight in all horizons below the "A" zone of the Fort Riley limestone, with that zone taking 38 g.p.m. of water in the pressure test and 13 sacks of cement (grout).

NOTE: In the light of experience gained in testing and grouting of the Holmesville shale since that time, it is considered likely that the 13 sacks of cement (grout) entered the Holmesville shale instead of the "A" zone of the Fort Riley limestone. During subsequent operations, much grout was injected into a stained solution-opened horizontal bedding plane that persists in the lower part of the Holmesville shale. This bedding plane, undoubtedly encountered by the 20-degree angle hole, could easily have been opened wider during the pressure test. The water pressure (35 p.s.i. on gage, plus head pressure) totaled 49 p.s.i.: too much to apply to the bedding plane, which lies at a vertical depth of 36-37 feet at this location on the grout line.

A third test hole 83+00), angled at 20-degrees, was then drilled to full depth at a location approximately 60 feet southward of the first two angle holes. It proved tight in all zones below the "A" zone of the Fort Riley limestone, which horizon took 4 sacks of cement (grout). At this point in the experimental grouting operation, it became reasonably certain that the right abutment grout curtain could be satisfactorily installed by means of vertical holes spaced at 10-foot intervals and grouted by the "stop" method. Two additional angle holes were drilled and tested.

Angle hole 83+05, drilled with air as the drilling fluid and tested progressively (by stage method) as the hole was advanced, took 24 g.p.m. of water and 14 sacks of cement (grout) in the Florence limestone. But this, the first angle-hole "take" in the Florence limestone, was attributed to the fact that this section of Florence had not been grouted on 10-foot centers, but on 20-foot centers. (Tertiary hole 83+50, which later halved the 20-foot space, had not yet been drilled.) Again, in this angle hole, there was a very considerable "take" (59 sacks cement) when the packer was set in the Holmesville shale. This "take," then supposed to have occurred in the "A" zone of the Fort Riley limestone, is now believed to have occurred in the solution-opened horizontal bedding plane that is present in the lower part of the Holmesville shale. A fifth angle hole (83+70), drilled with water as the drilling fluid, proved tight in all zones except the "D" zone of the Fort Riley limestone, where four sacks of cement (grout) were injected.

At this point in the operation, a review of the drilling and grouting data indicated that 10-foot spacing of grout holes would generally suffice to achieve installation of the grout curtain, and that vertical holes could be employed. All drilling and grouting operations that followed were performed in a more orderly manner. Primary holes, initially spaced at 80-foot intervals and finally at 40-foot intervals, were drilled to full depth and then grouted by the "stop" method. The interval between open ungrouted primary holes was always kept at 80 feet, which was adequate to prevent hole-to-hole communication of grout. When the drilling and grouting of the primary holes were completed, work was begun on the remaining secondary holes. Again, hole-to-hole communication of grout was carefully avoided by maintaining an 80-foot interval between successive open (ungrouted) secondary holes. Upon completion of the secondary holes, the tertiary holes were drilled and grouted in similar manner, with the 80-foot interval between open tertiary holes usually maintained.

Completion of the 34 tertiary holes resulted in a completed grout hole at each 10-foot interval along the entire length (680') of the line. With the line thus brought to 10-foot spacing, it was thought proper to test the tightness of the grout curtain by means of angle holes drilled into various parts of the curtain that were suspected of being open. In general, those parts of the curtain that had taken little or no grout were suspected, since it was assumed that failure of a zone to accept grout had been caused by failure of the vertical grout holes to communicate with vertical joints.

Accordingly, six additional 20° angle holes were drilled to full depth at Stations 87+82, 87+34, 86+51, 85+50, 84+54 and 82+65.

Combined grout "takes" of the final six 20-degree angle holes was as follows:

<u>Zone</u>	<u>Sacks Cement (Grout)</u> <u>(Total for six holes)</u>
Towanda limestone	88
Holmesville shale	35
A Zone (Ft. Riley)	27
B Zone (Ft. Riley)	4
D Zone (Ft. Riley)	0
Florence limestone	0

As a final precautionary effort, eight more vertical quaternary holes, spaced at 10-foot intervals, were added in the most landward 75-foot section of the grout line, (Station 88+25 to Station 89+00). Only 16 of a possible total of 68 quaternary holes were drilled. Thus the right abutment grout curtain is grouted with vertical 5-foot-spaced holes along 160 feet (24%) of its 680-foot length. The remaining 520 feet of the grout curtain is grouted with vertical holes spaced at 10-foot intervals. Only four of the 16 quaternary holes penetrated the Florence limestone. Thus only 40 feet (6%) of the lateral extent of the Florence limestone is grouted with vertical holes spaced at five-foot intervals, while 640 feet of it (94%) is grouted with vertical holes spaced at 10-foot intervals.

A-06. Sequence of operations, left abutment. --Drilling and grouting on the left abutment began on 5 July 1962 and was completed 15 November 1962. Towanda limestone in the immediate area was overlain by a blanket of sand approximately 13 feet thick and casing was required in drilling some of the grout holes. The first phase of the work consisted in drilling and grouting eleven primary holes spaced at 80-foot intervals along the entire 800-foot length of the grout line (Station 151+00 to Station 143+00 on the dam axis). The second phase of the work consisted in drilling and grouting 10 more primary holes, spaced at 80-foot intervals, with each successive hole being located midway between successive pairs of the initial eleven primary holes. Of the 21 primary holes drilled, complete loss of drilling fluid (water)

occurred in fifteen. With the 21 primary holes completed at 40-foot intervals along the entire length of the grout line, a comparison of the cement (grout) consumption that had occurred in the two groups of primary holes was made. The first group (eleven holes) took a total of 1,931 sacks of cement (grout), for an average of 176 sacks per hole. Florence limestone took an average of 70.4 sacks per hole. The second group (ten primary holes), which were regarded as "secondary" primary holes, took a total of 1,915 sacks of cement (grout), for an average of 192 sacks per hole, and the Florence limestone took an average of 55 sacks per hole. The conclusions arrived at were as follows:

- a. Grout injected into the first group of primary holes had not traveled a distance of 80 feet horizontally in any of the grouted zones above the Florence limestone.
- b. Grout injected into the Florence limestone could possibly have traveled more than 80 feet horizontally.
- c. The secondary, tertiary, and other grout holes yet to be drilled could safely be left open without the risk of their being accidentally undergrouted by premature introduction of grout originating from grout-pumping operations conducted on holes 80 feet away. As the Florence limestone had taken thick grout rather well, it was believed that the grout already placed in that member would prevent hole-to-hole travel of grout in secondary holes.

Drilling and grouting of the secondary holes with the 80-foot interval between, was maintained as successive "passes" of the drill and grout machine were made along the grout line. However, the drilling and grouting sequence was interrupted after only 13 of the 20 secondary holes had been completed, when the Contractor expressed a desire to begin cut-off-trench blasting operations along the riverward 100 feet of the grout line. It then became necessary to complete the landward 100 feet of grout line early by drilling and grouting the following six tertiary holes ahead of schedule: Stations 143+50, 143+10, 143+90, 143+70 and 143+30.

After the landward 100 feet of grout line was completed on 10-foot centers, the remaining seven secondary holes were drilled and grouted, which made a grouted hole at each 20-foot interval. A complete loss of drill water occurred during drilling of two of the secondary holes. Tertiary drilling began with 40-foot spacing in order to shorten "moves" of the drill and grouting machine but after five holes were complete inter-hole communication occurred. Wash water from tertiary hole 150+90 traveled through the sand overlying the Towanda limestone, or possibly through the Towanda joints, and entered cased tertiary hole 150+50. The 80-foot spacing was resumed.

During the last (third) tertiary-hole "pass" along the grout line; with three completely grouted and backfilled holes between the successive pairs of remaining tertiary holes, the 80-foot interval was discontinued in favor of the 40-foot interval. On completion of all (40) tertiary holes, the grout line included a completed (grouted) hole at each 10-foot interval along the full length of the line.

A stage-drilled angle test hole, (hole 149+68), was then drilled in order to test "tightness" of the grout curtain. This hole was inclined riverward twenty degrees. It took 9 sacks of cement (grout) in the "A" zone and 5-3/4 sacks in the "D" zone of the Fort Riley limestone, with all other groutable zones proving tight. As the injected grout was of high water-cement ratio (3:1, 2:1 and 1.5:1) and as the time required for injection of the grout was in both cases rather prolonged, (9-sack injection requiring 68 minutes, 5-3/4-sack injection requiring 60 minutes), it was concluded that the two "takes" of grout were not great enough to warrant the drilling quaternary holes in that area of the grout curtain. The 10-foot spacing of holes appeared to be sufficient.

The overburden overlying the top of bedrock was troublesome in that it very often was not firm enough to provide sufficient purchase for the setting of grouting packers. As a result, in many parts of the grout curtain, the uppermost groutable horizon had been undertreated. A series of shallow quaternary holes was drilled, along with additional 20-degrees-angle test holes. The results of pressure-testing and grouting of the five 20-degree-angle test holes are as follows:

<u>Zone</u>	<u>Sacks Cement (Grout)</u> <u>(Total for Five Holes)</u>
Towanda limestone	2
Holmesville shale	0
"A" Zone (Fort Riley)	27-1/2
"B" Zone (Fort Riley)	0
"D" Zone (Fort Riley)	18-1/4
Florence limestone	0

After completion of 34 quaternary holes, two shallow-depth quaternary holes (145+42.5; 145+62.5) were drilled in two areas of the grout curtain suspected of being open. The two holes took a total of four sacks of cement (grout). Only 34 of a possible 80 quaternary holes were drilled. Thus the left abutment grout curtain is grouted with vertical 5-foot spaced holes along only 340 feet (43%) of its 800-foot length. The remaining 460 feet of the grout curtain is grouted with holes spaced at 10-foot intervals. Only 14 of the 34 quaternary holes penetrated the "D" zone of the Fort Riley limestone, and only four of them penetrated the Florence limestone. Thus only 130 feet (16%) of the lateral extent of the "D" zone of the Fort Riley limestone was grouted with vertical holes spaced at 5-foot intervals, and only a 5% of the Florence limestone was grouted on such close spacing of holes.

A-07. Results and Conclusions. Results of the experimental drilling and grouting program are summarized in tables 1 thru 18, Pages IV-A-17 thru IV-A-33. The following conclusions were made:

(1) Inclined (angle) drill holes are not necessary for installation of a grout curtain but because they offer a better chance for inception of vertical joints, angle holes are superior to vertical holes as a means of grouting a formation containing vertical joints.

(2) The use of air as a drilling fluid proved workable but was less effective than the use of water. Air-drilling was given a trial and then abandoned in favor of the water drilling. As employed in drilling 14 of the 96 NX-size holes of the right abutment grout curtain, the air-drilling rate averaged only half as fast as water-drilling. Water-drilling proved superior in several instances when drill rods and drill bit suddenly became tightly wedged in the hole. Just as a drill that employs water as the drilling fluid can lose the water in an open joint, so a drill that employs air as the drilling fluid can lose air to such extent that very little air (far too little to remove cuttings from the hole) returns to the ground surface. When such action occurs in an air-drilled hole, not all the cuttings can escape into the open joint that is accepting the air, especially if the drill, as it descends, next enters a soft or a fairly moist shale. As moist or wet shale does not readily reduce to a manageably buoyant powder or to small non-adhering particles of rock, the result is often an accumulation of moist shale particles (probably at a level slightly above the indicated open joint). As drilling is continued, the particles rapidly collect into an adhering mass that prevents upward travel of the air and soon causes the drill rods to become tightly bound. Injections of water or detergent-treated water through the air line prevented the above described action to some extent but not to a sufficient extent.

(3) The bit found to be most effective for drilling of the very cherty Florence limestone proved to be the K-2 type of roller rock bit. The next best bit used was the K-1 type of roller rock bit. Both types are manufactured by Oil Tool Manufacturing Co., Inc., of Tonkawa, Oklahoma, and the writer recommends the K-2 type for NX boring of hard material. Rebuilt bits of either type (K-1 or K-2) proved generally unsatisfactory in that their bearings often failed to survive one drilling of the Florence limestone. Although several attempts were made to drill two full-depth holes with the same K-2 type of bit, only one of the attempts was successful, and this proved to be too time-consuming. It was far more economical to use a new roller rock bit in each hole to be drilled through the Florence limestone, and this was the procedure that became standard. Thus the number of roller rock bits consumed in the drilling is approximately equal to the number of holes drilled through the Florence limestone. Material other than the Florence limestone was readily and rapidly drilled with even fishtail bits and presented no problem.

TABLES

TABLES

Table 1.-- Footage Figures (Right Abutment)

<u>Type of Hole</u>	<u>Holes Drilled</u>	<u>Feet Drilled</u>
Primary	18	2,180
Secondary	17	2,051
Tertiary	34	4,094
Quaternary	16	1,374
Quinary	--	--
Angle	<u>11</u>	<u>1,369</u>
Totals	96	11,068*

*Includes overburden

Table 2.-- Summary of Drilling Footage (Right Abutment)

<u>Feet Drilled</u>	<u>Type of Material Drilled</u>
676	Overburden
7,876	Six horizons grouted (bedrock)
<u>2,516</u>	Four horizons not grouted (bedrock)
11,068	Total of all drilling

Table 3.-- Formation Footage (Right Abutment)

<u>Formation</u>	<u>Feet Drilled</u>
Overburden	676
Towanda limestone	1,140
Holmesville shale	1,453
Zone "A" (Fort Riley)	1,119
Zone "B" (Fort Riley)	485
Zone "D" (Fort Riley)	954
Florence limestone	<u>2,725</u>
Total	8,552*

*Excludes horizons not grouted: "C" Zone and "E" Zone of Fort Riley limestone, the Oketo shale and the Blue Springs shale. These horizons required 2,516 feet of drilling.

Table 4.-- Drilling and Grouting of Towanda Limestone.
Right Abutment

Type	Formation	Holes		Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement		Sacks Cement Per Lineal Foot (All Holes)
		Holes Drilled Through	Holes Pressure Tested			Per Hole (In Holes Successfully Tested		
Primary	18	0	0	211	--	--		--*
Secondary	17	0	0	200	--	--		--*
Tertiary	34	12	12	398	244	20.3		0.61
Quaternary	16	10	8	203	74	9.3		0.36
Quinary	--	--	--	--	--	--		--
Angle	11	6	6	128	107	17.8*		0.84*

*No attempt was made to test or grout the Towanda limestone until work had progressed into the tertiary hole phase. By that time, however, all primary and secondary holes, and approximately half the 34 tertiary holes of the grout curtain had been completed. Thus the Towanda limestone of the right abutment remains ungrouted along nearly the full extent of the grout line, except between grout line Stations 88+20 and 89+00.

Table 5.-- Drilling and Grouting of Holmesville Shale.
Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes		Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement		Sacks Cement Per Lineal Foot (All Holes)
			Successfully Pressure Tested	Tested			Per Hole (In Holes Successfully Tested	Per Hole	
Primary	18	17	17*	17*	271	327	19.2		1.20
Secondary	17	17	15*		259	140	9.3		0.54
Tertiary	34	34	31*		516	289	9.3		0.56
Quaternary	16	16	14*		221	38	2.7		0.17
Quinary	--	--	--	--	--	--	--	--	--
Angle	11	11	10*		186	90	9.0		0.47*

*It was often impossible, when testing the "A" zone of the Fort Riley Limestone, to obtain a tight packer setting at the base of the Holmesville shale, because the shale there is generally too soft and too yielding to allow the setting of a packer. Packers set at the base of the Holmesville shale usually "blew out," and so the place was avoided. Thus the packer was ordinarily set at a higher level, with the result that two groutable zones -- the horizontal bedding plane of the Holmesville shale and the "A" zone of the Fort Riley limestone.

Table 6.-- Drilling and Grouting of "A" Zone (Fort Riley Ls.)
Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	18	18*	209	313	17.4	1.50
Secondary	17	16	16*	195	183	11.4	0.94
Tertiary	34	32	32*	391	264	8.2	0.68
Quaternary	16	16	16*	188	91	5.7	0.48
Quinary	--	--	--	--	--	--	--
Angle	11	11	10*	136	69	6.9	0.51*

*See note table 5

Table 7.-- Drilling and Grouting of "B" Zone (Fort Riley I.s).
Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement	
						Per Hole (In Holes Successfully Tested	Per Lineal Foot (All Holes)
Primary	18	18	17	90	428	25.2	4.76
Secondary	17	17	17	85	80	4.7	0.94
Tertiary	34	34	32	170	153	4.8	0.90
Quaternary	16	16	14	80	4	0.29	0.05
Quinary	--	--	--	--	--	--	--
Angle	11	11	11	60	5	0.45	0.08

Table 8.-- Drilling and Grouting of "D" Zone (Fort Riley Ls.)
Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	18	18*	180	1,419	78.8	7.9
Secondary	17	17	17	170	225	13.2	1.3
Tertiary	34	34	34	340	25	0.74	0.07
Quaternary	15	15	14	150	6	0.43	0.04
Quinary	--	--	--	--	--	--	--
Angle	11	11	11	114	5.5	0.50	0.05

*Only 17 were successfully pressure tested. The 18th holes is presumed to have taken 32 sacks of cement.

Table 9.-- Drilling and Grouting of Florence Limestone.
Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	18	18	580	1,338	74.3	2.3
Secondary	17	16*	16	546	331	20.7	0.6
Tertiary	34	33*	33	1,094	407	12.3	0.37
Quaternary	4	4	4	126	18	4.5	0.14
Quinary	--	--	--	--	--	--	--
Angle	11	11	11	379	14	1.3**	0.04

*Holes caved. Could not be tested.

**Ten of the eleven holes were tight. The eleventh (angle hole 83+05) took the 14 sacks of cement (grout), but the area was devoid of any tertiary hole. The prevailing interval between grouted holes was 20 feet at the time.

Table 10
FOOTAGE FIGURES
(Left Abutment)

Type of Hole	Holes Drilled	Feet Drilled
Primary	21	2,255
Secondary	20	2,160
Tertiary	40	4,278
Quaternary	34	1,366
Quinary	2	47
Angle	<u>5</u>	<u>602</u>
Total	122	10,708*

*Includes Overburden.

Table 11

SUMMARY OF DRILLING FOOTAGE
(Left Abutment)

Feet <u>Drilled</u>	Type of Material <u>Drilled</u>
874	Overburden
6,942	Six Horizons Grouted
<u>2,892</u>	Four Horizons Not Grouted*
10,708	Total of all drilling.
*These horizons did not accept grout:	
"C" Zone (Ft. Riley)	
"E" Zone (Ft. Riley)	
Oketo shale	
Blue Springs shale	

Table 12

FORMATION FOOTAGE
(Left Abutment)

<u>Formation</u>	<u>Feet Drilled</u>
Overburden	874
Towanda Limestone	287
Holmesville Shale	1,042
Zone "A" (Ft. Riley)	1,120
Zone "B" (Ft. Riley)	545
Zone "D" (Ft. Riley)	954
Florence Limestone	<u>2,994</u>
	7,816*

*Excludes horizons not grouted: "C" Zone and "E" Zone of Ft. Riley limestone, the Oketo shale and the Blue Springs shale. These horizons required 2,892 feet of drilling.

Table 13

DRILLING AND GROUTING OF TOWANDA LIMESTONE, LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes		Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement		Sacks Cement Per Lineal Foot (All Holes)
		Holes Pressure Tested	Successfully Pressure Tested			Per Hole (In Holes Successfully Tested	Per Lineal Foot (All Holes)	
Primary	10	9	9	60	489	54.3		8.2
Secondary	10	9	9	60	160	17.8		2.7
Tertiary	20	18	13	113	138	10.6		1.2
Quaternary	6	5	5	34	13	2.6		0.4
Quinary	-	-	-	-	-	-		-
Angle	3	3	3	20	2	0.7		0.1
Total --					802			

Table 14

DRILLING AND GROUTING OF HOLMESVILLE SHALE, LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	14	13	13	207	291	22.4	1.4
Secondary	14	14	14	195	50	3.7	0.25
Tertiary	28	26	23	395	85	3.7	0.22
Quaternary	17	16	16	173	28	1.7	0.16
Quinary	2	2	2	5	0	0.0	0.0
Angle	4	4	4	67	0	0.0	0.0
Total --					454		

Table 15

DRILLING AND GROUTING OF "A" ZONE (FT. RILEY L.S.), LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes		Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement		Sacks Cement Per Lineal Foot (All Holes)
		Holes Pressure Tested	Successfully Pressure Tested			Per Hole (In Holes Successfully Tested		
Primary	19	19	18	196	979	54.4		5.0
Secondary	19	18	17	183	797	46.9		4.3
Tertiary	38	34	34	384	256	7.5		0.67
Quaternary	34	31	31	279	102	3.3		0.36
Quinary	2	2	2	26	4	2.0		0.15
Angle	5	5	4	52	<u>27-1/2</u>	6.9		0.53
Total --					2,165			

Table 16

DRILLING AND GROUTING OF "B" ZONE (FT. RILEY I.S.), LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes		Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement		Sacks Cement Per Lineal Foot (All Holes)
			Successfully Pressure Tested	Successfully Pressure Tested			Per Hole (In Holes Successfully Tested	Per Hole (In Holes Successfully Tested	
Primary	20	20	18	18	101	215	12.0	12.0	2.13
Secondary	20	19	19	19	98	76	4.0	4.0	0.77
Tertiary	40	38	37	37	196	214	5.7*	5.7*	1.09*
Quaternary	24	24	24	24	118	41	1.7	1.7	0.35
Quinary	1	1	1	1	5	0	0.0	0.0	0.0
Angle	5	5	5	5	27	0	0.0	0.0	0.0
Total --						546			

*Note: The high figure is ascribable to "jacking" believed to have occurred during grouting of holes 143+70 (94 sacks) and 143+90 (90 sacks).

Table 17

DRILLING AND GROUTING OF "D" ZONE (FT. RILEY L.S.). LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes		Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement		Sacks Cement Per Lineal Foot (All Holes)
		Holes Pressure Tested	Successfully Pressure Tested			Per Hole (In Holes Successfully Tested		
Primary	21	21	21	198	543	25.9		2.23
Secondary	20	20	20	188	341	17.0		1.81
Tertiary	40	40	40	379	237	5.9		0.62
Quaternary	14	14	14	139	0	0.0		0.0
Quinary	-	-	-	-	-	-		-
Angle	5	5	5	50	<u>18-1/4</u>	3.6		0.36
Total --					1,139			

Table 18

DRILLING AND GROUTING OF FLORENCE LIMESTONE. LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement	
						Per Hole (In Holes Successfully Tested	Per Lineal Foot (All Holes)
Primary	21	21	21	698	1,329	63.3	1.90*
Secondary	20	20	20	663	400	20.0	0.60
Tertiary	40	40	40	1,319	54	1.4	0.04
Quaternary	4	4	4	137	0	0.0	0.0
Quinary	-	-	-	-	-	-	-
Angle	5	5	5	177	0	0.0	0.0
Total --					1,783		

*"Per lineal foot" has little application here. It is practically certain that all grout delivered to the Florence Limestone entered the solution channel located at the "B" Zone - "C" Zone contact.