डेडीकेटेड फ्रेट कोरीडोर

DESIGN AND CONSTRUCTION OF CIVIL, STRUCTURES AND TRACK WORKS, INVOLVING FORMATION IN EMBANKMENT /CUTTING, BALLAST ON FORMATION, TRACK WORKS, BRIDGES, STRUCTURES, BUILDINGS, YARDS & INTEGRATION WITH INDIAN RAILWAY'S EXISTING RAILWAY SYSTEM AND TESTING & COMMISSIONING ON DESIGN-BUILD LUMP SUM BASIS OF KHURJA-PILKHANI SECTION (APPROXIMATELY 222 ROUTE KM OF SINGLE LINE) OF EASTERN DEDICATED FREIGHT CORRIDOR

CIVIL, STRUCTURES AND TRACK WORKS

CONTRACT PACKAGE NO: 303

ICB No.: **HQ/EN/EC/D-B/Khurja-Pilkhani Section**

PART-4 – REFERENCE DOCUMENT

GEOTECH DATA – VOLUME 3

KHURJA TO PILKHANI

From Km. 1367.0 (ALJN-GZB) to Km 187.5 (SRE-UMB)

GEO TECH DATA

(MEERUT DETOUR)

PART. 2/3
(VOLUME A)

EMPLOYER: DEDICATED FREIGHT CORRIDOR CORPORATION OF INDIA LTD
(A GOVERNMENT OF INDIA ENTERPRISE)
MINISTRY OF RAILWAYS

COUNTRY: **INDIA**

INDEX

List of Abbreviations

BH	Borehole
CBR	California Bearing Ratio
CD	Consolidated Drained
CH	Chainage
CR	Core Recovery
CRR	Cyclic Resistance Ratio
CSR	Cyclic Stress Ratio
CU	Consolidated Undrained
DBE	Design Basis Earthquake
DCPT	Dynamic Cone Penetration Test
E	Easting
EGL	Existing Ground Level
ERT	Electrical Resistivity Test
FS/ FOS	Factor of Safety
FSW	Free Swell Index
GL	Ground Level
GWT	Ground Water Table
HFL	High Flood Level
IRC	Indian Road Congress
IS	Indian Standard
LL	Liquid Limit
MJB	Major Bridge
MNB	Minor Bridge
MSF	Magnitude Scaling Factor
N	Northing
NABL	National Accreditation Board for Testing and Calibration Laboratories
NMC	Natural Moisture Content
OMC	Optimum Moisture Content
PI	Plasticity Index
PL	Plastic Limit
PLI	Point Load Index
PLT	Plate Load Test
RL	Reduce Level
RQD	Rock Quality Designation
SCPT	Static Cone Penetration Test
SPT	Standard Penetration Test
TP	Trial Pit
UC	Unconfined Compression

UCS	Unconfined Compressive Strength
UDS	Undisturbed Sample
UU	UnconsolidatedUndrained
VST	Vane Shear Test
VUP	Vehicular Under Pass

CHAPTER I
INDRODUCTION

1.1 General

M/s. Skylark Designer & Engineers Pvt. Ltd. has been entrusted with DPR preparation at Hapur-Meerut Section of DFCC Meerut. On behalf of Skylark Designer & Engineers Pvt. Ltd, M/s. Xplorer Consultancy Services Pvt. Ltd. is authorized to carry out the Laboratory testing of Soil samples supplied by Skylark for Hapur-Meerut Section from Ch. 0+650km to Ch.65+740km of DFCC Meerut.

Accordingly, as per the specifications provided by M/s. Skylark Designer & Engineers Pvt. Ltd, M/s Xplorer Consultancy Services Pvt. Ltd. carried Laboratory testing of soil samples, engineering analyses and recommending the type of foundations for the proposed structures LOA No. Skylark/GT/DFCCIL-Meerut/Khurja-Dadri Section/Xplorer/2015/01 dated 20.04.2015

1.2 Scope of Work

The scope of work broadly comprises of the followings:

- Carrying out various laboratory tests
    - Natural Moisture Content (NMC)
    - Sieve and Hydrometer Analysis
    - Atterberg Limits
    - Bulk and Dry Density
    - Unconsolidated Un-drained (UU) Triaxial Test / Unconfined Compression Test (UC)
    - Direct Shear Test
    - Chemical Analysis of Soil for pH, Sulphate and Chlorides.
- Analysis and recommending type of foundations

The field investigation was carried out by M/s Skylark and the samples are supplied to our laboratory for carrying out required test on the selected samples. The details of laboratory test quantities are presented in Table 1.1

Table 1.1 Details of Laboratory Test Quantities

Chainage	Borehole	Boring in Soil	Grain Size Analysis	Atterberg	Specific Gravity	MC, Density	Direct Shear Test	UU/UC	Chemical Analysis of Soil
0+650	BH-1	15.0	6	1	3	2	2	1	1
1+172	BH-1	30.0	11	4	4	4	2	3	1
	BH-2	30.0	11	4	4	4	2	3	1
2+109	BH-1	30.0	10	4	5	4	2	2	1
	BH-2	30.0	10	2	4	5	5	1	1
2+306	BH-1	30.0	10	4	4	4	2	2	1
	BH-2	30.0	9	4	4	5	3	2	1
	BH-3	30.0	10	3	4	3	3	2	1
2+873	BH-1	12.0	5	2	2	3	1	1	1
3+490	BH-1	12.0	5	2	3	3	1	2	1
4+252	BH-1	12.0	5	2	2	3	2	0	1
5+163	BH-1	12.0	5	2	3	3	2	1	1
6+099	BH-1	12.0	6	2	2	4	1	1	1
7+064	BH-1	12.0	5	1	2	4	1	1	1
8+060	BH-1	12.0	5	2	2	4	2	1	1
8+977	BH-1	12.0	7	4	3	4	0	3	1
10+030	BH-1	12.0	5	1	3	3	2	1	1
10+973	BH-1	12.0	5	2	3	3	1	2	1
11+987	BH-1	12.0	5	2	2	3	1	2	1
13+841	BH-1	30.0	11	4	4	5	3	2	1
	BH-2	12.0	5	3	2	3	0	2	1
	BH-3	30.0	10	3	4	5	3	2	1
14+069	BH-1	30.0	11	3	4	6	2	3	1
	BH-2	30.0	11	4	4	6	3	3	1
13+136	BH-1	12.0	5	2	2	4	1	1	1
15+227	BH-1	12.0	5	3	3	4	1	1	1
16+144	BH-1	12.0	4	3	3	4	1	1	1
17+338	BH-1	12.0	4	3	2	4	0	2	1
18+070	BH-1	12.0	4	3	2	3	1	1	1
19+051	BH-1	12.0	6	2	3	3	1	2	1
19+955	BH-1	12.0	4	1	2	3	1	1	1
	BH-2	12.0	5	1	2	3	1	1	1
20+935	BH-1	12.0	5	2	2	4	1	2	1
22+200	BH-1	12.0	5	1	2	3	1	1	1
23+808	BH-1	12.0	5	5	2	3	1	1	1
24+920	BH-1	12.0	5	1	2	2	4		1

Chainage	Borehole	Boring in Soil	Grain Size Analysis	Atterberg	Specific Gravity	MC, Density	Direct Shear	UU/UC	Chemical Analysis of Soil
25+760	BH-1	12.0	5	1	2	2	4		1
26+530	BH-1	12.0	5	1	2	2	4		1
27+290	BH-1	30.0	7	3	3	3	5	2	2
	BH-2	30.0	8	4	3	3	4	1	2
27+820	BH-1	12.0	4	2	2	2	2	2	1
28+660	BH-1	12.0	5	3	2	2	2	1	1
28+880	BH-1	30.0	6	2	3	3	2	3	1
30+780	BH-1	12.0	4	2	1	2	2	2	1
33+050	BH-1	30.0	6	1	2	3	1	1	1
34+360	BH-1	30.0	4	2	1	1	3	0	1
34+986	BH-1	30.0	6	0	2	4	0	1	0
	BH-2	30.0	6	2	2	3	0	1	1
35+549	BH-1	30.0	6	1	2	4	0	1	0
	BH-2	30.0	6	0	2	4	0	0	1
37+360	BH-1	12.0	4	0	0	4	0	1	1
38+580	BH-1	30.0	6	0	2	4	0	1	1
39+120	BH-1	30.0	6	2	2	4	0	0	1
41+916	BH-1	30.0	6	6	2	1	3	6	1
43+900	BH-1	30.0	6	4	2	2	2	4	1
46+362	BH-1	30.0	9	8	2	2	4	8	1
48+122	BH-1	30.0	7	6	2	1	3	6	1
48+400	BH-1	30.0	5	4	1	7	1	2	1
48+510	BH-1	30.0	8	6	2	4	0	7	1
49+250	BH-1	30.0	4	2	1	5	1	1	1
50+100	BH-1	12.0	2	1	1	1	2	0	1
51+000	BH-1	12.0	3	0	1	3	0	0	1
52+640	BH-1	12.0	3	0	1	3	0	0	1
54+825	BH-1	30.0	5	2	2	3	0	2	1
54+825	BH-2	30.0	3	1	1	0	2	0	1
55+850	BH-1	30.0	5	1	2	3	0	1	1
56+780	BH-1	30.0	5	1	2	3	0	1	1
57+555	BH-1	30.0	6	2	2	3	0	2	1
58+400	BH-1	30.0	6	3	2	2	1	3	1
59+305	BH-1	12.0	4	3	1	0	2	3	1
62+160	BH-1	12.0	4	2	1	3	0	2	1
63+570	BH-1	30.0	4	1	2	3	1	1	1

Chainage	Borehole	Boring in Soil	Grain Size Analysis	Atterberg	Specific Gravity	MC, Density	Direct Shear	UU/UC	Chemical Analysis of Soil
63+570	BH-2	30.0	3	1	1	2	1	0	1
64+270	BH-1	30.0	5	1	1	3	0	1	1
64+270	BH-2	30.0	3	1	1	1	2	0	1
65+740	BH-1	30.0	5	2	1	2	1	2	1
65+740	BH-2	30.0	3	1	1	1	1	0	1
TOTAL		**1665**	**448**	**177**	**172**	**241**	**116**	**126**	**77**

1.3 Scope of Report

This report covers the interpretation of field and laboratory test results and recommendations regarding foundation types along with recommended bearing capacities and pile capacities for the various bridges.

1.4 Organization of the Report

This report is presented in five (4) chapters as follows
Chapter I: Introduction
Chapter II: Laboratory Studies
Chapter III: General Site and Subsurface Condition
Chapter IV: Analysis and Recommendation

CHAPTER II

LABORATORY STUDIES

2.1 General

The laboratory tests were performed on undisturbed and selected SPT samples. The laboratory tests were performed in accordance with relevant IS codes. The testing for 35 borehole samples has been performed by Bhoomi Geotech Pvt Ltd in their own laboratory under the supervision of the technical representatives from M/s. Xplorer Consultancy Services Pvt. Ltd and rest of the borehole samples are tested in M/s Xplorer laboratory. Lab test results are presented in Annexure C. General descriptions of laboratory testing are presented below:

2.2 Physical Properties

2.2.1 Natural Moisture Content

To measure natural moisture content, a specimen from an undisturbed sample is taken in a container and its weight recorded as total weight. The sample is then dried in an oven at 105-110° C for 18-24 hours. After drying, the dry weight is taken and weight of water is calculated simply by subtracting the dry weight from the total weight. The moisture content is then calculated as the percentage of the weight of water over weight of dry soil.

2.2.2 Grain Size and Hydrometer Analysis

The grain size analysis has been carried out utilizing both sieve and hydrometer analysis.

The sieve analysis was carried out by wet sieving method in which the material was first washed through a 4.75 mm test sieve nested in a 75 μm test sieve. The soils retained in the sieves were then dried in an oven. The dried soils were then sieved by dry sieving by passing the soils through a series of square mesh sieves, which become progressively finer down to 75 μm mesh. Each fraction thus collected was then weighed and the percentage retained on each sieve was calculated by dividing individual weights by the total sample weight.

The soils passing through 75 μm mesh was analyzed by sedimentation using hydrometer method. The hydrometer method involves measuring the rate of settlement of fine particles suspended in a solution. Utilizing the principle of Stokes' law, particle size can be directly related to its rate of settlement in a fluid such as water. From this process, the particle diameter and percentage finer is calculated.

2.2.3 Atterberg Limits

Liquid limit of a specimen is derived using the cone penetration method. Plastic limit is defined as the moisture content of a specimen at the point where it can be satisfactorily rolled into a 3mm diameter thread without cracking. Plasticity index is then derived by subtracting the plastic limit from the liquid limit.

2.2.4 Specific Gravity

The sample is dried overnight in an oven at 110° C, cooled in desiccators, grind and sieved through 24mm/4.75mm IS Sieve for fine/coarse grained soils. About 10gm of sieved sample is taken in a specific gravity bottle and sufficient distilled water is added to just cover the soil and left it for soaking for 10-15 minutes after which it is shaken well and more distilled water added to fill the bottle about half. It is then placed in a sand bath to de-air. After air is totally removed, it is cooled and fills completely with water.

Various weights, e.g. , weight of empty bottle, weight of bottle filled with water, weight of bottle filled with water and sample, etc are taken from which specific gravity is calculated.

2.2.5 Bulk and Dry Density

The bulk density is the measured weight of a solid cylindrical soil specimen taken from an undisturbed sample divided by its volume. The dry density was calculated from bulk density and moisture content.

2.2.6 Unconsolidated Undrained (UU) Triaxial Test / Unconfined Compression Test (UC)

This test was performed as a set of three single stage tests. The general testing procedure is as explained below.

Three specimens were taken from a single undisturbed sample. The soil specimens were trimmed and cut until the length to diameter ratio is approximately two. The specimens were then weighed, measured and placed in a triaxial cell and were sheared under undrained conditions at a constant cell pressure and strain rate. Axial load and displacement were recorded at regular intervals until a maximum deviator stress, or 20% of strain, is reached. Cell pressures of 100, 200 and 300 kPa have been used for three specimens.

In case the sample was not adequate for three specimens, UC test was carried out on one specimen. This test is conducted without any confining pressure.

2.2.7 Direct Shear Test

Since the subsoil contains fair amount of sand, sampling for triaxial tests was not possible. Hence Direct Shear Tests were carried out. The tests were performed on remoulded samples under normal stresses of 50, 100 and 150 kPa. The samples were prepared at densities corresponding to SPT values.

2.2.8 Chemical Analysis

Chemical analysis was carried out to determine of pH, total SO_3, organic material and Chloride contents. The tests were carried out as per relevant IS code.

2.2.8.1 Measurement of pH

20gm of soil sample is mixed with 50ml of distilled water. The suspension is stirred for few seconds and is allowed to stand for 1 hour with occasional stirring. It is stirred again, immediately before testing.

The pH meter is calibrated with standard buffers and the pH of the soil suspension is measured.

2.2.8.2 Chloride

5 to 6 drops of potassium chromate indicator is added to 100 ml of filtered water sample to get yellow colour and then titrated against silver nitrate solution (0.028N)
End Point: Yellow to Brick Red Colour
Chloride (mg/l) = (V_2-V_1) x 35.46 x 1000 x N) / (ml of sample taken)
V_1 = Initial burette reading
V_2= Final burette reading
N = 0.028

2.2.8.3 Sulphate

100ml filtered Soil water extract is taken in a beaker. Then Barium Chloride Solution is added to the soil water extract and the mixture is allowed the ppt to settle and digest the ppt. at low temperature on a hot plate for 30 minutes. Filter the ppt. with Whatman No. 42 and wash with hot water till it is chloride free. Ignite the filter paper at 700°C in muffle furnace in weighed crucible (W1). Cool the crucible in desiccators and weigh (W2).

Sulphates (as SO_3), gm/l = (W2-W1) * 0.343*1000/100

CHAPTER-III

GENERAL SITE AND SUBSURFACE CONDITION

3.1 Site Geology

The site is underlain by the quaternary alluvium deposited by Ganga and Yamuna river system. Lithologically the alluvial sediment comprise of sand, silt, clay and *kankar* in varying proportions.

3.2 Subsoil Stratifications

Based on the findings of field and laboratory test results bore logs have been prepared incorporating all field and laboratory test results. A sub-soil profile for site showing the variations in subsoil stratification across the site, at borehole locations, are furnished in Annexure A.

As seen from the profiles, this site comprises of alluvial deposits consisting mainly of non- plastic Silty and Sandy soil with intermittent clayey silt layer. Top 3.0 m soils are generally in loose to medium dense state followed by medium to denser state.

3.2.1 Ch. 0+650 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.1. Top 9.0m soil is medium dense Silty SAND with SPT varying from 12 to 20 followed by dense fine SAND with SPT varying from 34 to 44 upto termination depth of 15.0m.

3.2.2 Major Bridge at Ch. 1+172 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.2. Top 16.0m soil is medium dense to dense sandy SILT with SPT varying from 6 to 44 followed hard silty clay with average SPT 38 from 16.0m to 21.0m underlain by dense to very dense fine sand with SPT varying from 45 to 68 upto termination depth of 30.0m.

3.2.3 Major Bridge at Ch. 2+109 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.3. Top 11.0m soil is medium dense to dense sandy SILT with SPT varying from 15 to 26 followed by dense to very dense fine sand with SPT varying from 31 to 61 upto termination depth of 30.0m.

3.2.4 Major Bridge at Ch. 2+306 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.4. Top 6.0m soil is medium dense clayey SILT with SPT varying from 7 to 20 followed by dense to very dense fine sand with SPT varying from 24 to 71 upto termination depth of 30.0m.

3.2.5 Minor Bridge at Ch. 2+873 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.5. Top 6.0m soil is loose to medium dense sandy SILT with SPT varying from 5 to 13 followed by medium dense silty SAND with SPT varying from 17 to 26 upto termination depth of 12.0m.

3.2.6 Minor Bridge at Ch. 3+490 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay, silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.6. Top 7.5m soil is medium dense sandy SILT with SPT varying from 14 to 21 followed by medium dense to dense fine SAND with SPT varying from 19 to 43 upto termination depth of 12.0m.

3.2.7 Minor Bridge at Ch. 4+252 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.7. Top 6.0m soil is loose medium dense sandy SILT with SPT varying from 5 to 10 followed by dense fine SAND with SPT varying from 22 to 45 upto termination depths of 12.0m.

3.2.8 Minor Bridge at Ch. 5+163 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.8. Top 7.5m soil is medium dense sandy SILT with SPT varying from 11 to 19 followed by medium dense to dense fine SAND with SPT varying from 23 to 36 upto termination depth of 12.0m.

3.2.9 Ch. 6+099 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.9. Top 6.0m soil is firm to very stiff silty CLAY with SPT varying from 7 to 17 followed medium dense to dense fine SAND with SPT varying from 23 to 43 upto termination depth of 12.0m.

3.2.10 Minor Bridge at Ch. 7+064 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.10. Top 4.5m soil is medium dense to dense sandy SILT with SPT varying from 19 to 31 followed to dense fine SAND with SPT varying from 23 to 49 upto termination depth of 12.0m.

3.2.11 Ch. 8+060 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and clayey soils. A graph showing variation in SPT with depth is presented in Fig. 3.11. Top 6.0m soil is medium dense sandy SILT with SPT varying from 12 to 17 followed by very stiff silty CLAY with SPT varying from 21 to 25 upto termination depth of 12.0m.

3.2.12 Major Bridge at Ch. 8+977 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey soils. A graph showing variation in SPT with depth is presented in Fig. 3.12. Top 6.0m soil is firm to stiff Silty CLAY with SPT varying from 4 to 13 followed by very stiff silty CLAY with SPT varying from 16 to 20 upto termination depth of 12.0m.

3.2.13 Minor Bridge at Ch. 10+030 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.13. Top 4.5m soil is firm Silty CLAY with SPT varying from 4 to 8 followed by medium dense fine SAND with SPT varying from 13 to 27 upto termination depth of 12.0m.

3.2.14 Major Bridge at Ch. 10+973 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.14. Top 7.5m soil is medium dense Silty SAND with SPT varying from 20 to 27 followed by dense fine SAND with SPT varying from 30 to 41 upto termination depth of 12.0m.

3.2.15 Ch. 11+987 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.15. Top 6.0m soil is medium dense sandy SILT with SPT varying from 11 to 19 followed by medium dense to dense fine SAND with SPT varying from 21 to 39 upto termination depth of 12.0m.

3.2.16 Major Bridge at Ch. 13+841 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.16. Top 4.0m soil is medium dense clayey SILT with SPT varying from 13 to 26 followed by medium dense to very dense fine sand with SPT varying from 16 to 80 upto termination depth of 30.0m.

3.2.17 RFO at Ch. 14+069 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.17. Top 4.0m soil is medium dense clayey SILT with SPT varying from 14 to 21 followed by medium dense to very dense fine sand with SPT varying from 24 to 78 upto termination depth of 30.0m.

3.2.18 Minor Bridge at Ch. 13+136 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.18 Top 6.0m soil is plastic sandy SILT with SPT varying from 5 to 18 followed by medium dense to dense fine Sand with SPT varying from 21.0m to 36.0m upto termination depth of 12.0m.

3.2.19 Minor Bridge at Ch. 15+227 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.19 Top 8.5m soil is silty CLAY with SPT varying from 5 to 29 followed by dense silty SAND with SPT varying from 34 to 42 upto termination depth of 12.0m.

3.2.20 Minor Bridge at Ch. 16+144 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay and silty soils. A graph showing variation in SPT with depth is presented in Fig. 3.20 Top 7.5m soil is silty CLAY with SPT varying from 8 to 16 followed by medium dense sandy SILT with SPT 16 upto depth of 9.0m underlain by hard silty CLAY with SPT varying from 33 to 37 upto termination depth of 12.0m.

3.2.21 Minor Bridge at Ch. 17+338 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay and silty soils. A graph showing variation in SPT with depth is presented in Fig. 3.21 Top 6.0m soil is silty CLAY with SPT varying from 8 to 13 followed by sandy SILT with SPT varying from 25 to 32 upto termination depth of 12.0m.

3.2.22 Minor Bridge at Ch. 18+070 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey and silty soils. A graph showing variation in SPT with depth is presented in Fig. 3.22 Top 4.5m soil is clayey SILT with SPT varying from 8 to 10 followed by silty CLAY with SPT varying from 16 to 24 upto termination depth of 12.0m.

3.2.23 Ch. 19+051 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.23 Top 4.5m soil is clayey SILT with SPT varying from 7 to 8 followed by medium dense silty SAND with SPT 15 upto depth 6.0m underlain by clayey SILT with SPT varying from 20 to 25 upto termination depth of 12.0m.

3.2.24 Minor Bridge at Ch. 19+955 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.24 Top 3.0m soil is clayey SILT with SPT 6 followed by medium dense silty SAND with SPT varying from 12 to 30 upto termination depth of 12.0m.

3.2.25 Minor Bridge at Ch. 20+935 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.25 Top 9.0m soil is clayey SILT with SPT varying from 12 to 18 followed by medium dense to dense silty SAND with SPT varying from 28 to 34 upto termination depth of 12.0m.

3.2.26 Ch. 22+200 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.26 Top 3.0m soil is silty CLAY with SPT 8 followed by medium dense to very dense silty SAND with SPT varying from 12 to 32 upto termination depth of 12.0m.

3.2.27 Minor Bridge at Ch. 23+808 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay, silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.27 Top 5.5m soil is silty clay with SPT varying from 5 to 7 followed by medium dense to dense fine sand with SPT varying from 27 to 39 upto termination depth of 12.0m.

3.2.28 Minor Bridge at Ch. 24+920 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.28. The SPT-N value (observed) for top 3.0m soils vary from 11 to 12. The soils below this are medium dense to very dense sand with SPT-N values ranging from 16 to 32.

3.2.29 Minor Bridge at Ch. 25+760 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.29. The SPT-N value (observed) for top 3.0m soils vary from 10 to 18. The soils below this are medium dense to dense sand with SPT-N values ranging from 17 to 31.

3.2.30 Minor Bridge at Ch. 26+530 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.30. The SPT-N value (observed) for top 3.0m soils vary from 2 to 8. The soils below this are medium dense to dense sand with SPT-N values ranging from 12 to 34.

3.2.31 Major Bridge at Ch. 27+290 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.31. The SPT-N value (observed) for top 5.0m soils vary from 4 to 12. The soils below this are medium dense to very dense silty sand with SPT-N values ranging from 18 to 100.

3.2.32 Minor Bridge at Ch. 27+820 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.32. The SPT-N value (observed) for top 6.0m soils vary from 5 to 12. The soils below this are medium dense to dense with SPT-N values ranging from 12 to 31.

3.2.33 Minor Bridge at Ch. 28+660 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.33. The SPT-N value (observed) for top 3.0m soils vary from 7 to 10. The soils below this are medium dense to dense with SPT-N values ranging from 13 to 34.

3.2.34 Major Bridge at Ch. 28+880 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.34. The soil is medium dense sandy SILT SPT-N value (observed) for top 15.0m soils vary from 17 to 25. The soils below this are dense to very dense fine SAND with SPT-N values ranging from 28 to 55.

3.2.35 Minor Bridge at Ch. 30+780 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.35. The soils are medium dense sandy SILT upto termination depth of 12.0m with SPT-N values ranging from 9 to 24.

3.2.36 Major Bridge at Ch. 33+050 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.36. The top soil is loose to medium dense sandy SILT upto 6.0m with SPT-N value (observed) varying from 7 to 17. The soils below this are medium dense to very dense with SPT-N values ranging from 12 to 53 upto termination depth of 30.45m.

3.2.37 Ch. 34+360 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.37. Top 9.0m soil is loose to medium dense sandy SILT with SPT varying from 7 to 17 followed by medium dense to very dense fine SAND with SPT varying from 18 to 61 upto termination depth of 30.45m.

3.2.38 RFO at Ch. 34+986 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.38. The top 4.0m soil is loose sandy SILT/Silty SAND with SPT-N value (observed) varying from 5 to 11. The soils below this are medium dense to very dense with SPT-N values ranging from 15 to 61 upto termination depth of 30.45m

3.2.39 Major Bridge at Ch. 35+549 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.39. The top 3.0m soil is loose sandy SILT/Silty SAND with SPT-N value (observed) of 12. The soils below this are medium dense to very dense fine SAND with SPT-N values ranging from 13 to 61 upto termination depth of 30.45m

3.2.40 Minor Bridge at Ch. 37+360 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.40. The SPT-N value (observed) for top 3.0m soils is 9. The soils below this are medium dense Silty SAND with SPT-N values ranging from 17 to 25.

3.2.41 Major Bridge at Ch. 38+580 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.41. The top 3.0m soil is loose sandy Silty SAND with SPT-N value (observed) of 9. The soils below this are medium dense to very dense fine SAND with SPT-N values ranging from 15 to 60 upto termination depth of 30.45m

3.2.42 Major Bridge at Ch. 39+120 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.42. The top 6.0m soil is loose to medium dense silty SAND with SPT-N value (observed) varying from 10 to 22. The soils below this are medium dense sandy SILT with SPT-N values varying from 27 to 30 follow by dense to very dense fine SAND with SPT-N values varying from 33 to 61 upto termination depth of 30.45m

3.2.43 Major Bridge at Ch. 41+916 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.43. The soil is firm to hard silty CLAY with SPT-N value (observed) for top 14.0m soils vary from 6 to 33. The soils below this are dense to very dense sandy SILT with SPT-N values ranging from 33 to 61 upto termination depth of 30.0m.

3.2.44 Major Bridge at Ch. 43+900 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.44. The soil is very stiff to hard silty CLAY with SPT-N value (observed) for top 18.0m soils vary from 21 to 34. The soils below this are dense to very dense fine SAND with SPT-N values ranging from 37 to 64 upto termination depth of 30.0m.

3.2.45 Major Bridge at Ch. 46+362 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.45. The top soil is medium dense sandy SILT upto 5.0m with SPT-N value (observed) varying from 11 to 12. The soils below this are very stiff to hard silty CLAY with SPT-N values varying from 20 to 65 followed by very dense fine SAND with SPT-N varying from 58 to 76 upto termination depth of 30.0m.

3.2.46 Major Bridge at Ch. 48+122 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.46. The top 6.0m soil is stiff silty CLAY with SPT-N value (observed) varying from 10 to 15. The soils below this are medium dense sandy SILT with SPT-N values ranging from 18 to 30 upto depth of 17.0m followed by hard silty CLAY with SPT-N varying from 32 to 36 underlain by dense to very dense sandy SILT with SPT-N varying from 32 to 65 upto termination depth of 30.0m

3.2.47 Major Bridge at Ch. 48+400 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.47. Top 9.0m soil is firm to very stiff Silty CLAY with SPT varying from 5 to 28 followed by hard silty CLAY upto 26.0m depth with SPT varying from 30 to 41 underlain very dense fine SAND with SPT varying from 43 to 58 upto termination depth of 30.45m.

3.2.48 Major Bridge at Ch. 48+510 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.48. The top 8.0m soil is loose to medium dense silty SAND with SPT-N value (observed) varying from 7 to 22. The soils below this are dense to very dense sandy SILT with SPT-N values ranging from 36 to 54 upto depth of 27.0m followed by very dense fine SAND with SPT-N varying from 51 to 63 upto termination depth of 30.0m

3.2.49 Major Bridge at Ch. 49+250 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and clayey soils. A graph showing variation in SPT with depth is presented in Fig. 3.49. Top 16.0m soil is stiff to very stiff silty CLAY with SPT varying from 9 to 25 followed hard silty CLAY with SPT varying from 32 to 34 upto 20.0m depth underlain by dense to very dense sandy SILT with SPT varying from 38 to 58 upto termination depth of 30.45m.

3.2.50 Minor Bridge at Ch. 50+100 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.50. Top 7.5m soil is loose to medium dense sandy SILT with SPT varying from 9 to 22 followed by medium dense fine SAND with SPT varying from 19 to 28 upto termination depth of 12.0m.

3.2.51 Minor Bridge at Ch. 51+000 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.51. The top 6.0m soil is medium dense silty SAND with SPT-N value (observed) varying from 11 to 14. The soils below this are medium dense to dense fine SAND with SPT-N values ranging from 17 to 37 upto termination depth of 12.0m

3.2.52 Minor Bridge at Ch. 52+640 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.52. The top 10.5m soil is medium dense sandy SILT with SPT-N value (observed) varying from 12 to 29. The soils below this are dense fine SAND with SPT-N values ranging from 34 to 37 upto termination depth of 12.0m.

3.2.53 Major Bridge at Ch. 54+825 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.53. The top 7.5m soil is medium dense sandy SILT with SPT-N value (observed) varying from 13 to 20. The soils below this are medium dense to dense silty SAND with SPT-N values ranging from 25 to 32 upto depth of 12.0m followed by dense fine SAND with SPT-N varying from 30 to 44 underlain by very dense sandy SILT with SPT-N varying from 51 to 67 upto termination depth of 30.0m

3.2.54 Major Bridge at Ch. 55+850 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.54. The top 3.0m soil is medium dense sandy SILT with SPT-N value varying from 12 to 21. The soils below this are medium dense to very dense fine SAND with SPT-N values ranging from 23 to 68 upto termination depth of 30.0m

3.2.55 Major Bridge at Ch. 56+780 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.55. The top 7.5m soil is loose to medium dense sandy SILT with SPT-N value (observed) varying from 6 to 19. The soils below this are medium dense to fine SAND with SPT-N values ranging from 20 to 30 upto depth of 14.0m followed by dense to very dense sandy SILT with SPT-N varying from 34 to 75 upto termination depth of 30.0m

3.2.56 Major Bridge at Ch. 57+555 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.56. The top 9.0m soil is medium dense sandy SILT with SPT-N value varying from 12 to 18. The soils below this are medium dense to very dense fine SAND with SPT-N values ranging from 33 to 76 upto termination depth of 30.0m

3.2.57 Major Bridge at Ch. 58+400 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.57. The top 7.5m soil is very stiff silty CLAY with SPT-N value varying from 15 to 18. The soils below this are medium dense to dense Silty SAND/Sandy SILT with SPT-N varying from 21 to 38 underlain by fine SAND with SPT-N values ranging from 40 to 65 upto termination depth of 30.0m

3.2.58 Minor Bridge at Ch. 59+305 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.58. The top 4.5m soil is stiff silty CLAY with SPT-N value varying from 8 to 12. The soils below this are medium dense silty SAND with SPT-N values varying from 18 to 31 underlain by hard silty CLAY with SPT-N varying from 26 to 33 upto termination depth of 12.0m

3.2.59 Minor Bridge at Ch. 62+160 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.59. The top 4.5m soil is loose sandy Silty SAND with

SPT-N value varying from 8 to 9. The soils below this are medium dense fine SAND with SPT-N values ranging from 15 to 60 underlain by dense sandy SILT with SPT-N varying from 30 to 38 upto termination depth of 12.0m

3.2.60 Major Bridge at Ch. 63+570 km

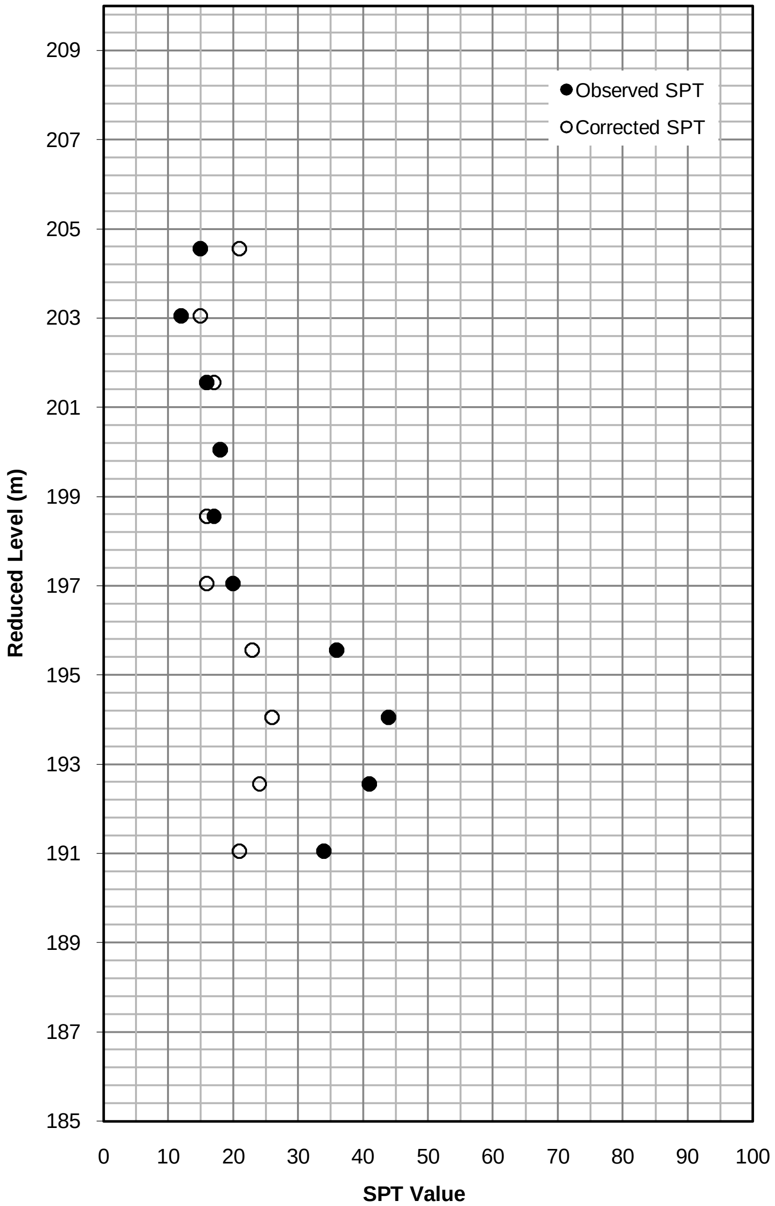
The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.60. The top 7.5m soil is firm to very stiff silty CLAY with SPT-N value varying from 5 to 17. The soils below this are medium dense to very dense fine SAND with SPT-N values varying from 21 to 71 upto termination depth of 30.0m

3.2.61 Major Bridge at Ch. 64+270 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.61. The top 11.0m soil is medium dense Silty SAND with SPT-N value varying from 14 to 22. The soils below this are medium dense to dense sandy SILT with SPT-N values varying from 25 to 35 underlain by dense to very dense fine SAND with SPT-N varying from 37 to 66 upto termination depth of 30.0m

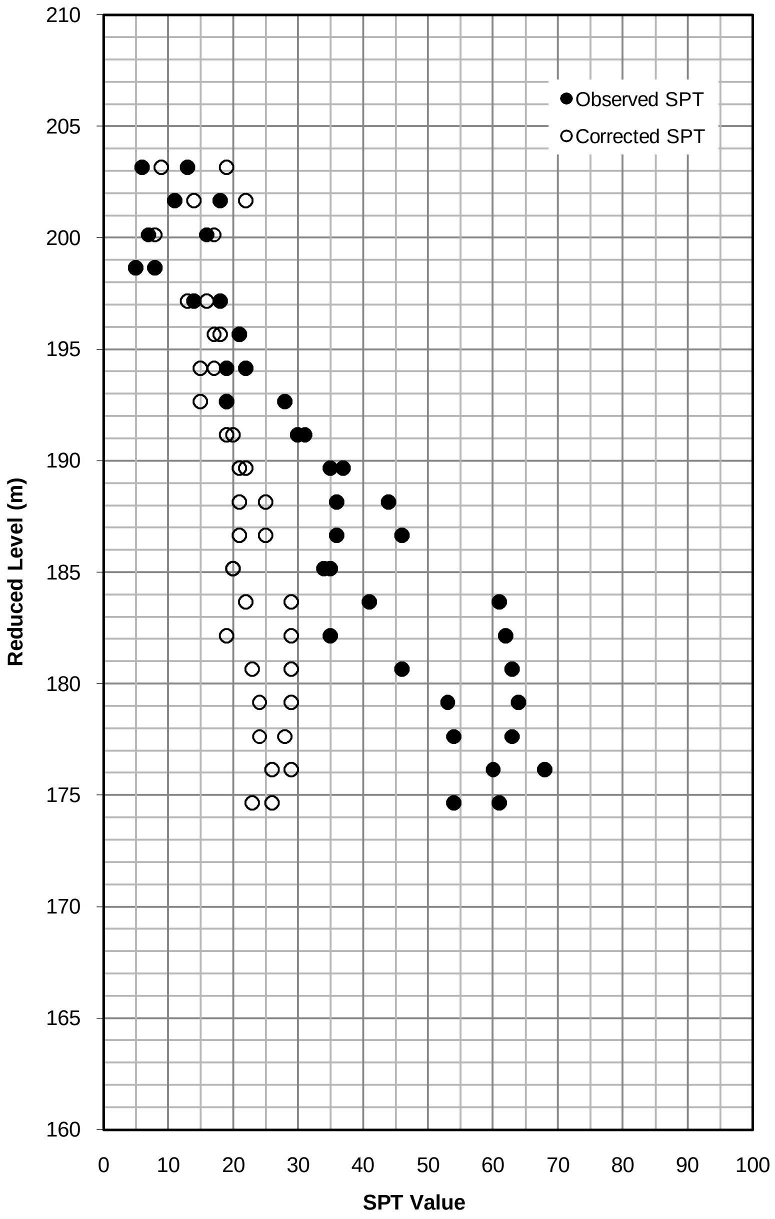
3.2.62 Major Bridge at Ch. 65+740 km

The density of soils generally increases with depth. A graph showing variation in SPT with depth is presented in Fig. 3.62. The top 11.0m soil is loose to medium dense sandy SILT with SPT-N value varying from 4 to 36. The soils below this are very stiff to hard silty CLAY with SPT-N varying from 21 to 32 underlain by dense to very dense silty SAND/fine SAND with SPT-N values varying from 36 to 67 upto termination depth of 30.0m

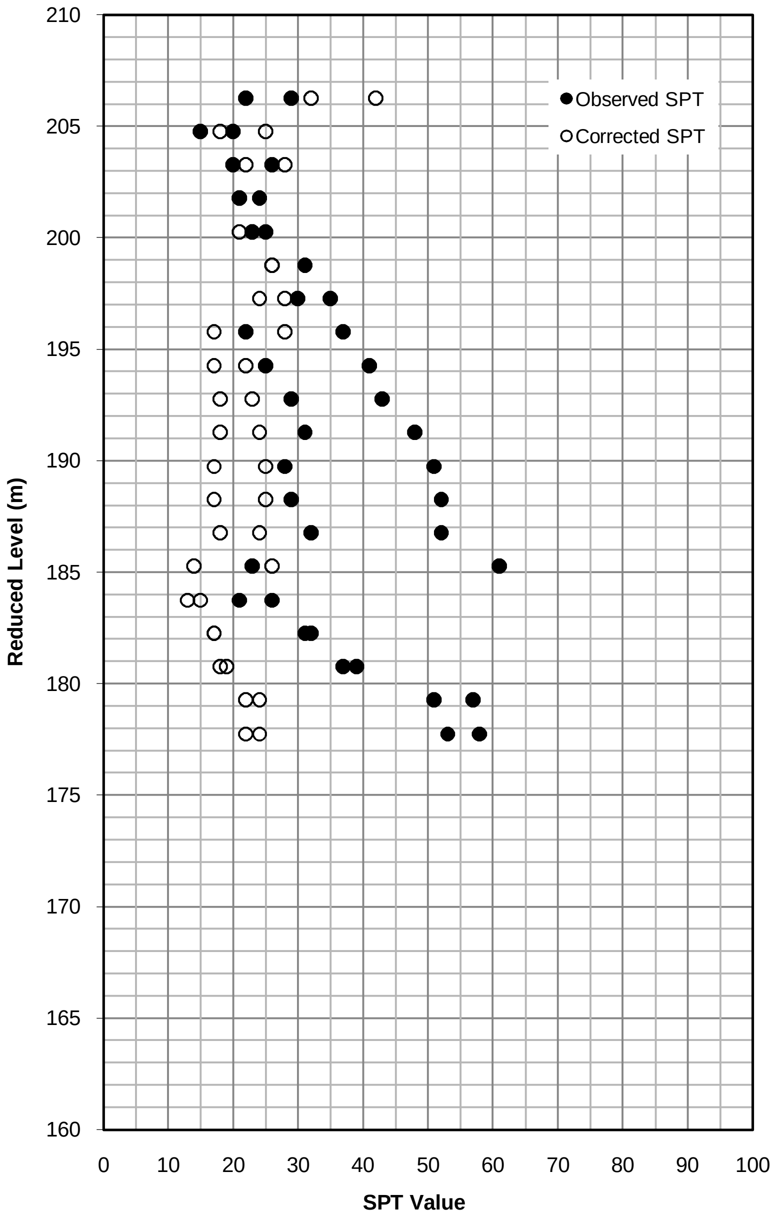


Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut

CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 0+650**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.1**	**SHEET No.** **1 of 1**

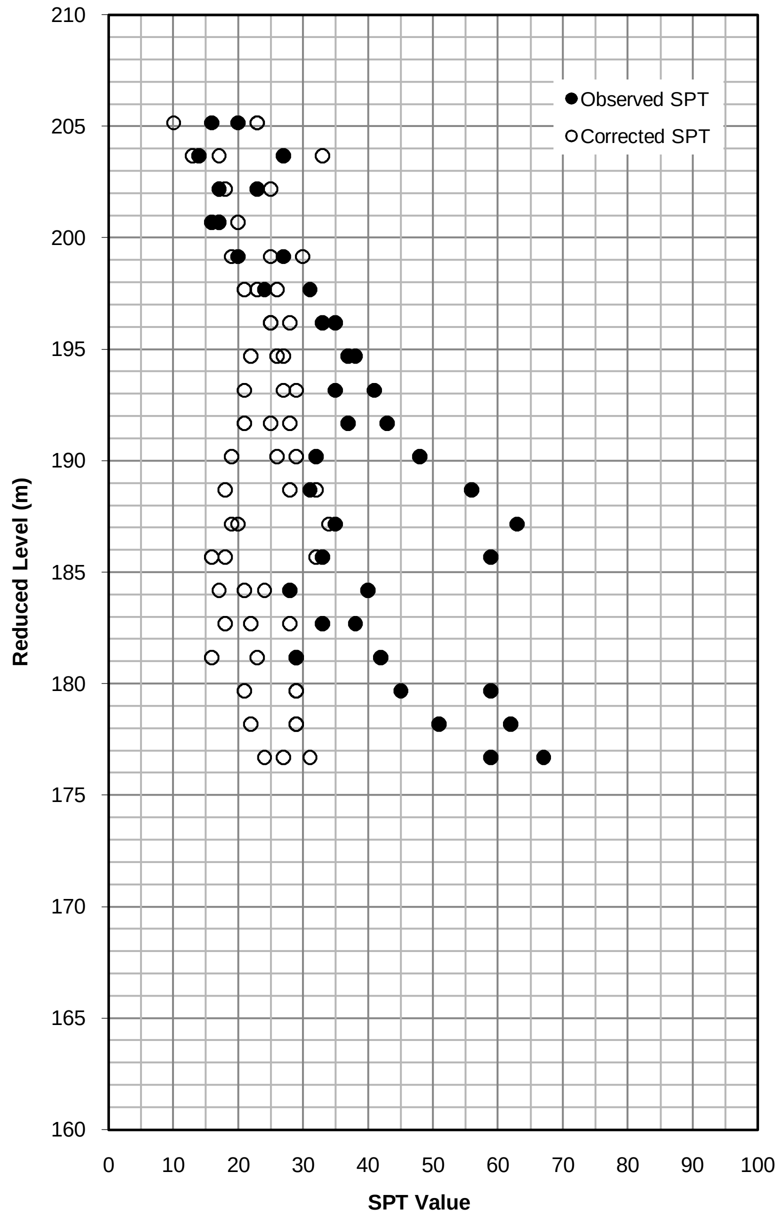


Geotechnical Investigation Works at Hapur-Merut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1 & BH-2)** **Chainage : 1+172**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.2**	**SHEET No.** **1 of 1**

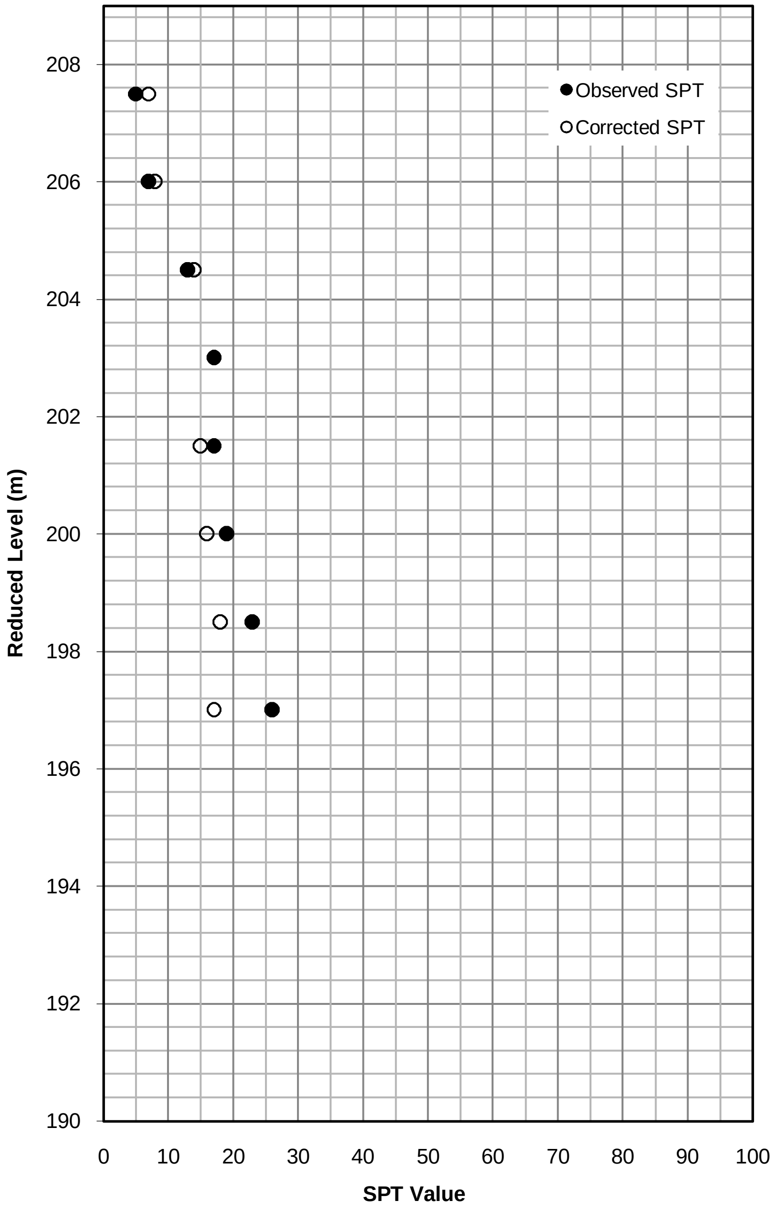


Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut

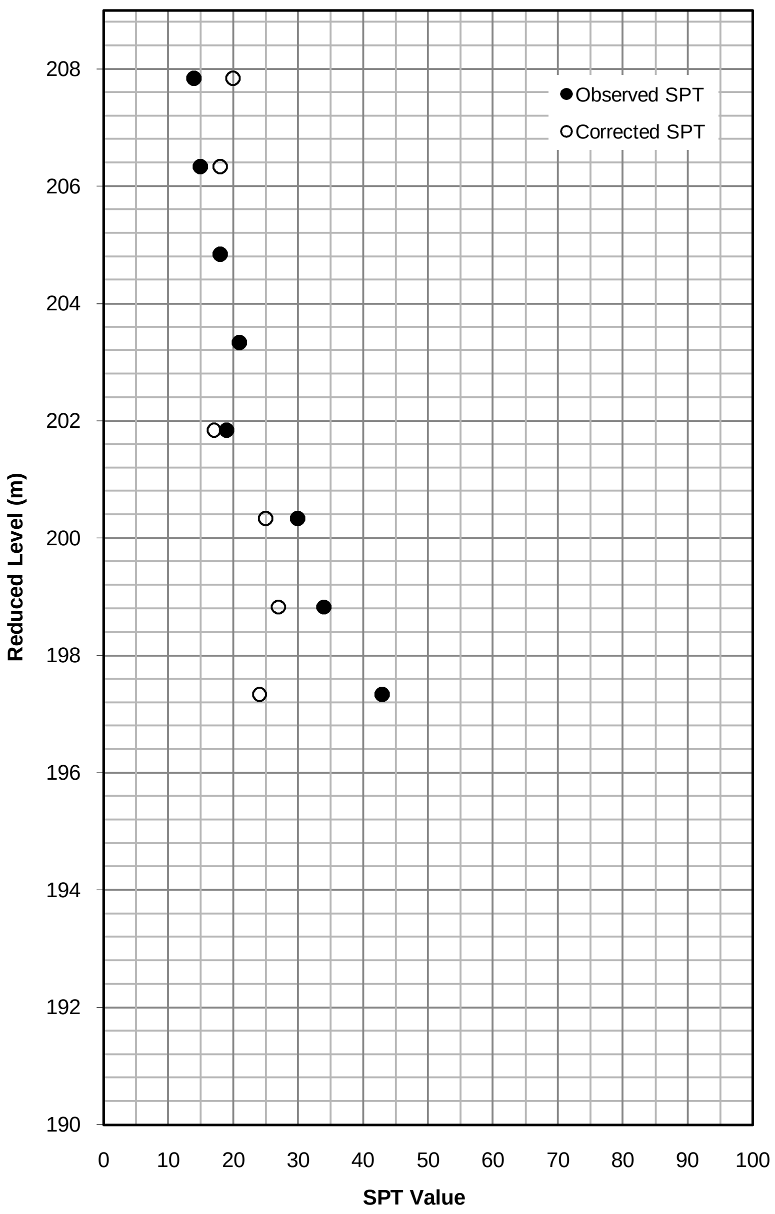
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1 & BH-2)** Chainage : 2+109	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.3	**SHEET No.** 1 of 1



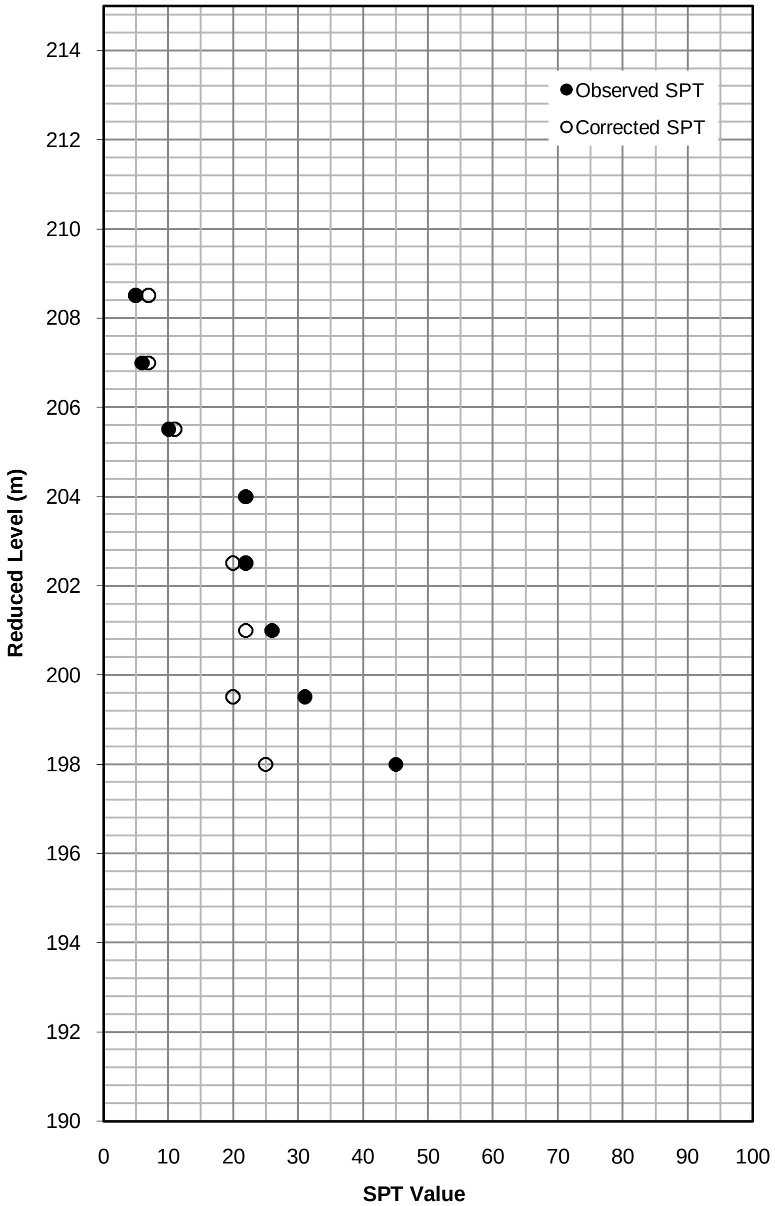
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1 & BH-2)** **Chainage : 2+306**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.4** **SHEET No.** **1 of 1**



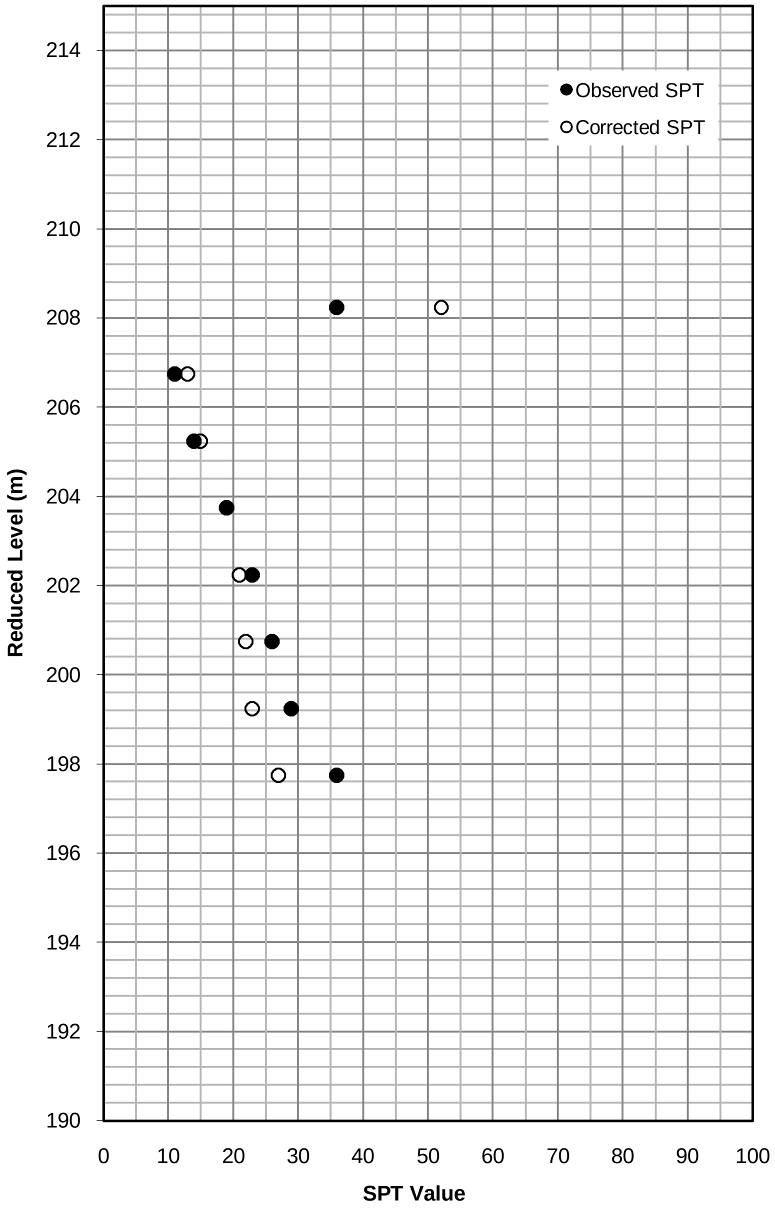
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 2+873**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.5**	**SHEET No.** **1 of 1**



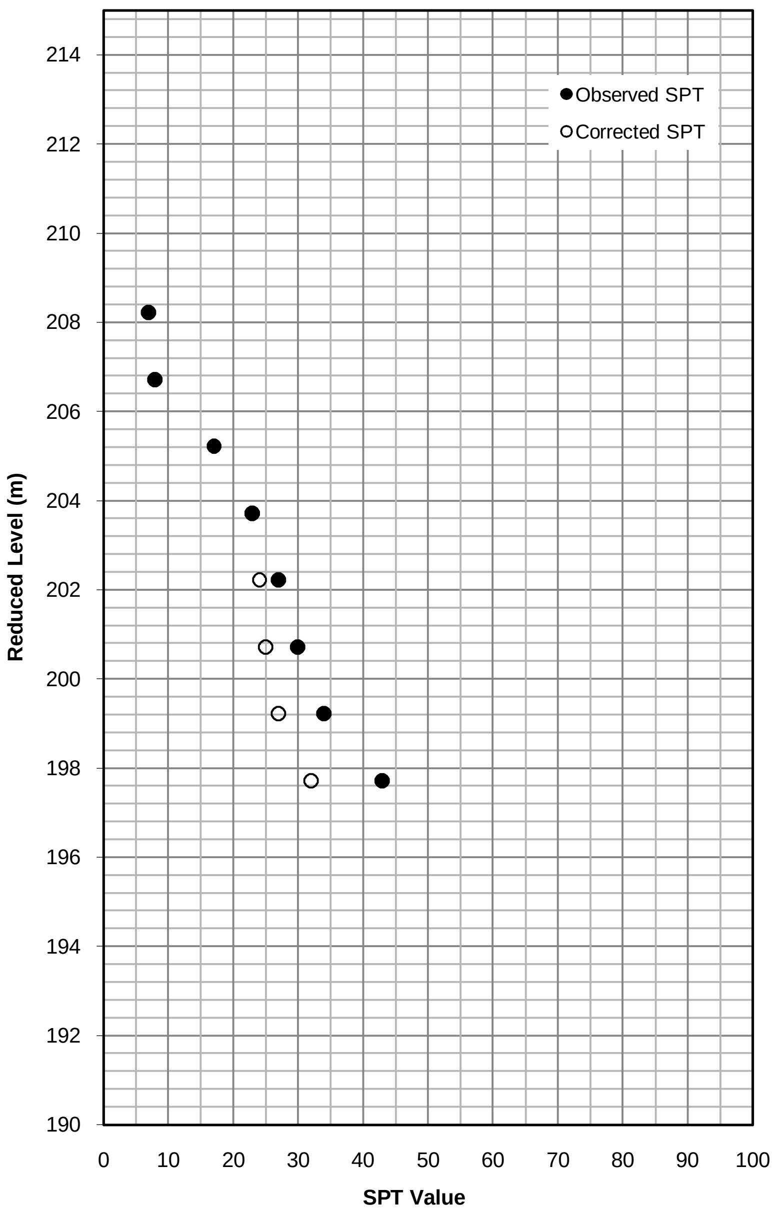
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 3+490**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.6**		**SHEET No.** **1 of 1**



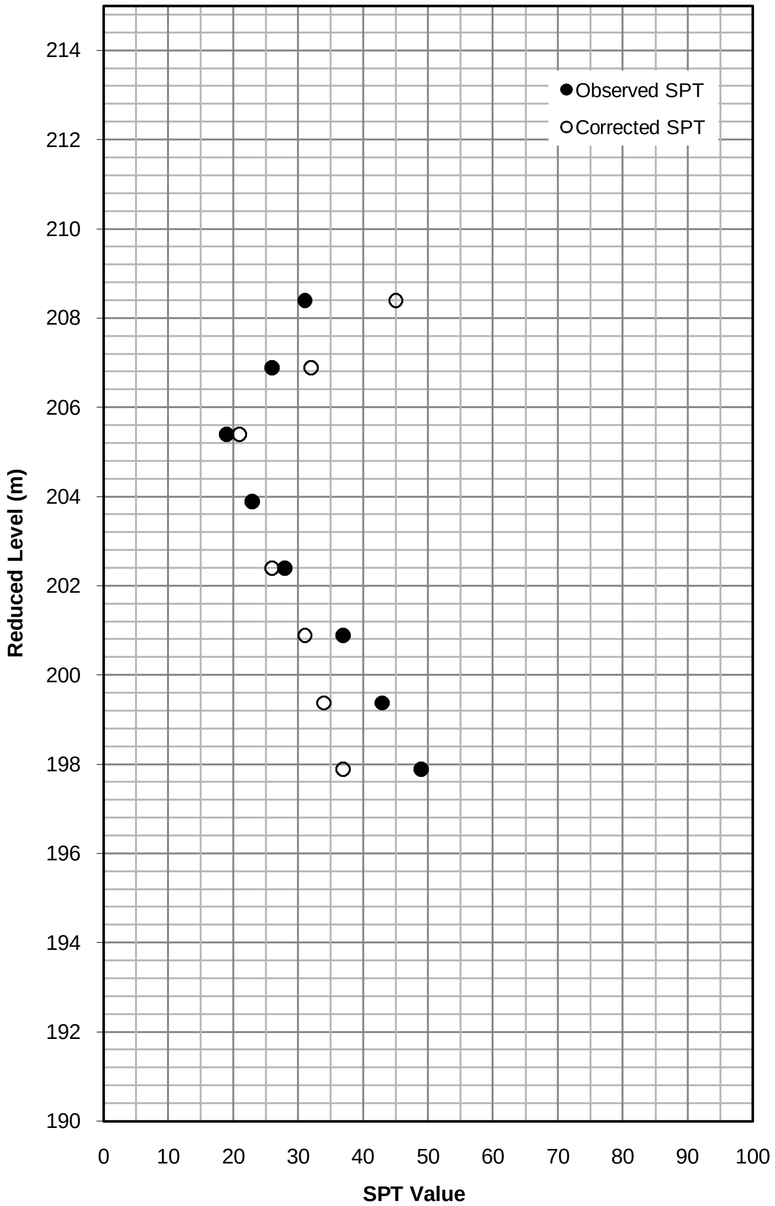
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 4+252**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.7**	**SHEET No.** **1 of 1**



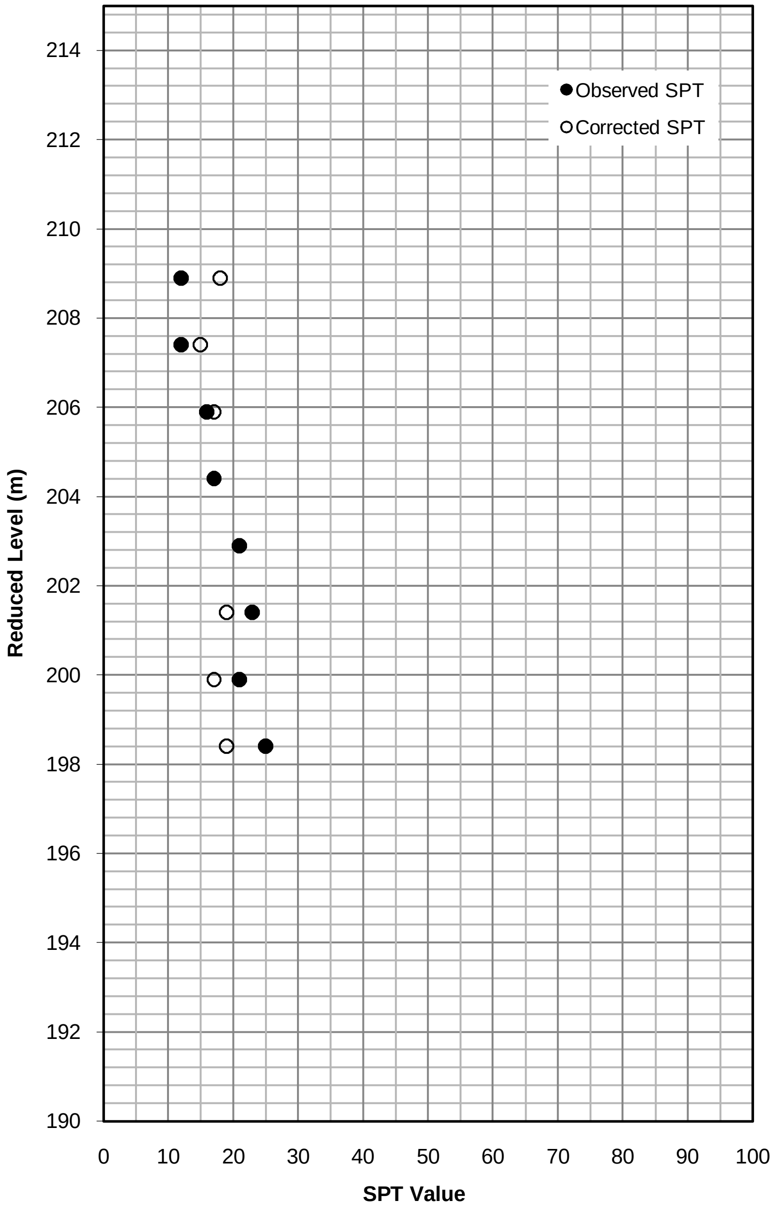
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 5+163**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.8**	**SHEET No.** **1 of 1**



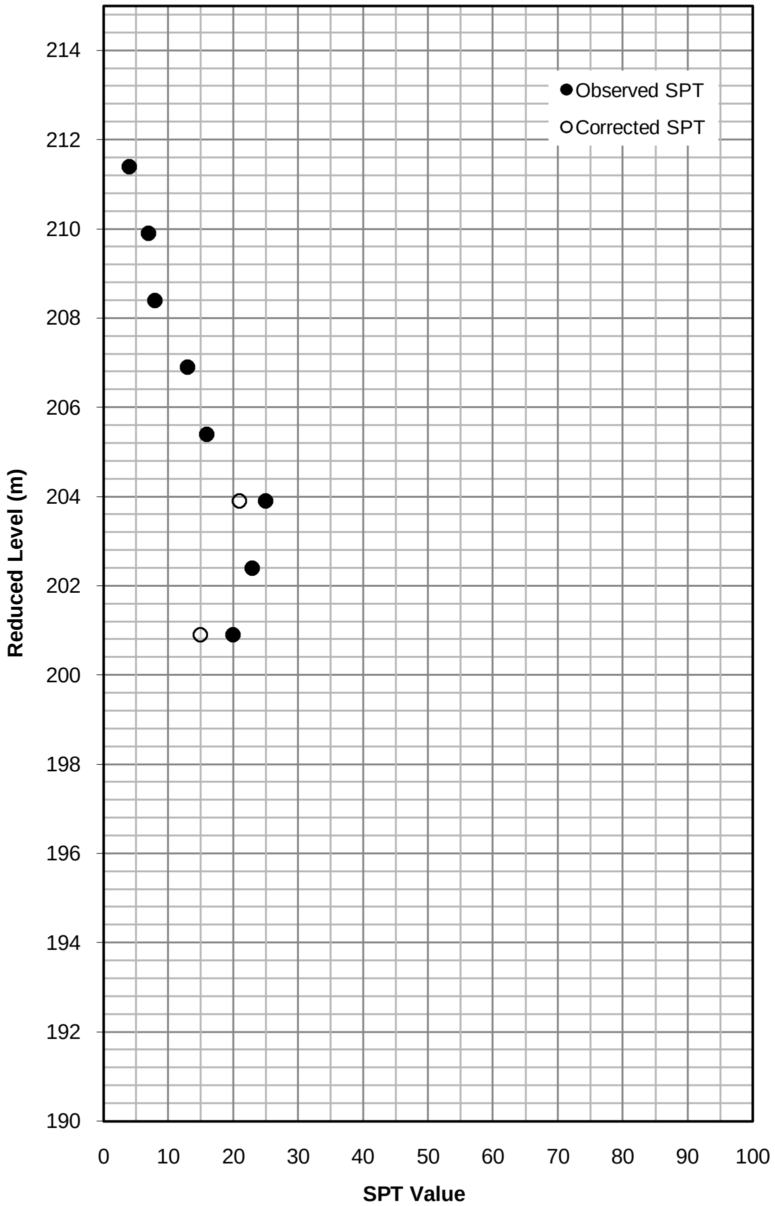
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1) Chainage : 6+099	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.9	SHEET No. 1 of 1



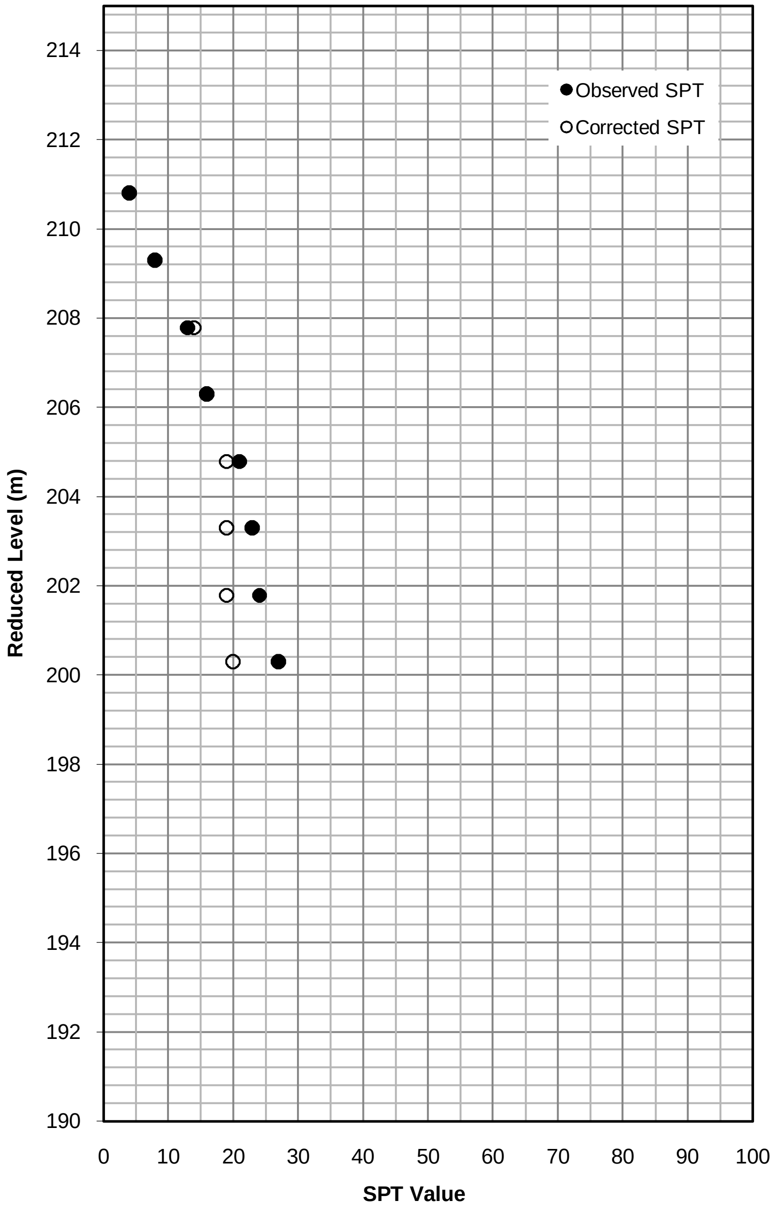
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 7+064**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.10**	**SHEET No.** **1 of 1**



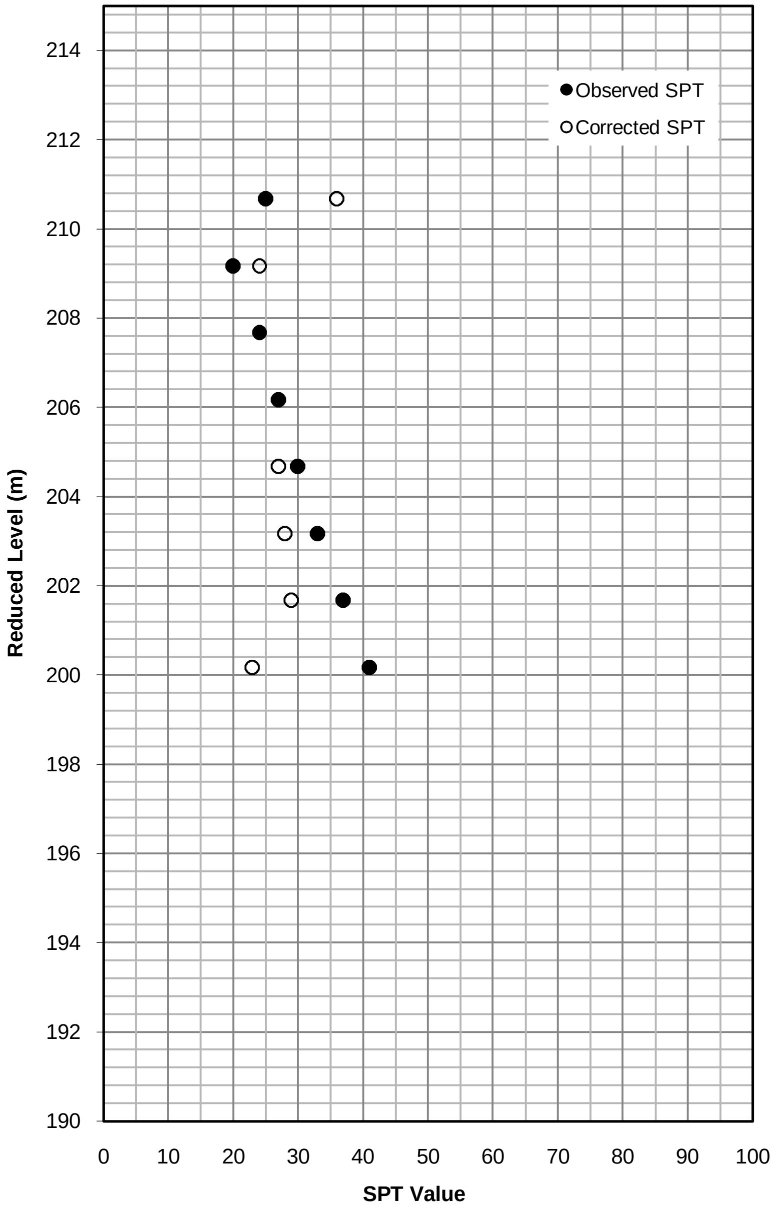
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut					
CLIENT:	**Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 8+060**			
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.**	**3.11**	**SHEET No.**	**1 of 1**



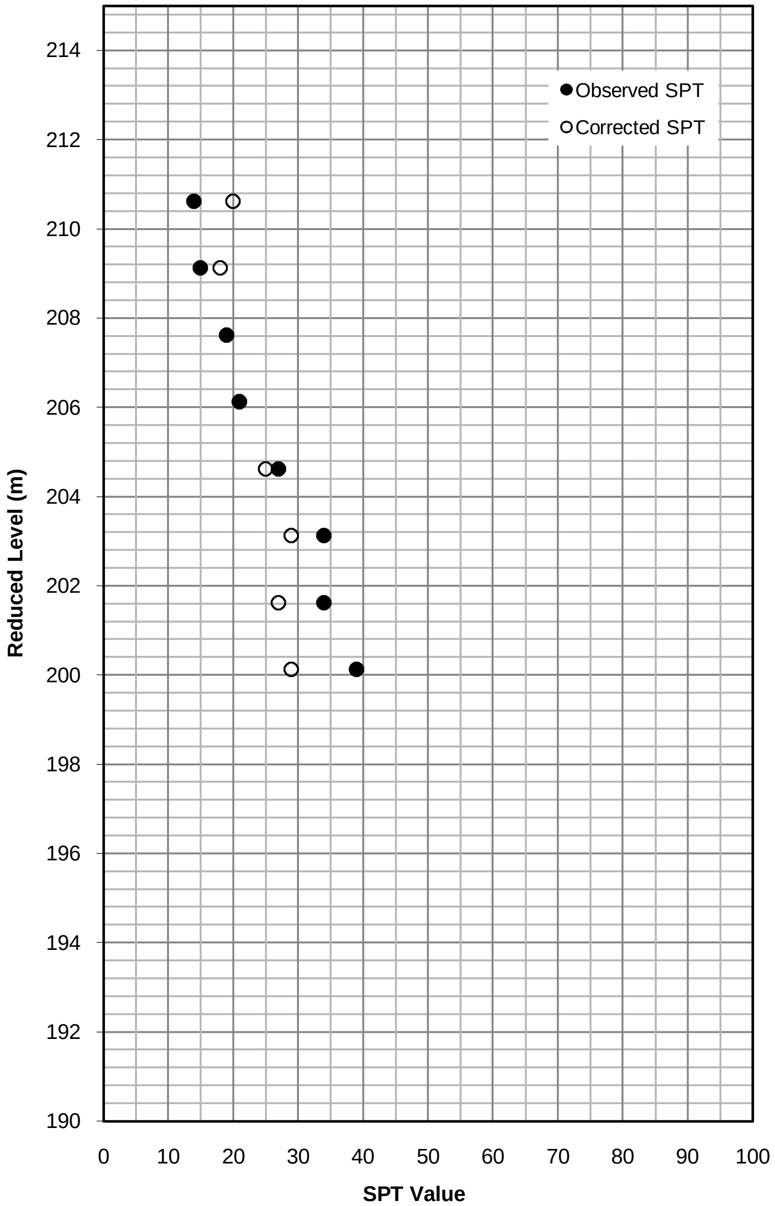
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 8+977**	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	**FIG. NO. 3.12**	**SHEET No. 1 of 1**	



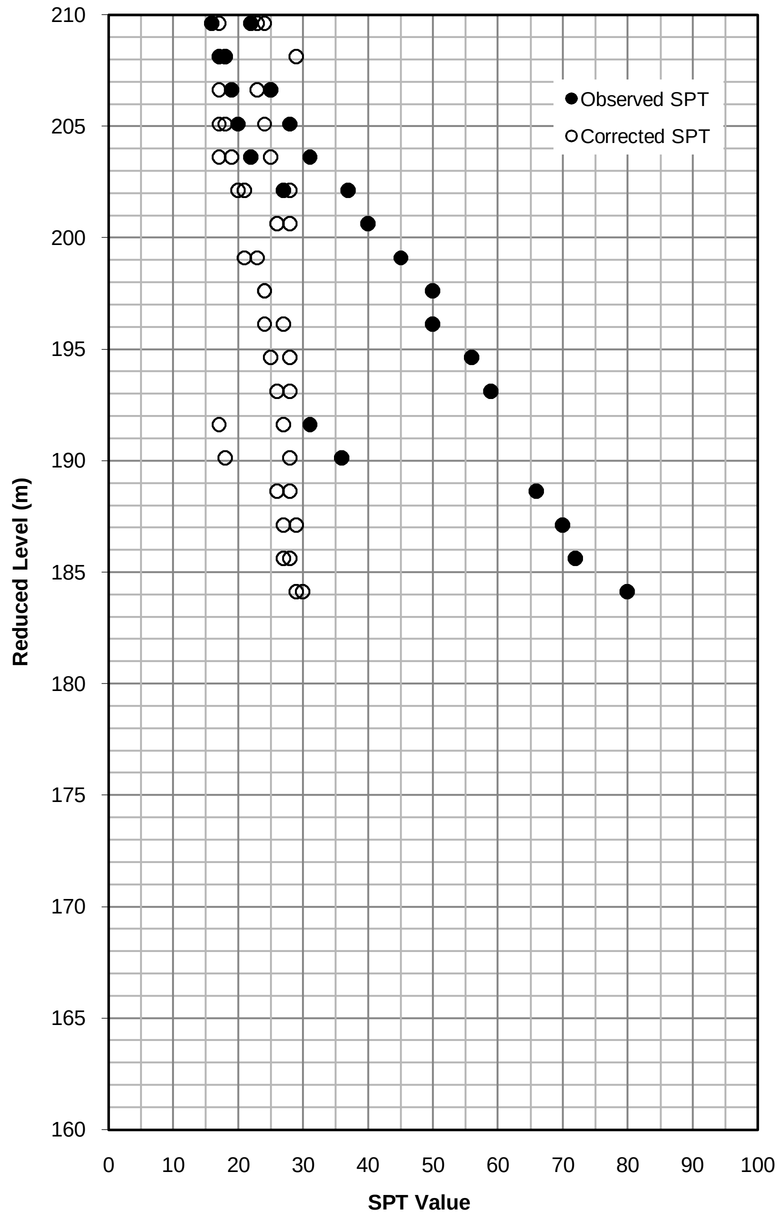
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 10+030**	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.		**FIG. NO. 3.13**	**SHEET No. 1 of 1**



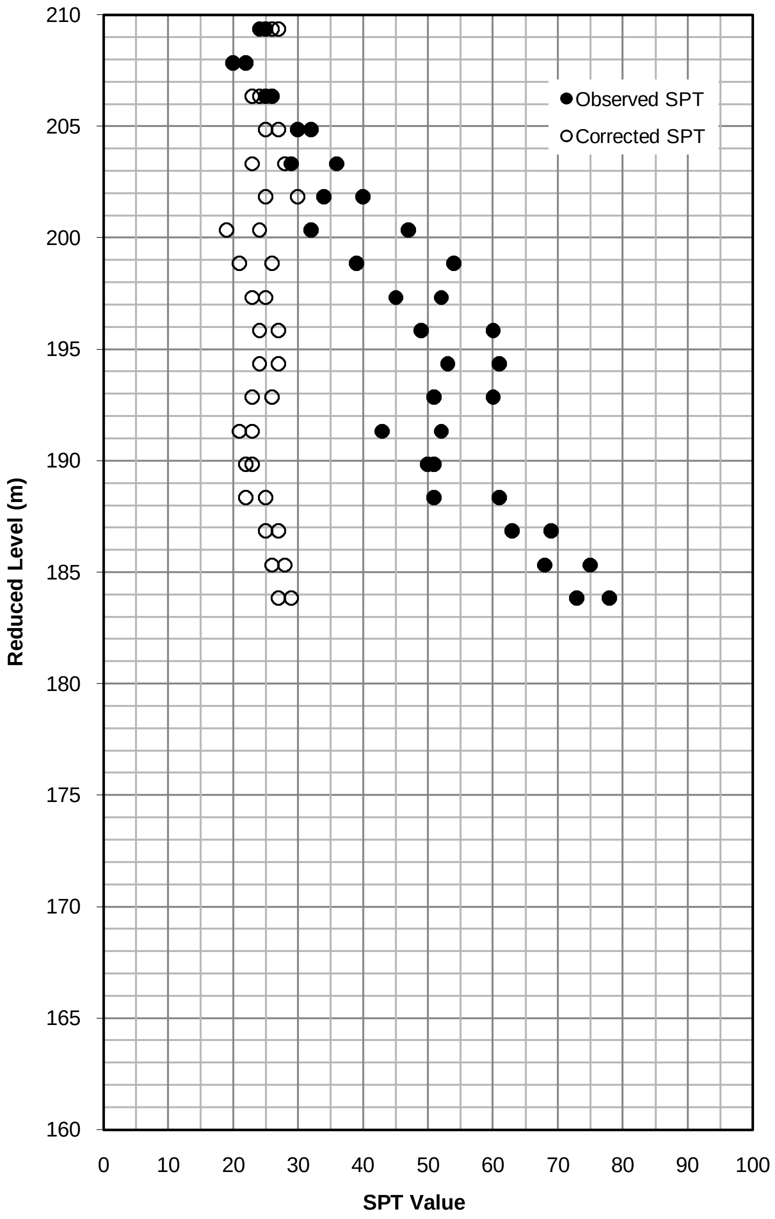
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1) Chainage : 10+973	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.14	SHEET No. 1 of 1



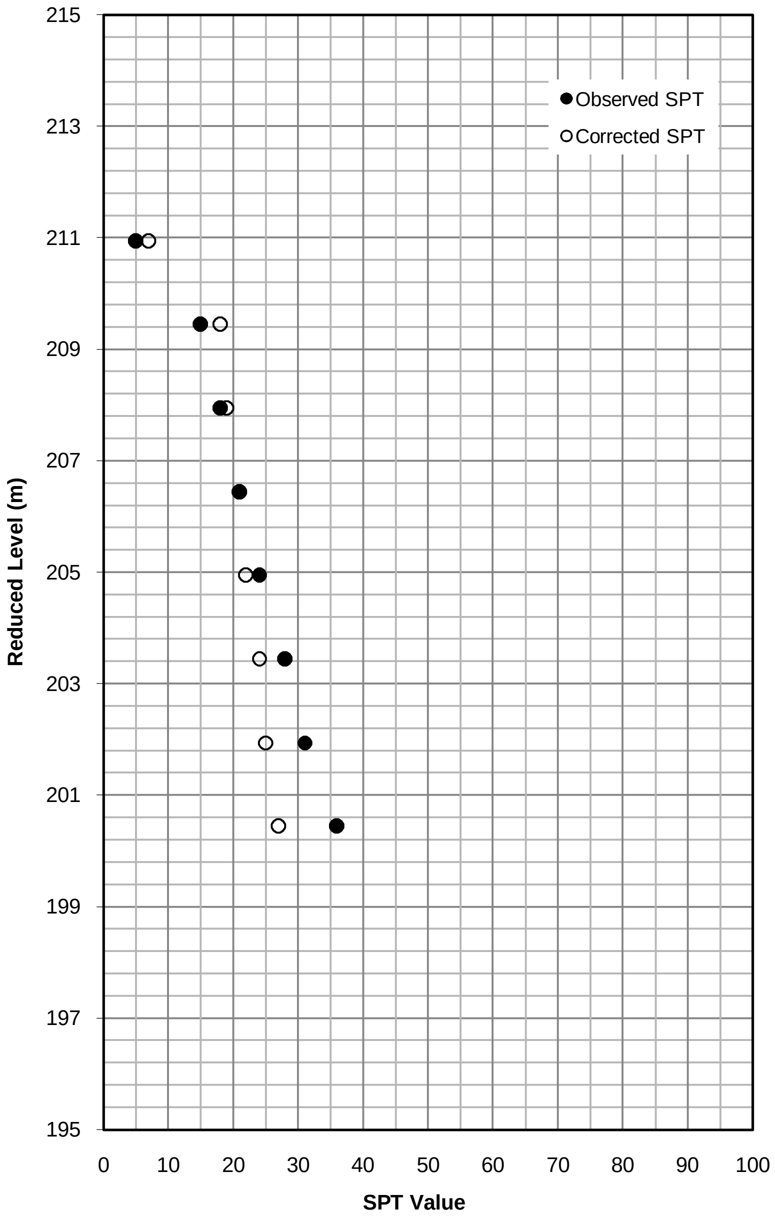
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 11+987**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.15**	**SHEET No.** **1 of 1**



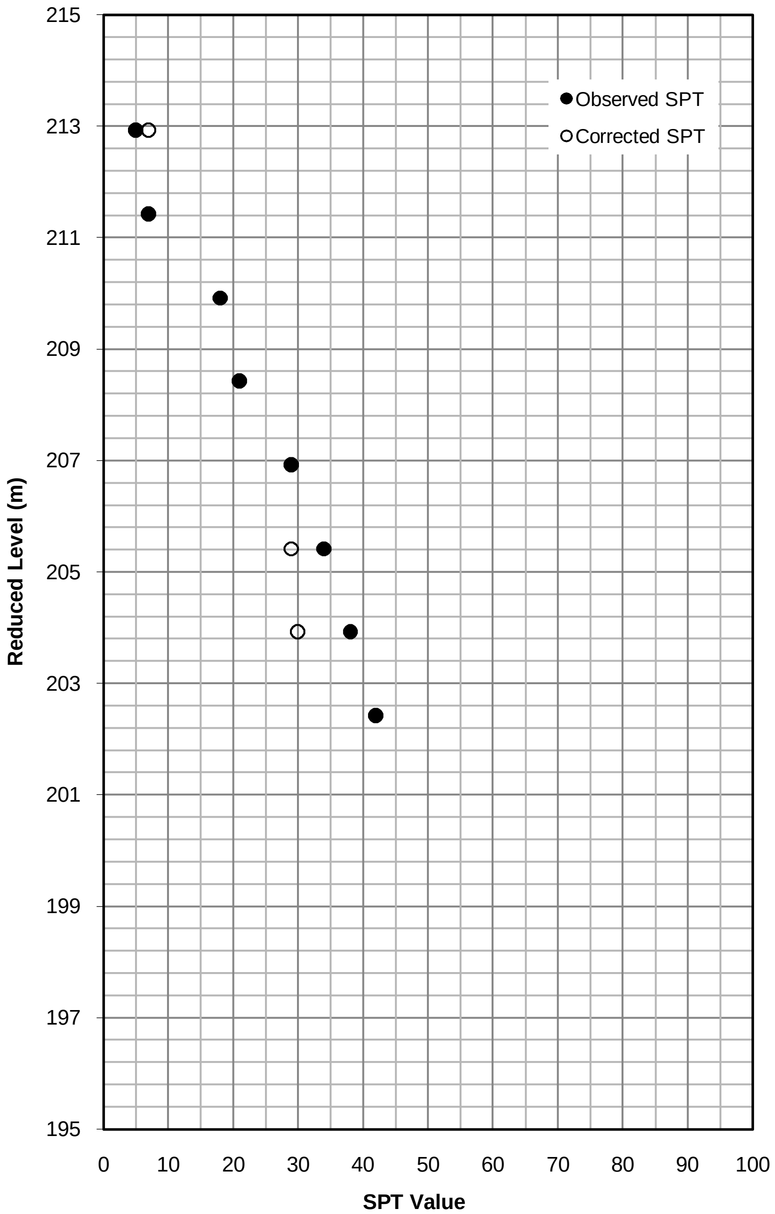
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1, BH-2 & BH-3)** **Chainage : 13+841**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.16**		**SHEET No.** **1 of 1**



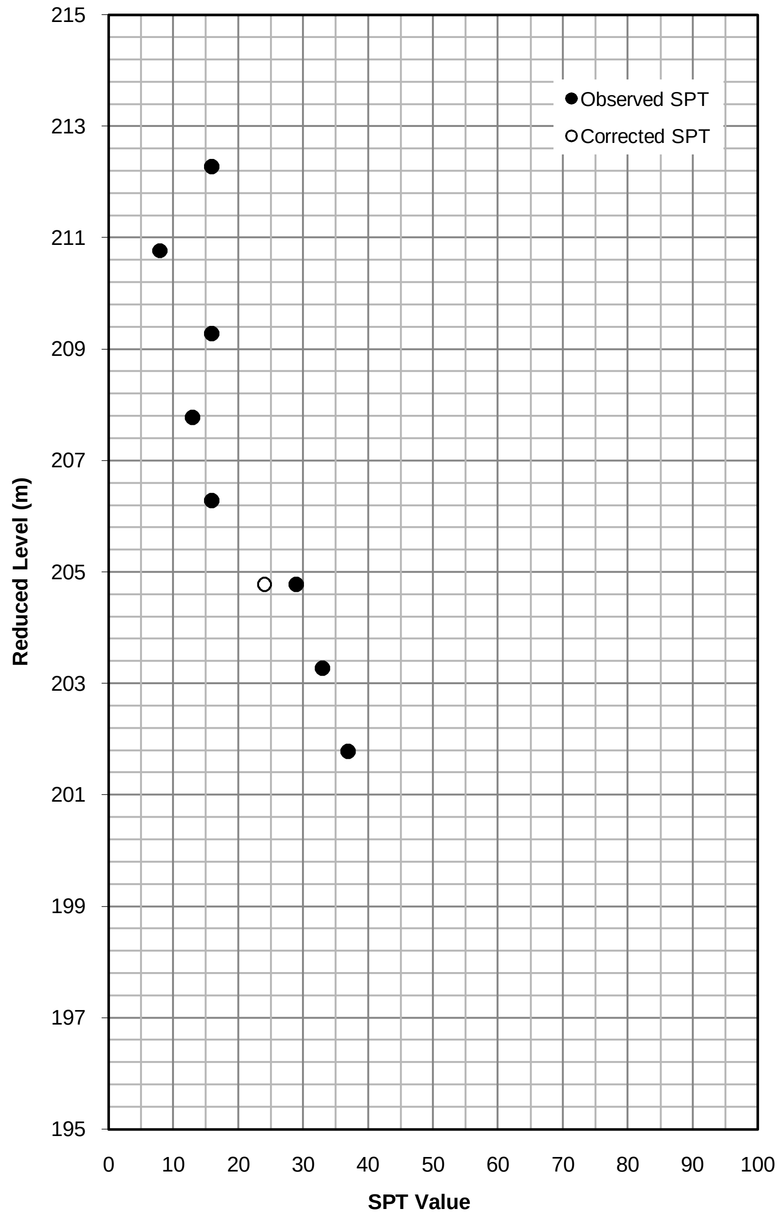
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1 & BH-2)** **Chainage : 14+069**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.17** **SHEET No.** **1 of 1**



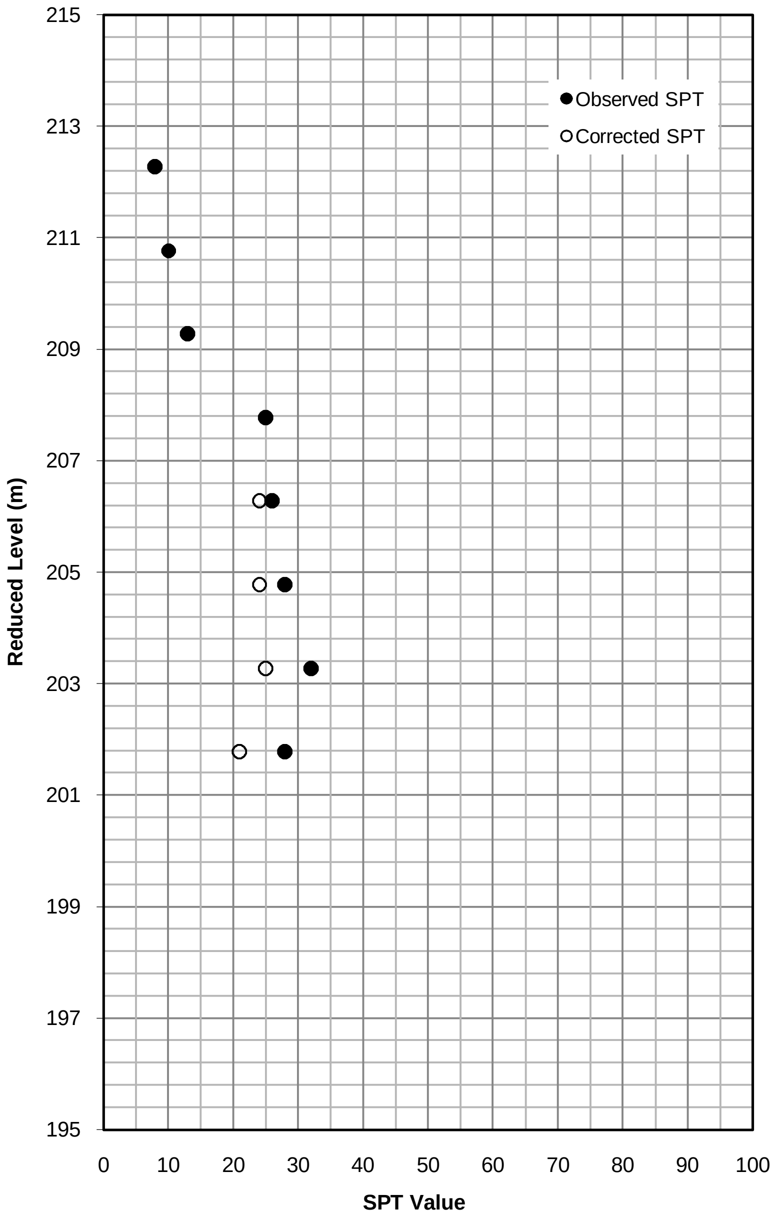
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1) Chainage : 13+136	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.18	SHEET No. 1 of 1



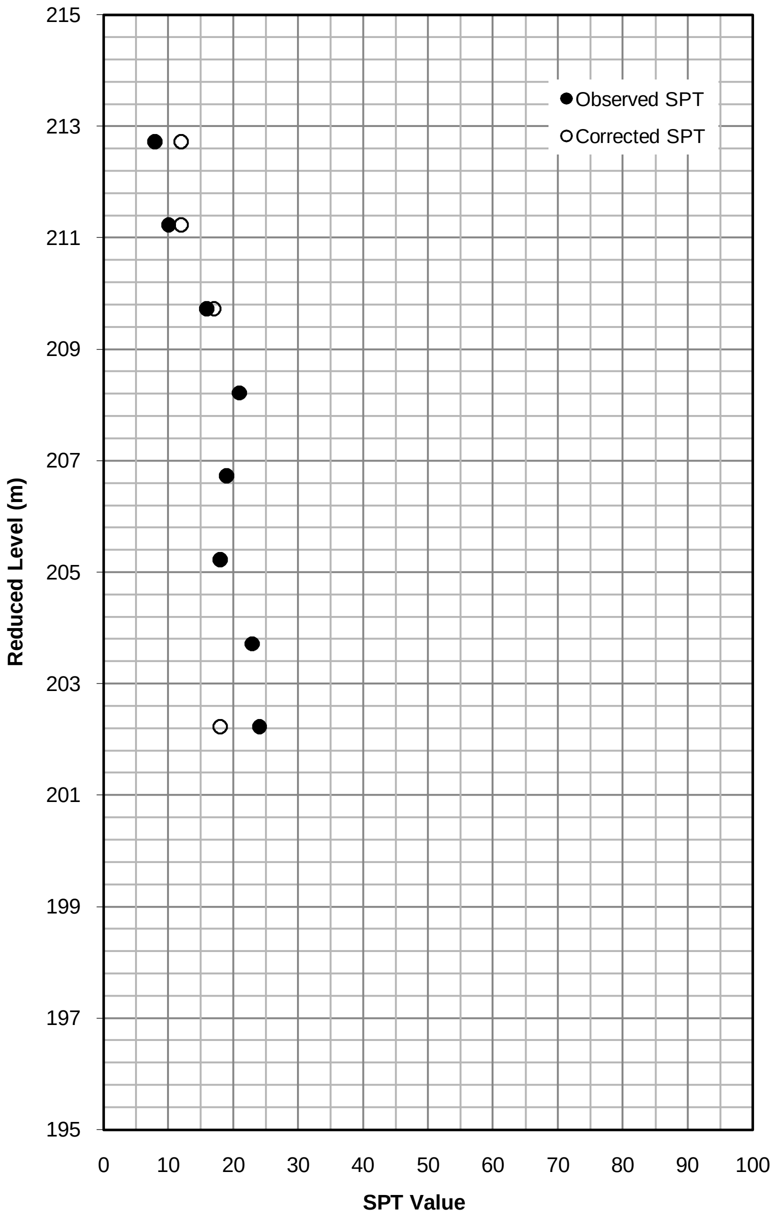
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 15+227**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.19**	**SHEET No.** **1 of 1**



Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 16+144**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.20** **SHEET No.** **1 of 1**

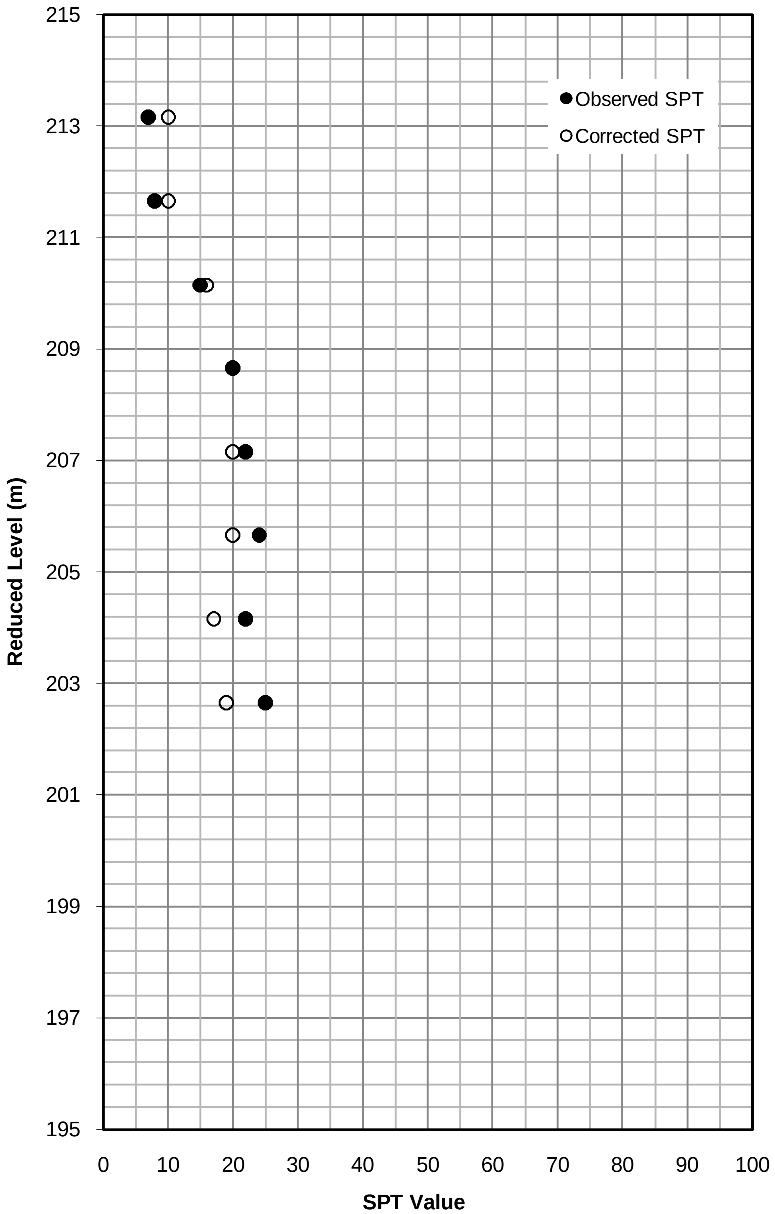


Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 17+338**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.21**	**SHEET No.** **1 of 1**

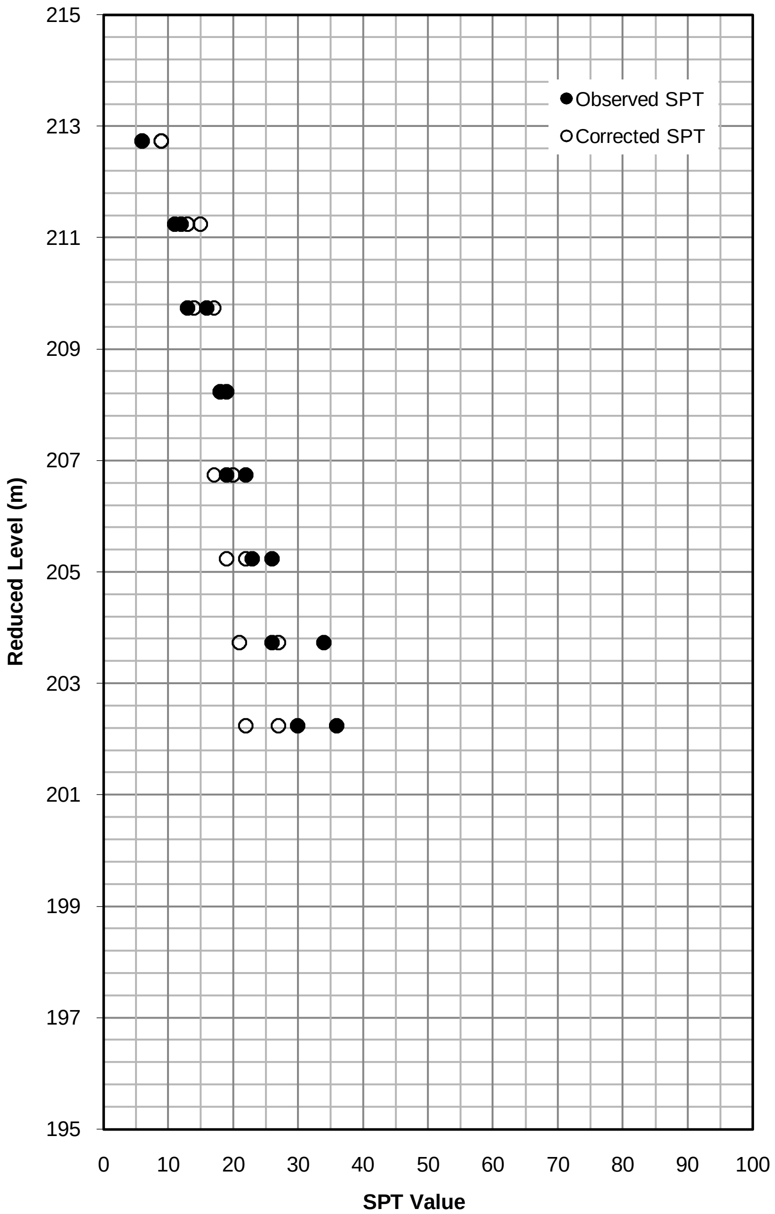


Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut

CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 18+070**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.22	**SHEET No.** 1 of 1

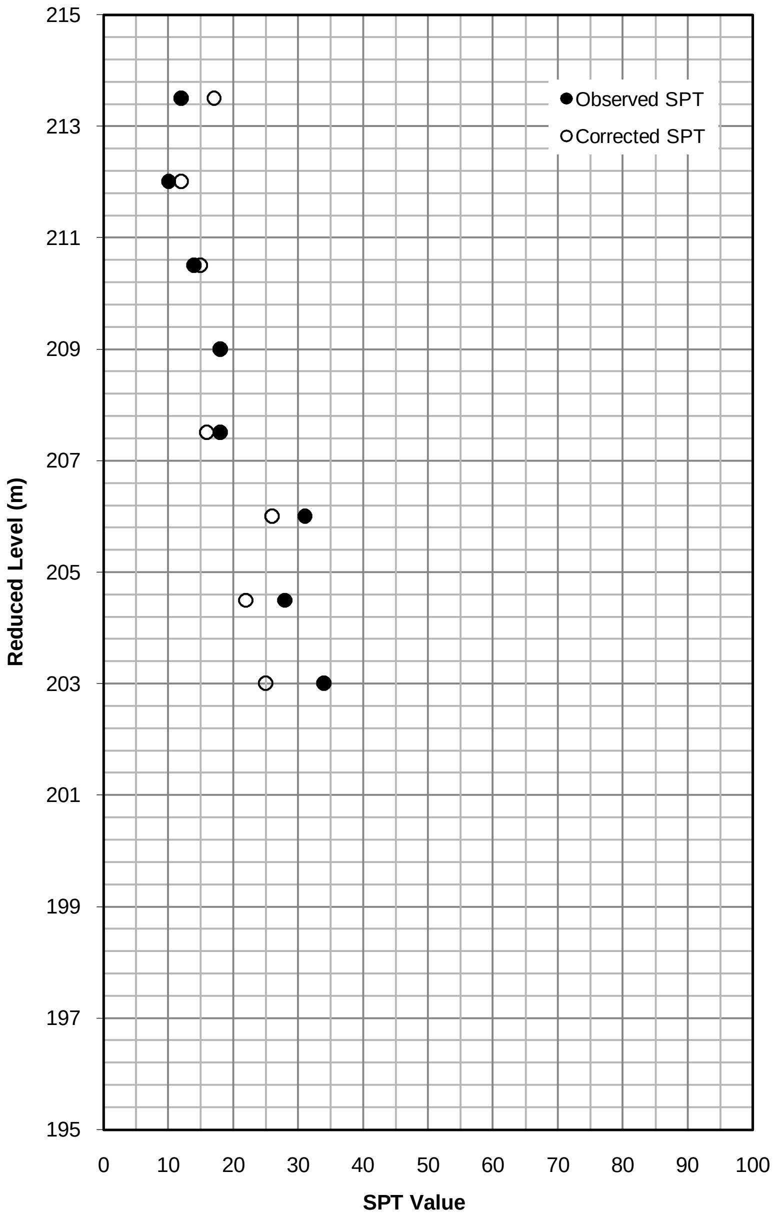


Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1) Chainage : 19+051	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.		FIG. NO. 3.23	SHEET No. 1 of 1



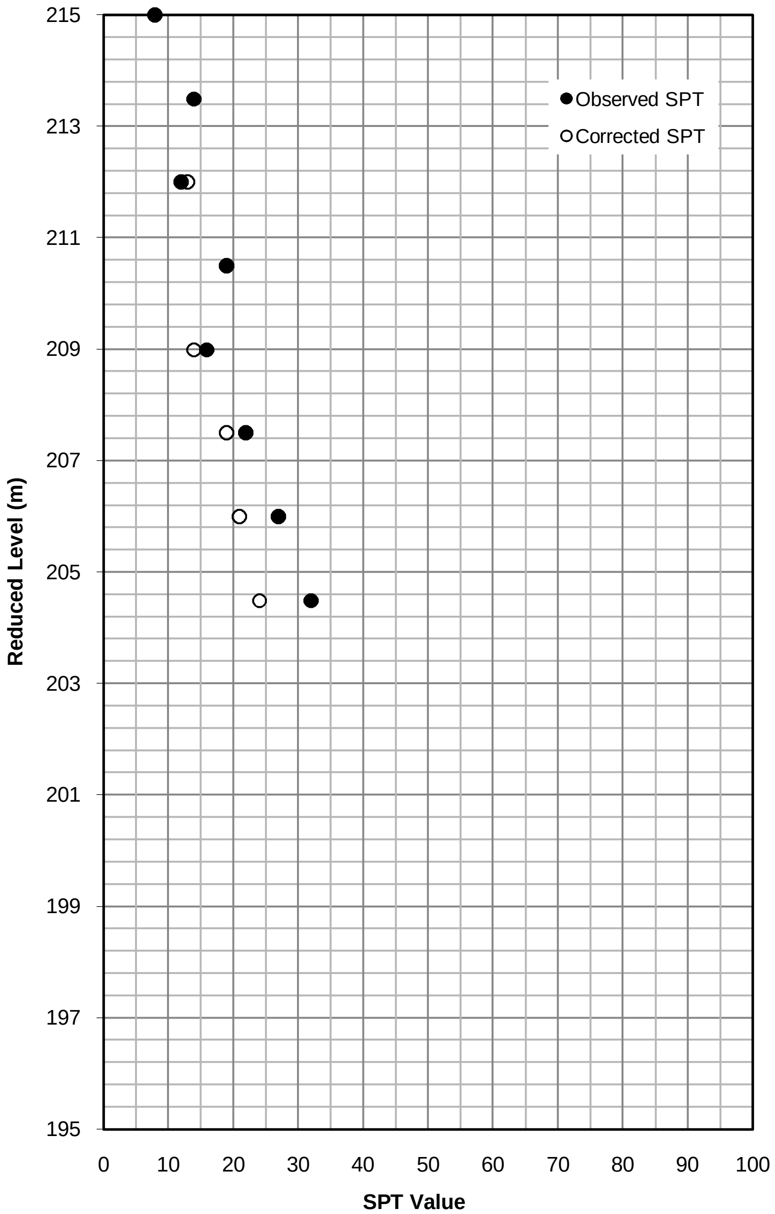
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut

CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** Chainage : 19+955	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.24	**SHEET No.** 1 of 1

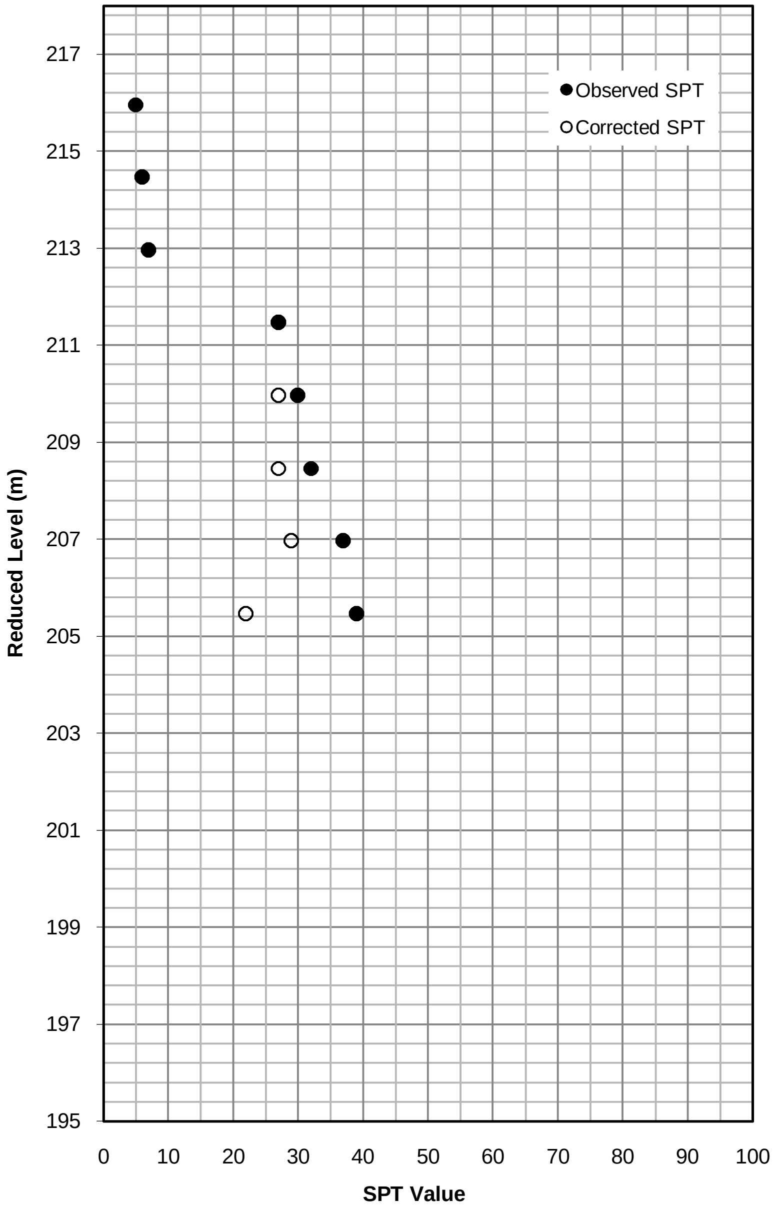


Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut

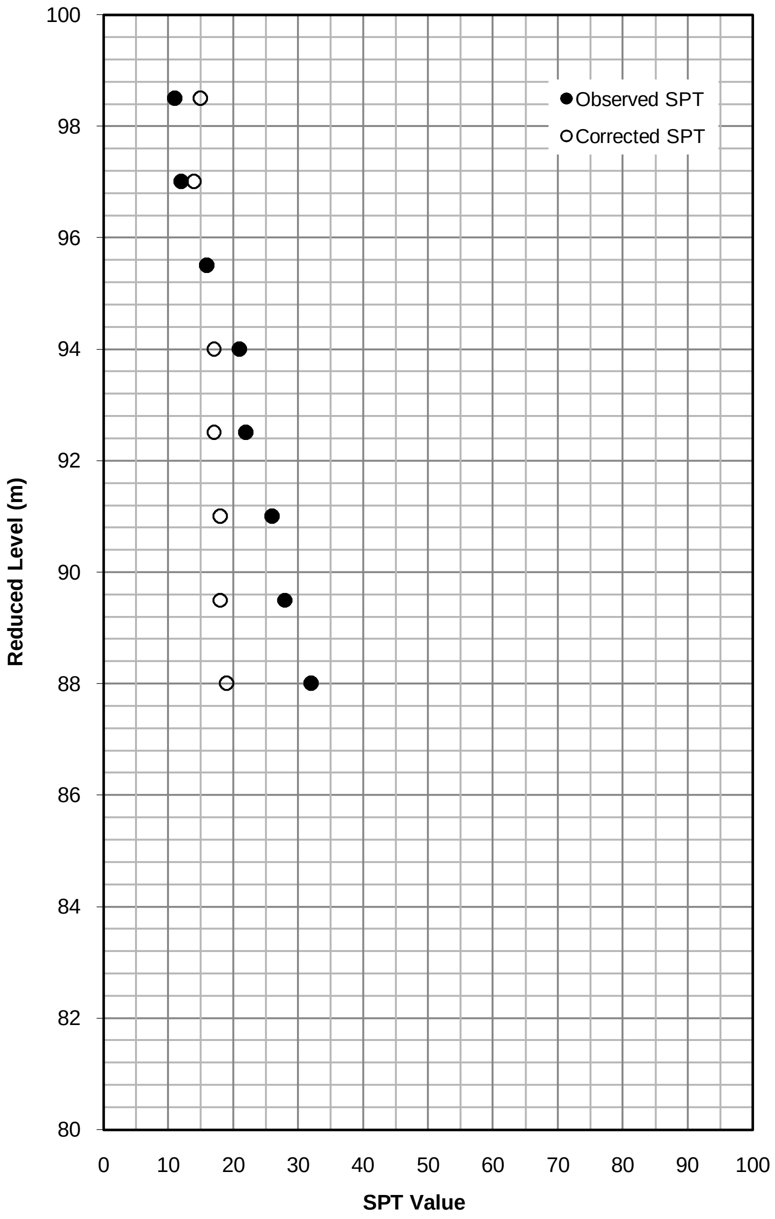
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 20+935**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.25**	**SHEET No.** **1 of 1**



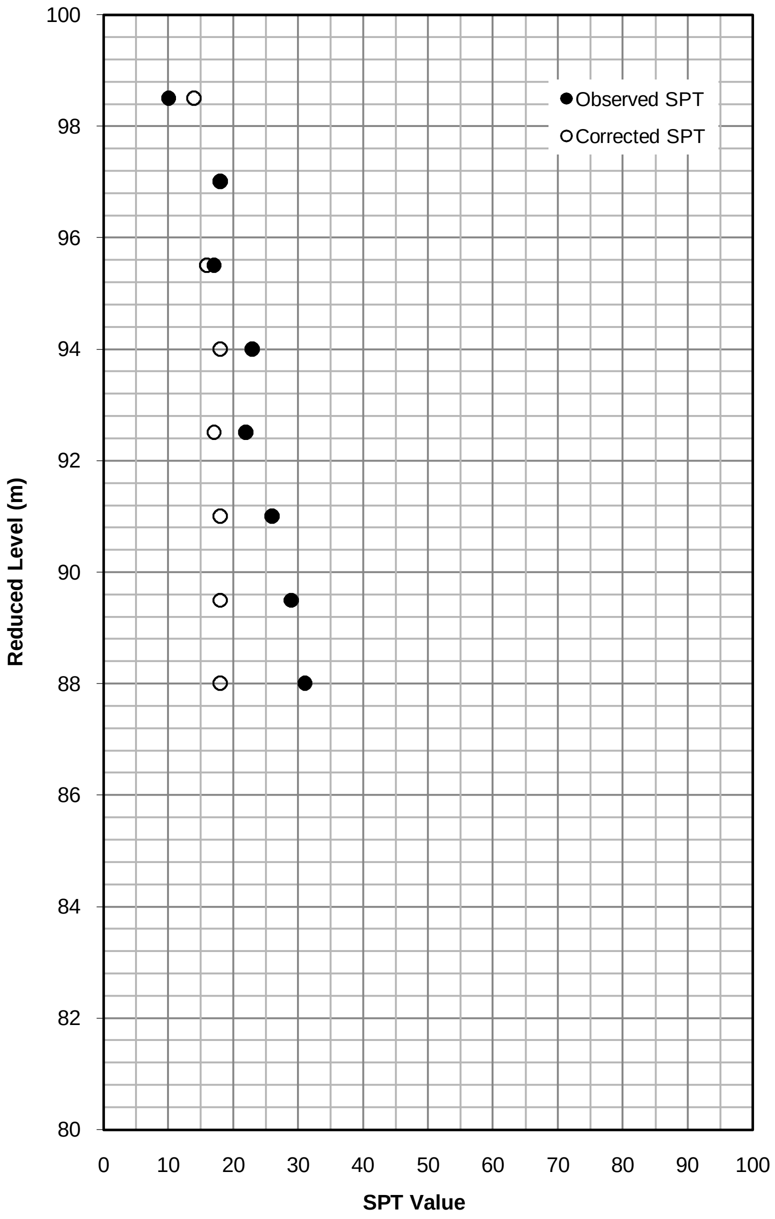
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 22+200**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.26**	**SHEET No.** **1 of 1**



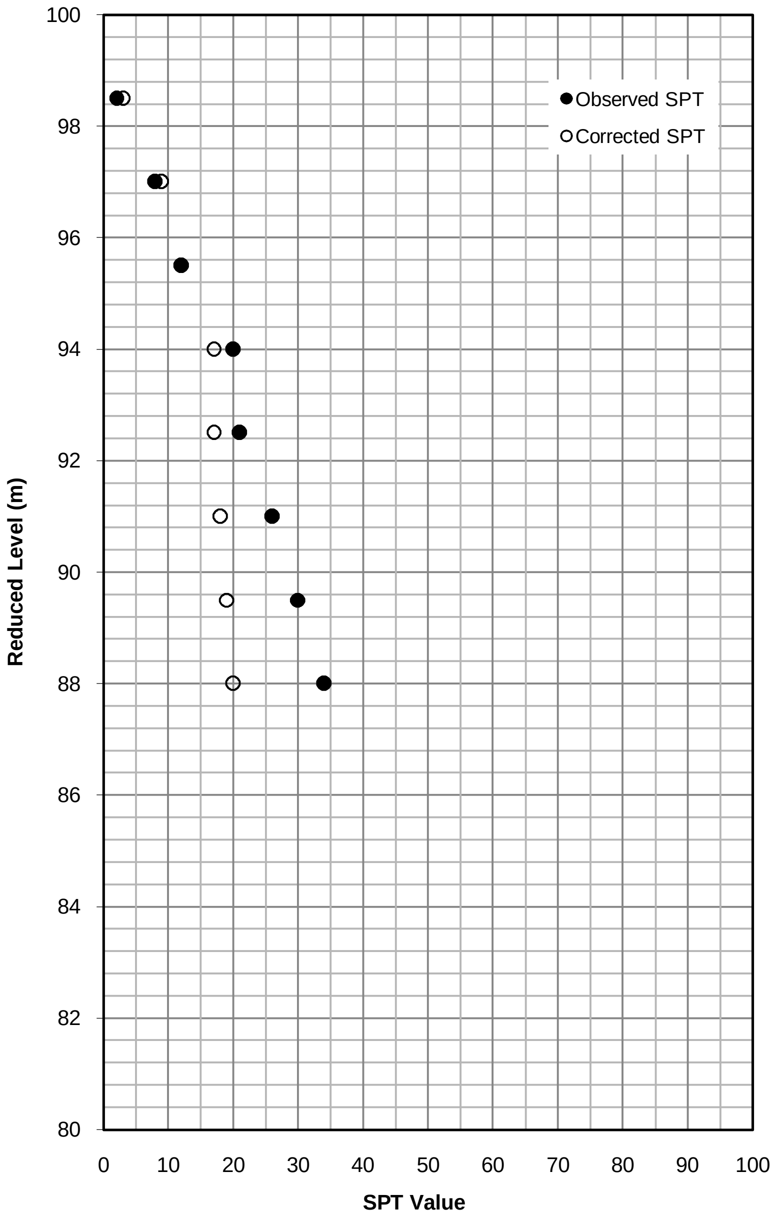
Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 23+808**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.27** | **SHEET No.** **1 of 1**



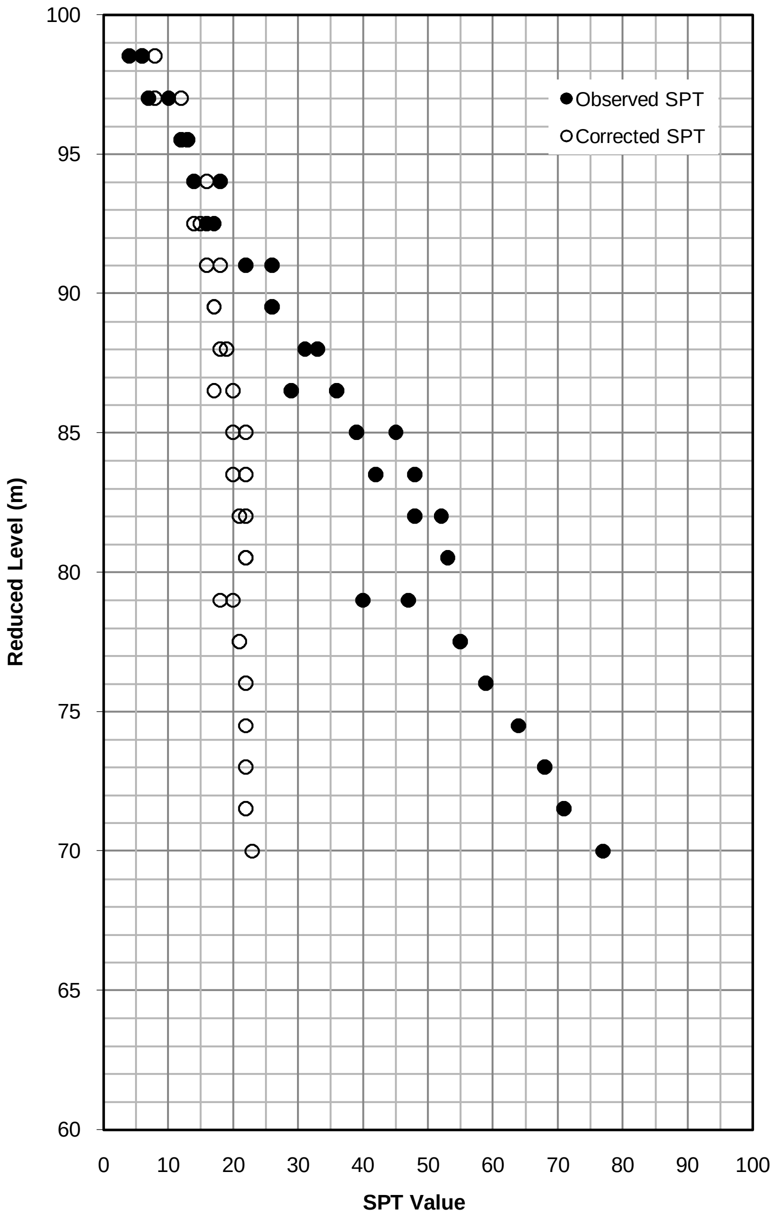
Geotechnical Investigation Works at Khurja-Dadri Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** Chainage : 24+920	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.28	**SHEET No.** 1 of 1



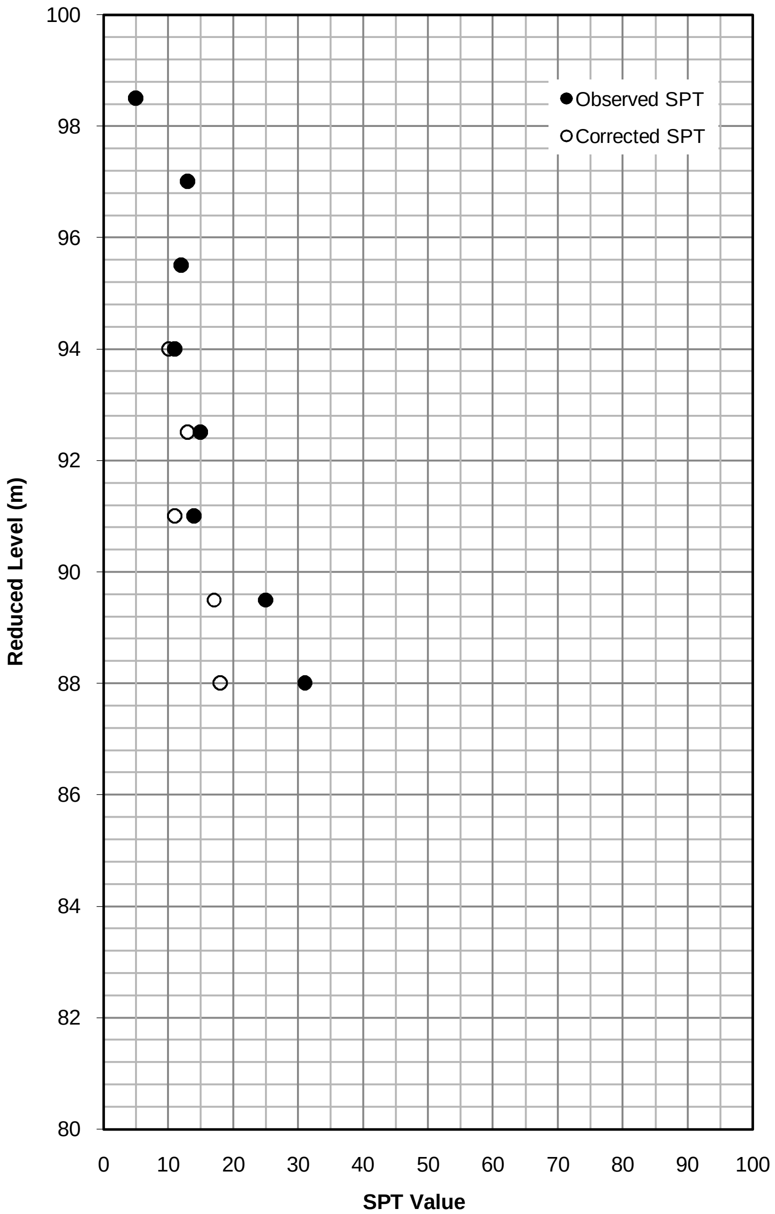
Geotechnical Investigation Works at Khurja-Dadri Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1) Chainage : 25+760	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.29	SHEET No. 1 of 1



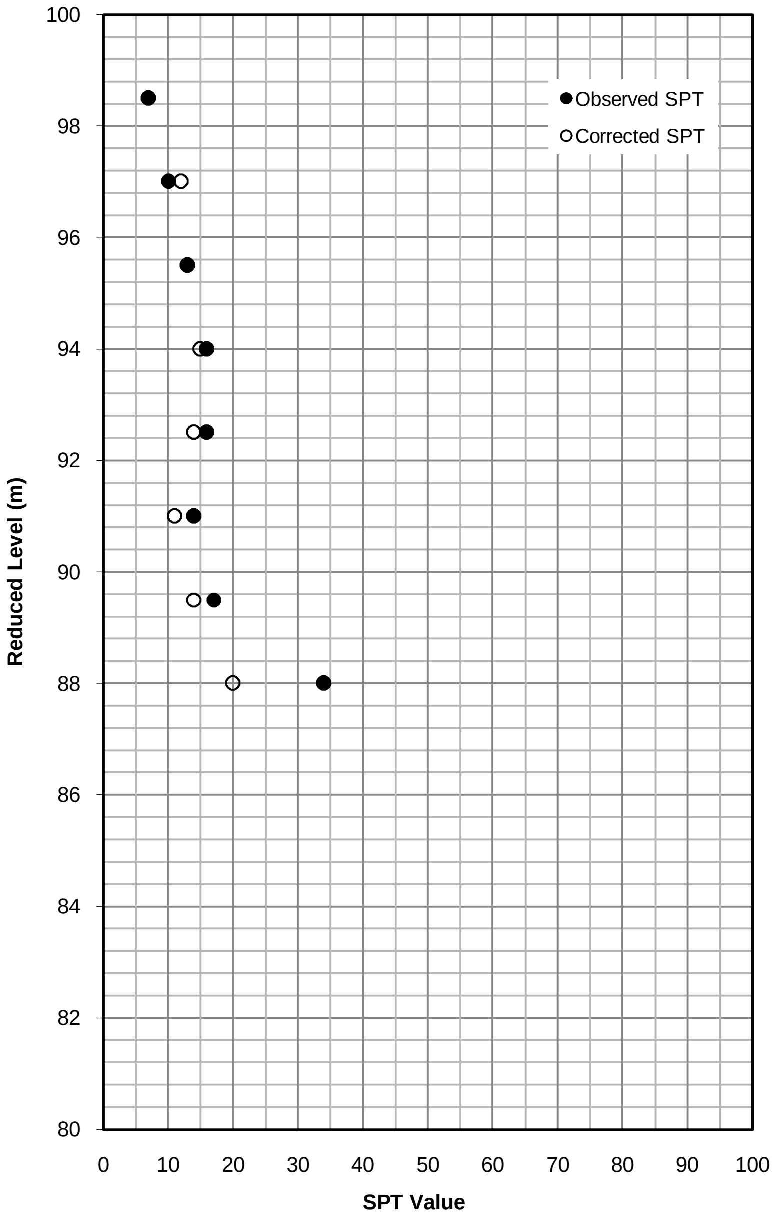
Geotechnical Investigation Works at Khurja-Dadri Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1) Chainage : 26+530	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.30	SHEET No. 1 of 1



Geotechnical Investigation Works at Khurja-Dadri Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1 & BH-2)** **Chainage : 27+290**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.31**	**SHEET No.** **1 of 1**

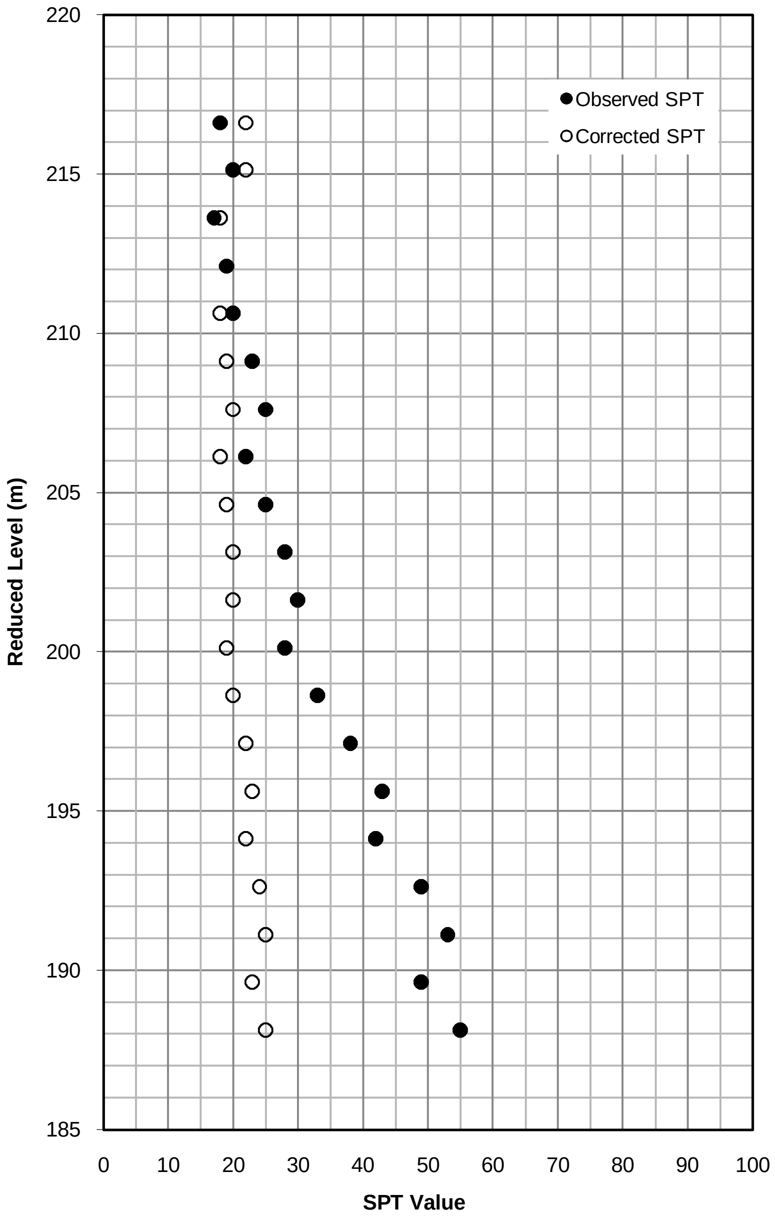


Geotechnical Investigation Works at Khurja-Dadri Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** Chainage : 27+820	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.32	**SHEET No.** 1 of 1



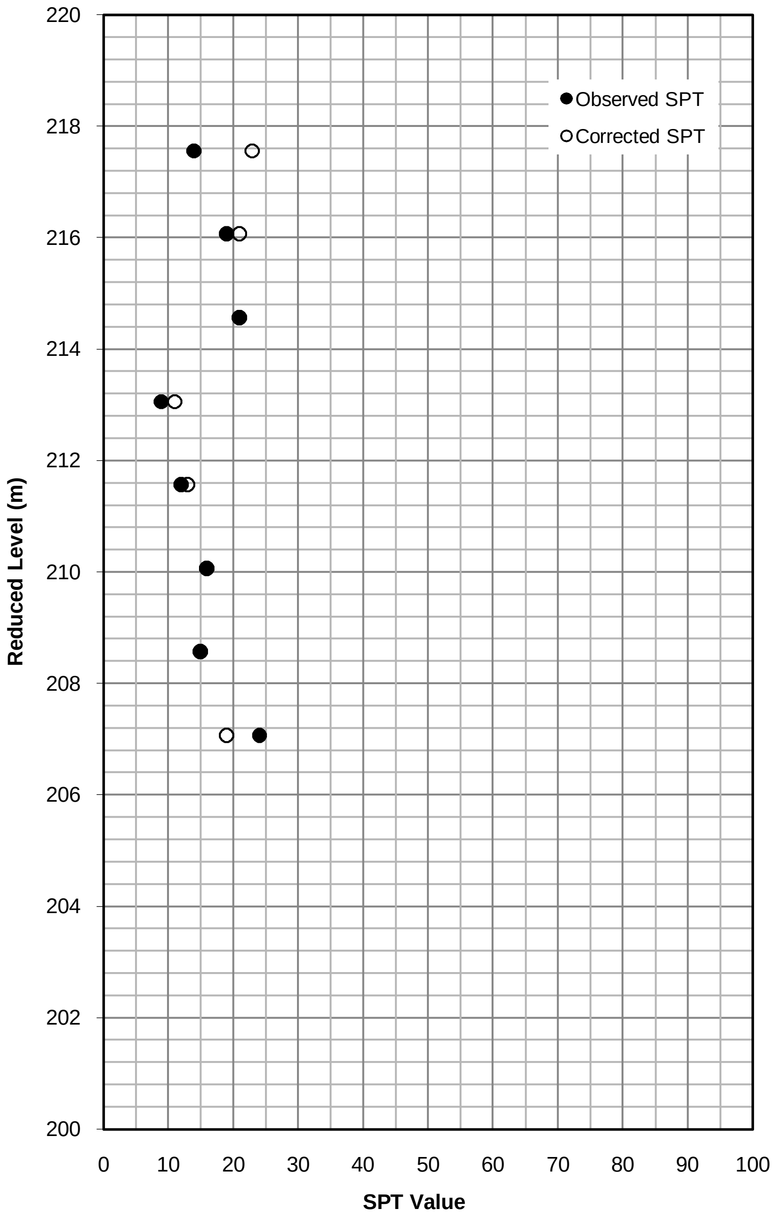
Geotechnical Investigation Works at Khurja-Dadri Section of DFCC Meerut

CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** Chainage : 28+660	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** 3.33	**SHEET No.** 1 of 1



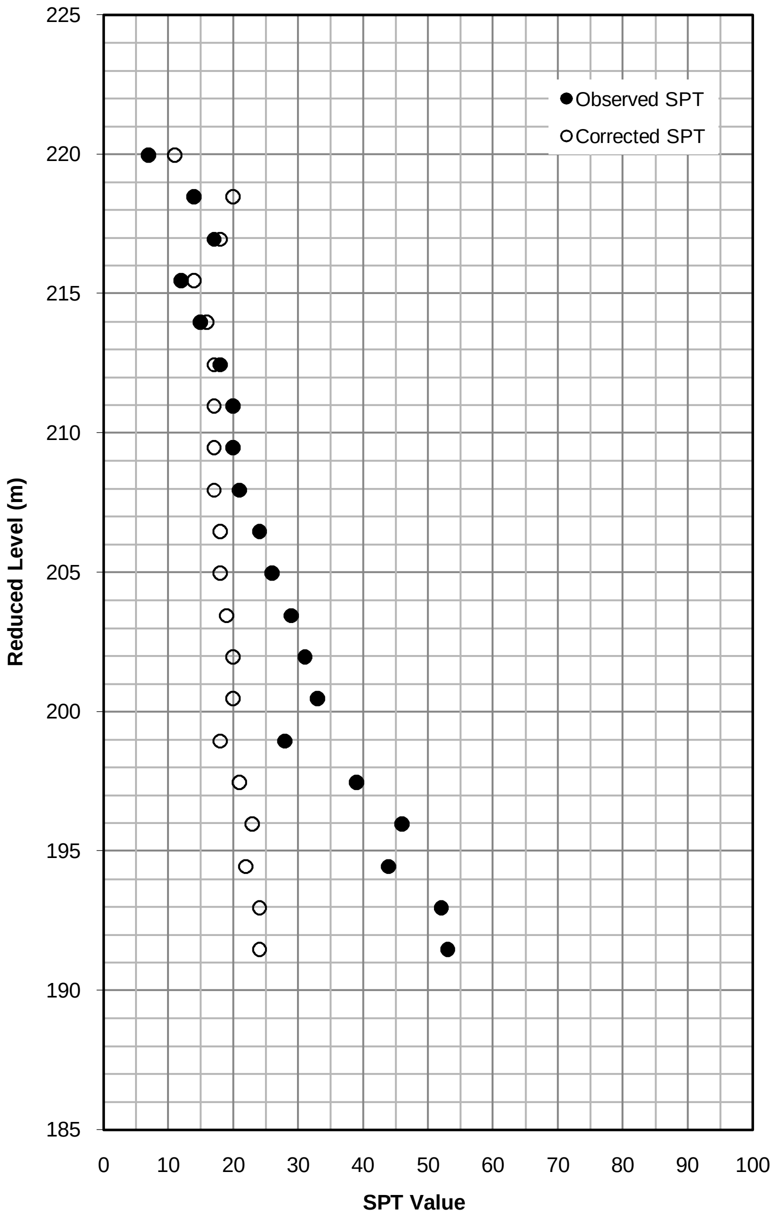
Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 28+880**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.34**	**SHEET No.** **1 of 1**

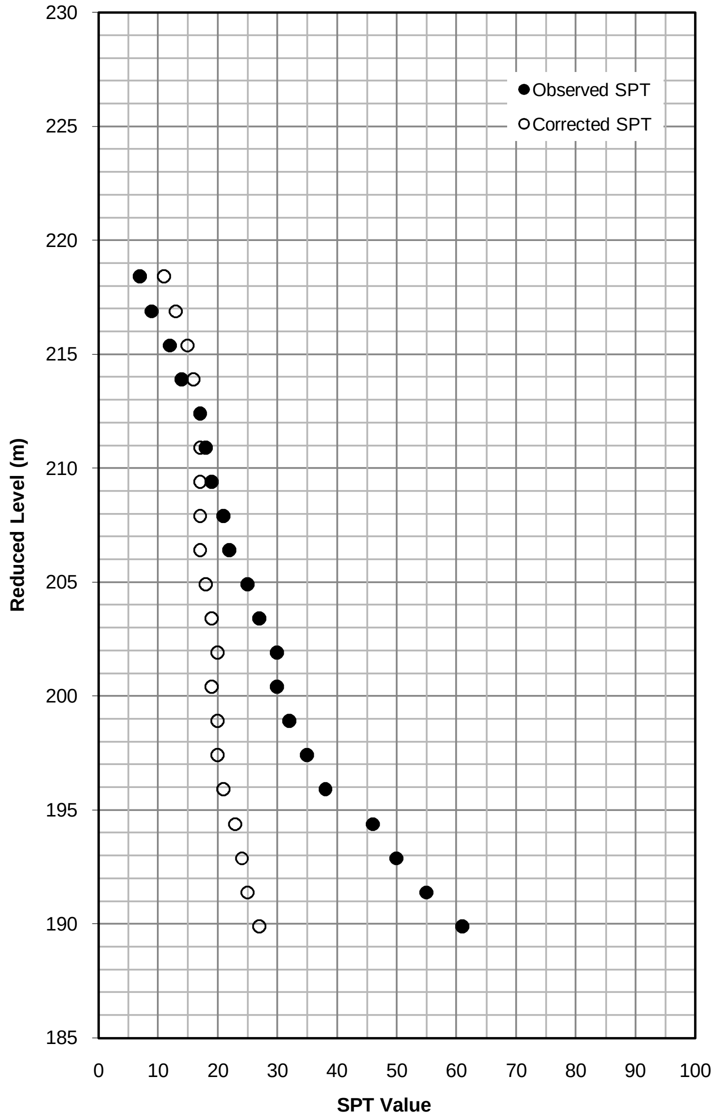


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 30+780**		
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.35**	**SHEET No.** **1 of 1**	

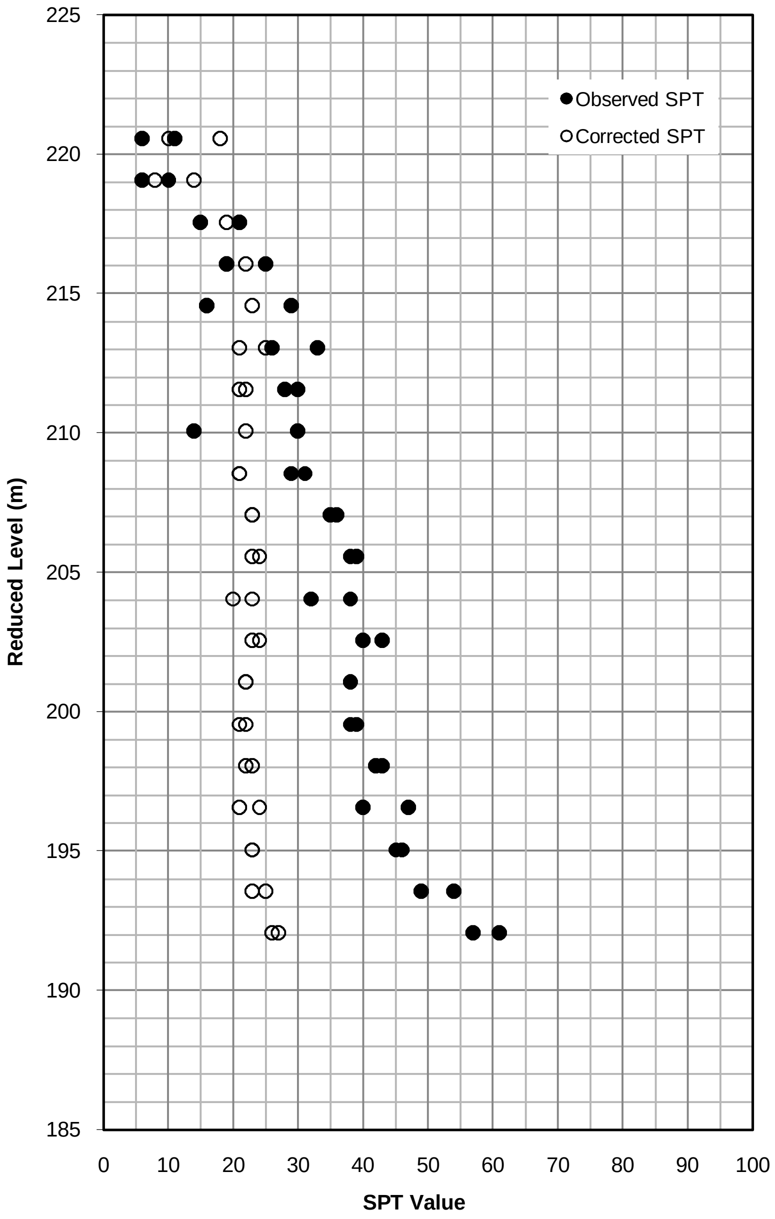


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 33+050**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.36** **SHEET No.** **1 of 1**

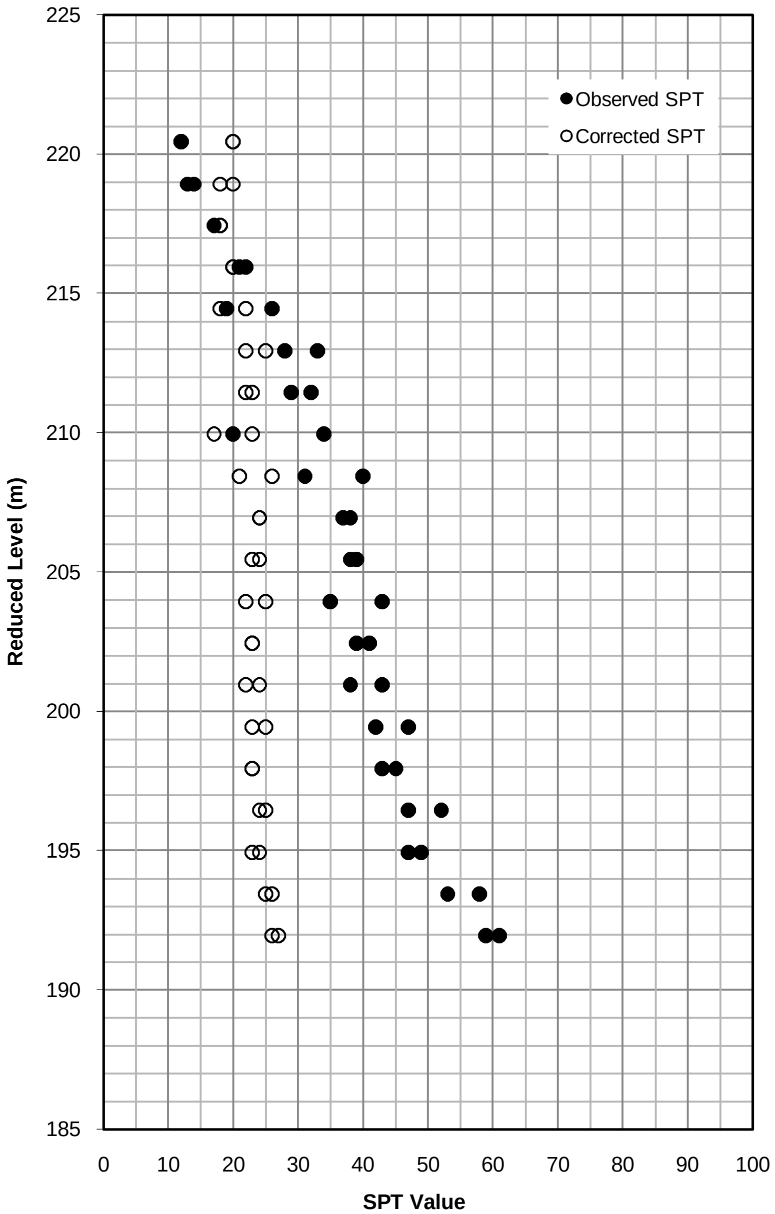


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

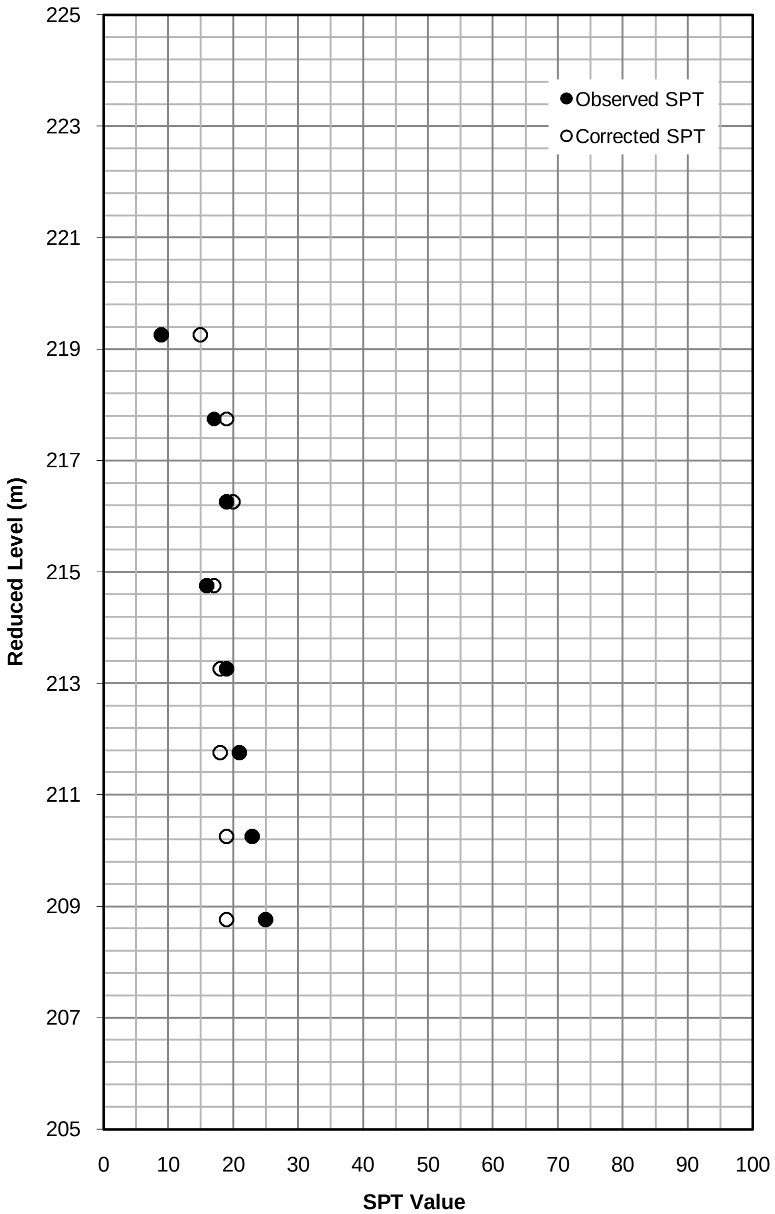
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 34+360**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.37**	**SHEET No.** **1 of 1**



Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1 & BH-2) Chainage : 34+986	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.		FIG. NO. 3.38	SHEET No. 1 of 1

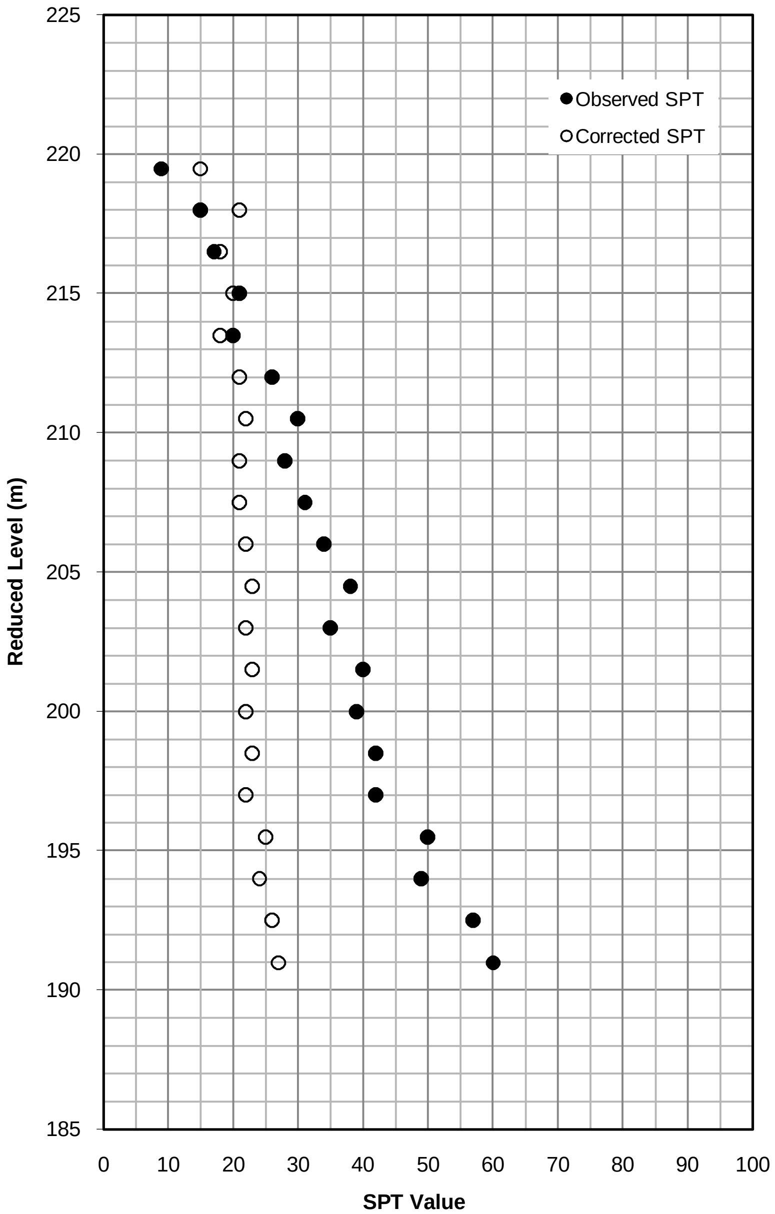


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1 & BH-2) Chainage : 35+549	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.39	SHEET No. 1 of 1

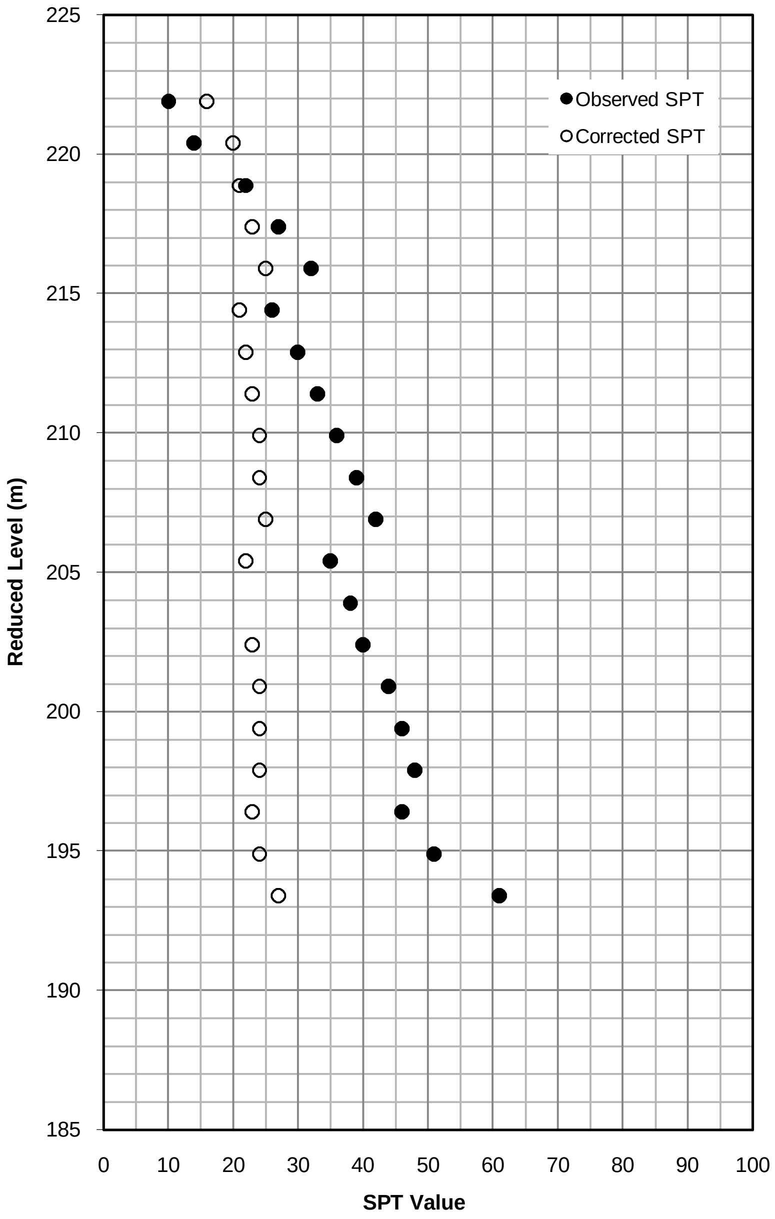


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

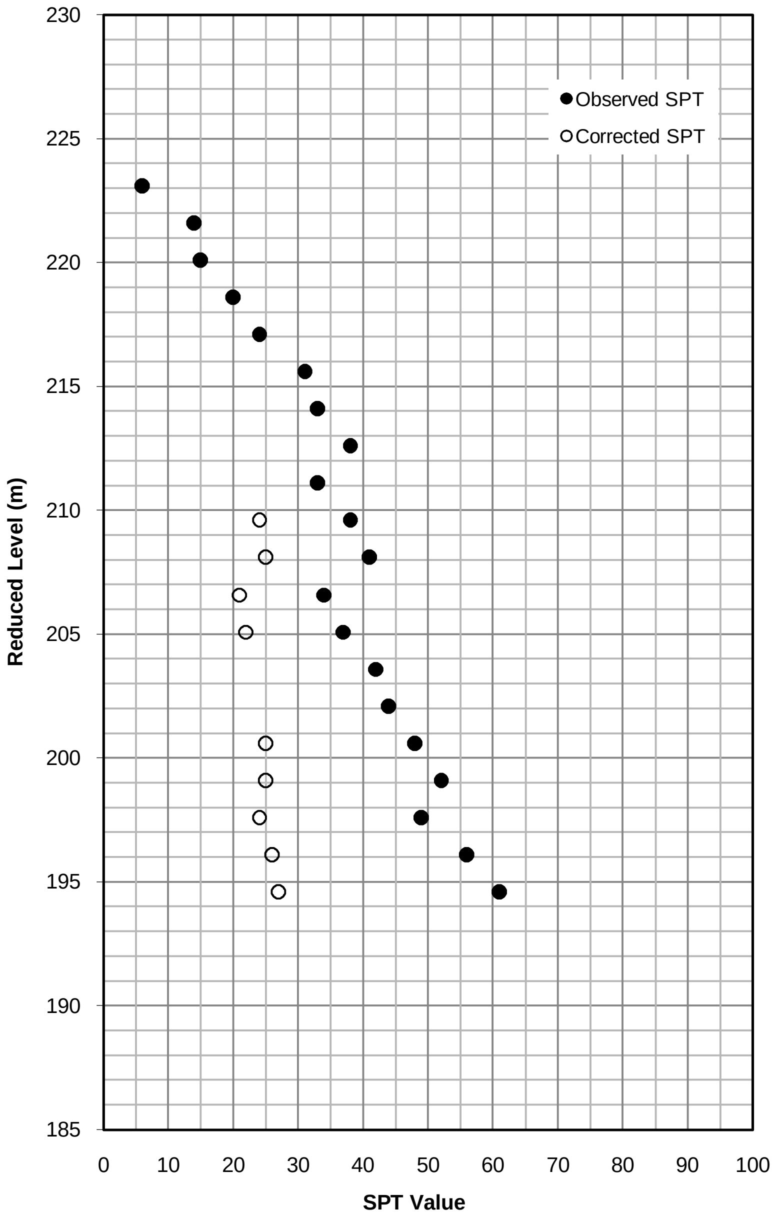
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1) Chainage : 37+360	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.40	SHEET No. 1 of 1



Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 38+580**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.41** | **SHEET No.** **1 of 1**

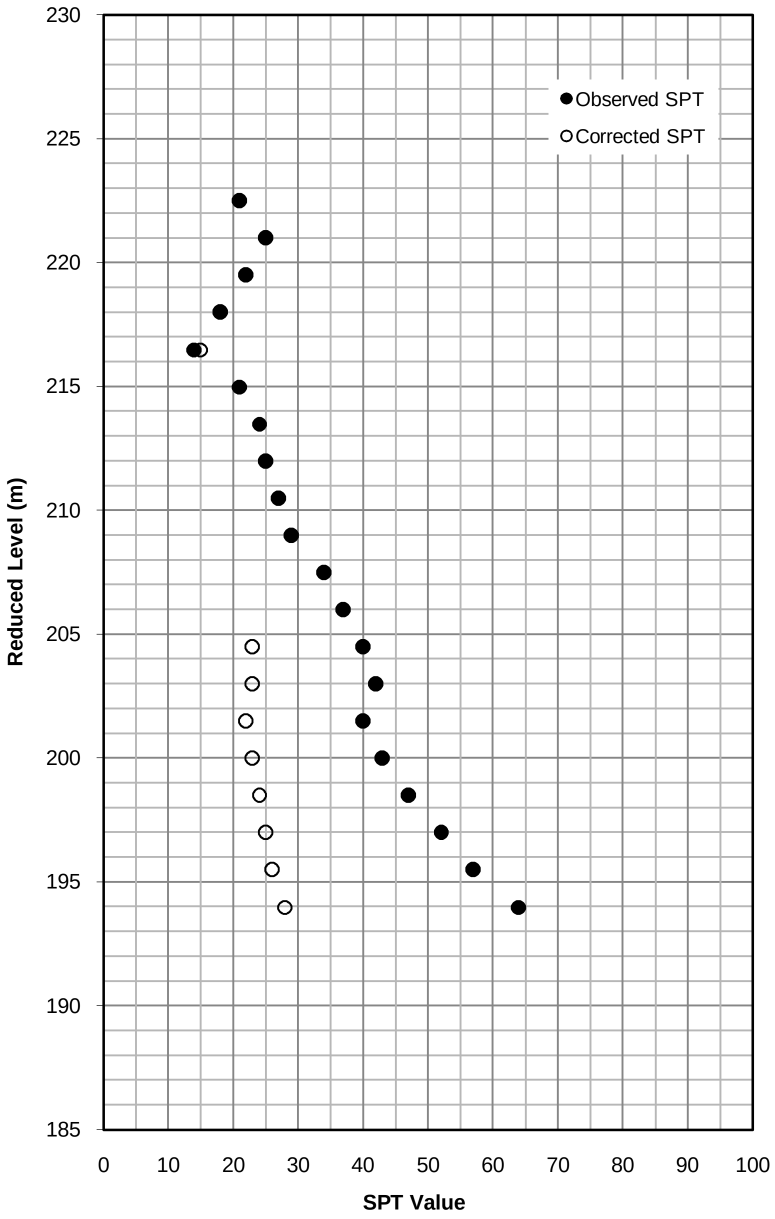


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: Skylark		Variation of SPT Value with Depth (BH-1) Chainage : 39+120	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.42	SHEET No. 1 of 1

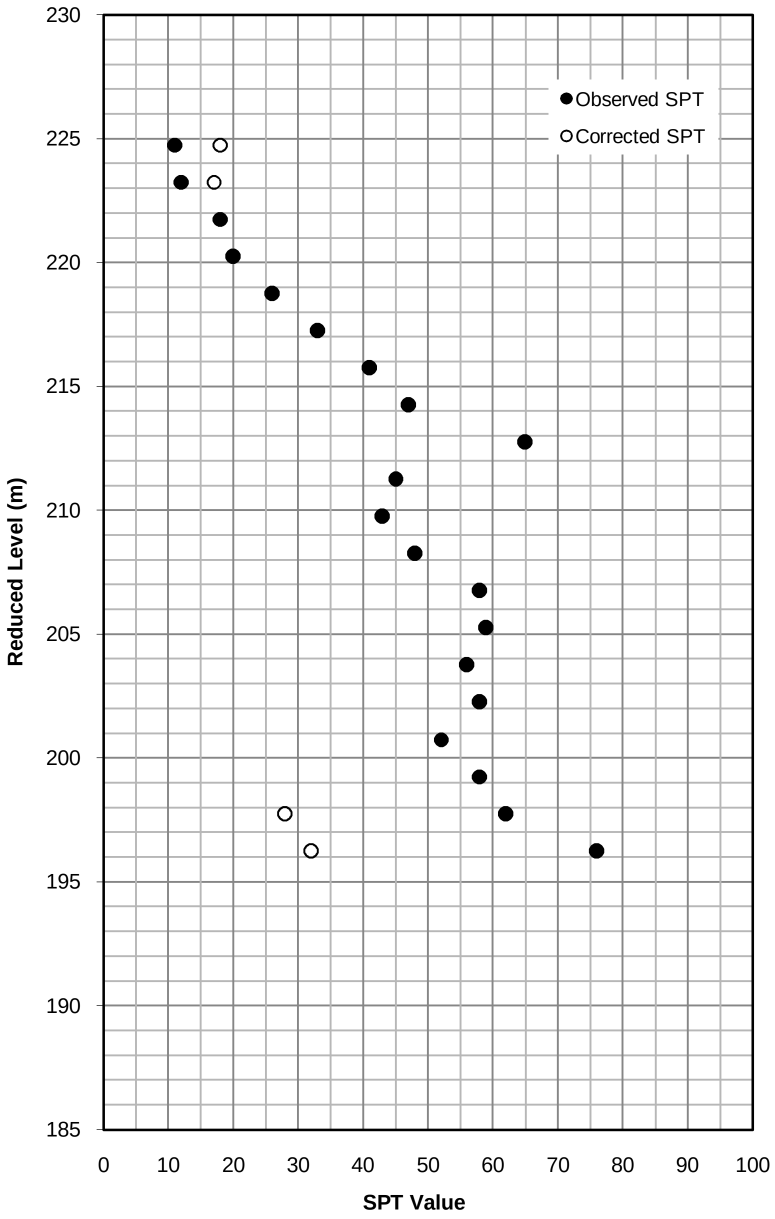


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

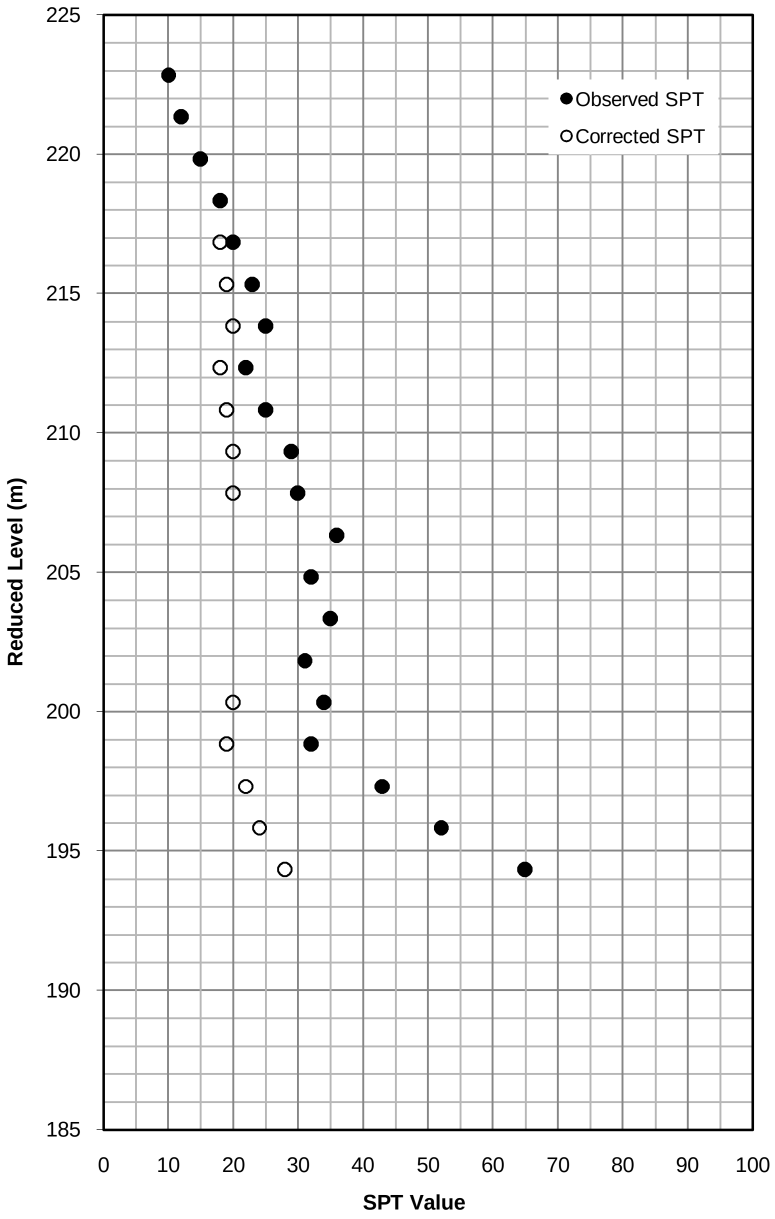
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 41+916**	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.43	SHEET No. 1 of 1



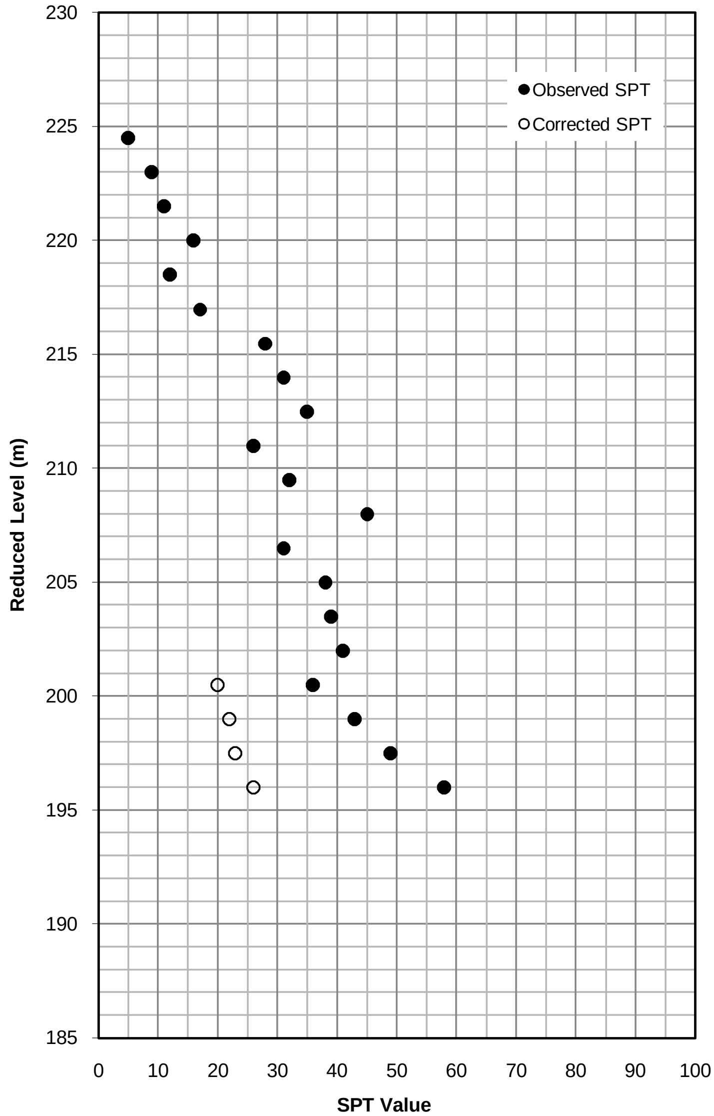
Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 43+900**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO. 3.44**	**SHEET No. 1 of 1**



Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 46+362**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.45**		**SHEET No.** **1 of 1**

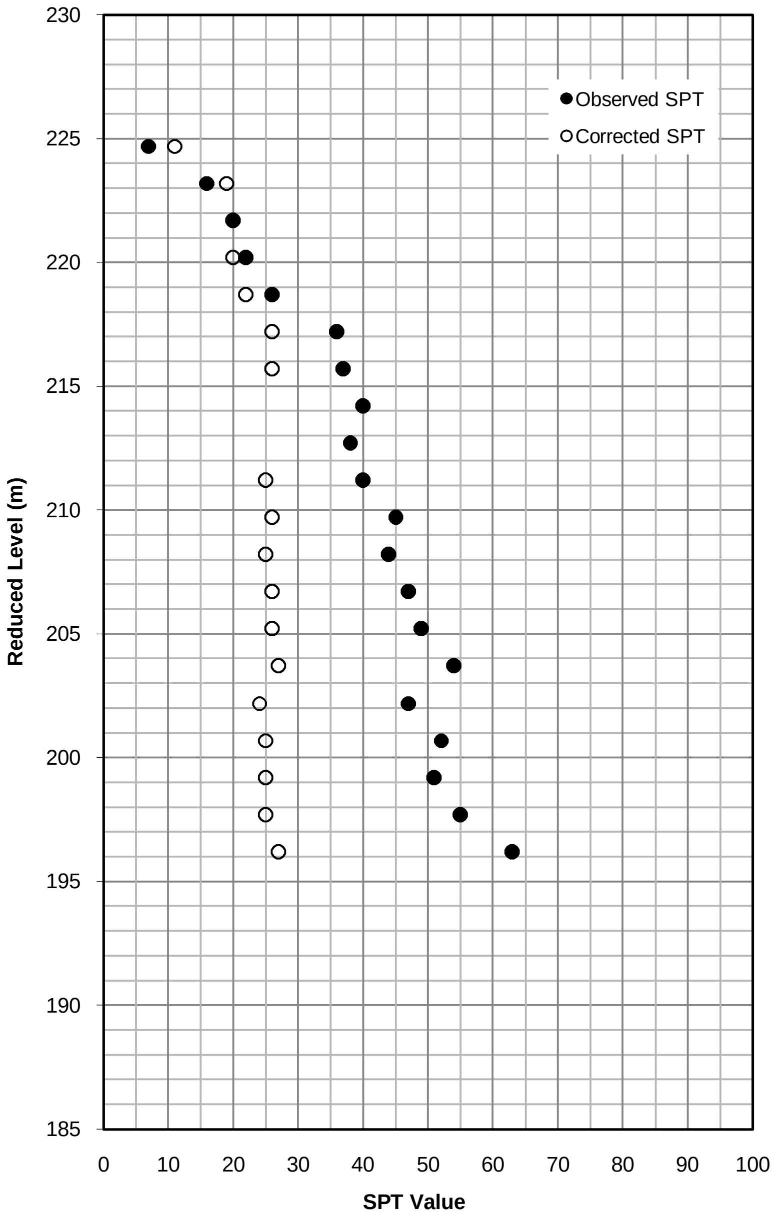


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 48+122**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.46**	**SHEET No.** **1 of 1**

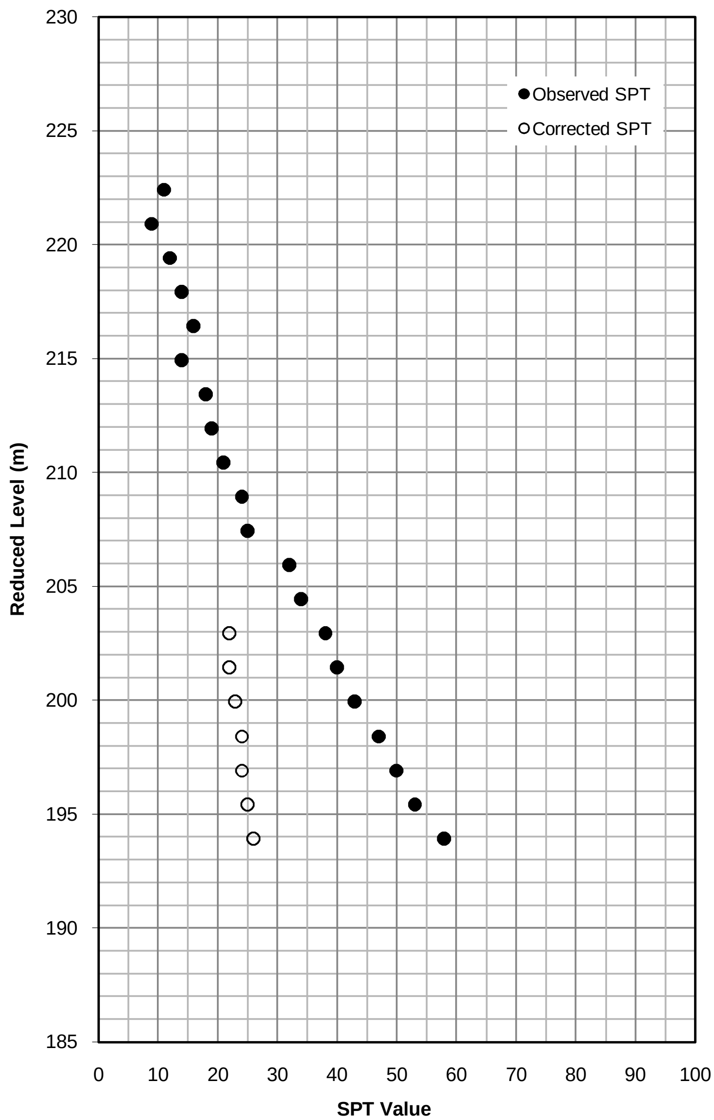


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

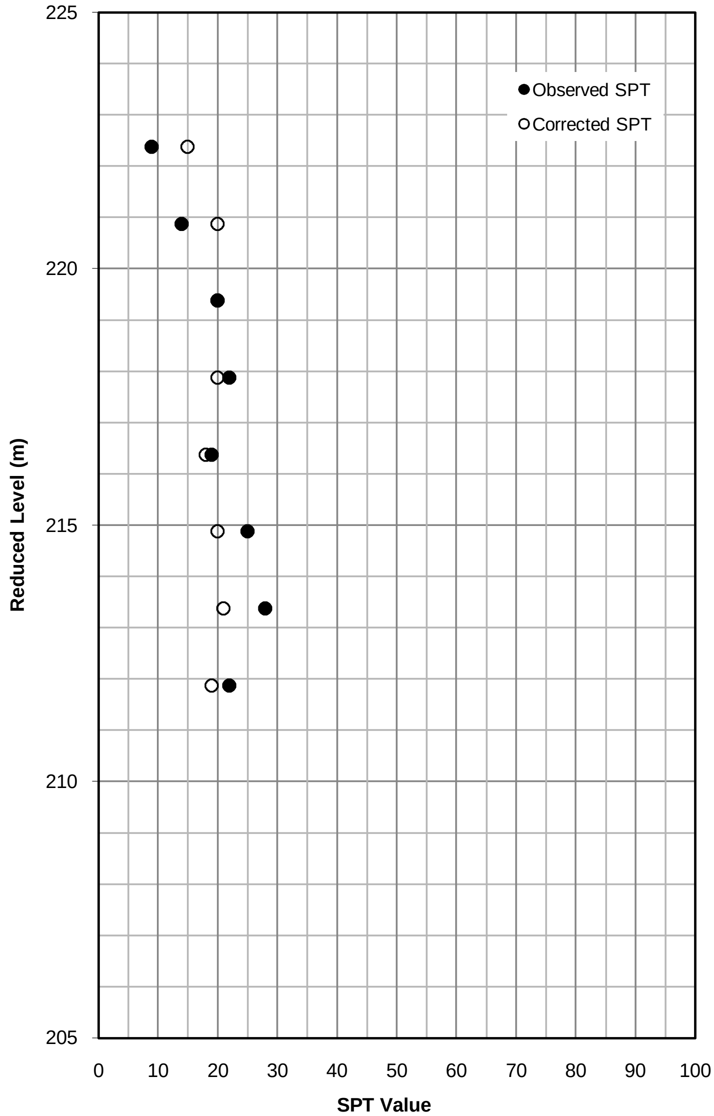
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 48+400**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.47**	**SHEET No.** **1 of 1**



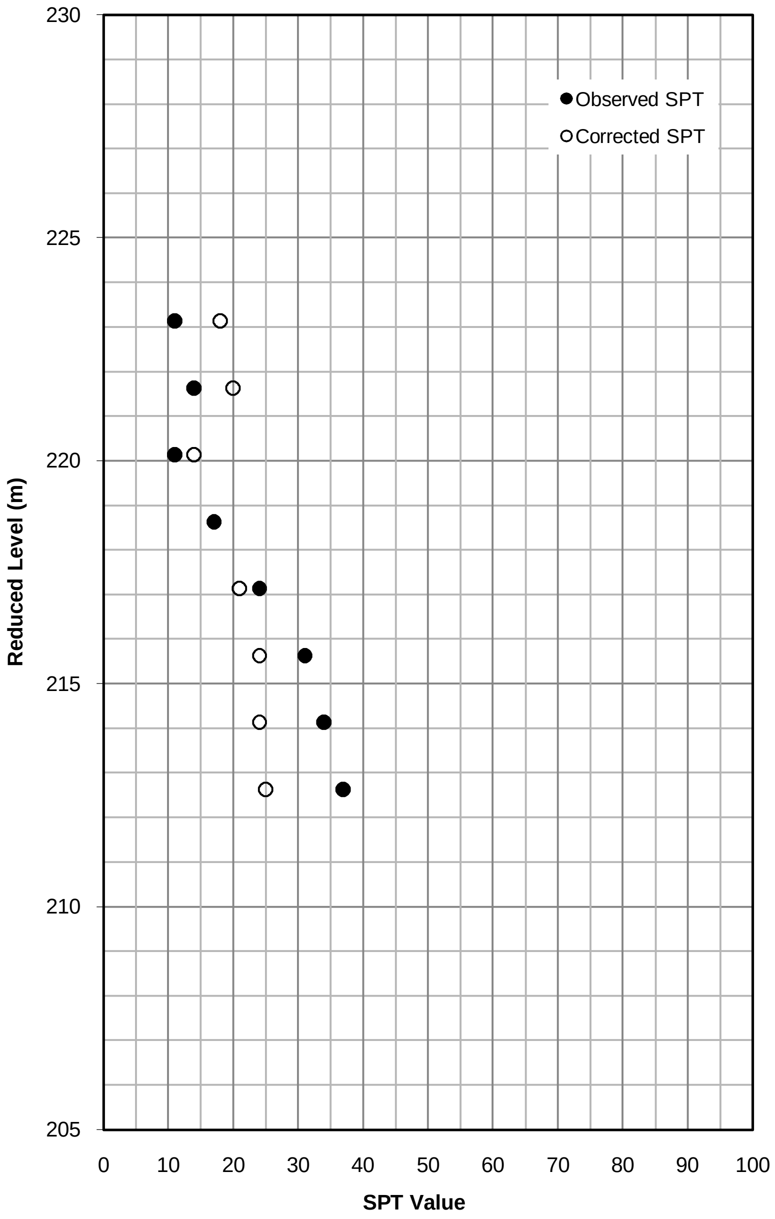
Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 48+510**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.48** / **SHEET No.** **1 of 1**



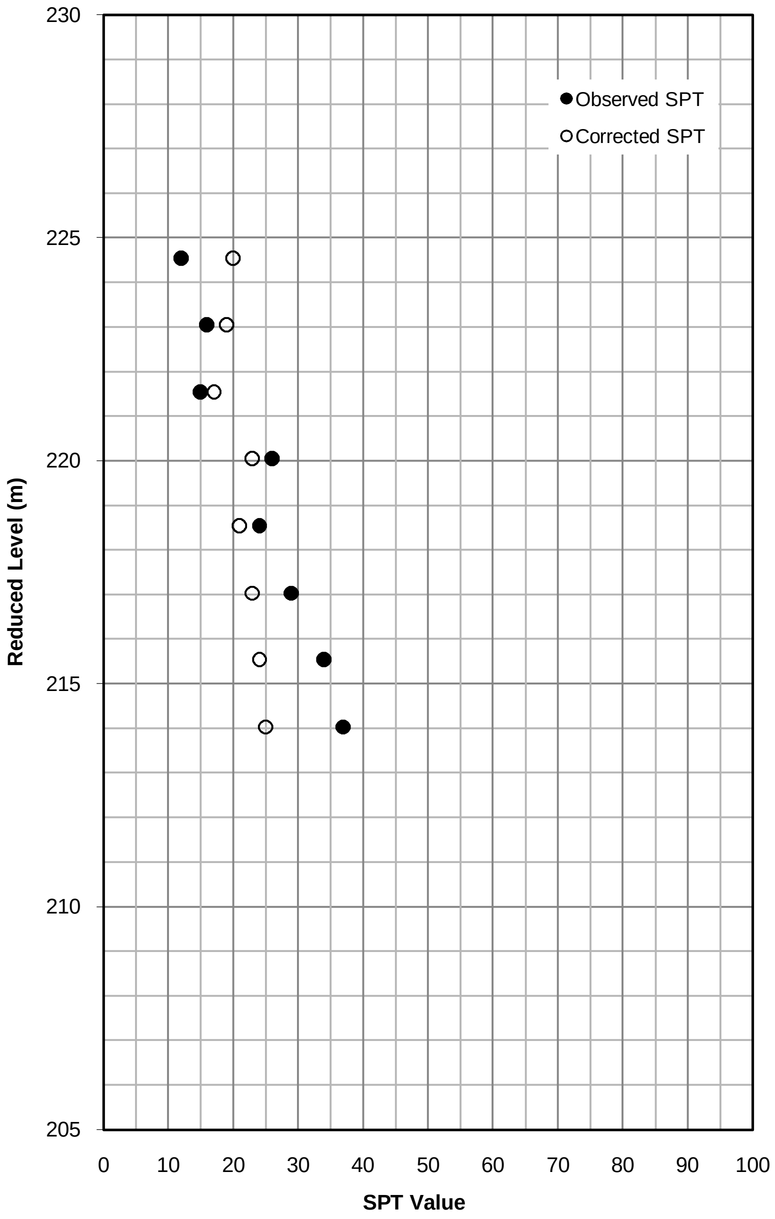
Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 49+250**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.49** | **SHEET No.** **1 of 1**



Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 50+100**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.50	**SHEET No.** 1 of 1

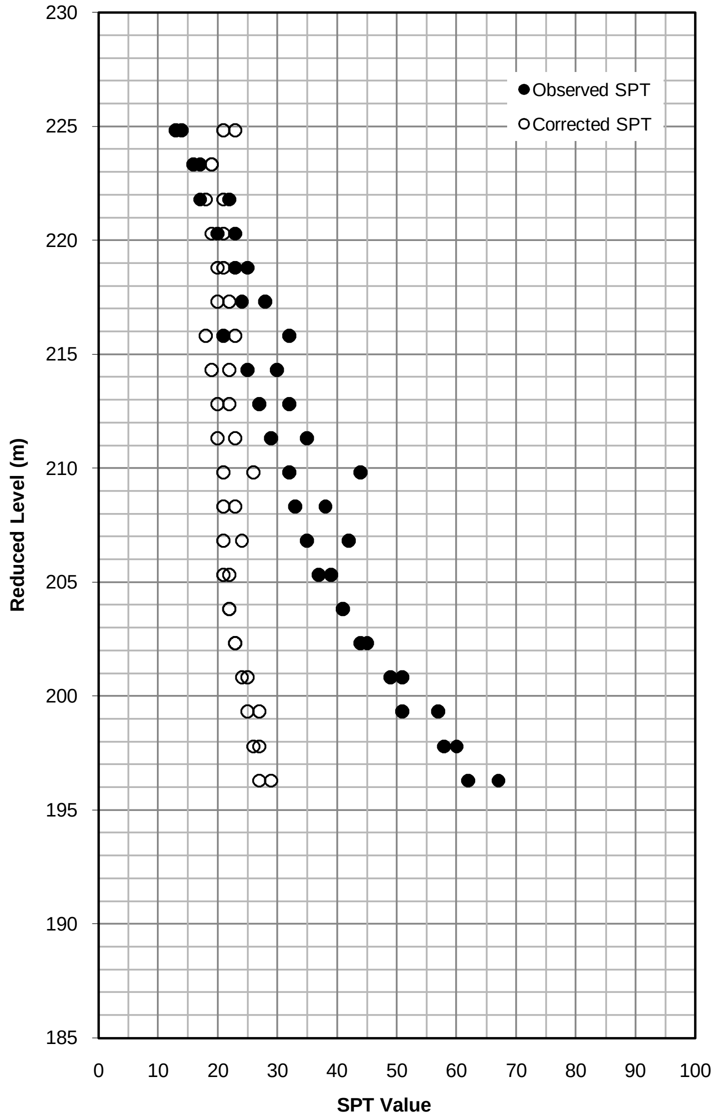


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** Chainage : 51+000	
CONTRACTOR :	XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.51	SHEET No. 1 of 1

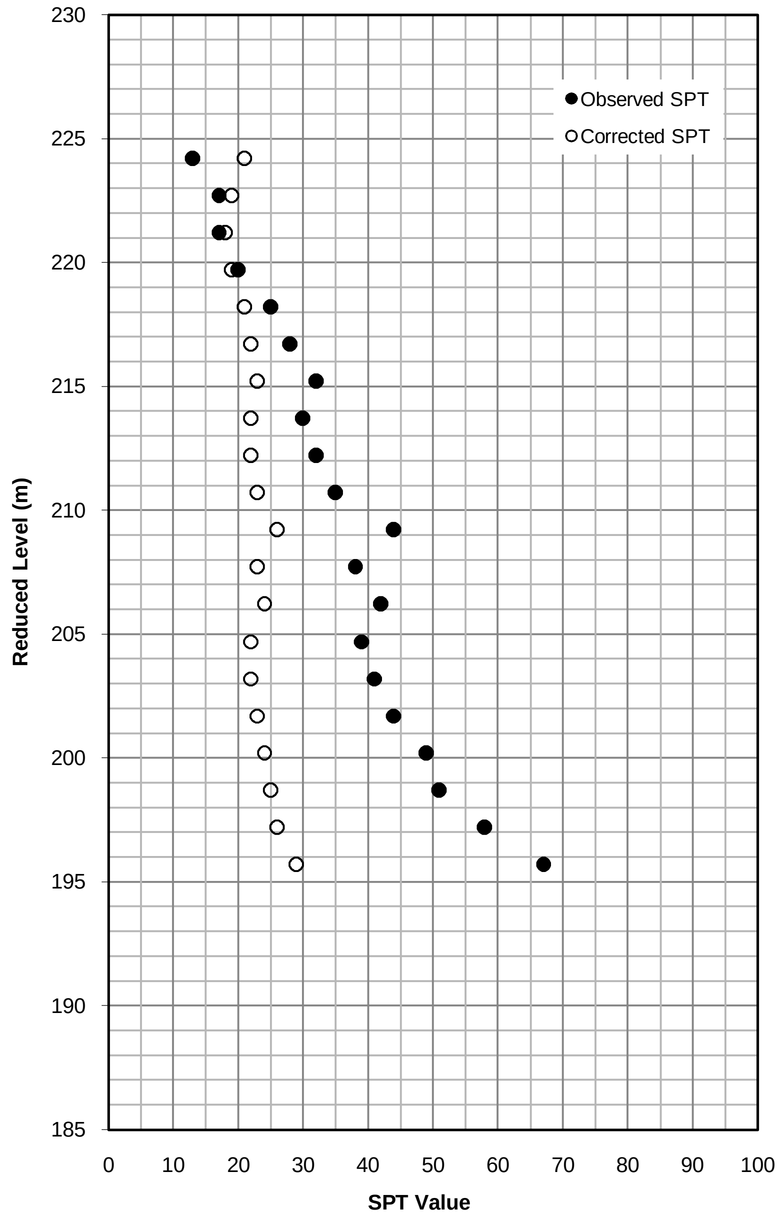


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 52+640**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.52	**SHEET No.** 1 of 1

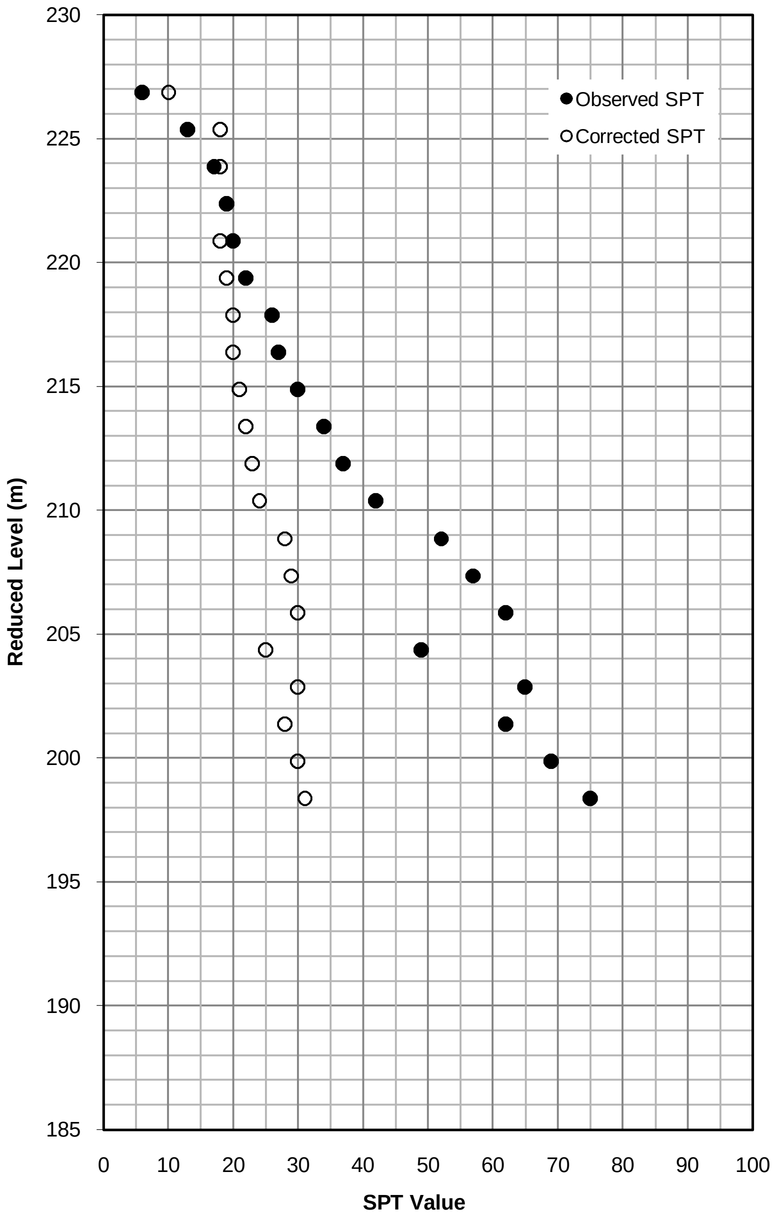


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut	
CLIENT: Skylark	**Variation of SPT Value with Depth (BH-1& BH-2)** Chainage : 54+825
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	**FIG. NO.** 3.53 / **SHEET No.** 1 of 1



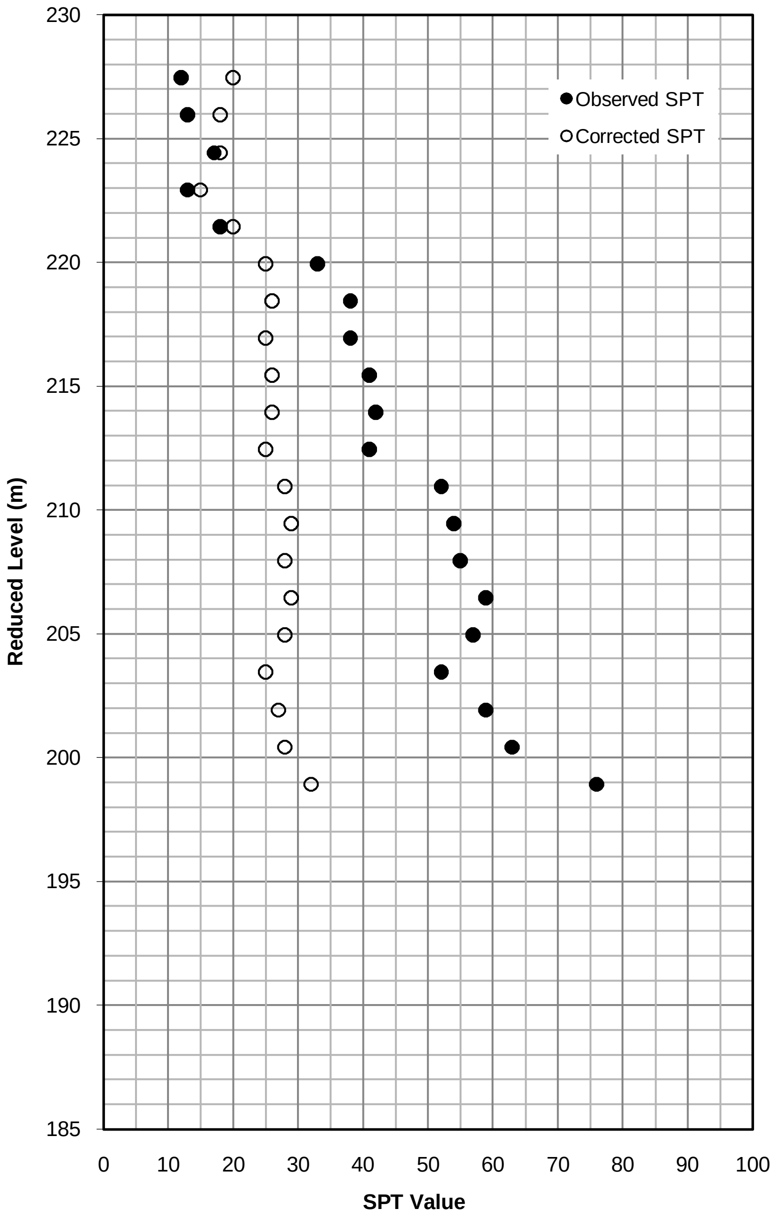
Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 54+825**	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.		FIG. NO. 3.54	SHEET No. 1 of 1



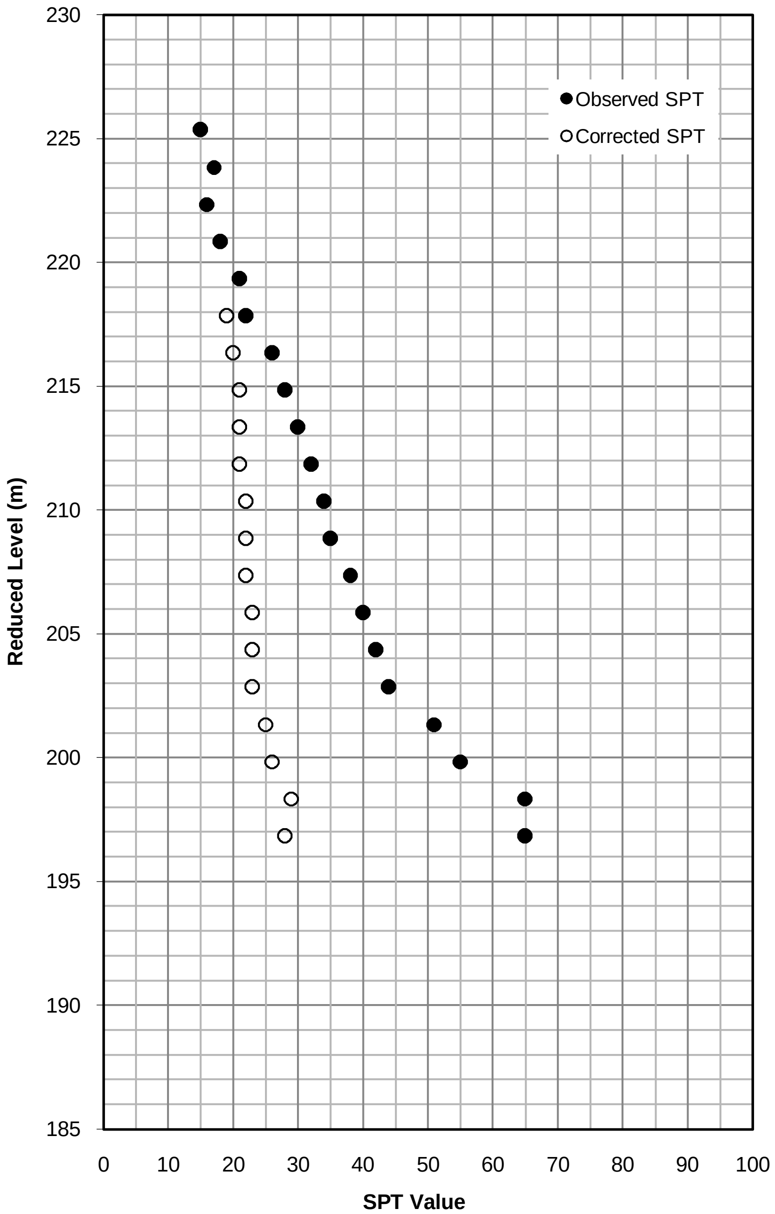
Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 56+780		
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.55	SHEET No. 1 of 1	



Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

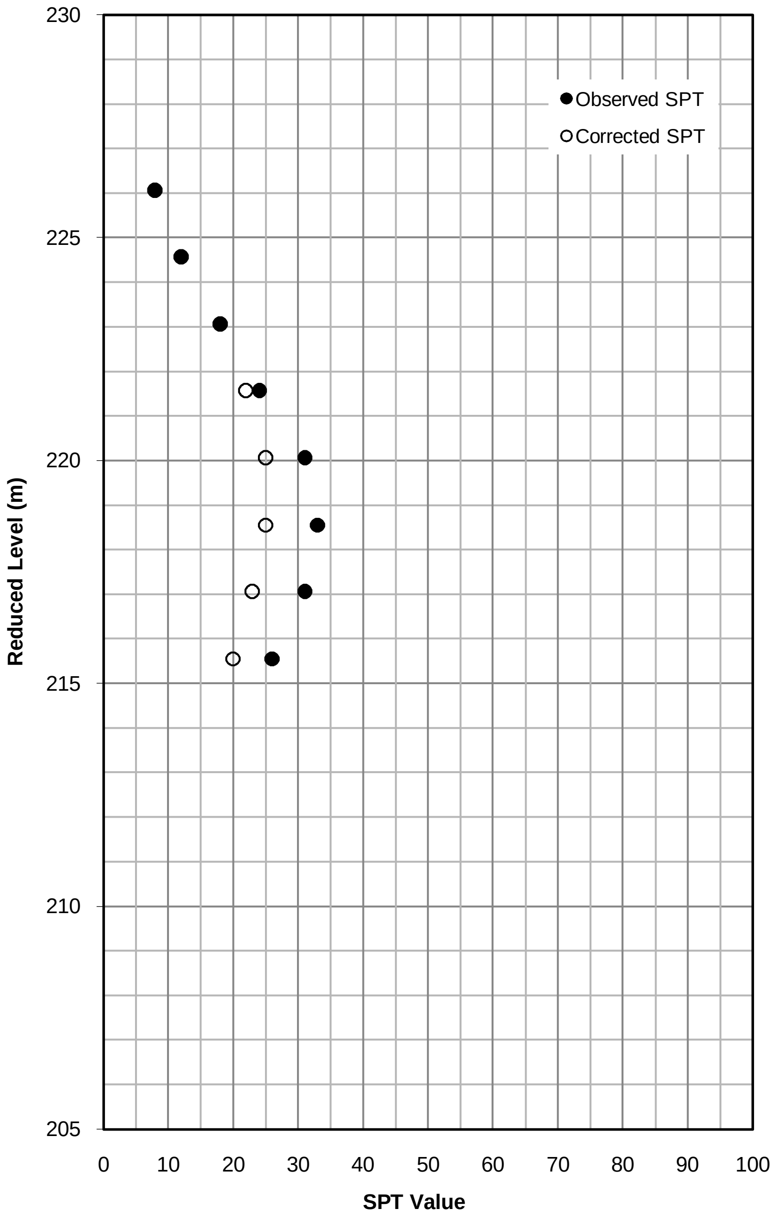
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 57+555**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**		**FIG. NO.** **3.56**	**SHEET No.** **1 of 1**



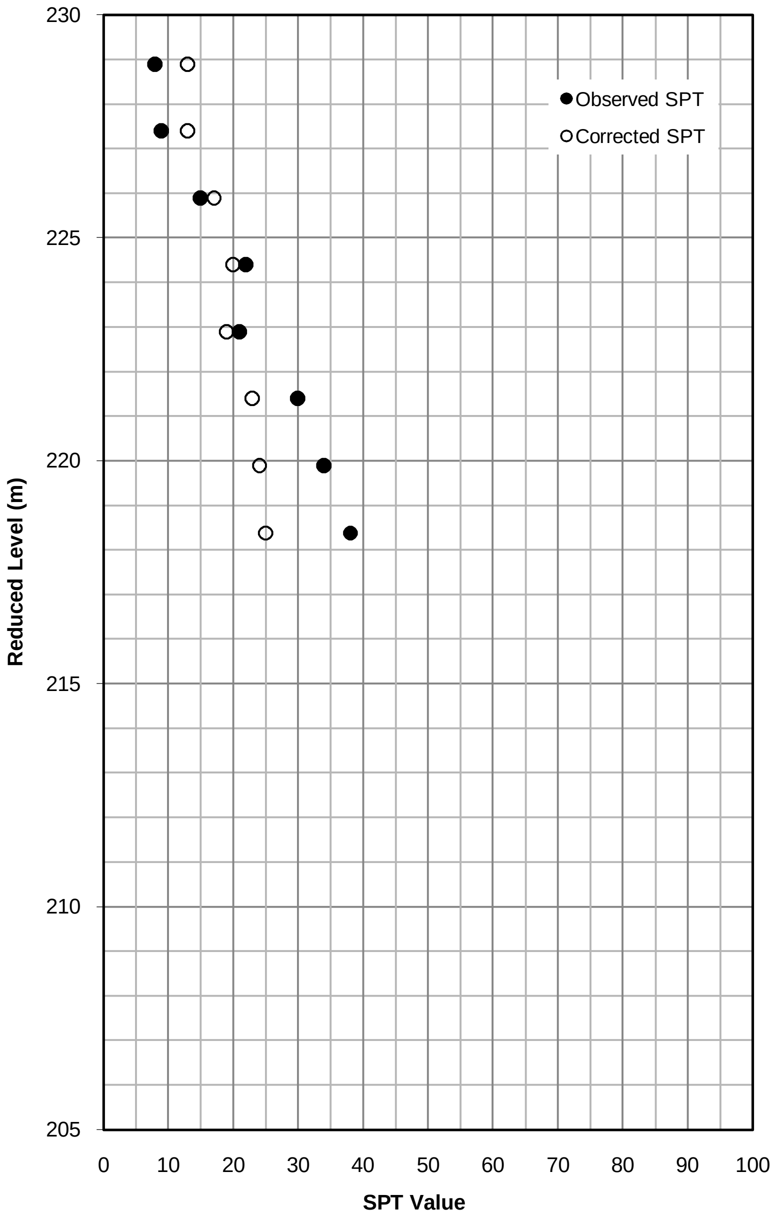
Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 58+400**

CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.**	**3.57**	**SHEET No.**	**1 of 1**

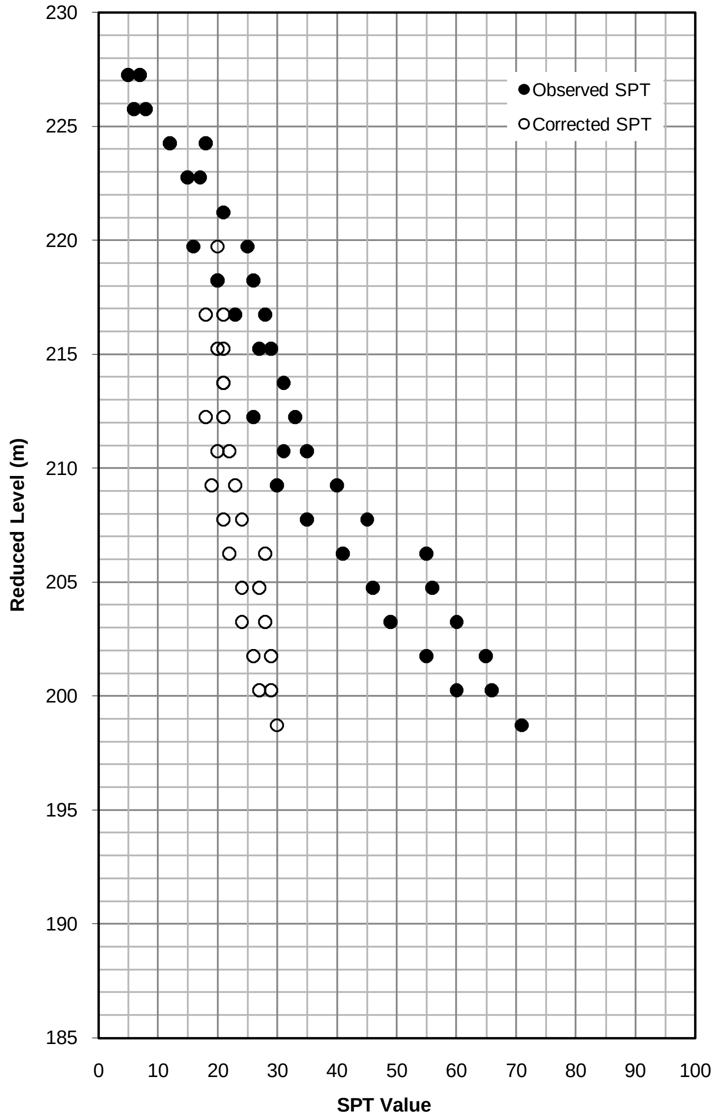


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 59+305**	
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.58**		**SHEET No.** **1 of 1**

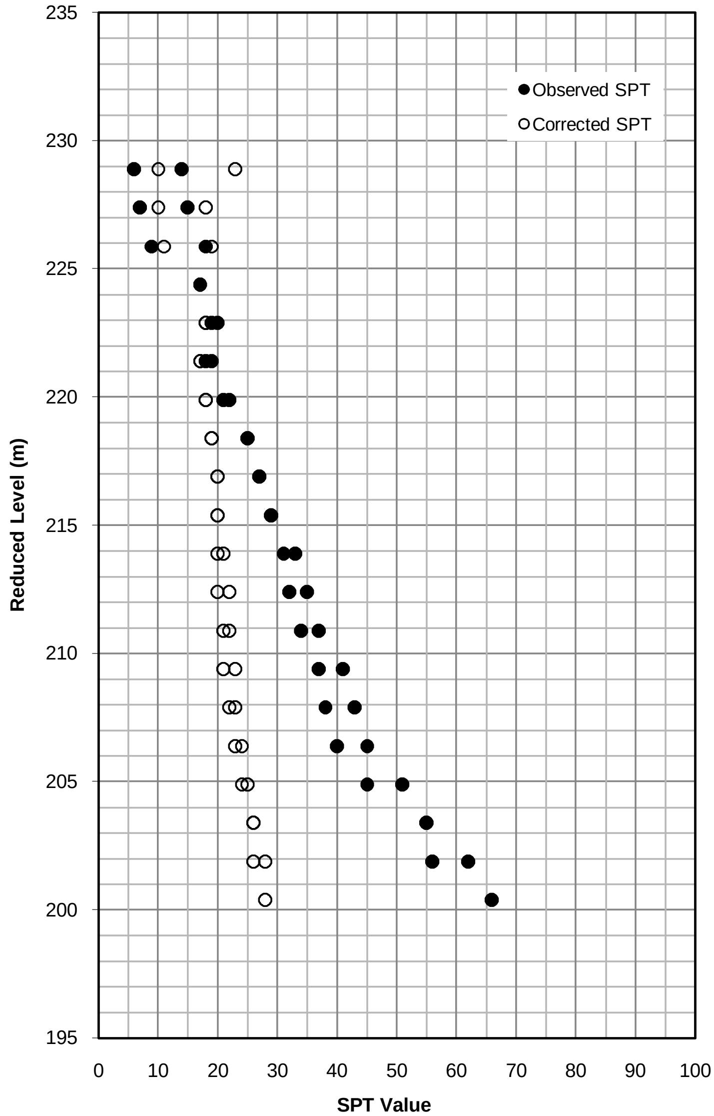


Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut

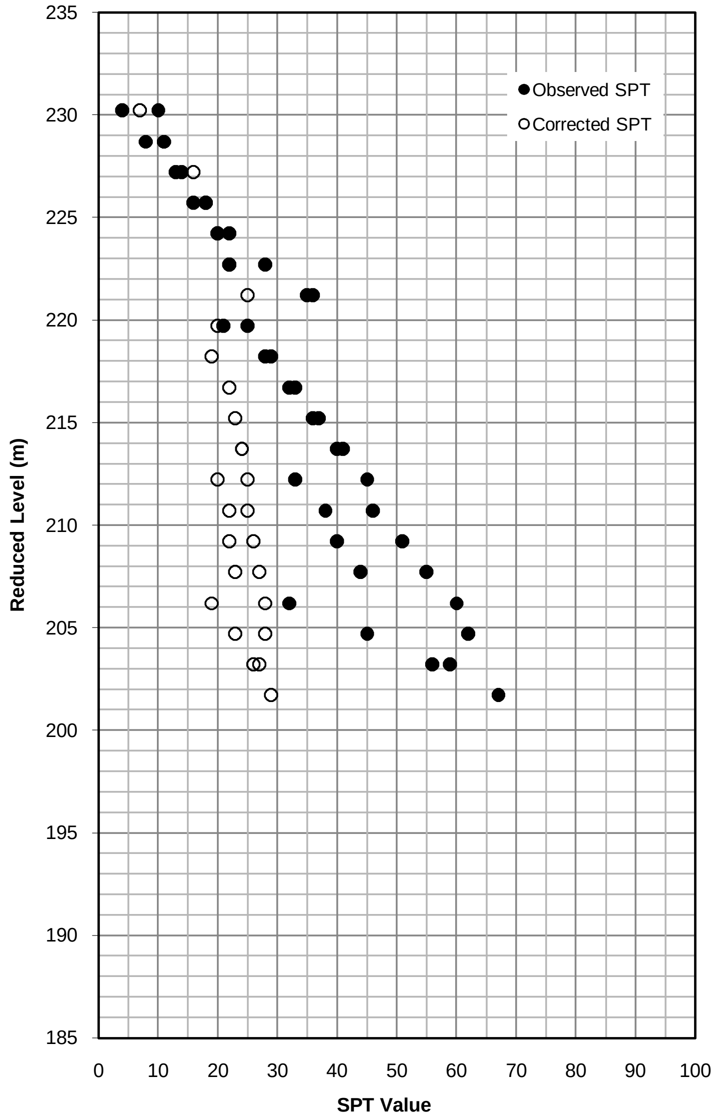
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 62+160**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.59**	**SHEET No.** **1 of 1**



Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut	
CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1 & BH-2)** **Chainage : 63+570**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** **3.60** | **SHEET No.** **1 of 1**



Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1& BH-2)** Chainage : 64+270	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.61	**SHEET No.** 1 of 1



Geotechnical Investigation Works at Hapur Meerut Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1& BH-2)** **Chainage : 65+740**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO.** 3.62	**SHEET No.** 1 of 1

CHAPTER-IV

ANALYSIS AND RECOMMENDATION

4.1 Subsoil Profile

The subsoil stratification as revealed from the borelogs in annexure A indicates that soils mainly comprises of alluvial deposits consisting of clay and fine grained soils. Generally, soils at upper horizons are Sandy SILT (ML) and Silty CLAY (CL). Soils at upper horizon upto 3.0 m depths are found to be in loose to medium dense. The soils below this are generally competent, non-plastic, medium dense to dense Fine SAND. The design parameters have been selected duly considering all the field and laboratory test results and presented in Table 4.1

Table 4.1 Design Subsoil Profile

S.No	Chainage	Soil layer Layer No.	Depth(m) From (m)	To (m)	Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density KN/m^3	c KPa	φ ^{0}
1	Ch. 0+650	I	0	3	3	Silty CLAY / Sandy SILT	15	18	50	0
		II	3	15	12	Medium Dense Fine SAND	26	19	0	31
2	Ch. 1+172	I	0.0	4.5	4.5	Sandy SILT	12	16.9	45	0
		II	4.5	7.5	3.0	Sandy SILT	9	17.4	50	0
		III	7.5	16.5	9.0	Fine Sand	25	17.4	0	32
		IV	16.5	21.0	4.5	Clayey SILT	38	19.9	150	0
		V	21.0	30.0	9.0	Fine Sand	56	20.0	0	33
3	Ch. 2+109	I	0.0	4.5	4.5	Sandy SILT	21	16.9	0	29
		II	4.5	7.5	3.0	Silty SAND	23	17.3	0	30
		III	7.5	11.5	4.0	Fine SAND	29	17.9	0	32
		IV	11.5	21.0	9.5	Silty SAND	36	17.9	0	32
		V	21.0	28.5	7.5	Sandy SILT	35	19.8	175	0
		VI	28.5	30.0	1.5	Fine SAND	55	19.9	0	33
4	Ch. 2+306	I	0.0	6.0	6.0	Clayey SILT	16	17.3	50	0
		II	6.0	15.0	9.0	Fine SAND	32	18.1	0	32
		III	15.0	19.5	4.5	Fine SAND	44	18.1	0	33
		IV	19.5	23.5	4.0	Sandy SILT	40	19.7	200	0
		V	23.5	30.5	7.0	Fine SAND	54	19.7	0	33

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m³	KPa	0
5	Ch. 2+873	I	0	6	6	Silty CLAY / Sandy SILT	8	18	45	0
		II	6	12	6	Medium Dense Fine SAND	20	19	0	31
6	Ch. 3+490	I	0	7.5	7.5	Silty CLAY / Sandy SILT	17	18	60	0
		II	7.5	12	4.5	Dense Fine SAND	31	19	0	33
7	Ch. 4+252	I	0	6	6	Sandy SILT	7	18	0	30
		II	6	12	6	Medium Dense Fine SAND	29	19	0	31
8	Ch. 5+163	I	0	4.5	4.5	Sandy SILT	12	18	45	0
		II	4.5	12	7.5	Medium Dense Fine SAND	26	19	0	31
9	Ch. 6+099	I	0	6	6	Silty CLAY	10	18	45	0
		II	6	12	6	Dense Fine SAND	31	19	0	31
10	Ch. 7+064	I	0	4.5	4.5	Silty CLAY / Sandy SILT	28	18	45	0
		II	4.5	12	7.5	Dense Fine SAND	33	19	0	32
11	Ch. 8+060	I	0	6	6	Sandy SILT	13	18	0	28
		II	6	12	6	Very Stiff Silty CLAY	21	19	70	0
12	Ch. 8+977	I	0	6	6	Silty CLAY	8	18	40	0
		II	6	12	6	Silty CLAY	19	19	65	0
13	Ch. 10+030	I	0	5	5	Silty CLAY	8	18	50	0
		II	5	12	7	Medium Dense Fine SAND	22	19	0	31
14	Ch. 10+973	I	0	7.5	7.5	Silty CLAY / Sandy SILT	24	18	65	0
		II	7.5	12.0	4.5	Dense Fine SAND	35	19	0	32

S.No	Chainage	Soil layer Layer No.	Depth(m) From (m)	To (m)	Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density KN/m³	c KPa	φ ⁰
15	Ch. 11+987	I	0	6	6	Silty CLAY / Sandy SILT	15	18	60	0
		II	6	12	6	Dense Fine SAND	31	19	0	31
16	13+841	I	0.0	4.5	4.5	Clayey SILT	21	17.3	50	0
		II	4.5	9.0	4.5	Sandy SILT	22	18.0	65	0
		III	9.0	12.0	5.0	Sandy SILT	24	18.5	0	31
		IV	12.0	22.5	10.5	Fine SAND	47	18.5	0	33
		V	22.5	30.0	7.5	Fine SAND	66	20.0	0	33
17	14+069	I	0.0	4.5	4.5	Clayey SILT	21	17.6	55	0
		II	4.5	8.5	4.0	Sandy SILT	24	18.0	85	0
		III	8.5	10.5	2.0	Sandy SILT	31	18.5	85	0
		IV	10.5	22.5	12.0	Silty SAND	46	18.8	0	32
		V	22.5	27.0	4.5	Clayey SILT	51	20.0	250	0
		VI	27.0	30.0	3.0	Fine SAND	71	20.0	0	33
18	13+136	I	0	6.0	6	Sandy SILT	12	1.8	60	0
		II	6.0	12.0	6	Medium Dense Silty SAND	28	1.85	0	31
19	15+227	I	0	8.5	8.5	Firm to Very stiff Silty CLAY	16	1.8	60	0
		II	8.5	12.0	3.5	Dense Silty SAND	38	1.9	0	31
20	16+144	I	0	7.5	7.5	Stiff Silty CLAY	14	1.8	60	0
		II	7.5	12.0	4.5	Dense Sandy SILT	33	1.9	0	30
21	17+338	I	0	6.0	6.0	Stiff Silty CLAY	10	1.8	40	0
		II	6.0	12.0	6.0	Sandy SILT	28	1.9	105	0

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	0
22	18+070	I	0	4.5	4.5	Loose Sandy SILT	9	1.8	0	29
		II	4.5	12.0	7.5	Very Stiff Silty CLAY	20	1.85	104	0
23	19+051	I	0	4.5	4.5	Sandy SILT	9	17	40	0
		II	4.5	6.0	1.5	Medium Dense Sandy SILT	16	18	0	30
		III	6.0	12.0	6.0	Very Stiff Silty CLAY	21	19	80	0
24	19+955	I	0	3.0	3.0	Sandy SILT	6	17	50	0
		II	3.0	12.0	9.0	Medium Dense Silty SAND	22	18	0	31
25	20+935	I	0	9.0	9.0	Sandy SILT	14	18	50	0
		II	9.0	12.0	3.0	Dense Sandy SILT	31	19	0	31
26	22+200	I	0	3.0	3.0	Firm Silty CLAY	8	18	50	0
		II	3.0	12.0	9.0	Medium Dense Silty SAND	20	18.5	0	31
27	23+808	I	0	5.5	5.5	Firm Silty CLAY	5	18	40	0
		II	5.5	12.0	6.5	Dense Fine SAND	33	18.5	0	32
28	24+920	I	0	3	3	Medium Dense Sandy SILT	11	18	0	30
		II	3	6	3	Medium Dense Silty SAND	14	19	0	31
		III	6	12	6	Medium Dense Fine SAND	26	19.5	0	33
29	25+760	I	0	3	3	Medium Dense Sandy SILT	10	18	0	30
		II	3	6	3	Medium Dense Silty SAND	17	19	0	31
		III	6	12	6	Medium Dense Fine SAND	26	19.5	0	33

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	0
30	26+530	I	0	4	4	Loose Sandy SILT	5	18	0	29
		II	4	8	4	Medium Dense Silty SAND	17	19	0	31
		III	8	12	4	Medium Dense Fine SAND	30	19.5	0	33
31	27+290	I	0	3	3	Loose Silty SAND/ Sandy SILT	6	18	0	29
		II	3	12	9	Medium Dense Sandy SILT	18	19	0	31
		III	12	18	6	Dense Silty SAND/Fine SAND	39	19.5	0	33
		IV	18	30	12	Very Dense Silty SAND/Fine SAND	60	20	0	34
32	27+820	I	0	3	3	Firm Silty CLAY	5	19	45	0
		II	3	6	3	Stiff Silty CLAY	12	19	60	0
		III	6	10	4	Medium Dense Sandy SILT	13	19	0	31
		IV	10	12	2	Medium Dense Silty SAND	28	19.5	0	32
33	28+660	I	0	3	3	Firm Silty CLAY	7	19	40	0
		II	3	10	7	Medium Dense Sandy SILT	14	19.5	0	31
		III	10	12	2	Medium Dense Silty SAND	25	20	0	33
34	28+880	I	0	15	15	Medium Dense Sandy SILT	21	18	0	31
		II	15	27	12	Dense Fine SAND	36	19	0	33
		III	27	30	3	Very Dense Fine SAND	52	20	0	34

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	0
35	30+780	I	0	9	9	Medium Dense Sandy SILT	16	18	0	30
		II	9	12	3	Medium Dense Sandy SILT	18	19	0	32
36	33+050	I	0	3	3	Loose Sandy SILT	7	18	0	28
		II	3	6	3	Medium Dense Sandy SILT	15	19	0	30
		III	6	20	14	Medium Dense Fine SAND	21	19.5	0	32
		IV	20	28	8	Dense Fine SAND	38	19.5	0	33
		V	28	30	2	Very Dense Fine SAND	52	20	0	35
37	34+360	I	0	9	9	Medium Dense Sandy SILT	12	18	0	29
		II	9	20	11	Medium Dense Fine SAND	24	19	0	31
		III	20	30	10	Dense Fine SAND	45	20	0	34
38	34+986	I	0	4	4	Loose Sandy SILT/ Silty SAND	8	18	0	30
		II	4	13	9	Medium Dense Fine SAND	21	19	0	31
		III	13	28	15	Dense Fine SAND	38	19	0	33
		IV	28	30	2	Very Dense Fine SAND	55	20	0	35

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	0
39	35+549	I	0	3	3	Medium Dense Silty SAND/Fine SAND	12	18	0	30
		II	3	12	8	Medium Dense Fine SAND	22	19	0	31
		III	12	28	16	Dense Fine SAND	41	20	0	33
		IV	28	30	2	Very Dense Fine SAND	57	20	0	35
40	37+360	I	0	3	3	Loose Silty SAND	9	18	0	30
		II	3	5	2	Medium Dense Silty SAND	18	19	0	31
		III	5	12	7	Medium Dense Silty SAND	21	19	0	33
41	38+580	I	0	3	3	Loose Silty SAND	9	18	0	30
		II	3	15	12	Medium Dense Fine SAND	23	19	0	32
		III	15	20	5	Dense Sandy SILT	36	19	0	32
		IV	20	28	8	Dense Fine SAND	44	20	0	33
		V	28	30	2	Very Dense Fine SAND	58	20	0	35
42	39+120	I	0	3	3	Loose Silty SAND	10	18	0	30
		II	3	6	3	Medium Silty SAND	18	19	0	31
		III	6	12	6	Medium Dense Sandy SILT	28	19	0	31
		IV	12	18	6	Dense Fine SAND	37	19.5	0	33
		V	18	20	2	Hard Silty CLAY	36	20	90	0
		VI	20	30	10	Very Dense Fine SAND	48	20	0	34

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	0
43	41+916	I	0	9	9	Firm to Very Stiff Silty CLAY	16	18	90	
		II	9	14	5	Hard Silty CLAY	34	19	150	
		III	14	23	9	Dense Sandy SILT	37	19		32
		IV	23	30	7	Very Dense Sandy SILT	53	20		32
44	43+900	I	0	5	5	Very Stiff Silty CLAY	23	18	95	0
		II	5	8	3	Medium Dense Sandy SILT	16	19	0	31
		III	8	18	10	Very Stiff Silty CLAY	26	19.5	130	0
		IV	18	30	12	Dense to Very Dense Fine SAND	50	20	0	33
45	46+362	I	0	5	5	Medium Dense Sandy SILT	11	18	0	29
		II	5	9	4	Very Stiff Silty CLAY	23	19	115	0
		III	9	27	18	Hard Silty CLAY	50	20	230	0
		IV	27	30	3	Very Dense Fine SAND	65	20	0	35
46	48+122	I	0	6	6	Stiff Silty CLAY	12	18	80	0
		II	6	17	11	Medium Dense Sandy SILT	24	19	0	30
		III	17	23	6	Hard Silty CLAY	33	19.5	130	0
		IV	23	30	7	Dense Sandy SILT	45	20	0	32
47	48+400	I	0	9	9	Stiff Silty CLAY	10	18	50	0
		II	9	16	7	Very Stiff Silty CLAY	27	19	130	0
		III	16	26	10	Hard Silty CLAY	37	19.5	180	0
		IV	26	30	4	Dense Fine SAND	50	20	0	34

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m³	KPa	⁰
48	48+510	I	0	8	8	Medium Dense Sandy SILT	18	18	0	30
		II	8	14	6	Dense Sandy SILT	37	19	0	31
		III	14	27	13	Dense Sandy SILT	47	19.5	0	32
		IV	27	30	3	Very Dense Fine SAND	56	20	0	34
49	49+250	I	0	7.5	7.5	Stiff Silty CLAY	11	18	60	0
		II	7.5	20	12.5	Very Stiff Silty CLAY	22	19	110	0
		III	20	30	10	Dense Sandy SILT	47	20	0	32
50	50+100	I	0	7.5	7.5	Medium Dense Sandy SILT	16	18	0	29
		II	7.5	12	4.5	Medium Dense Fine SAND	23	19	0	33
51	51+100	I	0	6	6	Medium Dense Silty SAND	12	18	0	31
		II	6	12	6	Medium Dense Fine SAND	28	19	0	33
52	52+640	I	0	10.5	10.5	Medium Dense Sandy SILT	20	18	0	30
		II	10.5	12	1.5	Dense Fine SAND	35	19	0	34
53	54+825	I	0	7.5	7.5	Medium Dense Sandy SILT	16	18	0	30
		II	7.5	12	4.5	Medium Dense Silty SAND	28	19	0	32
		III	12	26	14	Dense Fine SAND	38	19.5	0	33
		IV	26	30	4	Very Dense Sandy SILT	58	20	0	32

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	0
54	55+850	I	0	7.5	7.5	Medium Dense Sandy SILT	17	18	0	30
		II	7.5	13.5	6	Medium Dense Fine SAND	26	19	0	32
		III	13.5	30	16.5	Dense Fine SAND	45	20	0	35
55	56+780	I	0	7.5	7.5	Medium Dense Sandy SILT	13	18	0	30
		II	7.5	14	6.5	Medium Dense Fine SAND	24	19	0	32
		III	14	20	6	Dense Sandy SILT	41	19.5	0	32
		IV	20	30	10	Very Dense Fine SAND	62	20	0	34
56	57+555	I	0	9	9	Medium Dense Sandy SILT	14	18	0	30
		II	9	20	11	Dense Fine SAND	42	19.5	0	32
		III	20	30	10	Very Dense Fine SAND	60	20	0	34
57	58+400	I	0	7.5	7.5	Very Stiff Silty CLAY	16	18	60	0
		II	7.5	11	3.5	Medium Dense Silty SAND	23	19	0	31
		III	11	20	9	Dense Sandy SILT	33	19.5	0	32
		IV	20	30	10	Very Dense Fine SAND	51	20	0	35
58	59+305	I	0	4.5	4.5	Stiff Silty CLAY	10	18	50	0
		II	4.5	8	3.5	Medium Dense Silty SAND	24	19	0	31
		III	8	12	4	Hard Silty CLAY	30	20	130	0

S.No	Chainage	Soil layer Layer No.	Depth(m) From (m)	To (m)	Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density KN/m³	c KPa	φ ⁰
59	62+160	I	0	4.5	4.5	Loose Sandy SILT	8	18	0	28
		II	4.5	8	3.5	Medium Dense Fine SAND	19	19	0	31
		III	8	12	4	Dense Sandy SILT	34	19.5	0	33
60	63+570	I	0	7.5	7.5	Stiff Silty CLAY	11	18	45	0
		II	7.5	15	7.5	Medium Dense Fine SAND	26	19	0	31
		III	15	23	8	Dense Fine SAND	37	19.5	0	32
		IV	23	30	7	Very Dense Fine SAND	62	20	0	35
61	64+270	I	0	11	11	Medium Dense Silty SAND	18	18	0	31
		II	11	19	8	Medium Dense Sandy SILT	29	19	0	31
		III	19	30	11	Dense to very Dense Fine SAND	52	20	0	35
62	65+740	I	0	4.5	4.5	Loose Sandy SILT	6	18	0	28
		II	4.5	11	6.5	Medium Dense Sandy SILT	23	19	0	31
		III	11	16.5	5.5	Very Stiff Silty CLAY	27	19.5	130	0
		IV	16.5	20	3.5	Dense Silty SAND	40	20	0	33
		V	20	30	10	Very Dense Fine SAND	57	20	0	35

4.2 Ground Water Table

The ground water table as encountered during the site investigation works is presented in Table 4.2.

Table 4.2: Observed Ground Water Table

Chainage (km)	BH No.	Observed Ground Water Table(m)
0+650	1	8.0
1+172	1	7.0
	2	9.5
2+109	1	13.0
	2	12.5
2+306	1	11.5
	2	11.0
	3	8.0
2+873	1	10.5
3+490	1	11.0
4+252	1	10.2
5+163	1	Not met
6+099	1	Not met
7+064	1	Not met
8+060	1	Not met
8+977	1	10.5
10+030	1	Not met
10+973	1	11.0
11+987	1	Not met
13+841	1	14.8
	2	Not met
	3	13.6
14+069	1	13.4
	2	13.3
13+136	1	Not Met
15+227	1	Not Met
16+144	1	Not Met
17+338	1	Not Met
18+070	1	Not Met
19+051	1	Not Met
19+955	1	Not Met
	2	Not Met
20+935	1	Not Met
22+200	1	Not Met
23+808	1	11.00
24+920	1	-
25+760	1	10.1

Chainage (km)	BH No.	Observed Ground Water Table(m)
26+530	1	8.0
27+290	1	9.0
27+820	1	9.6
28+660	1	9.0
28+880	1	9.0
30+780	1	7.0
33+050	1	6.0
34+360	1	6.0
34+986	1	4.0
	2	3.5
35+549	1	3.75
	2	4.0
37+360	1	2.0
38+580	1	2.0
39+120	1	0.6
41+916	1	5.0
43+900	1	9.5
46+362	1	10.0
48+122	1	9.0
48+400	1	9.0
48+510	1	9.1
49+250	1	9.0
50+100	1	7.0
51+000	1	8.0
52+640	1	8.5
54+825	1	9.5
55+850	1	12.0
56+780	1	7.0
57+555	1	9.0
58+400	1	10.0
59+305	1	10.0
62+160	1	10.5
63+570	1	7.0
64+270	1	8.0
65+740	1	9.0

It may be noted that the ground water found at shallower depth in most of the borehole and hence it is likely that the GWT will rise during monsoon. Accordingly, the design ground water table (GWT) has been considered at the existing ground surface.

4.3 Liquefaction

As per IS 1893:2002, the site falls under earthquake zone-IV. The top soil upto around 3.0 are loose sandy soils at chainage 33+050(MJB), 37+360(MNB), 8+580(MJB) and 62+160(MNB) and are likely to liquefy during earthquake. The soils below 3.0 m are mainly medium dense to dense and are not liquefiable. As the depth of foundations for minor bridges are 3.0m or more there won't be any effect of liquefaction on the foundations. Major bridges are on pile foundations with minimum depth of pile cap as 2.0m; the effect of top 3.0m soils on pile capacities has been neglected.

4.4 Recommendations Regarding Type of Foundation

Based on the loading condition, open foundation for minor bridges and pile foundation for major bridges are considered suitable as per the subsoil conditions.

4.4.1 Shallow / Open Foundation

A properly designed foundation has to satisfy two limit states. They are limit state of shear strength and limit state of settlement.
Based on shear strength properties, the net Safe Bearing Capacities are calculated using Hansen's General Bearing Capacity Equation as recommended by Indian Standards with a Factor of Safety equal to 2.5 which takes care of L/B ratio, depth of foundation etc. along with other parameters. The calculations have been performed as per IS: 6403 using following equation:

$$Q\text{ (Safe, Net)} = \frac{\left(\left(C.N_c.S_c.d_c.i_c\right) + \left(\left(y * D\right).\left(N_q - 1\right).S_q.d_q.i_q\right) + \left(0.5.B.\gamma.N_\gamma.S_\gamma.d_\gamma.i_\gamma.W\right)\right)}{FS}$$

Where, C = Cohesion in kPa

N_c, N_q&N_γ = Bearing Capacity Factors taken from IS: 6403

S_c, S_q&S_γ = Shape Factors taken from IS: 6403

d_c, d_q&d_γ = Depth Factors taken from IS: 6403

i_c, i_q&i_γ = Inclination Factors taken from IS: 6403

γ = Unit Weight in kN/m^3

D = Depth of foundation in m

B = Width of foundation in m

W = Correction factor for water table (Taken as 0.5)

FS = Factor of Safety (2.5)

Detailed calculations are presented in Annexure – B

The foundation settlements are estimated using compressibility characteristics of the sub-soils. Computations are performed using isotropic stress distribution. The settlement for each layer is obtained and total settlement is arrived by adding components of each layer. This is corrected for depth factor as recommended by Fox and rigidity factor. Settlement analyses have been performed as per IS: 8009 – Part I using following equations:

For Clayey (Plastic) Soils

Settlement (Δ in mm) = $m_v * H * \Delta P * \mu_g * d_f *$ Rigidity Factor

Where, m_v = Coefficient of volume compressibility

H = Thickness of layer in m

ΔP = Pressure Increment = P*I

P = Design Bearing Capacity in kPa

I = Influence Factor for Immediate Settlement taken from Fig.18 of IS: 8009 (Part-I)

μ_g = A Factor Related to Pore Pressure Parameter A and the Dimensions of Loaded Area (From Table 1 of IS: 8009 (Part-1))

d_f = Depth Factor taken from Fig.12 of IS:8009 (Part-I)

Rigidity Factor = 0.8 taken from IS: 8009 (Part-I)

For Non-Plastic Soils (Sand/Silt)

Settlement (Δ in mm) = $2.303 * \frac{H}{C} * \text{Log}_{10}((Po+\Delta P)/Po) * d_f *$ Rigidity Factor

Where, H = Thickness of layer in m

ΔP = Pressure Increment = P*I

P = Design Bearing Capacity in kPa

I = Influence Factor for Immediate Settlement taken from Fig.18 of

IS: 8009 (Part-I)

d_f = Depth Factor taken from Fig.12 of IS: 8009 (Part-I)

Rigidity Factor = 0.8 taken from IS: 8009 (Part-I)

P_o = Overburden Pressure in kN/m^2

$C = 1.5 \times (C_{kd}/ P_o)$

C_{kd}/N – Taken from available correlations as per IS 2911 (Part1, Sec-2).

Detailed calculations are presented in Annexure – B

Allowable Bearing Capacities have been estimated for an allowable settlement of 25mm. The estimated safe and allowable bearing capacities are presented in Table 4.3

Table 4.3: Estimated Safe and Allowable Bearing Capacities

Location	Depth of Foundation(m)	Size of Foundation(m)	Shape	Safe Bearing capacity from Shear (KPa)	Allowable Bearing Capacity (KPa)
					25mm
2+873	3.0	5.5X4.5	Rectangular	120	80
3+490	2.0	5.5X4.5	Rectangular	150	115
4+252	3.0	5.5X4.5	Rectangular	120	95
5+163	3.0	5.5X4.5	Rectangular	120	120
7+064	3.0	5.5X4.5	Rectangular	120	120
8+977	3.0	5.5X4.5	Rectangular	120	80
10+030	3.0	5.5X4.5	Rectangular	135	95
10+973	3.0	5.5X4.5	Rectangular	175	140
13+136	3.0	5.5X4.5	Rectangular	160	105
15+227	3.0	5.5X4.5	Rectangular	160	155
16+144	3.0	5.5X4.5	Rectangular	160	110
17+338	3.0	5.5X4.5	Rectangular	105	95
18+070	3.0	5.5X4.5	Rectangular	110	110
19+955	3.0	5.5X4.5	Rectangular	180	160
20+935	3.0	5.5X4.5	Rectangular	135	100
23+808	3.0	5.5X4.5	Rectangular	105	80
24+920	2.0	5.5x3.5	Rectangular	128	109
25+760	2.0	5.5x4.5	Rectangular	132	103
26+530	2.0	5.5x3.5	Rectangular	137	104
27+290	3.0	5.5x5.5	Square	300	160
27+820	2.0	5.5x3.5	Rectangular	145	83
28+660	2.0	5.5x3.5	Rectangular	108	79
30+780	3.0	5.5x4.5	Rectangular	195	120
37+360	3.0	5.5x4.5	Rectangular	290	180
50+100	3.0	5.5x4.5	Rectangular	110	110
51+100	2.0	5.5x4.5	Rectangular	150	115
52+640	2.0	5.5x4.5	Rectangular	100	100
59+305	2.0	5.5x4.5	Rectangular	130	105
62+160	2.0	5.5x4.5	Rectangular	80	80

4.4.2 Pile Foundations

The computation of pile capacities has been carried out as per IS: 2911 (Part I/ Sec 2) – 2010 using following equation:

Ultimate Pile Capacity = Sum of skin friction for various layers + end bearing

$$= \Sigma f_u A_s + q_u A_p$$

For Non-Plastic (SAND/SILT) Soils,

Skin Friction, f_u (in kN) = $K*P_o*\tan\delta$

Where,

K = Coefficient of Earth Pressure (Taken as 1 from IS 2911 (Part1, Sec1))

P_o = Overburden Pressure in kN/m^2 at the centre of the layer (Limited to 15 times pile diameter)

$\delta = \varphi$

End Bearing, q_u (in kN) = $P_o * N_q$

Where,

P_o = Overburden Pressure in kN/m^2 at the pile tip (Limited to 15 times pile diameter)

Nq = Taken From Fig.1 of Amendment No.1 of IS: 2911 (Part1, Sec-2)-2010

For Plastic (CLAY) Soils,

Skin Friction, f_u (in kN) = $\alpha*C$

Where, C = Cohesion in kPa (taken from laboratory test results / available correlations with SPT.)

α = Reduction Factor Taken From IS:2911 (Part-1, Sec-2)-2010

End Bearing, q_u (in kN) = 9*C

A factor of safety of 2.5 has been adopted for both skin friction and end bearing to arrive at allowable pile capacity. For estimating uplift capacity a FOS of 3 has been applied on the skin friction component.

Calculations are presented in Annexure-B

Pile head deflection has been estimated for both fixed and free head conditions as per Annexure-D (Addendum No.3) of IS 2911 Part1 Sec2. Lateral capacity has been estimated corresponding to a deflection (i.e., 12 mm for 1200mm dia. piles) at pile head. For working piles, as the rotation at the pile head is restrained, capacity corresponding to fixed head has to be considered. Grade of concrete considered is M30. The Pile Capacities are presented in Table 4.4 below

Table 4.4 Recommended Pile Capacities

Chainage (km)	Structures	Pile Dia (m)	Pile Length below COL (m)	Comp. (T)	Pull out (T)	Lateral Capacity(T)	
						Fixed Head	Free Head
1+172	Major Bridge	1.2	23.0	380	150	38	15
2+109	Major Bridge	1.2	26.0	280	160	50	19
2+306	Major Bridge	1.2	25.0	440	190	40	16
13+841	Major Bridge	1.2	26.0	480	200	50	19
14+069	Major Bridge	1.2	25.0	350	200	50	19
28+880	Major Bridge	1.0	20	300	120	37	14
		1.2	17	400	120	60	22
33+050	Major Bridge	1.0	21	320	140	25	9
		1.2	18	400	130	42	16
34+986	Major Bridge	1.0	19	300	120	37	14
		1.2	16	400	100	60	22
35+549	Major Bridge	1.0	19	300	120	37	14
		1.2	16	400	110	60	22
38+580	Major Bridge	1.0	21	320	140	25	9
		1.2	18	400	140	42	16

39+120	Major Bridge	1.0	21	350	140	37	14
		1.2	18	400	130	60	22
41+916	Major Bridge	1.0	22.0	300	150	15	6
		1.2	16.0	350	110	22	9
43+900	Major Bridge	1.0	21.0	300	110	15	6
		1.2	21.0	470	150	22	9
46+362	Major Bridge	1.0	28.0	300	160	15	6
		1.2	28.0	400	200	22	9
48+122	Major Bridge	1.0	24.0	300	150	15	6
		1.2	25.0	450	200	22	9
48+400	Major Bridge	1.0	27.0	300	130	12	5
		1.2	28.0	400	160	17	7
48+510	Major Bridge	1.0	21.0	300	140	35	13
		1.2	19.0	400	160	55	21
49+250	Major Bridge	1.0	28.0	300	160	12	5
		1.2	25.0	400	180	17	7
54+825	Major Bridge	1.0	17.0	300	100	35	13
		1.2	15.0	400	110	55	21
55+850	Major Bridge	1.0	14.0	330	80	35	13
		1.2	15.0	400	100	55	21

56+780	Major Bridge	1.0	21.0	300	110	32	12
		1.2	18.0	400	150	51	20
57+555	Major Bridge	1.0	21.0	300	110	35	13
		1.2	18.0	400	150	55	21
58+400	Major Bridge	1.0	21.0	300	130	12	5
		1.2	18.0	400	150	18	7
63+570	Major Bridge	1.0	20.0	300	140	11	4
		1.2	18.0	400	150	16	6
64+270	Major Bridge	1.0	20.0	300	100	35	13
		1.2	17.0	350	140	55	21
65+740	Major Bridge	1.0	21.0	300	100	35	13
		1.2	18.0	420	110	55	21

4.5 Chemical Properties of Water

A summary of chemical properties results of water is presented in Table 4.5.

Table 4.5 Chemical Properties Test Results

Chainage	BH. No.	Soil-Water Extract		
		SO_3 (%)	Cl (%)	pH value
0+650	BH-1	0.08	0.06	7.9
1+172	BH-1	0.08	0.06	7.9
	BH-2	0.10	0.04	7.8
2+109	BH-1	0.10	0.04	7.6
	BH-2	0.08	0.04	7.6
2+306	BH-1	0.10	0.04	7.6
	BH-2	0.08	0.04	7.6
	BH-3	0.10	0.06	7.5

2+873	BH-1	0.06	0.04	7.6
3+490	BH-1	0.08	0.06	7.8
4+252	BH-1	0.10	0.06	7.6
5+163	BH-1	0.08	0.04	7.4
6+099	BH-1	0.10	0.06	7.6
7+064	BH-1	0.08	0.06	7.5
8+060	BH-1	0.08	0.06	7.8
8+977	BH-1	0.10	0.06	7.6
10+030	BH-1	0.08	0.06	7.8
10+973	BH-1	0.08	0.06	7.8
11+987	BH-1	0.06	0.04	7.4
13+841	BH-1	0.08	0.04	7.6
	BH-2	0.10	0.06	7.5
	BH-3	0.10	0.06	7.5
14+069	BH-1	0.10	0.04	7.6
	BH-2	0.08	0.04	7.6
13+136	BH-1	0.06	0.04	7.4
15+227	BH-1	0.12	0.03	7.5
16+144	BH-1	0.11	0.02	7.4
17+338	BH-1	0.13	0.03	7.5
19+051	BH-1	0.14	0.04	7.6
19+955	BH-1	0.14	0.04	7.4
	BH-2	0.13	0.02	7.3
20+935	BH-1	0.14	0.04	7.6
22+200	BH-1	0.12	0.03	7.4
23+808	BH-1	0.12	0.03	7.4
24+490	BH-1	Nil	139.00	7.69
25+760	BH-1	Nil	129.07	7.94
26+530	BH-1	Nil	119.15	7.72
27+290	BH-1	Nil	148.93	7.94
		Nil	139.00	7.99
	BH-2	24.0	119.15	7.90
		Nil	129.07	7.87
27+820	BH-1	Nil	129.07	8.00
28+660	BH-1	Nil	119.15	8.03
28+880	BH-1	Nil	168.79	7.61
30+780	BH-1	Nil	129.07	7.68
33+050	BH-1	Nil	148.93	7.31
34+360	BH-1	Nil	129.07	7.92
34+986	BH-2	Nil	119.15	7.33
35+549	BH-1	Nil	129.07	7.25

	BH-2	Nil	139.00	7.30
37+360	BH-1	Nil	139.00	7.20
38+580	BH-1	Nil	129.07	7.26
39+120	BH-1	Nil	129.07	7.43
41+916	BH-1	Nil	139.00	8.02
43+900	BH-1	Nil	99.29	7.52
46+362	BH-1	0.70	109.22	8.16
48+400	BH-1	Nil	89.36	7.15
48+510	BH-1	Nil	119.15	7.63
49+250	BH-1	Nil	99.29	7.60
50+100	BH-1	Nil	129.07	7.54
51+000	BH-1	Nil	89.36	7.76
52+640	BH-1	Nil	119.15	6.83
54+825	BH-1	Nil	89.36	7.03
54+825	BH-2	Nil	89.36	7.38
55+850	BH-1	Nil	89.36	7.96
56+780	BH-1	Nil	109.22	7.59
57+555	BH-1	Nil	89.36	7.03
59+305	BH-1	Nil	109.22	7.88
58+400	BH-1	Nil	99.29	7.40
62+160	BH-1	Nil	119.15	7.28
63+570	BH-1	Nil	79.43	7.18
63+570	BH-2	Nil	89.36	7.28
64+270	BH-1	Nil	89.36	7.98
64+270	BH-2	Nil	89.36	7.12
65+740	BH-1	Nil	109.22	7.87
65+740	BH-2	Nil	109.22	7.89

As per Table 3, IS: 456-2000, the exposure conditions for foundation works is low. As seen from the chemical analysis of subsoil and ground water the pH value is in near neutral condition (between 6 to 8). The SO_3 content of ground water falls in Class 1 (Table 4, IS: 456-2000).

The chloride contents in ground water are generally low. There is no specific recommendation in IS: 456 as regard to allowable limits of chloride in ground water. Warnings on chlorides in concrete are given in terms of chlorides coming from mix constituents like use of chloride based admixtures or contaminated aggregates rather than penetration of chlorides into concrete from environment.

4.6 Conclusions

- The findings presented in this report are based the subsoil conditions as found at the borehole locations. In case of any variation in subsoil conditions at the actual foundation location the matter shall be referred to the designer.

- In general the soils encountered at the investigated sites mainly comprises of non-plastic alluvial deposits of sandy silt and medium to dense fine sand with intermittent clayey silt.
- For the proposed Minor & Major Bridges, open and pile foundation are investigated respectively. The recommendation bearing and pile capacities are presented in Table 4.3 and Table 4.4
- After excavation, the founding strata shall be thoroughly checked and if any variation is found between the strata encountered and that reported in this report the matter shall be referred to the designer.
- The bearing and pile capacities can be increased under wind/seismic loading conditions as per provisions in relevant IS and/or IRC codes. The pile capacities need to be ascertained at site by conducting initial load tests.

(P.K. KUNDU)

List of References

S. No.	References
1	IS: 2131-1981:- Method For Standard Penetration Test For Soils.
2	IS: 1498-1970:- Classification and Identification of Soils For General Engineering Purposes.
3	IRC: 5 -1998:- Standard Specifications and Code of Practice For Road Bridges (Section-I – General Features of Design)
4	IRC: 78 -2014:- Standard Specifications and Code of Practice For Road Bridges (Section-VII – Foundations and Substructure)
5	IS: 1904-1986:- Code of Practice for Design and Construction of Foundations in Soils.
6	IS:2911 Part1,Sec-2-2010:- Design and Construction of Pile Foundations Bored Cast in-Situ Concrete piles
7	Foundation Analysis and Design by J.E. Bowles, McGraw-Hill, 1997
8	Settlement of Structures on Clay Soils by C.J.Padfield, M.J.Sharrock, Construction Industry Research and Information Association, 1983
9	Foundation Design and Construction by M. J. Tomlinson, Prentice Hall, 2001
10	Soil Mechanics in Engineering by Karl Terzaghi, Read Books, 2010
11	Foundation Design Manual by N.V. Nayak, Dhanpat Rai Publications, New Delhi, 1996
12	Geotechnical Engineering Hand Book by M. Carter, Pentech Press, 1983
13	Correlations of Soil Properties by Michael Carter and Stephen P Bentley, Pentech, 1991

ANNEXURE A

- LOCATION PLAN
- BORELOGS
- SOIL PROFILE

LEGEND:
● BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/01 March, 2016

LEGEND:
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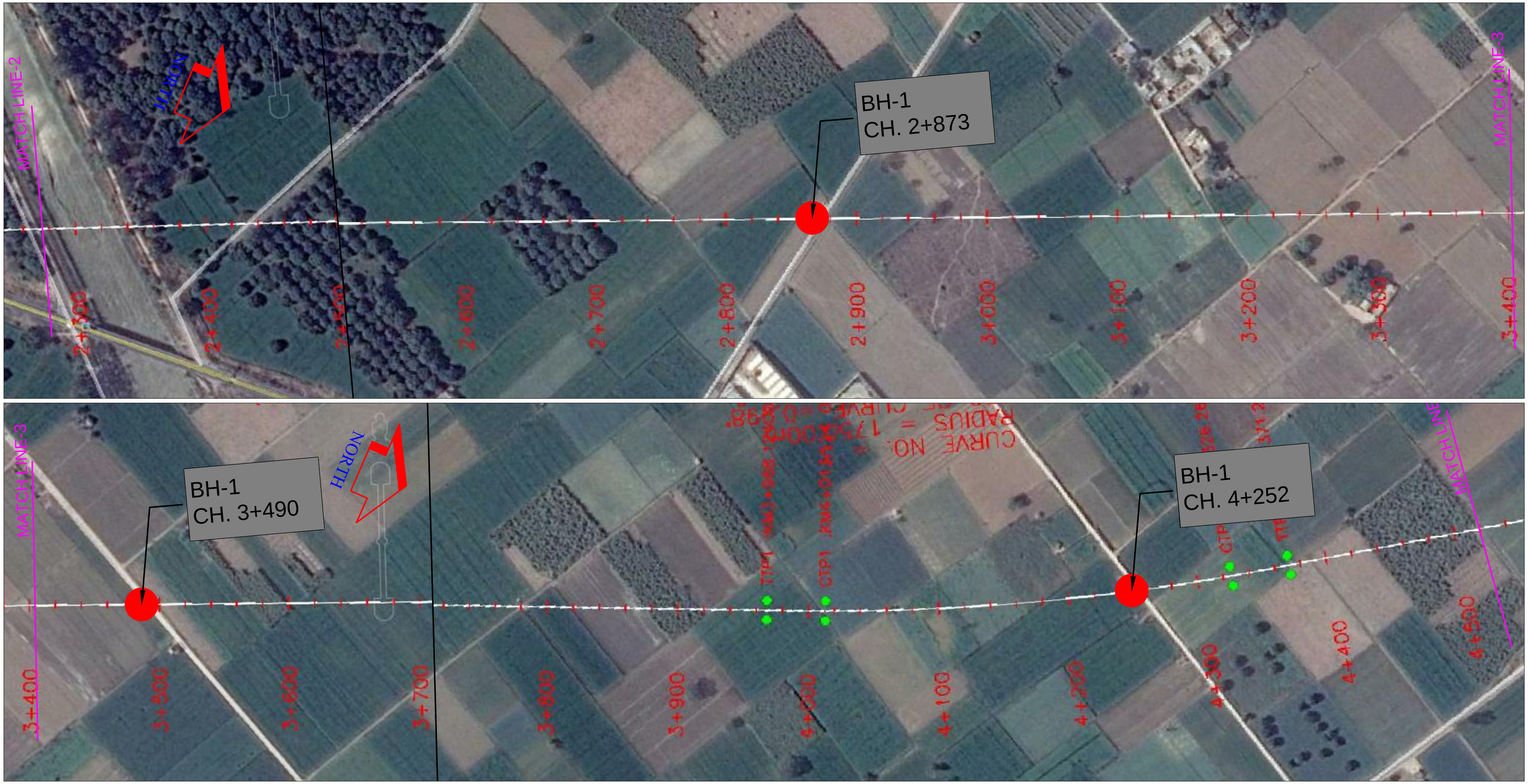

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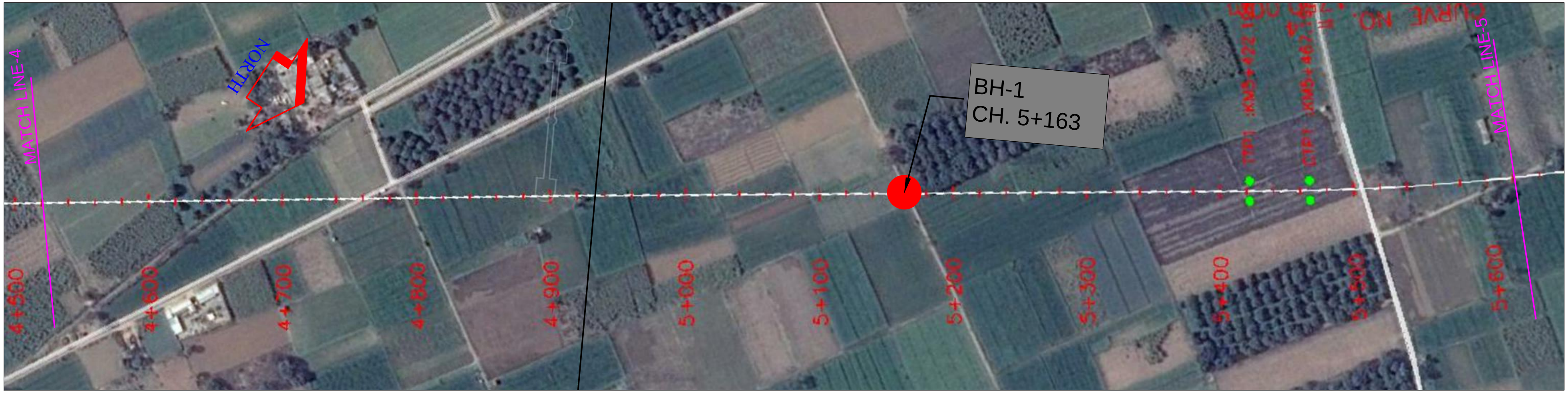

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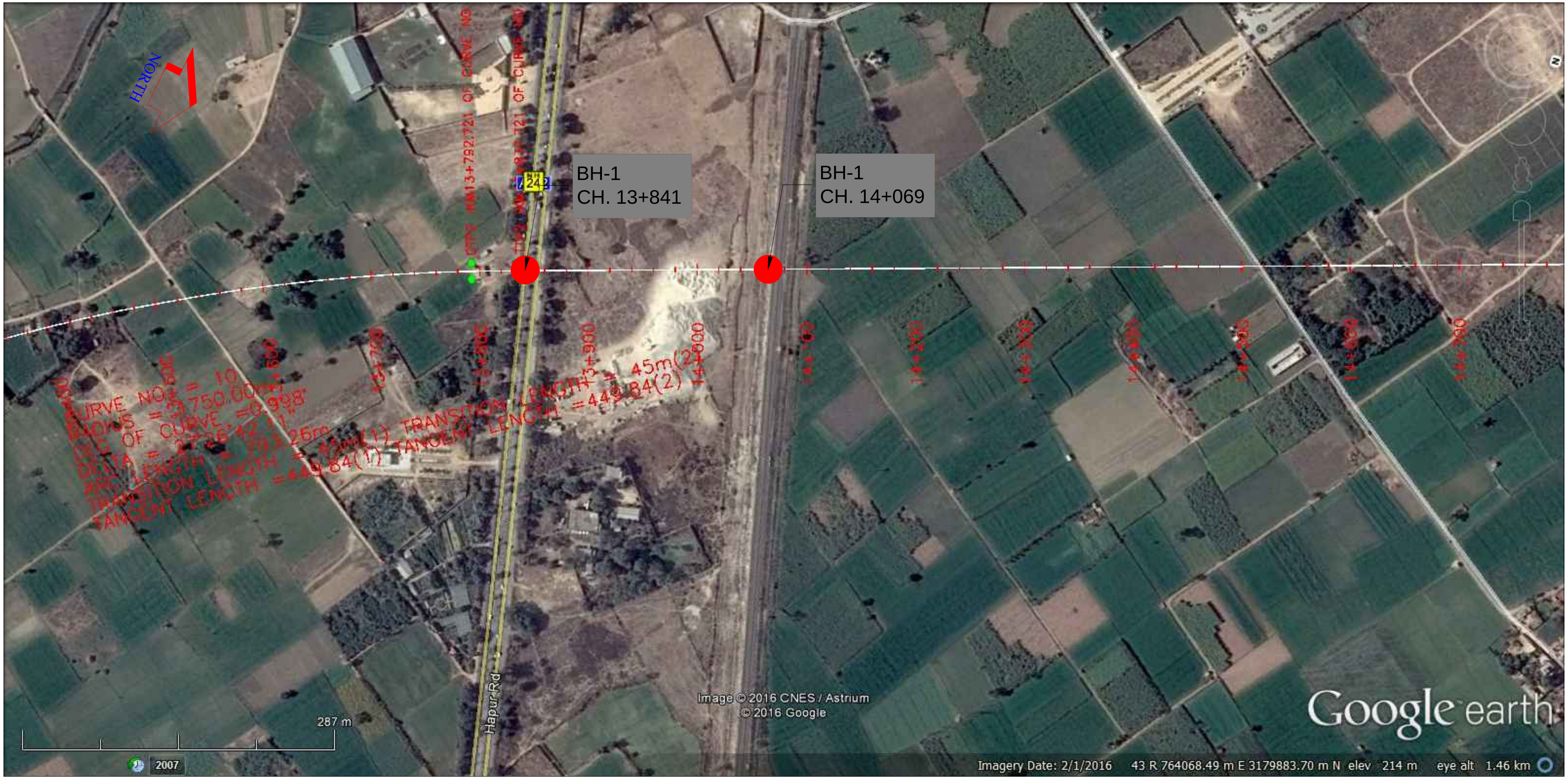

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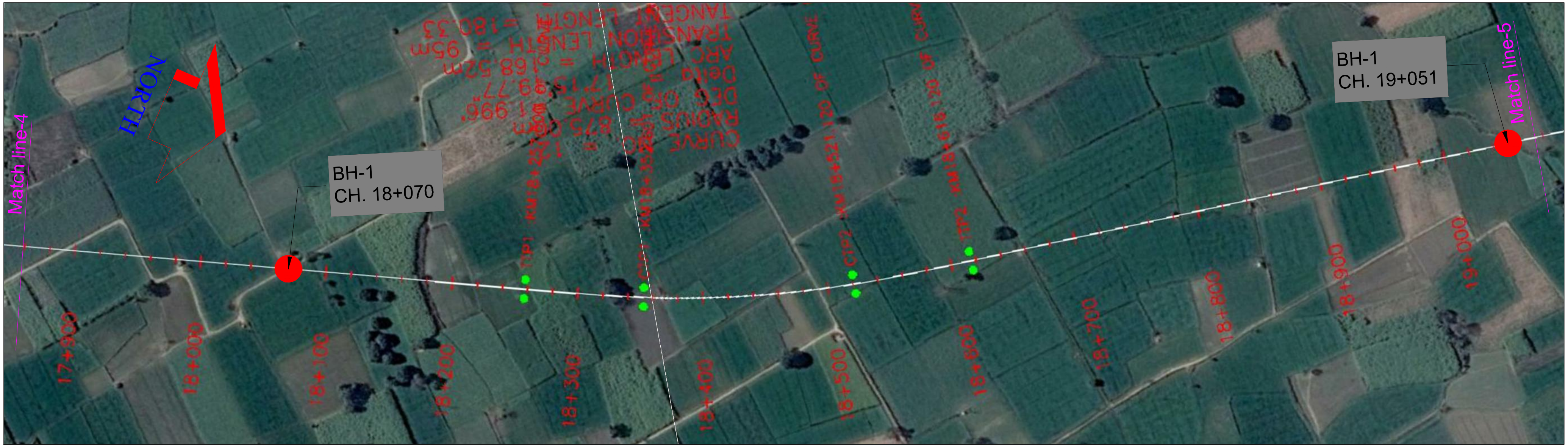
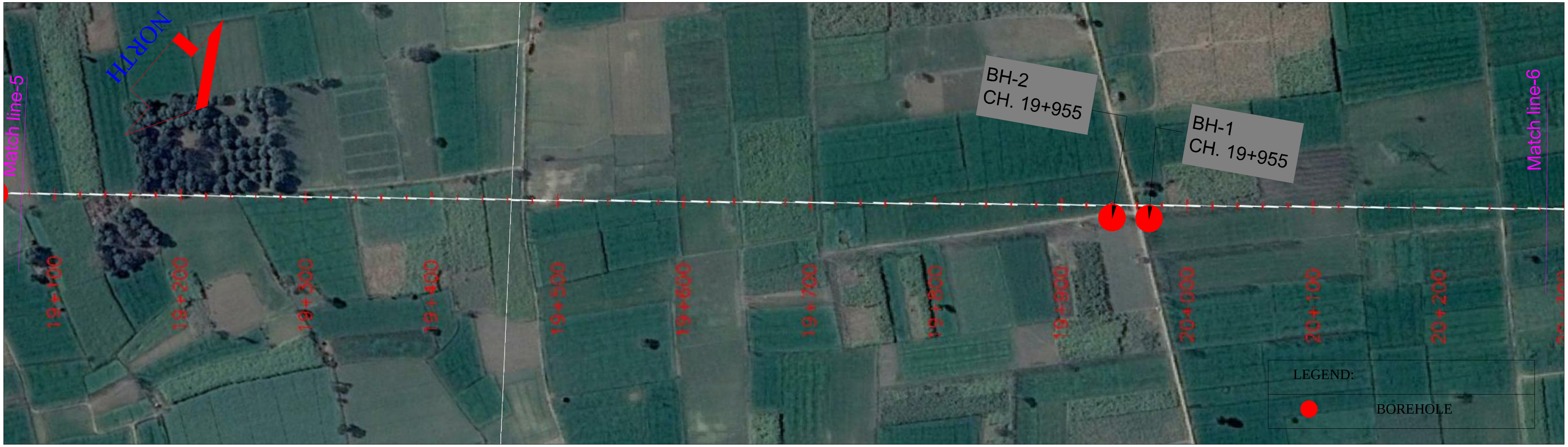
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/01 March, 2016

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/02 March, 2016





CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/03 March, 2016

CLIENT:

skylark Designer and Engineers (P) Limited

PROJECT:

Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut

DRAWING TITLE:

Borehole Location Plan

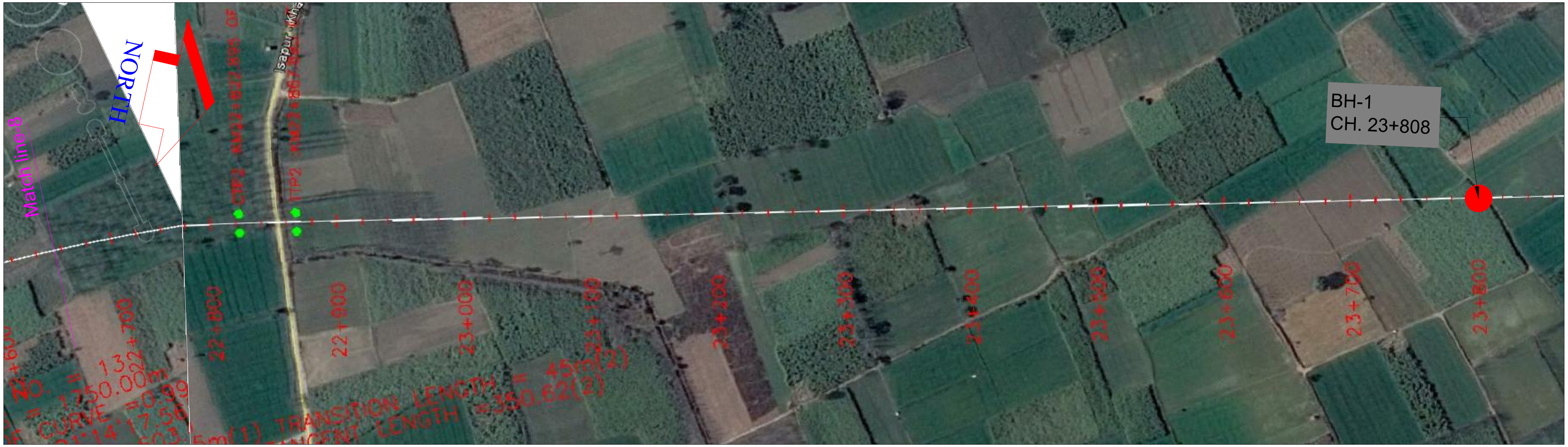
AGENCY:

XPLORER

Xplorer Consultancy Services Pvt. Ltd.
Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India
Tel: +91-124-4388659, Fax: +91-124-4241962
Email: xplorer@xplorer.in, Website: www.xplorer.in

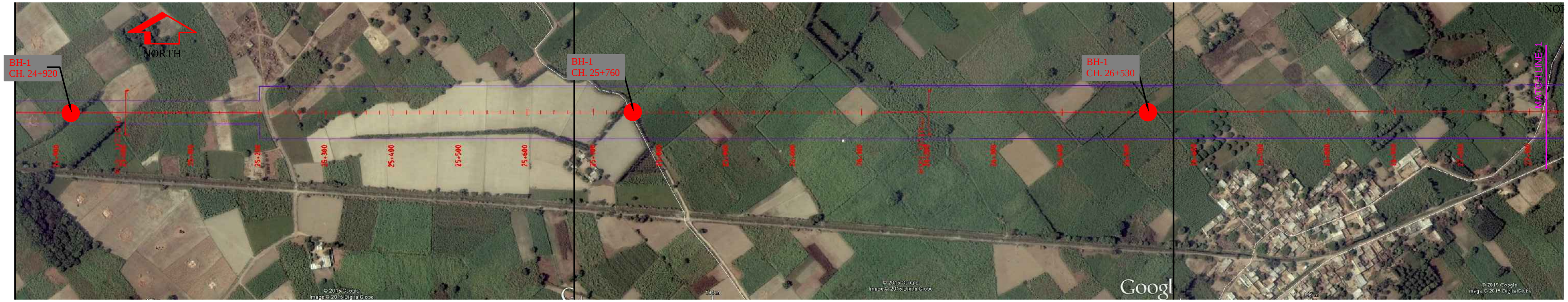
DRG. NO. PWD/LOCATION/04

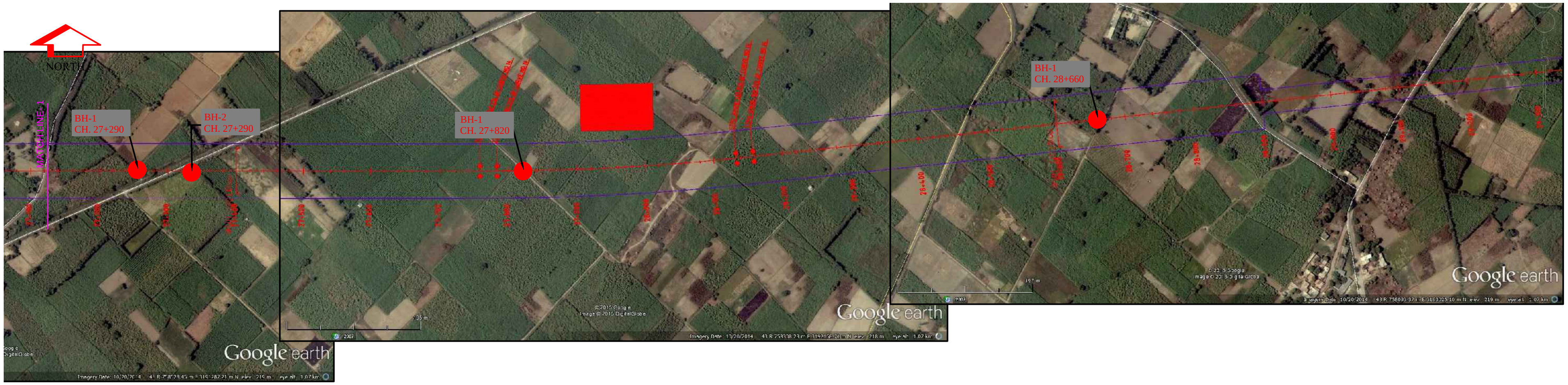
March, 2016



LEGEND:
● BOREHOLE

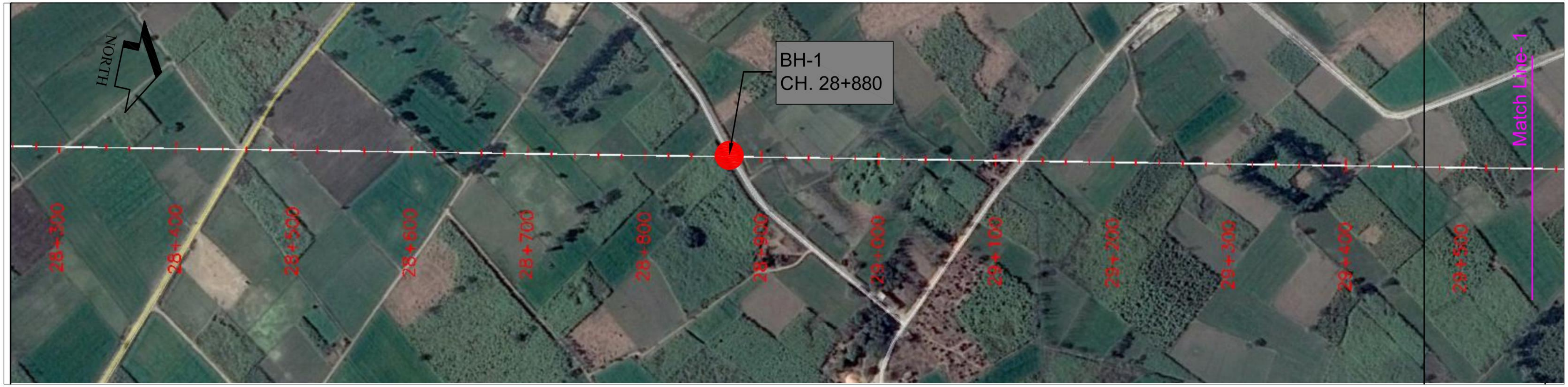
CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/05 March, 2016





LEGEND:	
●	BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/01 September, 2015

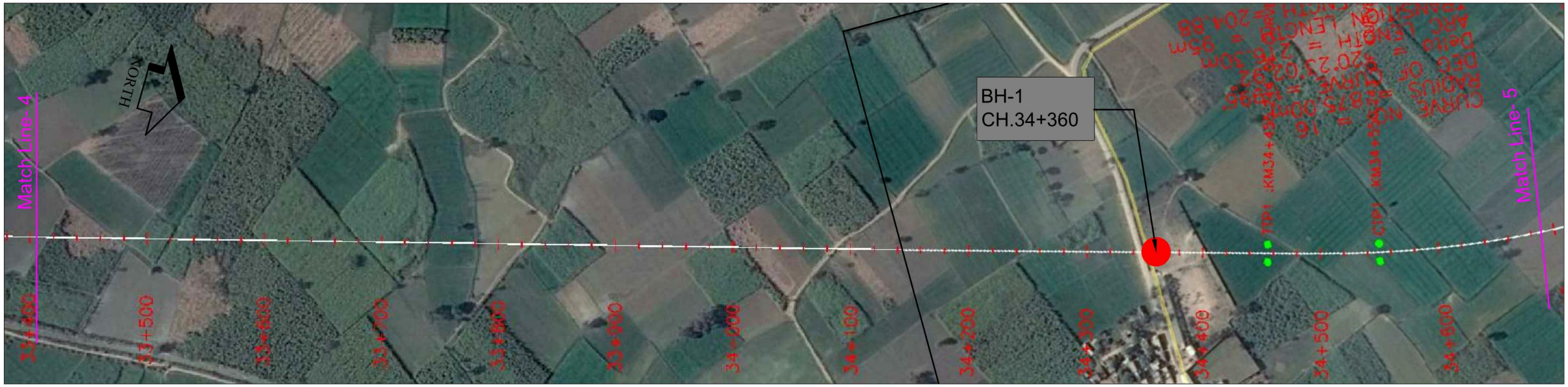


LEGEND:	
●	BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Consultancy Services Pvt. Ltd. Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/01 February, 2016

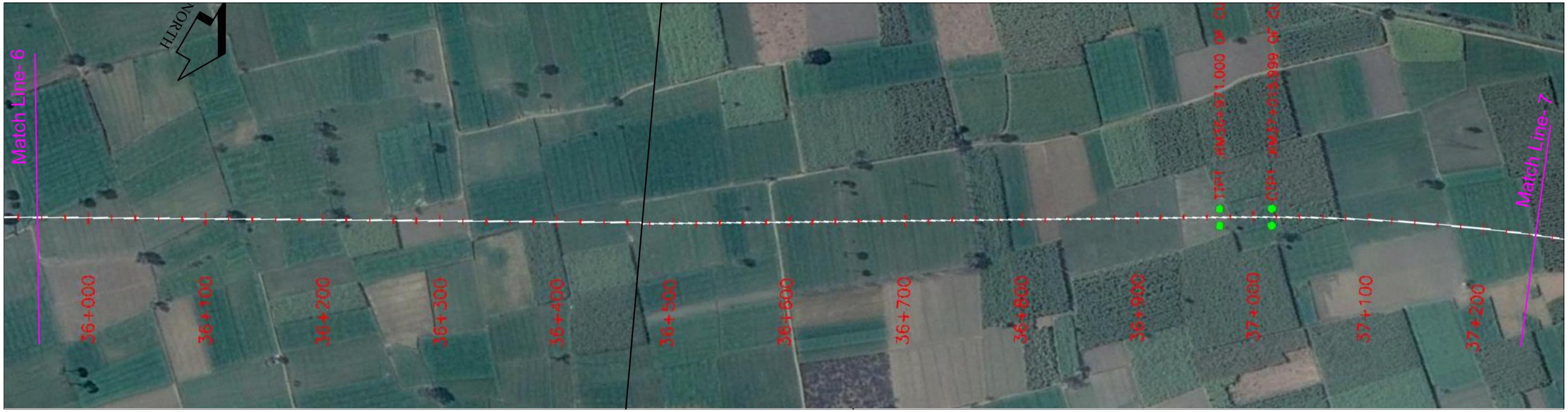
LEGEND:	
●	BOREHOLE

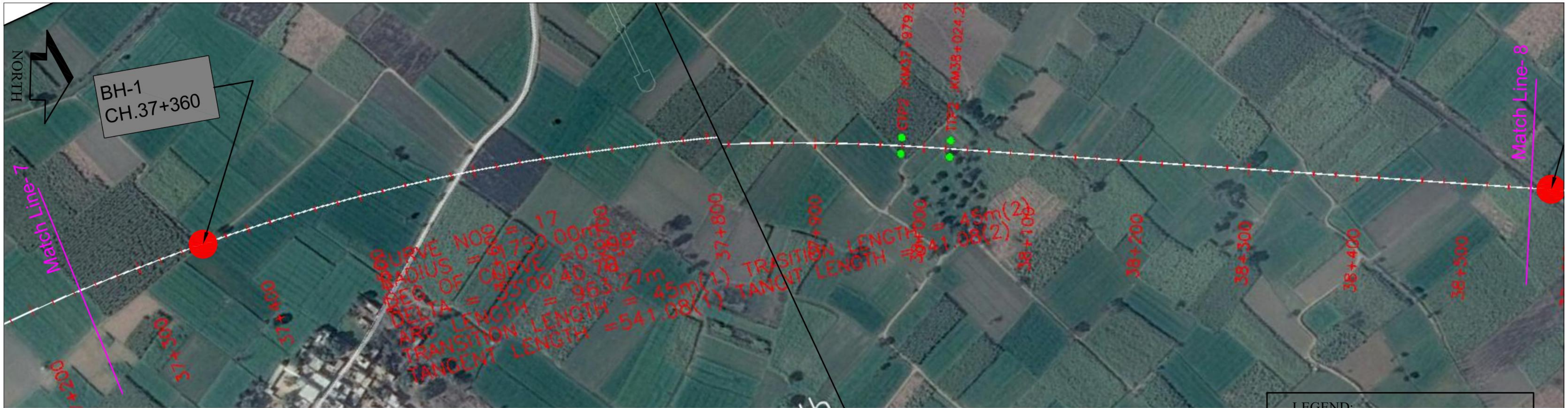
CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/02 February, 2016



LEGEND:
● BOREHOLE

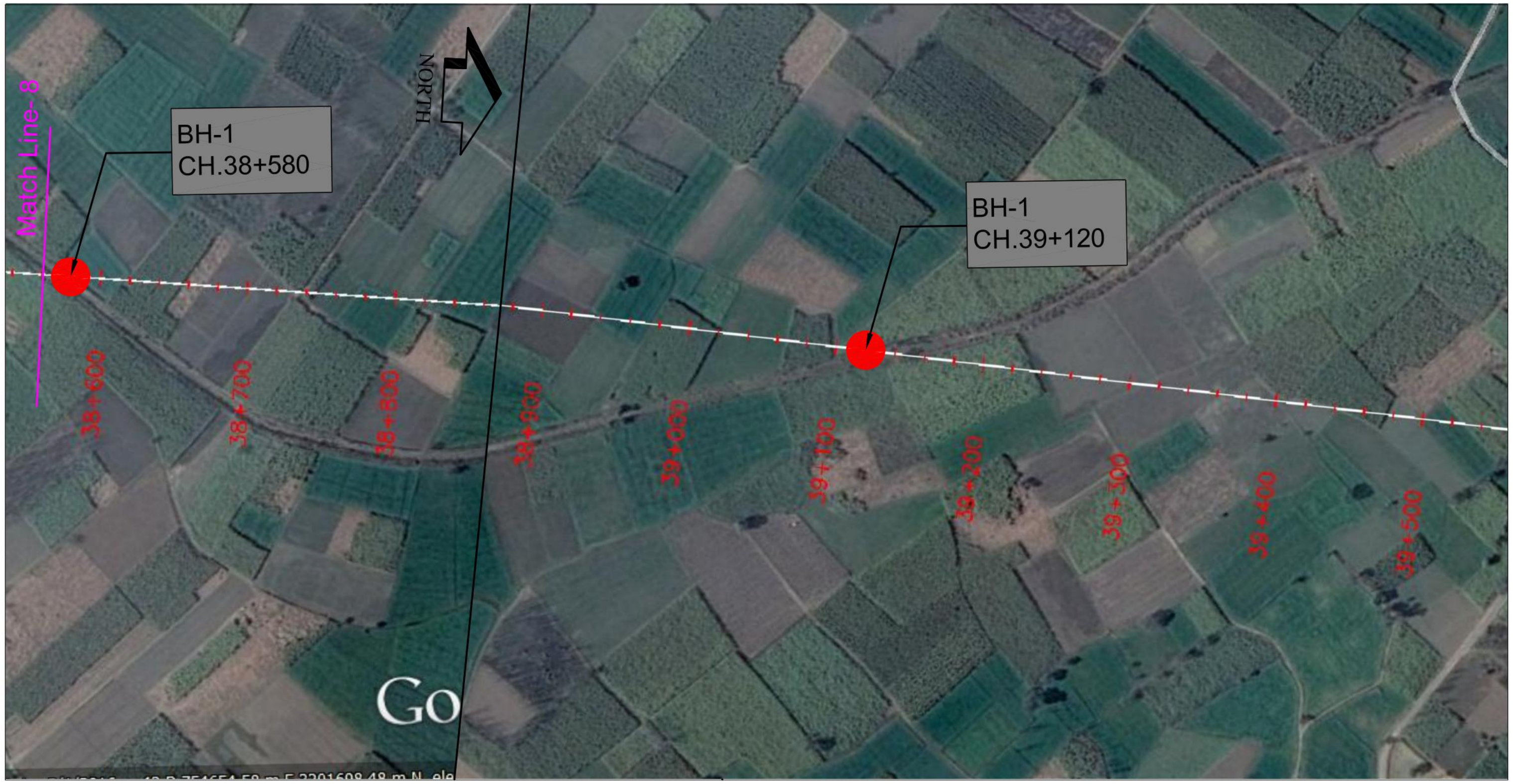
CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/03 February, 2016





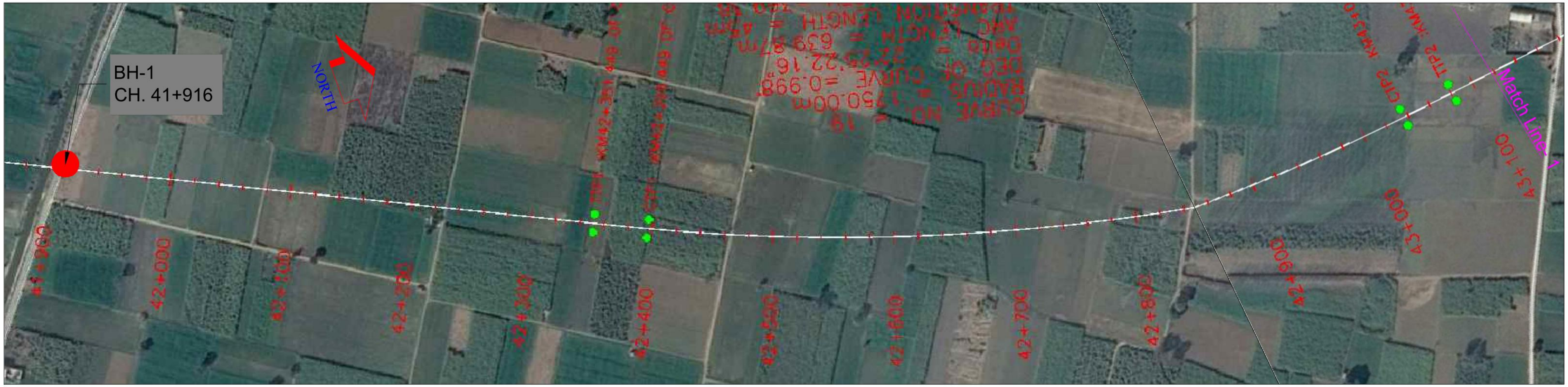
LEGEND:	
●	BOREHOLE

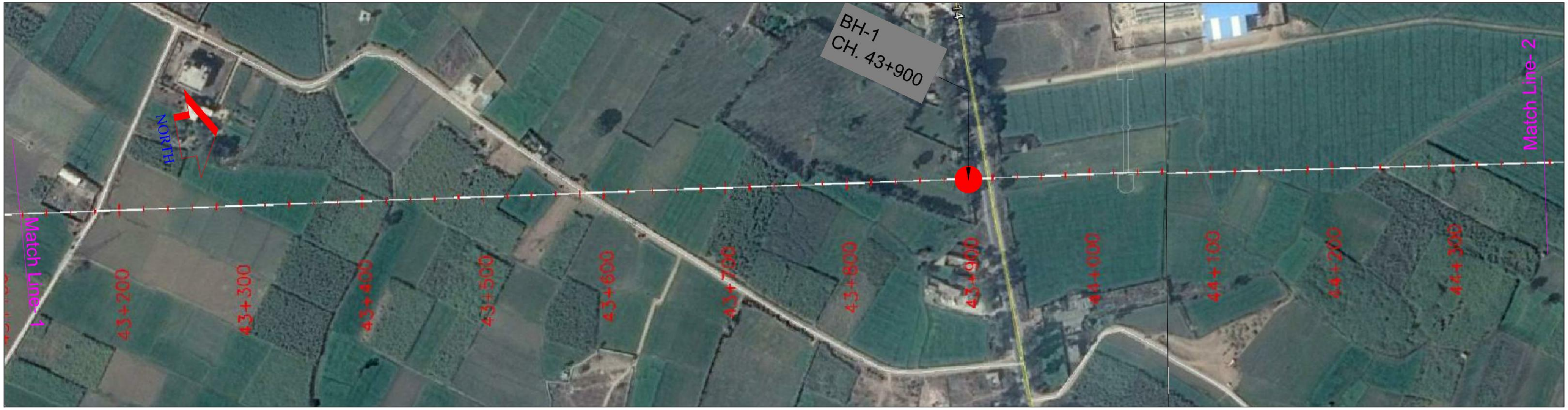
CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/04 February, 2016



LEGEND:	
●	BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	DRG. NO. PWD/LOCATION/05
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	February, 2016





LEGEND:	
●	BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/01 March, 2016

LEGEND:	
●	BOREHOLE

CLIENT:

skylark
Designer and Engineers (P) Limited

PROJECT:

Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut

DRAWING TITLE:

Borehole Location Plan

AGENCY:

XPLORER

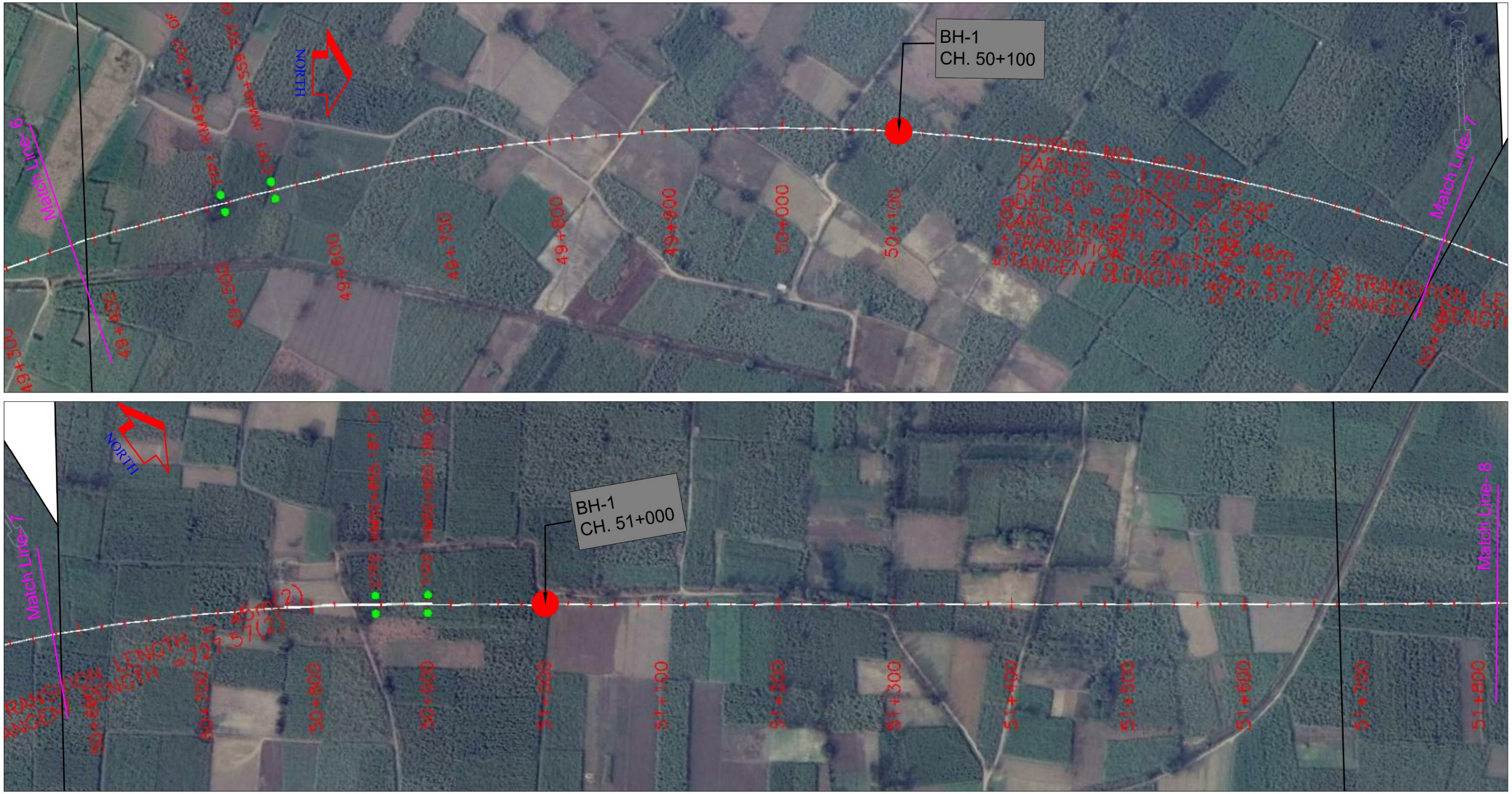
Xplorer Consultancy Services Pvt. Ltd.
Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India
Tel: +91-124-4388659, Fax: +91-124-4241962
Email: xplorer@xplorer.in, Website: www.xplorer.in

DRG. NO. PWD/LOCATION/02

March, 2016

LEGEND:	
●	BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/03 March, 2016



LEGEND:

● BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	DRG. NO. PWD/LOCATION/04
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	March, 2016

LEGEND:	
●	BOREHOLE

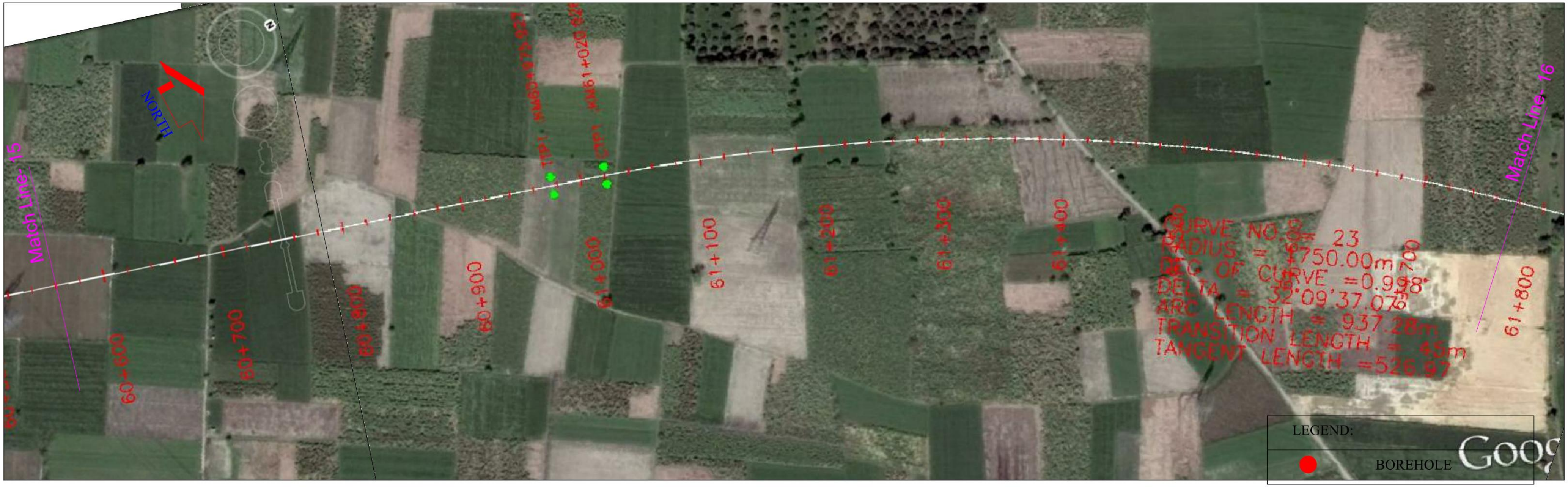
CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/05 March, 2016

LEGEND:	
●	BOREHOLE

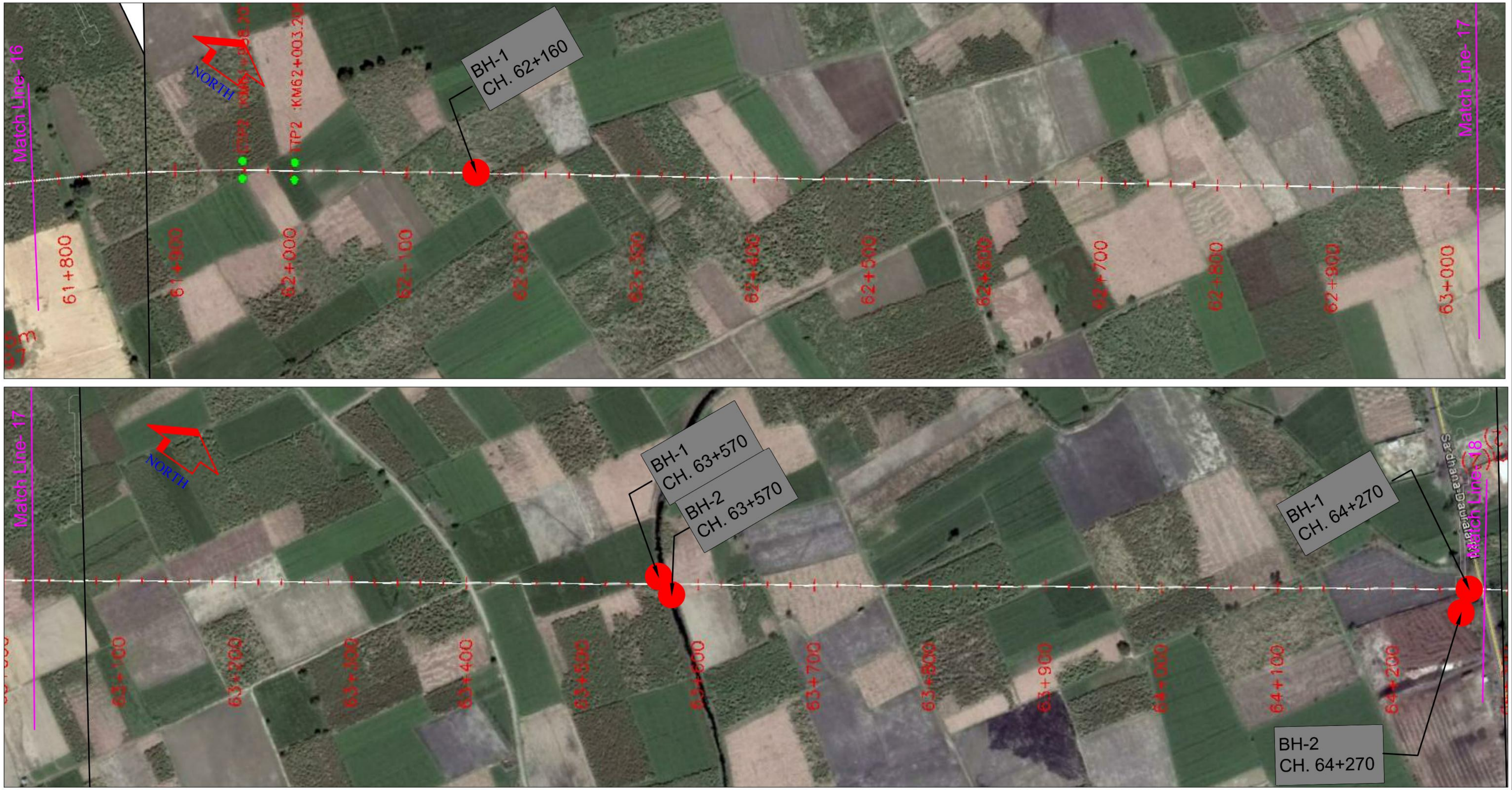
CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/06 March, 2016

LEGEND:	
●	BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/07 March, 2016



CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/08 March, 2016



LEGEND:

BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/09 March, 2016

LEGEND:

● BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	DRG. NO. PWD/LOCATION/10
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Hapur-Meerut Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	March, 2016