Kajaki Dam Spillways
Foundation Exploration Basis of Design
CENWP-EC-DC, J. Britton
22 March 2012

Background

USACE plans to gather geotechnical information to support future design and plans and specs for construction of the emergency spillway at Kajaki Dam. The original emergency spillway design included an earthen fuse plug. For the current foundation exploration, it is assumed that the emergency spillway will be designed using gates. The original design included a grout curtain. A grout curtain is assumed for future construction. The intention of the foundation exploration is to obtain subsurface information for design of a grout curtain, design of foundations for the gates, and design of erosion protection downstream of the gates.

The foundation rock is limestone. Drawings from the 1977 plans and specs are included below. Sheet C 12 shows the locations 8 borings: 7 around the service spillway and 1 between the embankment dam and the emergency spillway. Sheet C 12 also shows a couple faults in the service spillway footprint. Sheet C 13 shows the borehole logs. Note the faults with fault gouge. Sheets C 22-1 and 22-2 (partial) show the service spillway grout curtain and fault zone treatment. The 2005 photos next to partial Sheet C 22-2 below show that the fault zone treatment is not complete.

Borehole log RA-1 (between the embankment dam and the emergency spillway) shows: "LIMESTONE: Predominantly fine grained, little fractured to massive near the bottom, microcrystalline. Stylolites ranging from 1 in. to 1 foot apart, clay partings, pods and fracture fillings fairly common. With increasing depth core becomes darker and cherty." The log indicates "Water Loss" at one elevation and "Permeable opening" at another.

Basis of Design for Foundation Exploration

The primary goals in the emergency spillway foundation exploration are to 1) identify potential faults or voids in the limestone foundation rock, 2) obtain information needed to design a grout curtain, 3) obtain information needed to design the foundations for the gates, and 4) obtain information needed to evaluate erosion potential of rock downstream of the spillway gates.

The exploration program will consist of a geophysical survey (electrical resistivity) followed by 6 new drill holes. The electrical resistivity survey will probe the limestone for faults or voids. The foundation exploration contract will require the survey to gather information to a bottom elevation of 1018 m, which is 3 m below the bottom elevation of the 1977 grout curtain design. Sheet C 43 shows the minimum required electrical resistivity survey lines (ER-1 through 6).

Preliminary locations for the 6 drill holes are shown below on Sheet C 43 (DH-111 through 116). The locations may be moved based on the findings of the electrical resistivity survey. The

bottom elevation for all 6 drill holes will be 1018 m. Two recent photos of the emergency spillway, partially excavated, are shown below. It appears there will be little to no overburden to drill; the drilling will be rock core drilling.

The following data will be required from the core drilling:

- Color photographic record of core samples
- Borehole TV camera imagery
- Pressure (packer) tests on minimum 3 m spacing, with permeability expressed in terms of Lugeon Value
- Groundwater elevation
- Rock description per Section 5-10, Core Logging, in EM 1110-1-1804, with any gouge material classified per ASTM D2487
- Core recovery (%)
- Rock Quality Designation, RQD (%)
- Point Load Testing on minimum 3 m spacing, per ASTM D5731

A professional geologist will be required to log the holes and direct the drilling operations.

The rock core samples will be required to be saved at the project.

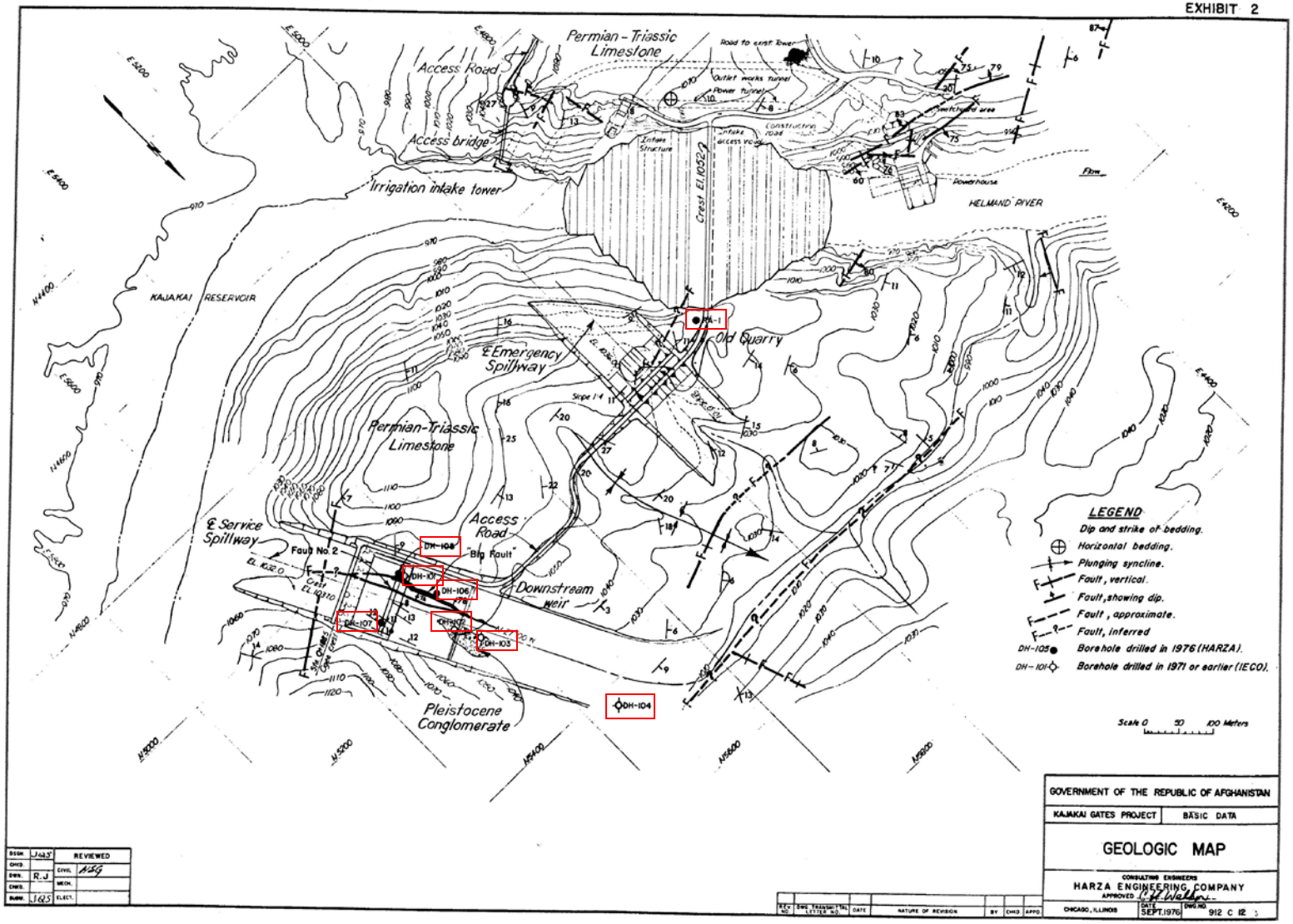
References

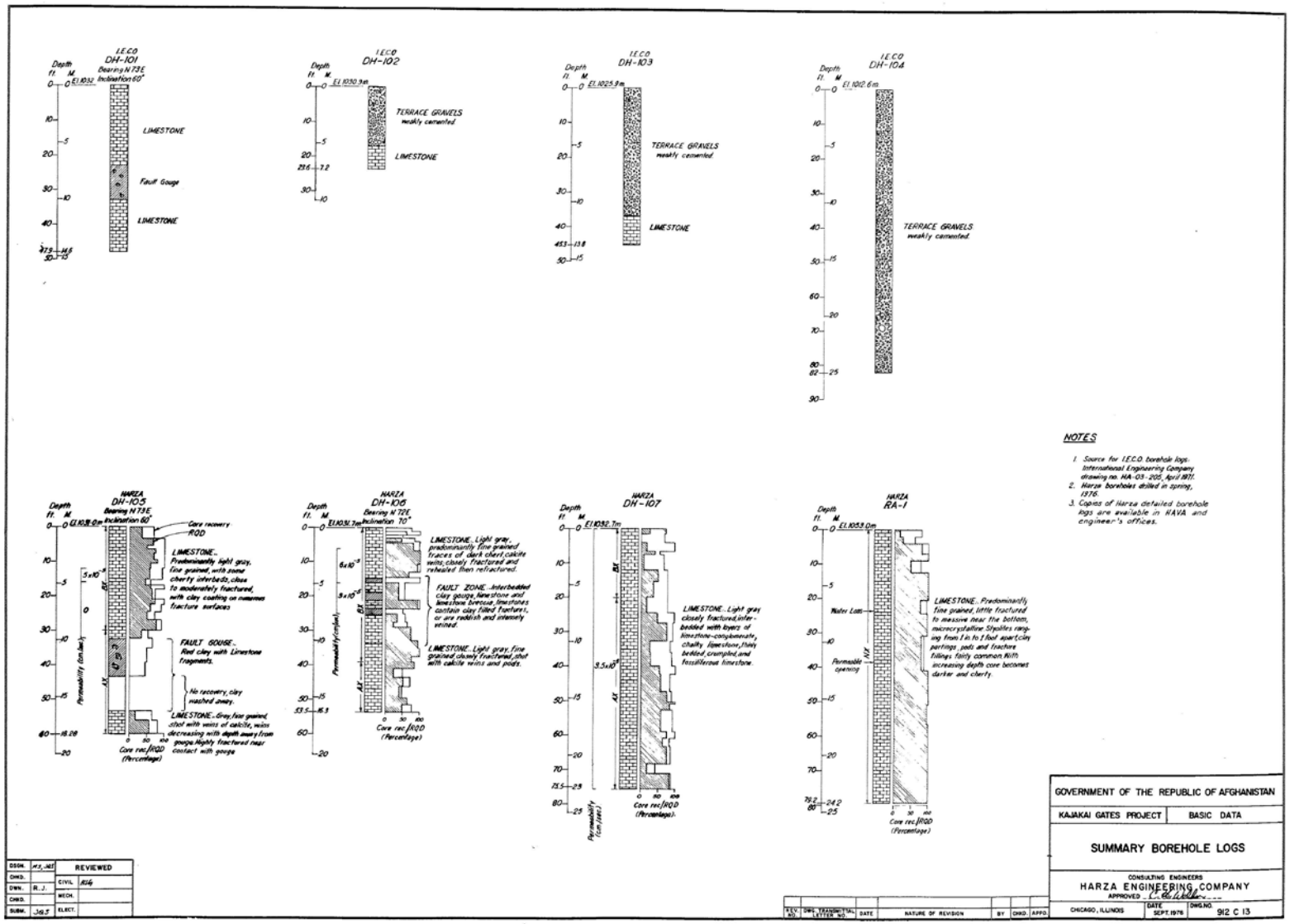
EM 1110-2-3506, Grouting Technology

EM 1110-1-1802, Geophysical Exploration for Engineering and Environmental Investigations

EM 1110-1-1804, Geotechnical Investigations

EXHIBIT 2


Permian-Triassic Limestone
Access Road
Access bridge
Irrigation intake tower
Outlet works tunnel
Power tunnel
Intake Structure
Intake access road
Construction road
Switchyard area
Powerhouse
Crest EL 1052
HELMAND RIVER
KAJAKAI RESERVOIR
Old Quarry
℄ Emergency Spillway
Slope 1:4
Permian-Triassic Limestone
℄ Service Spillway
Fault No. 2
"Big Fault"
Access Road
Downstream weir
Pleistocene Conglomerate
DH-101
DH-102
DH-103
DH-104
DH-105
DH-106
DH-107
DH-108
LEGEND
Dip and strike of bedding.
Horizontal bedding.
Plunging syncline.
Fault, vertical.
Fault, showing dip.
Fault, approximate.
Fault, inferred
DH-105 Borehole drilled in 1976 (HARZA).
DH-101 Borehole drilled in 1971 or earlier (IECO).
Scale 0 50 100 Meters
GOVERNMENT OF THE REPUBLIC OF AFGHANISTAN
KAJAKAI GATES PROJECT
BASIC DATA
GEOLOGIC MAP
CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS
DATE SEPT. 1976
DWG. NO. 912 C 12
REVIEWED
CIVIL
MECH.
ELECT.



NOTES

1. Source for I.E.C.O. borehole logs. International Engineering Company drawing no. HA-03-205, April 1971.
2. Harza boreholes drilled in spring, 1976.
3. Copies of Harza detailed borehole logs are available in HAVA and engineer's offices.

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DWN.	R.J.	CIVIL	R.J.G.
CHKD.		MECH.	
SUBM.	J.G.T.	ELECT.	

REV. NO.	DWG. TRANSMITTAL LETTER NO.	DATE	NATURE OF REVISION	BY	CHKD.	APPD.

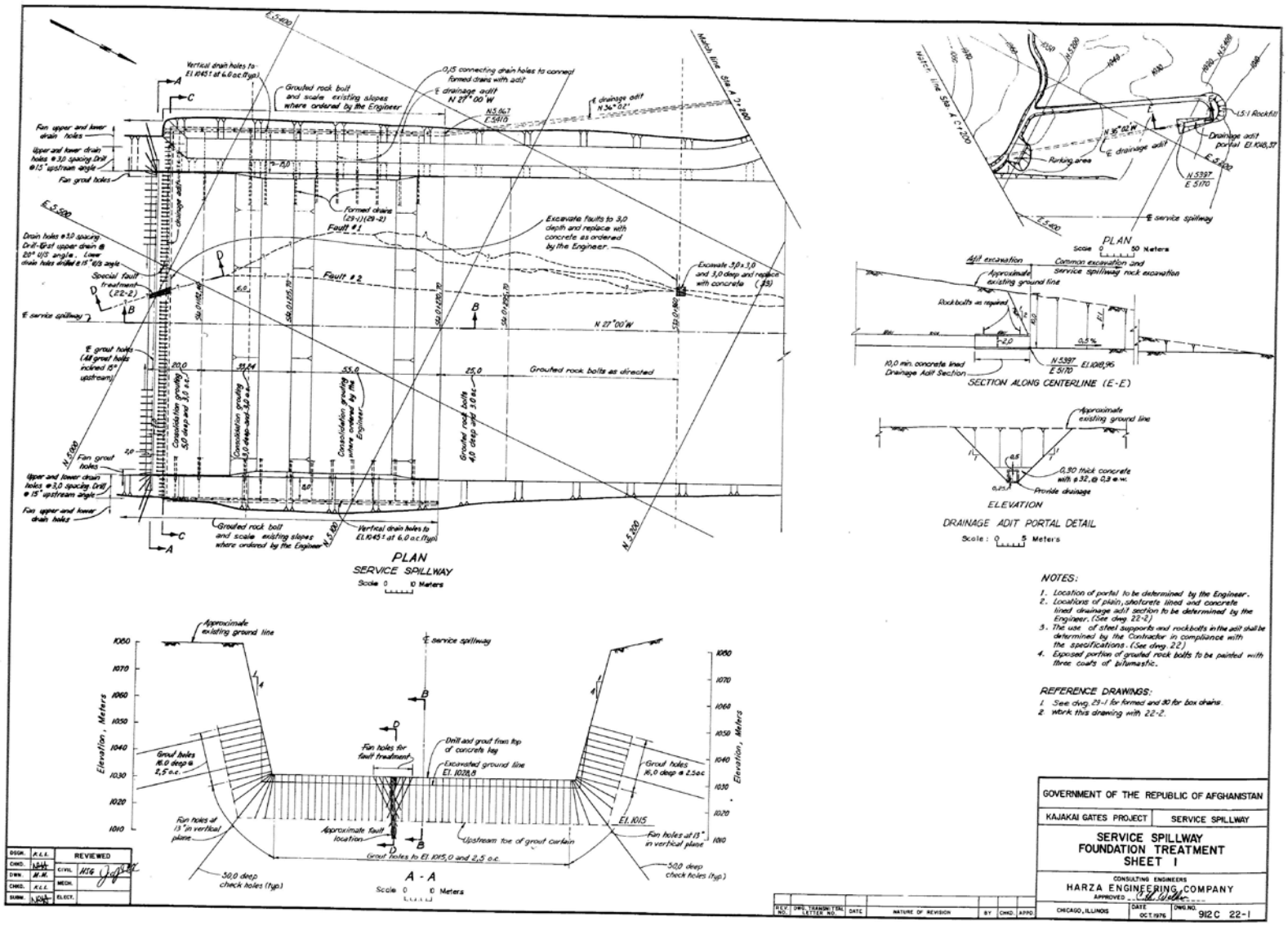
GOVERNMENT OF THE REPUBLIC OF AFGHANISTAN

KAJAKAI GATES PROJECT | BASIC DATA

SUMMARY BOREHOLE LOGS

CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
APPROVED _____

CHICAGO, ILLINOIS | DATE SEPT. 1976 | DWG. NO. 912 C 13


PLAN
SERVICE SPILLWAY
Scale 0 10 Meters
Fault #1
Fault #2
Grouted rock bolts as directed
Excavate faults to 3,0 depth and replace with concrete as ordered by the Engineer
Excavate 3,0 x 3,0 and 3,0 deep and replace with concrete (33)
Fan upper and lower drain holes
Upper and lower drain holes @ 3,0 spacing Drill @ 15° upstream angle
Fan grout holes
Special fault treatment (22-2)
℄ service spillway
N 27°00'W
Grouted rock bolt and scale existing slopes where ordered by the Engineer
Vertical drain holes to El. 1045,1 at 6,0 o.c. (typ.)
0,15 connecting drain holes to connect formed drains with adit
℄ drainage adit N 27°00'W
Match line Sta 4+200
A - A
Scale 0 10 Meters
Approximate existing ground line
Grout holes 16,0 deep @ 2,5 o.c.
Fan holes for fault treatment
Drill and grout fines top of concrete key
Excavated ground line El. 1028,8
Fan holes at 13° in vertical plane
Approximate fault location
Upstream toe of grout curtain
El. 1015
(Grout holes to El. 1015,0 and 2,5 o.c.)
50,0 deep check holes (typ.)
Elevation, Meters
PLAN
Scale 0 50 Meters
Parking area
1,5:1 Rockfill
Drainage adit portal El. 1048,37
N 5397 E 5170
SECTION ALONG CENTERLINE (E-E)
Adit excavation
Common excavation and service spillway rock excavation
Approximate existing ground line
Rock bolts as required
10,0 min. concrete lined Drainage Adit Section
N 5397 E 5170 El. 1048,96
ELEVATION
0,30 thick concrete with ø 32 @ 0,3 e.w.
Provide drainage
DRAINAGE ADIT PORTAL DETAIL
Scale: 0 5 Meters
NOTES:
1. Location of portal to be determined by the Engineer.
2. Locations of plain, shotcrete lined and concrete lined drainage adit section to be determined by the Engineer. (See dwg. 22-2)
3. The use of steel supports and rockbolts in the adit shall be determined by the Contractor in compliance with the specifications. (See dwg. 22)
4. Exposed portion of grouted rock bolts to be painted with three coats of bituminous.
REFERENCE DRAWINGS:
1. See dwg. 23-1 for formed and 30 for box drains.
2. Work this drawing with 22-2.
GOVERNMENT OF THE REPUBLIC OF AFGHANISTAN
KAJAKAI GATES PROJECT
SERVICE SPILLWAY
SERVICE SPILLWAY FOUNDATION TREATMENT SHEET I
CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
CHICAGO, ILLINOIS
DATE OCT. 1976
DWG. NO. 912 C 22-1
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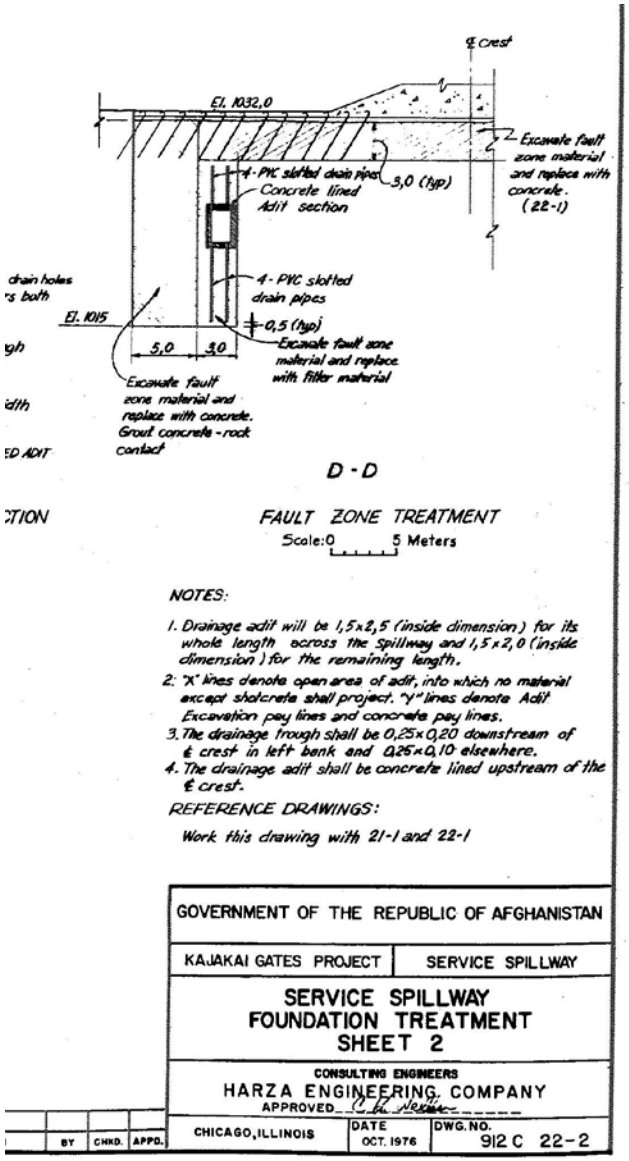
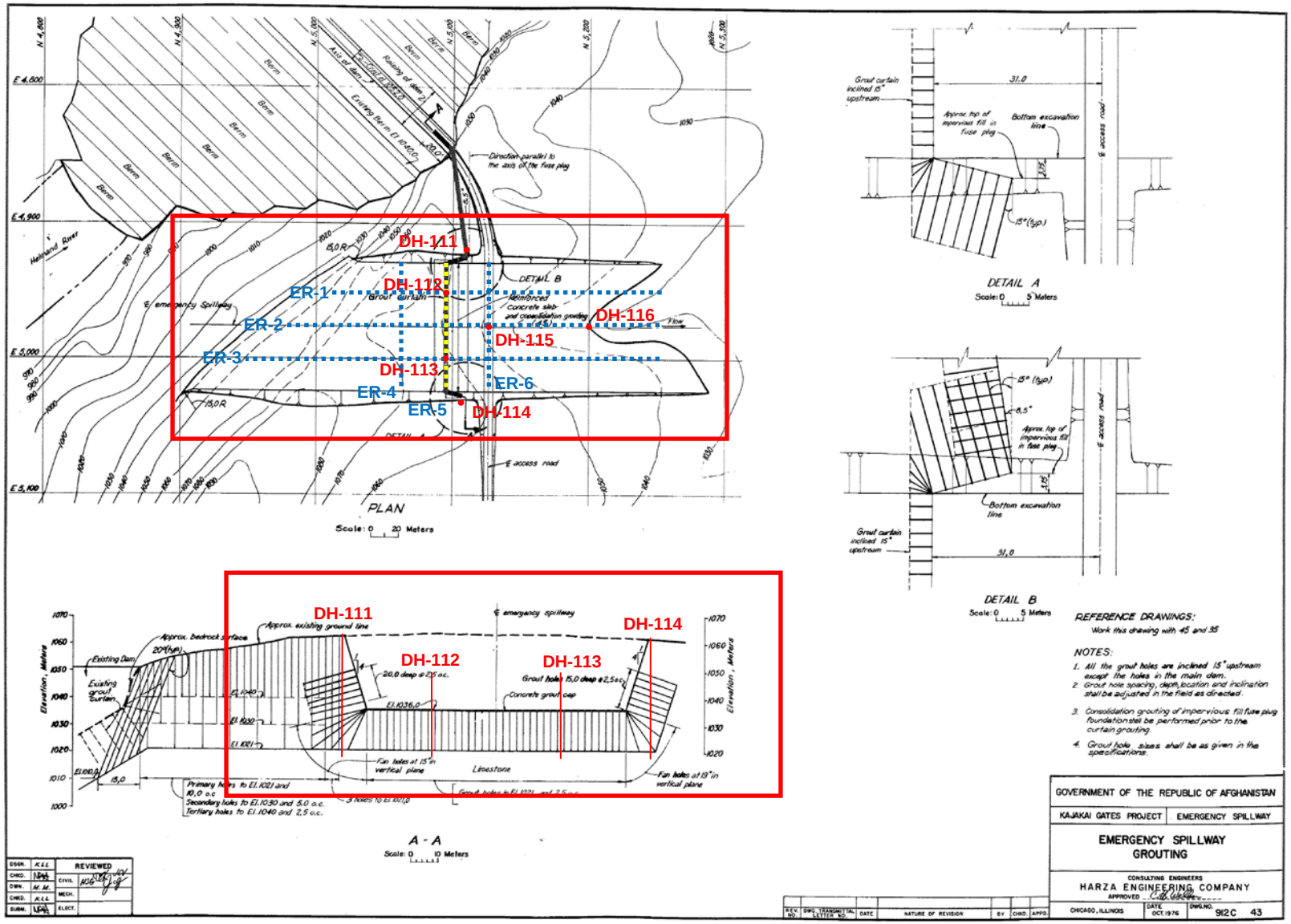

℄ crest
El. 1032,0
Excavate fault zone material and replace with concrete. (22-1)
4-PVC slotted drain pipes
3,0 (typ)
Concrete lined Adit section
4-PVC slotted drain pipes
El. 1015
0,5 (typ)
5,0
3,0
Excavate fault zone material and replace with filter material
Excavate fault zone material and replace with concrete. Grout concrete-rock contact
D-D
FAULT ZONE TREATMENT
Scale: 0 5 Meters
NOTES:
1. Drainage adit will be 1,5x2,5 (inside dimension) for its whole length across the Spillway and 1,5x2,0 (inside dimension) for the remaining length.
2. "X" lines denote open area of adit, into which no material except shotcrete shall project. "Y" lines denote Adit Excavation pay lines and concrete pay lines.
3. The drainage trough shall be 0,25x0,20 downstream of ℄ crest in left bank and 0,25x0,10 elsewhere.
4. The drainage adit shall be concrete lined upstream of the ℄ crest.
REFERENCE DRAWINGS:
Work this drawing with 21-1 and 22-1
GOVERNMENT OF THE REPUBLIC OF AFGHANISTAN
KAJAKAI GATES PROJECT
SERVICE SPILLWAY
SERVICE SPILLWAY FOUNDATION TREATMENT SHEET 2
CONSULTING ENGINEERS
HARZA ENGINEERING COMPANY
APPROVED
BY
CHKD.
APPD.
CHICAGO, ILLINOIS
DATE OCT. 1976
DWG. NO. 912 C 22-2



The foundation exploration work to be performed is shown in the two red boxes to the left. The Contractor shall perform electrical resistivity surveys along six alignments and shall drill six foundation holes. The six electrical resistivity survey lines are labeled ER-1 through ER-6. The six drill hole locations are labeled DH-111 through DH-116. The locations of the electrical resistivity survey lines and drill holes may be modified by the COR.

EMERGENCY SPILLWAY FOUNDATION EXPLORATION PLAN

Recent photo of emergency spillway

Recent photo of emergency spillway and upstream face of embankment dam