

**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL SOUTHERN ZONAL
BENCH, CHENNAI**

O.A.No. 176 of 2013 (SZ)

(earlier O.A. No. 562 of 2018 (PB))

IN THE MATTER OF:

V.P. Krishnamoorthy

...Applicant

Vs.

Union of Inida & Ors.

...Respondents

STATUS REPORT AND DOCUMENTS FILED BY THE 6TH RESPONDENT

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Dated at Chennai on this the 23rd day of August, 2021

S.RAMASUBBRAMANIAM & ASSOCIATES


COUNSEL FOR 6th RESPONDENT

PARTNER

1

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
SOUTHERN ZONAL BENCH, CHENNAI

O.A.No.176 of 2013 (SZ)
(earlier O.A.No.562 of 2018 (PB))

IN THE MATTER OF:

V.P. Krishnamoorthy

.. Applicant

vs.

Union of India & Ors.

.. Respondents

**STATUS REPORT FILED BY BHARAT PETROLEUM CORPORATION LIMITED
IN COMPLIANCE OF THE ORDER DATED 27.05.2021 OF THE HON'BLE
NATIONAL GREEN TRIBUNAL.**

The 6th Respondent (Bharat Petroleum Corporation Limited – BPCL) humbly submits as follows:

1. By Order dated 27.05.2021, this Hon'ble Tribunal accepted the recommendations of CPCB in their Reply Affidavit dated 19.06.2020 and directed BPCL:
 - a. to carry out detailed site investigation and risk investigation study to evolve Site Specific Target Levels (SSTLs) for remediation of oil contaminated site at Tondiarpet, Chennai; and
 - b. to augment SVE system by connecting as many wells as possible and by operating both the SVE system simultaneously to optimal extraction rate.
2. Thereafter, CPCB issued letter dated 03.08.2021 whereby BPCL was directed to submit compliance report in respect of following four items (which includes the two items mentioned in paragraph 1 above).
 - a. As per the action plan decided in joint meeting at the highest level held under the chairmanship of Chairman, CPCB at Chennai on March 01, 2019, upon completion of CMRL soil excavation works, M/s.BPCL to submit a Detailed Project Report (DPR) for revised remediation scheme based on re-assessment of site along with the specific target levels (SSTLs) for remediation based on human health risk assessment.
 - b. Installation of Soil Gas Probes to Monitor VOCs in Vadose Zone of Subsoil at 3 locations in affected area, which shall become part of revised remediation scheme.
 - c. Augmentation of SVE system by connecting all available wells to both SVE system and to operate both SVE systems continuously to optimize soil vapor extraction.
 - d. Steps taken to entrust the health impact study to ICMR.
3. In response, by letter dated 06.08.2021, BPCL provided its response to the four items suggested by CPCB. Further, by letter dated 05.08.2021, BPCL submitted the Detailed Project Report (DPR) prepared by BPCL's consultant namely Stratus

Territory Manager (Retail), Chennai
Bharat Petroleum Corporation Ltd.
35, Vaidyanathan Street,
Tondiarpet, Chennai-600 081.

International Inc. along with the Review of the DPR conducted by Dr. Indumathi M. Nambi, Ph.D., Professor, IIT, Madras, who had earlier reviewed the detailed site assessment report in the year 2015 and had been involved with the Tondiarpet contaminated site since the incident happened in the year 2013.

DIRECTIONS BY CPCB

4. As mentioned above, CPCB by its letter dated 03.08.2021 had suggested four items which includes the two items contained in the Reply Affidavit dated 19.06.2020 filed by CPCB. The four items and BPCL's response to the same as informed to CBCP vide BPCL's letter dated 06.08.2021 are extracted below:

"i. As per the action plan decided in joint meeting at the highest level held under the chairmanship of Chairman, CPCB at Chennai on March 01, 2019, upon completion of CMRL soil excavation works, M/s BPCL to submit a Detailed Project Report (DPR) for revised remediation scheme based on re-assessment of site along with site specific target levels (SSTLs) for remediation based on human health risk assessment.

We have already forwarded the Detailed Project Report (DPR) vetted by IIT, Madras as per reference no.TNP: OPS: 7/CON dated 05.08.2021.

As per the direction of the CPCB and TNPCB, BPCL's consultant Stratus Environmental, Inc. (Stratus), conducted an environmental site investigation between February and March 2021 to reassess the extent of petroleum hydrocarbon impact to soil and groundwater post CMRL excavation activity, and reinstalled monitoring borewells (replacement of wells lost due to CMRL activity) to evaluate the lateral extent of impact to groundwater.

Stratus has prepared a Detailed Project Report (DPR) to present the findings of the site assessment conducted at the Bharat Petroleum Corporation Limited (V. P Koil Street – T.H Main Road) Petroleum Contaminated Site, Tondiarpet, Chennai.

Based on the DPR, Stratus does not recommend a revised remediation scheme for the site. Given the presence of residual petroleum hydrocarbon mass between 25 to 35 feet bgs, Stratus recommended addition of more wells to SVE systems for soil vapor extraction. Stratus recommended connecting newly installed wells 26A, located in the alley, and well MW-25A, located in Devi Polymer property to the SVE-2, and SVE-1 respectively. Stratus in the DPR state that continued operation of SVE and AS would be adequate to remediate the residual mass in soil and groundwater.

ii. Installation of Soil Gas Probes to Monitor VOCs in Vadose zone of Subsoil at 3 locations in affected area, which shall become part of revised remediation scheme.

Given the low concentration in the influent air samples of the SVE system, we do not believe soil gas probes installation would be necessary at this point. However, if CPCB insists, we will direct Stratus to install the soil gas probes.

iii. Augmentation of SVE system by connecting all available wells to both SVE system and to operate both SVE system continuously to optimize soil vapour extraction."

As per the direction of the CPCB and TNPCB, BPCL's consultant Stratus Environmental Inc.(Stratus), have been focusing on extraction of petroleum hydrocarbon vapours from wells available for remediation activity in and around CMRL work area and in contaminated areas.

SVE SYSTEM OPERATION

Stratus is currently operating two SVE systems to mitigate petroleum hydrocarbon impact on the subsurface near VPK Street and TH Road, Tondiarpet, Chennai. The SVE -1 system consists of 10 HP extraction blower & SVE -2 system consists of a 20 HP Liquid ring vacuum pump used to extract petroleum hydrocarbon vapors from the contaminated area using vapor extraction wells. The extracted vapors are abated in a catalytic oxidizer & thermal oxidizer rated at 250 (CFM) and 500 (CFM) in systems SVE-1 and SVE-2, respectively.

In May 2019, Stratus completed the installation of 2 remediation (SVE-2a, SVE-3a) and 1 air sparge (AS-3a) wells in earmarked locations along T.H main road to compensate for those lost due to CMRL activity (see attached Figure) and these wells are connected to SVE unit-1. In November 2019, Stratus completed the installation of 2 remediation wells (SVE-11, and SVE-12) which are shown on figure 2. Stratus completed the construction activity to connect the remediation wells (SVE - 1, 11, 12 & MW - 2A, 4A) to the SVE unit-2. In March 2021, Stratus completed the installation of 2 remediation wells (MW-25A, and MW-26A) and 1 air sparge well (ASB-1) which are shown in the attached figure. In June 2021, Stratus connected the remediation wells (MW- 26A, ASB-1 & DBAS- 1) to the SVE unit-2.

Stratus began operating the SVE -1 system in May 2016 and SVE-2 beginning 13th January 2020. SVE-1 is operated 24-hours a day and SVE -2 is being operated for 12 hours since 10th June 2020.

SVE unit 1 is connected to remediation wells listed below.

Well ID	Operational status
SVE - 2A, 3A, 4, 5, 7, 8, 9 & MW - 16A	Currently in operation

SVE unit 2 is connected to remediation wells listed below

Well ID	Operational status
MW - 2A, 4A, 26A, SVE- 1, 11, 12	Currently in operation

AIR SPARGING UNIT OPERATION

Air Sparging unit-1 is currently operated at SVE Unit-2 and connected to AS wells listed below.

Well ID	Operational status
AS - 6, ASB - 1	Currently in operation
AS - 2, DBAS - 1	Currently not in operation

iv. Steps taken to entrust the health impact study to ICMR

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We are ready to go ahead with the health impact study at any moment direction to that effect is received from CPCB and TNPCB. As per the minutes of meeting conducted on 23.04.2021 through VC with officials of CPCB, TNPCB and ICMR ,the following is the latest status in this regard.

“ ICMR officials informed that Human Ethics Committee of ICMR has suggested carrying out the health hazard study after the COVID – 19 situation in view of the data collection like blood and urine samples from the affected people in the oil contaminated place at Tondiarpet will not reflect the accurate information.

In the meeting it was concluded that ICMR shall furnish a detailed report obtained from National Institute of Epidemiology containing proposal of health hazard study at affected place of Tondiarpet with information of proposed date of start of the study, time duration along with cost estimation, release of fund for study etc. to CPCB & TNPCB so as to proceed further in this regard as per Hon'ble court order.”

Again as per the letter no. NIE/D/TNPCB/21/15 dated 12th May 2021 addressed to The Member Secretary, TNPCB, ICMR clarified that their Institutional Human Ethics Committee (IHEC) has approved the study in principle and suggested that the initiation of the study may be postponed till COVID 19 pandemic subsides.

We are yet to get any direction in this regard from CPCB & TNPCB or ICMR.”

STATUS OF REMEDIATION ACTIVITIES

5. The executive summary of the assessment studies and remedial activities of petroleum contaminated site from 2015 to 2021 is provided below.

2015 Site Assessment – Key Findings

Residual Hydrocarbon Mass

- Based on the Soil analytical data, Stratus has calculated that approximately, **32,797.61 kg** of residual TPH is still remaining in the soil in 2015.
- Based on the Groundwater analytical data the residual mass of TPH in groundwater is estimated to be approximately **1,380.97 kg** in 2015.
- Cumulatively, **34,178.57 kg** of residual TPH is estimated to be present in soil and groundwater in 2015 at the petroleum contaminated site.

Estimated Mass of TPH present in Soil Surface (2015) (Kg)	Estimated Mass of (TPH) present in Groundwater (2015) (Kg)	Cumulative TPH Mass present in Soil and Groundwater(2015) (Kg)
32,797.61	1,380.97	34,178.57

Remedial Activities

SVE Systems Operation

- SVE system 1 has operated for **34,311 hours** since 20th May 2016 and SVE system 2 operated for **3,581 hours** since 13th January 2020 as of June 2021.

- The SVE -1 unit has extracted approx. **15,058.05 Kilograms of petroleum hydrocarbons (TPH)**, as of June 2021.
- The SVE -2 unit has extracted approx. **1,887.94 Kilograms of petroleum hydrocarbons (TPH)**, as of June 2021.
- Total amount of petroleum hydrocarbon vapor extracted beneath the subsurface soil through SVE 1 & 2 was estimated an amount of **16,945.99 Kilograms** (approximately) as of June 2021.

Estimated Mass of TPH Extracted by SVE-1 (May 2016) – June 2021) (Kg)	Estimated Mass of TPH Extracted by SVE-2 (January 2020) – June 2021) (Kg)	Cumulative Mass of TPH extracted by SVE- 1 & SVE-2(June 2021) (Kg)
15,058.05	1,887.94	16,945.99

Free Product Recovery (Socks Absorbent)

- Free product was not observed or identified in any of the existing or newly installed monitoring wells and borings during the 2021 site assessment. Free product removed through absorbent socks from 2015 - 2021 was calculated to an amount of **69.093 Kg** in the petroleum contaminated site from 2015- 2021.

CMRL Excavation Activity

- TPH mass removed by CMRL activity in the contaminated zone was **4,849.137 Kilograms** (approximately) from 2018- 2019.

2021 Site Assessment – Key Findings

Residual Hydrocarbon Mass

- Based on the Soil analytical data, Stratus has calculated that approximately, **1053.93 kg** of residual TPH is still remaining in the soil in March 2021, in comparison to estimated mass of **32,797.61 kg** of TPH in 2015.
- Based on the Groundwater analytical data the residual mass in ground water is estimated to be approximately **2.11kg** in March 2021, compared to **1,380.97 kg** of TPH estimated in 2015.
- Cumulatively, **1,056.043 kg** of residual TPH is estimated to be present in soil and groundwater in March, 2021 at the petroleum contaminated site.

Estimated Mass of TPH present in Soil Surface (2021) (Kg)	Estimated Mass of TPH present in Groundwater (2021) (Kg)	Cumulative TPH Mass present in Soil and Groundwater(2021) (Kg)
1,053.93	2.11	1,056.043

Mass Balance Summary of TPH from 2015 – 2021

- Below table summarize the total TPH mass estimated in 2015 assessment, Mass removed by SVE units and absorbent socks, Mass removed by CMRL activity and unaccounted mass removed by SVE units during the high slug movement into the treatment system till February 2021 and the remaining mass present at site in March 2021.

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 Bharat Petroleum Corporation Ltd
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 Tondiarpet, Chennai-500 081.

32, Vaidyanathan Street,
 Chennai-500 081.

6

Initial TPH Mass (2015) (Kg)	Mass Removed by SVE 1 & 2 (May, 2016-Feb, 2021) (Kg)	Mass Removed by Socks (2015-2020) (Kg)	Mass Removed by CMRL (2018-2019) (Kg)	Mass Removed by SVE units (Unaccounted)/ Natural Attenuation factors (Kg)	TPH Mass Remaining (March, 2021) (Kg)
34,178.57	16,739.58	69.093	4,849.137	11,464.717	1056.043

- The total TPH mass removed till February 2021 is estimated to be 33,122.527Kgs (SVE units -16,739.58 kg, Socks Absorbent - 69.093 kg, unaccounted mass removed by SVE units/ Natural Attenuation factors- 11,464.717 kg and CMRL remediated soil- 4849.137 kg).
- The reduction is calculated to be 96.91% of the total mass estimated in 2015 (34,178.57 kg).

Future Plan of Action

- Installation and commissioning of second air sparge system in SVE Unit - 1.
- Connect AS-4,5,7,3a and SVE-8 (dual purpose) to second air sparge system in SVE Unit -1.
- Connect MW-25A to SVE Unit -1 for soil vapors extraction.
- Stratus will focus on extraction of petroleum hydrocarbon vapors from wells available for remediation activity in and around CMRL work area and in contaminated areas. Stratus will also collect data to evaluate system performance and estimate mass removed.

SUPPLY OF WATER BY BPCL

6. BPCL has been supplying 18,000 ltrs. of water through metro water on a daily basis. This is evidenced from the water supply report of Chennai Metro water for the months of April to July 2021.

HEALTH STUDY BY ICMR

7. In respect of the health study to be conducted by ICMR, by letter dated 12.05.2021, ICMR informed TNPCB that the health study may be postponed till Covid-19 pandemic subsists. Subsequently, by letter dated 12.08.2021, ICMR informed TNPCB that they are ready to proceed with the health study for a total value of Rs.1,12,67,125/- and 90% of the said amount would have to be paid immediately and the balance 10% after submission of the final report. Thereafter, by letter dated 13.08.2021 which was received by BPCL on 16.08.2021, TNPCB directed BPCL to make payment to ICMR through TNPCB in the mode of Demand Draft as mentioned above. BPCL is in the process of making the advance payment of 90% for the health study.

DOCUMENTS

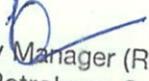
8. The following documents are submitted by BPCL:
 - a) Water Supply Report of Metro Water;
 - b) Detailed Project Report dated 15.04.2021;

Territory Manager (Retail), Chennai
 Bharat Petroleum Corporation Ltd.
 35, Vaidyanathan Street,
 Tondiarpet, Chennai-600 081.

Tondiarpet, Chennai-600 081
 35, Vaidyanathan Street,
 Bharat Petroleum Corporation Ltd.
 Chennai-600 081

- c) Letter dated 01.08.2021 from IIT, Madras to BPCL;
- d) Letter dated 03.8.2021 from CPCB to BPCL;
- e) Letter dated 05.08.2021 from BPCL to TNPCB;
- f) Letter dated 06.08.2021 from BPCL to CPCB;
- g) Letter dated 12.08.2021 with enclosures from ICMR to TNPCB; and
- h) Letter dated 13.08.2021 from TNPCB to BPCL.

Dated at Chennai on this the 23rd day of AUGUST 2021.


Territory Manager (Retail), Chennai
Bharat Petroleum Corporation Ltd
35, Vaidyanathan Street,
Tondiarpet, Chennai-600 081.

6TH RESPONDENT

VERIFICATION

I, Gururaj Sankh son of Naggapa Guruligappa Sankh, working as Territory Manager (Retail-Chennai) in Bharat Petroleum Corporation Limited do hereby declare that what is stated above is true to the best of my knowledge, information and belief.

Verified at Chennai on this the 23rd day of AUGUST 2021.


Territory Manager (Retail), Chennai
Bharat Petroleum Corporation Ltd.
35, Vaidyanathan Street,
Tondiarpet, Chennai-600 081.

6TH RESPONDENT

Mobile water supply To Varadharajaperumal Koil Street (Bharat Petroleum)
From Patel Nagar filling point
July - 2021 - Rs.1,050/- for 9000 Lts.

Date	Quantity in Lts.	No. of Trips	Ref. No. & Date	Amount	Opening Balance in Lts.	Closing Balance in Lts.	Vehicle Reg. No. (9 Kl.)
01-07-21	9,000	2	20214011169	300.00	15,03,000	14,85,000	7422 - 7498
02-07-21	9,000	2	20214011168	2,10,750.00	14,85,000	14,61,000	5325 - 6802
03-07-21	9,000	2	09-06-21	2,11,750.00	14,67,000	14,39,000	2503 - 0884
04-07-21	9,000	2		167 Loads	14,49,000	14,31,000	7872 - 7503
05-07-21	9,000	2			14,31,000	14,13,000	7526 - 3236
06-07-21	9,000	2			14,13,000	13,95,000	4633 - 7428
07-07-21	9,000	2			13,95,000	13,77,000	7623 - 4651
08-07-21	9,000	2			13,77,000	13,59,000	3236 - 7498
09-07-21	9,000	2			13,59,000	13,41,000	7557 - 5325
10-07-21	9,000	2			13,41,000	13,23,000	7872 - 0884
11-07-21	9,000	2			13,23,000	13,05,000	2503 - 7422
12-07-21	9,000	2			13,05,000	12,87,000	6802 - 2984
13-07-21	9,000	2			12,87,000	12,69,000	4633 - 7526
14-07-21	9,000	2			12,69,000	12,51,000	7428 - 7503
15-07-21	9,000	2			12,51,000	12,33,000	4651 - 7498
16-07-21	9,000	2			12,33,000	12,15,000	7623 - 7557
17-07-21	9,000	2			12,15,000	11,97,000	2503 - 0884
18-07-21	9,000	2			11,97,000	11,79,000	5325 - 7872
19-07-21	9,000	2			11,79,000	11,61,000	7422 - 3236
20-07-21	9,000	2			11,61,000	11,43,000	6802 - 7526
21-07-21	9,000	2			11,43,000	11,25,000	7623 - 2984
22-07-21	9,000	2			11,25,000	11,07,000	7498 - 4633
23-07-21	9,000	2			11,07,000	10,89,000	4651 - 7557
24-07-21	9,000	2			10,89,000	10,71,000	7428 - 2503
25-07-21	9,000	2			10,71,000	10,53,000	0884 - 7422
26-07-21	9,000	2			10,53,000	10,35,000	5325 - 2503
27-07-21	9,000	2			10,35,000	10,17,000	7872 - 2984
28-07-21	9,000	2			10,17,000	9,99,000	4651 - 7526
29-07-21	9,000	2			9,99,000	9,81,000	6802 - 3236
30-07-21	9,000	2			9,81,000	9,63,000	7503 - 4633
31-07-21	9,000	2			9,63,000	9,45,000	7498 - 7623
Total	5,58,000	62			Bal	9,45,000 (105 Trips)	

M.W.Siy. பட்டை நகர்
 பட்டை நகர் பரிகாரத்துக்குப் பின்பு
 பட்டை நகர் - 31

Mobile water supply To Varadharajaperumal Koil Street (Bharat Petroleum)

From Patel Nagar filling point

May - 2021 - Rs.1,050/- for 9000 Lts.

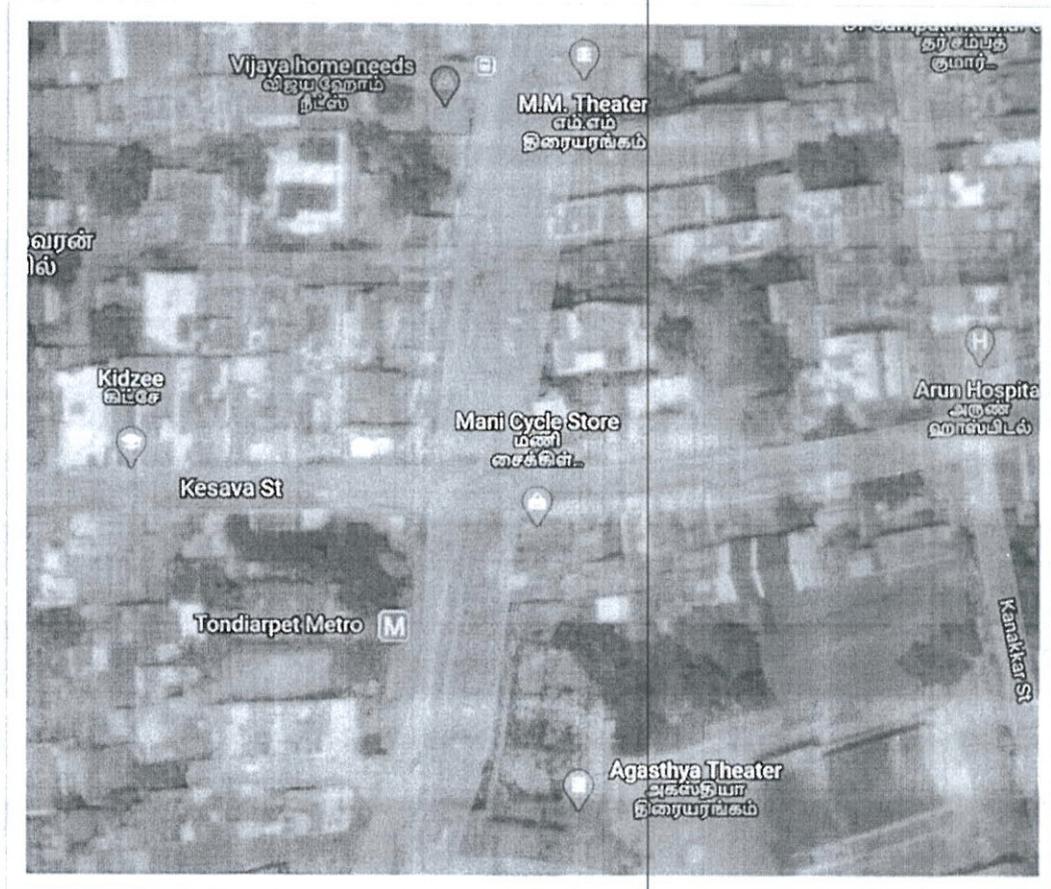
Date	Quantity in Lts.	No. of Trips	Ref. No. & Date	Amount	Opening Balance in Lts.	Closing Balance in Lts.	Vehicle Reg. No. (9 Kl.)
01-05-21	9,000	2	20204018364	3,00,000.00	7,92,000	7,74,000	7872 - 7503
02-05-21	9,000	2	20204018365	300.00	7,74,000	7,56,000	7422 - 2894
03-05-21	9,000	2	20-01-21	3,00,300.00	7,56,000	7,38,000	7557 - 5325
04-05-21	9,000	2		88 Loads	7,38,000	7,20,000	6802 - 7428
05-05-21	9,000	2			7,20,000	7,02,000	0448 - 4651
06-05-21	9,000	2			7,02,000	6,84,000	7498 - 3236
07-05-21	9,000	2			6,84,000	6,66,000	7526 - 4633
08-05-21	9,000	2			6,66,000	6,48,000	2503 - 7872
09-05-21	9,000	2			6,48,000	6,30,000	2984 - 7623
10-05-21	9,000	2			6,30,000	6,12,000	5325 - 7428
11-05-21	9,000	2			6,12,000	5,94,000	7557 - 0884
12-05-21	9,000	2			5,94,000	5,76,000	7422 - 6802
13-05-21	9,000	2			5,76,000	5,58,000	7498 - 4651
14-05-21	9,000	2			5,58,000	5,40,000	7503 - 3236
15-05-21	9,000	2			5,40,000	5,22,000	4651 - 7623
16-05-21	9,000	2			5,22,000	5,04,000	7526 - 2503
17-05-21	9,000	2			5,04,000	4,86,000	4651 - 7872
18-05-21	9,000	2			4,86,000	4,68,000	5325 - 2984
19-05-21	9,000	2			4,68,000	4,50,000	0884 - 7428
20-05-21	9,000	2			4,50,000	4,32,000	6802 - 7557
21-05-21	9,000	2			4,32,000	4,14,000	7503 - 7422
22-05-21	9,000	2			4,14,000	3,96,000	3236 - 4633
23-05-21	9,000	2			3,96,000	3,78,000	7623 - 7498
24-05-21	9,000	2			3,78,000	3,60,000	2503 - 7526
25-05-21	9,000	2			3,60,000	3,42,000	7872 - 0884
26-05-21	9,000	2			3,42,000	3,24,000	2984 - 7428
27-05-21	9,000	2			3,24,000	3,06,000	5325 - 6802
28-05-21	9,000	2			3,06,000	2,88,000	7422 - 7557
29-05-21	9,000	2			2,88,000	2,70,000	4651 - 7503
30-05-21	9,000	2			2,70,000	2,52,000	4633 - 3236
31-05-21	9,000	2			2,52,000	2,34,000	7498 - 7623
Total	5,58,000	62			Bal	2,34,000 (26 Trips)	

10-08-21
M.W.Sly.

பட்டினத்தாருக்குப் தயவுசெய்து
பதிலிடுவதற்காக.

DETAILED SITE ASSESSMENT REPORT POST CMRL EXCAVATION - 2021

At
Petroleum Contaminated Site, V.P Koil Street - T.H Main Road,
Tondiarpet, Chennai, Tamil Nadu



Prepared on

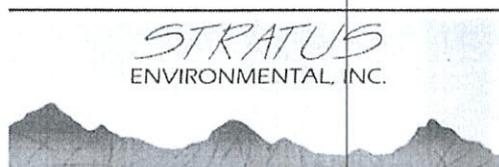
15 April 2021

Prepared for

Bharat Petroleum Corporation Limited
Chennai – 600 081.

Tender No. BPCL/TMP/02/2014-2015

Prepared by



Stratus Project No. 400-01-01

13



2 B Sulochana Terrace
81 First Main Road
Gandhi Nagar, Adyar,
Chennai - 600020
Phone: 044-48547879

15 April 2021
Project No. 400-001-001

Mr. Rajesh Kumbhare
DGM – OPS I/c, Retail South
Bharat Petroleum Corporation Limited
Chennai

Subject: Detailed Site Assessment Report Post Chennai Metro Rail Limited (CMRL) Excavation 2021 at Bharat Petroleum Corporation Limited (V.P Koil Street- T.H Main Road) Petroleum Contaminated Site, Tondiarpet, Chennai, Tamil Nadu.

Respected Sir,

Stratus Environmental Inc. (Stratus) has prepared a Detailed Project Report (DPR) to present findings of the site assessment conducted, at the Bharat Petroleum Corporation Limited (V.P Koil Street- T.H Main Road) Petroleum Contaminated Site in Tondiarpet, Chennai. The objective of this report was to collect confirmation soil samples to quantify the residual petroleum hydrocarbon in soil and groundwater post remediation and CMRL excavation activity.

This report contains details associated with site geology, hydrogeology, and reassessment the lateral extent of hydrocarbon impact to soil and groundwater. It includes results of the geological site investigation, laboratory reports, conclusions & recommendations.

If you have any questions regarding this report, please contact by telephone at +91-9840615603 or by email at GKowtha@stratusinc.net

Submitted,

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Executive Summary

Stratus Environmental, Inc. (Stratus), conducted an environmental site investigation to reassess the extent of petroleum hydrocarbon impact to soil and groundwater, at the Bharat Petroleum Corporation Limited (V.P Koil Street – T.H Main Road) Petroleum Contaminated Site, Tondiarpet, Chennai, Tamil Nadu (See Figure 1).

In order to reassess the extent of hydrocarbon contamination at the petroleum contaminated site,

- Stratus prepared and submitted a Work Plan (dated 18 September 2020) proposing a detailed scope of work to be completed. This work plan was subsequently approved by Central Pollution Control Board (CPCB) and TNPCB.
- Stratus advanced three soil borings (3) and seven monitoring wells (7) at strategic locations adjacent/near to existing monitoring wells (see Figure 2). Well construction details are presented in Table 1.
- Undisturbed, depth specific soil samples were collected and analyzed in a NABL certified laboratory. In addition, PID readings from soil samples were recorded onsite.
- Soil samples were collected every 5 feet using a split spoon sampler to develop a detailed understanding of the local geologic conditions.
- Surveyed elevations of each well casing, to update the site map.
- The newly installed wells were developed. Groundwater samples were collected from the existing and newly installed monitoring wells at the petroleum contaminated site and forwarded to NABL certified laboratory.

Subsurface Geologic Conditions

Overall, the geology at the locations investigated in the petroleum contaminated site, were similar to the 2015 investigation. Native materials encountered during drilling, consisted of poorly graded sand to well graded sand ranging from surface to 30 and 44 feet below ground surface (bgs). This sandy stratum appeared to be laterally continuous across the study area. Groundwater was first encountered within this sandy stratum. All shallow-screened groundwater monitoring wells are installed within this sandy stratum. In the deeper well borings, the sandy stratum was observed to overlay a relatively thick fine-grained unit consisting predominantly of clay. This clayey stratum also appears to be laterally continuous across the study area. The clayey stratum overlies a second sandy, water-bearing stratum. The deep-screened groundwater monitoring wells are installed within this second sandy stratum. Bedrock was encountered in one of the deep well's borings at depths 78 and 80 feet below ground surface (bgs). The deeper sandy stratum also appears to extend laterally across the study area.

Groundwater Flow

Groundwater flow in the upper water bearing zone, during 1st quarter 2021, (see Table 2) was towards the south southeast, with calculated hydraulic gradients at 0.023 ft/ft, and towards the Bay of Bengal, consistent with historical flow measurements. Depth to water (DTW) in the shallow-screened wells was measured between 16.21 and 39.70 feet bgs (-1.70 to -23.29 meters below mean sea level [MSL]).

DTW in the deep-screened wells was measured between 24.51 and 54.13 feet bgs (-5.61 to -37.63 meters below mean sea level [MSL]). Within the deep-screened monitoring wells, groundwater flow was predominantly towards east, with calculated hydraulic gradients at 0.43 ft/ft, consistent with historical flow measurements.

Depth to water measurements in adjacent pairs of deep and shallow-screened monitoring wells indicated the presence of downward vertical flow gradients, with relatively high flow gradients ranging from 0.023 ft/ft to 0.43 ft/ft, again suggestive of groundwater pumping in the site vicinity.

Soil Analytical Data

- Low concentrations of Diesel Range Organics (DRO) were reported in almost all samples analyzed, the detected concentrations are in the range of 0.08 mg/kg - 144.61 mg/kg.
- Gasoline Range Organics (GRO) were not detected in majority of the samples analyzed. Low concentrations were reported at few locations, ranging from 0.02 mg/kg to 4.49 mg/kg (See Table 3).
- Low concentrations of Total Petroleum Hydrocarbon (TPH) was reported in almost all samples analyzed, the detected concentrations ranged from 0.08 mg/kg to 153.83 mg/kg.
- Benzene and naphthalene were not reported in any of the soil samples analyzed.
- Toluene, ethylbenzene and xylenes were not reported in any of the soil samples analyzed.
- The DRO & TPH Concentrations detected in soil samples collected in February 2021 are significantly lower, compared to the concentrations recorded in 2015 site assessment.

Shallow Zone Groundwater Analytical Data

- DRO was not detected in majority of the shallow screened monitoring wells. Low concentrations were reported at few wells ranging from 0.08 mg/L to 0.66 mg/L at MW-25A and MW-26A respectively which are adjacent to abounded wells MW-17A & MW-12A.
- TPH was not detected in majority of the shallow screened monitoring wells. Low concentrations were reported at few wells ranging from 0.08 mg/L to 0.66 mg/L at MW-25A and MW-26A respectively.
- Benzene and naphthalene were not reported in any of the groundwater samples analyzed. Xylenes were only reported in MW-2A with concentration of 76.50 mg/L.
- The DRO & TPH Concentrations detected in groundwater samples collected from the existing shallow screened wells and newly installed wells adjacent to the abounded wells in March 2021 are significantly lower, compared to the DRO & TPH concentrations recorded in 2015 site assessment.
- Polycyclic Aromatic hydrocarbons (PAH) were not detected in any of the ground water samples analyzed.

Deep Zone Groundwater Analytical Data

- DRO was not detected in majority of the shallow screened monitoring wells. Low concentrations were reported at few wells ranging from 0.10 mg/L to 0.35 mg/L at MW-26B and MW-3B, respectively (See Table 4).
- TPH was not detected in majority of the shallow screened monitoring wells. Low concentrations were reported at few wells ranging from 0.10 mg/L to 0.35 mg/L at MW-26B and MW-3B, respectively.
- Benzene and naphthalene were not reported in any of the groundwater samples analyzed. Xylenes were only reported in MW-3B with concentration of 22.97 mg/L.
- The DRO & TPH Concentrations detected in groundwater samples collected from the existing deep screened wells and newly installed wells adjacent to the abounded wells in March 2021 are significantly lower, compared to the DRO & TPH concentrations recorded in 2015 site assessment.
- Polycyclic Aromatic hydrocarbons (PAH) were not detected in any of the ground water samples analyzed.

Free Product

Free product was not observed or identified in any of the existing or newly installed monitoring wells and borings during the assessment. Free product removed through adsorbent socks was calculated an amount of 80.0 Liters (69093.0 Grams) from the petroleum contaminated site (See Appendix -G).

Residual Hydrocarbon Mass

- Based on the laboratory analytical data and TPH Iso concentration contour maps of Soil [0'-50'] feet bgs (See Figure 10 to 14), the lateral extent of petroleum hydrocarbon impact to soil was calculated.
- Approximately, **1053.93 kg** of residual TPH is estimated to be present in soil (See Table 8), in comparison to estimated mass of 32,797.61 kg of TPH in 2015 (See Appendix -E).
- Based on the Groundwater analytical data and TPH Iso concentration contour maps of groundwater in shallow and deep screened wells (See Figure 19 & 20) the lateral extent and impact of petroleum hydrocarbon impact to groundwater was calculated.
- Residual mass in groundwater is estimated to be approximately 2.11 kg (See Table 9), in March 2021, compared to 1,380.97 kg of TPH estimated in 2015 (See Appendix -E).

Mass Balance Summary

Below table summarize the total mass estimated in 2015 assessment with SVE mass removal till February 2021 and the remaining mass present at site in 2021 (See Table 10).

<i>Initial Mass (Kg)</i>	<i>Mass Removed by SVE (Kg)</i>	<i>Mass Removed by Socks (Kg)</i>	<i>Mass Removed by CMRL (Kg)</i>	<i>Mass Removed but not accounted by SVE calculation (Kg)</i>	<i>Mass Remaining (Kg)</i>
<i>34,178.57</i>	<i>16,739.31</i>	<i>69.093</i>	<i>12,595.162</i>	<i>3,718.692</i>	<i>1056.043</i>

Conclusions and Recommendations

- Significant reduction in soil and groundwater concentrations is being observed due to remedial efforts and natural attenuation factors.
- Residual mass continues to be present in the 25 to 35 feet bgs interval that warrants additional remediation (See Figure 3 to 4).
- Although only low concentrations of petroleum hydrocarbons are being reported in groundwater samples, Stratus does not yet, recommend use of groundwater in private bore wells.
 - Given the observation of relatively higher concentrations of DRO and TPH observed between 25 and 35 feet bgs at a few locations, we recommend continued SVE systems to reduce concentration of petroleum hydrocarbons in soil for a period of 6 months.
- We also recommend the continued operation of the air sparge system located at SVE Unit -2. In addition, Stratus recommends operation of a second air sparge system at SVE Unit-1 and connecting the second AS system to wells AS-3a and SVE-8.
- We recommend connecting newly installed wells 26A, located in the alley, and MW-25A, located in Devi Polymer property to the SVE-2, and SVE-1 respectively.

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SITE DESCRIPTION

Petroleum pipelines that transport refined petroleum products are located beneath the streets in Tondiarpet, Chennai. One such pipeline leaked petroleum products in 2012 at the junction of TH Road and VPK Street, Tondiarpet, Chennai (the Site, see Figure 1 and 2). The neighborhood surrounding the release is densely developed, with both residential and commercial uses. Petroleum odors and/or free phase petroleum (free product) were reported in some domestic water wells, and dissolved petroleum compounds have been reported in water samples from beneath the site. In 2015, Stratus Environmental conducted a detailed study of the lateral and vertical extent of contamination at the site and submitted a Detail Site Investigation Report (DPR) dated 21 October 2015.

SITE BACKGROUND

The following presents a summary of environmental activities completed to date and information pertinent to the environmental issues associated with the site.

- Residents of the neighborhood, near the intersection of TH Road and VPK Street, began observing the presence of petroleum products in groundwater recovered from wells (bore wells) used as a local water supply in October 2012.
- BPCL subsequently retained the services of the Indian Institute of Technology – Madras (IITM) to perform an initial evaluation of the extent of a petroleum release to the subsurface.
- IITM completed 20 exploratory soil borings (exploratory bore wells) to a depth of approximately 30 feet below ground surface (bgs) using manual-augering techniques. An electrical resistivity tomography survey was also performed. IITM assessed the extent of free product in the local water supply bore wells. IITM prepared a report documenting the baseline findings of site conditions.
- BPCL initiated recovery of free product in the domestic bore wells and continued these activities through February 2015. Approximately 6,947 liters of free product and 7,141 liters of free product/water mixture were recovered from the subsurface as of February 2015. Stratus initiated Free product recovery in February 2015. Product recovery information performed by Stratus personnel between February 2015 and September 2017 is included in Appendix-G.
- In May 2015, Stratus mobilized a hollow-stem auger drilling rig to India. Between May 2015 and September 2015, twenty-seven (27) groundwater monitoring wells and 18 (9-SVE, 9-AS) remediation wells were installed. In compliance with CPCB directives, Stratus installed 5 additional (three shallow and two deep) ground water monitoring wells during September 2016. In all 32 groundwater monitoring wells were installed to characterize the lateral and vertical extent of contamination (Site Plan - Shallow Screened Wells, Deep Screened Wells, Soil Vapor Extraction Wells and Air Sparge Wells, see Figure 2).
- Soil samples were collected during environmental drilling activities to assess geological conditions and for analytical testing. The soil samples confirmed that both diesel and gasoline – related fuels were released to the subsurface, but that

most contaminant mass was in the diesel range. Using the 2015 soil analytical data, Stratus estimated that approximately 29,952 kilograms (65,894 pounds) of diesel range organics (DRO) to be present in soil within upper 50ft bgs, and approximately 2,845 kilograms (6,259 pounds) of gasoline range organics (GRO) to be present in soil within upper 50 feet bgs.

- Sand was encountered in the shallow subsurface at depths ranging from surface about 30 to 44 feet bgs. A laterally continuous interval of clay and silt, ranging in thickness from about 15 to 50 feet, was observed below the shallow sand. Additional sand interval, containing significant interstitial fines, was observed below the clay/silt stratum. Twenty-two groundwater monitoring wells (MW-1A through MW-20A, MW-22A and MW-23A) are screened within the shallow sand strata and ten groundwater monitoring wells (MW-1B, MW-3B, MW-5B, MW-7B, MW-10B, MW-11B, MW-16B, MW-17B, MW-20B and MW-23B) are screened within the deeper sand strata which recommend SV/AS to be the effective remedial alternative.
- Stratus prepared and submitted a Corrective Action Plan (CAP) dated February 10, 2016, recommending soil vapor extraction (SVE) and Air Sparging (AS) as the most effective remedial alternative. In accordance with the CAP, subsurface conveyance piping was connected to the remediation well heads, and the piping was routed back to a centralized location where a Soil Vapour Extraction (SVE) system was installed. After connecting the SVE system to local utility services, remediation was started for continuous operation on May 20, 2016.
- In 2016, Chennai Metro Rail Limited (CMRL) started their construction activity for building a metro railway network involving a combination of above ground and below ground railway track.
- The CMRL construction encroached a portion of the contaminated area of the Site. Meetings were held between CMRL and BPCL to better understand the nature and extent of excavation associated with their construction and its impact on the contaminated site.
- In 2017, Stratus observed that construction activity by CMRL has compromised the remediation pipeline network. Due to construction activity by CMRL, a few of the remediation wells were abandoned (MW-17A, SVE-2, SVE-3, SVE-10, AS-1, AS-3, AS-8 and AS-10) and connectivity to SVE system was disrupted.
- In view of the above, a need arose to relocate the SVE system. Based on meetings with CMRL engineers and their consultant (Systra), Stratus proposed alternate piping layout plan on 26 October 2016 and 19th January 2017. In an onsite meeting between BPCL, Stratus and CMRL on 21 August 2018, CMRL proposed and identified a new location for the SVE system. Stratus initiated the SVE unit relocation work on 9th September 2018 and restarted the SVE unit operations in the new location from 27th October 2018.
- In 2018, CMRL began excavating in and around the contaminated area. All activities associated with CMRL excavation and construction were documented on field data sheets. Stratus site engineer collected soil samples from the excavated soil stockpiles, and recorded PID readings to evaluate for the presence of petroleum hydrocarbons, prior to disposal of the stockpiled soil.

- Cumulatively, during the period from 24th February 2018, to 31st December, 2019 approximately 34,064.80 cubic meters (m³) of soil was excavated from the contaminated site along T.H main road between M.M Theater and junction of V.P.K Street-T.H main road, and it is our understanding that the excavated soil was transported to Tiruneermalai and Cut & Cover- Area 2, Nandanam, Chennai.
- Stratus imported and installed a second SVE system in February 2020. System was started for continuous operation on June 2020. Connection to wells, MW-2A, SVE-1, 11, and SVE-12 were rerouted and connected to the SVE System-2.
- The SVE -1 and SVE-2 units have been very effective in extracting petroleum hydrocarbon vapors from the subsurface. SVE-1 and SVE-2 units have extracted approx. 14,979.31 Kilograms & 1,760.27 Kilograms respectively as of February 2021 (see Table 5 & 6).
- A total of 69.09 Kilograms (80 liters) of free product has been removed by the absorbent socks as of February 2020 (see Appendix-G).
- A Mass Balance Summary of the Total Petroleum hydrocarbon (TPH) is evaluated using the lab analytical data, accounting the total hydrocarbon mass removed by SVE 1 & 2, Absorbent socks, CMRL activity in contaminated zone and unaccounted TPH mass removed by SVE systems during the high slug movement into treatment system have been estimated for the period 2015 to 2021 (see Table 10).

2021 SITE ASSESSMENT

Stratus prepared and submitted a workplan for the reassessment activity on 18th September 2020. This workplan was approved by CPCB on 21st October 2020 and TNPCB on 14th December 2020. The objectives of the site assessment work undertaken were:

- Reassess the residual extent of petroleum hydrocarbon contamination to soil and groundwater beneath the site.
- Reinstall monitoring bore wells (replacement of wells lost due to CMRL activity) to evaluate the lateral extent of impact to groundwater.

To accomplish these objectives, Stratus implemented the following work activities:

- Advanced three (3) exploratory borings (ASB-1, B-2 & B-3) using 8-inch diameter hollow stem augers at the strategic locations adjacent to existing monitoring wells.
- Completed the installation of five, 2-inch diameter shallow screened groundwater monitoring wells (MW-25A, MW-26A, MW-27A, MW-28A & MW-30A) to depths ranging from 25-35 feet bgs.
- Completed the installation of two, 2-inch diameter deep screened groundwater monitoring wells (MW-25B & MW-26B) to depths ranging from 65-75 feet bgs using hollow stem auger.
- Collected soil samples at 5-foot intervals during the advancement of monitoring wells and borings and forwarded the samples to NABL certified laboratory for chemical analysis for concentration comparison.
- Developed and surveyed each of the newly installed monitoring well.
- Purged and collected groundwater samples from each monitoring well and forwarded them to the laboratory for the analysis.
- Segregated all waste material in drums, (drill cuttings and purge water) for disposal.
- A total of 56 soil samples, 22 groundwater samples and 1 trip blank, were forwarded to the laboratory for the analysis.

Pre-Field Activities

Stratus used a state-of-the-art Hollow Stem Auger Drilling Rig imported from USA to conduct the assessment. Hollow-stem auger drilling (HSA) is the international standard for characterizing hydrogeologic conditions and installing monitoring wells at environmental investigation sites. Soil sampling and well construction are performed without removing the augers from the boring, preventing cross-contamination and borehole collapse. Undisturbed soil samples are collected ahead of the augers using a split-spoon sampler. Specific intervals or the entire boring can be sampled continuously to identify exact depths of potential migration pathways, confining layers, critical stratigraphic changes, or contaminated intervals. Keeping the augers in the boring prevents vertical migration of contaminated soil and groundwater to deeper soils.

Prior to initiating the drilling, the following tasks were performed:

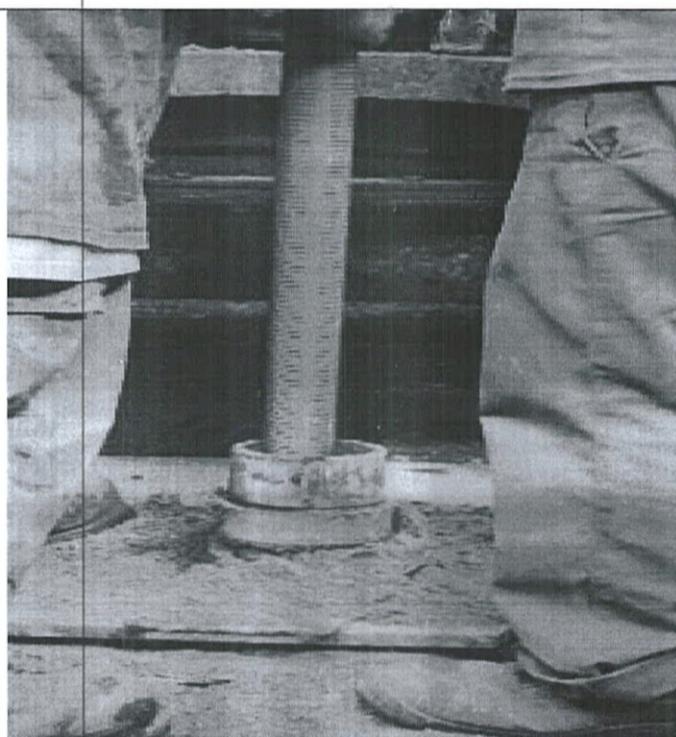
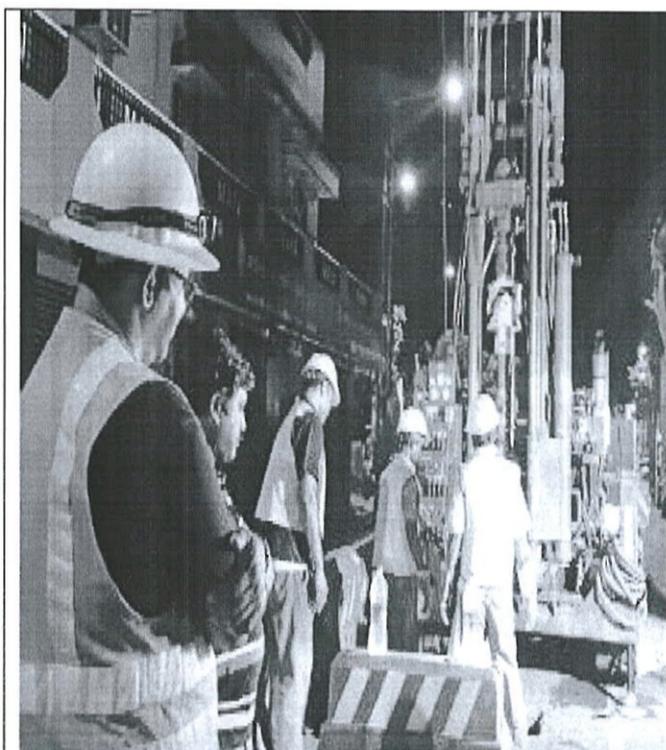
- Prepared a detailed health and safety plan.
- Visited site to find the suitable locations with accessibility and adjacent to existing monitoring wells.
- Conducted negotiations with private property owners to obtain any access agreements needed to conduct drilling work.
- Obtain permits (Chennai Corporation and Traffic Police North Chennai, Chennai Metro Rail Limited and Private property owners), as necessary, to install the wells at locations shown on Figure 2.
- Mobilize drilling equipment to the site.
- Identified the locations of underground utility corridors near the work areas.
- Provide work notifications to appropriate parties, as necessary.
- Conducted pre-drilling site safety meeting.
- Procured materials necessary to construct the monitoring wells.

Field Activities

Soil Borings Installation

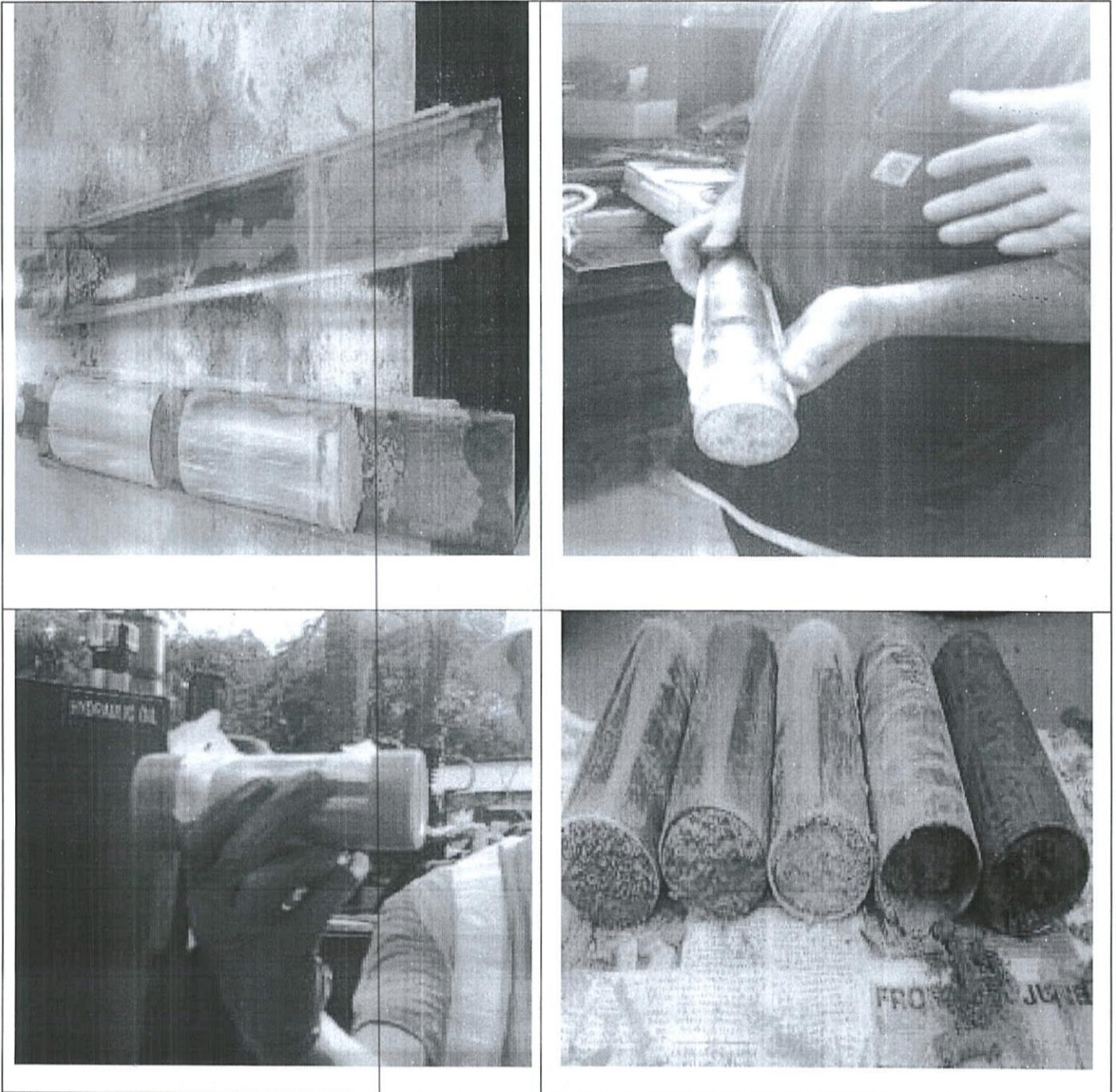
Stratus personnel utilized a hollow stem auger drilling rig to complete the environmental drilling, soil sampling, and well construction work between 19th and 28th February 2021. The upper portion of each borehole (up to 4 feet) was advanced using hand tools in order to reduce the possibility of damaging underground utilities during drilling work. After clearing the shallow subsurface, each borehole was advanced using 8-inch diameter hollow stem augers. After advancement to the required depth, some of the borings were converted to a groundwater monitoring wells. Soil samples collected from borings ASB-1, B-2, B-3, MW-25AB, MW-26AB, MW-27A, MW-28A and MW-30A. A general description of field practices and procedures employed by Stratus personnel is provided in Appendix-A. Boring logs and well construction details are included in Appendix-B.

Soil samples were collected at 5-foot interval range at each identified location, using a California modified split spoon sampler equipped with three six-inch length by 2-inch diameter stainless steel liners. A 140-pound slide hammer was used to drive the sampler into native soil immediately below the bottom-most hollow stem auger. The bottom-most intact sleeve of soil was capped, sealed, and stored in an ice-chilled container bag until delivery to the laboratory (see the chain of custody - COC attached in Appendix D). The remaining soil sample was used for lithologic classification and the soil was designated using the Unified Soil Classification System. The bore log description prepared in the field, included particle size distribution, soil colour referenced to a Munsell soil colour chart, moisture content, etc., along with other pertinent geologic information and drilling observations. PID readings were measured in each soil sample collected, using Mini RAE 3000 and the readings were recorded in the boring logs (see Appendix-B).



Drilling Operations and Well Construction

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Collection of Depth Specific Undisturbed Soil Samples using Split Spoon

Monitoring Wells Installation

Monitoring bore wells MW-25A, MW-25B, MW-26A, MW-26B MW-27A, MW-28A and MW-30A were installed through the hollow stem augers using 2-inch diameter PVC well casing fitted with 10 to 20 feet of well screen (1.0-millimeter machine slots). The wells were installed with a longer well screen in order to accommodate anticipated fluctuations in groundwater levels influenced by seasonal climatic conditions. A sand filter pack consisting of Indian Standard Sand Grade I (1 to 2 mm) was placed in the annular space around each well screen from the bottom of the borehole up to approximately 2 feet above the top of the screen. Bentonite chips were placed on top of the filter pack, hydrated with clean water, to provide a transition seal for the well. Neat

cement was subsequently used to backfill the remaining annular space around the well casing. A watertight cap was placed over the top of the well casing, and a vault box was installed around the top of the well.

Well Development

Stratus developed all monitoring wells (MW-25A, MW-25B, MW-26A, MW-26B MW-27A, MW-28A and MW-30A) installed at the petroleum contaminated site on 26th and 27th February 2021. Prior to development, the depth to groundwater (DTW), depth to product (DTP) and total depth of well were measured using an electronic water level sounder. The wells were also checked for the presence of floating product using a disposable plastic bailer. The data was recorded on field data sheets (Appendix-C). Well development consisted of aggressively surging the well with new and clean PVC biodegradable bailers. Bailing was continued until the extracted water was free of visual suspended sediment. Approximately 20 to 22 well casing volumes were evacuated from the wells during development.

Groundwater Monitoring and Sampling Event

The newly installed groundwater monitoring wells were gauged on 3rd March 2021. The groundwater sampling of the existing and newly installed wells was executed on 27th March 2021. Prior to sampling, the depth to groundwater was measured in all wells using an electronic water level sounder; these data were recorded in field data sheets (Appendix- C). Water level data were used to calculate the appropriate volume of groundwater in the monitoring wells. Prior to sampling purging was done at each well (three well casing volumes). Once the required volume of water was purged from each well, using a new plastic bailer, the water sample was collected in laboratory supplied containers. The sampling procedure is recorded in field data sheets (See Appendix-C) The sample containers were subsequently labelled and stored in ice-chilled containers until delivery to a NABL certified laboratory.

Surveying

A licensed surveyor was retained to survey the elevations and locations of each monitoring well on 4th March 2021. The survey results were tied to the previous survey work performed at the site. Well casing elevations are summarized in surveyor report and it is included in Appendix-B.

LABORATORY ANALYSIS

A total of 56 soil samples, 22 groundwater samples and 1 trip blank were collected and delivered to NABL accredited Lab (HECS and Glens Laboratory), for the analysis with strict chain of custody (See Appendix-D). All the samples were analyzed for specific petroleum hydrocarbon components by Glens laboratory. Samples were analyzed for:

- Polycyclic Aromatic Halocarbons (PAHs) by GC MS MS-HECS/INS/SOP/072 Method,

- Volatile Organic Compounds, Gasoline-Range Organics (GRO), Total Organic Compounds (TOC) and Benzene, toluene, ethylbenzene, and xylenes (BTEX) by GC MS-HECS/INS/SOP/73,
- Diesel-Range Organics (DRO) and Total Petroleum Hydrocarbon (TPH) by GC MS-HECS/INS/SOP/080.
- Mineral Oil (MO) by FTIR Method HECS/INS/SOP/069,
- Oil and Grease (O&G) by In House Method.

Soil Analytical data of these samples received from HECS Lab are tabulated in Table 3, Groundwater Analytical data of these water samples are tabulated in Table 4. (also see Figures 5-14, 16-20). The copies of HECS and Glens Laboratory reports and chain of custody documents (COC) are incorporated in Appendix-D.

Decontamination of Equipment

Soil Sampling Equipment

Stainless steel tubes employed to line the split spoon sampler were washed with detergent solution (Alconox), then rinsed with potable water prior to use. The split spoon sampler is washed after each use in a similar manner. The tape measure is similarly washed and rinsed after each well is installed.

Drilling Equipment

The pump on the drill rig was used to clean residual soil from the augers after each well boring was completed and the well is constructed. The augers were then washed with a detergent solution (Alconox), and then rinsed with potable water.

Groundwater Sampling Equipment

Bailers were not cleaned or reused. Stratus uses only clean, disposable bailers for well development and sampling. These bailers are disposed after each well.

Waste Management

Drill cuttings were temporarily placed in drum and covered by plastic sheet at the BPCL facility for proper disposal after the identification of contaminants present at the locations.

SITE GEOLOGY AND HYDROGEOLOGY

Lithologic Observations

Subsurface lithologic relationships are illustrated in Cross-Sections A-A' and B-B' (Figure 3 and 4, respectively). Below the pavement, road base, and backfill materials covering the ground surface, native materials encountered during drilling consisted of poorly graded sand to well graded sand depths ranging from surface to 30 and 44 feet bgs. Fine gravel (up to 10% fines) was observed in some boings. The sandy stratum was remarkably homogeneous across the study area. The poorly graded (well sorted) nature of the sand, and the lack of interstitial fines, indicates this sand stratum was likely

deposited in an energetic sub-littoral to supra-littoral marine environment, similar to a modern beach environment. First encountered groundwater was observed at approximately 20 feet bgs. Historical groundwater elevations in shallow monitoring wells have ranged from as shallow as 11.2 feet bgs to as deep as 35 feet bgs creating a rather large smear zone.

In the deeper well borings, the sandy stratum was observed to overlay a relatively thick fine-grained unit consisting predominantly of clay. This clayey stratum appears to be laterally continuous across the study area with the thickness ranging from 10 to 40 feet bgs. Some samples exhibited behavior that indicated up to 10% silt was present. This unit appeared to be saturated near the top and bottom, but middle portion of the unit did not appear to be completely saturated. Total depth of the investigation was 97 feet bgs. Below the clayey stratus, a latterly continuous well graded saturated sandy formation was observed with the thickness of 10 to 15 feet. Bottom of this sandy layer was in laid over the weathered rock surface.

Field Observations during Soil Borings

During the advancement of Soil Boring (ASB-1) at the junction of V.P.K Street -T.H road located at the vicinity of the source of petroleum leak, significant petroleum hydrocarbon odors were observed between 25 feet bgs and 35 feet bgs, in the soil samples (collected through split spoon sampler). A PID reading of 15,000 ppm at 25 feet bgs, was recorded. During the advancement of monitoring well (MW-25A/B), the highest recorded PID reading of 210 ppm. During the advancement of soil boring (B-2), a maximum PID reading of 55 ppm was measured at 25 feet bgs. Similarly, during the advancement of monitoring wells MW-26A & MW-26B, with PID readings of 229 ppm at 30 feet bgs, and 280 ppm at 30 feet bgs, measured respectively.

Site Hydrogeology

Depth to water (DTW) in the monitoring well network was measured on 27 March 2021. DTW measurements are included on the field data sheets (Appendix-C), and have been summarized in Table 2. Well depths and screen intervals are summarized in Table 1. Free product was not observed or identified in any of the existing or newly installed monitoring wells and borings during the assessment. Over all the newly installed did not change the understanding of the regional groundwater flow direction or gradient.

On 27 March 2021, DTW in the shallow-screened wells was measured between 16.21 and 39.70 feet bgs (-1.70 to -23.29 meters below mean sea level [MSL]). These groundwater data were normalized to MSL, and then used to construct a groundwater flow elevation map (See Figure 15). Within the shallow-screened monitoring wells, groundwater flow was predominantly towards east and southeast, with calculated hydraulic gradients ranging from 0.005 to 0.023 ft/ft. Groundwater flow to the east was observed to be at a gradient of 0.005 ft/ft, but a component of flow to the south was observed to be at a gradient of 0.023 ft/ft.

On 27 March 2021, DTW in the deep-screened wells was measured between 24.51 and 54.13 feet Bgs (-5.61 to -37.63 meters below mean sea level [MSL]). These groundwater data were normalized to MSL, and then used to construct a groundwater

flow elevation map (See Figure 16). Within the deep-screened monitoring wells, groundwater flow was predominantly towards east, with calculated hydraulic gradients at 0.43 ft/ft.

Extent of Petroleum Hydrocarbon Impact

Soil Analytical Results

Soil analytical data is summarized in Tables 3. Soil analytical data of DRO and TPH are plotted on a series of Iso-concentration contour maps [0'-10', 10'-20', 20'-30', 30'-40', 40'-50'] feet bgs that are used to illustrate the lateral extent of DRO, TPH concentrations (see Figure 6 to 14). In addition, based on the highest concentration of TPH in each boring, Stratus plotted an extent of impact to soil iso concentration contour (see Figure 14A). The lateral extent of impact to soil appears to be adequately characterized, with the exception of the Suhas Eye Hospital property. High concentrations of petroleum hydrocarbons were observed in soil samples collected from MW-3a, and we were unable to verify the reduction in petroleum hydrocarbons in soil on this property.

Soil analytical data are discussed below.

- Low concentrations of DRO was reported in almost all samples analyzed, the detected concentrations ranged from 0.08 mg/kg to 144.61 mg/kg.
- The highest concentrations of DRO was reported in soil samples collected between 30 to 35 feet bgs. in MW-25AB (144.61 mg/kg) located in the Devi polymer property, and MW-26A (74.04 mg/kg) located in the alley south of Mani Cycle shop.
- GRO was not detected in majority of the soil samples collected. Low concentrations were reported at few locations ranged from 0.02 mg/kg to 4.49 mg/kg. The highest concentration of GRO was reported in soil samples collected between 30 to 31.5 feet bgs in MW-25AB (4.49 mg/kg).
- Low concentrations of TPH were reported in almost all samples analyzed, the detected concentrations are in the range of 0.08 mg/kg - 153.83 mg/kg.
- High concentrations of TPH were reported in soil samples collected between 35-36.5 feet bgs in MW-26A (153.83 mg/kg.) located near SVE-3, 10-11.5 feet bgs in Boring-2 (25.09 mg/kg) located near MW-16AB in Devi polymerproperty, and in ASB-1 (23.02 mg/kg) & (50.58 mg/kg) located near MW-1AB on V.P.K Street.
- Benzene and naphthalene were not reported in any of the soil samples analyzed.
- Toluene, ethylbenzene and xylenes were not reported in any of the soil samples analyzed.
- PAHs were not reported in any of the soil samples analyzed.
- The Soil analytical results indicate that all soil samples have TPH concentrations lesser than 5000 mg/kg, which is the permissible limit for disposal as per CPCB guidelines in the affidavit dated 14 October and 16 November 2016 to the NGT.

Overall, there is a significant reduction in petroleum hydrocarbon concentrations in soil compared to 2015 data. The Ministry of Environment and Forestry (MOEF) document titled *Guidance document for assessment and remediation of contaminated sites in India, dated March 2015*, identifies screening levels for benzene at 0.5 mg/kg, xylenes at 5 mg/kg, toluene at 3 mg/kg naphthalene at 1 mg/kg and ethylbenzene 5 mg/kg, for

a residential neighborhood. For TPH an intervention screening level of 5,000 mg/kg was identified, as per CPCB guidelines in the affidavit dated 14 October and 16 November 2016 to the NGT. TPH, benzene, xylenes, ethylbenzene, and naphthalene concentration is low, and do not exceed CPCB screening levels. At a few areas high DRO and TPH concentrations continue to exist (MW-26A, MW-25AB and ASB-1) between 20 - 55 feet bgs that warrant continued remediation.

Groundwater Analytical Results

Groundwater analytical data are summarized in Tables 4. Groundwater analytical data of DRO and TPH are plotted on a series of Iso-concentration contour maps for shallow and deep screened monitoring wells that are used to illustrate the lateral extent of DRO and TPH concentrations. These maps are included along with this report (See Figure 17-20). Groundwater analytical data are discussed below.

- Analytical data of water samples collected from shallow water bearing zone shows, DRO was not detected in majority of the groundwater samples.
- The highest concentrations of DRO were reported in groundwater samples collected in MW-26A (0.66 mg/L) and MW-2A (0.48 mg/L).
- Low concentrations were reported at few wells in the range between 0.08 mg/L to 0.66 mg/L at MW-25A and MW-26A respectively.
- TPH was not detected in majority of the shallow screened monitoring wells. The highest concentrations of TPH were reported in groundwater samples collected in MW-26A (0.66 mg/L) and MW-2A (0.57 mg/L).
- Xylenes were only reported in MW-2A (76.50 mg/L) and the recorded concentration is above the permissible limit as per CPCB guidelines.
- In all the groundwater samples GRO was reported below detection limits with the exception on the sample collected from MW-2A. In well MW-2A, GRO was reported at 490.77 mg/L.
- Benzene and naphthalene were not reported in any of the groundwater samples analyzed.
- Analytical data of water samples collected from the deep-water bearing zone, the highest concentration of DRO was reported in groundwater sample collected in MW-3B (0.35 mg/L).
- Low concentrations of TPH were reported in few wells ranging from 0.10 mg/L - 0.35 mg/L at MW-26B and MW-3B, respectively.
- Low concentrations of GRO were reported in few monitoring wells.
- Benzene and naphthalene were not reported in any of the groundwater samples analyzed.
- Xylenes were only reported in MW-3B with concentration of 22.97 mg/L in deep-water bearing zone.

Overall, the groundwater analytical data indicates that concentration of petroleum hydrocarbons in groundwater within the shallow and deep-screened monitoring wells has decreased significantly since 2015. The Ministry of Environment and Forestry (MOEF) document titled *Guidance document for assessment and remediation of contaminated sites in India, dated March 2015*, identifies screening levels for, benzene at 0.005 mg/L, xylenes at 0.5 mg/L, toluene at 0.7 mg/L TPH at 0.5 mg/L and ethylbenzene 0.3 mg/L, for drinking water. TPH, benzene, and ethylbenzene concentrations do not exceed CPCB screening levels.

ESTIMATE OF RESIDUAL HYDROCARBON MASS

DRO and TPH analytical data from soil and groundwater analysis were used to estimate the mass of residual hydrocarbons beneath the site. The same general steps are used to estimate the residual mass in both soil and groundwater. The steps outlined below.

Estimating Residual Hydrocarbon Mass in Soil

The following methodology was used to estimate the residual DRO and TPH masses in soil beneath the site. Table 5 summarizes the estimated mass calculations for soil between the ground surface and 50 feet bgs.

1. DRO and TPH concentrations (refer to Table 3) were plotted on maps representing 10-foot thick intervals between the ground surface and 50 feet Bgs (0 – 10 feet bgs, 10 – 20 feet bgs, 20 – 30 feet bgs, 30 – 40 feet bgs, and 40 – 50 feet bgs).
2. Iso concentration contours were then constructed using these data to the extent that the detection limit for DRO and TPH (1.0 mg/kg) was reached. These maps are included in the report (See Figure 5-14).
3. Areas bounded between the contours are calculated using the measurement tools built into AutoCAD. Calculated areas are listed on each figure.
4. Average concentrations for areas between the contours are assumed to be the arithmetic mean of the upper and lower iso concentration contour values. (e.g. the average concentration between the 10 mg/kg and 100 mg/kg iso concentration contours is $[10+100]/2=55$ mg/kg). Where an area is enclosed within a single contour, the average concentration is assumed to be the arithmetic mean of the iso concentration contour and the highest value within the iso concentration contour (e.g. if the 100 mg/kg contour encloses an area where the highest reported concentration is 955 mg/kg, the average concentration is assumed to be $[955+100]/2=527.5$ mg/kg). Average concentrations are assumed to be homogeneous throughout the contour interval.
5. The soil volume (cubic feet [ft³]) is calculated by multiplying the area by the interval thickness.
6. The soil mass (kilograms [kg]) is calculated by multiplying the soil volume (ft³) by the soil density (kg/ ft). Soil density is assumed to be 43.04 kg/ft³ for sand, and 33.98 kg/ft³ for clay.
7. The hydrocarbon mass is calculated by multiplying the soil mass (kg) and the average concentration (mg/kg), then dividing by 10⁶ mg/kg.

Estimating Residual Hydrocarbon Mass in Groundwater

The following methodology was used to estimate the residual TPH mass in groundwater beneath the site. Table 6 summarizes the estimated mass calculations for groundwater between the ground surface and 50 feet bgs. TPH concentrations (refer to Table 4) were plotted on maps representing upper and lower water-bearing zones.

1. The upper water-bearing zone is approximately 15 feet thick (20 to 35 feet bgs). The lower water bearing zone is approximately 10 feet thick (65 to 75 feet bgs).
2. Iso concentration contours were then constructed using these data to the extent that the detection limit for TPH (1.0 mg/kg) was reached. These maps are included in report (See Figure 17-20). Areas bounded between the contours are

calculated using the measurement tools built into AutoCAD. Calculated areas are listed on each figure.

3. Average concentrations for areas between the contours are assumed to be the arithmetic mean of the upper and lower iso concentration contour values. (e.g. the average concentration between the 10 µg/L and 100 mg/L iso concentration contours is $[10+100]/2=55$ mg/L). Where an area is enclosed within a single contour, the average concentration is assumed to be the arithmetic mean of the Iso concentration contour and the highest value within the iso concentration contour (e.g. if the 1,000 mg/L contour encloses an area where the highest reported concentration is 5,260 mg/L, the average concentration is assumed to be $[5,260+1,000]/2=3,130$ mg/L). Average concentrations are assumed to be homogeneous throughout the contour interval.
4. The groundwater volume (cubic feet [ft³]) is calculated by multiplying the area by the interval thickness (15 feet in the shallow groundwater zone, 10 feet in the deep groundwater zone), and then multiplying this product by the porosity. The porosity for clean, medium sand is assumed to be 32%.
5. The hydrocarbon mass is calculated by multiplying the groundwater volume (litres [L]) and the average concentration (mg/L), then dividing by 10⁹ mg/L.

Residual Hydrocarbon Mass - 2021

- Based on analytical data, and TPH Iso concentration contour maps the mass of petroleum hydrocarbon remaining in soil was calculated. Residual mass of petroleum hydrocarbons in soil is estimated to be approximately **1,053.93 kg** based on DRO and TPH concentrations (See Table 8).
- Total mass of petroleum hydrocarbon in soil was estimated to be **32,797.61 kg** based on GRO and TPH concentrations in 2015 (See Appendix-E & F).
- Based on the groundwater analytical data, and TPH Iso concentration contour maps the mass of petroleum hydrocarbons in groundwater was calculated. Mass of petroleum hydrocarbons in groundwater is estimated to be approximately 2.11 kg (See Table 9).
- Total mass of petroleum hydrocarbons in groundwater was estimated to be 1,380.97 kg in 2015 (See Appendix -E).

Comparison between 2015 & 2021 Soil Analytical Data

- The DRO & TPH concentrations detected in samples collected from soil in February 2021 are very low compared to the concentrations recorded in 2015.
- Significant reduction in concentration of petroleum hydrocarbons was observed at all depths. A reduction of greater than 90% was observed at most depths and locations indicating remedial efforts are effective.

Table A - Comparison Study & % Reduction of DRO concentration [0'-10'] bgs of Soil from 2015-2021

Well Installed in 2015	DRO [0'-10'] (mg/kg)	Well Installed in 2021	DRO [0'-10'] (mg/kg)	% Reduction
MW- 1AB / SVE -1	955.00	ASB - 1	0.51	99.93 %

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MW - 16AB	25.60	B - 2	23.97	6.37 %
MW - 17AB	46.00	MW - 25AB	1.68	99.42 %
SVE - 3 / AS -3	844.95	MW - 26A	0.14	99.98 %

Table B - Comparison Study & % Reduction of DRO concentration [10'-20'] bgs of Soil from 2015-2021

Well Installed in 2015	DRO [10'-20'] (mg/kg)	Well Installed in 2021	DRO [10'-20'] (mg/kg)	% Reduction
MW- 1AB / SVE - 1	181.00	ASB - 1	0.21	99.88 %
MW - 6A	166.17	MW - 27A	0.21	99.87 %
MW - 9A	50.10	MW - 28A	BDL	100.00 %
MW - 10AB	172.10	MW - 30A	BDL	100.00 %
MW - 14A	110.50	B - 3	5.92	94.64 %
MW - 16AB	49.40	B - 2	0.48	99.03 %
MW - 17AB	35.69	MW - 25AB	7.90	77.86 %
SVE - 3 / AS -3	346.96	MW - 26A	BDL	100.00 %

Table C - Comparison Study & % Reduction of DRO concentration [20'-30'] bgs of Soil from 2015-2021

Well Installed in 2015	DRO [20'-30'] (mg/kg)	Well Installed in 2021	DRO [20'-30'] (mg/kg)	% Reduction
MW- 1AB / SVE - 1	7220.00	ASB - 1	16.09	99.78 %
MW - 4A	301.00	MW - 26B	1.28	99.57 %
MW - 6A	156.55	MW - 27A	21.86	86.04 %
MW - 9A	39.90	MW - 28A	4.71	88.20 %
MW - 10AB	74.90	MW - 30A	0.22	99.71 %
MW - 14A	185.00	B - 3	0.29	99.84 %
MW - 16AB	54.60	B - 2	7.97	85.40 %

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MW - 17AB	54.50	MW - 25AB	6.17	88.68 %
SVE - 3 / AS - 3	449.58	MW - 26A	0.96	99.79 %

Table D - Comparison Study & % Reduction of DRO concentration [30'-40'] bgs of Soil from 2015-2021

Well Installed in 2015	DRO [30'-40'] (mg/kg)	Well Installed in 2021	DRO [30'-40'] (mg/kg)	% Reduction
MW- 1AB / SVE - 1	186.95	ASB - 1	2.77	98.52 %
MW - 4A	563.52	MW - 26B	10.49	98.14 %
MW - 6A	171.81	MW - 27A	0.44	99.74 %
MW - 9A	2.40	MW - 28A	2.15	10.42 %
MW - 14A	132.30	B - 3	23.14	82.51 %
MW - 16AB	6549.00	B - 2	15.83	99.76 %
SVE - 3 / AS - 3	420.20	MW - 26A	74.07	82.37 %

Table E - Comparison Study & % Reduction of DRO concentration [40'-50'] bgs of Soil from 2015-2021

Well Installed in 2015	DRO [40'-50'] (mg/kg)	Well Installed in 2021	DRO [40'-50'] (mg/kg)	% Reduction
MW - 16AB	1693	B - 2	0.65	99.96 %
MW - 17AB	47.98	MW - 25AB	6.11	87.27 %

Table F - Comparison Study & % Reduction of TPH concentration [0'-10'] bgs of Soil from 2015-2021

Well Installed in 2015	TPH [0'-10'] (mg/kg)	Well Installed in 2021	TPH [0'-10'] (mg/kg)	% Reduction
MW- 1AB / SVE - 1	955.00	ASB - 1	0.70	99.93 %
MW - 9A	7.90	MW - 28A	13.55*	NA*
MW - 16AB	219.60	B - 2	25.09	88.57 %
MW - 17AB	305.00	MW - 25AB	1.78	99.42 %

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SVE - 3 / AS -3	844.95	MW - 26A	0.14	99.98 %
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Table G - Comparison Study & % Reduction of TPH concentration [10'-20'] bgs of Soil from 2015-2021

Well Installed in 2015	TPH [10'-20'] (mg/kg)	Well Installed in 2021	TPH [10'-20'] (mg/kg)	% Reduction
MW- 1AB / SVE - 1	181.00	ASB - 1	1.23	99.32 %
MW - 6A	166.17	MW - 27A	0.21	99.87 %
MW - 9A	54.90	MW - 28A	BDL	100.00 %
MW - 10AB	173.59	MW - 30A	0.33	99.81 %
MW - 14A	120.20	B - 3	6.21	94.83 %
MW - 16AB	256.04	B - 2	1.17	99.54 %
MW - 17AB	344.69	MW - 25AB	7.90	97.71 %
SVE - 3 / AS -3	346.96	MW - 26A	BDL	100.00 %

Table H - Comparison Study & % Reduction of TPH concentration [20'-30'] bgs of Soil from 2015-2021

Well Installed in 2015	TPH [20'-30'] (mg/kg)	Well Installed in 2021	TPH [20'-30'] (mg/kg)	% Reduction
MW- 1AB / SVE - 1	7220.00	ASB - 1	23.02	99.68 %
MW - 4A	301.00	MW - 26B	1.28	99.57 %
MW - 6A	156.55	MW - 27A	30.29	80.65 %
MW - 9A	46.30	MW - 28A	6.95	84.99 %
MW - 10AB	77.70	MW - 30A	0.22	99.72 %
MW - 14A	188.90	B - 3	0.29	99.85 %
MW - 16AB	279.60	B - 2	7.97	97.15 %
MW - 17AB	304.50	MW - 25AB	6.17	97.97 %
SVE - 3 / AS -3	449.58	MW - 26A	0.96	99.79 %

Table I - Comparison Study & % Reduction of TPH concentration [30'-40'] bgs of Soil from 2015-2021

Well Installed in 2015	TPH [30'-40'] (mg/kg)	Well Installed in 2021	TPH [30'-40'] (mg/kg)	% Reduction
MW- 1AB / SVE - 1	186.95	ASB - 1	3.37	98.20 %
MW - 4A	563.52	MW - 26B	10.49	98.14 %
MW - 6A	171.81	MW - 27A	0.44	99.74 %
MW - 9A	6.90	MW - 28A	2.15	68.84 %
MW - 14A	143.20	B - 3	26.77	81.31 %
MW - 16AB	7336.30	B - 2	16.42	99.78 %
SVE - 3 / AS -3	420.20	MW - 26A	153.83	63.39 %

Table J - Comparison Study & % Reduction of TPH concentration [40'-50'] bgs of Soil from 2015-2021

Well Installed in 2015	TPH [40'-50'] (mg/kg)	Well Installed in 2021	TPH [40'-50'] (mg/kg)	% Reduction
MW - 16AB	1707.3	B - 2	0.65	99.96 %
MW - 17AB	47.98	MW - 25AB	6.50	86.45 %

Comparison between 2015 & 2021 Groundwater Analytical Data

Shallow Screened Wells

- Significant reduction in concentration of petroleum hydrocarbons was observed in groundwater monitoring wells.
- The reduction in DRO & TPH concentrations in groundwater samples collected at on March 2021 in comparison to the hydrocarbon concentrations recorded in 2015 assessment is calculated in terms of percentage and are in the range of 92.27% to 100% (See Table K to L).

Table K - Comparison Study & % Reduction of DRO concentration of groundwater of shallow wells from 2015-2021

Well Sampled in 2015	DRO in 2015 (mg/L)	Well Sampled in 2021	DRO in 2021 (mg/L)	% Reduction
MW- 2A	100.50	MW-2A	0.44	99.56 %
MW-3A	5260.00	MW-3A	BDL	100 %
MW-4A	105.50	MW-4A	0.16	99.85 %
MW-5A	7.51	MW-5A	BDL	100 %
MW-6A	1.72	MW-27A	BDL	100 %
MW-9A	57.27	MW-28A	BDL	100 %
MW-10A	359.16	MW-30A	BDL	100 %
MW-12A	8.54	MW-26A	0.66	92.27 %
MW-13A	25.60	MW-13A	BDL	100 %
MW-15A	9.78	MW-15A	BDL	100 %
MW-16A	1696.00	MW-16A	0.21	99.99 %
MW-17A	31.00	MW-25A	0.08	99.74 %
MW-18A	0.08	MW-18A	BDL	100 %
MW-22A	0.12	MW-22A	0.15	-25%
MW-23A	0.99	MW-23A	BDL	100 %

Table L - Comparison Study & % Reduction of TPH concentration of groundwater of shallow wells from 2015-2021

Well Sampled in 2015	TPH in 2015 (mg/L)	Well Sampled in 2021	TPH in 2021 (mg/L)	% Reduction
MW- 2A	100.50	MW-2A	0.57	99.43 %
MW-3A	5260.00	MW-3A	BDL	100 %
MW-4A	105.50	MW-4A	0.16	99.85 %
MW-5A	7.51	MW-5A	BDL	100 %
MW-6A	1.72	MW-27A	BDL	100 %
MW-9A	57.27	MW-28A	BDL	100 %
MW-10A	359.16	MW-30A	BDL	100 %
MW-12A	8.54	MW-26A	0.66	92.27 %
MW-13A	25.60	MW-13A	BDL	100 %

MW-15A	9.78	MW-15A	BDL	100 %
MW-16A	1696.00	MW-16A	0.21	99.99 %
MW-17A	31.00	MW-25A	0.08	99.74 %
MW-18A	0.08	MW-18A	BDL	100 %
MW-22A	0.12	MW-22A	0.15	-25 %
MW-23A	0.99	MW-23A	BDL	100 %

Deep Screened Wells

- The DRO & TPH concentrations detected in groundwater samples collected from the existing deep screened wells and newly installed wells are very low compared to the DRO & TPH concentrations recorded in 2015 site assessment.
- Significant reduction in concentration of petroleum hydrocarbons was observed in groundwater monitoring wells.

Table M - Comparison Study & % Reduction of DRO concentration of groundwater of Deep wells from 2015-2021

Well Sampled in 2015	DRO in 2015 (mg/L)	Well Sampled in 2021	DRO in 2021 (mg/L)	% Reduction
MW-3B	55.00	MW-3B	0.35	99.36 %
MW-5B	2.70	MW-5B	0.12	95.56 %
MW-16B	156.00	MW-16B	BDL	100 %
MW-17B	7.50	MW-25B	BDL	100 %
MW-23B	0.08	MW-23B	BDL	100 %
-	-	MW-26B	0.10	NA

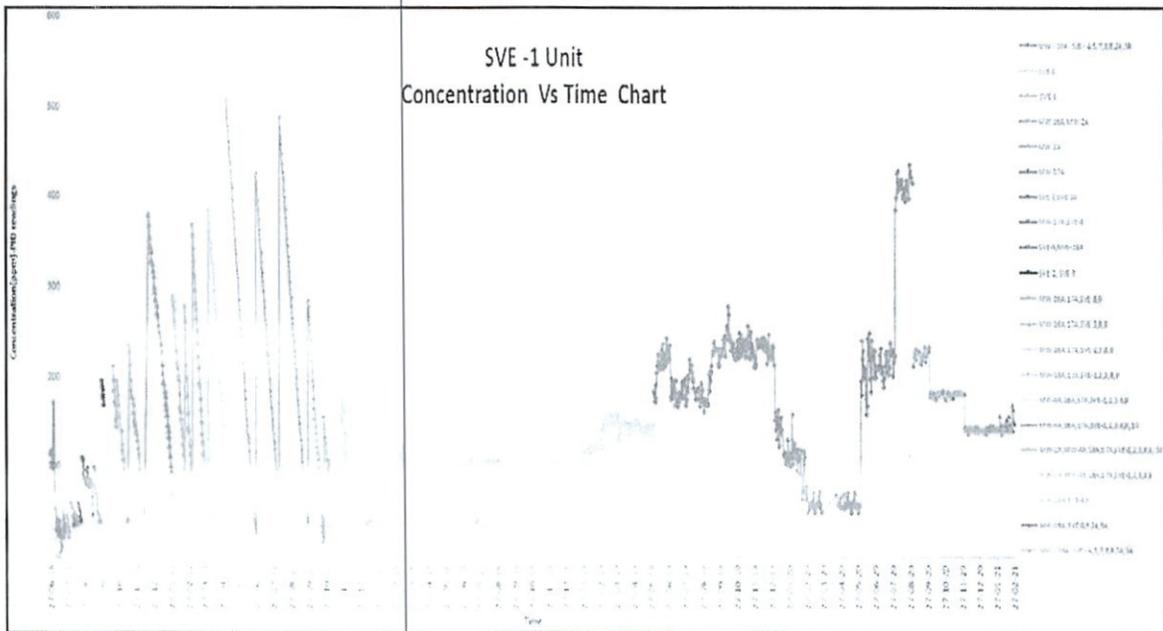
Table N - Comparison Study & % Reduction of TPH concentration of groundwater of Deep wells from 2015-2021

Well Sampled in 2015	TPH in 2015 (mg/L)	Well Sampled in 2021	TPH in 2021 (mg/L)	% Reduction
MW-3B	55.00	MW-3B	0.35	99.36 %
MW-5B	2.70	MW-5B	0.12	95.56 %
MW-16B	156.00	MW-16B	BDL	100 %
MW-17B	8.50	MW-25B	BDL	100 %
MW-23B	0.08	MW-23B	BDL	100 %
-	-	MW-26B	0.10	NA

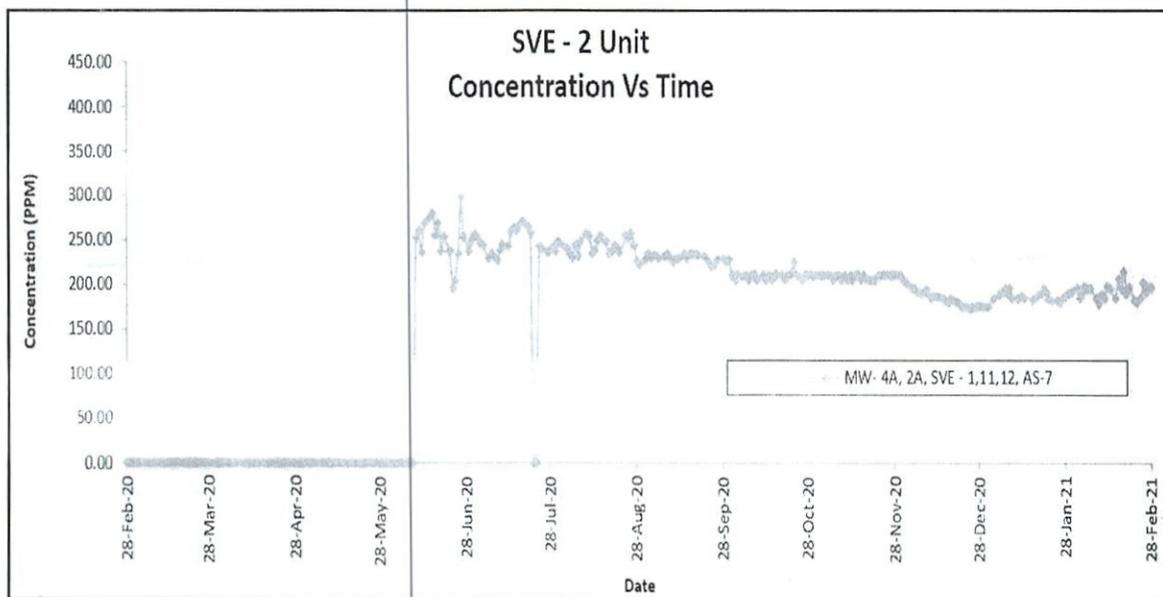
REMEDIAL EFFORTS

SVE Systems Operation

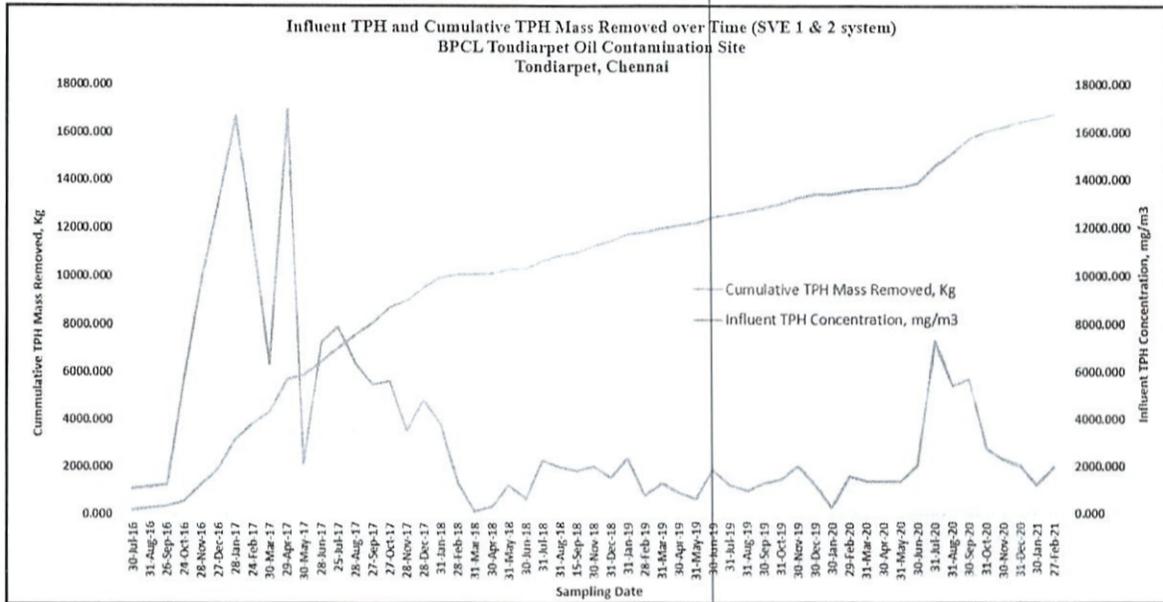
- The SVE -1 and SVE-2 unit has been very effective in extracting petroleum hydrocarbon vapor from the subsurface.
- SVE System No. 1 has operated for 32,238 hours since 20th May 2016 and SVE System No. 2 has operated for 2,555 hours since 13th January 2020 till February 2021.
- SVE-1 and SVE-2 unit extracted approx. 14,979.31 Kilograms & 1,760.27 Kilograms respectively as of February 2021 and a total of 16,739.58 Kilograms (Approximately) had been removed as of February 2021 (see Table 5 & 6).



Concentration vs Time (SVE-1)



Concentration vs Time (SVE-2)



Concentration vs Time and TPH Mass Removed

CMRL Excavation Activity

- In 2018, CMRL began excavating in and around the contaminated area. Cumulatively, during the period from 24th February 2018, to 31st December, 2019 approximately 34,064.80 cubic meters (m³) of soil was excavated from the contaminated site along T.H main road between M.M Theater and junction of V.P.K Street-T.H main road,
- TPH mass removed by CMRL activity in the contaminated zone was 12,595.16 Kilograms (approximately) and it is estimated using the soil analytical data of the soil boring advanced from the period 2015-2017 and the TPH Iso concentration contour maps (See Table 7 & Figures 21 to 25).

Mass Balance Summary of TPH from 2015 – 2021

- A Mass Balance Summary of the Total Petroleum hydrocarbon (TPH) is evaluated using the lab analytical data, accounting the total hydrocarbon mass removed by SVE 1 & 2, Hydrocarbon recovery through absorbent socks, CMRL activity in contaminated zone and unaccounted TPH mass removed by SVE systems during the high slug movement into treatment system have been estimated for the period 2015 to 2021 (see Table 10).

CONCLUSIONS

- Lateral extent of impact to soil is adequately characterized given site constraints and access issues.
- Lateral extent of impact to groundwater is adequately characterized to the north by MW-11A and 23A, to the west by MW-7A and MW-18A, to the east by MW-5A and MW-22A and to the south by MW-27A.
- Significant reduction in soil and groundwater concentrations is being observed due to remedial efforts and natural attenuation factors.
- Residual mass continues to be present in the 25 to 35 feet bgs interval that

warrants additional remediation.

- Residents report groundwater quality has improved and water from the bore wells does not smell of petroleum.
- Stratus does not recommend use of groundwater in private bore wells.

RECOMMENDATIONS

Stratus recommends the following based on the performance of the SVE systems and the most recent assessment report.

- Given the observation of relatively higher concentrations of DRO and TPH observed between 25 and 35 feet bgs at a few locations, we recommend continued SVE systems to reduce concentration of petroleum hydrocarbons in soil for a period of 6 months.
- We also recommend the continued operation of the air sparge system located at SVE-2. In addition, Stratus recommends operation of a second air sparge system at SVE-1 and connecting the second AS system to wells AS-3a and SVE-8.
- We recommend connecting newly installed wells 26A, located in the alley, and MW-25A, located in Devi Polymer property to the SVE-2, and SVE-1 respectively.

LIMITATIONS:

This document was prepared in general accordance with accepted standards of care that existed at the time this work was performed. No other warranty, expressed or implied, is made. Conclusions and recommendations are based on field observations and data obtained from this work and previous investigations. It should be emphasized that evaluation of geologic conditions has not been exhaustive and hence judgments leading to conclusions and recommendations are generally made with an incomplete knowledge of the subsurface conditions. More extensive studies may be performed to reduce uncertainties. This document is solely for the use and information of our client unless otherwise noted. This report documents activities associated with the advancement of the soil borings, collection of soil and groundwater samples, construction, development, and surveying of the monitoring wells, geological/hydrogeological interpretations associated with completion of the subsurface investigation, and information regarding the extent of petroleum hydrocarbon impact to the subsurface.



Dr. Indumathi M Nambi
 Professor
 Environmental & Water Resources Engineering Division
 Department of Civil Engineering
 Indian Institute of Technology Madras
 Chennai – 600036, India.

E-mail: indunambi@iitm.ac.in
 Phone: --91-44-22574289(O)
 --01-44-22576289(R)

August 1, 2021

Mr. Rajesh Kumbhare
 GM Operations, Retail South
 Bharat Petroleum Corporation Limited
 Anna Nagar, Chennai-600040

Subject: Review of Detailed Site Assessment Report Prepared by Stratus Environmental for the Oil Contaminated Site, Tondiarpet, Chennai.

Dear Mr. Rajesh

Indian Institute of Technology, Madras (IITM), has prepared this letter to provide M/s Bharat Petroleum Corporation Limited (BPCL) a review of the detailed project report (DPR) prepared by M/s Stratus Environmental (Stratus). IITM reviewed a DPR prepared by Stratus dated April 15, 2021 regarding the status of contamination and effectiveness of remediation at the Oil Contaminated Site, Tondiarpet, Chennai. In addition, IITM also reviewed the 2015 Detailed Site Assessment Report (DSAR), prepared by Stratus and compared the two documents.

In the DPR Stratus claims the following:

- Overall geology of the site has not changed since the initial report prepared by Stratus in 2015.
- Depth to water at this site has varied greatly between 16 and 39 feet below ground surface creating a large smear zone.
- Free phase product has been completely eliminated.
- Large reductions in the concentrations of diesel range organics (DRO) in soil samples analyzed in the laboratory, were observed compared to the 2015 data. GRO, and BTEX components were hardly detected in any of the soil samples and indicate significant reduction compared to the 2015 data.
- Although a large smear was created by the fluctuating water table, given that the soil horizon was primarily sand, it appears to have been responsive to soil vapor extraction.
- Levels of contamination in first encountered groundwater (shallow wells) indicate significant reduction. DRO concentrations have decreased significantly in most monitoring wells. GRO and BTEX concentrations are non-existent.
- Very low concentrations of DRO were reported in the lower water bearing zone (deep wells). BTEX components were not detected in any of the deep monitoring wells.
- Residual Mass of contamination in soil was calculated to be 1054 kgs as Total Petroleum Hydrocarbons (TPH) compared to the mass calculated in 2015 of 32,797 kgs.



Dr. INDUMATHI M. NAMBI
 Professor
 Environment & Water Resources Division
 Department of Civil Engineering
 Indian Institute of Technology Madras
 Chennai – 600 036, India

Mr. Rajesh Kumbhare
BPCL
Review of 2021 Oil Contamination Site DPR

Residual Mass in groundwater was calculated to be 2.11 kgs based on data in the shallow groundwater compared to 1381 kgs in 2015.

- Mass of hydrocarbons removed by SVE system is 16,740 kgs and Mass removed by CMRL excavation is 4849 kgs. Other mass losses could be accounted for through volatilization and natural attenuation of the biodegradable components (20-30% typical) over the five years which has been reported in literature. Air sparging must have accelerated natural bioremediation in the deeper aquifers.

My review of the two documents indicates that the assessment completed in 2021 is consistent with the assessment conducted in 2015. Overall remediation approach of Stratus has been done as per the international standards in spite of the field constraints and unexpected changes due to CMRL work. They have done a thorough job of assessment, compilation of data and prepared a good report. The most important part of the report appears to be the calculation of mass in soil and groundwater. The data (figures and calculations) presented by Stratus was thoroughly reviewed by me and they are consistent with the 2015 calculation and representative of site conditions. Stratus does indicate that residual mass continues to be present in the soil horizon between 25 and 35 feet below ground surface in some of the wells.

However, based on my review, I have the following concerns:

1. No water or soil samples were collected from the lower water bearing zone and in the clay layer separating the upper water bearing zone and lower water bearing zone. In the 2015 study significant contamination was observed in the clay layer. I am concerned that DRO will continue to dissolve from this layer into the upper and lower water bearing zones for a long period of time due to water table fluctuations.
2. No assessment was conducted on the properties where MW-3 and MW-10 are located. Significant contamination was detected on these two properties during the 2015 assessment.
3. PAH were analyzed in the laboratory but the values are not reported in the report. Since these are priority pollutants the data needs to be rechecked in soil samples closer to MW3 and MW10
4. In page 12, Xylene concentrations were reported to be as high as 76.5mg/l which is on the higher side of WHO recommended 0.5mg/l for drinking water. But this is found only in 2% of the samples. A reassessment is required for these sampling locations too since BTEX are priority pollutants like PAH
5. Similarly, some mass of soil from CMRL site was moved to different places for landfilling. I understand TNPCB monitored the excavation and permitted removal of soil with TPH



Dr. INDUJYOTI M. WADGAONKAR
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Environment & Water Resources Division
Department of Civil Engineering
Indian Institute of Technology Bombay
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Mr. Rajesh Kumbhare
BPCL
Review of 2021 Oil Contamination Site DPR

below CPCB permissible limits. I hope the water pumped is also disposed properly after treatment to permissible limits.

Recommendations:

1. The residual TPH in the zones which were impacted heavily can be removed only by continued operation of SVE and AS until the Dutch standards are met in every location particularly closer to spill source as per the tender. Based on experience, this may take one year. An assessment at locations close to spill site such as Suhas hospital and alley will give a confirmation of clean up.
2. Odour thresholds are much lower than health risk based regulatory levels. The reported concentrations have met regulatory levels in soil and water in most of the locations. In order to make the aquifer usable by the residents, point of use treatment systems can be provided in the impacted households to eliminate trace level organics. The residents using the water will be the ultimate proof of the cleanup and bring closure to the entire operation.

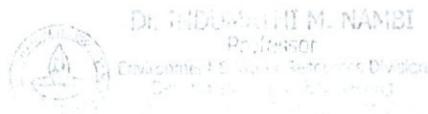
Overall, I appreciate BPCL's commitment to clean up the site and the excellent execution of the project to come to this level. To my knowledge, this is the first oil contaminated site to be cleaned up with advanced insitu SVE- Air Sparging technology. This project will set the precedence for cleanup of oil contaminated sites in India and BPCL's role in this is commendable.

Sincerely,



Dr. Indumathi M. Nambi, Ph. D
Professor,
Department of Civil Engineering

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS



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**CENTRAL POLLUTION CONTROL BOARD
REGIONAL DIRECTORATE - CHENNAI**

F.No./02/legal(NGT)/TN/RDC/2020-21
To,

NGT Matter
August 03, 2021

Mr. K. B. Reddy
Chief Installation Manager
Bharat Petroleum Corporation Ltd.
35, Vaidynathan Street, Tondairpet
Chennai – 600081

Sub: Hon'ble National Green Tribunal, Principal Bench, New Delhi order dated May 27, 2021 in the matter of OA No. 176 of 2013 (SZ) (Earlier O. A. No. 562/2019) V. P. Krishnamoorthy Vs. The Union of India &Ors. on remediation of oil contaminated site at Tondiarpet, Chennai - regarding

Sir,

This has reference to Hon'ble NGT order dated May 27, 2021 in the matter of O.A. No. 176 of 2013 (SZ) V.P. Krishnamoorthy Vs. The Union of India &Ors is enclosed for ready reference. The Hon'ble NGT directed that as reproduce below:

“The Central Pollution Control Board as well as Tamil Nadu Pollution Control Board and M/s BPCL are directed to file their further status and compliance report including the steps taken regarding further remediation process that is being suggested by the CPCB and regarding the health study that is directed to be done by the ICMR and submit the reports to this Tribunal on or before 27.08.2021 by e-filing in the form of Image PDF along with necessary hardcopies to be produced as per Rules”

In view of the above and in order to comply with NGT directions, M/s BPCL is hereby directed to submit compliance report of following tasks on or before August 06, 2021:

- i. As per the action plan decided in joint meeting at the highest level held under the chairmanship of Chairman, CPCB at Chennai on March 01, 2019, upon completion of CMRL soil excavation works, M/s BPCL to submit a Detailed Project Report (DPR) for revised remediation scheme based on re-assessment of site along with site specific target levels (SSTLs) for remediation based on human health risk assessment.
- ii. Installation of Soil Gas Probes to Monitor VOCs in Vadose zone of Subsoil at 3 locations in affected area, which shall become part of revised remediation scheme.
- iii. Augmentation of SVE system by connecting all available wells to both SVE system and to operate both SVE system continuously to optimise soil vapour extraction.
- iv. Steps taken to entrust the health impact study to ICMR.

Yours faithfully

(H.D. Varalaxmi)
Regional Director

Encl.: As above

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Copy to,

- (i) The Member Secretary
Tamil Nadu Pollution Control Board
No. 76, Mount Salai, Guindy
Chennai - 600032 : For kind information and with request to
follow up & necessary action, pls
- (ii) The District Environmental Engineer
Tamil Nadu Pollution Control Board
1st floor, 6/1, Sri Jothi Complex
Murugesan Street, Bala Vinayagar Nagar
Arumbakkam, Chennai - 600106 : For kind information and with request to
follow up & necessary action, pls
- (iii) Divisional Head, WM -1,
CPCB, Delhi - 32 : For kind Information, pls

H.D. Varalaxmi

**(H.D. Varalaxmi)
Regional Director**

भारत पेट्रोलियम कॉर्पोरेशन लिमिटेड
भारत सरकार का उद्यम



ब-ने टॉर्स्टोर
नं. 35, वैद्यनाथन स्ट्रीट, डा.प.नं. 1152,
टोन्डियारपेट, चेन्नई 600 081. ग्राम : इन्स्टाल्केट
दूरभाष : 25952381, 25952384, 25951158, 25953884
दूरभाष : 25951288, 25228129 टेलिफैक्स : 044-25956949

BHARAT PETROLEUM CORPORATION LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

CHENNAI TERRITORY
No. 35, Vaidyanathan Street, Post Box No. 1152,
Tondiarpet, Chennai-600 081. Grams : INSTALKET
Phone : 25952381, 25952384, 25951158, 25953884
Phone : 25951288, 25228129 TeleFax : 044-25956949

REF: TNP: OPS: 7/CON

Dt.06.08.2021

To

The Regional Director
CENTRAL POLLUTION CONTROL BOARD
Ministry of Environment, Forests & Climate Change
2nd Floor, 77-A, South Avenue Road
Ambattur Industrial Estate, Chennai – 600058

Kind Attn: Ms H.D.Varalaxmi

Respected Madam,

SUB: REMEDIATION WORK OF OIL CONTAMINATED SITE AT TONDIARPET

Ref: Your letter ref : F.No./02/legal(NGT)/TN/RDC/2020-21 dated August 03, 2021

Action plan/reply with respect to four points sought in above letter is as follows.

i. **As per the action plan decided in joint meeting at the highest level held under the chairmanship of Chairman, CPCB at Chennai on March 01, 2019, upon completion of CMRL soil excavation works, M/s BPCL to submit a Detailed Project Report (DPR) for revised remediation scheme based on re-assessment of site along with site specific target levels (SSTLs) for remediation based on human health risk assessment.**

We have already forwarded the *Detailed Project Report (DPR) vetted by IIT, Madras as per reference no. TNP: OPS: 7/CON dated 05.08.2021.*

As per the direction of the CPCB and TNPCB, BPCL's consultant Stratus Environmental, Inc. (Stratus), conducted an environmental site investigation between February and March 2021 to reassess the extent of petroleum hydrocarbon impact to soil and groundwater post CMRL excavation activity, and reinstalled monitoring bore wells



(replacement of wells lost due to CMRL activity) to evaluate the lateral extent of impact to groundwater.

Stratus has prepared a Detailed Project Report (DPR) to present the findings of the site assessment conducted at the Bharat Petroleum Corporation Limited (V. P Koil Street – T.H Main Road) Petroleum Contaminated Site, Tondiarpet, Chennai.

Based on the DPR, Stratus does not recommend a revised remediation scheme for the site. Given the presence of residual petroleum hydrocarbon mass between 25 to 35 feet bgs, Stratus recommended addition of more wells to SVE systems for soil vapor extraction. Stratus recommended connecting newly installed wells 26A, located in the alley, and well MW-25A, located in Devi Polymer property to the SVE-2, and SVE-1 respectively. Stratus in the DPR state that continued operation of SVE and AS would be adequate to remediate the residual mass in soil and groundwater.

ii. Installation of Soil Gas Probes to Monitor VOCs in Vadose zone of Subsoil at 3 locations in affected area, which shall become part of revised remediation scheme.

Given the low concentration in the influent air samples of the SVE system, we do not believe soil gas probes installation would be necessary at this point. However, if CPCB insists, we will direct Stratus to install the soil gas probes.

iii. Augmentation of SVE system by connecting all available wells to both SVE system and to operate both SVE system continuously to optimize soil vapour extraction."

As per the direction of the CPCB and TNPCB, BPCL's consultant Stratus Environmental, Inc. (Stratus), have been focusing on extraction of petroleum hydrocarbon vapours from wells available for remediation activity in and around CMRL work area and in contaminated areas.

SVE SYSTEM OPERATION

Stratus is currently operating two SVE systems to mitigate petroleum hydrocarbon impact on the subsurface near VPK Street and TH Road, Tondiarpet, Chennai. The SVE -1 system consists of **10 HP extraction blower** & SVE -2 system consists of a **20 HP Liquid ring vacuum pump** used to extract petroleum hydrocarbon vapors from the contaminated area using vapor extraction wells. The extracted vapors are abated in a catalytic oxidizer & thermal oxidizer rated at **250 (CFM)** and **500 (CFM)** in systems SVE-1 and SVE-2, respectively.

A handwritten signature in blue ink, appearing to be a stylized 'S' or similar character.



In May 2019, Stratus completed the installation of 2 remediation (**SVE-2a, SVE-3a**) and 1 air sparge (**AS-3a**) wells in earmarked locations along T.H main road to compensate for those lost due to CMRL activity (see attached Figure) and these wells are connected to SVE unit-1. In November 2019, Stratus completed the installation of 2 remediation wells (**SVE-11, and SVE-12**) which are shown on figure 2. Stratus completed the construction activity to connect the remediation wells (SVE – 1, 11, 12 & MW – 2A, 4A) to the SVE unit-2. In March 2021, Stratus completed the installation of 2 remediation wells (**MW-25A, and MW-26A**) and 1 air sparge well (**ASB-1**) which are shown in the attached figure. In June 2021, Stratus connected the remediation wells (MW– 26A, ASB-1 & DBAS– 1) to the SVE unit-2.

Stratus began operating the SVE -1 system in May 2016 and SVE-2 beginning 13th January 2020. SVE-1 is operated 24-hours a day and SVE -2 is being operated for 12 hours since 10th June 2020.

SVE unit 1 is connected to remediation wells listed below.

Well ID	Operational status
SVE – 2A, 3A, 4, 5, 7, 8, 9 & MW – 16A	Currently in operation

SVE unit 2 is connected to remediation wells listed below

Well ID	Operational status
MW – 2A, 4A, 26A, SVE- 1, 11, 12	Currently in operation

AIR SPARGING UNIT OPERATION

Air Sparging unit-1 is currently operated at SVE Unit-2 and connected to AS wells listed below.

Well ID	Operational status
AS – 6, ASB – 1	Currently in operation
AS – 2, DBAS – 1	Currently not in operation

iv. Steps taken to entrust the health impact study to ICMR

We are ready to go ahead with the health impact study at any moment direction to that effect is received from CPCB and TNPCB. As per the minutes of meeting conducted on

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23.04.2021 through VC with officials of CPCB, TNPCB and ICMR , the following is the latest status in this regard.

" ICMR officials informed that Human Ethics Committee of ICMR has suggested carrying out the health hazard study after the COVID – 19 situation in view of the data collection like blood and urine samples from the affected people in the oil contaminated place at Tondiarpet will not reflect the accurate information.

In the meeting it was concluded that ICMR shall furnish a detailed report obtained from National Institute of Epidemiology containing proposal of health hazard study at affected place of Tondiarpet with information of proposed date of start of the study, time duration along with cost estimation, release of fund for study etc. to CPCB & TNPCB so as to proceed further in this regard as per Hon'ble court order."

Again as per the letter no. NIE/D/TNPCB/21/15 dated 12th May 2021 addressed to The Member Secretary, TNPCB, ICMR clarified that their Institutional Human Ethics Committee (IHEC) has approved the study in principle and suggested that the initiation of the study may be postponed till COVID 19 pandemic subsides.

We are yet to get any direction in this regard from CPCB & TNPCB or ICMR.

Thanking you,
Yours faithfully,
For Bharat Petroleum Corporation Ltd,

A handwritten signature in black ink, appearing to be 'S. J.' or similar, written over a horizontal line.

Chief Installation Manager

CC : Chairman,CPCB,Delhi.
CC : TNPCB,Guindy, Chennai.
CC : DEE,TNPCB,Chennai.



ICMR - NATIONAL INSTITUTE OF EPIDEMIOLOGY

राष्ट्रीय जाणपादिक रोग विज्ञान संस्थान

B-17, Second Main Road, Tamil Nadu Housing Board,
Ayapakkam, Chennai - 600 077, India
Phone -91-44-26136204 - 26136201 - 26820469 (D)
Fax -91-44-26820464 Website - www.nie.gov.in
E-mail - manojmurhekar@nie.gov.in
manojmurhekar@nie.gov.in

Ministry of Health Research
Ministry of Health & Family Welfare,
Government of India

Dr. Manoj V. Murhekar, M.D.

NIE/D/TNPCB/2021/46

12th August 2021

The Member-Secretary
Tamil Nadu Pollution Control Board
Chennai

Sir,

Sub: Tondiarpet oil leak health impact study_submission of documents, reg.

Ref: 1. Discussion during the meeting held on 11 Aug 2021 at 3 PM at TNPCB, Guindy, Chennai.

2. Letter from ICMR-NIE: NO.NIE/D/TNPCB/21/15 dated 12th May 2021

As discussed during the meeting cited above, we wish to submit the following details for your perusal:

1. Study proposal along with the budget requirement
2. Mandate form for funds transfer.
Funds can be transferred from TNPCB to the account of ICMR-NIE mentioned in the mandate form or through a DD drawn in favour of "The Director, ICMR NIE", payable at Chennai
3. Schedule of payment: 90% of the budget to be transferred to the Institute for initiation of the study processes and 10% of budget at the time of submission of final report
4. Study period:
Ten months (1 month for preparatory activities, 6 months for field data collection and 3 months for laboratory testing and data analysis; from the date of receipt of funds)

Since the reported number of COVID 19 cases have been reduced, we wish to undertake the study upon receipt of the funds from TNPCB.

Thanks and with regards,

Sincerely,

(Dr Manoj V Murhekar)



WHO Collaborating Centre for Leprosy Research and Epidemiology

MANDATE FORM
ELECTRONIC CLEARING SERVICE (CREDIT CLEARING) REAL TIME
GROSS SETTLEMENT (RTGS) FACILITY FOR RELIABLE PAYMENTS

A. DETAILS OF ACCOUNT HOLDER(S)

1	NAME OF THE ACCOUNT HOLDER	DIRECTOR ICMR NIE
2	COMPLETE CONTACT ADDRESS	ICMR - National Institute of Epidemiology, R-127, Second Main Road, TNHB, Ayapakkam, Chennai - 600 077.
3	TELEPHONE NUMBER/ FAX/ EMAIL	044-26136253 Nieprojects1@gmail.com
4	NAME & ADDRESS OF THE PROJECT INVESTIGATOR	Dr. R. Prabhu, Sci - D, ICMR - National Institute of Epidemiology, R-127, Second Main Road, TNHB, Ayapakkam, Chennai - 600 077.

B. BANK ACCOUNT DETAILS

1	BANK NAME	Canara Bank
2	BRANCH NAME WITH COMPLETE ADDRESS	Ambattur Branch, Chennai.
3	WHETHER THE BRANCH IS COMPUTERISED?	YES
4	WHETHER THE BRANCH IS RTGS ENABLED? IF YES, THEN WHAT IS THE BRANCH'S IFSC CODE	YES CNRB00000936
5	IS THE BRANCH ALSO NEFT ENABLED?	YES
6	TYPE OF BANK ACCOUNT (SB/CURRENT)	Savings Bank Account
7	COMPLETE BANK ACCOUNT NUMBER (LATEST)	09361011107744
8	MICR CODE OF BANK	600015004

I hereby declare that the particulars given above are correct and complete. If the transaction is delayed or not effected at all for reasons of incomplete or incorrect information I would not hold the user institution responsible.

(Signature)
 Project Investigator

(Signature)
 (Signature of the Accounts Officer
 Jr. Grade of the Institute)
 NATIONAL INSTITUTE OF EPIDEMIOLOGY
 Ayapakkam, Chennai - 600 077

Certified that the particulars furnished above are correct as per our records.
 Date: 18.01.2021

NOTE: Photocopy of cancelled cheque is enclosed for purpose of verification of the concerned bank account where money is to be remitted.

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Canara Bank

CHENNAI AMBATTUR
CHENNAI, TAMIL NADU - 600093
IFSC: CNRB0000936

Pay **CANCELLED**

Amount

Ac. No **0936101107744**

077843

Payable at par at all our branches in India

077843 6000 1500 41 0000 18 3 1

Valid for three months only from the date of instrument

MULTIPLICITY 58

D D M M Y Y Y Y

Signature of or Board

Signature

For DIRECTOR ICMR NIE

Authorised Signatories

Please sign above

Health Impact of Petroleum Oil Leak among residents of Tondiarpet, Chennai – A Cross Sectional Study

Investigators: R Prabu, BS Bagepally, B Ganesh, G Elavarasu, and A Elangovan

Background:

Petroleum products contain more than 1000 chemicals, which are considered as carcinogens.¹ The exposure (both acute and chronic) to chemical components of petroleum products can affect the health and cause illness.² Although pipeline transportation of natural gas and petroleum is considered safer and cheaper than ground transportation, pipeline failures, failing infrastructure, human errors, and natural disasters can result in major pipeline disasters.³ As such, previous incidents have been shown to cause detrimental effects to the environment and the public's safety.⁴ Oil spills have major environmental and economic effects as well affects human health.

Northern part of Chennai is a major industrial hub and many petroleum refineries, storage terminals are also located. The petroleum products are transported to the storage terminals from the refineries using underground pipelines, which traverse through residential and commercial areas. Leakage in the petroleum carrying pipeline systems had been reported in news papers in the past. One such leakage incidence took place in an underground pipeline of Bharat Petroleum Corporation Limited (BPCL), at Tondiarpet area of Chennai during the year 2013. That underground pipeline was laid between Chennai Port and BPCL terminal and transporting motor spirit and high speed diesel petroleum products. A public complaint was filed by the residents of Tondiarpet regarding contamination of groundwater. The complaint was investigated by Tamil Nadu Pollution Control Board (TNPCB) on 13/07/2013 and the inspection revealed presence of petroleum products in groundwater. A public interest litigation (PIL) petition was filed in Hon'ble National Green Tribunal (NGT), South Bench, Chennai by residents, which was admitted as Application No. 176 of 2013 in August 2013. Following, BPCL has dummied and abandoned that pipeline and the initiated remediation works as per the directions of Central Pollution Control Board. Some of remediation work include provision of water to the public residing in the complained area and to measures to extract the spilled petroleum products from the ground.

A joint meeting was conducted by the stakeholders on 1st March 2018 to take stock of the remediation work and finalize further action plan for expediting the remediation process. As decided by the Committee, TNPCB has requested ICMR-National Institute of Epidemiology/ICMR-National Institute for Research in Environmental Health/ICMR-National Institute of Occupational Health to work in coordination to conduct a study to assess the health impact due to oil leakage in the population living in the affected area and submit the report.

ICMR-NIE conducted a consultative meeting involving experts in General Medicine (Madras Medical College), Environmental Engineering (IIT-Madras), Occupational Health (ICMR-NIOH) and Epidemiology (ICMR-NIE) on 6th January 2020 to discuss and finalize the plan

for assessing the health impact of the residents living in the affected area. As decided in the meeting, we propose to conduct the study with the objective to assess the health impact of the population exposed to oil pipeline-leak in Tondiarpet area and unexposed population in Royapuram area in Chennai in collaboration with IIT-Madras, Madras Medical College, ICMR-NIOH-ROHC(S), ICMR-NIREH.

Objectives:

1. To assess the health impact of the population exposed to oil pipeline-leak in Tondiarpet area and unexposed population in Royapuram area in Chennai
2. To obtain the data on current level of petroleum residues in the soil and ground water in the exposed area from the agency involved in remediation process/IIT-M/other relevant agencies

Study design: Cross-sectional study

Study population: Residents (aged 5 years and above) of the oil pipeline leaked area in Tondiarpet (exposed to oil leak) and residents of Royapuram area (unexposed to oil pipeline leak).

Sample size: We will include all the eligible individuals residing within 200 m² radius from the oil leakage point. The population density of Chennai is 26553/KM² as per 2011 census. The approximate number of population residing in 200 m² radius is 3335. Hence the sample size for this study is 3335 each in study and control areas.

The sampling area is based on the plume boundaries of the environmental study conducted by IIT-M. (Fig 1)

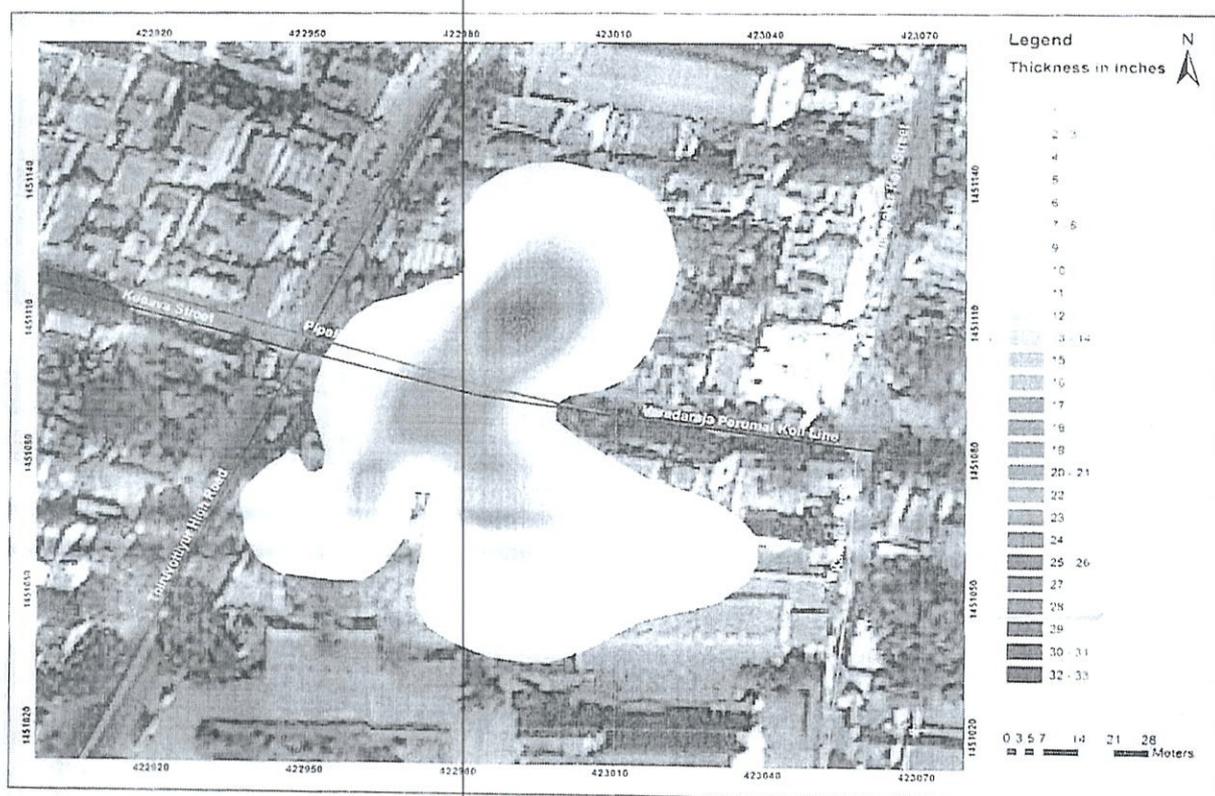


Figure 1: Spread of oil plume in study area

Definitions:

Residents: living in the study area

- Residents of Tondiarpet area (200 meters radius from the main site of Oil leak in Varadaraja Perumal Street) (Figure 2)

Version 1.2&12/8/2021

Exclusion Criteria

- Refusal to provide written informed consent

Controls:

- Residents of Royapuram area residing within the radius of 200 meters from St. Anne's Girls Higher Secondary School, Royapuram. The area was chosen, since the exposure parameters are similar to case area except underground petroleum pipelines.

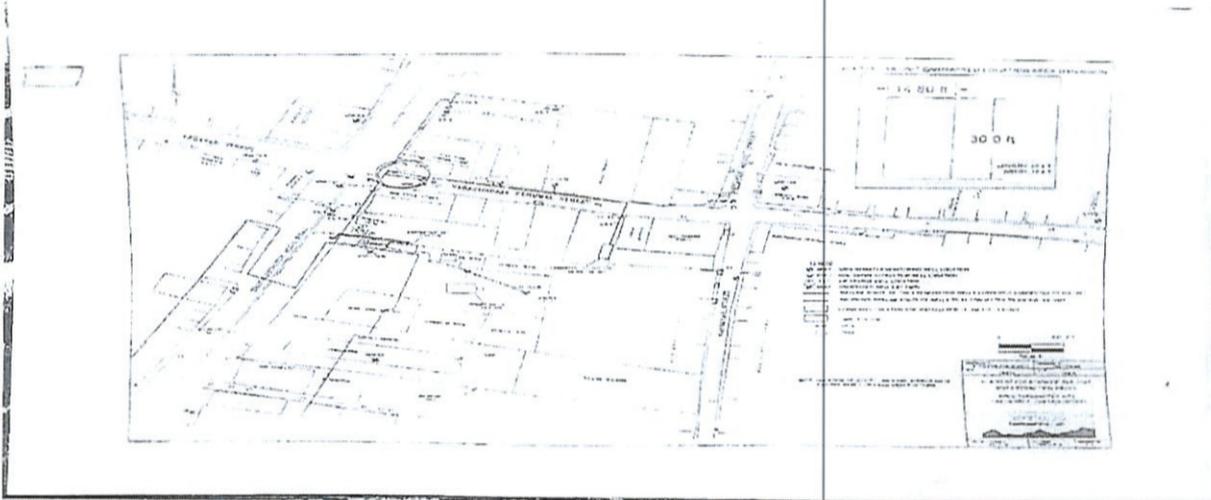


Figure 2: Oil leak area in Tondiarpet (marked in circle)

Sampling method:

We will recruit all the population residing in the exposed and unexposed areas. If any resident is not available during the survey, only one more attempt will be done on next day for recruiting.

Data collection:

Socio-demographic details including duration of their stay in the area, occupational details, self reported morbidity details, maternal & child health and developmental delays related will be collected from the participants. Venous blood (10 ml) and urine (50 ml) samples will be collected from randomly chosen 10% of the study population aged 5 years and tested for biochemical parameters and metabolites of the petrochemicals. In a 10% of population aged ≥ 18 years, spirometry and resting state heart rate variability tests will also be done. (10% of population in exposed and unexposed area [(3332+3332)-20% non response/absence during the visits=533 rounded to 550]

List of investigations:

- Complete Blood Count
- Lipid profile
- Liver function test
- Renal Function Test
- Lung function – spirometry
- Heart Rate Variability
- Urinary metabolite -Polycyclic aromatic hydrocarbons

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- Blood petroleum metabolites (PAH metabolites as per environmental protection agency, USEPA)

Attempts will be made to obtain the Health Management Information System data from the hospitals in the area such as Department of dermatology of Stanley Medical College, MMC, KMC, Government Peripheral hospital, CDH and major private health facilities to assess the trend of morbidities before and after the oil leak events and will be analysed.

Mortality data:

We will collect the mortality data of both the included areas from the concerned public authorities.

Environmental and biomonitoring data:

The report of historical and current environmental sample testing particularly ground water, and soil will be obtained from IIT-M, the agency involved in the remediation process, CPCB/TNPCB and other agencies to assess the presence of petrochemicals and their concentration in the exposed area. ICMR-NIOH-ROHC(S) will involve in assessing the urinary biomarkers of polycyclic aromatic hydrocarbons (PAHs).

Human participant protection:

We will obtain approval from Ethics Committee of ICMR-NIE before initiating the study. The written informed consent/assent from all the study participants before study enrolment. We will provide suitable referral services to the nearest public health facility to the participants, if necessary.

Expected Outcome:

1. Morbidity pattern among the residents of oil leak exposure and the control area
2. Description of the plausible effect of remediation works on morbidity pattern

We will develop scientific manuscripts from the study findings for wider scientific dissemination.

Study duration: Total: 10 months

Preparatory activities: 1 month

Data collection including training and pilot study: 6 months

Lab testing: 2 months

Data analysis and report preparation: 1 month

Study timelines

Scientific Advisory Committee – Approval obtained

Institutional Ethics Committee – Approval obtained

Study start date – Date of receipt of funds from TNPCB

Budget (amounts mentioned are excluding applicable taxes):

S No	Head	Amount
1	Non recurring	3,70,000
2	Recurring	94,27,500
3	Contingency	4,89,875
4	Institutional overhead	9,79,750
	Total	1,12,67,125

References

1. Phillips B. Oil pipelines and spills Alabama, USA: Auburn University; 2017 [cited 2020 9 Nov 2020]. Available from: <https://cla.auburn.edu/ces/energy/oil-pipelines-and-spills/>.
2. Anderson AR. Health Effects of Cut Gas Lines and Other Petroleum Product Release Incidents - Seven States, 2010-2012. MMWR Morb Mortal Wkly Rep. 2015;64(22):601-5.
3. Fractracker. An introduction to oil and gas pipelines [cited 2020 9 Nov]. Available from: <https://www.fractracker.org/2016/06/introduction-oil-gas-pipelines/>
4. Adegboye MA, Fung WK, Karnik A. Recent Advances in Pipeline Monitoring and Oil Leakage Detection Technologies: Principles and Approaches. Sensors (Basel). 2019;19(11).

Budget for Tandiarpet oil leak health impact study

Item	Number	Rate	Duration	Amount
A Non-recurring				
1 Tabs for data collection	6	20000 -		₹ 120,000.00
2 Spirometer	1	250000 -		₹ 250,000.00
<i>Sub-total non-recurring</i>				
				₹ 370,000.00
B Recurring				
<i>1 Manpower</i>				
a				
Scientist B Medical	2	70000	6 ₹	840,000.00
Staff Nurse	4	32000	4 ₹	512,000.00
Field Investigator	6	31000	4 ₹	744,000.00
Lab Technician - grade III	2	18000	4 ₹	144,000.00
Technical Officer (Lab) (NIOH-ROHCS, Bengaluru)	1	32000	6 ₹	192,000.00
<i>Multi Tasking Staff</i>	2	16000	4 ₹	128,000.00
2 CBC	550	300 -		₹ 165,000.00
Lipid profile	550	400 -		₹ 220,000.00
Liver function test (Bilirubin, AST, ALT, protein)	550	500 -		₹ 275,000.00
Renal Function Test	550	800 -		₹ 440,000.00
Lung function – spirometry	550	100 -		₹ 55,000.00
HRV	550	50 -		₹ 27,500.00
Urinary – Polycyclic aromatic hydrocarbon	550	4000 -		₹ 2,200,000.00
Blood petroleum metabolites (PAH metabolites as per environmental protection agency, USEPA)	550	5500 -		₹ 3,025,000.00
Travel				
Field travel	60	4000 -		₹ 240,000.00
Supervision/monitoring/sample shipment	1	100000		₹ 100,000.00
Consumables:				
Sample collection kit: 200/sample	600	200		₹ 120,000.00
<i>Sub total recurring</i>				₹ 9,427,500.00
Contingency	5%			₹ 489,875.00
Institutional overhead	10%			₹ 979,750.00
Grand total (=F6+F29+F30+F31)				₹ 11,267,125.00



TAMIL NADU POLLUTION CONTROL BOARD

From,
Thiru R Kannan M.Tech.,
Member Secretary
Tamil Nadu Pollution Control Board,
76, Mount Salai, Guindy,
Chennai - 600 032.

To
The Installation Manager
M/s Bharath Petroleum
Corporation Limited
Elya Mudali Street,
Chennai - 600081.

Letter No. T2/TNPCB/F.0173/HWM/NGT-176/2013(SZ)/2021 Dt.13.08.2021

Sir,

Sub : TNPCB-HWM - Remediation of oil contaminated site at Tondiarpet -
Compliance of orders Dt. 27.5.2021 of the Hon'ble NGT(SZ) in O.A No.
176/2013(SZ) -to conduct health study in the vicinity of Oil
contaminated site & proposal received from M/s ICMR- communicated
and to provide necessary funds-Regarding.

- Ref 1. Orders Dt. 27.5.2021 of the Hon'ble NGT(SZ) in O.A No.
176/2013(SZ)
2. Joint meeting held on 11.8.2021 at TNPCB with officials of CPCB,
ICMR & BPCL.
3. ICMR-NIE Lr.No. NIE/D/TNPCB/2021/46 dt. 12.8.2021

This has reference to the compliance of order dt 27.5.2021 of the
Hon'ble NGT (SZ) order Dt 27.5.2021 in O A No. 176 of 2013 related to
remediation of oil contaminated site at Tondiarpet by BPCL. As per the
Tribunal order, CPCB, TNPCB & BPCL shall file their further status report and
compliance report including the steps being taken regarding remediation
process by BPCL and the health study by the ICMR before 27.8.2021.

In order to observe status on remediation work being done, at oil
contaminated site Tondiarpet, a joint inspection was carried out by team of
officials of CPCB, TNPCB & BPCL on 6.8.2021 and observed the work progress
and collected the samples.

A Joint meeting was held on 11.8.2021 at TNPCB Corporate office with
officials of CPCB, ICMR & BPCL regarding to carry out health study on health
hazard that has happened in that area due to leakage of the pipeline of BPCL.

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Based on the decision taken in the meeting, the ICMR has furnished the proposal for the said study along with budget estimation at a cost of Rs. 1,12,67,125/- to TNPCB, is hereby enclosed.

Hence, it is requested to take necessary steps in this regard and release 90% of the total budget Rs. 1,01,40,413/- in the mode of Demand Draft favour of "The Director, ICMR NIE" payable at Chennai and the same may be delivered to ICMR through O/o TNPCB.

Receipt of this letter shall be acknowledged.


For Member Secretary

Encl : As above

Copy To

1. The Regional Director
Regional Directorate (South)
Central Pollution Control Board
77-A South Avenue
Ambattur Industrial Estate
Ambattur
Chennai - 600 058.
2. The Director
National Institute of Epidemiology (ICMR)
R 125, 3rd Avenue
Tamil Nadu Housing Board
Ayapakkam
Chennai- 60077.
3. DEE, TNPCB, Chennai

**BEFORE THE HON'BLE NATIONAL
GREEN TRIBUNAL SOUTHERN ZONAL
BENCH, CHENNAI**

**O.A. No.176 of 2013(SZ)
(earlier O.A. No. 562 of 2018 (PB))**

IN THE MATTER OF:

V.P. Krishnamoorthy
...Applicant

Vs.

Union of India & Ors.
...Respondents

**STATUS REPORT AND DOCUMENTS
FILED BY THE 6TH RESPONDENT**

**S. RAMASUBRAMANIAM AND
ASSOCIATES
COUNSEL FOR 6TH RESPONDENT**