PTTEP

PTTEP South Asia Limited
(PTTEP SA)

Monitoring Report of Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign (Well Abandonment Phase)

REM-UAE
LABORATORY AND CONSULTANT COMPANY LIMITED

B702 Delta Plaza, Shwegondaing Rd.,
Bahan, 11201 Yangon, Myanmar.
Tel: (959) 73013448; (959) 5144005; (959) 5376382

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Executive Summary

Executive Summary

REM-UAE Laboratory and Consultant Company Limited conducted the monitoring program for Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign in well abandonment phase.

The objective of this report is to evaluate the effectiveness of implementation of the Environmental Impact Assessment, including monitoring measures as per commitment in EIA Report.

1. Project Overview

PTTEP SA was granted the petroleum Production Sharing Contract (PSC) for Block MOGE-3, which is in Magway Region, in Central Myanmar. Block MOGE-3 encompasses 1,217 km^2, and is in the south of Magway Region, in the Dry Zone in the central Myanmar lowlands. PTTEP SA drilled four (4) exploration drilling wells during 2018-2019 located in Thayet Township, Magway Region, Myanmar.

Four wellsites were started construction and installation phase in 2018 and then drilling phase in 2018-2019. Finally, after drilling phase completion, PTTEP SA carried out the activities for well abandonmentfor all four wellsites in 2020. The wellsites name are listed as below;

- Padaukpin wellsite (PDP)
- Sakangyi wellsite (SKG)
- Ngabetkya wellsite (NBK)
- Moenatkone wellsite (MNK)

2. Well Completion and Abandonment

After finishing the drilling and the well completion operations, the rig and associated equipment dismantled and loaded onto trucks and then moved to the next operator's drilling location. It was considered that these 4 wells were commercially unacceptable. Therefore, the wells were permanently abandoned and well site restoration work was commenced immediately. The requirements for the physical abandonment followed the best industry practices. After the abondonment, the land will be completely returned to MOGE with an agreeable condition.

3. Emission, Discharges and Waste Management

3.1 Extra Drilling Mud

At the end of the first well location, the left over drilling mud was transferred and used at the next well location. At the end of drilling campaign, the left over mud was sent back to mud contractor for reuse or disposal or use for PTTEP offshore drilling campaign or handover to MOGE for future use. After the wells were actually abandoned rather than completed as a producer, some of this mud was used to make the kill weight spacer between the cement plugs.

3.2 Drilled Cuttings Management

The largest waste stream from the exploration drilling program are the drilled cuttings removed from the wellbore and spent drilling fluids. Drilling fluids are circulated downhole and routed to a solids control system such as shale shaker and centrifuge at the surface facilities where fluids can be separated from the cuttings so that they may be recirculated downhole leaving the cuttings behind for disposal. The cuttings placed in the concrete lined pits and further transferred to High Density Polyethylene (HDPE) lined pits for storage until the drilling campaign finished. Finally, all the drilled cuttings treated onsite and further dispose at DOWA waste management facility at Thilawa SEZ. PTTEP SA managed the drilled cuttings according to the IFC Onshore Oil and Gas Guidelines for the treatment and disposal of drilling fluids and drilled cuttings. The total weight of all wastes from each well sites are listed as below and the detail of drilled cuttings waste management are provided in Chapter 1.

Well Name	Weight of wastes (Kg)				
	Non-Hazardous	Hazardous			
	WBM Cuttings	SBM Cuttings	Waste Water	Oil waste	Soil Waste
Sakangyi	396,660	729,580	215,840	2,340	7,650
Monatkone	836,220	2,260,880	137,560	6,350	8,585
Padaukpin	467,780	1,002,500	316,300	6,320	3,410
Nagbatkya	328,140	943,200	457,800	6,250	2,120
Total	**2,028,800**	**4,936,160**	**1,127,500**	**21,260**	**21,765**

3.3 Air Emission

During the well abandonment phase, dust was the main air quality issue while demolition & restoration activity and transportation. Any emissions were reduced significantly by the standard procedure of equipping all transportation with proper packaging and covering. For combustion emission, combustion product from demolition & restoration activity and transportation was diesel fuel combustion. Diesel combustion from vehicles were emitted greenhouse gases. The amount of emissions would be varying with time, depend on the operational activity and power demand.

3.4 Noise

During the well abandonment phase, noise was generated from machines/engines during site demolition & restoration and transportation. However, all the well sites are far away from community area and assumed it is not affected to community. In addition, the workers are provided with PPE throughout the operation phase.

4. Safety, Security, Health and Environment Management System

4.1 PTTEP Corporate Vision and Mission

All levels of line management at PTTEPI are responsible for implementing and maintaining its SSHE policy and SSHE MS. Both documents are reviewed and revised at regular intervals.

- **Vision Mission and Corporate Values**

  Vision: "Energy Partner of Choice" through Competitive Performance and Innovation for Long-term Value Creation."

  Mission: "PTTEP operates globally to provide reliable energy supply and sustainable value to all stakeholders."

4.2 PTTEP Myanmar Asset Safety Security Health and Environment (SSHE) Policy

PTTEP Myanmar Asset is committed to safe Exploration and Production (E&P) Operations in Myanmar with an ultimate goal of "Target Zero - Nobody Gets Hurts in Our Operations" which covers (1) Zero Injury, (2) Zero Major Accident (e.g. zero major hydrocarbon leak, vehicle accident, ship collision), and (3) Zero Spill or External Complaint (e.g. zero complaint by authorities/ communities/ sea users).

To accomplish this, PTTEP Myanmar Asset Implements Safety, Security, Health and Environmental Management System (SSHE-MS) that outlines the main principles and accountabilities to drive for continuous improvement. We are committed to:

- Comply with Myanmar SSHE laws, other applicable requirements and PTTEP Standards.
- Perform hazard identification and SSHE risk assessments so that risks are As Low As Reasonably Practicable (ALARP).
- Hold employees accountable for SSHE performance by setting and monitoring SSHE Plans and KPIs.
- Prevent operational and process incidents by implementing asset integrity programs and monitoring of Safety Critical Elements addressed in Safety Cases and complying with Management of Change (MOC) Standard.
- Work with contractors and suppliers to achieve PTTEP's SSHE requirement.
- Ensure all employees and contractors are assessed and maintain the required level of job and SSHE competency.
- Apply "Stop Work Authority Policy" for unsafe work by implementing Behavior-Based Safety (BBS) programs to improve positive SSHE culture.
- Implement security management for potential threats to safeguard personnel, assets, information and reputation.
- Promote occupational health and hygiene in the workplace by conducting health risk assessments, medical
- Surveillances, education and regular industrial hygiene monitoring.
- Prevent environmental impacts by strictly following the mitigation measures stated in Environmental Impact Assessment.
- Promote sustainable development by implementing waste management, greenhouse gas reduction and energy efficiency programs.
- Report, investigate and analyse SSHE incidents to prevent recurrence and close out corrective actions with evidence.
- Ensure that emergency and crisis management plans are proactive and effective.
- Ensure policy and SSHE Management System compliance through regular SSHE audits and Senior Management visits with corrective actions follow up for continuous improvement.

  Strong leadership and commitment is a key successful implementation of this policy which is required from PTTEP employees and contractors at all levels.

4.3 SSHE Management System Manual

PTTEP SA's SSHE Management System Manual objective is to serve as practical interpretation of Company SSHE policy with respect to their moral obligations for SSHE issues for all persons working on, visiting or affected by operations at sites for which PTTEP SA has responsibility.

The manual covers details on the area as specified in Table 1. The document is designed to serve as a comprehensive guide for all Operational Assets to develop its own SSHE management system and related documents. This document also provides an overview of SSHE management system approach.

It should be noted that PTTEP SA currently does not have its own internal SSHE policies, however PTTEP International Limited (PTTEPI) Myanmar Asset policies will be applied. For this project, PTTEP SA will adopt all of PTTEPI's relevant SSHE policies and procedures. Throughout this chapter, SSHE policies, procedures and documents was referred to as belonging to PTTEP SA, however they actually belong to PTTEPI and are being adopted by PTTEP SA for this project. The detail Plan and Procedure have been submitted at EIA report.

Table 1 PTTEPI SSHE Management System

Document Code	Document
11027-PDR-SSHE-306/01-R03	Myanmar Asset SSHE Compliance Obligations Procedure
11027-PDR-SSHE-505_37-R01	Myanmar Asset Land Transport Safety Procedure
11027-PDR-SSHE-503/01-R02	Myanmar Asset Waste Management Procedure
11027-PDR-SSHE-502-006-R00	Myanmar Asset Emergency Management Plan
11027-PDR-SSHE-501-005-R00	Myanmar Asset Crisis Management Plan
11027-PDR-SSHE-564-002-R00	Myanmar Asset Alcohol and Drugs Testing Procedure
11027-PDR-SSHE-530-004-R00	Myanmar Asset Security Management Procedure
11027-PDR-SSHE-501/03-R02	Myanmar Asset Spill Contingency Plan
Myanmar-SSHE-11027-PDR-508	Fitness to Work Procedure
Myanmar-0550-MNL-004	Land Campaign Blowout Contingency Plan
11027-PDR-SSHE-340-003-R01	SSHE Training and Competency Procedure
Myanmar 13036-PDR-078	PTTEPI SSHE Requirements for Contractors
11027-PDR-SSHE-501-007-R02	MOGE-3 Operations Medical Emergency Response Plan (MERP)

5. Compliance Status

5.1 Environmental Monitoring Result

The results of Environmental Impact Monitoring determined that the project completely complied with 100%.

1) Air Quality Monitoring

There is no complaint throughout the project activities, therefore, air quality monitoring is not required to conduct for all 4 well sites.

2) Noise Monitoring

There is no complaint throughout the project activities, therefore, noise monitoring is not required to conduct for all 4 well sites.

3) Soil Monitoring

Soil monitoring was conducted for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited during June 22-23, 2020. The results were found that most of parameters at each station complied with the standard for Coarse Grained Agricultural Soil from Canadian Council of Ministers of the Environment. 2007. Canadian soil quality guidelines for the protection of environmental and human health: Summary tables. Updated September, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg except Chromium (Cr) at Well 04 Sakangyi and Nickel (Ni) at all stations same as the baseline result and its concentration decreased when comparing with baseline result.

4) Surface Water Monitoring

Surface water monitoring was conducted for well abandonment phase at station SW01_02 of Moenatkone wellsite, station SW02_04 of Ngabetkya wellsite, station SW03_05 of Padaukpin wellsite and station SW04_07 of Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited during June 22-23, 2020. Some stations couldn't be collected the samples due to run out of water and some stations don't exist anymore. The results were found that most of parameters at each station complied with the guideline values. Some parameters were higher than the guideline values since baseline survey but tend to decrease. The weather might have resulted in high value in some parameters especially, Total Suspended Solids and Total

Dissolved Solids due to sampling during dry season. Besides, the condition surrounded each monitoring station could also lead to high value in some parameters for example, some stations was surrounded by livestock and agricultural area that might cause high value of Total Coliform Bacteria. For heavy metal, Iron (Fe) was detected in all stations since baseline survey including groundwater locations. The high levels are attributed to naturally high iron content resulting from geological weathering as detailed in the EIA report.

5) Groundwater Monitoring

Groundwater monitoring was conducted for well abandonment phase at station GW01_01 and GW01_02 of Moenatkone wellsite, station GW02_03 and GW02_04 of Ngabetkya wellsite, station GW03_05 and GW03_06 of Padaukpin wellsite and station GW04_07 and GW04_08 of Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited during June 22-23, 2020. The results were found that most of parameters at each station complied with the guideline values. Some parameters were higher than the guideline values since baseline results. The condition of each monitoring station might have caused high value of Total Dissolved Solids (TDS), Conductivity and Total Suspended Solids (TSS) because the stations were opened-artesian wells that could be contaminated naturally by evaporation or precipitation. Ammonia and Total Nitrogen at some stations were also over the guideline values but continuously decreased until complied with the guideline values. Besides, surrounded area of each monitoring station could also lead to high value in some parameters for example, some stations was surrounded by livestock, agricultural area or villages, therefore fecal contamination might have resulted in high value of TCB. For heavy metals, Iron (Fe) were detected higher than the guideline values since baseline result in some stations. The high values are attributed to naturally high iron content resulting from geological weathering as detailed in the EIA report.

6) Social Monitoring

Social monitoring results for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite were done by PTTEP SA. There was no any complaint from the community throughout the well abandonment phase.

7) Public and Occupational Health and Safety Monitoring

Public and occupational health and safety monitoring results for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite were done by PTTEP SA. There was no incident case from project activity during well abandonment phase. PTTEP SA had strictly follow PTTEP SA's procedure for all case such as record data, find cause of accidents and performed mitigation measures.

Chapter 1

Introduction

Chapter 1
Introduction

1.1 Introduction

The Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign ("the Project") is an exploration project operated by PTTEP South Asia Limited (PTTEP SA), a subsidiary of PTTEP, PTTEP SA drilled four (4) exploration drilling wells in Block MOGE-3 during 2018-2019 located in Thayet Township, Magway Region, Myanmar. The Environmental Impact Assessment (EIA) Report for Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign was submitted to Myanmar Oil and Gas Enterprise (MOGE) and Environmental Conservation Department (ECD) on 28th September 2018, according to the submission letter no. PTTEP SA 13253/01-2967/2018 (Appendix A-1). After that ECD called reviewed team meeting on 1st November 2018 and requested PTTEP SA to revise the EIA report. Then PTTEP SA submitted the revised EIA report on 23rd November 2018 (Appendix A-2). EIA report was approved on 1st November 2019 according to MOGE and ECD letter number MD – (15) 3/6 (2631) 2019 and EIA-2/ Petroleum (2301/2019) respectively (Appendix A-3). As per commitment in EIA Report, PTTEP SA has the responsibility to follow the environmental impact monitoring including submits the monitoring report to MOGE and ECD. Therefore, PTTEP SA, as the project owner, has assigned a qualified third party, REM-UAE Laboratory and Consultant Company Limited to perform the monitoring at frequency specified in the EIA's environmental management plan and report the results to MOGE and ECD as prescribing in EIA.

In this monitoring report, environmental impact monitoring measures implementation compliance are covered for Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign during Well Abandonment Phase.

1.2 Objective

The main objectives of this report is:

- To evaluate the effectiveness of implementation of the Environmental Impact Assessment, including monitoring measures as per commitment in EIA Report.

1.3 Briefly Information of The Project

1.3.1 General Information and Background

1) Project Name: Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign
2) Project Location: Block MOGE-3 lies within Thayet and Kamma Townships in Thayet District of Magway Region
3) Project Owner: PTTEP South Asia Limited
4) Report Preparation: REM-UAE Laboratory and Consultant Company Limited
5) Project Start Date: Project was started in 2018.

1.3.2 Project Location

Block MOGE-3 lies within Thayet and Kamma Townships in Thayet District of Magway Region. The block encompasses 1,217 square kilometers (km^2) and is located in the Southern part of Magway region in the dry, central zone of the Myanmar lowlands. The block boundaries of MOGE-3 are shown in Table 1-1.

Table 1-1 Coordinates of Block MOGE-3 Boundary

Corner point	Coordinates (UTM Datum WGS 1984)		
	Zone	East (X)	North (Y)
A	46Q	705437.87	2164705.93
B	46Q	729049.83	2164991.86
C	46Q	731479.28	2111501.61
D	46Q	710428.60	2111249.24
E	46Q	709319.72	2131534.74

Four (4) drilling locations were selected to operate in 2018-2019 for drilling campaign. Four drilling locations are shown in Table 1-2 and Figure 1-1.

Table 1-2 Coordinates of Four Drilling Locations within Block MOGE-3

Wellsite	Coordinates (UTM Datum WGS 1984)		
	Zone	East (X)	North (Y)
Moenatkone (MNK)	46Q	709266.43	2158633.42
Ngabetkya (NBK)	46Q	708668.74	2149921.69
Padaukpin (PDP)	46Q	718230.84	2143521.79
Sakangyi (SKG)	46Q	721062.26	2143376.77

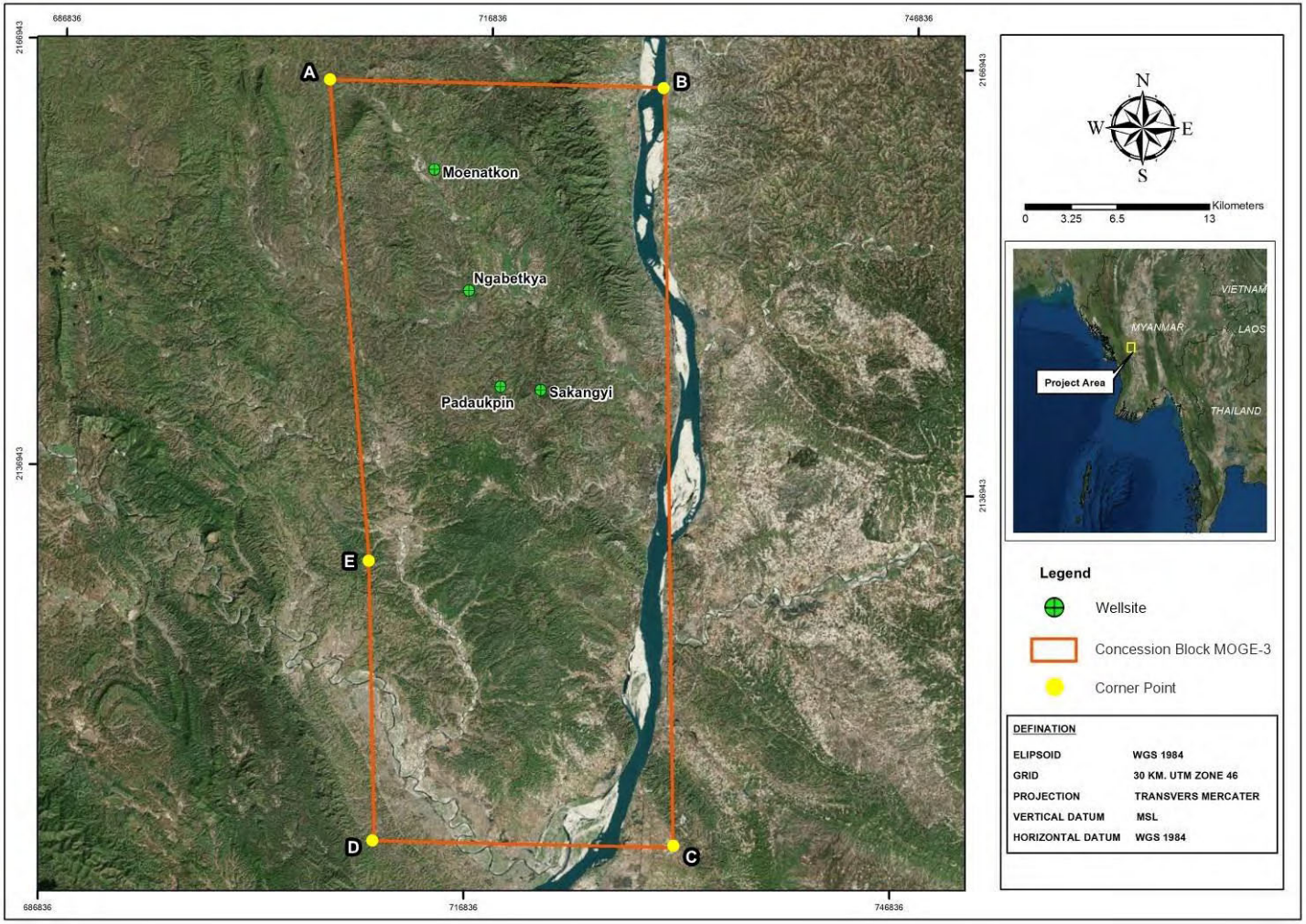

Figure 1-1 Four Drilling Locations within Block MOGE-3

1.3.3 Status of Current Operation

Four drilling locations were started construction and installation phase in 2018, then started drilling phase in 2019. Finally, after finishing those phases during 2018-2019, the main activity of the project in 2020 is well abandonment phase of four drilling locations. The status of each wellsite is summarized as Table 1-3.

Table 1-3 Status of each wellsite for Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign

Wellsite	Status
Moenatkone (MNK)	Well Abandonment
Ngabetkya (NBK)	Well Abandonment
Padaukpin (PDP)	Well Abandonment
Sakangyi (SKG)	Well Abandonment

Remark: PTTEP SA, 2020.

The example for current condition of each wellsite as shown in Figure 1-2 to Figure 1-5.

Figure 1-2 Moenatkone (MNK) Wellsite in Well Abandonment Phase

Figure 1-3 Ngabetkya (NBK) Wellsite in Well Abandonment Phase

Figure 1-4 Padaukpin (PDP) Wellsite in Well Abandonment Phase

Figure 1-5 Sakangyi (SKG) Wellsite in Well Abandonment Phase

1.4 Well Completion and Abandonment

After finishing the drilling and the well completion operations, the rig and associated equipment dismantled and loaded onto trucks and then moved to the next operator's drilling location.

It was considered that these 4 wells were commercially unacceptable. Therefore, the wells were permanently abandoned and well site restoration work was commenced immediately. The requirements for the physical abandonment followed the best industry practices. The following procedure for plugging and abandoning the well bore ensured that the land was completely returned to MOGE with an agreeable condition. The procedure for abandonment and restoration of 4 well sites were long established and relatively routine operation.

The well abandonment followed normal industry practices and procedures, conforming to all International regulations. A reservoir section was filled with heavy kill weight mud and a cement plug was put in position, 30 m below top of liner lap and 30 m. above as one 60 m. long plug (Minimum length).

After curing/thickening time, the position of the plug was confirmed physically by tagging with the cementing string. It was pressure tested. Then a 30 m. (Minimum length) cement plug was spotted at surface. Wellhead was removed and casing was cut off at bottom of cellar. A steel plate was welded on the top of the cut off casing. The cellar was removed and the cellar back filled with clean soil.

The well sites were cleared of all equipment and cleaned up. The well pipes were approximately 3 m. below grade and capped with a steel plate before the rig cellars were backfilled with soil. The concrete rig pads, other foundations and the cuttings pits were left on site for MOGE future use.

1.5 Emission, Discharges and Waste Management

1.5.1 Extra Drilling Mud

At the end of the first well location, the left over drilling mud was transferred and used at the next well location. At the end of drilling campaign, the left over mud was sent back to mud contractor for reuse or disposal or use for PTTEP offshore drilling campaign or handover to MOGE for future use. After the wells were actually abandoned rather than completed as a producer, some of this mud was used to make the kill weight spacer between the cement plugs.

1.5.2 Drilled Cuttings Management

The largest waste stream from the exploration drilling program are the drilled cuttings removed from the wellbore and spent drilling fluids. Drilling fluids are circulated downhole and routed to a solids control system such as shale shaker and centrifuge at the surface facilities where fluids can be separated from the cuttings so that they may be recirculated downhole leaving the cuttings behind for disposal. These cuttings contain a proportion of residual drilling fluid. The cuttings placed in the concrete lined pits and further transferred to High Density Polyethylene (HDPE) lined pits for storage until the drilling campaign finished. Finally, all the drilled cuttings treated onsite and further dispose at DOWA waste management facility at Thilawa SEZ. PTTEP SA managed the drilled cuttings according to the IFC On-shore Oil and Gas Guidelines for the treatment and disposal of drilling fluids and drilled cuttings. The detail of drilled cuttings waste management are as follows;

(a) General Information

PTTEP SA already drilled four exploration wells at MOGE-3 Onshore Block Thayat Township and kept all synthetic-based mud (SBM) cutting and water-based mud (WBM) cutting in separate pit. All waste pits are covered by tarpaulin sheet to avoid rain water come into the pit (as Figure 1-6).

Figure 1-6 All waste pits are covered by tarpaulin sheet

Figure 1-6 (Cont.) All waste pits are covered by tarpaulin sheet

Golden Dowa Eco-System Myanmar Co., Ltd who has license waste management company in Myanmar was contracted to provide waste collection, transportation and disposal service of drilling wastes from PTTEP SA drilling site to Dowa secured landfill area and wastewater treatment plant-Thilawa, Yangon.

(b) Detail waste disposal process

All the cuttings from WBM and SBM pits are disposed at hazardous and non-hazardous land fill at DOWA facility according to the nature of the drilled cuttings and disposal method.

Firstly, the fluid from the cuttings pits are transferred into the available water pit at site. Then the cuttings are transferred into jumbo bag by using hopper. Jumbo bag are designed to prevent any spillage with PE liner and cross bottom sling (Figure 1-7). After the jumbo bag is 80% full, it is ready to transport. Then the jumbo bag will be transferred to trailer with open top container which designed with HDPE liner inside and covered with canvas during transportation.

Figure 1-7 Jumbo bag with PE liner and cross bottom sling

The total weight of all wastes from each well sites are listed as Table 1-4 and all the disposal certificate provided in Appendix C-1.

Table 1-4 Total weight of all wastes from each well site

Well Name	Weight of wastes (Kg)				
	Non-Hazardous	Hazardous			
	WBM Cuttings	SBM Cuttings	Waste Water	Oil waste	Soil Waste
Sakangyi	396,660	729,580	215,840	2,340	7,650
Monatkone	836,220	2,260,880	137,560	6,350	8,585
Padaukpin	467,780	1,002,500	316,300	6,320	3,410
Nagbatkya	328,140	943,200	457,800	6,250	2,120
Total	**2,028,800**	**4,936,160**	**1,127,500**	**21,260**	**21,765**

(c) Transportation

All the trailers and boxers to use in the waste disposal are inspected by PTTEP SA and waste management company before mobilization to site. Example of trailers and boxer are shown in Figure 1-8.

Figure 1-8 Example of trailers and boxers for waste disposal transportation

Additional leakage prevention also provided by applying HDPE liner inside the bottom of the container until 80% of the container. The purpose of the container is to ensure the jumbo bag are well secure from dropping and leaking to public road. Container will be covered with Canvas during the transport that is to minimize the exposure to the public area as shown in Figure 1-9.

Figure 1-9 HDPE liner was applied inside the bottom of container and covered by Canvas

The waste disposal transportation routes are provided as shown in Figure 1-10.

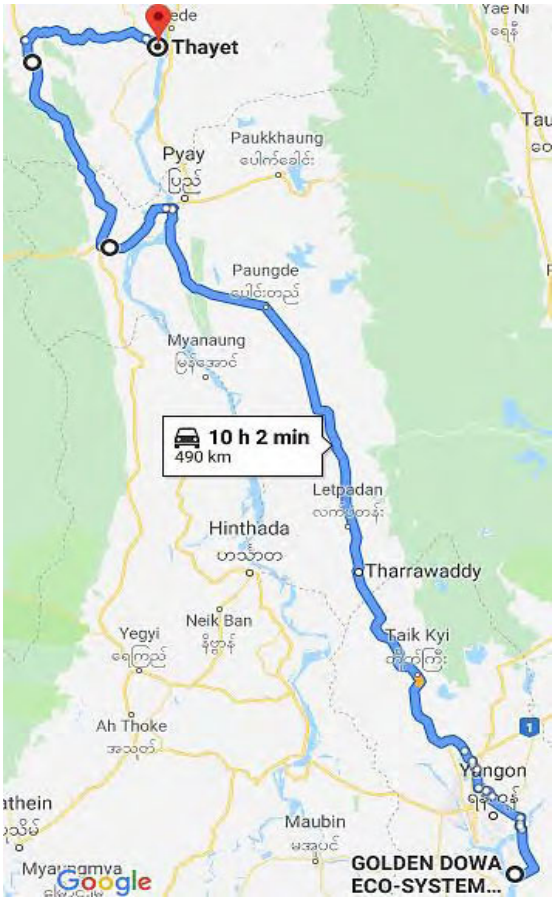

Figure 1-10 Waste disposal transportation route

(d) Others Control Measures

During waste management on site and transportation, proper safety measures are provided such as PPE for all crew, safety sign at site, safety equipment and spill response equipment and journey management plan. In addition, emergency response plan for any spill and accident are also in place in case of any emergency.

1.5.3 Air Emission

During the well abandonment phase, dust was the main air quality issue while demolition & restoration activity and transportation. Any emissions were reduced significantly by the standard procedure of equipping all transportation with proper packaging and covering. For combustion emission, combustion product from demolition & restoration activity and transportation was diesel fuel combustion. Diesel combustion from vehicles were emitted greenhouse gases. The amount of emissions would be varying with time, depend on the operational activity and power demand.

1.5.4 Noise

During the well abandonment phase, noise was generated from machines/engines during site demolition & restoration and transportation. However, all the well sites are far away from community area and assumed it is not affected to community. In addition, the workers are provided with PPE throughout the operation phase.

1.6 Safety, Security, Health and Environment Management System

1.6.1 PTTEP Corporate Vision and Mission

All levels of line management at PTTEPI are responsible for implementing and maintaining its SSHE policy and SSHE MS. Both documents are reviewed and revised at regular intervals.

- **Vision Mission and Corporate Values**

  Vision: “Energy Partner of Choice” through Competitive Performance and Innovation for Long-term Value Creation.”

  Mission: “PTTEP operates globally to provide reliable energy supply and sustainable value to all stakeholders.”

1.6.2 PTTEP Myanmar Asset Safety Security Health and Environment (SSHE) Policy

PTTEP Myanmar Asset is committed to safe Exploration and Production (E&P) Operations in Myanmar with an ultimate goal of "Target Zero - Nobody Gets Hurts in Our Operations" which covers (1) Zero Injury, (2) Zero Major Accident (e.g. zero major hydrocarbon leak, vehicle accident, ship collision), and (3) Zero Spill or External Complaint (e.g. zero complaint by authorities/ communities/ sea users).

To accomplish this, PTTEP Myanmar Asset Implements Safety, Security, Health and Environmental Management System (SSHE-MS) that outlines the main principles and accountabilities to drive for continuous improvement. We are committed to:

- Comply with Myanmar SSHE laws, other applicable requirements and PTTEP Standards.
- Perform hazard identification and SSHE risk assessments so that risks are As Low As Reasonably Practicable (ALARP).
- Hold employees accountable for SSHE performance by setting and monitoring SSHE Plans and KPIs.
- Prevent operational and process incidents by implementing asset integrity programs and monitoring of Safety Critical Elements addressed in Safety Cases and complying with Management of Change (MOC) Standard.
- Work with contractors and suppliers to achieve PTTEP's SSHE requirement.
- Ensure all employees and contractors are assessed and maintain the required level of job and SSHE competency.
- Apply "Stop Work Authority Policy" for unsafe work by implementing Behavior-Based Safety (BBS) programs to improve positive SSHE culture.
- Implement security management for potential threats to safeguard personnel, assets, information and reputation.
- Promote occupational health and hygiene in the workplace by conducting health risk assessments, medical
- Surveillances, education and regular industrial hygiene monitoring.
- Prevent environmental impacts by strictly following the mitigation measures stated in Environmental Impact Assessment.
- Promote sustainable development by implementing waste management, greenhouse gas reduction and energy efficiency programs.

- Report, investigate and analyse SSHE incidents to prevent recurrence and close out corrective actions with evidence.
- Ensure that emergency and crisis management plans are proactive and effective.
- Ensure policy and SSHE Management System compliance through regular SSHE audits and Senior Management visits with corrective actions follow up for continuous improvement.

  Strong leadership and commitment is a key successful implementation of this policy which is required from PTTEP employees and contractors at all levels.

1.6.3 SSHE Management System Manual

PTTEP SA's SSHE Management System Manual objective is to serve as practical interpretation of Company SSHE policy with respect to their moral obligations for SSHE issues for all persons working on, visiting or affected by operations at sites for which PTTEP SA has responsibility.

The manual covers details on the areas specified in Table 1-5. The document is designed to serve as a comprehensive guide for all Operational Assets to develop its own SSHE management system and related documents. This document also provides an overview of SSHE management system approach.

It should be noted that PTTEP SA currently does not have its own internal SSHE policies, however PTTEP International Limited (PTTEPI) Myanmar Asset policies will be applied. For this project, PTTEP SA will adopt all of PTTEPI's relevant SSHE policies and procedures. Throughout this chapter, SSHE policies, procedures and documents was referred to as belonging to PTTEP SA, however they actually belong to PTTEPI and are being adopted by PTTEP SA for this project. The detail Plan and Procedure have been submitted at EIA report and monitoring report of Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign (Construction and Installation Phase).

Table 1-5 PTTEPI SSHE Management System

Document Code	Document
11027-PDR-SSHE-306/01-R03	Myanmar Asset SSHE Compliance Obligations Procedure
11027-PDR-SSHE-505_37-R01	Myanmar Asset Land Transport Safety Procedure
11027-PDR-SSHE-503/01-R02	Myanmar Asset Waste Management Procedure
11027-PDR-SSHE-502-006-R00	Myanmar Asset Emergency Management Plan
11027-PDR-SSHE-501-005-R00	Myanmar Asset Crisis Management Plan
11027-PDR-SSHE-564-002-R00	Myanmar Asset Alcohol and Drugs Testing Procedure
11027-PDR-SSHE-530-004-R00	Myanmar Asset Security Management Procedure
11027-PDR-SSHE-501/03-R02	Myanmar Asset Spill Contingency Plan
Myanmar-SSHE-11027-PDR-508	Fitness to Work Procedure
Myanmar-0550-MNL-004	Land Campaign Blowout Contingency Plan
11027-PDR-SSHE-340-003-R01	SSHE Training and Competency Procedure
Myanmar 13036-PDR-078	PTTEPI SSHE Requirements for Contractors
11027-PDR-SSHE-501-007-R02	MOGE-3 Operations Medical Emergency Response Plan (MERP)

1.7 Environmental Impact Monitoring Implementation

Environmental impact monitoring result and conclusion are shown in Chapter 2 and Chapter 3, respectively.

Chapter 2

Environmental Monitoring Result

Chapter 2
Environmental Monitoring Results

Environmental monitoring was conducted as specified in the EIA's environmental impact monitoring measures (Appendix B) which the project has assigned REM-UAE Laboratory and Consultant Company Limited to perform the environmental monitoring. This chapter presents the environmental monitoring results of Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign during Well Abandonment Phase, the detail is presented as follow;

2.1 Environmental Monitoring Plan

Environmental monitoring for Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign during Well Abandonment Phase is shown in Table 2-1.

Table 2-1 Environmental Monitoring Plan of Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign in Well Abandonment Phase at Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite

Environmental Quality	Parameter	Period/Frequency	Location	Status of Implementation
1. Air Quality	• PM-10 • PM-2.5 • NO_2 • SO_2 • O_3 • H_2S	**Duration:** 1 day continuously **Frequency:** • In case of any complaint regarding air quality, an additional air quality measurement may be conducted in response to specific complaints (if necessary)	Nearest sensitive receptor or downwind of complaint area (if necessary)	The monitoring is not required since there is no complaint throughout the project activity.
2. Noise	• $L_{Aeq\ 24\ hrs}$ • L_{Amax} • L_{Adn}	**Duration:** 1 day continuously **Frequency:** • In case of a complaint regarding noise from project site, an additional noise measurement may be conducted (if necessary)	100 meters from Drilling Rig / Sensitive Receptor	The monitoring is not required since there is no complaint throughout the project activity.
3. Soil	• Soil Texture • Conductivity • Salinity • Moisture Content • Chloride • Ammonia as N • Heavy Metals: As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, V, Zn • Total PAH • Total DDT • Total PCBs • TPH	• Once after well abandoned and site restored within 3 months.	Project site <u>Moenatkone (MNK) wellsite:</u> - Well 01 Moenatkone <u>Ngabetkya (NBK) wellsite:</u> - Well 02 Ngabetkya <u>Padaukpin (PDP) wellsite:</u> - Well 03 Padaukpin <u>Sakangyi (SKG) wellsite:</u> - Well 04 Sakangyi	Monitored by REM-UAE Laboratory and Consultant Co., Ltd. The result as shown in Section 2.2.
		• In an event of spillage and leakage.	At the spillage or leakage areas	The monitoring is not required since there is no spillage throughout the project activity.

Table 2-1 Environmental Monitoring Plan of Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign in Well Abandonment Phase at Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite

Environmental Quality	Parameter	Period/Frequency	Location	Status of Implementation
4. Surface water	• pH • Temperature • Conductivity • Total Dissolved Solids (TDS) • Salinity • Dissolved Oxygen (DO) • Total Suspended Solids (TSS) • Chlorine (Total residual) • Cyanide (free) • Cyanide (Total) • Fluoride • Ammonia • Total Nitrogen • Total Phosphorus • Sulphide • Heavy Metals: Cr^{6+}, As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn, Fe • Oil and grease • COD • BOD (BOD_5) • Phenols (as Phenol) • Total Coliform Bacteria (TCB)	• Once after well abandoned and site restored within 3 months.	• At the same surface water sampling station before having project (Baseline) <u>Moenatkone (MNK) wellsite:</u> - SW01_01 MOENATKONE[1/] - SW01_02 MOENATKONE <u>Ngabetkya (NBK) wellsite:</u> - SW02_03 NGABETKYA[2/] - SW02_04 NGABETKYA <u>Padaukpin (PDP) wellsite:</u> - SW03_05 PADAUKPIN - SW03_06 PADAUKPIN[3/] <u>Sakangyi (SKG) wellsite:</u> - SW04_07 SAKANGYI - SW04_08 SAKANGYI[2/]	Monitored by REM-UAE Laboratory and Consultant Co., Ltd. The result as shown in Section 2.3.
		• In an event of spillage and leakage.	• Water sources which are potentially affected (in case of spillage of leakage.	The monitoring is not required since there is no spillage throughout the project activity.

Table 2-1 Environmental Monitoring Plan of Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign in Well Abandonment Phase at Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite

Environmental Quality	Parameter	Period/Frequency	Location	Status of Implementation
5. Groundwater	• pH • Temperature • Conductivity • Total Dissolved Solids (TDS) • Salinity • Total Suspended Solids (TSS) • Chlorine (Total residual) • Cyanide (free) • Cyanide (Total) • Fluoride • Ammonia • Total Nitrogen • Total Phosphorus • Sulphide • Heavy Metals: Cr^{6+}, As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn, Fe • Oil and grease • COD • BOD (BOD_5) • Phenols (as Phenol) • Total Coliform Bacteria (TCB)	• Once after well abandoned and site restored within 3 months.	• Nearest groundwater well or just off well pad area <u>Moenatkone (MNK) wellsite:</u> - GW01_01 MOENATKONE - GW01_02 MOENATKONE <u>Ngabetkya (NBK) wellsite:</u> - GW02_03 NGABETKYA - GW02_04 NGABETKYA <u>Padaukpin (PDP) wellsite:</u> - GW03_05 PADAUKPIN - GW03_06 PADAUKPIN <u>Sakangyi (SKG) wellsite:</u> - GW04_07 SAKANGYI - GW04_08 SAKANGYI	Monitored by REM-UAE Laboratory and Consultant Co., Ltd. The result as shown in Section 2.4.
		• In event of spillage and leakage	• Area of possible spill	The monitoring is not required since there is no spillage throughout the project activity.

Table 2-1 Environmental Monitoring Plan of Myanmar Onshore Block MOGE-3 Exploration Drilling Campaign in Well Abandonment Phase at Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite

Environmental Quality	Parameter	Period/Frequency	Location	Status of Implementation
6. Social	• Complaint • Monitoring and solving	• Once after well abandoned and site restored within 3 months.	• Project area, community around project area, and transportation route	Monitored by PTTEP SA throughout the project activity at all four well sites. The result are shown in Section 2.5.
7. Public and Occupational Health and Safety	• Accidental statistics • cause of accidents • Mitigation measures	• Throughout well abandonment phase	Project area, community around project area, and transportation route	Monitored by PTTEP SA throughout the project activity at all four well sites. The result are shown in Section 2.6.

Remarks: 1/ Surface water sampling at SW01_01 was not collected due to lack of water in the stream.

2/ Surface water sampling at SW04_08 and SW02_03 were not collected because there is no access road and no water.

3/ Surface water sampling at SW03_06 was not collected because the station was made into a fish pond by local people.

2.2 Soil Monitoring

Soil monitoring was conducted for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited. The detail as shown in Table 2-2 and Figure 2-1.

Table 2-2 Soil Monitoring on 22-23 June 2020

Parameter	Location
• Soil Texture • Conductivity • Salinity • Moisture Content • Chloride • Ammonia as N • Heavy Metals: As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, V, Zn • Total PAH • Total DDT • Total PCBs • TPH	Moenatkone (MNK) wellsite: - Well 01 Moenatkone Ngabetkya (NBK) wellsite: - Well 02 Ngabetkya Padaukpin (PDP) wellsite: - Well 03 Padaukpin Sakangyi (SKG) wellsite: - Well 04 Sakangyi

Well 01 Moenatkone

Well 02 Ngabetkya

Well 03 Padaukpin

Well 04 Sakangyi

Figure 2-1 Soil monitoring in Well Abandonment Phase during June 22-23, 2020

2.2.1 Soil Monitoring Station

Soil monitoring stations are shown in Table 2-3 and Figure 2-2.

Table 2-3 Coordinate of Soil Monitoring Stations

Monitoring Station	Coordinates (UTM Datum WGS 84)		
	Zone	East (X)	North (Y)
Moenatkone (MNK) well site			
- Well 01 Moenatkone	46Q	709302.07	2158652.90
Ngabetkya (NBK) well site			
- Well 02 Ngabetkya	46Q	708761.00	2150024.00
Padaukpin (PDP) well site			
- Well 03 Padaukpin	46Q	718227.82	2143554.35
Sakangyi (SKG) well site			
- Well 04 Sakangyi	46Q	721000.78	2143463.06

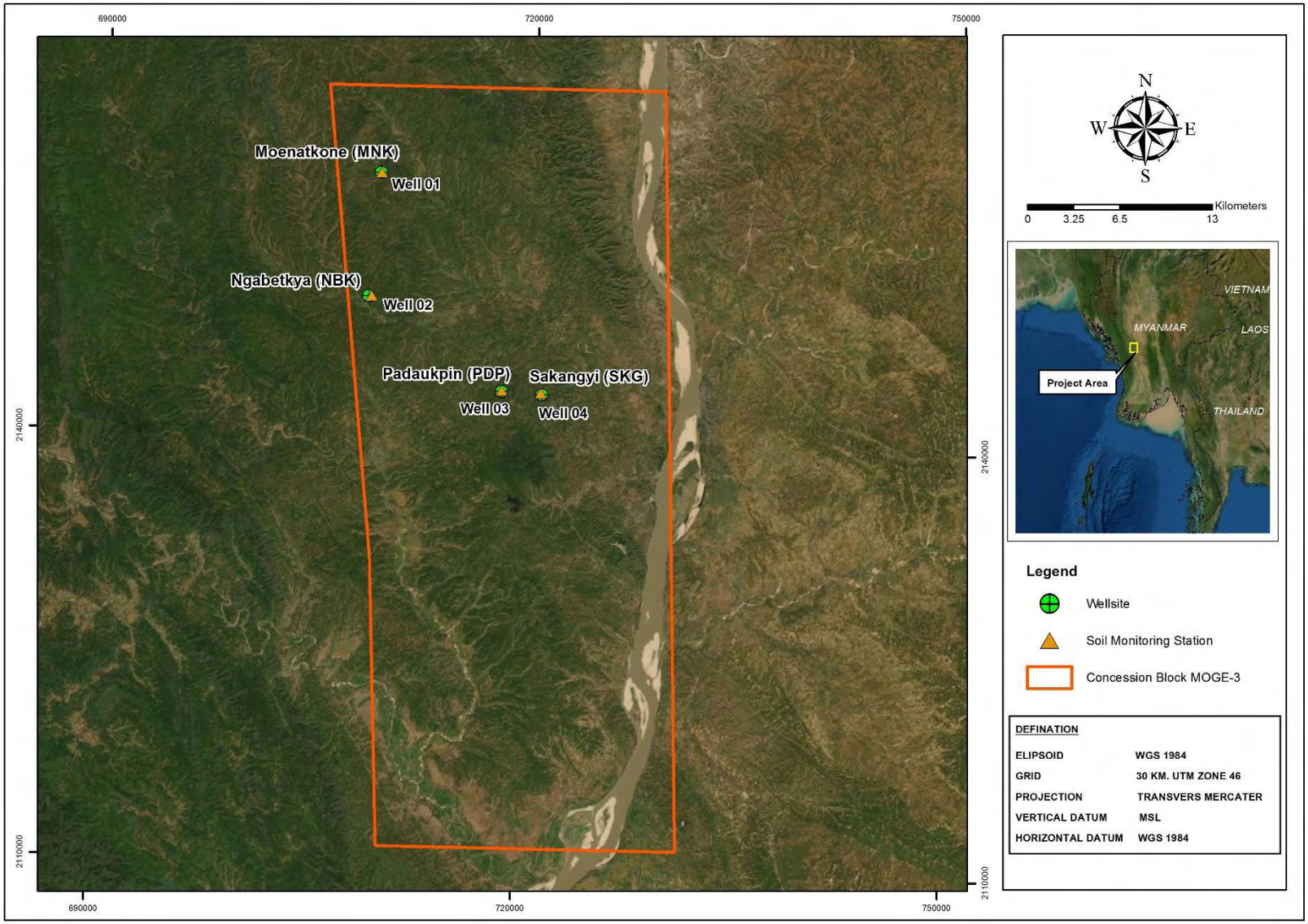

Figure 2-2 Soil Monitoring Stations

2.2.2 Soil Monitoring Method

Details of Soil monitoring including parameters and analysis methods are shown in Table 2-4.

Table 2-4 Parameters and Analysis Methods for Soil Monitoring

Parameter	Unit	Analysis Method*
1. Soil texture	-	Sieve Analysis and Hydrometer Testing
2. Conductivity	ds/m	Electrical Conductivity Method
3. Salinity	ppt	Electrical Conductivity Method
4. Moisture Content	%	ASTM D2974 - 14
5. Chloride	% w/w	BS 1377 Part 3, 1990
6. Ammonia as N	mg/kg	Kjeldahl Method (SM: 4500-NH_3 B and 4500-NH_3 C)
7. Arsenic (As)	mg/kg As	Acid Digestion and Hydride Generation AAS Method
8. Cadmium (Cd)	mg/kg Cd	Acid Digestion and Direct Air-Acetylene Flame Method
9. Chromium (Cr)	mg/kg Cr	Acid Digestion and Direct Air-Acetylene Flame Method
10. Copper (Cu)	mg/kg Cu	Acid Digestion and Direct Air-Acetylene Flame Method
11. Lead (Pb)	mg/kg Pb	Acid Digestion and Direct Air-Acetylene Flame Method
12. Mercury (Hg)	mg/kg Hg	Acid Digestion and Cold Vapor AAS Method
13. Nickel (Ni)	mg/kg Ni	Acid Digestion and Direct Air-Acetylene Flame Method
14. Silver (Ag)	mg/kg Ag	Acid Digestion and Inductively Coupled Plasma (ICP) Method
15. Vanadium (V)	mg/kg V	Acid Digestion and Inductively Coupled Plasma (ICP) Method
16. Zinc (Zn)	mg/kg Zn	Acid Digestion and Direct Air-Acetylene Flame Method
17. Total PAH	mg/kg	Ultrasonic Extraction and Gas Chromatographic (FID) Method
18. Total DDT	mg/kg	Ultrasonic Extraction and Gas Chromatographic (ECD) Method
19. Total PCBs	mg/kg	Ultrasonic Extraction and Gas Chromatographic (ECD) Method
20. Total Petroleum Hydrocarbons		
- TPH C_6 - C_9	mg/kg	Purge and Trap/Gas Chromatographic (FID) Method
- TPH C_{10} - C_{14}	mg/kg	Ultrasonic Extraction and Gas Chromatographic (FID) Method
- TPH C_{15} - C_{28}	mg/kg	Ultrasonic Extraction and Gas Chromatographic (FID) Method
- TPH C_{29} - C_{36}	mg/kg	Ultrasonic Extraction and Gas Chromatographic (FID) Method

Remark: * U.S.EPA = Test Methods Evaluating Solid Waste, Physical/Chemical Methods (SW 846), United States Environmental Protection Agency)

2.2.3 Soil Sampling Method

All soil sampling stations were marked on ground. For each station, soil sample was grabbed at 30-45 cm depth from soil surface by Hand Auger as shown in Figure 2-1.
At field site, quality control was conducted by the scientists to comply with procedures of ISO/IEC 17025:2017 by wearing free-flour rubber gloves to protect any contamination during sampling. The sampler was cleaned by distilled water at each sampling location before drilling soil sample. At every soil sampling stations, sampling station code and sampling date were recorded.
Soil sample was collected in clean container. Equipment Blank was conducted to check the equipment contamination during sampling by washing all sampling equipment with distilled water and analysis the rinsed water for all parameters as the sample. All containers were sealed in zip lock plastic bags to protect any contamination from ice during preservation in cooling box and shipped to the laboratory.

2.2.4 Preservation Methods for Soil Sample

All samples were preserved with specific procedure and storage as shown in Table 2-5.

Table 2-5 Preservation Methods for Soil Sample

Parameter	Container	Preservation Method*
1. Soil texture	Plastic Zip Lock Bag	Refrigerate $\leq 6\,^{0}C$
2. Conductivity	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
3. Salinity	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
4. Moisture Content	Polyethylene Bottle 150 mL	-
5. Chloride	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
6. Ammonia as N	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
7. Arsenic (As)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
8. Cadmium (Cd)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
9. Chromium (Cr)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
10. Copper (Cu)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
11. Lead (Pb)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
12. Mercury (Hg)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
13. Nickel (Ni)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
14. Silver (Ag)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
15. Vanadium (V)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
16. Zinc (Zn)	Polyethylene Bottle 150 mL	Refrigerate $\leq 6\,^{0}C$
17. Total PAH	Amber Glass 300 mL	Refrigerate $\leq 6\,^{0}C$
18. Total DDT	Amber Glass 300 mL	Refrigerate $\leq 6\,^{0}C$

Table 2-5 (Cont.) Preservation Methods for Soil Sample

Parameter	Container	Preservation Method*
19. Total PCBs	Amber Glass 300 mL	Refrigerate ≤ 6 ^{0}C
20. Total Petroleum Hydrocarbons	Amber Glass 300 mL	Refrigerate ≤ 6 ^{0}C

Remark: * U.S.EPA = Test Methods Evaluating Solid Waste, Physical/Chemical Methods (SW 846), United States Environmental Protection Agency)

2.2.5 Soil Monitoring Results and Comparison

Referring to analysis no. T20AJ906-0001 to T20AJ906-0004, soil was collected by REM-UAE staff on June 22-23, 2020 during well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite. Most of parameters at each station complied with the standard for Coarse Grained Agricultural Soil from Canadian Council of Ministers of the Environment. 2007. Canadian soil quality guidelines for the protection of environmental and human health: Summary tables. Updated September 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg except Chromium at Well 04 and Nickel at all stations.

In comparison of soil monitoring results in well abandonment phase in 2020 with baseline survey in 2018 of the project found that most of parameters rather similar to baseline survey and below the guideline value for agricultural purposes. However, Chromium (Cr) at Well 01 and Well 02 was found above the guideline value in baseline survey but decreased until complied with the guideline value in well abandonment phase. For Well 04, Chromium (Cr) has exceeded the guideline value since baseline survey. Nickel (Ni) was also found above the guideline value since baseline survey at Well 01, Well 02 and Well 04.

Base on the baseline survey, these areas have been used for agriculture including cultivated, uncultivated and livestock. Therefore, accumulation of heavy metals from fertilizers, pesticides or animal manures might have contaminated to the land and resulted in detected heavy metals. Moreover, chemical used for drilling phase of the project were not different from the list that mentioned in the EIA report and not contained Chromium (Cr) and Nickel (Ni). In conclusion, the project's activity during well abandonment phase doesn't result in the detected heavy metals.

The monitoring results and comparison are shown in Table 2-6. The analysis results, certificate for laboratory instrument and approval registration certificate of laboratory are shown in Appendix E, F and G.

Table 2-6 The Comparison of Soil Monitoring results

Parameter	Unit	The Results of Soil Monitoring								Standard	Detection Limit
		Well 01 Moenatkone		Well 02 Ngabetkya		Well 03 Padaukpin		Well 04 Sakangyi			
Date of sampling	**-**	**7-Feb-18**	**23-Jun-20**	**8-Feb-18**	**23-Jun-20**	**6-Feb-20**	**23-Jun-20**	**6-Feb-20**	**22-Jun-20**	**-**	**-**
Soil texture	-	Silty Clay	Silty Clay	Silt Loam	Silty Clay	Sandy Clay Loam	Silty Clay	Clay	Silty Clay	-[3/]	-
Particles size											
- Clay (< 0.002 mm.)	%	37	67.6	23	66.4	24	69.7	46	73.3	-[3/]	-
- Gravel (> 2.00 mm.)	%	0	1.4	2	1.4	0	1.1	0	0.0	-[3/]	-
- Sand (0.063-2.00 mm)	%	5	4.3	15	4.8	51	3.6	18	2.2	-[3/]	-
- Silt (0.002-0.063 mm.)	%	58	26.7	60	27.4	25	25.6	36	24.5	-[3/]	-
Conductivity	ds/m	0.014	0.55 (25°C)	0.324	0.36 (25°C)	0.026	1.70 (25°C)	0.094	0.67 (25°C)	2[1/]	-
Salinity	ppt	< 0.1	0.0	0.2	0.0	< 0.1	0.1	0.1	0.0	-[3/]	-
Moisture Content	%	9.1	9.3	6.6	8.1	3.2	7.9	18.8	7.6	-[3/]	-
Chloride	% w/w	110[4/]	ND	540[4/]	ND	80[4/]	ND	80[4/]	ND	-[3/]	0.01
Ammonia as N	mg/kg	< 10	12.1	< 10	ND	< 10	ND	< 10	ND	-[3/]	10
Arsenic (As)	mg/kg As	8	5.18	7	7.16	3	3.51	5	3.29	12[1/]	0.100
Cadmium (Cd)	mg/kg Cd	< 0.2	ND	< 0.2	ND	< 0.2	ND	< 0.2	ND	1.4[1/]	0.300
Chromium (Cr)	mg/kg Cr	**92**	50.5	**77**	46.4	39	49.4	**111**	**71.8**	64[1/]	0.500
Copper (Cu)	mg/kg Cu	33	25.4	30	16.1	10	25.4	39	31.1	63[1/]	0.300
Lead (Pb)	mg/kg Pb	20	15.1	24	10.9	9	13.0	14	11.7	70[1/]	1.55
Mercury (Hg)	mg/kg Hg	< 0.05	ND	< 0.05	ND	< 0.05	ND	< 0.05	ND	6.6[1/]	0.100
Nickel (Ni)	mg/kg Ni	**102**	**88.9**	**81**	**66.7**	32	**71.4**	**108**	**104**	50[1/]	1.00
Silver (Ag)	mg/kg Ag	< 1.0	ND	< 1.0	ND	< 1.0	ND	< 1.0	ND	20[1/]	0.250
Vanadium (V)	mg/kg V	78	46.4	63	48.0	32	39.2	97	66.7	130[1/]	0.250

Table 2-7 (Cont.) The Comparison of Soil Monitoring

Parameter	Unit	The Results of Soil Monitoring								Standard	Detection Limit
		Well 01 Moenatkone		Well 02 Ngabetkya		Well 03 Padaukpin		Well 04 Sakangyi			
Date of sampling	**-**	**7-Feb-18**	**23-Jun-20**	**8-Feb-18**	**23-Jun-20**	**6-Feb-20**	**23-Jun-20**	**6-Feb-20**	**22-Jun-20**	**-**	**-**
Zinc (Zn)	mg/kg Zn	93	76.4	82	56.1	28	75.2	101	84.7	200[1/]	0.350
Total PAH	mg/kg	ND[5/]	ND	ND[5/]	ND	ND[5/]	ND	ND[5/]	ND	-[3/]	0.18
Total DDT	mg/kg	< 0.20	ND	< 0.20	ND	< 0.20	ND	< 0.20	ND	0.7[1/]	0.001
Total PCBs	mg/kg	< 0.1	ND	< 0.1	ND	< 0.1	ND	< 0.1	ND	0.5[1/]	0.10
Total Petroleum Hydrocarbons											
- TPH C_6 - C_9	mg/kg	< 2	ND	< 2	ND	< 2	ND	< 2	ND	30[2/]	1.00
- TPH C_{10} - C_{14}	mg/kg	< 50	ND	< 50	ND	< 50	ND	< 50	ND	150[2/]	1.00
- TPH C_{15} - C_{28}	mg/kg	< 100	ND	**4,370**	ND	< 100	ND	< 100	ND	300[2/]	1.00
- TPH C_{29} - C_{36}	mg/kg	< 100	ND	2,440	ND	< 100	ND	< 100	ND	2,800[2/]	1.00
Sample Condition	-	-	Brown soil	-	Brown soil	-	Brown soil	-	Brown soil	-	-

Remark:

1/ : Standard for Coarse Grained Agricultural Soil from Canadian Council of Ministers of the Environment. 2007. Canadian soil quality guidelines for the protection of environmental and human health: Summary tables. Updated September, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

2/ : Canadian Council of Ministers of the Environment, CANADA-WIDE STANDARDS for PETROLEUM HYDROCARBONS (PHC) IN SOIL, 2008.

3/ : Not specified in the standards.

4/ : Chloride of baseline survey result was analyzed in unit of mg/kg.

5/ : The value of detection limit for Total PAH was not remarked in the baseline survey result.

ND : Non-Detectable

2.3 Surface Water Monitoring

Surface water monitoring was conducted for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited. The detail as shown in Table 2-7 and Figure 2-3.

Table 2-7 Surface Water Monitoring on 22-23 June 2020

Parameter	Location	Remark
• pH • Temperature • Conductivity • Total Dissolved Solids (TDS) • Salinity • Dissolved Oxygen (DO) • Total Suspended Solids (TSS) • Chlorine (Total residual) • Cyanide (free) • Cyanide (Total) • Fluoride • Ammonia • Total Nitrogen • Total Phosphorus • Sulphide • Heavy Metals: Cr^{6+}, As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn, Fe • Oil and grease • COD • BOD (BOD_5) • Phenols (as Phenol) • Total Coliform Bacteria (TCB)	Moenatkone (MNK) wellsite: - SW01_01 MOENATKONE - SW01_02 MOENATKONE Ngabetkya (NBK) wellsite: - SW02_03 NGABETKYA - SW02_04 NGABETKYA Padaukpin (PDP) wellsite: - SW03_05 PADAUKPIN - SW03_06 PADAUKPIN Sakangyi (SKG) wellsite: - SW04_07 SAKANGYI - SW04_08 SAKANGYI	The sample for SW01_01, SW02_03 and SW04_08 cannot be collected due to the stream is run out of water. The sample for SW03_06 cannot be collected due to the area is not allowed to enter since it was changed to be a fish farm by local people.

SW01_01 Moenatkone

SW01_02 Moenatkone

SW02_04 Ngabetkya

SW03_05 Padaukpin

SW04_07 Sakangyi

Figure 2-3 Surface water monitoring in Well Abandonment Phase during June 22-23, 2020

2.3.1 Surface Water Monitoring Station

Surface water monitoring stations are shown in Table 2-8 and Figure 2-4.

Table 2-8 Coordinate of Surface Water Monitoring Stations

Monitoring Station	Coordinates (UTM Datum WGS 84)		
	Zone	East (X)	North (Y)
Moenatkone (MNK) well site			
- SW01_02 MOENATKONE	46Q	711073.80	2159568.29
Ngabetkya (NBK) well site			
- SW02_04 NGABETKYA	46Q	708346.24	2149398.20
Padaukpin (PDP) well site			
- SW03_05 PADAUKPIN	46Q	719033.75	2142490.03
Sakangyi (SKG) well site			
- SW04_07 SAKANGYI	46Q	722011.00	2142012.87

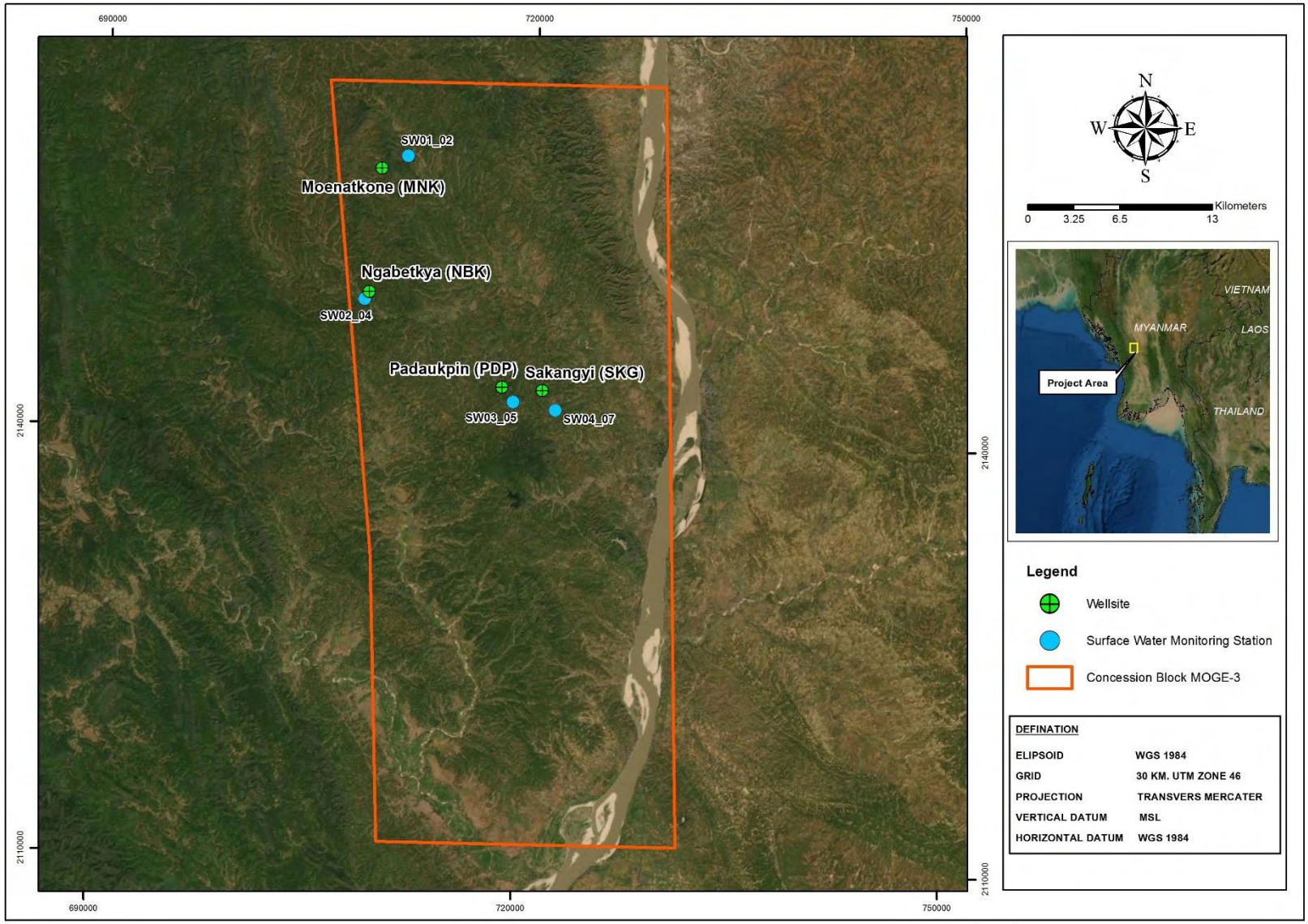

Figure 2-4 Surface Water Monitoring Stations

2.3.2 Surface Water Monitoring Method

Details of Surface water monitoring including parameters and analysis methods are shown in Table 2-9.

Table 2-9 Parameters and Analysis Methods for Surface Water Monitoring

Parameter	Unit	Analysis Method*
1. pH	-	Electrometric method at site
2. Temperature	^{0}C	Thermometer at site
3. Conductivity	µS/cm	Electrical conductivity method at site
4. Total dissolved solid (TDS)	mg/L	Total dissolved solid dried at 180^{0}C
5. Salinity	ppt	Electrical conductivity method at site
6. Dissolved Oxygen (DO)	mg/L	Membrane Electrode method at site
7. Total suspended solid (TSS)	mg/L	Total suspended solid dried at 103-105^{0}C
8. Chlorine (Total residual)	mg/L	Iodometric method I
9. Cyanide (free)	mg/L	Cyanide-Ion selective electrode method
10. Cyanide (total)	mg/L	Distillation, Pyridine-Barbituric acid method
11. Fluoride	mg/L	Spadns method
12. Ammonia	mg/L	Phenate method
13. Total Nitrogen	mg/L	Persulphate method
14. Total Phosphorus	mg/L	Persulphate digestion and ascorbic acid method
15. Sulphide	mg/L	Methylene blue method
16. Hexavalent Chromium (Cr^{6+})	mg/L	Colourimetric method
17. Oil and grease	mg/L	Partition-Gravimetric method
18. COD	mg/L	Closed reflux, Titrimetric method
19. BOD	mg/L	Membrane Electrode method
20. Phenols (as Phenol)	mg/L	Distillation, 4-Aminoantipyrine method
21. Arsenic (As)	mg/L As	Hydride generation AAS method
22. Cadmium (Cd)	mg/L Cd	In-House method UAE.TP.SW.01 (Nitric acid digestion and direct air acetylene flame method)
23. Total Chromium (Cr)	mg/L Cr	In-House method UAE.TP.SW.01 (Nitric acid digestion and direct air acetylene flame method)
24. Copper (Cu)	mg/L Cu	In-House method UAE.TP.SW.01 (Nitric acid digestion and direct air acetylene flame method)
25. Lead (Pb)	mg/L Pb	In-House method UAE.TP.SW.01 (Nitric acid digestion and direct air acetylene flame method)
26. Mercury (Hg)	mg/L Hg	Cold vapour AAS method
27. Nickel (Ni)	mg/L Ni	In-House method UAE.TP.SW.01 (Nitric acid digestion and direct air acetylene flame method)
28. Selenium (Se)	mg/L Se	Hydride generation AAS method

Table 2-9 (Cont.) Parameters and Analysis Methods for Surface Water Monitoring

Parameter	Unit	Analysis Method*
29. Silver (Ag)	mg/L Ag	Nitric acid-Hydrochloric acid digestion and inductively coupled plasma (ICP) method
30. Zinc (Zn)	mg/L Zn	In-House method UAE.TP.SW.01 (Nitric acid digestion and direct air acetylene flame method)
31. Iron (Fe)	mg/L Fe	In-House method UAE.TP.SW.01 (Nitric acid digestion and direct air acetylene flame method)
32. Total Coliform Bacteria (TCB)	MPN/100 ml	Multiple tube fermentation technique

Remark: * American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WEF). 2017. Standard Methods for the Examination of Water and Wastewater. 23rd Edition. Washington, DC: American Public Health Association

2.3.3 Surface Water Sampling Method

Sampling and analysis methods will be conducted according to Standard Methods for the Examination of Water and Wastewater by APHA, AWWA and WEF 23rd Edition. Surface water will be collected by using the grab sampling method as shown in Figure 2-3. To prevent contamination on site during sampling, scientist will clean hands and wear powder-free rubber gloves. All samples will be specifically preserved, labelled and recorded information in field logbook and chain of custody, then keep bottles cool, ship the samples back to United Analyst and Engineering Consultant Co., Ltd. Laboratory (UAE) in Bangkok for analysis within recommended holding times. For station SW01_01, SW02_03, SW03_06 and SW04_08, surface water samples were not collected as the reasons that remarked in Table 2-1 and Table 2-7.

2.3.4 Preservation Methods for Surface Water Sample

All samples were preserved with specific procedure and storage as shown in Table 2-10.

Table 2-10 Preservation Methods for Surface Water Sample

Parameter	Container	Preservation Method*
1. pH	-	Measure at Site
2. Temperature	-	Measure at Site
3. Conductivity	-	Measure at Site
4. Total dissolved solids (TDS)	Polyethylene Bottle 1 L	Refrigerate at > 0^0C , ≤ 6 ^{0}C
5. Salinity	-	Measure at Site
6. Dissolved Oxygen (DO)	-	Measure at Site
7. Total suspended solids (TSS)	Polyethylene Bottle 1 L	Refrigerate at > 0^0C , ≤ 6 ^{0}C

Table 2-10 (Cont.) Preservation Methods for Surface Water Sample

Parameter	Container	Preservation Method*
8. Chlorine (Total residual)	Polyethylene Bottle 1 L	Refrigerate > 0^0C , ≤ 6 ^{0}C
9. Cyanide (free)	Brown, Polyethylene Bottle 500 mL	Refrigerate > 0^0C , ≤ 6 ^{0}C
10. Cyanide (total)	Brown, Polyethylene Bottle 500 mL	Add NaOH to pH < 12 and Refrigerate > 0 ^{0}C, ≤ 6 ^{0}C
11. Fluoride	Polyethylene Bottle 1 L	Refrigerate at > 0^0C , ≤ 6 ^{0}C
12. Ammonia	Glass Bottle 500 mL	Add H_2SO_4 to pH < 2 and Refrigerate > 0 ^{0}C ≤ 6 ^{0}C
13. Total Nitrogen	Polyethylene Bottle 500 mL	Refrigerate > 0 ^{0}C, ≤ 6 ^{0}C
14. Total Phosphorus	Brown Glass Bottle 150 mL	Add H_2SO_4 to pH<2 and Refrigerate > 0^0C, ≤ 6 ^{0}C
15. Sulphide	Polyethylene Bottle 1 L	Add 4 drops 2N Zinc Acetate/ 100 mL Sample, Add NaOH to pH > 9, Refrigerate > 0 ^{0}C ≤ 6 ^{0}C
16. Hexavalent Chromium (Cr^{6+})	Polyethylene Bottle 1 L	Add Ammonium Sulfate Buffer to pH 9.3-9.7 and Refrigerate >0^0C, ≤6 ^{0}C
17. Oil and grease	Glass wide Mouth Bottle 1 L	Add H_2SO_4 to pH < 2 and Refrigerate at > 0^0C, ≤ 6 ^{0}C
18. COD	Glass Bottle 250 mL	Add H_2SO_4 to pH < 2 and Refrigerate > 0 ^{0}C ≤ 6 ^{0}C
19. BOD	Polyethylene Bottle 1 L	Refrigerate at > 0^0C , ≤ 6 ^{0}C
20. Phenols (as Phenol)	Glass Bottle, PTFE Lined Cap 1 L	Add H_2SO_4 to pH < 2 and Refrigerate > 0 ^{0}C, ≤ 6 ^{0}C
21. Arsenic (As)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
22. Cadmium (Cd)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
23. Total Chromium (Cr)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
24. Copper (Cu)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
25. Lead (Pb)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
26. Mercury (Hg)	Glass 250 mL with Teflon Cap	Add HNO_3 to pH < 2 and refrigerate at > 0 ^{0}C, ≤ 6 ^{0}C
27. Nickel (Ni)	Polyethylene Bottle 500 mL	Add HNO_3 to pH<2
28. Selenium (Se)	Polyethylene Bottle 500 mL	Add HNO_3 to pH<2
29. Silver (Ag)	Polyethylene Bottle 500 mL	Add HNO_3 to pH<2
30. Zinc (Zn)	Polyethylene Bottle 500 mL	Add HNO_3 to pH<2
31. Iron (Fe)	Polyethylene Bottle 500 mL	Add HNO_3 to pH<2
32. Total Coliform Bacteria (TCB)	Sterile, Brown Glass Bottle 150 mL	Add 10% $Na_2S_2O_3$ 0.1 mL/100 mL and Refrigerate > 0^0C , < 10 ^{0}C

Remark: * American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WEF). 2017. Standard Methods for the Examination of Water and Wastewater. 23rd Edition. Washington, DC: American Public Health Association

2.3.5 Surface Water Monitoring Results and Comparison

Referring to analysis no. T20AK085-0002, T20AK088-0002, T20AK91-0002, T20AK094-0002, LAA112/2020, LAA115/2020, LAA118/2020 and LAA110/2020. Surface water samples were collected by REM-UAE staff on June 22-23, 2020 during well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite. Most of parameters complied with the guideline values, Environmental, Health, and Safety (EHS) Guidelines, GENERAL EHS GUIDELINES and Myanmar Environmental Quality (Emission) Guidelines, Water Quality Guideline for the Protection of Freshwater Aquatic Life and Agriculture, Canadian Council of Ministers of the Environment.

In comparison of surface water monitoring results during well abandonment phase in 2020 with baseline survey in 2018 found that most of parameters slightly increased from baseline survey but still complied with the guideline values.

pH at SW03_05 and SW04_07, Total Suspended Solids (TSS) at SW01_02, SW02_04 and SW03_05 and Total Coliform bacteria (TCB) at all stations in well abandonment phase increased from baseline survey until above the EHS Guidelines.

Phenols at SW03_05 and SW04_07 and Arsenic (As) at SW03_05 in well abandonment phase increased from baseline survey until above the Water Quality Guideline for the Protection of Freshwater Aquatic Life. Iron (Fe) at SW01_02, SW02_04 and SW04_07 were detected above the guideline value since baseline result and SW03_05 increased from baseline result until not complied with the guideline value. Refer to the result of baseline survey in the EIA report, Iron (Fe) was detected in all stations including groundwater locations. The high levels are attributed to naturally high iron content resulting from geological weathering.

In conclusion, the conditions of each monitoring station might have resulted in high values of some parameters. SW01_02 was a stream which flowing through the laterite road and local people usually use as livestock area, so animal's fecal could contaminate to the water. SW02_04 and SW04_07 was a small pond surrounded by trees and weeds above surface water and there were some herd of cows lived around there. SW03_05 was a small lake which local people use for utilization and there were some municipal wastes contaminated in the lake which might have resulted in high value of Arsenic and Phenols.

The monitoring result and comparison are shown in Table 2-11. The analysis results, certificate for laboratory instrument and approval registration certificate of laboratory are shown in Appendix E, F and G.

Table 2-11 The Comparison of Surface Water Monitoring Results

Parameter	Unit	The Surface Water Monitoring Station								Standard	Detection Limit
		SW01_02 Moenatkone		SW02_04 Ngabetkya		SW03_05 Padaukpin		SW04_07 Sakangyi			
Date of sampling	**-**	**7-Feb-18**	**23-Jun-20**	**8-Feb-18**	**23-Jun-20**	**6-Feb-18**	**23-Jun-20**	**6-Feb-18**	**22-Jun-20**	**-**	**-**
pH	-	8.3	9.0 (34 ^{0}C)	8.5	8.6 (30 ^{0}C)	8	**9.9 (33 ^{0}C)**	8.5	**9.4 (33 ^{0}C)**	6.0 - 9.0[1/]	-
Temperature	^{0}C	20.2	34	23.5	30	22.4	33	22.8	33	-[4/]	-
Conductivity	µS/cm	766	642 (34 ^{0}C)	1,344	351 (30 ^{0}C)	3,200	1,574 (33 ^{0}C)	1,029	2,295 (33 ^{0}C)	-[4/]	-
Total dissolved solid (TDS)	mg/L	543	420	957	293	2,270	890	730	3,010	500-3,500[2/]	25
Salinity	ppt	0.40	0.3	0.74	0.2	1.83	0.7	0.56	1.0	-[4/]	-
Dissolved Oxygen (DO)	mg/L	5.26	7.3	7.76	4.6	5.03	14.9	6.53	13.2	-[4/]	-
Total suspended solid (TSS)	mg/L	11	**59.5**	14	**53.0**	11	**56.0**	15	30.8	35[1/]	5.0
Chlorine (Total residual)	mg/L	< 0.2	ND	< 0.2	ND	< 0.2	ND	< 0.2	ND	0.2[1/]	0.1
Cyanide (free)	mg/L	< 0.005	ND	< 0.005	ND	< 0.005	ND	< 0.005	ND	0.005[3/]	0.05
Cyanide (total)	mg/L	< 0.005	0.005	< 0.005	ND	< 0.005	0.001	< 0.005	ND	1[1/]	0.001
Fluoride	mg/L	0.6	0.44	0.6	0.25	1.1	0.67	2.1	0.74	20[1/]	0.02
Ammonia	mg/L	0.05	0.08	0.05	ND	0.03	3.64	0.01	2.95	10[1/]	0.05
Total Nitrogen	mg/L	0.5	2.05	0.5	0.49	1.1	3.66	1.7	2.75	10[1/]	0.1
Total Phosphorus	mg/L	< 0.10	0.06	< 0.10	0.11	< 0.10	0.05	< 0.10	0.04	2[1/]	0.01
Sulphide	mg/L	< 0.1	0.02	< 0.1	0.02	< 0.1	4.43	< 0.1	0.11	1[1/]	0.02
Hexavalent Chromium (Cr^{6+})	mg/L	< 0.02	ND	< 0.02	ND	< 0.02	ND	< 0.02	ND	0.001[3/]	0.006
Oil and grease	mg/L	< 5	ND	< 5	ND	< 5	ND	< 5	ND	10[1/]	3
COD	mg/L	11	51	11	51	28	49	38	45	125[1/]	25

Table 2-11 (Cont.) The Comparison of Surface Water Monitoring Results

Parameter	Unit	The Surface Water Monitoring Station								Standard	Detection Limit
		SW01_02 Moenatkone		SW02_04 Ngabetkya		SW03_05 Padaukpin		SW04_07 Sakangyi			
Date of sampling	**-**	**7-Feb-18**	**23-Jun-20**	**8-Feb-18**	**23-Jun-20**	**6-Feb-18**	**23-Jun-20**	**6-Feb-18**	**22-Jun-20**	**-**	**-**
BOD	mg/L	< 2	4.4	< 2	4.1	< 2	5.9	4	3.2	25[1/]	1.0
Phenols (as Phenol)	mg/L	< 0.2	ND	< 0.2	ND	< 0.2	**0.117**	< 0.2	**0.017**	0.004[3/]	0.005
Arsenic (As)	mg/L	< 0.01	0.0015	< 0.01	0.0026	< 0.01	**0.0054**	< 0.01	0.0028	0.005[3/]	0.0003
Cadmium (Cd)	mg/L	< 0.0002	ND	< 0.0002	ND	< 0.0002	ND	< 0.0002	ND	0.0051[2/]	0.003
Total Chromium (Cr)	mg/L	< 0.001	ND	0.001	ND	< 0.001	ND	< 0.001	ND	0.0089[3/]	0.010
Copper (Cu)	mg/L	0.001	ND	0.001	ND	< 0.001	ND	0.001	ND	0.7[3/]	0.003
Lead (Pb)	mg/L	< 0.001	ND	< 0.001	ND	< 0.001	ND	< 0.001	ND	0.2[2/]	0.010
Mercury (Hg)	mg/L	< 0.0005	ND	< 0.0005	0.0003	< 0.0005	0.0004	< 0.0005	0.0007	0.003[2/]	0.0002
Nickel (Ni)	mg/L	0.002	ND	0.002	ND	0.002	ND	0.002	ND	0.2[2/]	0.005
Selenium (Se)	mg/L	< 0.01	ND	< 0.01	ND	< 0.01	ND	< 0.01	ND	0.05[2/]	0.0005
Silver (Ag)	mg/L	< 0.001	ND	< 0.001	ND	< 0.001	ND	< 0.001	ND	0.5[1/]	0.003
Zinc (Zn)	mg/L	0.02	ND	< 0.01	< LOQ	< 0.01	ND	< 0.01	ND	0.03[3/]	0.005
Iron (Fe)	mg/L	**0.380**	**4.13**	**0.420**	**2.20**	0.260	**0.775**	**0.340**	**0.318**	0.3[3/]	0.010
Total Coliform Bacteria (TCB)	MPN/ 100 ml	ND[5/]	**4,600**	ND[5/]	**9,400**	**420**	**3,300**	ND[5/]	**3,300**	400[1/]	1.8
Water's colour/Turbid	-	-	Yellow / Turbid	-	Yellow / Turbid	-	Yellow / Turbid	-	Yellow / Turbid	-	-
Sediment	-	-	Yellow	-	Yellow	-	Yellow	-	Yellow	-	-

Remark: 1/ : Environmental, Health, and Safety (EHS) Guidelines, GENERAL EHS GUIDELINES and Myanmar Environmental Quality (Emission) Guidelines

2/ : Water Quality Guideline for the Protection of Agriculture, Canadian Council of Ministers of the Environment

3/ : Water Quality Guideline for the Protection of Freshwater Aquatic Life, Canadian Council of Ministers of the Environment

4/ : Not specified in the standards.

5/ : The value of detection limit for TCB was not remarked in the baseline survey result.

ND : Non-Detectable

< LOQ : < Level of Quantitation (Zinc $\geq$ 0.005 and < 0.025 mg/L)

2.4 Groundwater Monitoring

Groundwater monitoring was conducted for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited. The detail as shown in Table 2-12 and Figure 2-5.

Table 2-12 Groundwater Monitoring on 22-23 June 2020

Parameter	Location
• pH • Temperature • Conductivity • Total Dissolved Solids (TDS) • Salinity • Total Suspended Solids (TSS) • Chlorine (Total residual) • Cyanide (free) • Cyanide (Total) • Fluoride • Ammonia • Total Nitrogen • Total Phosphorus • Sulphide • Heavy Metals: Cr^{6+}, As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn, Fe • Oil and grease • COD • BOD (BOD_5) • Phenols (as Phenol) • Total Coliform Bacteria (TCB)	<u>Moenatkone (MNK) wellsite:</u> - GW01_01 MOENATKONE - GW01_02 MOENATKONE <u>Ngabetkya (NBK) wellsite:</u> - GW02_03 NGABETKYA - SW02_04 NGABETKYA <u>Padaukpin (PDP) wellsite:</u> - GW03_05 PADAUKPIN - GW03_06 PADAUKPIN <u>Sakangyi (SKG) wellsite:</u> - GW04_07 SAKANGYI - GW04_08 SAKANGYI

GW01_01 Moenatkone

GW01_02 Moenatkone

GW02_03 Ngabetkya

GW02_04 Ngabetkya

GW03_05 Padaukpin

GW03_06 Padaukpin

GW04_07 Sakangyi

GW04_08 Sakangyi

Figure 2-5 Groundwater monitoring in Well Abandonment Phase during June 22-23, 2020

2.4.1 Groundwater Monitoring Station

Groundwater monitoring stations are shown in Table 2-13 and Figure 2-6.

Table 2-13 Coordinate of Groundwater Monitoring Stations

Monitoring Station	Coordinates (UTM Datum WGS 84)		
	Zone	East (X)	North (Y)
Moenatkone (MNK) well site			
GW01_01 MOENATKONE	46Q	711453.97	2159751.45
GW01_02 MOENATKONE	46Q	711930.68	2158496.05
Ngabetkya (NBK) well site			
GW02_03 NGABETKYA	46Q	708217.60	2149369.66
GW02_04 NGABETKYA	46Q	708424.09	2149276.39
Padaukpin (PDP) well site			
GW03_05 PADAUKPIN	46Q	718546.83	2143604.95
GW03_06 PADAUKPIN	46Q	719362.32	2142572.74
Sakangyi (SKG) well site			
GW04_07 SAKANGYI	46Q	722311.71	2142058.38
GW04_08 SAKANGYI	46Q	722244.95	2141955.76

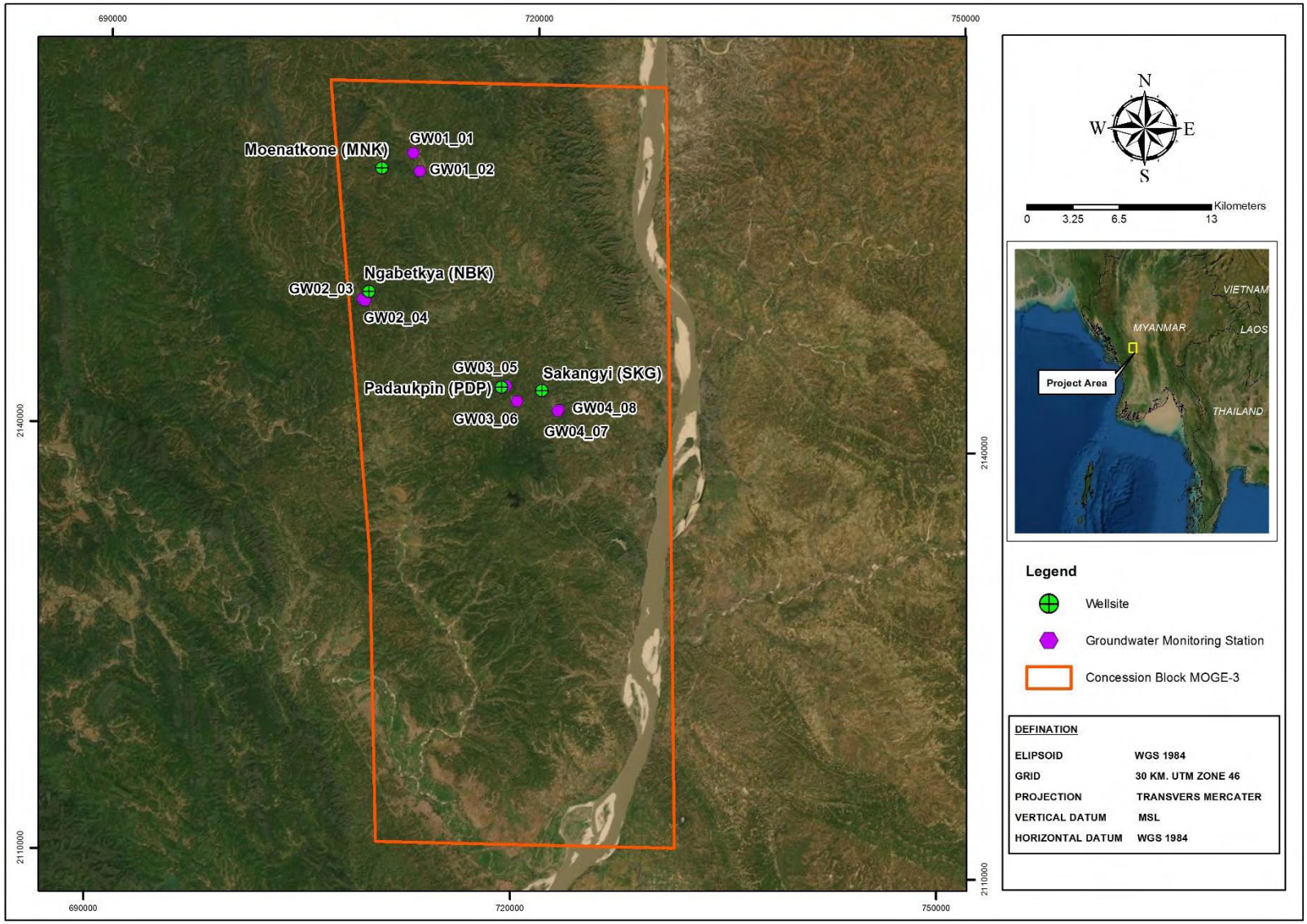

Figure 2-6 Groundwater Monitoring Stations

2.4.2 Groundwater Monitoring Method

Details of groundwater monitoring including parameters and analysis methods are shown in Table 2-14.

Table 2-14 Parameters and Analysis Methods for Groundwater Monitoring

Parameter	Unit	Analysis Method*
1. pH	-	Electrometric method at site
2. Temperature	^{0}C	Thermometer at site
3. Conductivity	µS/cm	Electrical conductivity method at site
4. Total dissolved solid (TDS)	mg/L	Total dissolved solid dried at 180^{0}C
5. Salinity	ppt	Electrical conductivity method at site
6. Total suspended solid (TSS)	mg/L	Total suspended solid dried at 103-105^{0}C
7. Chlorine (Total residual)	mg/L	Iodometric method I
8. Cyanide (free)	mg/L	Cyanide-Ion selective electrode method
9. Cyanide (total)	mg/L	Distillation, Pyridine-Barbituric acid method
10. Fluoride	mg/L	Spadns method
11. Ammonia	mg/L	Phenate method
12. Total Nitrogen	mg/L	Persulphate method
13. Total Phosphorus	mg/L	Persulphate digestion and ascorbic acid method
14. Sulphide	mg/L	Methylene blue method
15. Hexavalent Chromium (Cr^{6+})	mg/L	Colourimetric method
16. Oil and grease	mg/L	Partition-Gravimetric method
17. COD	mg/L	Closed reflux, Titrimetric method
18. BOD	mg/L	Membrane Electrode method
19. Phenols (as Phenol)	mg/L	Distillation, 4-Aminoantipyrine method
20. Arsenic (As)	mg/L As	Hydride generation AAS method
21. Cadmium (Cd)	mg/L Cd	In-House method UAE.TP.GW.01 (Nitric acid digestion and direct air acetylene flame method)
22. Total Chromium (Cr)	mg/L Cr	In-House method UAE.TP.GW.01 (Nitric acid digestion and direct air acetylene flame method)
23. Copper (Cu)	mg/L Cu	In-House method UAE.TP.GW.01 (Nitric acid digestion and direct air acetylene flame method)
24. Lead (Pb)	mg/L Pb	In-House method UAE.TP.GW.01 (Nitric acid digestion and direct air acetylene flame method)
25. Mercury (Hg)	mg/L Hg	Cold vapour AAS method
26. Nickel (Ni)	mg/L Ni	In-House method UAE.TP.GW.01 (Nitric acid digestion and direct air acetylene flame method)
27. Selenium (Se)	mg/L Se	Hydride generation AAS method
28. Silver (Ag)	mg/L Ag	Nitric acid-Hydrochloric acid digestion and inductively coupled plasma (ICP) method

Table 2-14 (Cont.) Parameters and Analysis Methods for Surface Water Monitoring

Parameter	Unit	Analysis Method*
29. Zinc (Zn)	mg/L Zn	In-House method UAE.TP.GW.01 (Nitric acid digestion and direct air acetylene flame method)
30. Iron (Fe)	mg/L Fe	In-House method UAE.TP.GW.01 (Nitric acid digestion and direct air acetylene flame method)
31. Total Coliform Bacteria (TCB)	MPN/100 ml	Multiple tube fermentation technique

Remark: * American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WEF). 2017. Standard Methods for the Examination of Water and Wastewater. 23rd Edition. Washington, DC: American Public Health Association

2.4.3 Groundwater Sampling Method

For shallow wells, a Kemmerer Sampler or peristaltic pump will be used for collecting groundwater sample depending on the diameter of the well. For deep well, the peristaltic pump, submersible pump or bailer will be used for collecting groundwater sample depending on water level as shown in Figure 2-5. Before sampling at deep well, to ensure that a representative water sample was grabbed, it is necessary to purge water prior to sampling. Purging out the stagnant water can be performed by various samplers based on the parameters of interest, the diameter of the well, the water level and other site conditions. At each well, three to five well volumes of water will be removed or until the result of pH, conductivity, and temperature will be stable. To protect any contamination during sampling, scientist will wear free-flour rubber gloves. All samples will be specifically preserved, labelled and recorded information in field logbook and chain of custody, then keep bottles cool, ship the samples back to United Analyst and Engineering Consultant Co., Ltd. Laboratory (UAE) in Bangkok for analysis within recommended holding times.

2.4.4 Preservation Methods for Groundwater Sample

All samples were preserved with specific procedure and storage as shown in Table 2-15.

Table 2-15 Preservation Methods for Groundwater Sample

Parameter	Container	Preservation Method*
1. pH	-	Measure at Site
2. Temperature	-	Measure at Site
3. Conductivity	-	Measure at Site
4. Total dissolved solids (TDS)	Polyethylene Bottle 1 L	Refrigerate at > 0 ºC , ≤ 6 ºC
5. Salinity	-	Measure at Site
6. Total suspended solids (TSS)	Polyethylene Bottle 1 L	Refrigerate at > 0 ºC , ≤ 6 ºC
7. Chlorine (Total residual)	Polyethylene Bottle 500 mL	Refrigerate > 0 ºC, ≤ 6 ºC
8. Cyanide (free)	Brown, Polyethylene Bottle 500 mL	Refrigerate > 0 ºC , ≤ 6 ºC
9. Cyanide (total)	Brown, Polyethylene Bottle 1 L	Add NaOH to pH<12 and Refrigerate > 0 ºC , ≤ 6 ºC
10. Fluoride	Polyethylene Bottle 1 L	Refrigerate at > 0 ºC , ≤ 6 ºC
11. Ammonia	Polyethylene Bottle 500 mL	Add H_2SO_4 to pH<2 and Refrigerate > 0 ºC , ≤ 6 ºC
12. Total Nitrogen	Polyethylene Bottle 500 mL	Refrigerate > 0 ºC , ≤ 6 ºC
13. Total Phosphorus	Brown Glass Bottle 150 mL	Add H_2SO_4 to pH<2 and Refrigerate > 0 ºC , ≤ 6 ºC
14. Sulphide	Polyethylene Bottle 1 L	Add 4 drops 2N Zinc Acetate/ 100 mL Sample, Add NaOH to pH > 9, Refrigerate > 0 ºC , ≤ 6 ºC
15. Hexavalent Chromium (Cr^{6+})	Polyethylene Bottle 1 L	Add Ammonium Sulfate Buffer to pH 9.3-9.7 and Refrigerate > 0 ºC , ≤ 6 ºC
16. Oil and grease	Glass wide Mouth Bottle 1 L	Add H_2SO_4 to pH < 2 and Refrigerate at > 0 ºC , ≤ 6 ºC
17. COD	Glass Bottle 250 mL	Add H_2SO_4 to pH < 2 and Refrigerate > 0 ºC , ≤ 6 ºC
18. BOD	Polyethylene Bottle 1 L	Refrigerate at > 0 ºC , ≤ 6 ºC
19. Phenols (as Phenol)	Glass Bottle, PTFE Lined Cap 1 L	Add H_2SO_4 to pH < 2 and Refrigerate > 0 ºC , ≤ 6 ºC
20. Arsenic (As)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
21. Cadmium (Cd)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
22. Total Chromium (Cr)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
23. Copper (Cu)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
24. Lead (Pb)	Polyethylene Bottle 500 mL	Add HNO_3 to pH < 2
25. Mercury (Hg)	Glass 250 mL with Teflon Cap	Add HNO_3 to pH < 2 and refrigerate at > 0 ºC , ≤ 6 ºC
26. Nickel (Ni)	Polyethylene Bottle 500 mL	Add HNO3 to pH<2
27. Selenium (Se)	Polyethylene Bottle 500 mL	Add HNO3 to pH<2
28. Silver (Ag)	Polyethylene Bottle 500 mL	Add HNO3 to pH<2
29. Zinc (Zn)	Polyethylene Bottle 500 mL	Add HNO3 to pH<2

Table 2-15 (Cont.) Preservation Methods for Groundwater Sample

Parameter	Container	Preservation Method*
30. Iron (Fe)	Polyethylene Bottle 500 mL	Add HNO3 to pH<2
31. Total Coliform Bacteria (TCB)	Sterile, Brown Glass Bottle 150 mL	Add 10% $Na_2S_2O_3$ 0.1 mL/100 mL and Refrigerate > 0 ºC , ≤ 6 ºC

Remark: * American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WEF). 2017. Standard Methods for the Examination of Water and Wastewater. 23rd Edition. Washington, DC: American Public Health Association

2.4.5 Groundwater Monitoring Results and Comparison

Referring to analysis no. T20AK085-0003 to T20AK085-0004, T20AK088-0003 to T20AK088-0004, T20AK91-0003 to T20AK91-0004, T20AK094-0003 to T20AK094-0004, LAA112/2020, LAA115/2020, LAA118/2020 and LAA110/2020. Groundwater samples were collected by REM-UAE staff on June 22-23, 2020 during well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite. Most of parameters at each station complied with the guideline values.

In comparison of groundwater monitoring result during well abandonment phase in 2020 with baseline survey in 2018 of the project found that most of parameters rather similar to baseline survey and complied with the guideline values. pH at all stations complied with the National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations, published by the US EPA, May 2009 except station GW04_07 in baseline result. Total Dissolved Solids (TDS) at all stations were above the US EPA standard since baseline survey except GW03_05 that decreased until comply the guideline value in well abandonment phase, so this is most likely natural in the area. Moreover, most of groundwater stations were opened-artesian well, the high TDS might be caused naturally by evaporation or precipitation. This also resulted in high value of conductivity at all stations and over the guideline value (UK Drinking Water Standards from Water Supply (Water Quality) Regulations 2000, (SI 2000/3184) (as amended)) at GW01_01, GW03_05, GW03_06, GW04_07 and GW04_08 since baseline result except GW03_05 that decreased from baseline until comply the UK Drinking Water Standards in well abandonment phase.

Total Suspended Solids (TSS) at GW02_04 was over the Environmental, Health, and Safety (EHS) Guidelines, GENERAL EHS GUIDELINES in baseline but decreased until complied with the guideline. For GW03_05, TSS was over the guidelines in well abandonment phase. Phenols at GW02_03 and GW03_06 and Cyanide (total) at GW01_01 also exceeded the EHS guideline in well abandonment phase.

Ammonia at GW03_06, GW04_07 and GW04_08 were over the European Union Drinking Water Standards (1998) since baseline results and GW03_05 was over the EU standard in well abandonment phase. Only the result at GW03_06 and GW04_07 that decreased from baseline survey until complied with the EU Standards in well abandonment phase.

Total Nitrogen at all stations complied with the World Health Organization Drinking Water Standards (1993) except GW01_01 in baseline results that was higher than the WHO standard but continuously decreased until complied with the standard in well abandonment phase.

Most heavy metals were complied with the guideline values except Iron (Fe) at GW02_04 and GW03_06 that were higher than the US EPA standards since baseline results. Only Iron (Fe) at GW03_06 that decreased from baseline result until complied with the US EPA standards. For GW02_03, GW03_05 and GW04_07, the results were detected higher than the standards in well abandonment phase. The high values of Iron (Fe) are attributed to naturally high iron content resulting from geological weathering.

Total Coliform Bacteria (TCB) at all stations in well abandonment phase were detected higher than the EU standards. For GW02_04, the result was exceeded the standard since baseline survey. Due to the condition of each station which were opened wells and surrounded by agriculture, livestock area and villages, this fecal contamination might have resulted in high value of TCB.

The monitoring results and comparison are shown in Table 2-16 to Table 2-19. The analysis results, certificate for laboratory instrument and approval registration certificate of laboratory are shown in Appendix E, F and G.

Table 2-16 The Comparison of Groundwater Monitoring Results at Moenatkone Wellsite

Parameter	Unit	The Groundwater Monitoring Station of Moenatkone Wellsite				Standard	Detection Limit
		GW01_01		GW01_02			
Date of sampling	**-**	**7-Feb-18**	**23-Jun-20**	**7-Feb-18**	**23-Jun-20**	**-**	**-**
pH	-	7.6	7.3 (29 ^{0}C)	7.8	7.5 (31 ^{0}C)	6.5-8.5[1/]	-
Temperature	^{0}C	25.3	29	25.8	31	-[7/]	-
Conductivity	µS/cm	**3,020**	**2,773 (29 ^{0}C)**	979	724 (31 ^{0}C)	2,500[2/]	-
Total dissolved solid (TDS)	mg/L	**2,140**	**1,799**	**696**	**620**	500[1/]	-
Salinity	ppt	1.72	1.3	0.50	0.4	-[7/]	-
Total suspended solid (TSS)	mg/L	< 2	ND	< 2	ND	35[3/]	5.0
Chlorine (Total residual)	mg/L	< 0.2	ND	< 0.2	ND	0.2[3/]	0.1
Cyanide (free)	mg/L	< 5	ND	< 5	ND	5[4/]	0.05
Cyanide (total)	mg/L	< 0.005	**6**	< 0.005	ND	1[3/]	5
Fluoride	mg/L	0.5	0.53	0.6	0.47	4[1/]	0.02
Ammonia	mg/L	0.02	0.07	0.04	0.07	0.50[5/]	0.05
Total Nitrogen	mg/L	**68.2**	8.75	0.3	1.15	50[6/]	0.1
Total Phosphorus	mg/L	< 0.10	0.03	< 0.10	0.04	2[3/]	0.01
Sulphide	mg/L	< 0.1	ND	< 0.1	ND	1[3/]	0.02
Hexavalent Chromium (Cr^{6+})	mg/L	< 0.02	ND	< 0.02	ND	0.1[1/]	0.006
Oil and grease	mg/L	< 5	ND	< 0.5	ND	10[3/]	3
COD	mg/L	7	ND	< 2	ND	125[3/]	25
BOD	mg/L	3	1.6	< 2	1.8	30[3/]	1.0
Phenols (as Phenol)	mg/L	< 0.02	ND	< 0.02	ND	0.0005[3/]	0.005
Arsenic (As)	mg/L	< 0.01	ND	< 0.01	ND	0.01[1/]	0.0003
Cadmium (Cd)	mg/L	< 0.0002	ND	< 0.0002	ND	0.005[1/]	0.003

Table 2-16 (Cont.) The Comparison of Groundwater Monitoring Results at Moenatkone Wellsite

Parameter	Unit	The Groundwater Monitoring Station of Moenatkone Wellsite				Standard	Detection Limit
		GW01_01		GW01_02			
Date of sampling	**-**	**7-Feb-18**	**23-Jun-20**	**7-Feb-18**	**23-Jun-20**	**-**	**-**
Total Chromium (Cr)	mg/L	< 0.001	ND	< 0.001	ND	0.1[1/]	0.010
Copper (Cu)	mg/L	0.002	ND	< 0.001	ND	1.3[1/]	0.003
Lead (Pb)	mg/L	< 0.001	ND	< 0.001	ND	0.015[1/]	0.010
Mercury (Hg)	mg/L	< 0.0005	0.0004	< 0.0005	0.0002	0.002[1/]	0.0002
Nickel (Ni)	mg/L	0.002	ND	< 0.001	ND	0.02[1/]	0.005
Selenium (Se)	mg/L	< 0.01	ND	< 0.01	ND	0.05[1/]	0.0005
Silver (Ag)	mg/L	< 0.001	ND	< 0.001	ND	0.5[3/]	0.003
Zinc (Zn)	mg/L	< 0.01	ND	< 0.01	ND	5[6/]	0.005
Iron (Fe)	mg/L	< 0.05	< LOQ	< 0.05	< LOQ	0.3[1/]	0.010
Total Coliform Bacteria (TCB)	MPN/100 ml	ND[8/]	**70**	ND[8/]	**70**	0[5/]	1.8
Water's colour/Turbid	-	-	Colourless/Clear	-	Colourless/Clear	-	-
Sediment	-	-	Yellow	-	Yellow	-	-

Remark:
[1/] : National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations, published by the USEPA, May 2009.
[2/] : UK Drinking Water Standards from Water Supply (Water Quality) Regulations 2000, (SI 2000/3184) (as amended).
[3/] : Environmental, Health, and Safety (EHS) Guidelines, GENERAL EHS GUIDELINES
[4/] : Ontario Soil, Ground Water and Sediment Standards for Ontario, Use Under Part XV.1 of the Environmental Protection Act, 9-Mar-04, Canada
[5/] : European Union Drinking Water Standards (1998)
[6/] : World Health Organization Drinking Water Standards (1993)
[7/] : Not specified in the standards.
[8/] : The value of detection limit for TCB was not remarked in the baseline survey result.
ND : Non-Detectable
< LOQ : < Level of Quantitation (Iron ≥ 0.010 and < 0.050 mg/L)

Table 2-17 The Comparison of Groundwater Monitoring Results at Ngabetkya Wellsite

Parameter	Unit	The Groundwater Monitoring Station of Ngabetkya Wellsite				Standard	Detection Limit
		GW02_03		GW02_04			
Date of sampling	**-**	**7-Feb-18**	**23-Jun-20**	**8-Feb-18**	**23-Jun-20**	**-**	**-**
pH	-	8.1	7.4 (28 ^{0}C)	7.5	7.1 (29 ^{0}C)	6.5-8.5[1/]	-
Temperature	^{0}C	22.9	28	28.2	29	-[7/]	-
Conductivity	µS/cm	747	1,314 (28 ^{0}C)	1,722	1,642 (29 ^{0}C)	2,500[2/]	-
Total dissolved solid (TDS)	mg/L	**531**	**868**	**1,220**	**716**	500[1/]	-
Salinity	ppt	0.40	0.6	0.97	0.5	-[7/]	-
Total suspended solid (TSS)	mg/L	< 2	19.5	**80**	28.9	35[3/]	5.0
Chlorine (Total residual)	mg/L	< 0.2	ND	< 0.2	ND	0.2[3/]	0.1
Cyanide (free)	mg/L	< 5	ND	< 5	ND	5[4/]	0.05
Cyanide (total)	mg/L	< 0.005	ND	< 0.005	ND	1[3/]	5
Fluoride	mg/L	0.6	0.61	0.7	0.78	4[1/]	0.02
Ammonia	mg/L	0.02	0.07	0.01	0.06	0.50[5/]	0.05
Total Nitrogen	mg/L	0.1	1.16	12.3	4.47	50[6/]	0.1
Total Phosphorus	mg/L	< 0.10	0.04	< 0.10	0.05	2[3/]	0.01
Sulphide	mg/L	< 0.1	ND	< 0.1	ND	1[3/]	0.02
Hexavalent Chromium (Cr^{6+})	mg/L	< 0.02	ND	< 0.02	ND	0.1[1/]	0.006
Oil and grease	mg/L	< 5	ND	< 5	ND	10[3/]	3
COD	mg/L	< 2	35	< 2	40	125[3/]	25
BOD	mg/L	< 2	1.5	< 2	1.4	30[3/]	1.0
Phenols (as Phenol)	mg/L	< 0.02	**0.010**	< 0.02	ND	0.0005[3/]	0.005
Arsenic (As)	mg/L	< 0.01	ND	< 0.01	0.0003	0.01[1/]	0.0003
Cadmium (Cd)	mg/L	< 0.0002	ND	< 0.0002	ND	0.005[1/]	0.003

Table 2-17 (Cont.) The Comparison of Groundwater Monitoring Results at Ngabetkya Wellsite

Parameter	Unit	The Groundwater Monitoring Station of Ngabetkya Wellsite				Standard	Detection Limit
		GW02_03		GW02_04			
Date of sampling	**-**	**7-Feb-18**	**23-Jun-20**	**8-Feb-18**	**23-Jun-20**	**-**	**-**
Total Chromium (Cr)	mg/L	< 0.001	ND	< 0.001	ND	0.1[1/]	0.010
Copper (Cu)	mg/L	< 0.001	ND	< 0.001	ND	1.3[1/]	0.003
Lead (Pb)	mg/L	< 0.001	ND	0.002	ND	0.015[1/]	0.010
Mercury (Hg)	mg/L	< 0.0005	0.0002	< 0.0005	0.0005	0.002[1/]	0.0002
Nickel (Ni)	mg/L	< 0.001	ND	0.001	ND	0.02[1/]	0.005
Selenium (Se)	mg/L	< 0.01	ND	< 0.01	ND	0.05[1/]	0.0005
Silver (Ag)	mg/L	< 0.001	ND	< 0.001	ND	0.5[3/]	0.003
Zinc (Zn)	mg/L	< 0.01	ND	< 0.01	ND	5[6/]	0.005
Iron (Fe)	mg/L	< 0.06	**0.387**	**0.430**	**0.598**	0.3[1/]	0.010
Total Coliform Bacteria (TCB)	MPN/100 ml	ND[8/]	**79**	**690**	**79**	0[5/]	1.8
Water's colour/Turbid	-	-	Colourless/ Clear	-	Colourless/ Clear	-	-
Sediment	-	-	Brown	-	Blue	-	-

Remark: 1/ : National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations, published by the USEPA, May 2009.

2/ : UK Drinking Water Standards from Water Supply (Water Quality) Regulations 2000, (SI 2000/3184) (as amended).

3/ : Environmental, Health, and Safety (EHS) Guidelines, GENERAL EHS GUIDELINES

4/ : Ontario Soil, Ground Water and Sediment Standards for Ontario, Use Under Part XV.1 of the Environmental Protection Act, 9-Mar-04, Canada

5/ : European Union Drinking Water Standards (1998)

6/ : World Health Organization Drinking Water Standards (1993)

7/ : Not specified in the standards.

8/ : The value of detection limit for TCB was not remarked in the baseline survey result.

ND : Non-Detectable

Table 2-18 The Comparison of Groundwater Monitoring Results at Padaukpin Wellsite

Parameter	Unit	The Groundwater Monitoring Station of Padaukpin Wellsite				Standard	Detection Limit
		GW03_05		GW03_06			
Date of sampling	**-**	**6-Feb-18**	**23-Jun-20**	**6-Feb-18**	**23-Jun-20**	**-**	**-**
pH	-	7.2	7.0 (30 ^{0}C)	7.3	8.1 (29 ^{0}C)	6.5-8.5[1/]	-
Temperature	^{0}C	30.1	30	28.5	29	-[7/]	-
Conductivity	µS/cm	**5,860**	38 (30 ^{0}C)	**5,820**	**4,481 (29 ^{0}C)**	2,500[2/]	-
Total dissolved solid (TDS)	mg/L	**4,160**	34	**4,110**	**2,880**	500[1/]	-
Salinity	ppt	3.51	0	3.46	2.2	-[7/]	-
Total suspended solid (TSS)	mg/L	4	**47.6**	12	ND	35[3/]	5.0
Chlorine (Total residual)	mg/L	< 0.2	ND	< 0.2	ND	0.2[3/]	0.1
Cyanide (free)	mg/L	< 5	ND	< 5	ND	5[4/]	0.05
Cyanide (total)	mg/L	< 0.005	ND	< 0.005	ND	1[3/]	5
Fluoride	mg/L	1.7	0.69	0.6	0.62	4[1/]	0.02
Ammonia	mg/L	0.02	**0.95**	**1.98**	0.36	0.50[5/]	0.05
Total Nitrogen	mg/L	0.6	14.0	2.7	1.42	50[6/]	0.1
Total Phosphorus	mg/L	< 0.10	0.04	< 0.10	0.03	2[3/]	0.01
Sulphide	mg/L	< 0.1	ND	< 0.1	ND	1[3/]	0.02
Hexavalent Chromium (Cr^{6+})	mg/L	< 0.02	ND	< 0.02	ND	0.1[1/]	0.006
Oil and grease	mg/L	< 5	ND	< 5	ND	10[3/]	3
COD	mg/L	19	45	< 2	32	125[3/]	25
BOD	mg/L	< 2	4.5	< 2	1.9	30[3/]	1.0
Phenols (as Phenol)	mg/L	< 0.02	ND	< 0.02	**0.054**	0.0005[3/]	0.005
Arsenic (As)	mg/L	< 0.01	0.0003	< 0.01	ND	0.01[1/]	0.0003
Cadmium (Cd)	mg/L	< 0.0002	ND	< 0.0002	ND	0.005[1/]	0.003

Table 2-18 (Cont.) The Comparison of Groundwater Monitoring Results at Padaukpin Wellsite

Parameter	Unit	The Groundwater Monitoring Station of Padaukpin Wellsite				Standard	Detection Limit
		GW03_05		GW03_06			
Date of sampling	**-**	**6-Feb-18**	**23-Jun-20**	**6-Feb-18**	**23-Jun-20**	**-**	**-**
Total Chromium (Cr)	mg/L	< 0.001	ND	< 0.001	ND	0.1[1/]	0.010
Copper (Cu)	mg/L	< 0.001	ND	0.003	ND	1.3[1/]	0.003
Lead (Pb)	mg/L	< 0.001	ND	0.006	ND	0.015[1/]	0.010
Mercury (Hg)	mg/L	< 0.0005	0.0004	< 0.0005	0.0005	0.002[1/]	0.0002
Nickel (Ni)	mg/L	0.003	< LOQ	< 0.001	ND	0.02[1/]	0.005
Selenium (Se)	mg/L	< 0.01	ND	< 0.01	ND	0.05[1/]	0.0005
Silver (Ag)	mg/L	< 0.001	ND	< 0.001	ND	0.5[3/]	0.003
Zinc (Zn)	mg/L	0.02	ND	< 0.01	ND	5[6/]	0.005
Iron (Fe)	mg/L	0.270	**4.10**	**1.180**	< LOQ	0.3[1/]	0.010
Total Coliform Bacteria (TCB)	MPN/100 ml	ND[8/]	**200**	ND[8/]	**7.8**	0[5/]	1.8
Water's colour/Turbid	-	-	Yellow/ Turbid	-	Colourless/ Clear	-	-
Sediment	-	-	Brown	-	Yellow	-	-

Remark: [1/] : National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations, published by the USEPA, May 2009.

[2/] : UK Drinking Water Standards from Water Supply (Water Quality) Regulations 2000, (SI 2000/3184) (as amended).

[3/] : Environmental, Health, and Safety (EHS) Guidelines, GENERAL EHS GUIDELINES

[4/] : Ontario Soil, Ground Water and Sediment Standards for Ontario, Use Under Part XV.1 of the Environmental Protection Act, 9-Mar-04, Canada

[5/] : European Union Drinking Water Standards (1998)

[6/] : World Health Organization Drinking Water Standards (1993)

[7/] : Not specified in the standards.

[8/] : The value of detection limit for TCB was not remarked in the baseline survey result.

ND : Non-Detectable

< LOQ : < Level of Quantitation (Iron ≥ 0.010 and < 0.050 mg/L and Nickel ≥ 0.005 and < 0.050 mg/L)

Table 2-19 The Comparison of Groundwater Monitoring Results at Sakangyi Wellsite

Parameter	Unit	The Groundwater Monitoring Station of Sakangyi Wellsite				Standard	Detection Limit
		GW04_07		GW04_08			
Date of sampling	**-**	**6-Feb-18**	**23-Jun-20**	**6-Feb-18**	**23-Jun-20**	**-**	**-**
pH	-	**8.6**	8.4 (29 ^{0}C)	7.6	7.2 (29 ^{0}C)	6.5-8.5[1/]	-
Temperature	^{0}C	32.6	29	28.8	29	-[7/]	-
Conductivity	µS/cm	**3,370**	**4,710 (29 ^{0}C)**	**4,140**	**3,947 (29 ^{0}C)**	2,500[2/]	-
Total dissolved solid (TDS)	mg/L	**2,390**	**1,445**	**2,940**	**3,090**	500[1/]	-
Salinity	ppt	1.94	2.3	2.41	1.9	-[7/]	-
Total suspended solid (TSS)	mg/L	< 2	8.7	< 2	ND	35[3/]	5.0
Chlorine (Total residual)	mg/L	< 0.2	ND	< 0.2	ND	0.2[3/]	0.1
Cyanide (free)	mg/L	< 5	ND	< 5	ND	5[4/]	0.05
Cyanide (total)	mg/L	< 0.005	ND	< 0.005	ND	1[3/]	5
Fluoride	mg/L	1.5	0.70	0.6	0.49	4[1/]	0.02
Ammonia	mg/L	**2.46**	ND	**1.55**	**1.49**	0.50[5/]	0.05
Total Nitrogen	mg/L	4.2	2.23	2.0	4.94	50[6/]	0.1
Total Phosphorus	mg/L	< 0.10	0.06	< 0.10	0.02	2[3/]	0.01
Sulphide	mg/L	< 0.1	ND	< 0.1	ND	1[3/]	0.02
Hexavalent Chromium (Cr^{6+})	mg/L	< 0.02	ND	< 0.02	ND	0.1[1/]	0.006
Oil and grease	mg/L	< 5	ND	< 5	ND	10[3/]	3
COD	mg/L	8	ND	5	ND	125[3/]	25
BOD	mg/L	< 2	1.8	< 2	1.5	30[3/]	1.0
Phenols (as Phenol)	mg/L	< 0.02	ND	< 0.02	ND	0.0005[3/]	0.005
Arsenic (As)	mg/L	< 0.01	ND	< 0.01	ND	0.01[1/]	0.0003
Cadmium (Cd)	mg/L	< 0.0002	ND	< 0.0002	ND	0.005[1/]	0.003

Table 2-19 (Cont.) The Comparison of Groundwater Monitoring Results at Sakangyi Wellsite

Parameter	Unit	The Groundwater Monitoring Station of Sakangyi Wellsite				Standard	Detection Limit
		GW04_07		GW04_08			
Date of sampling	**-**	**6-Feb-18**	**23-Jun-20**	**6-Feb-18**	**23-Jun-20**	**-**	**-**
Total Chromium (Cr)	mg/L	< 0.001	ND	< 0.001	ND	0.1[1/]	0.010
Copper (Cu)	mg/L	< 0.001	ND	< 0.001	ND	1.3[1/]	0.003
Lead (Pb)	mg/L	0.002	ND	< 0.001	ND	0.015[1/]	0.010
Mercury (Hg)	mg/L	< 0.0005	0.0005	< 0.0005	0.0004	0.002[1/]	0.0002
Nickel (Ni)	mg/L	< 0.001	ND	< 0.001	ND	0.02[1/]	0.005
Selenium (Se)	mg/L	< 0.01	ND	< 0.01	ND	0.05[1/]	0.0005
Silver (Ag)	mg/L	< 0.001	ND	< 0.001	ND	0.5[3/]	0.003
Zinc (Zn)	mg/L	< 0.01	ND	< 0.01	ND	5[6/]	0.005
Iron (Fe)	mg/L	0.210	**0.374**	0.130	0.084	0.3[1/]	0.010
Total Coliform Bacteria (TCB)	MPN/100 ml	ND[8/]	**110**	ND[8/]	**79**	0[5/]	1.8
Water's colour/Turbid	-	-	Colourless/ Clear	-	Colourless/ Clear	-	-
Sediment	-	-	Yellow	-	Yellow	-	-

Remark: 1/ : National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations, published by the USEPA, May 2009.

2/ : UK Drinking Water Standards from Water Supply (Water Quality) Regulations 2000, (SI 2000/3184) (as amended).

3/ : Environmental, Health, and Safety (EHS) Guidelines, GENERAL EHS GUIDELINES

4/ : Ontario Soil, Ground Water and Sediment Standards for Ontario, Use Under Part XV.1 of the Environmental Protection Act, 9-Mar-04, Canada

5/ : European Union Drinking Water Standards (1998)

6/ : World Health Organization Drinking Water Standards (1993)

7/ : Not specified in the standards.

8/ : The value of detection limit for TCB was not remarked in the baseline survey result.

ND : Non-Detectable

2.5 Social Monitoring

Social monitoring was conducted for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite by PTTEP SA. The detail as shown in Table 2-20.

Table 2-20 Social Monitoring Plan

Environmental Quality	Parameter	Location	Period
Social	• Complaint • Monitoring and solving	Project area, community around project area, and transportation route - Moenatkone well site - Ngabetkya well site - Padaukpin well site - Sakangyi well site	Throughout the project activity at all four well sites.

2.5.1 Social Monitoring Methods

Social monitoring is the investigation of complaints from the community. PTTEP SA provided grievance handling guideline to receive any complaints from the stakeholder and resolve the complaint in the immediate (Appendix D-1). If any damage occurs, PTTEP SA will be responsible to solve and track them. In addition, problem's cause will be analyzed to prevent same problem occurring again. The Grievance Handling Process of PTTEP SA as shown in Figure 2-7.

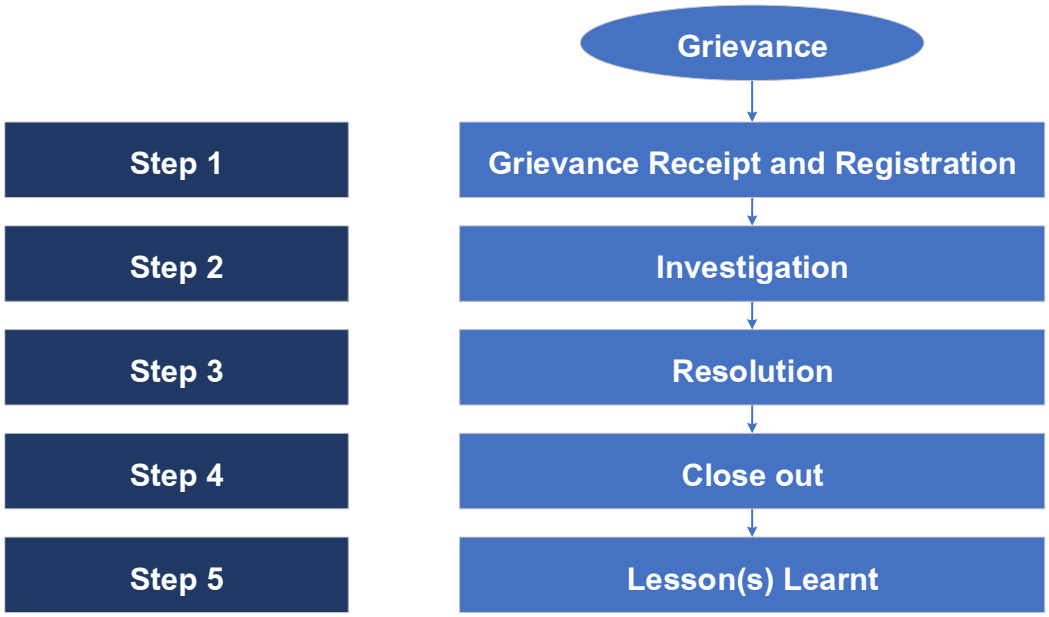

Figure 2-7 Grievance Handling Process

2.5.2 Social Monitoring Result

Social monitoring results for well abandonment phase of Moenatkone well site, Ngabetkya well site, Padaukpin well site and Sakangyi well site was done by PTTEP SA. There was no complaint from the community throughout the project operation.

2.6 Public and Occupational Health and Safety Monitoring

Public and occupational health and safety monitoring was conducted for well abandonment phase of Moenatkone well site, Ngabetkya well site, Padaukpin well site and Sakangyi well site were done by PTTEP SA. The detail as shown in Table 2-21.

Table 2-21 Public and Occupational Health and Safety Monitoring Plan

Environmental Quality	Parameter	Location	Period
Public and Occupational Health and Safety	• Accidental statistics • cause of accidents • Mitigation measures	Project area, community around project area, and transportation route - Moenatkone well site - Ngabetkya well site - Padaukpin well site - Sakangyi well site	Throughout the project activity at all four well sites.

2.6.1 Public and Occupational Health and Safety Monitoring Methods

PTTEP SA provided SSHE Management System Manual and training program on Safety, Security Health and Environment Management System (SSHE-MS) and other concerned safety standards have been provided to the contractor for follow with the PTTEP SA's plan. Public and Occupational health and safety monitoring was conducted by recording the accident during working time; including causes, accident level, and performed mitigation measures. Monitoring program and report were conducted throughout operation period following the specified measures in EIA report.

2.6.2 Public and Occupational Health and Safety Monitoring Results

Public and occupational health and safety monitoring results for well abandonment phase of Moenatkone well site, Ngabetkya well site, Padaukpin well site and Sakangyi well site were done by PTTEP SA. There was no incident throughout the project operation.

Chapter 3

Environmental Monitoring Conclusion

Chapter 3
Environmental Monitoring Conclusion

From the environmental monitoring during well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite, it was found that the project has implemented the monitoring measures specified in EIA report and the results are summarized as following details:

3.1 Environmental Monitoring Results Conclusion

Environmental monitoring programs implemented during the project' s period is provided as following details:

1) Air Quality Monitoring

There is no complaint throughout the project activities, therefore, air quality monitoring is not required to conduct for all 4 well sites.

2) Noise Monitoring

There is no complaint throughout the project activities, therefore, noise monitoring is not required to conduct for all 4 well sites.

3) Soil Monitoring

Soil monitoring was conducted for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited during June 22-23, 2020. The results were found that most of parameters at each station complied with the standard for Coarse Grained Agricultural Soil from Canadian Council of Ministers of the Environment. 2007. Canadian soil quality guidelines for the protection of environmental and human health: Summary tables. Updated September, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg except Chromium (Cr) at Well 04 Sakangyi and Nickel (Ni) at all stations same as the baseline result and its concentration decreased when comparing with baseline result.

4) Surface Water Monitoring

Surface water monitoring was conducted for well abandonment phase at station SW01_02 of Moenatkone wellsite, station SW02_04 of Ngabetkya wellsite, station SW03_05 of Padaukpin wellsite and station SW04_07 of Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited during June 22-23, 2020. Some stations couldn't be collected the samples due to run out of water and some stations don't exist anymore. The results were found that most of parameters at each station complied with the guideline values. Some parameters were higher than the guideline values since baseline survey but tend to decrease. The weather might have resulted in high value in some parameters especially, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) due to sampling during dry season. Besides, the condition surrounded each monitoring station could also lead to high value in some parameters for example, some stations was surrounded by livestock and agricultural area that might cause high value of Total Coliform Bacteria (TCB). For heavy metal, Iron (Fe) was detected in all stations since baseline survey including groundwater locations. The high levels are attributed to naturally high iron content resulting from geological weathering as detailed in the EIA report.

5) Groundwater Monitoring

Groundwater monitoring was conducted for well abandonment phase at station GW01_01 and GW01_02 of Moenatkone wellsite, station GW02_03 and GW02_04 of Ngabetkya wellsite, station GW03_05 and GW03_06 of Padaukpin wellsite and station GW04_07 and GW04_08 of Sakangyi wellsite by REM-UAE Laboratory and Consultant Company Limited during June 22-23, 2020. The results were found that most of parameters at each station complied with the guideline values. Some parameters were higher than the guideline values since baseline results. The condition of each monitoring station might have caused high value of Total Dissolved Solids (TDS), Conductivity and Total Suspended Solids (TSS) because the stations were opened-artesian wells that could be contaminated naturally by evaporation or precipitation. Ammonia and Total Nitrogen at some stations were also over the guideline values but continuously decreased until complied with the guideline values. Besides, surrounded area of each monitoring station could also lead to high value in some parameters for example, some stations was surrounded by livestock, agricultural area or villages, therefore fecal contamination might have resulted in high value of

Total Coliform Bacteria (TCB). For heavy metals, Iron (Fe) were detected higher than the guideline values since baseline result in some stations. The high values are attributed to naturally high iron content resulting from geological weathering as detailed in the EIA report.

6) Social Monitoring

Social monitoring results for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite were done by PTTEP SA. There was no any complaint from the community throughout the well abandonment phase.

7) Public and Occupational Health and Safety Monitoring

Public and occupational health and safety monitoring results for well abandonment phase of Moenatkone wellsite, Ngabetkya wellsite, Padaukpin wellsite and Sakangyi wellsite were done by PTTEP SA. There was no incident case from project activity during well abandonment phase. PTTEP SA had strictly follow PTTEP SA's procedure for all case such as record data, find cause of accidents and performed mitigation measures.

The results of environmental impact monitoring determined that the project completely complied with 100% as shown in Figure 3-1.

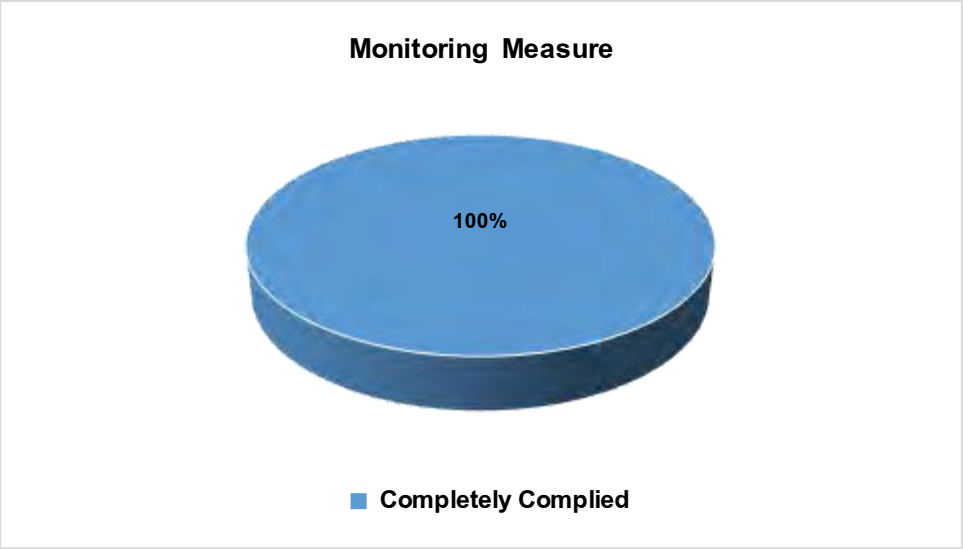

Figure 3-1 Summary of Monitoring Measure Implementation Results