2023

Amman Citadel Southern Slope Project

Topography, Geotechnical, Hydrology Study and Design

THIS STUDY IS SUPPORTED BY

USAID-FUNDED SUSTAINABLE CULTURAL HERITAGE THROUGH ENGAGEMENT OF LOCAL COMMUNITIES PROJECT (SCHEP), IMPLEMENTED THROUGH THE AMERICAN CENTER OF RESEARCH (ACOR)

RESPECTFULLY SUBMITTED BY DR. PEARCE PAUL CREASMAN | ACOR, 8 RASHED AL-ABADLI STREET, TLA'A ALI

PROJECT PARTICIPANTS

American Center of Research (ACOR)

- Executive Director: Dr. Pearce Paul Creasman
- SCHEP Chief of Party: Dr. John Shearman
- SCHEP CHR Field Manager: Hisham Al Majali

Jordan Ministry of Tourism and Antiquities

- Assistant Secretary-General for Technical Affairs: Ayman Abu-Kharoub

Jordan Department of Antiquities (DoA)

- Director General: Prof. Fadi Bala'awi
- Amman Antiquities Director: Asem Asfour
- Amman Citadel Project Supervisor: Bilal Hussein

Jordan Engineering Laboratories

- CEO: Eng. Suhair Abdulhadi
- General Manger: Eng. Ahmad Suliman.
- Eng . Derar Shbelat
- Eng: Najeh Kanaan
- Eng. Bashar Zeyadeen
- Eng. Mohammad Awad

TABLE OF CONTENT

TOPOGRAPHICAL SURVEY

GEOTECHNICAL STUDY

TEST PITS

STANDARD TEST METHODS FOR LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX FOR SOIL

SLOPE STABILITY STUDY

List of Figures:

List of Tables:

About the Study:

The Amman Citadel Southern Slope Project is a collaborative effort between the Jordanian Ministry of Tourism and Antiquities (MoTA), the Department of Antiquities (DoA) and USAID/SCHEP implemented by the American Center of Research (ACOR). Among the improvements initiated by USAID/SCHEP is the reconstruction of the main gate and the topology, hydrology, stability study and drainage design that is presented in this document. The aforementioned improvements were all financed by USAID. With improvements ongoing to open the southern gate for visitors in the near future, USAID/ACOR/SCHEP commenced the study to provide the DoA with the necessary information to conduct the improvements based upon sound engineering analysis, particularly the hydrology study. With rainfall a key ingredient in deterioration of historic structural stability, USAID/ACOR/SCHEP completed the study in January 2023 along with the design of the drainage configurations in February 2023. Pending the installation of the drainage system, this will relieve the water saturation problem and assist in securing the structural integrity of the existing structures and extend the life of the recent improvements including the USAID/ACOR/SCHEP Archaeological Field School excavations at the archway located in the lower section of the southern slope.

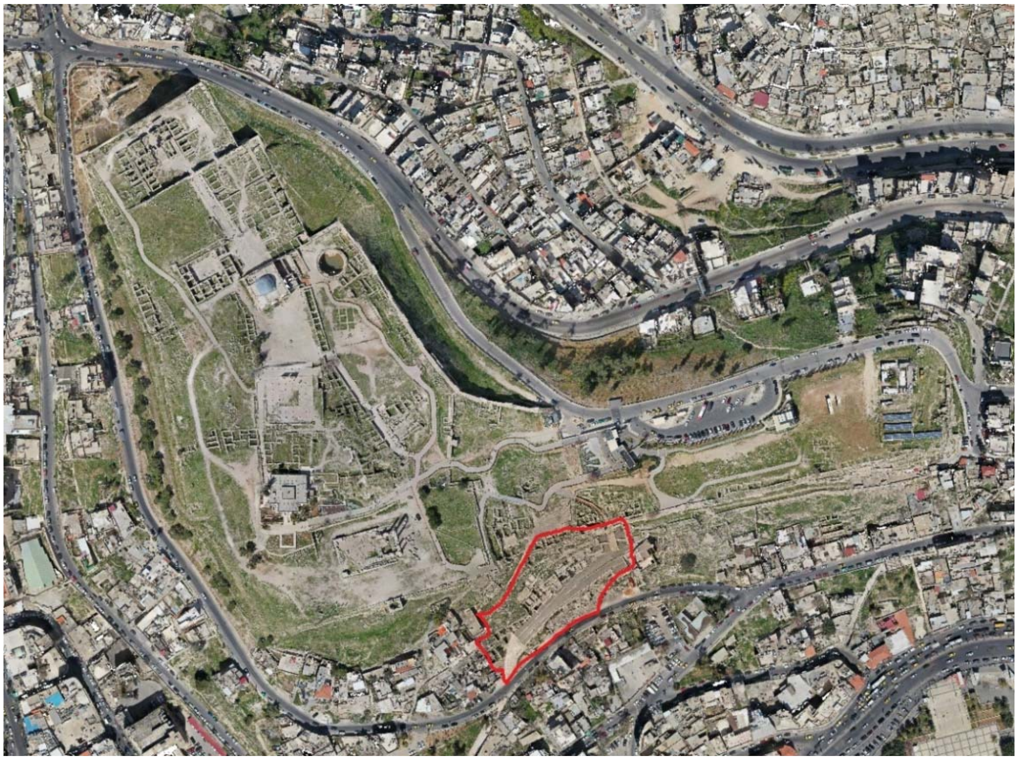


Figure 1- Amman Citadel – Southern Slope Area of Study (Circled in Red)

1.1 Introduction

The main purpose of this study is to present the work and tests results of the geotechnical investigation, slope stability and hydrological study of the proposed project site.

The investigation is to determine the surface and subsurface ground conditions of the southern slope section of the Amman Citadel and to define the physical, mechanical engineering properties of the slope material; and to specify other characteristics such as the hydrological characteristics of the available strata. This will assist in assuring that all means are performed in order to achieve an adequate estimation and protection of the historical landmark. The method of investigation as follows:

a) Research and collection of available information about geological features, surface topography, surface drainage and any other distinct structures encountered in the field during drilling.
b) Drilling and sampling (disturbed and undisturbed samples) of four (4) Test pits and two (2) boreholes.
c) Conducting the necessary field and laboratory tests.
d) Conclusions and recommendations.

1.2 Site Description

The area of study is part of the southern facade of the Amman Citadel

1.3 General Geology

The materials described in this report are geologically related to Amman Silicified Limestone Formation (Santonian-Campanian) and is 50m thick in the study area. The formation covers broad areas of Amman city. This formation consists mainly of dark brown to grey thick bedded chert, silicified limestone, chalk, marl of dark brown to grey, thick bedded chert, silicified limestone, chalk, marl, siliceous coquina, cherty phosphate, brecciated chert, and tripoli. The formation was deposited in a shallow marine environment.

A geological map is shown in (figure no. 3).

Table 1 - JEL Report Data

Company	Jordan Engineering Laborites
Report No.	124/S-2022
To	USAID/ACOR/SCHEP
Village	Amman
Plot No.	355
Block No.	33/ALMADINA
Date	31/12/2022

Topographical Survey

2.1 Topographical Survey:

The topographical elevations and contours is the basis for any hydrology and stability study. The survey of the southern slope established temporary benchmark elevations for near term use. For long term use, topographical mapping is important in recording the history of the site to document differences in physical changes of the landscape.

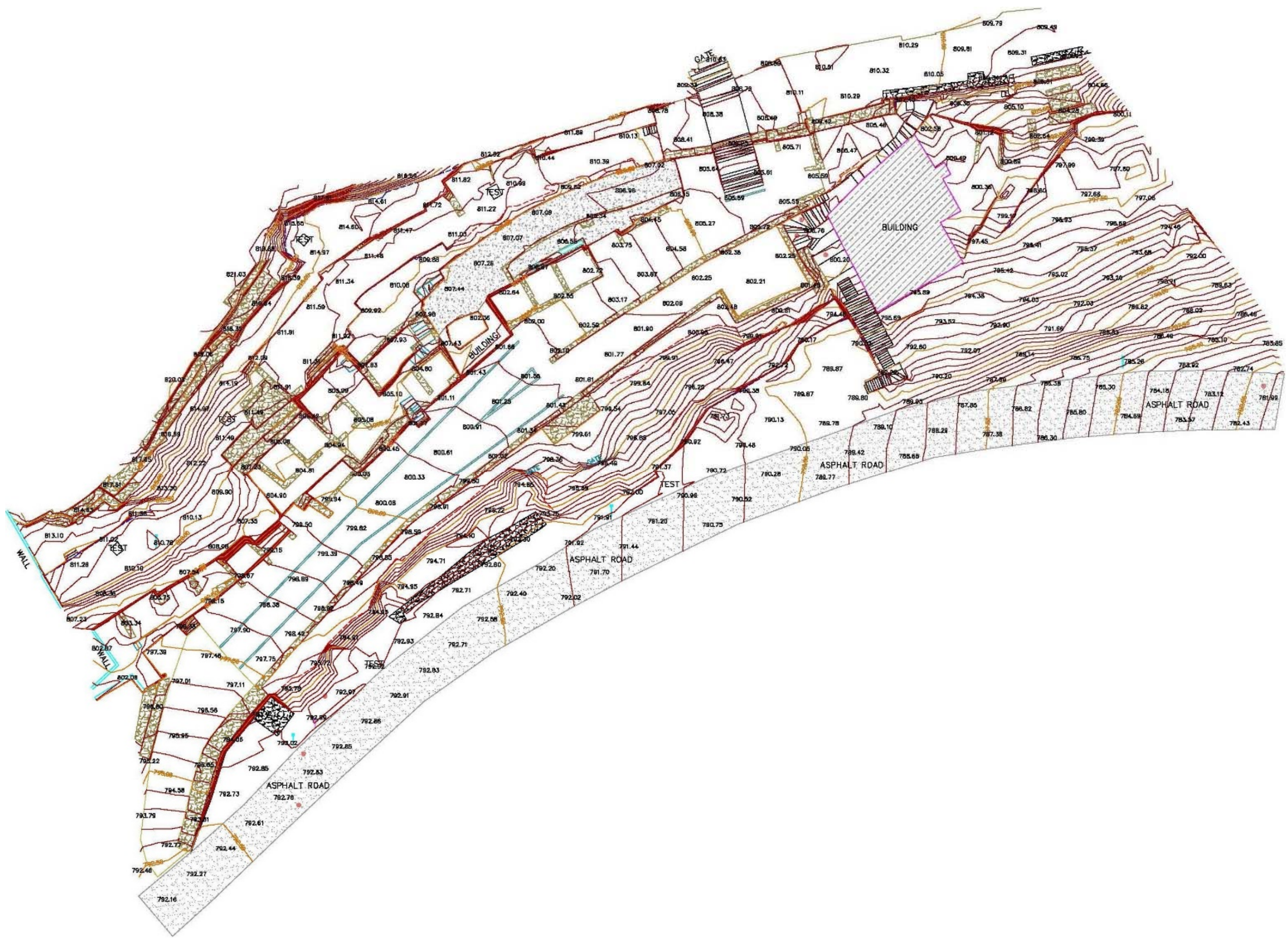
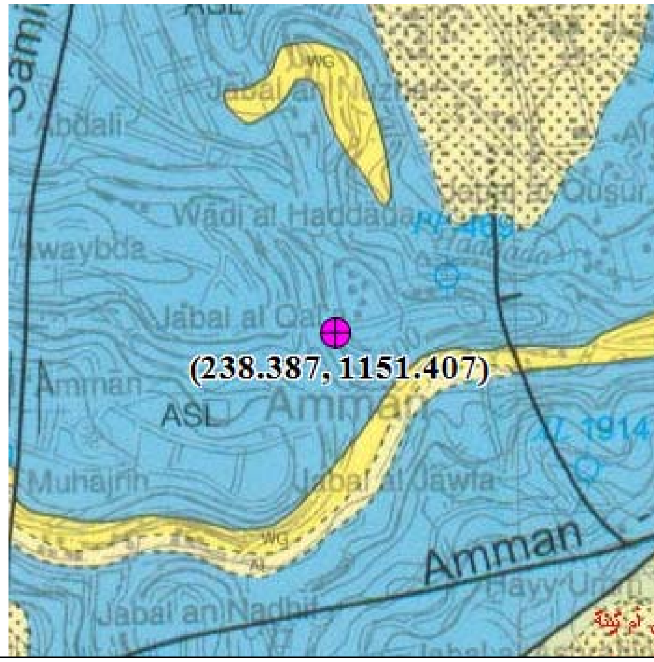


Figure 2- Topography Map

GELOGICAL MAP OF THE SITE

(Natural Resources Authority –map of) (scale 1: 50,000)



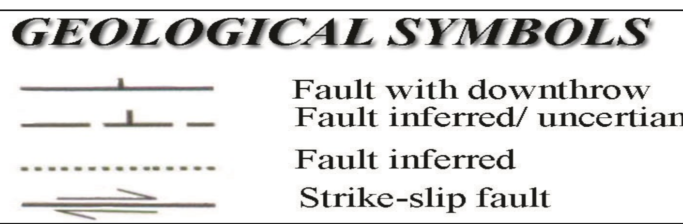
LEGEND		
S S	**Soil**	The materials described below are geologically related to Amma Silicified Limestone Formation (Santonian-Campanian) is 50m thick in the study area. The formation covers broad areas of Amman city. This formation consists mainly of dark brown to grey thick bedded chert, silicified limestone, chalk, marl of dark brown to grey thick bedded chert, silicified limestone, chalk, marl, siliceous coquina, and cherty phosphate, brecciated chert and Tripoli. The formation was deposited in a shallow marine environment.
Al	**Alluvium**	
PI	**Pleistocene**	
ct	**Calcrete**	
AHP	**Al Hisa Phosphorite**	
ASL	**Amman Silicified**	
WG	**Wadi Umm Ghudran**	
LM	**Lisan Marl**	
MCM	**Muwaqqar Chalk Marl**	
UT	**Umm Tina**	
IR/UT	**Iraq El Amir**	
MK	**Mukherieris Sandstone**	
B	**Basalt**	

Figure 3 - Geological Map

Geotechnical Study

3.1 Field Exploration and Drilling

On 12-Nov-2022, two (2) boreholes were drilled at the site as following:

Table 2 - Boreholes

BH No.	Depth (m)	Elevation
BH-1	15	792.92
BH-2	15	791.09

Bulk samples were collected from each meter depth and where Litho-logical changes of strata occur. Samples recovered were described and classified by our geological engineer and taken to the lab in watertight plastic bags for further testing. The drilling was executed using the rotary air flush method HW-412 Sampling core barrel and four inch bit hammer. These boreholes are good enough to supply the designer with sufficient information to the type of subsurface lithology and their characteristics. The field-testing included coring at 2m depth. A general site plan (Figure no.7) showing the boreholes location in the site is attached in Figure ,4 ,3 and5 . The subsurface profile is attached in (Figure no.3).

The logs of the boreholes showing the depth of each stratum and some other characteristics of it are attached in Table 2.

Note: *There was no free ground water or cavities encountered until the bottom of the drilled boreholes.*

3.2 Laboratory Testing

Laboratory testing included water content determination and unconfined compression strength. Recommended procedures are in ASTM designation D2938-71a. All of the undisturbed samples were collected utilizing modified core recovery, as described in the Rock Quality Designation (RQD) by Deere (1963), as the method of measurement for these samples. The results of these tests are shown on the borehole logs in Figure 4 and Figure 5.

3.3 Type of Material

The surface and subsurface materials after drilling has been geologically described. The first borehole (BH1) is located at Hashem Al-Kheir Street on the north side of the road in front of the local hotel. The second borehole (BH2) is located to the east on the north side of the road near a large archway on the southern slope. The descriptions are shown in the following Table no.3:

Table 3 - Material Types and Properties

BH No	Depths m	Ground Materials
BH-1	0.0m To 4.0m	Backfill materials clayey silt mixed with gravels and cobbles of limestone
BH-2	0.0m To 4.0m	
BH-1	4.0m To 15.0m	Alternated layers of Yellowish beige hard marl, Yellowish cream weak marlstone, white moderately weak fractured limestone and thin bands of grey chert
BH-2	4.0m To 15.0m	

3.4 Analysis of Tests Results

Safe bearing capacity test was performed to check the capacity of the soil to withstand loads. The ultimate and safe bearing capacity for soils in the boreholes is calculated using the number of blows from the standard penetration tests results, considering a factor of safety of three, depth of footing of 1.5 m (Terzaghi’s equation).

Table 4 - Safe Bearing Capacity

Description	Soft	Firm	Stiff	Hard
N	2-4	4-8	8-29	>29
q_u (kg/cm)	0.25-0.50	0.50-1.00	1.00-4.00	>4.0

3.5 Conclusions and Recommendations

The top soil material are composed of Back fill material clayey silt mixed with gravels and cobbles of limestone, extending from existing ground surface till 4.00 meters depth, followed by alternated layers of yellowish beige hard marl, yellowish cream weak marlstone, white moderately weak fractured limestone and thin bands of grey chert.

3.6 The Coefficients of Earth Pressures

γ = Unit weight of rock (g/cm^3)

C = Cohesion of rock (kg/cm^2)

ϕ = Angle of internal friction of rock.

K_a = Coefficient of active earth pressure = $\frac{1-\sin\phi}{1+\sin\phi}$

Pa = 0.5 * γ* H2*Ka (kg/cm^2)

K_p = Coefficient of passive earth pressure = $1/Ka$

μ = Poisson's ratio of soil.

K_o = Coefficient of earth pressure at rest = $\frac{\mu}{1-\mu}$. (Equation (13.4) ALAM SINGH. P398)

q_a = Allowable rock pressure (kg/cm^2)

S.F= Safety factor

K_s = Modulus of sub grade reaction = 40*SF*q_a (Bowles equation

δ = Friction angle between structure & soil or rock[1].

[1] Bowles, J.E. (1997). *Foundation Analysis and Design*. International Edition. McGraw-Hill Publishing. (Table 11.6, p. 619)

Table 5 - Earth Pressure Factors

Material	Silty Clay	Marlstone
ɣ	1.56	2.2
C	0.6	0.1
Ø	33	36
K_a	0.295	0.260
P_a	0.230	0.286
K_p	3.392	3.852
μ	0.3	0.18
K_o	0.429	0.412
q_a	1.2	2.4
S.F	3	18.5
K_s	144	1776
δ	22	24

Table 6 - Modulus of Elasticity (KPa)

Material	Marl	Marlstone	Marly limestone	Limestone	Chert
$E_s = \frac{\Delta stress}{\Delta strain}$	750-1,250	4,000-55,000	55,000-65,000	65,000-80,000	75,000-100,000

3.7 Boring Log Designation

Total Core Recovery (TCR) is the total length of the core recovered from a borehole as a percentage of the length of the borehole.

Rock Quality Designation (RQD) is a measure of quality of rock core taken from a borehole.

Table 7 - Rock Quality Designation

Rock Quality	Very Poor	Poor	Fair	Good	Excellent
RQD Percent	0-25%	25-50%	50-75%	75-90%	90-100%

Standard Penetration Test (SPT) indicates the relative density of granular deposits.

Table 8 - Standard Penetration Test

Relative Density	SPT Value	Bulk Density (kg/m^3)
Very Loose	0–4	< 1,600
Loose	5–10	1,530–2,000
Medium	11–30	1,750–2,100
Dense	31–50	1,750–2,245
Very Dense	>50	>2,100

Owner : ACOR-USAID SCHEP	Borehole No 1	Coordinates (35.93276186 31.95604445
Project: Amman Citadel	Depth 15m	
Location: -Plot:355	Elevation:792.92m	
	Drilling Method : Rotary Air Flush	

Depth (m)	Sampling	Legend	Detailed Soil and Rock Description	Density gm/cm3	TCR(%)	RQD (%)	mc %	SPT	blows	L.L(%)	P.I.()
1 2 3 4			Back fill materials clayey silt mixed with gravels and cobbles of limestone					22 23 24			
5 6 7 8 9 10 11 12 13 14 15			Alternated layers of Yellowish beige hard marl, Yellowish cream weak marlstone , white moderatly weak fractured limestone and thin bands of grey chert		81	66					
			End of Boring								

Keys : TCR: Total core recovery RQD: Rock quality Designation SPT: Standard Pentration Test	Ground Water Data: Not Exist Depth while drilling : --- Depth after drilling: ---	**sample Keys:** core sample SPT sample

Figure 4 – Boring Log (BH-1)

Owner : ACOR-USAID SCHEP	Borehole No: 2	Coordinates
Project: Amman Citadel	Depth: 15m	(35.93283160
Location: -Plot 355	Elevation:791.09m	31.95565532)
	Drilling Method : Rotary Air Flush	

Depth (m)	Sampling	Legend	Detailed Soil and Rock Description	Density gm/cm^3	TCR(%)	RQD (%)	m.c %	SPT	blows	L.L(%)	P.L()
1 2 3 4			Back fill materials clayey silt mixed with gravels and cobbles of limestone					23 24 25			
5 6 7 8 9 10 11 12 13 14 15			Alternated layers of Yellowish beige hard marl, Yellowish cream weak marlstone , white moderatly weak fractured limestone and thin bands of grey chert		88	62					
			End of Boring								

Keys:	Ground Water Data: Not Exist	sample Keys:
TCR: Total core recovery	Depth while drilling : ---	core sample
RQD: Rock quality Designation	Depth after drilling: ---	SPT sample
SPT: Standard Pentration Test		

Figure 5 - Boring Log (BH-2)

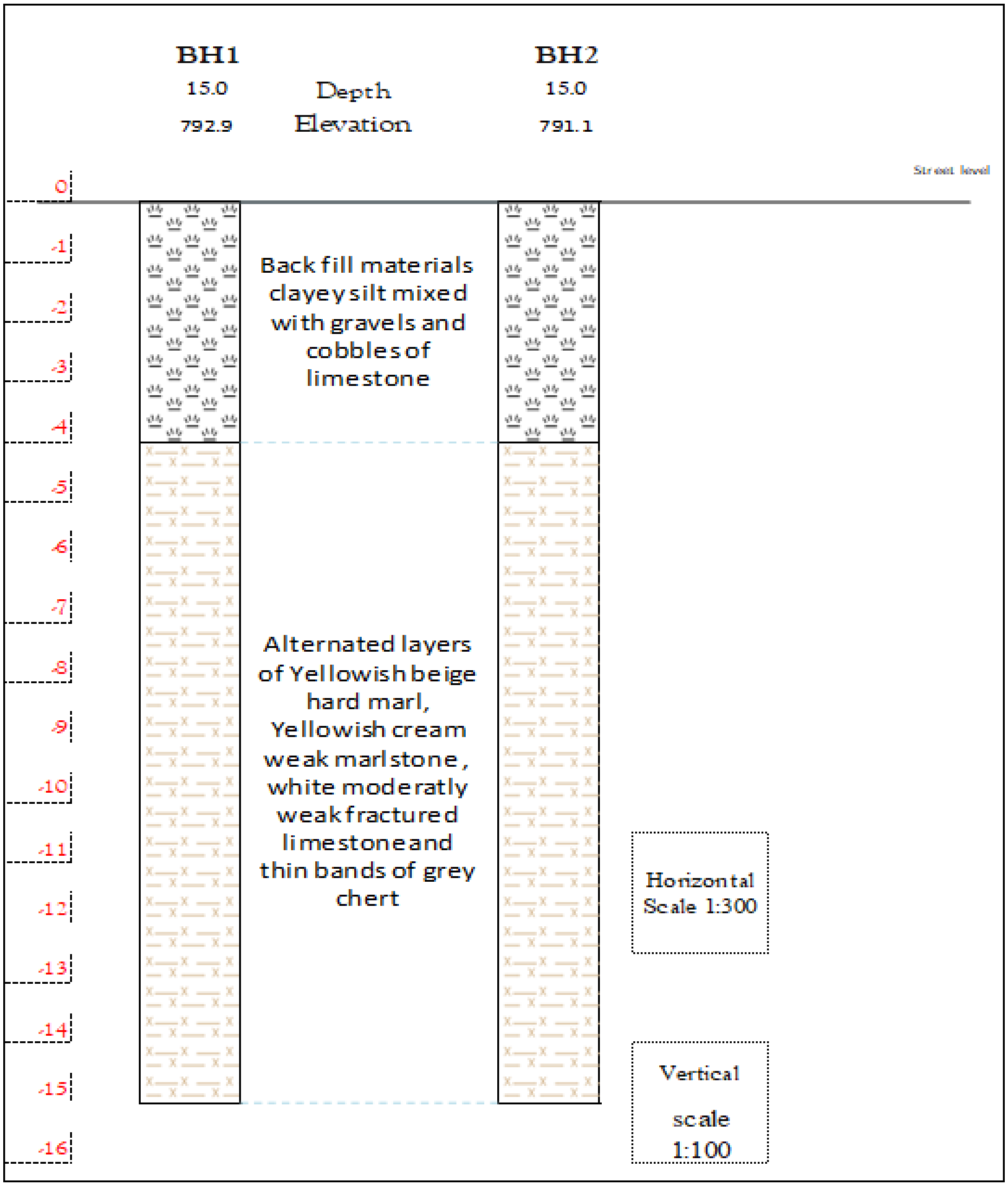


Figure 6 - Subsurface Profile (BH-1 and BH-2)

Test Pits

4.1 Test Pit Description

Four Test Pits were excavated at locations shown in Drawing SR-01. Samples were taken from each test pit and tested as per Standard Test Methods for Liquid limit, Plastic limit, and Plasticity Index for Soil (ASTM D4318-17) to determine the soil classification and parameters for each test pit

4.2 Field Exploration and Drilling

Table 9 - Test Pit Soil Description

Test Pit No.	Ground Material	Date
Test Pit-1	Backfill silty clayey materials with gravels and cobbles	11th-Nov-2022
Test Pit-2		11th-Nov-2022
Test Pit-3		13th-Nov-2022
Test Pit-4		14th-Nov-2022

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index for Soil (ASTM D4318-17)

5.1 Test Pits Profile

The locations of the required samples associated with the stability study made it impossible to utilize a drilling rig. This coupled with the matrix of the soil left the only feasible remaining option of hand excavated test pits. The location of the test pits can be found on Drawing SR-01.

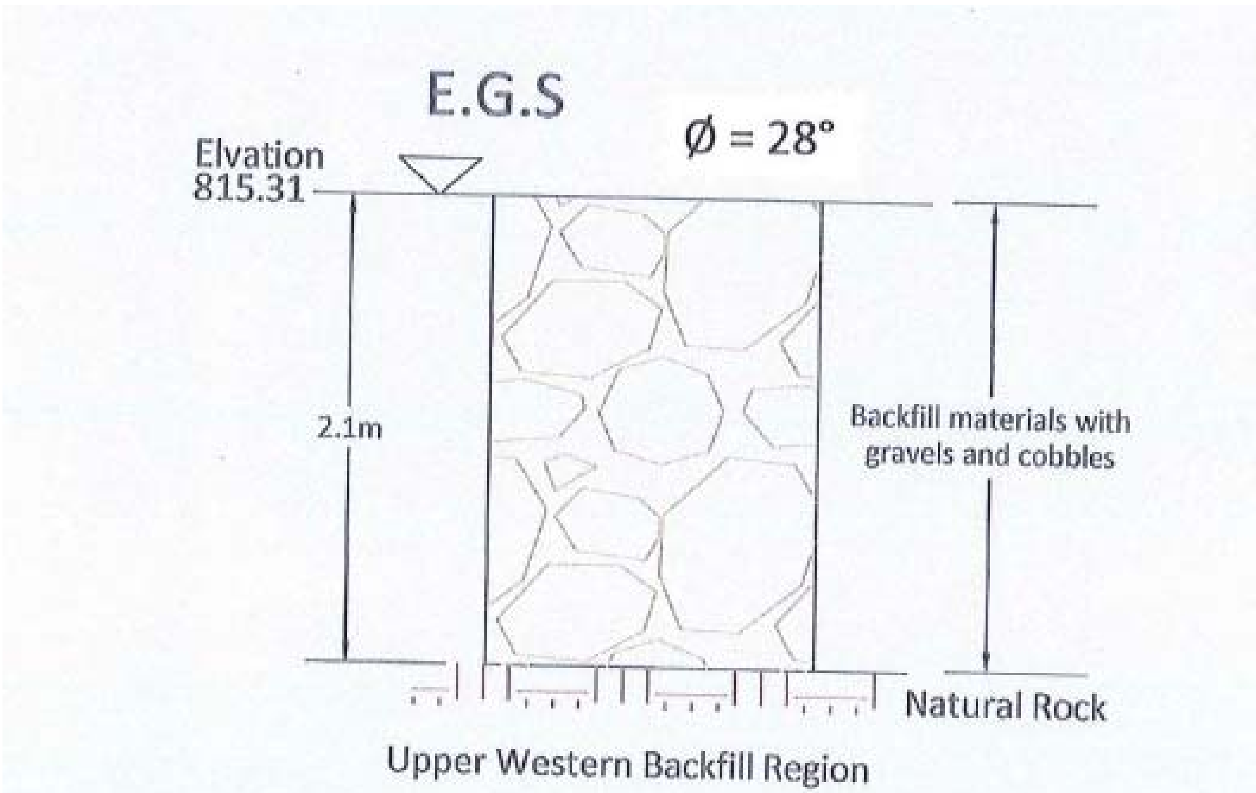


Figure 7 - Test Pit 1 Profile

Table 10 - Test Pit Sample

فحص تدرج التربة بالمناخل

C136-19) ASTM)

(ASTM D1140-2017)

تاريخ الادخال :	رقم التقرير الفني : **23/R/2023**	رقم الادخال : **23/R**
تاريخ الفحص:		**المختبر: التربة- المواد الخام-الخرسانة**

LOCATION BH-1 (0.0---3.0)M

Material For :	**Reddish brown medium plastic silty clay with gravels**

Weight of dry sample= 17855 weight of sample after washing= 12713

Sieve		**Weight Retained (gm)**	**Percent Passing (%)**	SPECIFICATION	
Size	**Opening (mm)**	(gm)	(%)		
No.4	4.75	8302.6	54		
10	2.00	9945.2	44		
40	0.43	11391.5	36		
200	0.075	12712.8	29		

Classification Of Soil (A-2-6) ***ملاحظات:***

شهادة معايرة الميزان رقم : 6200/22

إسم الفاحص:	**التوقيع:**	**التاريخ:**
تدقيق:	**التوقيع:**	**التاريخ:**

T-AGG#6REV.1

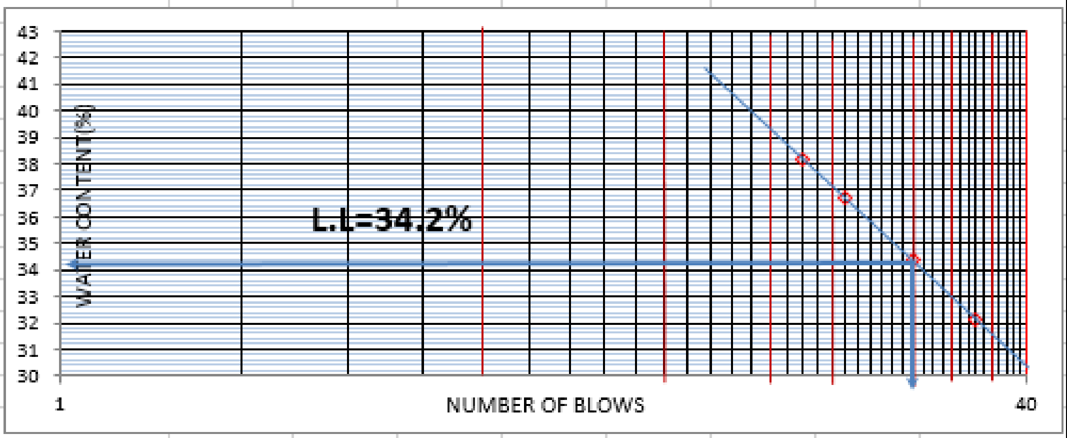
Table 11 - Atterberg Limits (Test Pit 1)

ATTERBERG LIMITS

According to ASTM D4318-2017

REQ:		124/R/2022					
TYPE OF MATERIAL:		Backfill silty clayey materials with gravels and cobbles		☑ wet preparation			
LOCATION:		TEST PIT(1)		☐ dry preparation			
DATE RECEIVED:		12/25/2022		☑ multi point liquid limit			
				☐ one- point liquid limit			
DATE TESTED :		12/27/2022					

	Liquid Limit				Plastic Limit		
Container NO.	D	4	9	15		1	15
Number of Blows	33	26	20	17		-----	----
Wet sample + Container g.	40.37	42.58	42.16	39.09		28.95	30.71
Dry sample + Container g.	34.94	36.3	35.69	33.25		27.25	28.79
Weight of Container g.	18.01	18.05	18.07	17.95		18.03	18.02
Weight of Water g.	5.435	6.278	6.467	5.845		1.70	1.92
Weight of Dry sample g.	16.930	18.250	17.620	15.300		9.22	10.77
Water content %	32.1	34.4	36.7	38.2		18.4	17.8



Note:

L.L. =	34	P.L. =	18	P.I. =	16

Date :	Tested By :	Checked By:

T-S#2-rev.1

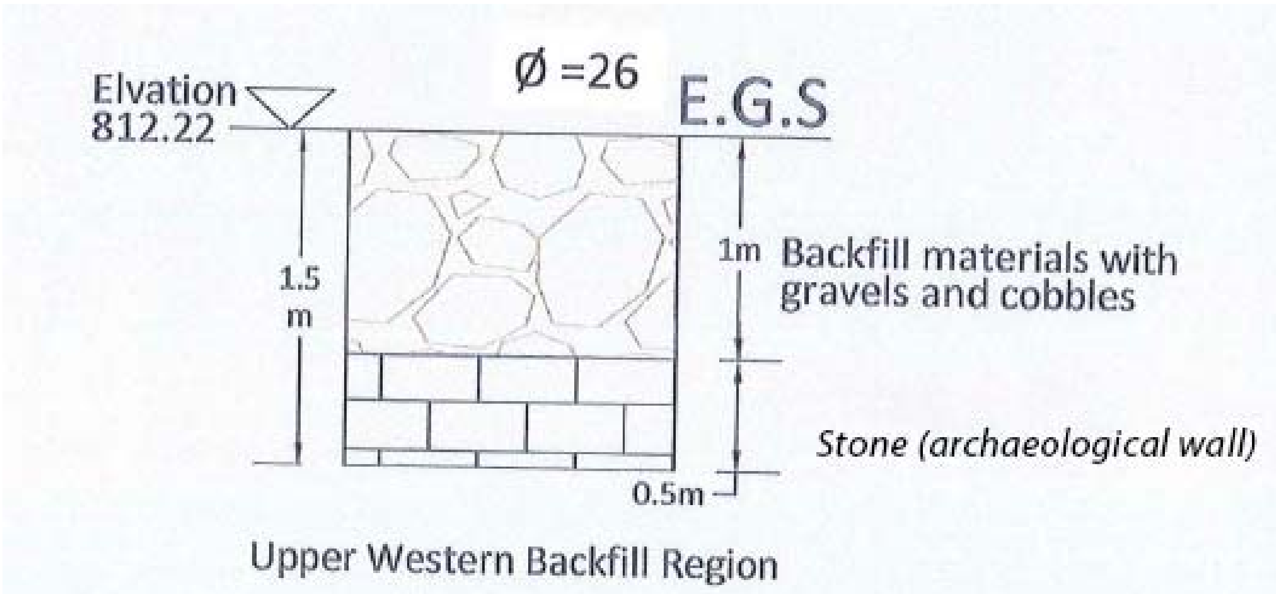


Figure 8 - Test Pit 2 Profile

Table 12 - Test Pit 2 Sample

فحص تدرج التربة بالمناخل (ASTM C136-19) (ASTM D1140-2017)				
12/25/2022	تاريخ الادخال :	رقم التقرير الفني : **124/R/2022**	**124/R**	رقم الادخال :
12/27/2022	تاريخ الفحص:		المختبر: التربة- المواد الخام–الخرسانة	
LOCATION	TEST PIT(3)			
Material For :	**Backfill silty clayey materials with gravels and cobbles**			
Weight of dry sample=	18914	weight of sample after washing=	12578	

Sieve		**Weight Retained (gm)**	**Percent Passing (%)**	SPECIFICATION
Size	**Opening (mm)**	(gm)	(%)	
No.4	4.75	7130.6	62	
10	2.00	9910.9	48	
40	0.43	11556.5	39	
200	0.075	12577.8	34	

Classificatio Of Soil (A-2-6)	ملاحظات:
(6200/22)	شهادة معايرة الميزان رقم :

التاريخ:		التوقيع:		إسم الفاحص:	
التاريخ:		التوقيع:		تدقيق:	

T-AGG#6REV.1

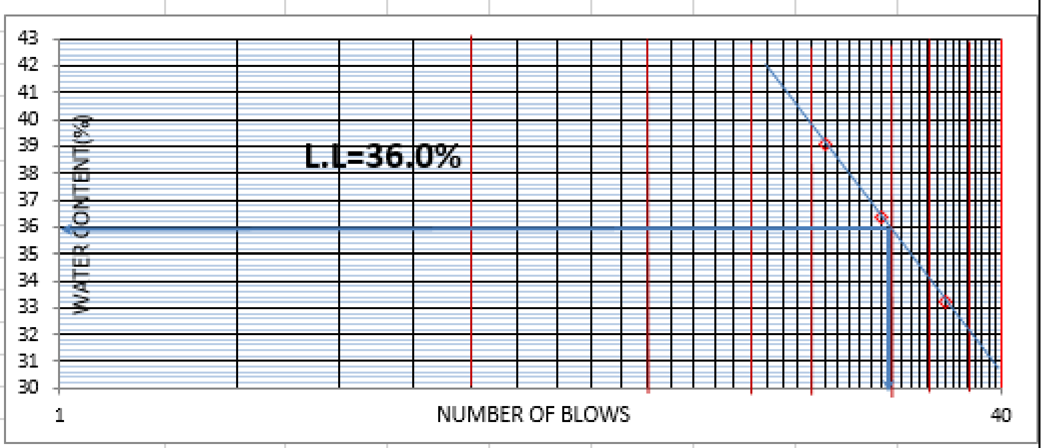
Table 13 - Atterberg Limits (Test Pit 2)

ATTERBERG LIMITS

According to ASTM D4318-2017

REQ:	**124/R/2022**	
TYPE OF MATERIAL:	Backfill silty clayey matetials with gravels and cobbles	☑ wet preparation
3	TEST PIT (3)	☐ dry preparation
DATE RECEIVED:	12/25/2022	☑ multi point liquid limit
		☐ one- point liquid limit
DATE TESTED :	12/27/2022	

	Liquid Limit					Plastic Limit	
Container NO.	1A	2	3			5	6
Number of Blows	32	25	20			-----	----
Wet sample + Container g.	40.85	42.90	42.55			29.32	31.18
Dry sample + Container g.	35.23	36.26	35.66			27.27	28.83
Weight of Container g.	18.3	18.01	18.04			18.05	18.06
Weight of Water g.	5.621	6.643	6.889			2.05	2.35
Weight of Dry sample g.	16.930	18.250	17.620			9.22	10.77
Water content %	33.2	36.4	39.1			22.2	21.8



Note: ....

L.L. =	**36**	P.L. =	**22**	P.I. =	**14**

Date :	Tested By :	Checked By:

T-S#2-rev.1

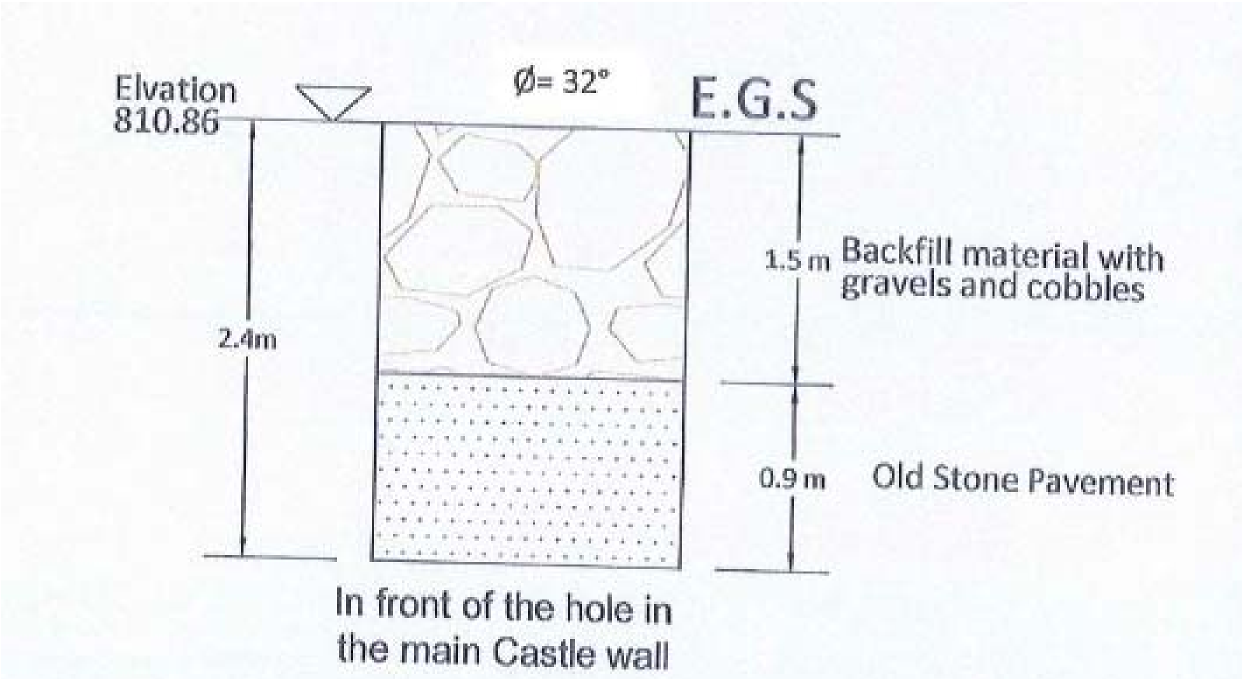


Figure 9 - Test Pit 3 Profile

Table 14 - Test Pit 3 Sample

فحص تدرج التربة بالمناخل					
(ASTM C136-19)					
(ASTM D1140-2017)					
12/25/2022	تاريخ الادخال :	رقم التقرير الفني :		124/R	رقم الادخال :
12/27/2022	تاريخ الفحص:	124/R/2022		المختبر: التربة- المواد الخام- الخرسانة	
LOCATION	TEST PIT(2)				
Material For :	**Backfill silty clayey matetials with gravels and cobbles**				
Weight of dry sample=	15822	weight of sample after washing=		11376	
Sieve		**Weight Retained (gm)**	**Percent Passing (%)**	SPECIFICATION	
Size	Opening (mm	(gm)	(%)		
No.4	4.75	7705	51		
10	2.00	8844	44		
40	0.43	10727	32		
200	0.075	11376	28		
Classification Of Soil (A-2-6)					ملاحظات :
(6200/22) : شهادة معايرة الميزان رقم					
التاريخ:		التوقيع:			إسم الفاحص:
التاريخ:		التوقيع:			تدقيق:
				T-AGG#6REV.1	

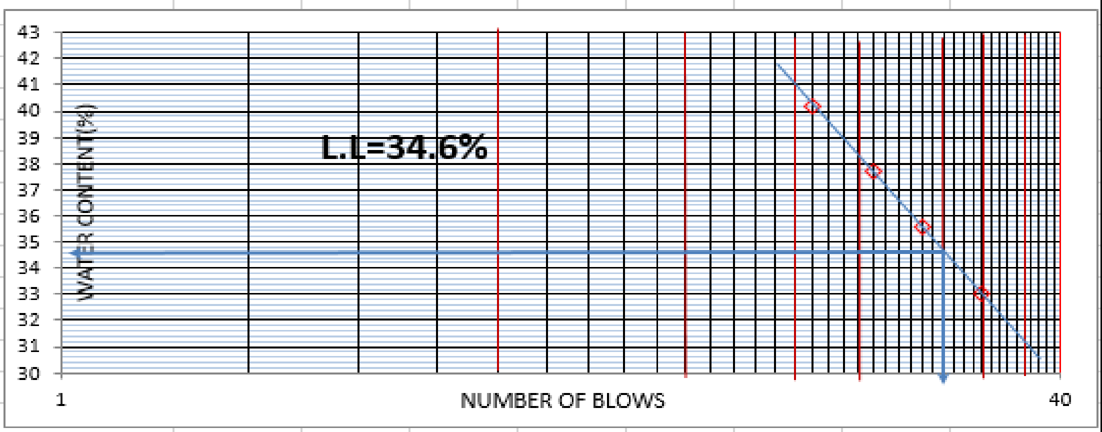
Table 15 - Atterberg Limits (Test Pit 3)

ATTERBERG LIMITS

According to ASTM D4318-2017

REQ:	**124/R/2022**		
TYPE OF MATERIAL:	Backfill silty clayey matetials with gravels and cobbles	☑	wet preparation
LOCATION:	Test Pit (2)	☐	dry preparation
DATE RECEIVED:	12/25/2022	☑	multi point liquid limit
		☐	one- point liquid limit
DATE TESTED :	12/27/2022		

	Liquid Limit				Plastic Limit		
Container NO.	A	B	C	D		E	F
Number of Blows	30	24	20	16		-----	----
Wet sample + Container g.	40.82	42.76	42.30	42.74		29.31	31.24
Dry sample + Container g.	35.23	36.26	35.66	35.66		27.27	28.83
Weight of Container g.	18.3	18.01	18.04	18.04		18.05	18.06
Weight of Water g.	5.587	6.497	6.643	7.083		2.04	2.41
Weight of Dry sample g.	16.930	18.250	17.620	17.620		9.22	10.77
Water content %	33	35.6	37.7	40.2		22.1	22.4



Note:

L.L. =	**35**	P.L. =	**22**	P.I. =	**13**

Date :	Tested By :	Checked By:

T-S#2-rev.1

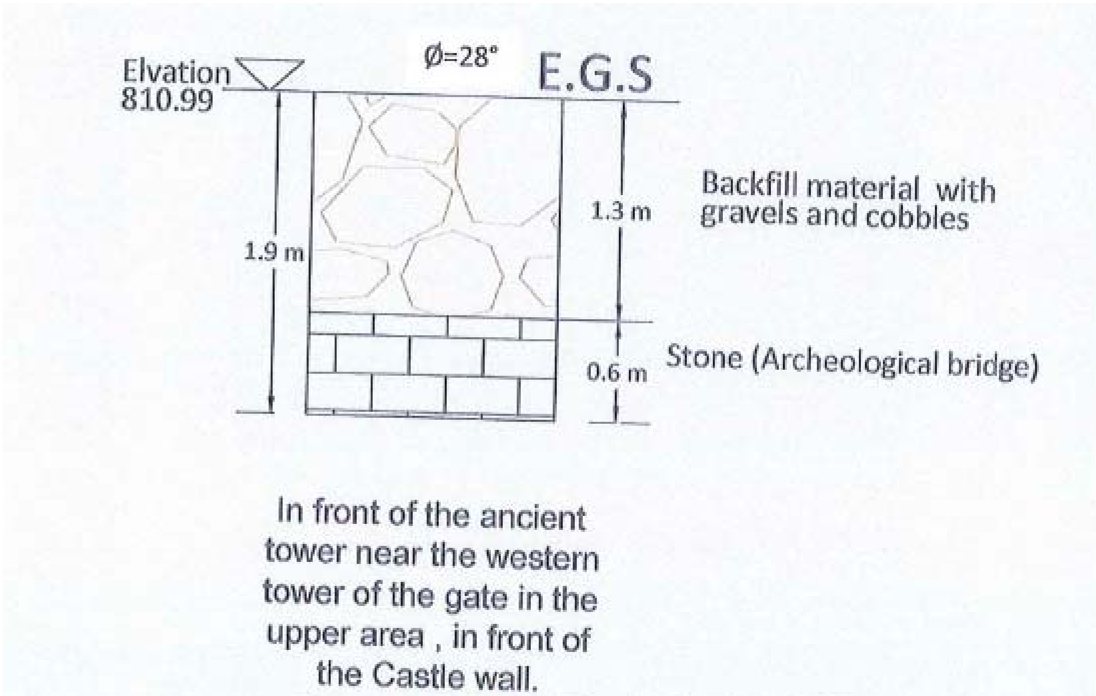


Figure 10 - Test Pit 4 Profile

Table 16 - Test Pit 4 Sample

فحص تدرج التربة بالمناخل					
(ASTM C136-19)					
(ASTM D1140-2017)					
12/25/2022	تاريخ الادخال :	رقم التقرير الفني :		124/R	رقم الادخال :
12/27/2022	تاريخ الفحص:	124/R/2022		مختبر: التربة- المواد الخام-الخرسانة	
LOCATION	TEST PIT(3)				
Material For :	**Backfill silty clayey matetials with gravels and cobbles**				
Weight of dry sample=	18914	weight of sample after washing=		12578	
Sieve		**Weight Retained (gm)**	**Percent Passing (%)**	SPECIFICATION	
Size	Opening (mm	(gm)	(%)		
No.4	4.75	7130.6	62		
10	2.00	9910.9	48		
40	0.43	11556.5	39		
200	0.075	12577.8	34		
Classificatio Of Soil (A-2-6)					ملاحظات:
		(6200/22) : شهادة معايرة الميزان رقم			
التاريخ:		التوقيع:		إسم الفاحص:	
التاريخ:		التوقيع:		تدقيق:	
				T-AGG#6REV.1	

USAID FROM THE AMERICAN PEOPLE

acor أكور المركز الأمريكي للأبحاث AMERICAN CENTER OF RESEARCH

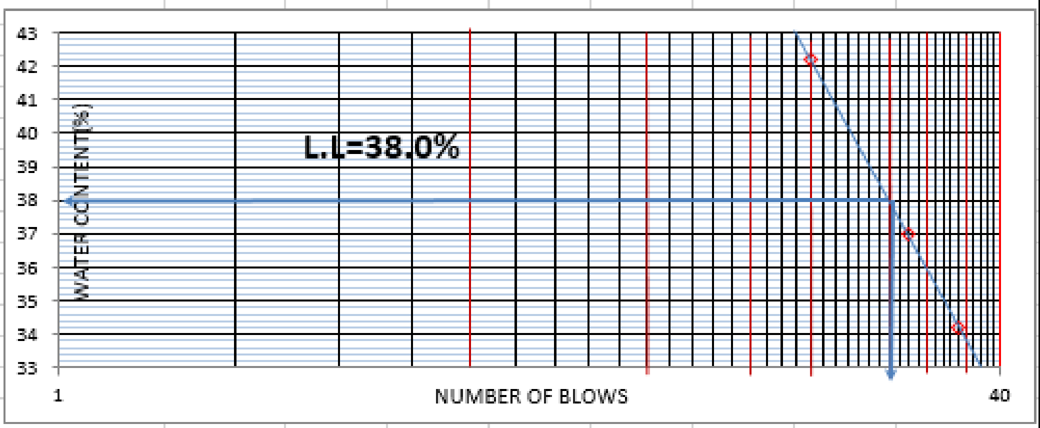
Table 17 - Atterberg Limits (Test Pit 4)

ATTERBERG LIMITS

According to ASTM D4318-2017

REQ:	124/R/2022		
TYPE OF MATERIAL:	Backfill silty clayey matetials with gravels and cobbles	☑	wet preparation
LOCATION:	TEST PIT(4)	☐	dry preparation
DATE RECEIVED:	12/25/2022	☑	multi point liquid limit
		☐	one- point liquid limit
DATE TESTED :	12/27/2022		

	Liquid Limit					Plastic Limit	
Container NO.	12	13	14			20	23
Number of Blows	34	28	19			-----	----
Wet sample + Container g.	40.75	43.60	43.11			29.28	30.98
Dry sample + Container g.	34.96	36.85	35.67			27.31	28.79
Weight of Container g.	18.03	18.6	18.05			18.09	18.02
Weight of Water g.	5.790	6.753	7.436			1.97	2.19
Weight of Dry sample g.	16.930	18.250	17.620			9.22	10.77
Water content %	34.2	37.0	42.2			21.4	20.3



Note:

L.L. =	38	P.L. =	21	P.I. =	17

Date :	Tested By :	Checked By:

T-S#2-rev.1

Slope Stability Study

6.1 *Slope Stability 3D Elevations*

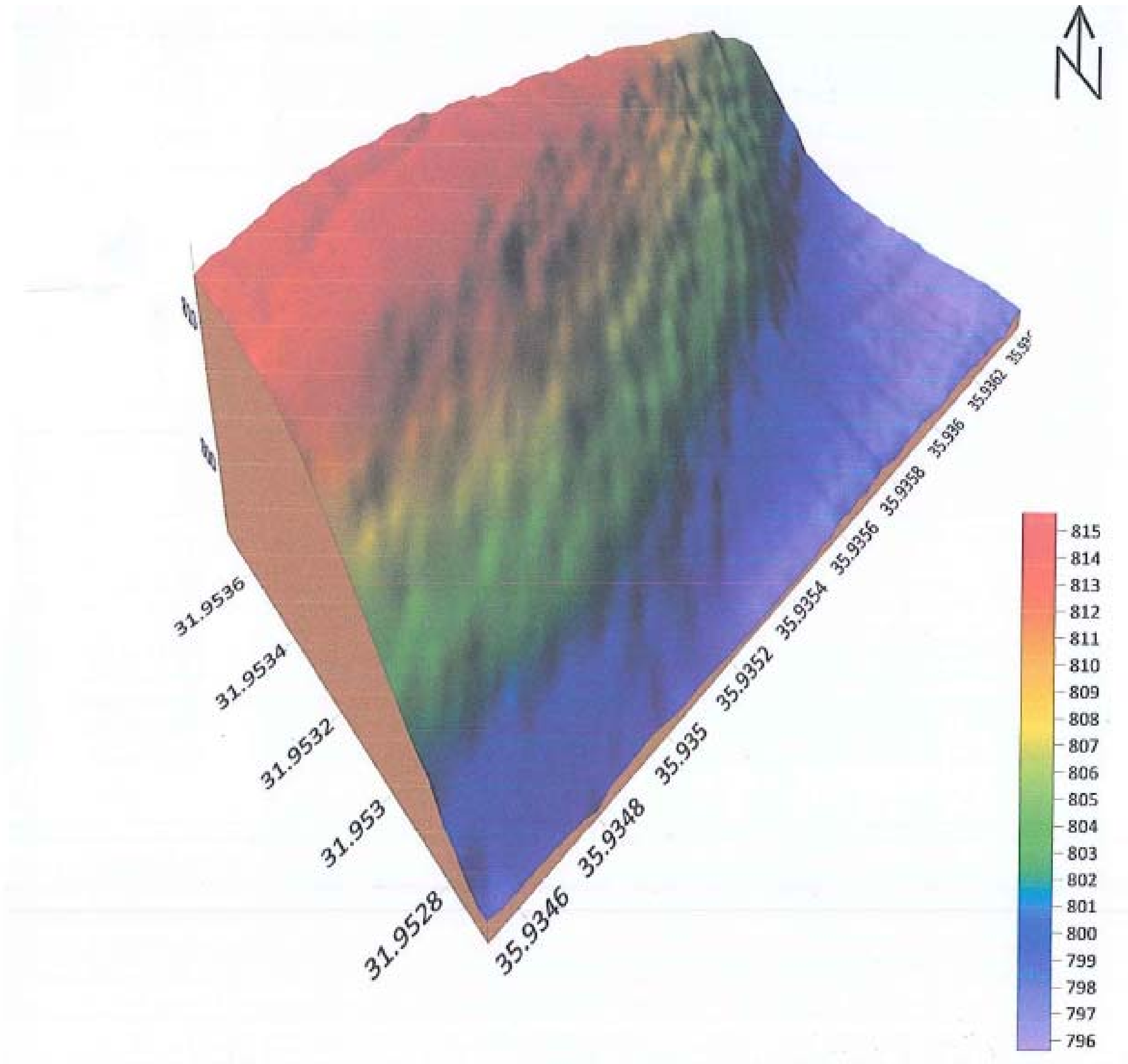


Figure 11 - Slope Stability 3D Elevations

6.2 Test Pits (Classification Study)

Slope Stability

Depending on the test pits study results and the topographic measures; the slope stability is calculated as follows:

$$Slope = \frac{\text{Difference in elevation}}{\text{Horizontal Distance}}$$

Test Pit No. 1

$$Slope = \frac{(815.65-814.97)}{5.983} *100$$

Slope = 11.37%

Ø = 28°, from laboratory results

11.37 < 28° → Safe

Recommendation: Slope is Safe

Test Pit No. 2

$$Slope = \frac{(812.22-811)}{4.03} *100$$

Slope = 30.2

Ø= 32°, from laboratory results

30.2 < 32° → Safe

Recommendation: The slope can be relieved to be less than 25°

Test Pit No. 3

$$Slope = \frac{(811.02-810.1)}{5.86} *100$$

Slope = 15.7

Ø = 26°, from laboratory results

15.7 < 26° → Safe

Recommendation: Slope is Safe

Test Pit No. 4

$$\text{Slope} = \frac{(812.5-810.5)}{8.76} * 100$$

Slope = 22.8

Ø= 28°, from laboratory results

22.8 < 28° → Safe

Recommendation: Slope is Safe

Jordan Seismic Zones
Jordan Code for Earthquakes

7.1 Earthquake Recommendation

The site is located within zone (2A) of the Jordan earthquake map. According to the map (12) from Jordan code for earthquakes (see Figure 12):

The soil profile is described as SC from table (1–2).

Z: the coefficient of the earthquake zone = 0.15 from table (2–2).

Ca: coefficient of earthquake = 0.18 from table (3–2).

Cv: coefficient of earthquake = 0.25 from table (4–2).

We suggest that the structural engineer take into consideration the above factors, and any future effect due to earthquakes, especially with regard to the footing system.

Figure 12- Seismicity and Earthquake Map

٢/٣/٢ جيولوجية الموقع وصفات التربة:

يُعـيّن نوع مقطع التربة لكل موقع بناء على بيانات جيوتقنية موثقة وحسب تصنيف المواقع المبيّن في المادة (٢/٩)، والجدول (٢-١). وفي حال عدم معرفة خصائص التربة بالتفصيل الكافي لتحديد نوع مقطع التربة فيجب استخدام النوع (S_D).

الجدول (٢-١): أنواع مقطع التربة

نوع مقطع التربة	اسم مقطع التربة/ الوصف العام	معدّل خواص التربة في مسافة (30) متراً العلوية من مقطع التربة		
		سرعة أمواج القص ($\bar{V}_s$) (م/ثانية)	فحص الاختراق المعياري ($\bar{N}$) أو لطبقات التربة المفككة ($\bar{N}_{CH}$) (عدد الضربات/(٣٠٠) مم)	مقاومة القص بدون تصريف ($\bar{S}_u$) (كيلو باسكال)
S_A	صخر قاسٍ	>1500	-	-
S_B	صخر	760-1500		
S_C	تربة عالية الكثافة وصخر طري	360-760	> 50	> 100
S_D	مقطع تربة صلدة	180-360	15-50	50-100
S_E[1]	مقطع تربة طرية	< 180	< 15	< 50
S_F	تربة تتطلب تقييماً خاصاً للموقع، أنظر البند (٢/٩/١).			

[1] يتضـمّن نـوع مقطع التربة (S_E) أي نـوع مقطع تـربة يزيد فيه عمق التربة الطينية عن (3) أمتار مع ($PI>20$) و($W_{mc}\geq40\%$) و($\bar{S}_u<25$) كيلو باسكال. ويتم تحديد دليل اللدونة ونسبة محتوى الرطوبة وفقاً للمقاييس الوطنية المعتمدة.

٣/٣/٢ الخطورة الزلزالية للموقع:

(أ) المنطقة الزلزالية:

تُعـيّن المنطقة الزلزالية للموقع حسب الشكل (٢-١). ويُعـيّن عامل المنطقة الزلزالية (Z) لكل منشأ حسب الجدول (٢-٢).

(ب) معاملات التجاوب الزلزالي:

يُعـيّن المعامل الزلزالي المنسـوب للتسارع (C_a) لكـل منشأ حسب الجدول (٢-٣) والمعامل الزلزالي المنسوب للسرعة (C_v) حسب الجدول (٢-٤).

USAID FROM THE AMERICAN PEOPLE

acor أكور المركز الأمريكي للأبحاث AMERICAN CENTER OF RESEARCH

الجدول (٢-٢): عامل المنطقة الزلزالية (Z)

3	2B	2A	1	المنطقة
0.30	0.20	0.15	0.075	Z

ملاحظة: يجب تحديد المنطقة من خارطـــة التقسيم الزلزالي في الشكل (٢-١).

الجدول (٢-٣): المعامل الزلزالي (C_a)

عامل المنطقة الزلزالية Z				نوع مقطع التربة
Z = 0.3	Z = 0.2	Z = 0.15	Z = 0.075	
0.24	0.16	0.12	0.06	S_A
0.30	0.20	0.15	0.08	S_B
0.33	0.24	0.18	0.09	S_C
0.36	0.28	0.22	0.12	S_D
0.36	0.34	0.30	0.19	S_E
يجب إجراء تحريات جيوتقنية وتحليلات ديناميكية خاصة للموقع لتحديد المعاملات الزلزالية لنوع مقطع التربة (S_F).				S_F

الجدول (٢-٤): المعامل الزلزالي (C_v)

عامل المنطقة الزلزالية Z				نوع مقطع التربة
Z = 0.3	Z = 0.2	Z = 0.15	Z = 0.075	
0.24	0.16	0.12	0.06	S_A
0.30	0.20	0.15	0.08	S_B
0.45	0.32	0.25	0.13	S_C
0.54	0.40	0.32	0.18	S_D
0.84	0.64	0.50	0.26	S_E
يجب إجراء تحريات جيوتقنية وتحليلات ديناميكية خاصة للموقع لتحديد المعاملات الزلزالية لنوع مقطع التربة (S_F).				S_F

٢/٣/٤ فئات الإشغال:

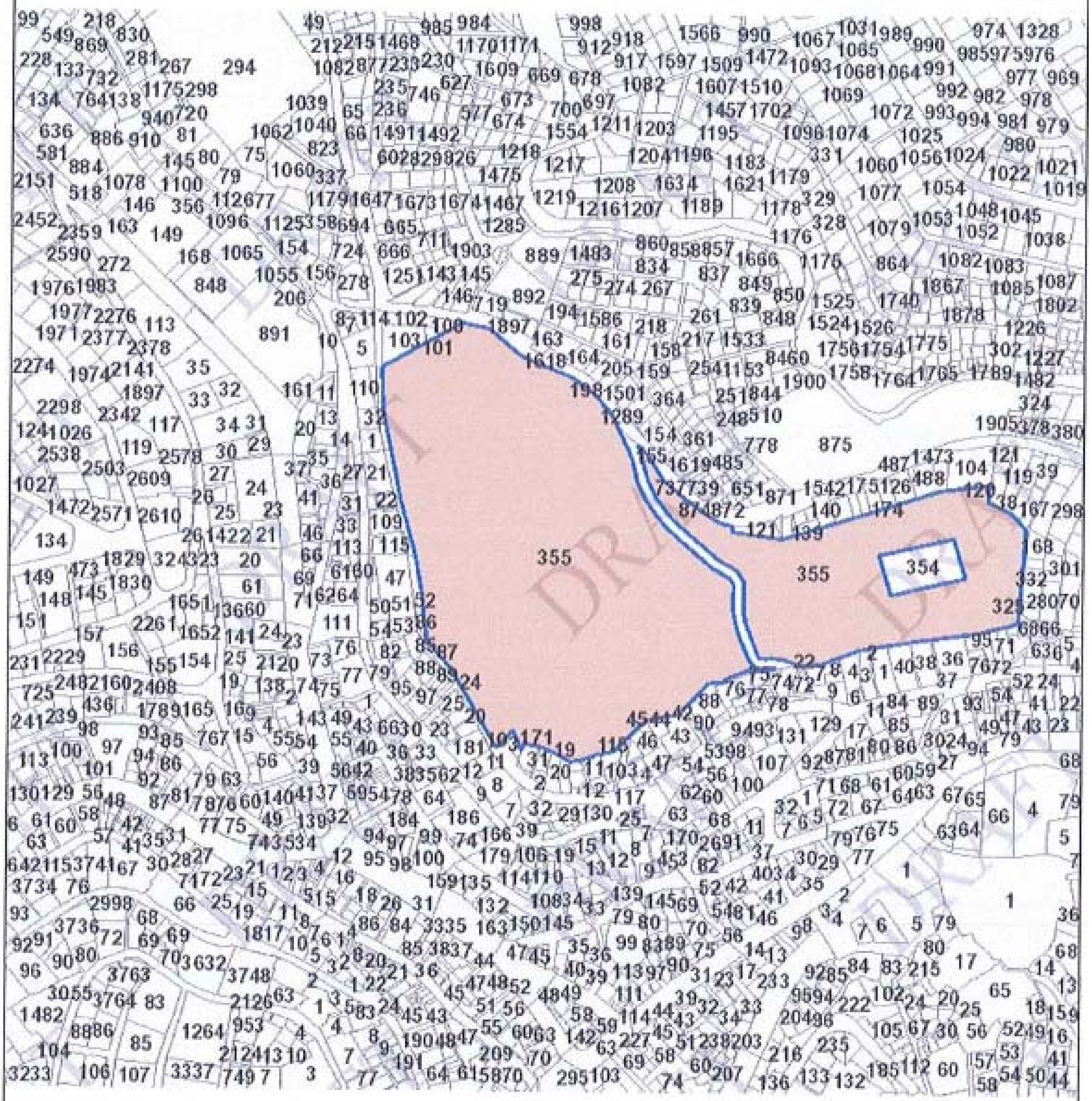
لأغـــــراض التصـــميم لمقاومـــة الزلازل، يُصنّف كل منشأ في إحدى فئات الإشغال الـــواردة في الجدول (٢-٥)، ويُعـــيّن عامل الأهمية (I) لكامل المنشأ و(I_p) للجزء أو العنصر في المنشأ كما هو مبيّن لكل فئة.

المملكة الأردنية الهاشمية

دائرة الأراضي والمساحة

مخطط اراضي

المحافظة:	محافظة العاصمة	الحوض:	المدينه	33	
المديرية:	اراضي عمان	الحي:	جبل القلعه	4	
القرية:	عمان 1	رقم القطعة:	00355		



مقياس الرسم: 5000

التاريخ: 18/12/2022

المملكة الأردنية الهاشمية

دائرة الأراضي والمساحة

إحداثيات النقاط المحيطة بالقطعة

المحافظة:	محافظة العاصمة	الحوض:	المدينه 033
المديرية:	اراضي عمان	الحي:	جبل القلعه 004
القرية:	عمان 0001	رقم القطعة:	00355

	الوصف	إحداثي X	إحداثي Y
1	تسوية / اسود	238387.76	1151407.56
2	غير معرف	238434.832	1151370.836
3	غير معرف	238342.91	1151531.9
4	تسوية / اسود	238342.91	1151531.9
5	تسوية / اسود	238450.6	1151352.29
6	تسوية / اسود	238450.6	1151352.29
7	تسوية / اسود	238464.79	1151349.21
8	تسوية / اسود	238494.45	1151335.19
9	تسوية / اسود	238522.34	1151342.55
10	تسوية / اسود	238543.58	1151351.08
11	تسوية / اسود	238615.8	1151396.75
12	تسوية / اسود	238630.28	1151412.16
13	غير معرف	238643.956	1151412.695
14	تسوية / اسود	238671.15	1151422.44
15	افراز / احمر	238771.202	1151574.363
16	تسوية / اسود	238902.85	1151590.482
17	تسوية / اسود	238904.14	1151465.75
18	افراز / احمر	238914.573	1151584.566
19	تسوية / اسود	238924.568	1151580.109
20	تسوية / اسود	238932.92	1151473.2
21	افراز / احمر	238937.796	1151536.666
22	تسوية / اسود	238309.59	1151675.44
23	غير معرف	238318.939	1151677.029
24	تسوية / اسود	238523.96	1151341.76
25	تسوية / اسود	238539.01	1151346.07
26	تسوية / اسود	238551.96	1151359.17
27	تسوية / اسود	238600.85	1151381.75
28	تسوية / اسود	238600.85	1151381.75
29	تسوية / اسود	238605.58	1151386.66

Hydrological study

8.1 Description of the Area

The Amman Citadel is one of the most significant historical sites in the city. It is located along King Ali bin al-Hussein Street on a hill that provides views of Amman's center as shown in Figure 1. It is an exceptionally rich archaeological site with monuments.

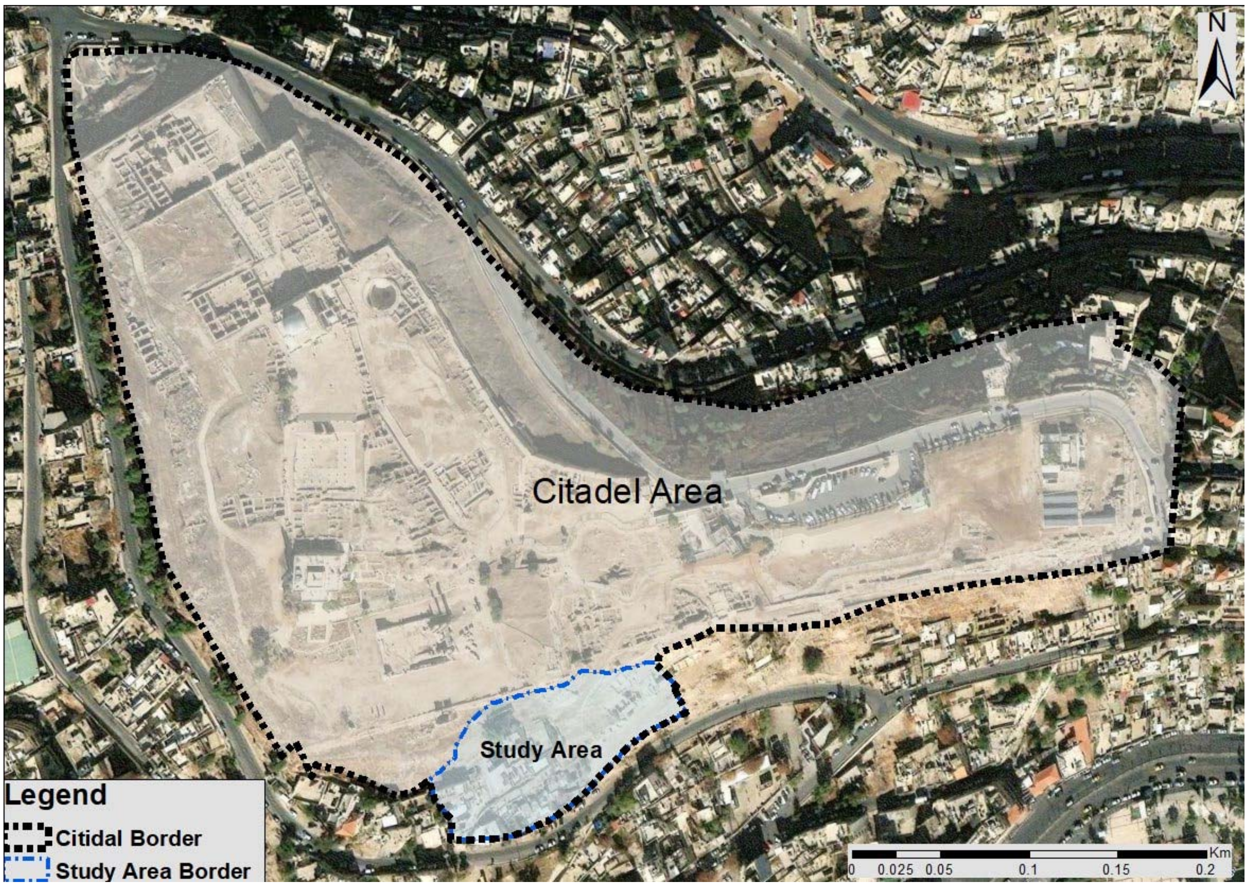


Figure 13 - Study Area

8.2 Catchment Area

The catchment area that discharges storm water runoff toward the southern area of Amman Citadel as shown in Figure 14 was delineated from available digital elevation model files, with a total area of about 2.57 hectare (25,700 m^2), the characteristics of the catchment are presented in Table 19.

Figure 14 - Catchment Area of Southern Area of Jabal Al Qala'a

Table 18 - Catchment Area Characteristics

Catchment Area	Area (ha)	Maximum flow distance (m)	Mean Basin Elevation (m)	Slope (m/m)	Curve Number	Lag Time (Min)	Time of Concentration (Min)
	2.57	429	822	0.16	69	3.2	5.4

8.3 The Observations from Site Visit

The existing stormwater drainage is made up of grates that drain water into drainage pipes that free discharge the water to the study area of (Figure 15).

Figure 15 - Stormwater Drain Grates

8.4 Objectives of The Hydrology Study

The hydrology study conducted for the project estimated the stormwater runoff that would be generated by the catchment area under various storm return periods.

The following principles formed the foundation for the hydrological study:

- Rainfall analysis: This study examined the rainfall statistics that are now available and used statistical analysis to extrapolate the data to storms with extreme values, such as the storm with a 100-year return period.

- Models for simulating rainfall and runoff were used to transform rainfall to runoff.
- The simulation models were used to generate runoff hydrographs, which are then utilized to estimate the peak flow rates and quantities of stormwater runoff.

8.5 Rainfall Data Analysis

Roads and properties are protected from frequent floods by storm water drainage systems. Such flooding may result from runoff from catchments that contribute drainage flows toward the targeted properties or from rain directly falling on the property. This study quantifies the catchment area that contributes to the Southern Area of Amman Citadel and recommends a drainage approach to enhance site drainage.

8.6 Storm Return Period

Return period is the average number of year between storm events equal to and exceeding the design storm. The 10, 25, 50 and 100-year return period will be investigated for the Southern Area of Amman Citadel area.

8.7 Rainfall Gage Station

The Amman Hussein College station was adopted for this study. Daily rainfall data were collected from Jordan's Water Authority from 1987 to 2019. The daily record was used to determine the Maximum Daily Rainfall for the Amman Hussein College station, and statistical analysis were done on these records. The maximum daily rainfall at Amman Hussein College station is shown in the Figure 16 and Table 20.

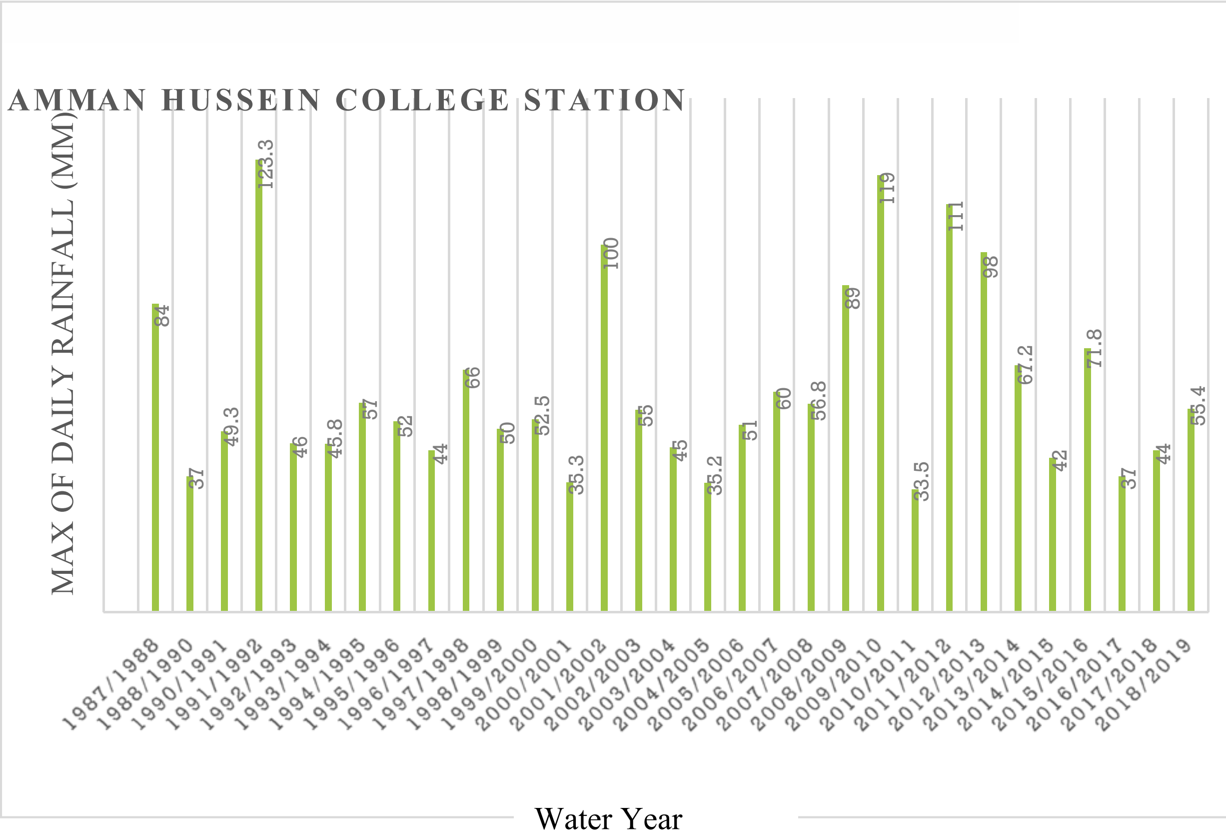


Figure 16 - The Maximum Daily Rainfall for Amman Hussein College Station

Table 19 - The Maximum Daily Rainfall for Amman Hussein College Station

Water Year	Max of Daily Rainfall (mm)
1987/1988	84
1988/1990	37
1990/1991	49
1991/1992	123
1992/1993	46
1993/1994	46
1994/1995	57
1995/1996	52
1996/1997	44
1997/1998	66
1998/1999	50
1999/2000	53
2000/2001	35
2001/2002	100
2002/2003	55
2003/2004	45
2004/2005	35
2005/2006	51
2006/2007	60
2007/2008	57
2008/2009	89
2009/2010	119
2010/2011	34
2011/2012	111
2012/2013	98
2013/2014	67
2014/2015	42
2015/2016	72
2016/2017	37
2017/2018	44
2018/2019	55

Based on records from past years, the maximum 24-hour rainfall depth for each water year (October to May) were determined and ranked in order to determine how frequently they will be exceeded. The probability of exceedance for the 24-hour rainfall depth is shown in the Figure 16.

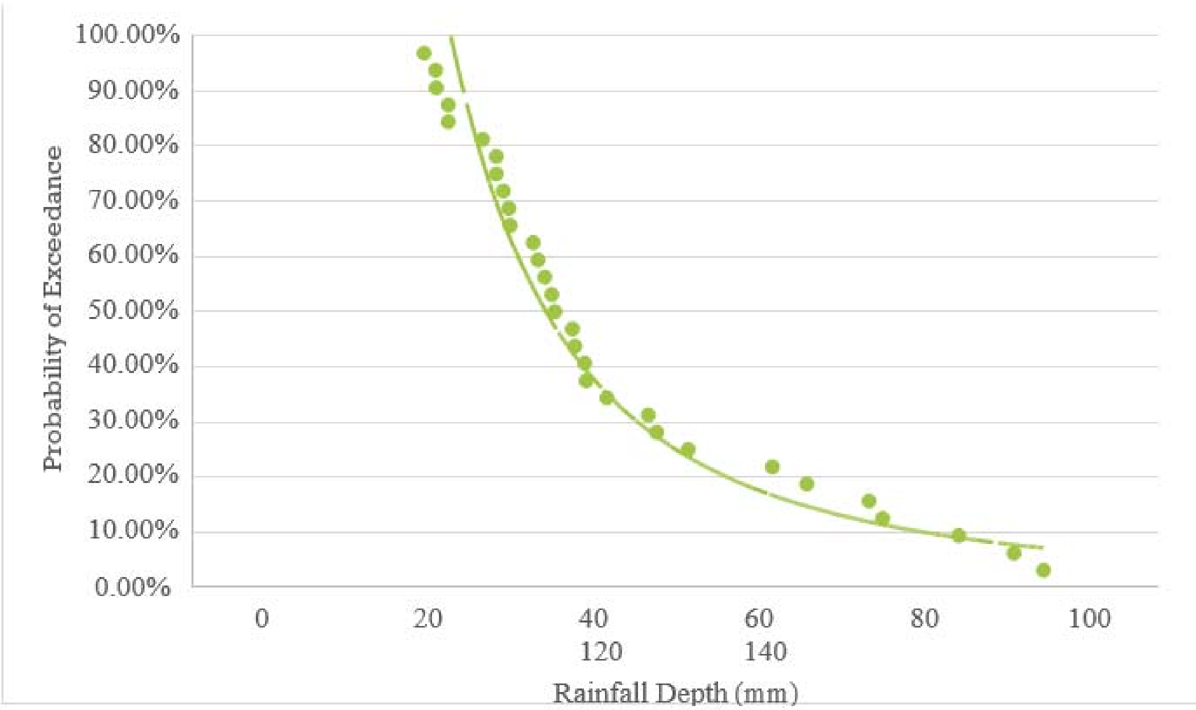


Figure 17 - 24-Hour Rainfall Exceedance Probability for Amman Hussein College Station

The 24-hour maximum rainfall depth for the 10, 25 and 50 and 100 year return period was estimated using the Exponential distribution by Hyfran Plus Software as shown in Figure 18 and the Table 21.

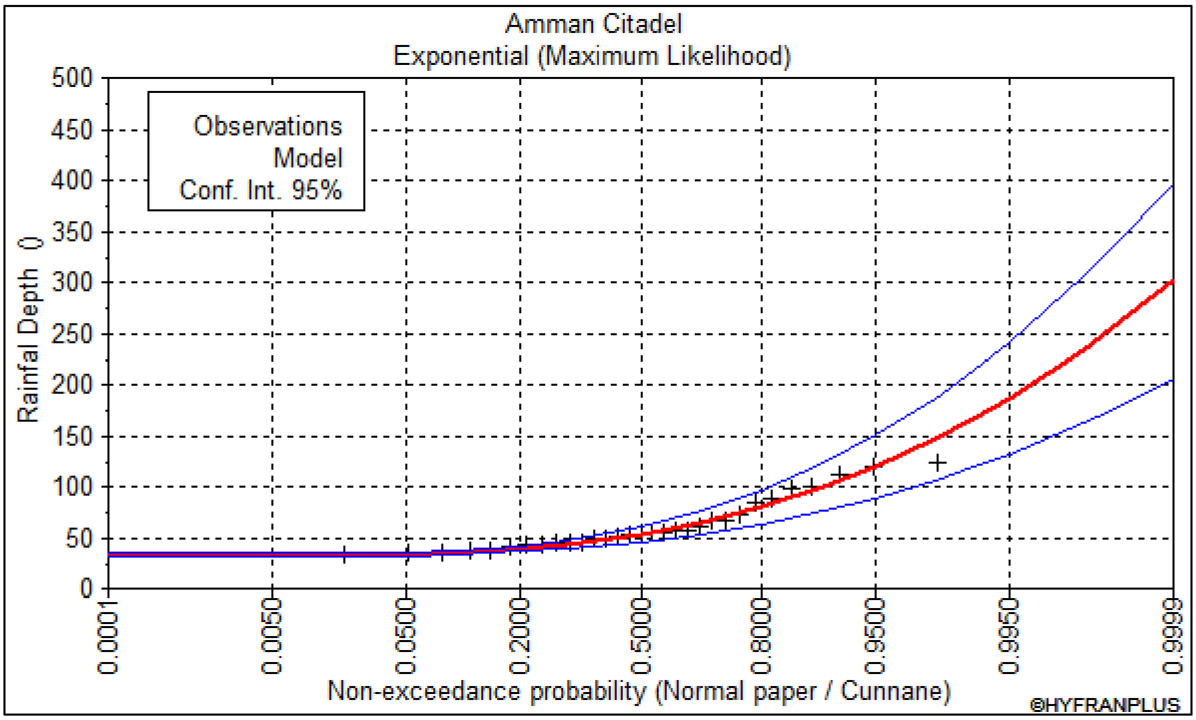


Figure 18 - Statistical Distribution using Hyfran Software for Amman Hussein College Station

Table 20 - 24-Hour Rainfall Depth for Amman Hussein College station

Return Period (Year)	Rainfall depth (mm)
10	100
25	126
50	147
100	167

8.8 Rainfall-Runoff Modeling

The unit hydrograph method was adopted to determine the peak discharges and volumes of runoff for the catchment area that discharges flow toward South Area of Amman Citadel.

8.9 The Unit Hydrograph Theory

The unit hydrograph theory is based on the property of proportionality and the principle of superposition. The linearity of a watershed assumes that

- Rainfall excesses of equal duration produce hydrographs with equivalent time bases, and
- Direct runoff ordinates are directly proportional to rainfall excess volumes.

These linear assumptions are useful because they are relatively simple and are the best developed methods, and the results obtained are acceptable for hydrological simulation purposes.

Unit hydrographs are produced for gaged watersheds from historical records and are then applied to predict the basin's response to design storm events. However, when stream flow data are not available to develop the unit hydrograph, other methods can be applied to relate hydrograph peak flow and timing to basin characteristics. These are normally referred to as Synthetic Unit Hydrographs.

For this study the SCS dimensionless unit hydrograph method was used to develop synthetic unit hydrographs.

8.10 Soil Conservation Service (SCS) Method

L = 0.6 tc

Where:

L is the basin lag time

tc is the time of concentration

The time of concentration is the time of equilibrium, at which time the whole catchment contributes to flow at the outfall.

A number of equations were developed by researchers to estimate the time of concentration for different basins and boundary conditions. For this study, the Kirpich equation was used in estimating the time of concentration as follows:

tc = 0.0195 L0.77 S-0.385

tc = Time of concentration (min);

L = Length of channel from headwater to outlet (m);

S = Average watershed slope (m/m), which is the difference in elevation between the outlet and the most remote point divided by the length (L).

8.11 Application of The Unit Hydrograph Theory

The Unit hydrograph is used to compute the design discharge of a watershed as follows:

A. Develop Design Precipitation Hyetographs: The design hyetograph was developed from the Intensity-Duration-Frequency (IDF) curves using the Alternate Block Method. The design hyetograph produced by this method specifies the precipitation depth occurring in n successive time intervals of duration Δt over a total duration $T = n \Delta t$. After selecting the design return period, the intensity is read from the IDF curves for each of the durations Δt, $2 \Delta t$, $3 \Delta t$, etc., and the corresponding precipitation depth found as the product of intensity and duration. By taking differences between successive precipitation depth values, the amount of precipitation to be added for each additional unit of time Δt is found. These increments, or blocks, are re-ordered into a time sequence with the maximum intensity occurring in the center of the required duration T, and the remaining blocks arranged in descending order alternately to the right and left of the central block to form the design hyetograph.
B. Compute Rainfall Excess: The rainfall excess is the resulting rainfall after accounting for losses due to precipitation and infiltration. The rainfall excess was computed using the SCS Curve Number Method, which abstracts initial loss.
C. Cumulative rainfall excess as a function of cumulative precipitation is calculated using the following equations:
   S = (1000 / CN) –10
   Where S is the potential abstraction in inches.
   Ia = 0.2 S
   Where Ia is the initial abstraction in inches, and in this project, it will be assumed to equal zero.

R = (P-Ia) 2 / (P – Ia + S)
Where:
R = Rainfall Excess (in) P = Precipitation (in) Infiltration = P – R

A. Sub-basin Runoff Calculation: Computation of runoff from the sub-basin was carried out by applying the convolution equation. In this process, the unit hydrograph ordinates are multiplied by the rainfall excess and added and lagged in sequence to produce the resulting storm hydrograph. The discrete convolution equation can be written in the following form:

$$Q_n = \sum_{m=1}^{n \leq M} P_m U_{n-m+1}$$

B. Baseflow Calculation: The baseflow of the catchments in the study area is either zero or negligible compared with the direct runoff of the design storm, which dominates the peak of the hydrograph, and as such it will not be added to the storm hydrograph.

8.12 Runoff Coefficients

The SCS Curve Number Method requires soils types to assess infiltration versus runoff percentages. Soil properties influence the process of generation of runoff from rainfall and they must be considered in the runoff estimation. The SCS defined four hydrologic soil groups (A, B, C and D) as given in Table 16.

Table 21 - The SCS Hydrologic Soil Groups

Soil Group	Description
A	Deep sand, deep loess, aggregated silts group
B	Shallow loess, sandy loam
C	Clay loams, shallow sandy loam, soils low in organic content, and
D	Soils that swell significantly when wet, heavy plastic clays

The Soil types of catchments areas are defined based on online maps of the Harmonized World Soil Database v 1.2, the hydrologic soil group "B" is adopted for the study area as shown in Figure 18, the runoff curve number CN=69 is adopted for the site conditions from Table 17.

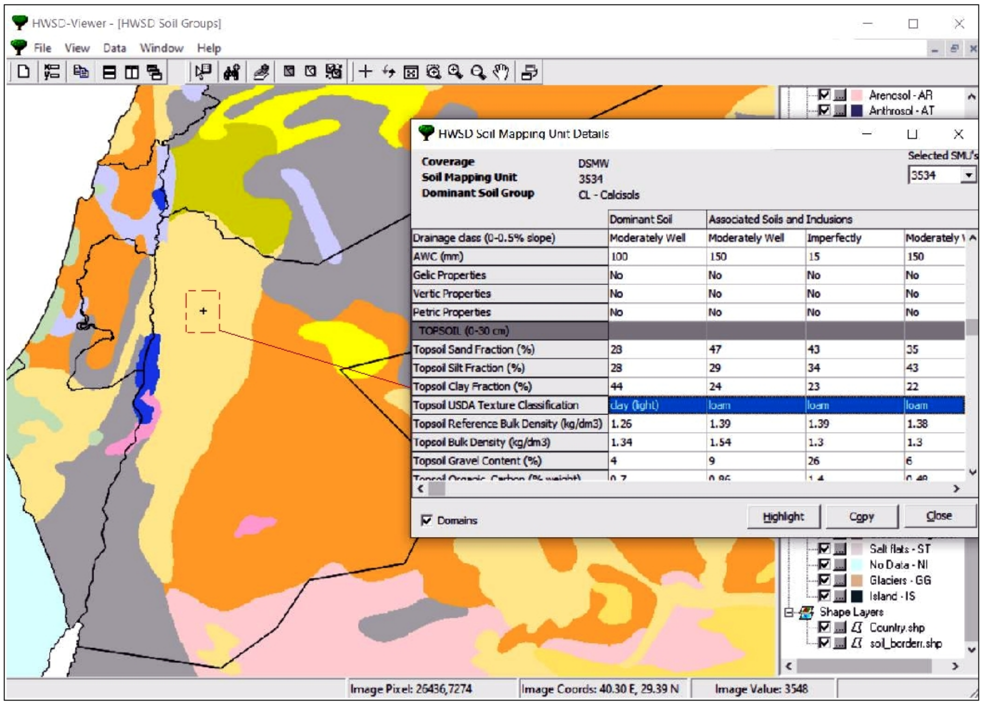


Figure 19 - Soil Type Classification of the Catchment Area

Table 22 - Runoff Curve Numbers

Land Use Description		Hydrologic Soil Group A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential[3]:					
Average lot size	Average % impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

8.13 Simulation of Software

The generation of runoff from rainfall will be modeled using the HEC-HMS software, developed by the U.S. Army Corps of Engineers.

8.14 Runoff Quantities

Using HEC-HMS software, the flood hydrographs were calculated for the various return periods. The following Table 6 summarizes the flow calculations results, and the figures below show the generated hydrographs for the different return periods.

Table 23 - Flow Calculations Results

Return Period (year)	Peak discharge (Q) m^3/s	Volume 1000 m^3
10	0.2	0.8
25	0.4	1.3
50	0.5	1.7
100	0.6	2.1

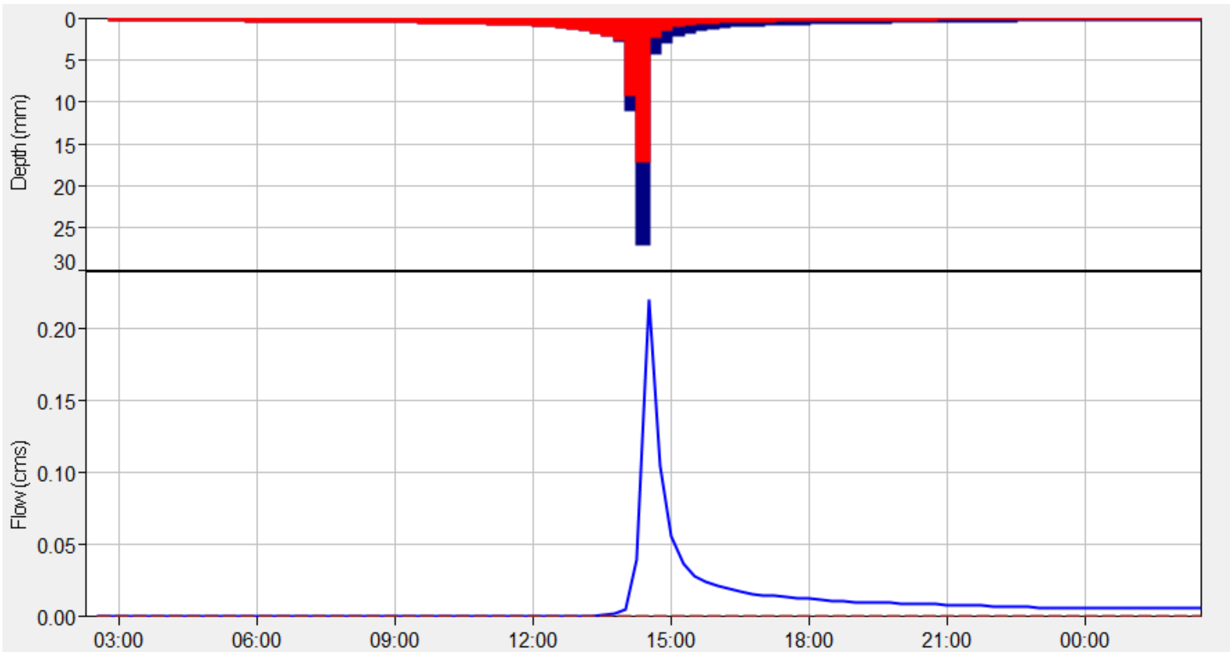


Figure 21 - 10 Year Return Periods Hydrograph

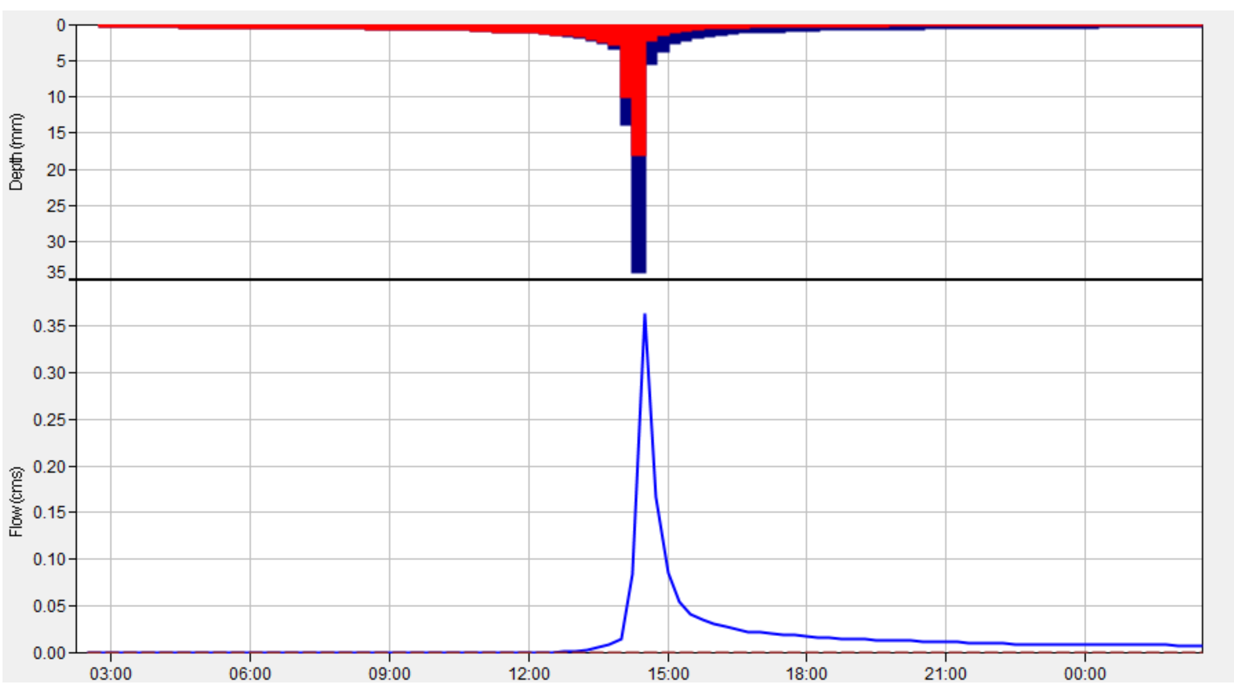


Figure 20 - 25 Year Return Periods Hydrograph

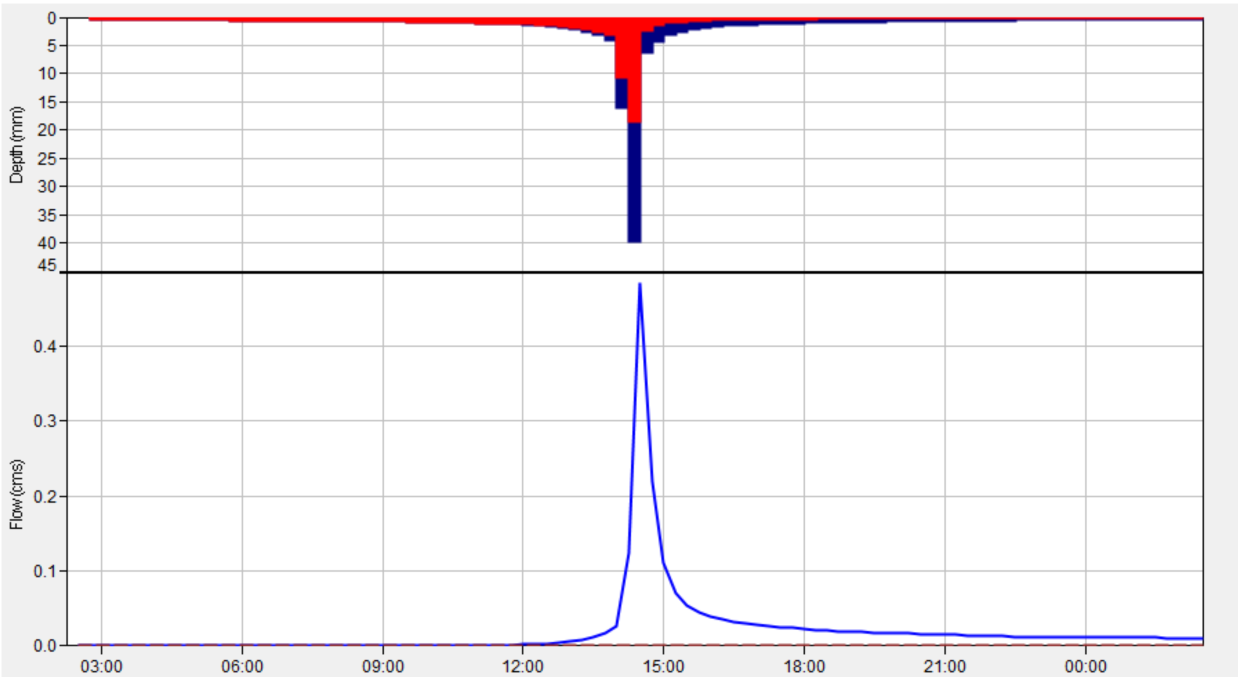


Figure 23 - 50 Year Return Periods Hydrograph

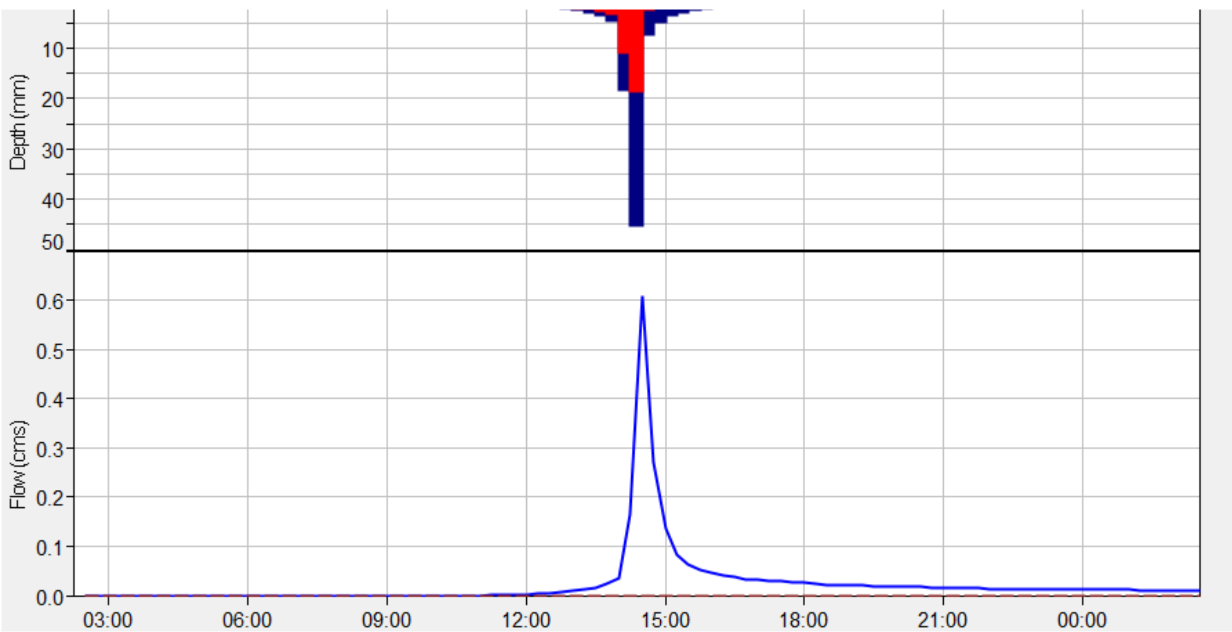


Figure 22 - 100 Year Rete run Periods Hydrograph

8.15 Runoff Quantities for the Sub Catchment of the Study Area

The study area is affected by the storm water runoff generated from the sub catchment area which delineated from available digital elevation model, the sub catchment area is shown in the Figure 23 and the characteristics of the catchment are presented in Table 19.

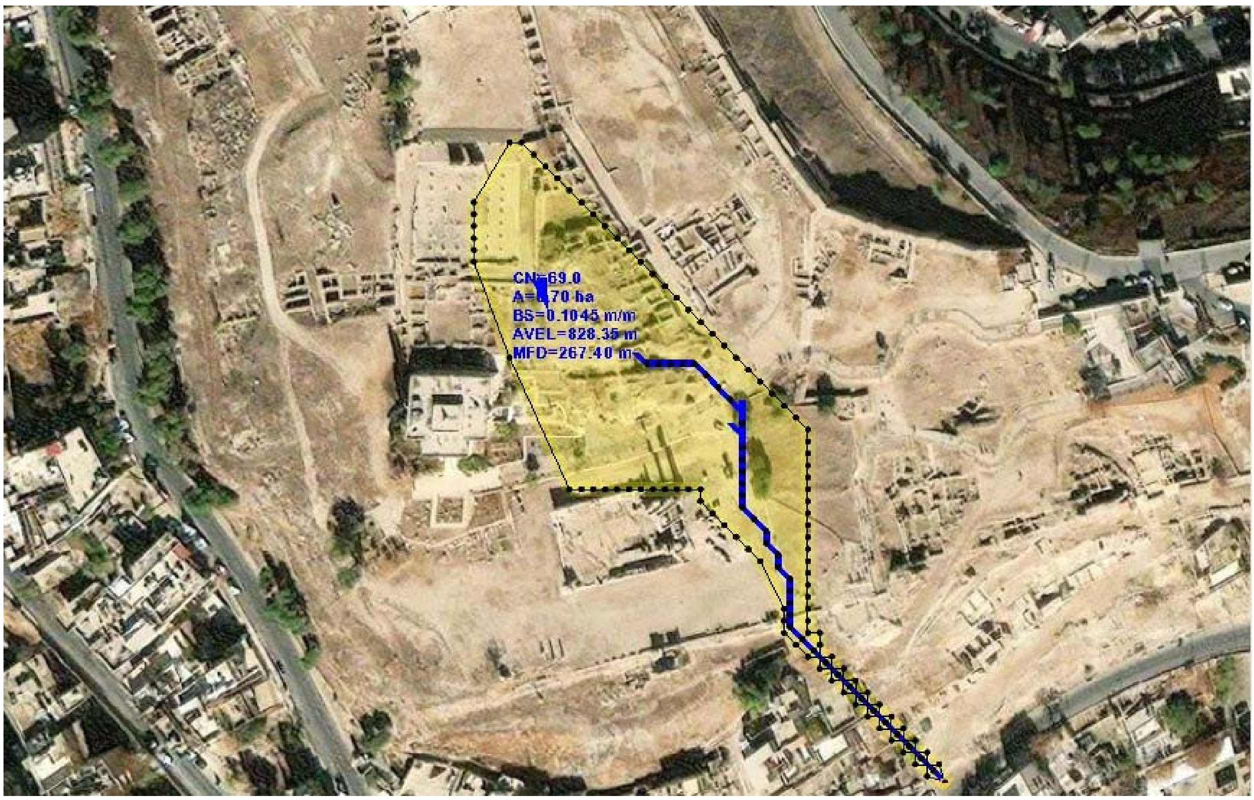


Figure 24 - Sub Catchment Area

Table 24 - Catchment Area Characteristics

Sub Catchment Area	Area (ha)	Maximum flow distance (m)	Mean Basin Elevation (m)	Slope (m/m)	Curve Number	Lag Time (Min)	Time of Concentration(Min)
	0.7	267	828	0.1	69	1.8	3.0

Using HEC-HMS software, the flood hydrographs were calculated for the sub catchment area for the various return periods. The following Table 8 summarizes the flow calculations results, and the figures below show the generated hydrographs for the different return periods.

Table 25 - Flow Calculations Results for the Sub Catchment Area

Return Period (year)	Peak discharge (Q) m^3/s	Volume 1000 m^3
10	0.06	0.217
25	0.097	0.341
50	0.129	0.541
100	0.162	0.561

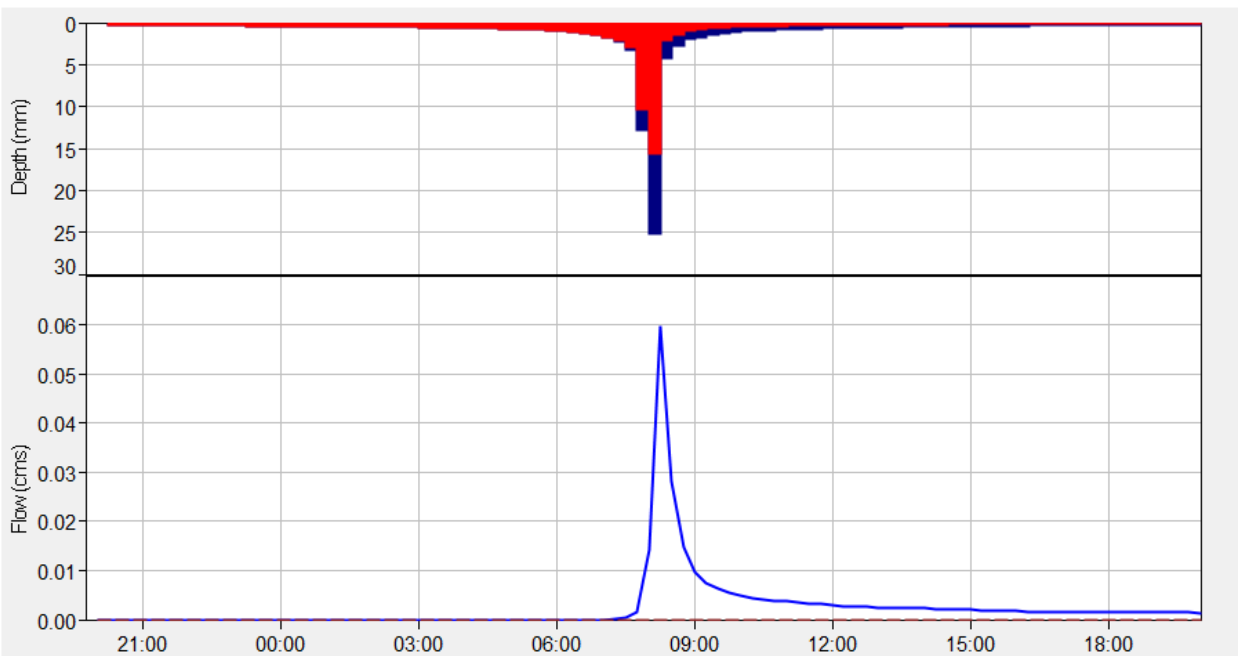


Figure 25 - 10 Year Return Periods Hydrograph

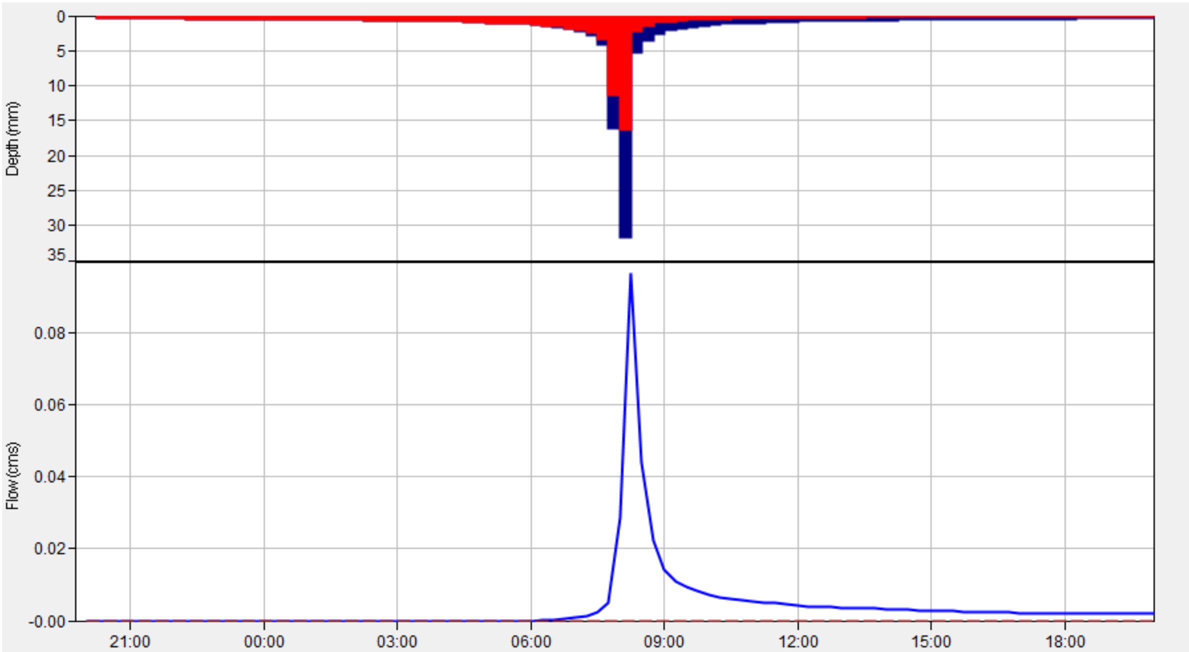


Figure 26 - 25 Year Return Periods Hydrograph

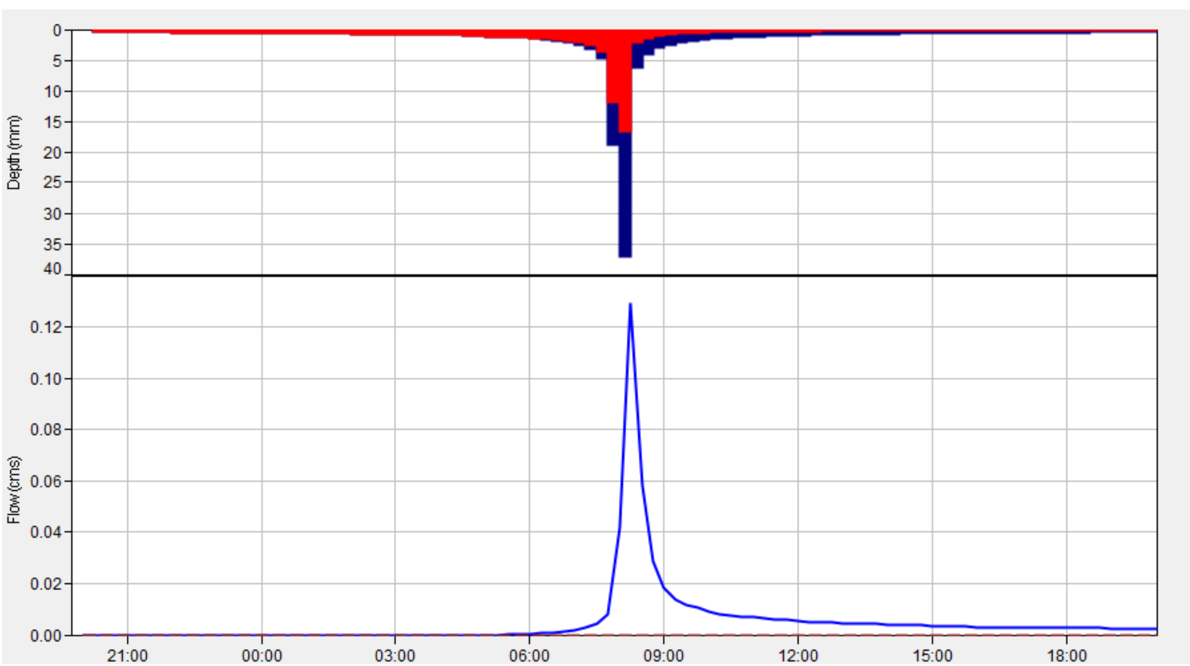


Figure 27 - 50 Year Return Periods Hydrograph

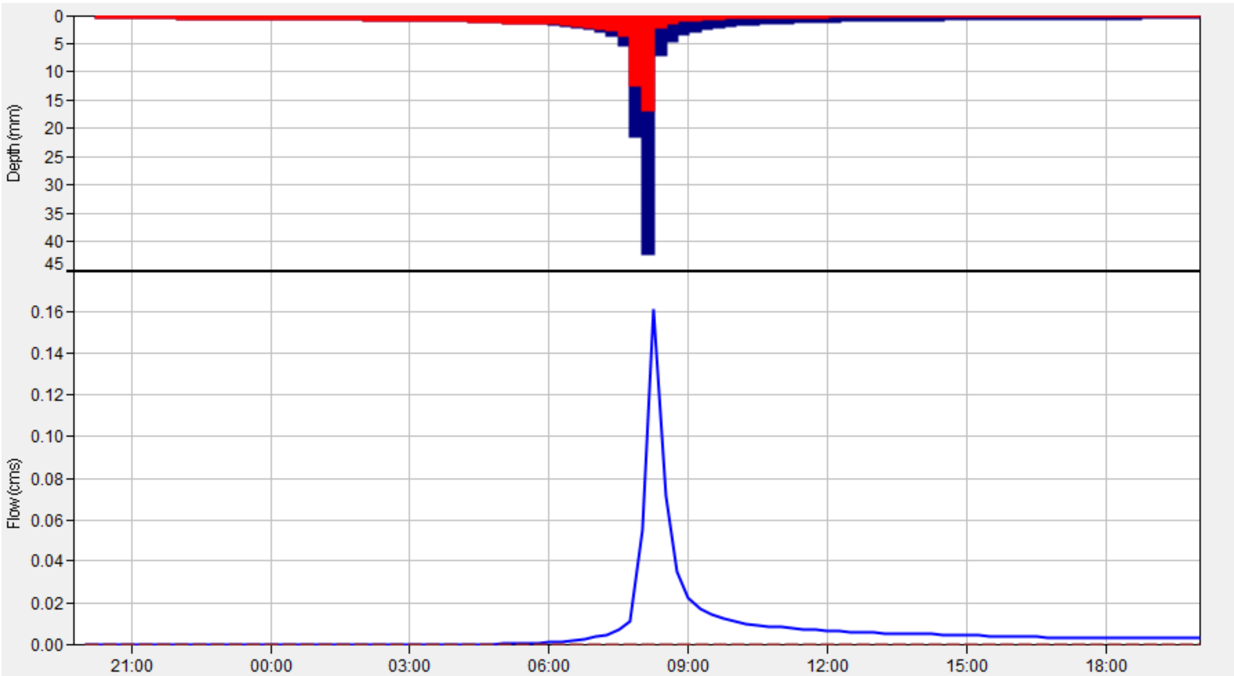


Figure 28 - 100 Year Return Periods Hydrograph

8.16 Proposed Mitigation Measures

Based on the results of the pre mentioned hydrological analysis there is a major and a minor stream that passes in the study area that needed to be drained by suitable hydraulic structure to ensure the study area protection.
The mitigation measures are to drain flood of 25 Yr. return period and checked against 50 Yr. return period resulting from the flood streams.

The proposed mitigation measures are summarized as following:

Option 1a (shown in blue)

- Proposing a Main rectangular channel to drain the 25 Yr. flood of the catchment area to mitigate the flood toward the study area, the channel dimensions are 0.7 m width, 0.3 m depth with approximate length of 150 m and the construction slope shall not be less than 1%, the path of the proposed channel is shown in Figure 17 and the calculations results of the used Software Flow Master are presented Table 10.

Option 1b (shown in red)

- Proposing a secondary rectangular channel to drain the 25 Yr. flood of the sub catchment area to mitigate the flood toward the study area, the channel dimensions are 0.4m width, 0.2 m depth with approximate length of 170 m and the construction slope shall not be less than 1%, the path of the proposed channel is shown in Figure 20 and the calculations results of the used Software Flow Master are presented Table 9.

Option 1

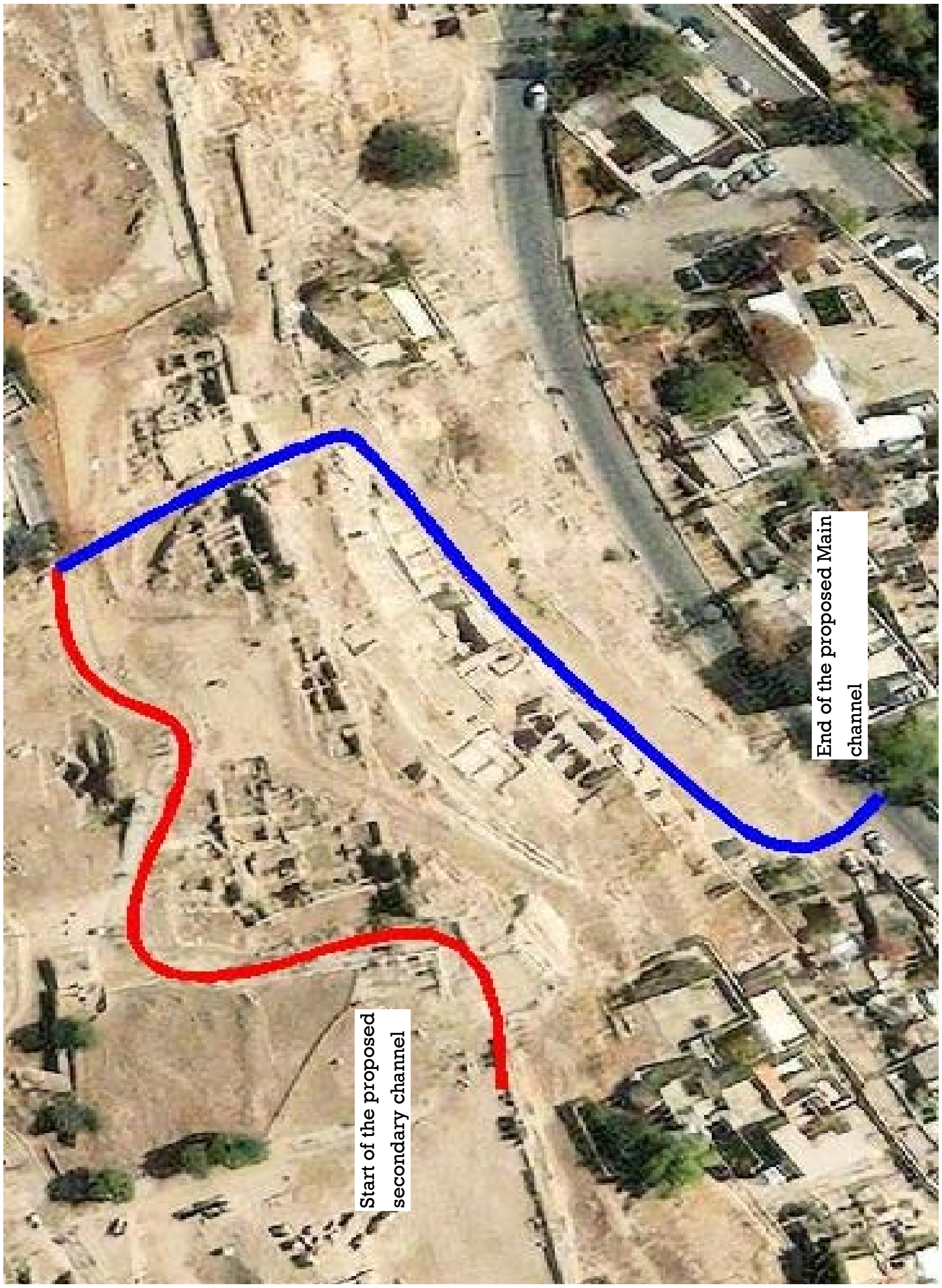


Figure 29 - Path for the Proposed Channels

Table 27 - Calculations for the Proposed Main Rectangular Channel for 25 Yr. Flood Eventd

Worksheet for Proposed Secondary Rectangular Channel

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.010 m/m
Normal Depth	0.2 m
Bottom Width	0.40 m

Results	
Discharge	0.13 m^3/s
Flow Area	0.1 m^2
Wetted Perimeter	0.8 m
Hydraulic Radius	0.1 m
Top Width	0.40 m
Critical Depth	0.2 m
Critical Slope	0.007 m/m
Velocity	1.66 m/s
Velocity Head	0.14 m
Specific Energy	0.34 m
Froude Number	1.183
Flow Type	Supercritical

Table 28 - Calculations for the Proposed Main Rectangular Channel for 25 Yr. Flood Event

Worksheet for Proposed Main Rectangular Channel

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.010 m/m
Normal Depth	0.3 m
Bottom Width	0.70 m

Results	
Discharge	0.49 m^3/s
Flow Area	0.2 m^2
Wetted Perimeter	1.3 m
Hydraulic Radius	0.2 m
Top Width	0.70 m
Critical Depth	0.4 m
Critical Slope	0.006 m/m
Velocity	2.30 m/s
Velocity Head	0.27 m
Specific Energy	0.57 m
Froude Number	1.327
Flow Type	Supercritical

Option 2

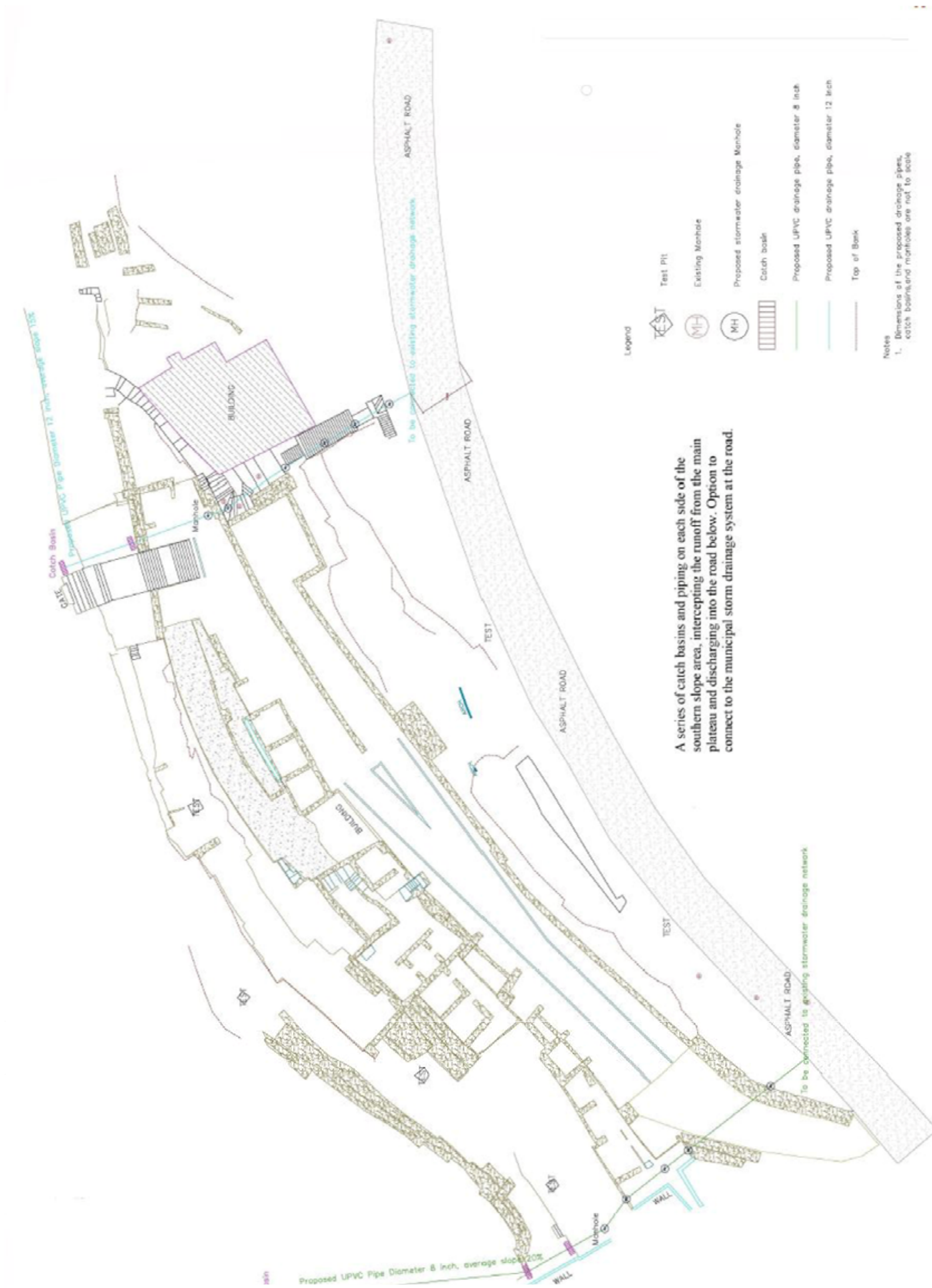


Figure 30 - Catch Basin and Piping Paths

9.1 References

- Chow.V. T., Maidment, D. R., Mays, L.W. (1988). Surface Water. Applied Hydrology. United Sates: McGraw-Hill Book Company.
- Harmonized World Soil Database v 1.2.
- Jordan's Water Authority.

Southern Slope Drainage Design

10.1 Designs

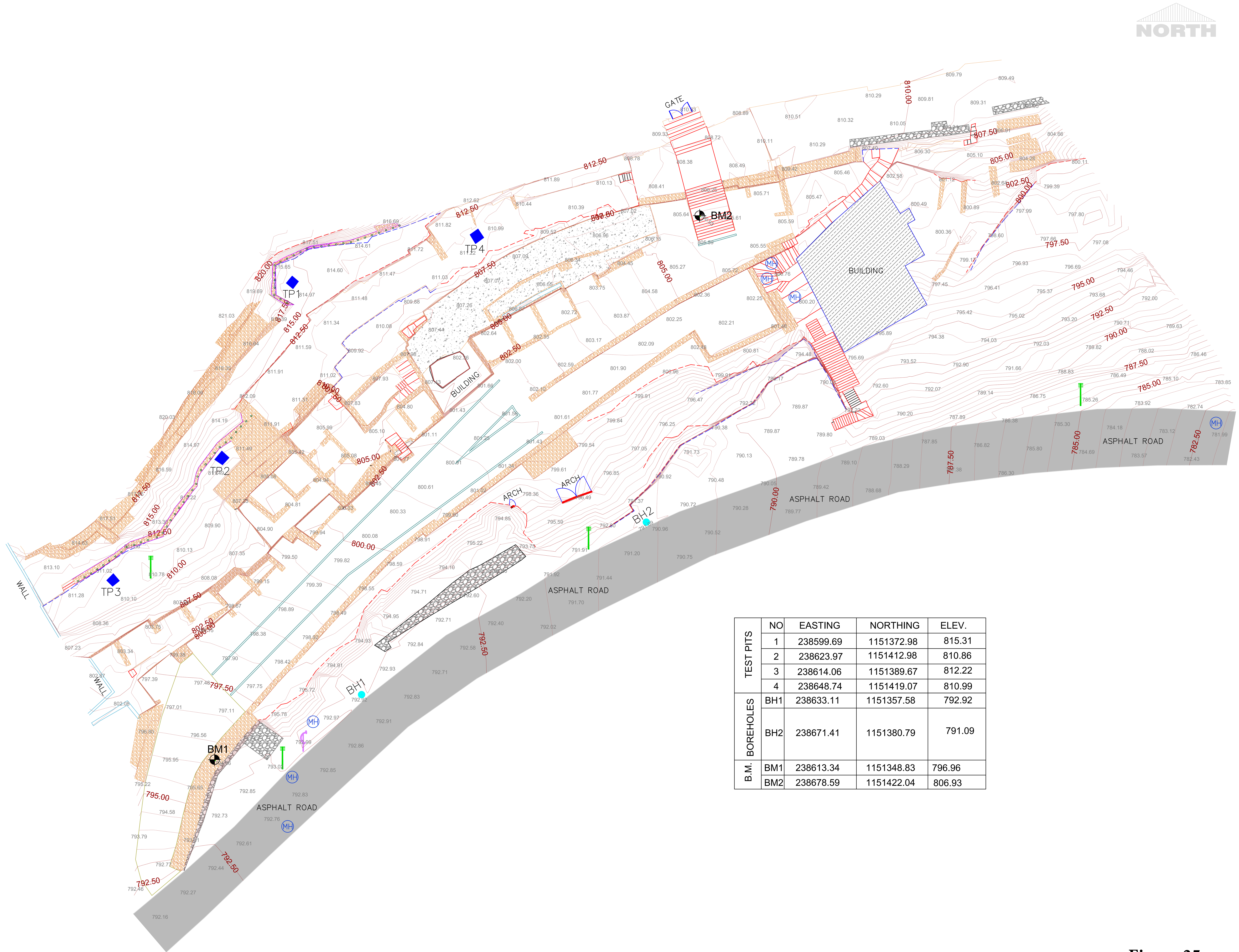
With the data derived from the Topography, Geotechnical, Hydrology Study and Design, a drainage solution was engineered to improve the site drainage and protect the deterioration of the historic structures from further damage due to the effects of water saturation. Images of the effects are shown in Figures below:

Figure 31 - Drainage Path Depositing Soil on Southern Entrance

Figure 33 - Moisture Saturation Evidence

Figure 32 - Moisture Saturation on Existing Wall

Figure 34 - Effects of Salts on Existing Structures



	NO	EASTING	NORTHING	ELEV.
TEST PITS	1	238599.69	1151372.98	815.31
	2	238623.97	1151412.98	810.86
	3	238614.06	1151389.67	812.22
	4	238648.74	1151419.07	810.99
BOREHOLES	BH1	238633.11	1151357.58	792.92
	BH2	238671.41	1151380.79	791.09
B.M.	BM1	238613.34	1151348.83	796.96
	BM2	238678.59	1151422.04	806.93

NOTES :

USAID FROM THE AMERICAN PEOPLE

acor

LEGEND :

	CONTOUR LINE
	INDEX CONTOUR LINE
100.00	ELEVATION
11.56	DISTANCE
	SYMBOLS LEGEND
	ASPHALT ROAD
MH	MANHOLE
	BOUNDARY POINT
	BENCH MARCH
EP	ELECTRIC POLE
TMH	TELECOM MH
	BUILDING
	BOUNDRARY LINE
	WALL
	EXCAVATION-LIMIT
	STAIR
	SUGGESTED ROCK WALL
	WEEP HOLES(DIAMETER=3INCHES) AT BOTTOM OF WALL
	BOREHOLE
TP4	TEST PIT
	ELECTRIC POLE
	TELEPHNLE POLE

REV	NAME	DATE	DESCRIPTION
3			
2			
1			

CLIENT:

PROJECT NAME:

CONSULTANT:

DRAWING NAME:

SURVEY LAYOUT PLAN

DESIGNED:	**	CHECKED:	**
APPROVED:	**	DRAWN:	**
DRAWING NO.:	SR-01		
DATE:	February-2023	SCALE:	1/200

Figure 35

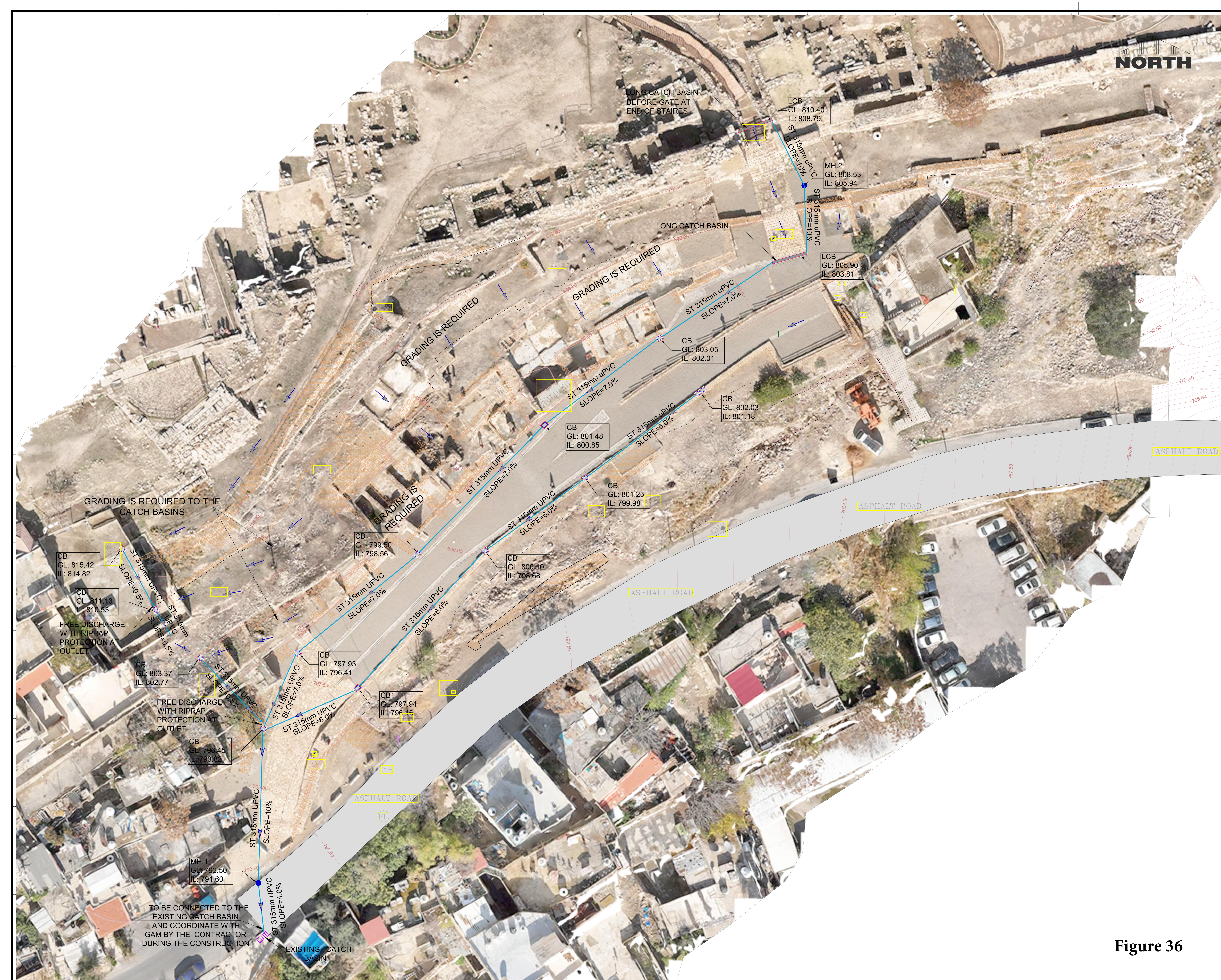


Figure 36

NOTES :

1-ALL OF PROPOSED WORKS ARE BASED ON THE FINDINGS OF CONDUCTED HYDROLOGICAL STUDY.

2- THE CONTRACTOR SHALL ALLOCATE THE PROPOSED CATCH BASINS AT THE LOW POINTS BASED ON SITE CONDITIONS & GRADING IS ALSO REQUIRED TO ROUTE THE FLOW TOWARDS THE INLETS.

3- THE CONTRACTOR SHALL INVESTIGATE AND COORDINATE WITH GAM AND RELATED AUTHORITIES REGARDING THE CONNECTION POINT.

USAID FROM THE AMERICAN PEOPLE

acor

LEGEND :

STORMWATER PIPE UPVC 315mm NAME & DIRECTION	ST
MANHOLE	
CATCH BASIN	CB
LONG CATCH BASIN	LCB
EXISTING CATCH BASIN	

REV	NAME	DATE	DESCRIPTION
3			
2			
1			

CLIENT:

ACOR/SCHEP

PROJECT NAME:

AMMAN CITADEL SOUTHERN SLOPE PROJECT

CONSULTANT:

Jordan Engineering Laboratories

DRAWING NAME:

DRAINAGE NETWORK LAYOUT SITE PLAN AT SATELLITE IMAGE

DESIGNED:	**	CHECKED:	**
APPROVED:	**	DRAWN:	**
DRAWING NO.:	PL-01		
DATE:	February-2023	SCALE:	1/200

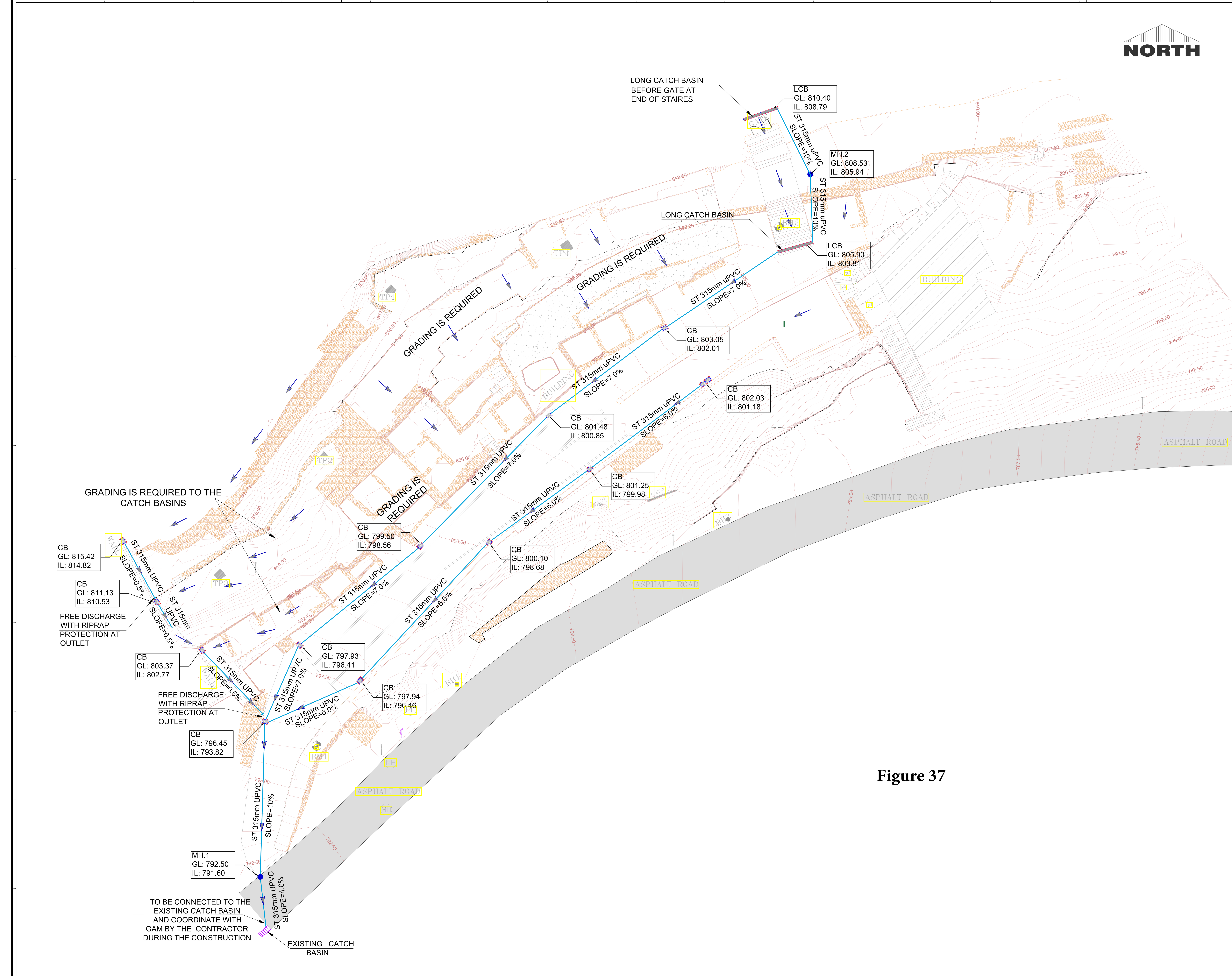


Figure 37

NOTES :

1-ALL OF PROPOSED WORKS ARE BASED ON THE FINDINGS OF CONDUCTED HYDROLOGICAL STUDY.

2- THE CONTRACTOR SHALL ALLOCATE THE PROPOSED CATCH BASINS AT THE LOW POINTS BASED ON SITE CONDITIONS & GRADING IS ALSO REQUIRED TO ROUTE THE FLOW TOWARDS THE INLETS.

3- THE CONTRACTOR SHALL INVESTIGATE AND COORDINATE WITH GAM AND RELATED AUTHORITIES REGARDING THE CONNECTION POINT.

USAID FROM THE AMERICAN PEOPLE

LEGEND :

STORMWATER PIPE UPVC 315mm NAME & DIRECTION	ST
MANHOLE	
CATCH BASIN	CB
LONG CATCH BASIN	LCB
EXISTING CATCH BASIN	

REV	NAME	DATE	DESCRIPTION
3			
2			
1			

CLIENT:

ACOR/SCHEP

PROJECT NAME:

AMMAN CITADEL SOUTHERN SLOPE PROJECT

CONSULTANT:

Jordan Engineering Laboratories

DRAWING NAME:

DRAINAGE NETWORK LAYOUT SITE PLAN

DESIGNED:	**	CHECKED:	**
APPROVED:	**	DRAWN:	**
DRAWING NO.:	PL-01		
DATE: February-2023		SCALE:	1/200

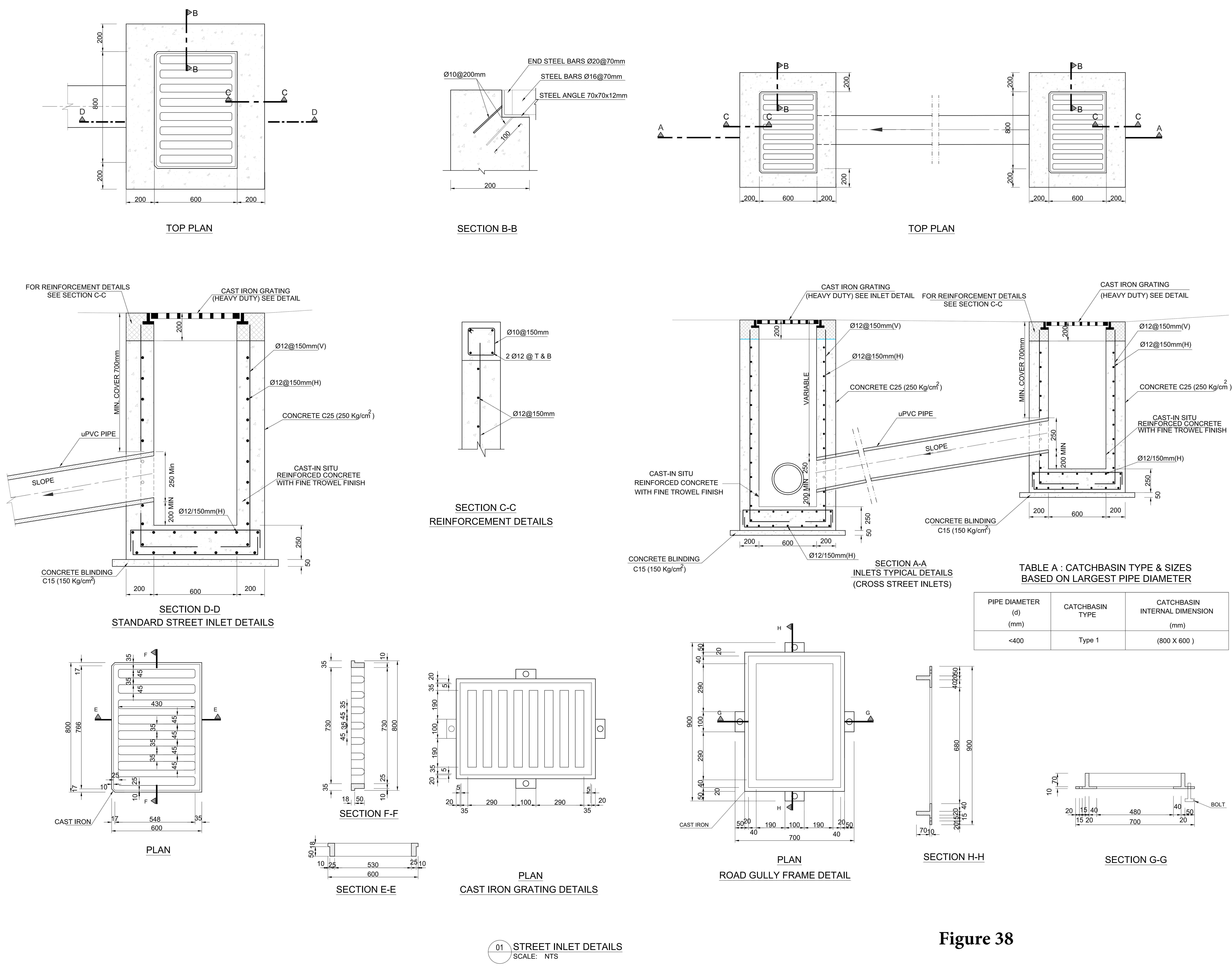


TABLE A : CATCHBASIN TYPE & SIZES BASED ON LARGEST PIPE DIAMETER

PIPE DIAMETER (d) (mm)	CATCHBASIN TYPE	CATCHBASIN INTERNAL DIMENSION (mm)
<400	Type 1	(800 X 600)

Figure 38

NOTES :

LEGEND :

REV	NAME	DATE	DESCRIPTION
3			
2			
1			

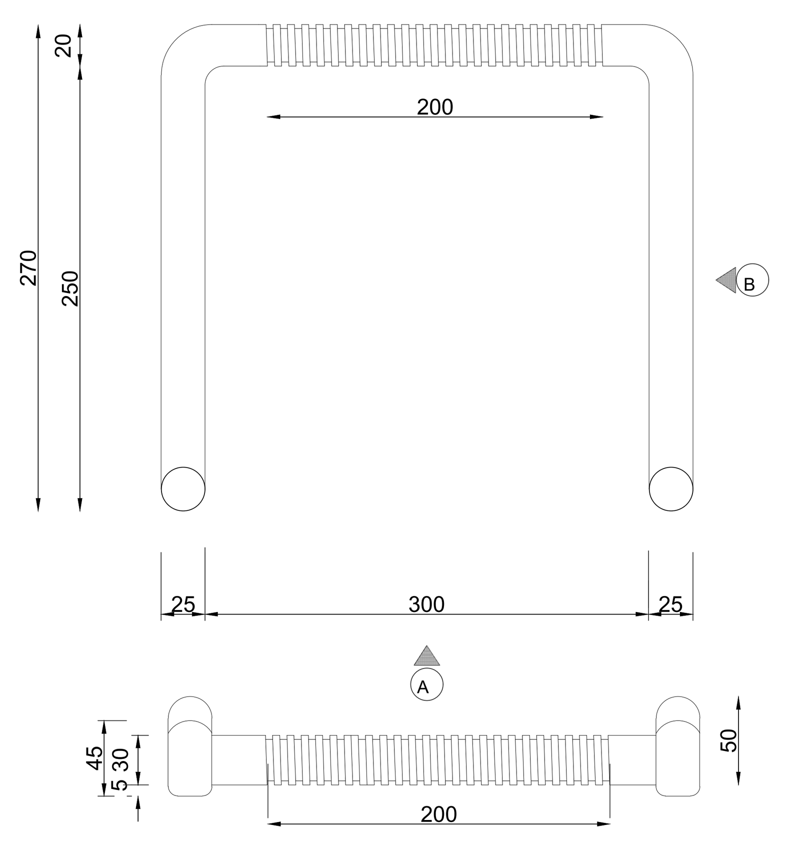
CLIENT:
ACOR/SCHEP

PROJECT NAME:
AMMAN CITADEL SOUTHERN SLOPE PROJECT

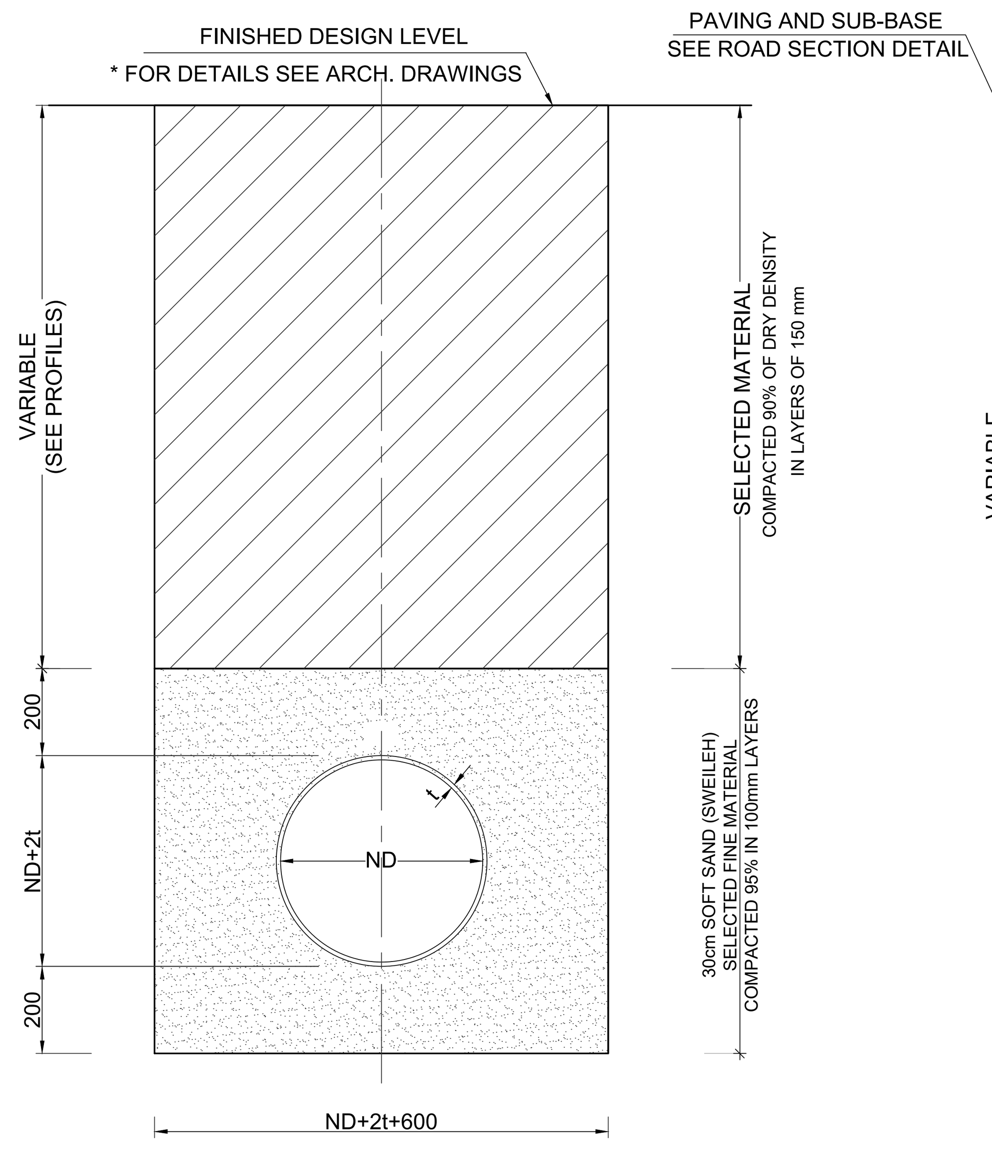
CONSULTANT:
Jordan Engineering Laboratories

DRAWING NAME:
DRAINAGE DETAILS (1 - 4)

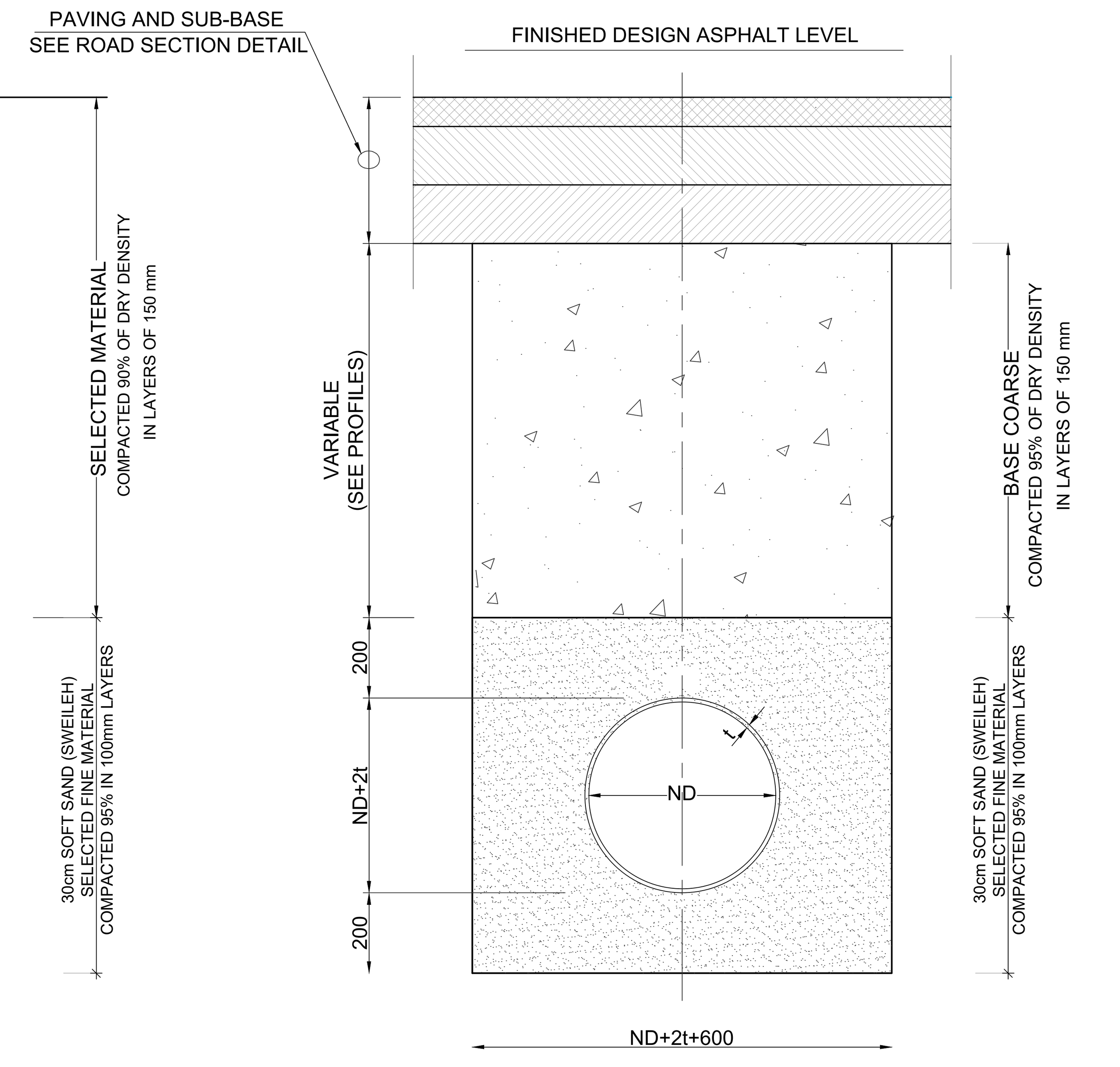
DESIGNED:	**	CHECKED:	**
APPROVED:	**	DRAWN:	**
DRAWING NO.:	D-01		
DATE:	February-2023	SCALE:	N.T.S



VIEW A

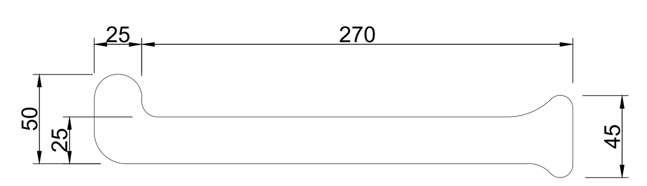


TYPICAL PIPE TRENCH DETAIL
OUTSIDE ROADS

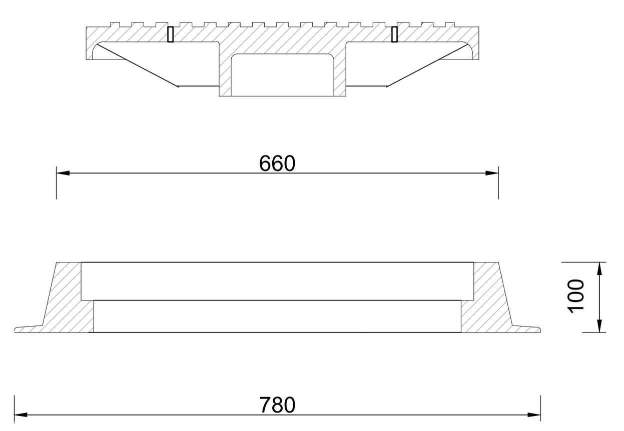


TYPICAL PIPE TRENCH DETAIL
ALONG ROADS

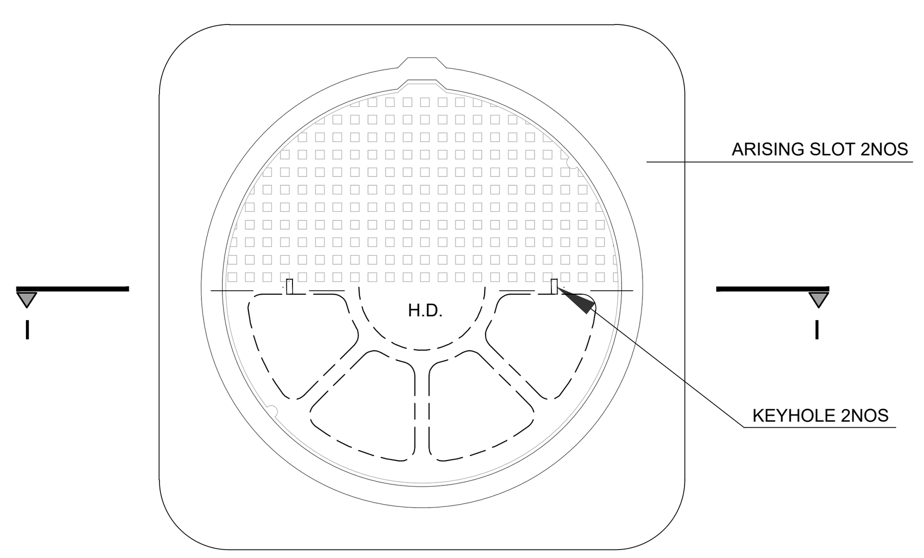
Type of Backfill Materials: Base Course , Compacted 95% of Dry Density in layers of 150 mm



VIEW B
TYPICAL MANHOLE STEP



SECTION I-I
HEAVY DUTY CAST
IRON COVER AND FRAME



PLAN

MANHOLE SIZES
BASED ON LARGEST PIPE DIAMETER

PIPE DIAMETER (d) (mm)	INTERNAL MANHOLE DIAMETER (D) (mm)
300-400	900 PRE-CAST
500-600	1000 PRE-CAST

01 TYPICAL PIPE TRENCH DETAIL
SCALE: NTS

Figure 39

NOTES :

LEGEND :

REV	NAME	DATE	DESCRIPTION
3			
2			
1			

CLIENT:
ACOR/SCHEP

PROJECT NAME:
AMMAN CITADEL
SOUTHERN SLOPE PROJECT

CONSULTANT:
Jordan Engineering Laboratories

DRAWING NAME:
DRAINAGE DETAILS
(2 - 4)

DESIGNED: **	CHECKED: **
APPROVED: **	DRAWN: **
DRAWING NO.: D-02	
DATE: February-2023	SCALE: N.T.S

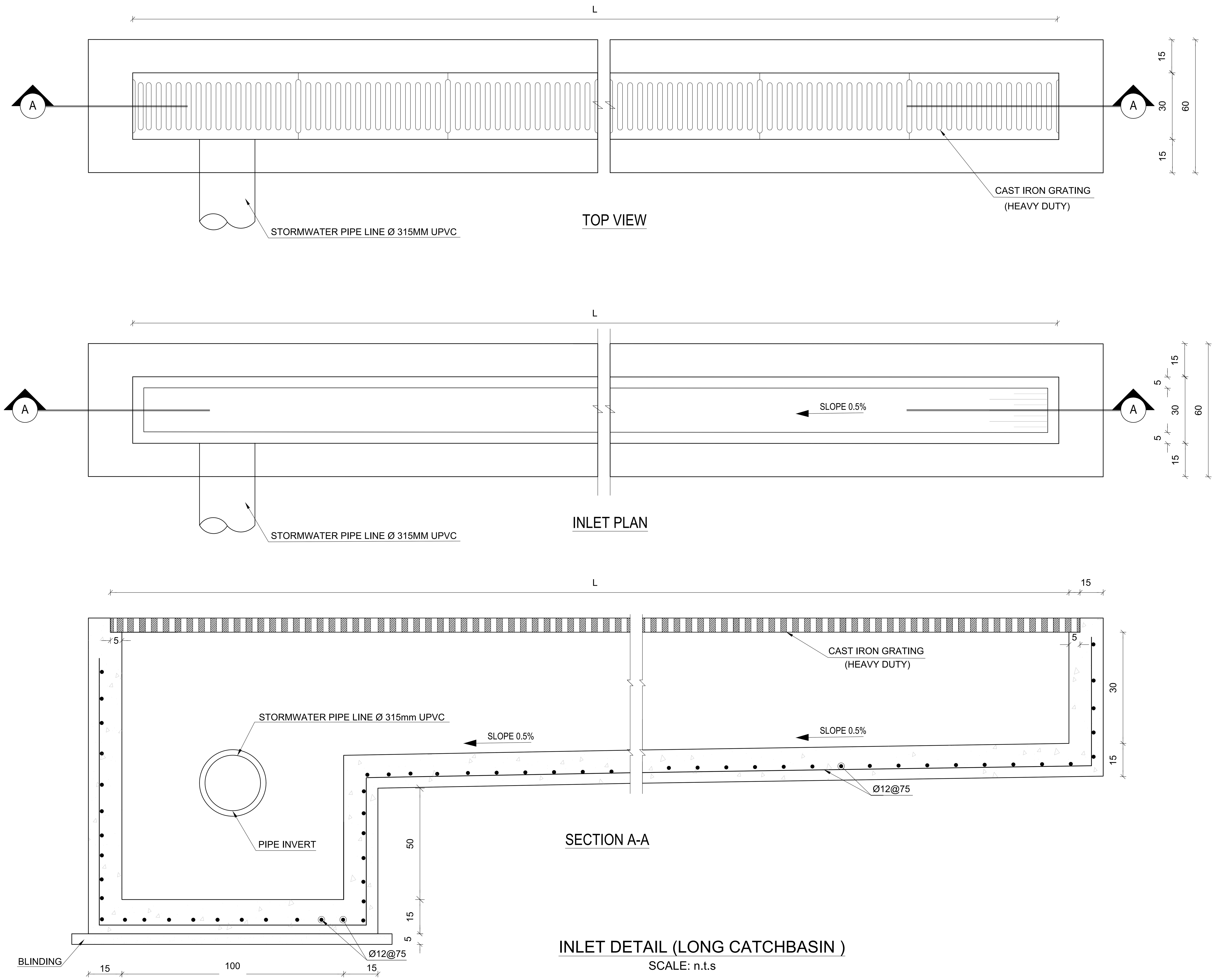


Figure 40

NOTES :

LEGEND :

REV	NAME	DATE	DESCRIPTION
3			
2			
1			

CLIENT:

ACOR/SCHEP

PROJECT NAME:

AMMAN CITADEL
SOUTHERN SLOPE PROJECT

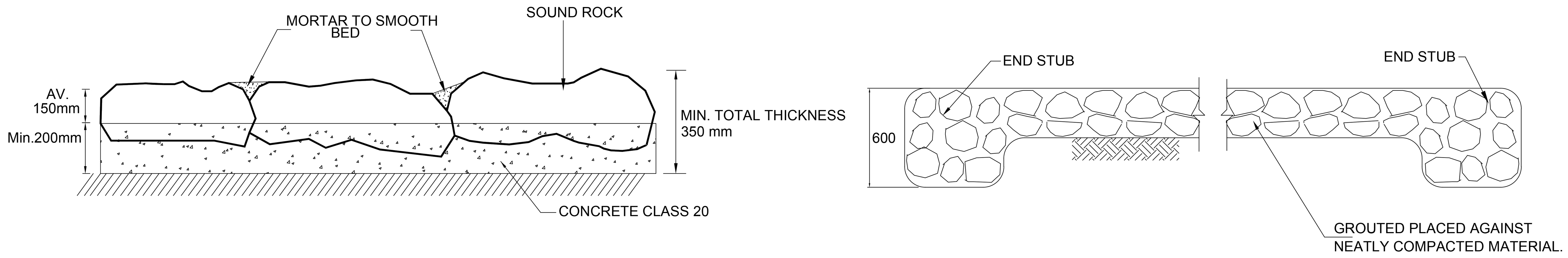
CONSULTANT:

Jordan Engineering Laboratories

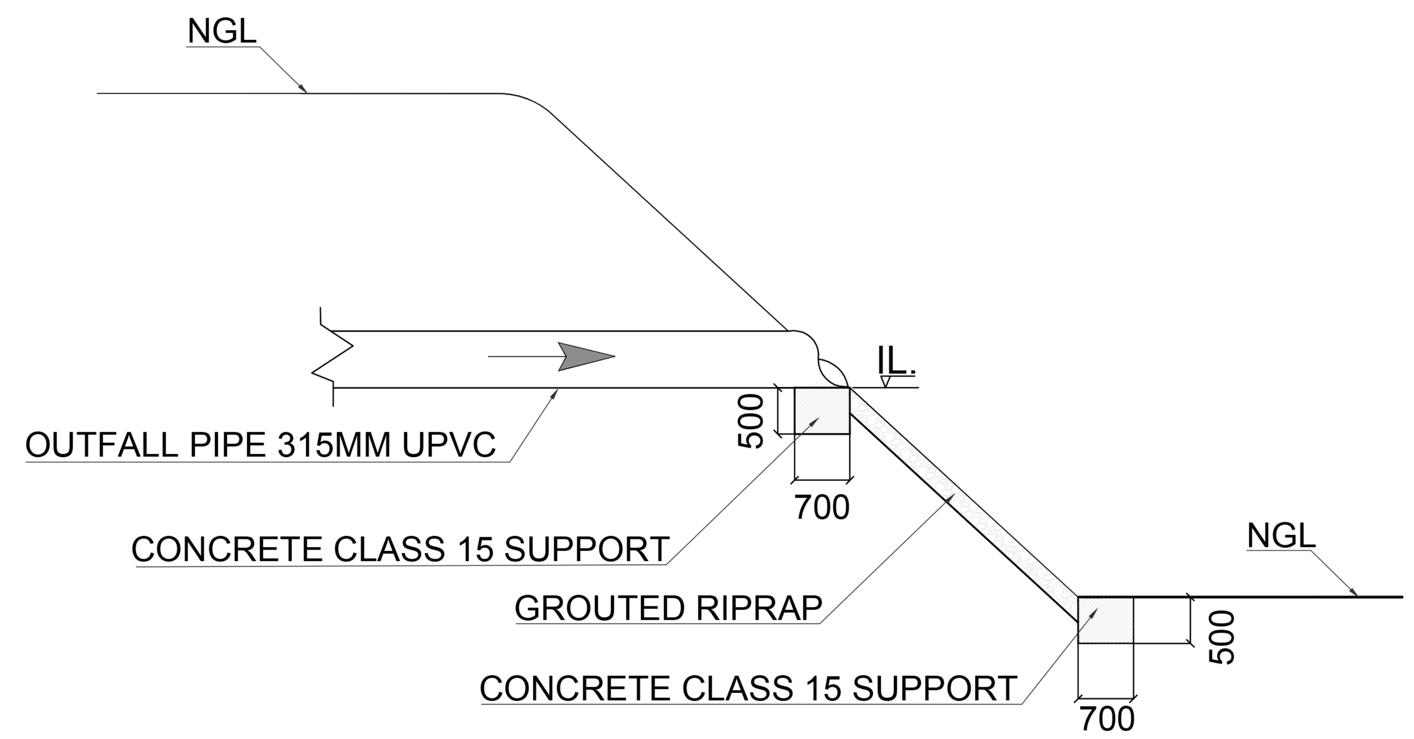
DRAWING NAME:

DRAINAGE DETAILS
(3 - 4)

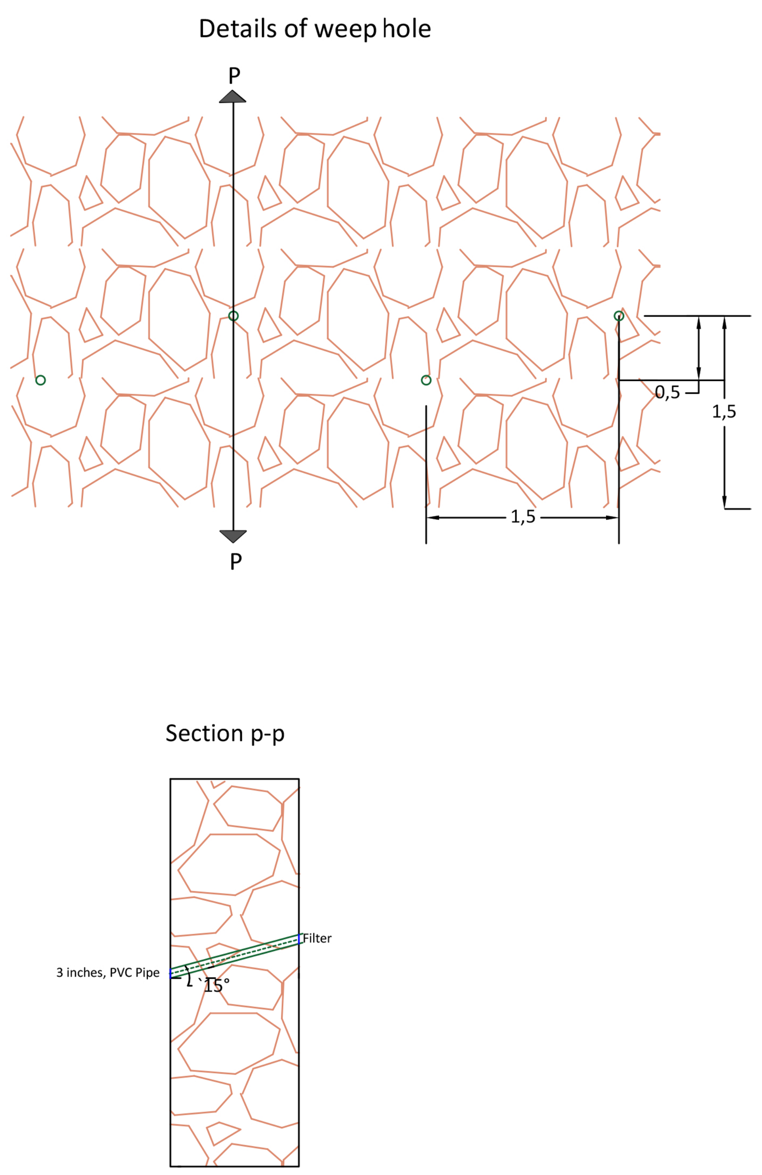
DESIGNED:	**	CHECKED:	**
APPROVED:	**	DRAWN:	**
DRAWING NO.:	D-04		
DATE:	February-2023	SCALE:	N.T.S



TYPICAL DETAILS - CEMENTED GROUTED RIPRAP PROTECTION DETAIL
N.T.S



OUTFALL - FREE DISCHARGE WITH RIPRAP PROTECTION
SCALE: NTS



WEEP HOLE DETAIL N.T.S

Figure 41

NOTES :

LEGEND :

REV	NAME	DATE	DESCRIPTION
3			
2			
1			

CLIENT:

PROJECT NAME:

CONSULTANT:

DRAWING NAME:

DRAINAGE DETAILS
(4 - 4)

DESIGNED: **	CHECKED: **
APPROVED: **	DRAWN: **
DRAWING NO.: D-04	
DATE: February-2023	SCALE: N.T.S