SRWMA/J-PRISM II Pilot Project

COMPLETION REPORT

Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management in Pacific Island Countries Phase II (J-PRISM II)

SRWMA/J-PRISM II Pilot Project
Comppletion Report

February 2023

J-PRISM II Project Office

https://www.sprep.org/j-prism-2/home

c/o P.O. Box 240, Secretariat of the Pacific Regional Environment
Programme (SPREP), Apia, Samoa

SRWMA/J-PRISM II Pilot Project

COMPLETION REPORT

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LIST OF ACRONYMS

3R	Reduce, Reuse and Recycle
ABS	Acrylonitrile Butadiene Styrene
ADR	Accord Dangereux Routier (Agreement on the International Carriage of Dangerous Goods by Road)
BOQ	Bill of Quantities
DFAT	Department of Foreign Affairs and Trade
EDX	Energy Dispersive X-Ray Analysis
EU's RoHS Directive	Restriction of Hazardous Substances Directive of the European Union
GC-MS	Gas chromatography–mass spectrometry
GGP	Assistance for Grassroots Human Security Projects
HS	Harmonized System (internationally standardized system of names and numbers to classify traded products)
IBC	Intermediate Bulk Container
IMO	International Maritime Organization
ISO tank	International Organisation for Standardisation. ISO Tank is a tank container which is built to the ISO standard
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
J-PRISM I	Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management Phase I
J-PRISM II	Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management Phase II
MNRE	Ministry of Natural Resources and Environment of Samoa
MOU	Memorandum of understanding
MSDS	Material Safety Data Sheet
PACPLAN	Pacific Islands Regional Plan for Marine Spill Response
PacWastePlus	Pacific – European Union (EU) Waste Management Programme
PET	polyethylene terephthalate
PICs	Pacific Island Countries
PS	Polystyrene
PWFI	Plastic Waste Free Islands Project of IUCN
SPREP	Secretariat of the Pacific Regional Environment Programme
SROS	Scientific Research Organisation of Samoa
SRWMA	Samoa Recycling and Waste Management Association
SWAP	Sustainable Waste Actions in the Pacific
SWOMP	Samoa Waste Oil Management Programme
TPH	Total Petroleum Hydrocarbons
USP	University of the South Pacific
WMPC	Waste Management & Pollution Control Programme at SPREP

Acknowledgements

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We received generous technical support and advice from TAIBO Co., Ltd., including Mr Kazutoyo Hirano; HORAI Co., Ltd., including Mr Teruo Noguchi; NIHON YUKI Co., Ltd., including Mr Masato Takahashi; TAISEI Co., including Ms Hiroe Iwasaki, Mr Yousuke Shimada, Mr Masanori Negishi; Mr Amano Shiro, and Mr Atsuo Sakuma, the Scientific Research Organisation of Samoa (SROS), including Dr Fiso Fiame Leo, Mr Phillip Reti; the University of South Pacific (USP), including Dr Abdul Kader, Dr Viliame Savou; the Secretariat of the Pacific Regional Environment Programme (SPREP), including Mr Anthony Talouli, Mr Paul Irvin (PACPLAN), Mr Lance Richman (PacWastePlus), Ms Julie Pillet (SWAP). Without your guidance and persistent help, this pilot project would not have been possible.

Support, arrangements, procurements, and encouragement given by JICA Headquarters and JICA Samoa Office have been a great help in making the pilot project a reality.

We would like to express our gratitude to all the project stakeholders who helped us a lot in finalizing this challenging pilot project within the limited time frame.

EXECUTIVE SUMMARY

Purpose of Report

This report summarizes the results of the pilot project that was conducted by J-PRISM II in partnership with the Samoa Recycling and Waste Management Association (SRWMA) and Ministry of Natural Resources and Environment of Samoa (MNRE) from May 2021 to November 2022. PET bottle recycling, brick manufacturing from plastics used in air conditioner indoor units, waste oil collection, and landfarming were the main focus areas of the pilot project.

This pilot project has the following objectives.

- The recycling capacity for Samoa is strengthen.
- The economical and eco-friendly waste treatment methods are studied.
- The necessary improvements and adjustments to continue a sustainable and practical 3R+Return system are proposed.

Activity Details

Output 1
PET Bottle Recycling

- Support for the construction of a plastic recycling facility.
- Design of the PET bottle recycling process at the facility.
- Procurement and installation of a crusher and an extruder, including operation training and guidance.
- Development of the sales destinations and assistance with the income and expenditure calculation for PET bottle flakes and pellets.

Output 2
Plastic Bricks Manufacturing

- Support for the construction of a plastic recycling facility.
- Design of a recycling process for plastics used in air conditioner indoor units.
- Support in sorting plastic used in indoor units of air conditioners by types.
- Procurement and installation of a crusher and an extruder, including operation training and guidance.
- Production support for final products.
- Development of the sales destinations and assistance with the income and expenditure calculation for the distribution of flakes and pellets of various types of plastic used in air conditioner indoor units.

Output 3
Waste Oil Collection & Storage

- Implementation of the waste oil collection and storage activities and data collection.
- Proposals for operational improvements based on the results of activities and calculation of the income and expenditure.
- Proposal of waste oil leakage prevention measures.
- Proposal of landfarming implementation plan for remediation of contaminated soil affected by the leakage of waste oil.
- Implementing landfarming and coordinating with SROS for laboratory analysis and USP for contaminated soil management and data collection.

Findings and Conclusions

<table>
<tr><th colspan="2">PLASTICS RECYCLING (OUTPUT 1 AND OUTPUT 2)</th></tr>
<tr><td>Flake Production: 100% achieved</td><td rowspan="3">Refer to the 2.10 Conclusions in Part 2 for the details of the implementation results of each deliverable.</td></tr>
<tr><td>Pellet Production: 70% achieved</td></tr>
<tr><td>Extrusion and Molding: 30% achieved (Bricks Manufacturing)</td></tr>
<tr><td>Conclusions</td><td>It is confirmed that, with the aid of a certain amount of initial investment, plastic processing and recycling in Samoa is feasible.
In the future, it will be vital to maintain customer retention, and develop products that meet their needs.
Employment of workers by SRWMA is unstable. Without donor help, it will be challenging in the medium to long-term to secure human resources who can carry on the plastic recycling technology, maintain the machine operations, that were implemented during this project, and develop recycled plastic products.</td></tr>
</table>

10mm plastic flakes produced by crushing machine.

Extruder-produced plastic pellets recycled from PET bottles and plastic used in air conditioners.

Plastic stuck to the brick mold and could not be removed from the mold after cooling.

Experiments with extruding and molding various types of plastic using a variety of molds.

WASTE OIL COLLECTION, STORAGE, LANDFARMING (OUTPUT 3)	
Conclusions	■ Equipment required for safe collection and storage of waste oil at Samoa Waste Oil Management Programme (SWOMP) facility is currently not fully deployed. Current SWOMP collection fees do not reflect the costs that must be invested in purchasing and deploying the equipment required by safety measures. ■ Waste oil leakage risks exist in the process of collecting, storing and exporting waste oil. Current SWOMP collection fees do not cover the costs that must be invested in purchasing and deploying equipment required for waste oil leakage prevention measures. ■ Current SWOMP collection fee rate does not account for the costs of the establishment of appropriate storage facility, residue treatment facilities, and export costs. ■ Landfarming implementation is possible in Samoa. To accurately measure the changes and effects, support from external laboratories and universities is necessary. ■ In order to analyze and judge the sustainability of SRWMA's SWOMP, it is necessary to select a final disposal scenario (including an export scenario), further analyze the overall processing flow, and revise the current SWOMP collection fee from customers.

45,513 liters of waste oil collected and stored in one month.

Excavating and removing soil affected by waste oil leakage.

Conducted landfarming for a month and a half to remediate oil contaminated soil.

Recommendations

Plastic Recycling

- Customer base building and product development: Locate and secure reliable customers (recyclers, buyers, etc.) globally, choose plastic types that suit their needs and uses, improve processing methods, and continue to develop products.
- Strengthening technical support network of plastic recycling experts: Establishing a support network of plastic manufacturers and recyclers for receiving professional guidance on selecting plastic raw materials, molding products and developing recycled plastic products.
- Employment support for workers, succession of recycling technology, strengthening of training system for chief engineers: Samoa's plastic recycling system must be built in collaboration with MNRE and donor organizations to secure this kind of support.

Waste Oil Collection, Storage, Landfarming

- Revision of SWOMP waste oil collection fees: In addition to calculating total SWOMP operation costs, SWOMP waste oil collection fees should be revised to include the cost of purchasing necessary supplies to meet safety requirements and oil leakage prevention requirements, establishing an appropriate storage facility and residue treatment facility, required workers' employment costs and export costs.
- Continuation of landfarming activities: We confirmed that landfarming can be implemented in Samoa as a remediation measure when waste oil leaks into the soil. It is desirable to continue these activities in the future and verify the effectiveness of soil remediation.
- Strengthening collaboration and capacity building with laboratories and universities: Strengthening close collaboration and capacity building with the relevant organizations is very effective in facilitating activities and analyzing data.

History of the SRWMA/J-PRISM II Pilot Project

Plastics - PET bottle/Brick Manufacturing

January-June 2020
J-PRISM II and SRWMA have begun regular meetings to discuss the pilot project's details.

April 2020
J-PRISM II experts returned to Japan due to pandemic and remained there until June 2021.

June-September 2020
Interviews with plastic recyclers and recycling machine manufacturers were conducted.
Provided assistance to SRWMA in applying for a plastic recycling facility construction project from the GGP of the Embassy of Japan.

September-December 2020
Determined specification design of a crusher and an extruder machine and prepared.

February 2021
The SRWMA recycling facility construction project was adopted by GGP and construction commenced

March 2021
SRWMA held a school competition and collected 8 tons of PET bottles.

June 2021
A tender was conducted for a procurement of a crusher and an extruder by JICA HQs

November 2021
SRWMA plastic recycling facility construction completed by GGP.

January 2022
Crusher and extruder arrived in Samoa.

May 2022
Electricity work completed at the SRWMA plastic recycling facility.

June 2022
Sorted and dismantled air conditioner indoor unit's plastic for brick manufacturing.

July 2022
A four-day training on the operation and maintenance of an extruder was conducted by the manufacturer.

July-November 2022
Practiced daily operations using a crusher and an extruder for PET and bricks manufacturing

December 2022
A three-day workshop was held and the machine was handed over.

Waste Oil Collection and Storage

August 2019
SRWMA commenced Samoa Waste Oil Management Program (SWOMP).

January-June 2020
J-PRISM II and SRWMA have begun regular meetings to discuss the pilot project's details.

January-June 2020
J-PRISM II and SRWMA have begun regular meetings to discuss the pilot project's details.

June-September 2020
Interviews with waste oil recyclers were conducted.

February 2021
SWOMP waste oil storage facility construction completed by SRWMA.

September 2021
As part of the pilot project SRWMA/J-PRISM II, waste oil was collected and stored for one month.

February-March 2022
Two waste oil leak accidents occurred at SWOMP storage facility during the COVID-19 lockdown.

April-August 2022
Taisei Corporation, SROS, USP provided technical advice and discussed implementation methods on Land farming technology, that activates microorganisms inhabiting the soil and decomposes the oil in the soil.

September 2022
Contaminated soil with waste oil leaks was excavated and moved to the landfarming implementation site.

October-November 2022
Landfarming was implemented.

December 2022
Soil samples were sent to SROS and GC-MS analysis to identify the oil types was conducted.

1. INTRODUCTION

1 Background

1.1 Recycling Association Establishment Support Activities in JPRISM II

Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management Phase II (J-PRISM II) was launched in February 2017 as a 5-year project that targets nine Pacific Island Countries (PICs). There are four outputs under the J-PRISM II regional cooperation activities. “Practical and sustainable 3R+Return system is enhanced” is the fourth expected output, that was established from the beginning of the project.

The “3R+Return” concept has been promoted by J-PRISM for more than 10 years. Most of the countries in the region are lacking recycling facilities and have limited recycling markets due to the small scale of their economy. The “3R+Return” concept promotes proper resource recycling and appropriate disposal by exporting (=returning) recyclable waste or difficult waste for disposal, while returning organic waste into soil for effective resource utilization.

In its effort to enhance the practical and sustainable 3R+Return system, J-PRISM recognized the importance of private recycling companies in improving waste management in the region through the good impact of their ongoing work on recovery of scrap metals and its shipment overseas. J-PRISM identified the need to improve the support of these private recycling operations through upgrading their recycling technology, facilities, and equipment. Based on that, one of the approaches considered by J-PRISM II was for the private recycling companies to voluntarily establish an association (a nonprofit organization (NPO)), where the support from the Japan International Cooperation Agency (JICA) can be channeled to assist its members activities.

J-PRISM II is working on strengthening the regional network of recyclers in the Pacific through supporting the recycling association activities and promoting regional practical and sustainable 3R+Return system. As a result of the 3R+Return activity of J-PRISM II, recycling associations were established in Samoa, Vanuatu, Solomon Islands, PNG, and Tonga, as shown in Figure 1 and 2.

Country	Date of Launch	Association Name
Samoa	November 2017	Samoa Recycling and Waste Management Association (SRWMA)
Solomon Islands	November 2019	Solomon Islands Recyclers and Waste Management Association (SIRWMA)
Vanuatu	November 2019	Vanuatu Recyclers and Waste Management Association (VRWMA)
PNG	October 2021	PNG Waste Management & Recyclers Association (PNGWMR)
Tonga	October 2022	Tonga Recyclers Association (TRA)

Figure 1. Recycling associations in the Pacific.

SRMWA Strategic Plan launching event in October 2018.

SIRWMA launching event in November 2019.

VRWMA launching event in November 2019.

PNGWMR launching in October 2021.

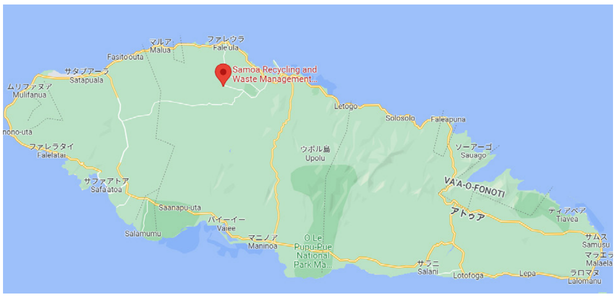
Figure 2. Establishment of recycling associations.

Lessons learnt from the establishment of the recycling associations and support for their activities provided by J-PRISM II are summarized in a report (Figure 3), that can be accessed via this link https://www.sprep.org/j-prism-2/lessons-learnt.

Figure 3. Lessons Learnt from the recycling association establishment.
https://www.sprep.org/j-prism-2/lessons-learnt

1.2 SRWMA Recycling Facility Location

SRWMA was established in 2017 with members including recyclers, car dealers, manufacturers, and universities in Samoa. Since February 2021, the SRWMA office and facilities have been set up in the Tafaigata landfill site (Figure 4).



SRMWA location at the Tafaigata landfill.

Aerial photo of SRWMA location at the Tafaigata landfill site (inside the red frame).

SRWMA main entrance.

SRWMA office.

SRWMA waste oil management facility.

Used glass clashing facility and glass stockpiles.

SRWMA plastic recycling facility constructed by GGP, Embassy of Japan funding.

SRWMA PET bottle segregation area.

Figure 4. SRMWA office and facility.

1.3 SRWMA Activity Highlights

As the top runner in the region, SRWMA has been collecting PET bottle, aluminum cans, glass bottles, waste oil, electronic waste, etc. as a voluntary waste collection initiative since 2019.

Waste collection events are planned by SRWMA in collaboration with their members, MNRE, private companies, donor partners and organizations. As a result, SRWMA has become widely recognized in the society, and the system of cooperation for waste collection events has been gradually expanding, e.g. the number of supporters who attend such events has been increasing.

Through the hard work of its executive members, SRMWA has organized waste collection events, raised funds, and promoted recycling pilot projects with relevant organizations and donor agencies.

SRWMA's ability to plan events, recruit collaborators, and reach out to the media is at the high level among recycling associations in the Pacific.

Community clean-up in March 2021.

Recycling school competition in March 2021.

Environmental Day in May 2021.

Plastic Free event in September 2022.

Coastal clean-up in October 2022.

Savaii e-waste collection drive in October 2022.

Figure 5. SRWMA event flyers.

It is highly appreciated that SRWMA holds events aimed toward educating future generations about the environment, such as waste plastic collection activities and fashion show - activities held jointly with primary schools and universities.

About 8 tons of PET bottles collected at these events were compressed by SRWMA and exported in 20ft container to Australian recycler in November 2021 with the support of the IUCN PWFI project. This was Samoa's first case of exporting used PET bottles to a foreign country, and it was a big achievement for both SRWMA and Samoa.

SRWMA Recycling Day event with award ceremony for recycling school competition in March 2021.

Recycling school competition in which 14 primary schools competed to collect beverage containers in March 2021.

(Source: https://www.samoaobserver.ws/category/samoa/81030)

Trashion Show (fashion items made of waste materials) held in November 2021.

(Source: https://www.samoaobserver.ws/category/samoa/94210)

First PET bottles shipment to a recycler in Australia in November 2021 supported by IUCN PWFI project.

Figure 6. SRWMA activity highlights.

1.4 SRWMA's Challenges

SRWMA's chronic problems are the lack of workers and funds for the activities.

To date, most of SRWMA's activities have been supported by workers of the companies run by the executive members of SRWMA. The association cannot employ workers without financial support from donors. Donor support is especially crucial to promoting recycling of plastics, which have low economic value.

In order for SRWMA projects and activities to be successful, this challenge must be addressed first, and a financial support system put in place by donor agencies or SPREP. Medium- to long-term improvement of recycling capacity and business profitability cannot be achieved without technology transfer and technology succession for workers who are continuously employed by SRWMA.

1.5 Plastics Waste and Basel Convention

As of January 1, 2021, the Basel Convention controls international shipments of most plastic scrap and waste destined for recycling or disposal. It means transboundary movements of most plastic scrap and waste are subject to Basel Convention prior notice and consent requirements. In particular, the following points should be considered when exporting plastics from Samoa.

Point 1: Tightening of Plastic Imports

Asian countries such as China and Thailand, which have the world's highest plastic demand, have completely banned or plan to ban the import of plastic wastes under their domestic laws. The Basel Convention has given each party the responsibility to enact its own regulations and standards for the transboundary movement of wastes. Based on that, as the requirements for exporting plastics become more stringent among the Basel parties and the number of receiving countries decreases, Samoa will face a more challenging path to process and export plastics.


Malaysia to send plastic waste back to Australia and other developed nations

Posted Wed 29 May 2019 at 12:52pm, updated Wed 29 May 2019 at 1:32pm

(Source: https://www.abc.net.au/news/2019-05-29/malaysia-to-send-tonnes-of-plastic-waste-back-to-foreign-nations/11159208)


Thailand to ban plastic scrap imports in 2025

Published Oct. 6, 2022

Megan Quinn
Reporter

Thirawatana Phaisalratana via Getty Images

First published on WASTEDIVE

(Source: https://www.supplychaindive.com/news/thailand-scrap-ban-plastic-basel-is-ril/633436/)

Figure 7.Relevant articles on plastic exports.

Point 2: Trade Restrictions for Basel Non-party Members

The most drastic change brought on by the Basel amendments are trade restrictions for non-party members. Under the previous provisions of the convention, parties were able to conduct plastic waste transactions with non-parties. The new amendment prohibits parties to the convention from trading certain plastic waste and scraps with non-parties. However, there are countries in the Pacific that have not ratified the Basel, such as Fiji, but have ratified the Waigani Convention. There is no change in the fact that hazardous waste (including plastics) can continue to be imported and exported between the Pacific, which are parties to the Waigani Convention.

Point 3: Recipient Countries of Baled Plastics Are Limited

It has been common practice in Samoa to compress used PET bottles and export bales of plastic. This had the advantage that the process was simple and the treatment costs on the Samoan side could be minimized. However, due to the revision of the Basel Convention, it is expected that the recipient countries that accept baled plastic will become more limited in the future. It is important for Samoa to strengthen its capacity to process plastics to meet the international demand for recycled plastics.

1.6 Outline of the SRWMA/J-PRISM II Pilot Project

1) Background of the Pilot Project

The pilot project implementation plan has been discussed by J-PRISM II and SRWMA since 2020.

This pilot project was designed to promote and strengthen the recyclable waste collection activities that have been already actioned by SRWMA. Amongst them is a Recycling Station program (collection of drinking containers such as PET bottles and aluminum cans), as well as the SWOMP program (waste oil collection).

From April 2020 to May 2021, due to the COVID-19 global border restrictions, the J-PRISM II expert team was temporarily evacuated to Japan, and project work had to be carried out remotely from there. During this time J-PRISM II visited plastic recyclers and plastic recycling machine manufacturers in Japan and determined the specifications of machines and items that can be introduced in the SRWMA/J-PRISM II pilot project.

2) Objectives of the Pilot Project

- The recycling capacity for Samoa is strengthened.
- The economical and eco-friendly waste treatment methods are studied.
- The necessary improvements and adjustments to continue sustainable and practical 3R+Return system are proposed.

3) Activities

- Output 1: PET bottle recycling
- Output 2: plastic bricks manufacturing
- Output 3: waste oil collection and storage

4) Duration

18 months, from June 2021 (signing of MOU) to November 2022

5) Implementation Site

SRWMA facilities in Tafaigata landfill site

Output 1 and 2: Plastic recycling facility.

Construction year: November 2021
Facility area: 3,008m^2
Project name: Grant Assistance for Grassroots Human Security Projects (GGP) by the Embassy of Japan
J-PRISM II support: GGP application documentation support, architectural design and BOQ estimate cost support

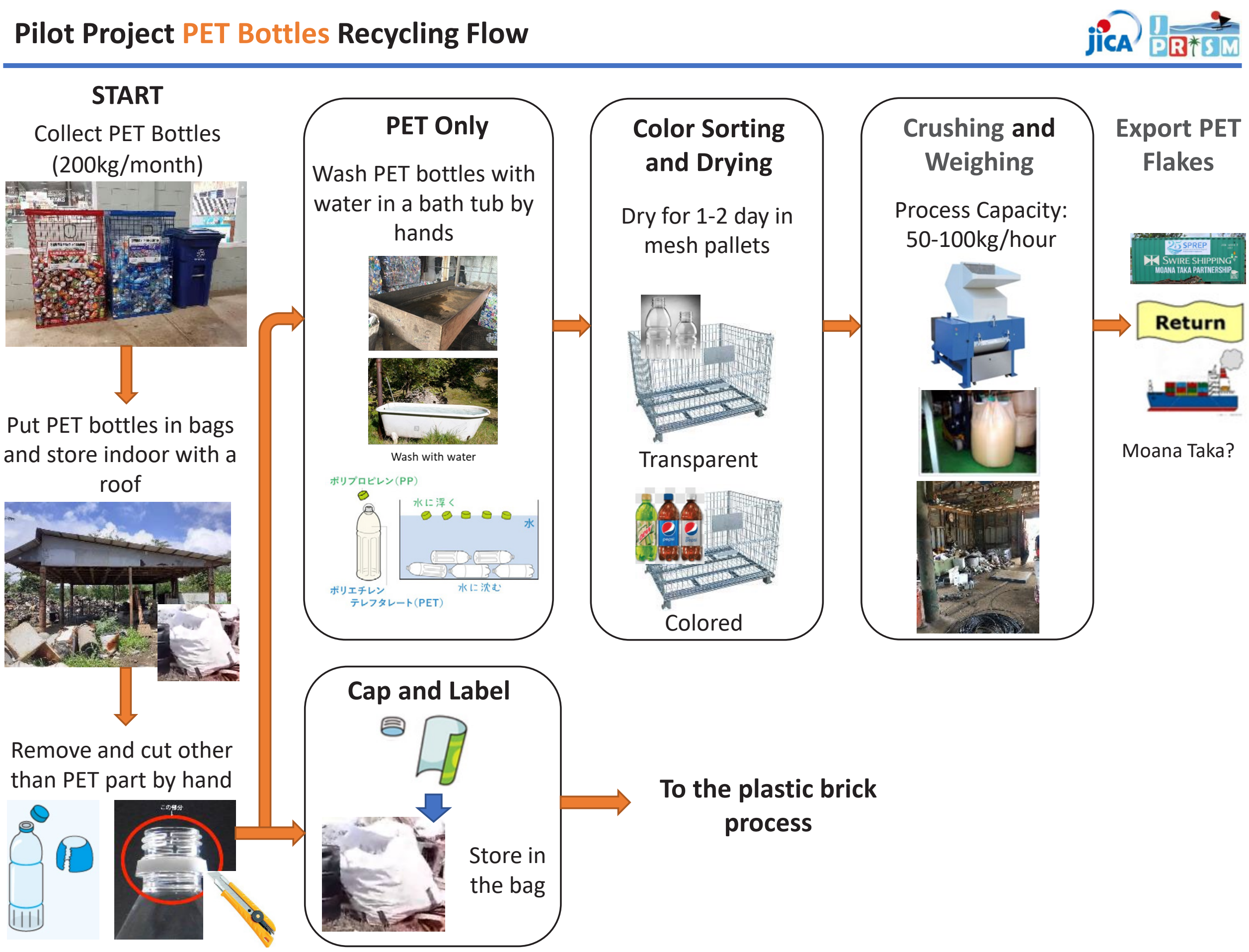
Output 3: Waste oil management facility.

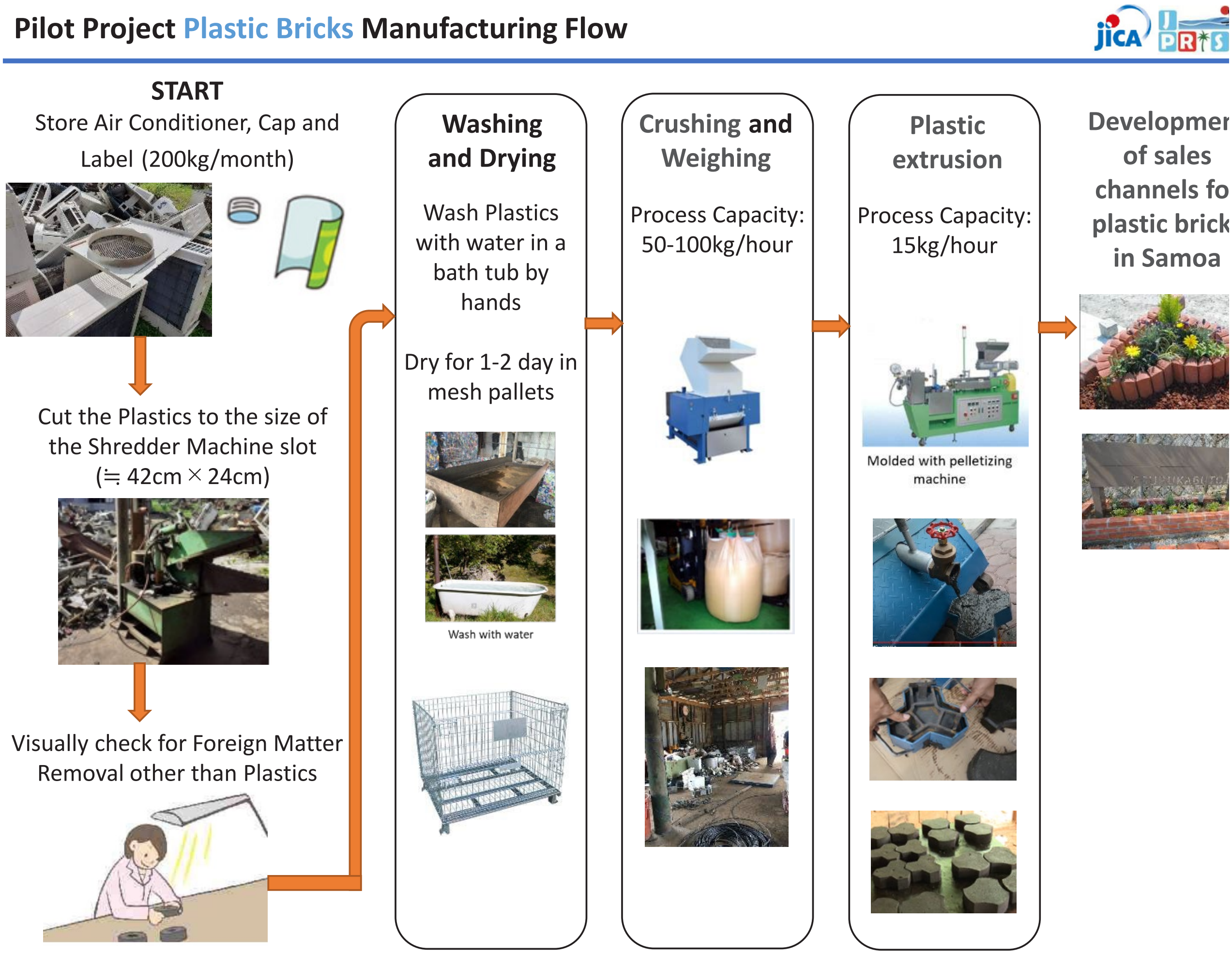
Construction year: March 2021
Storage capacity: maximum 96,264 liters

Figure 8. SRWMA facilities where the pilot project was implemented.

6) Waste Process Flow

Figure 9 below illustrates the process flow of the three target wastes as described in the SRWMA/J-PRISM II Pilot Project implementation report that was created in May 2021 and was attached to the MOU. Parts 2 and 3 summarize how these planned processing flows were operated or changed during the SRWMA/J-PRISM II pilot project period.





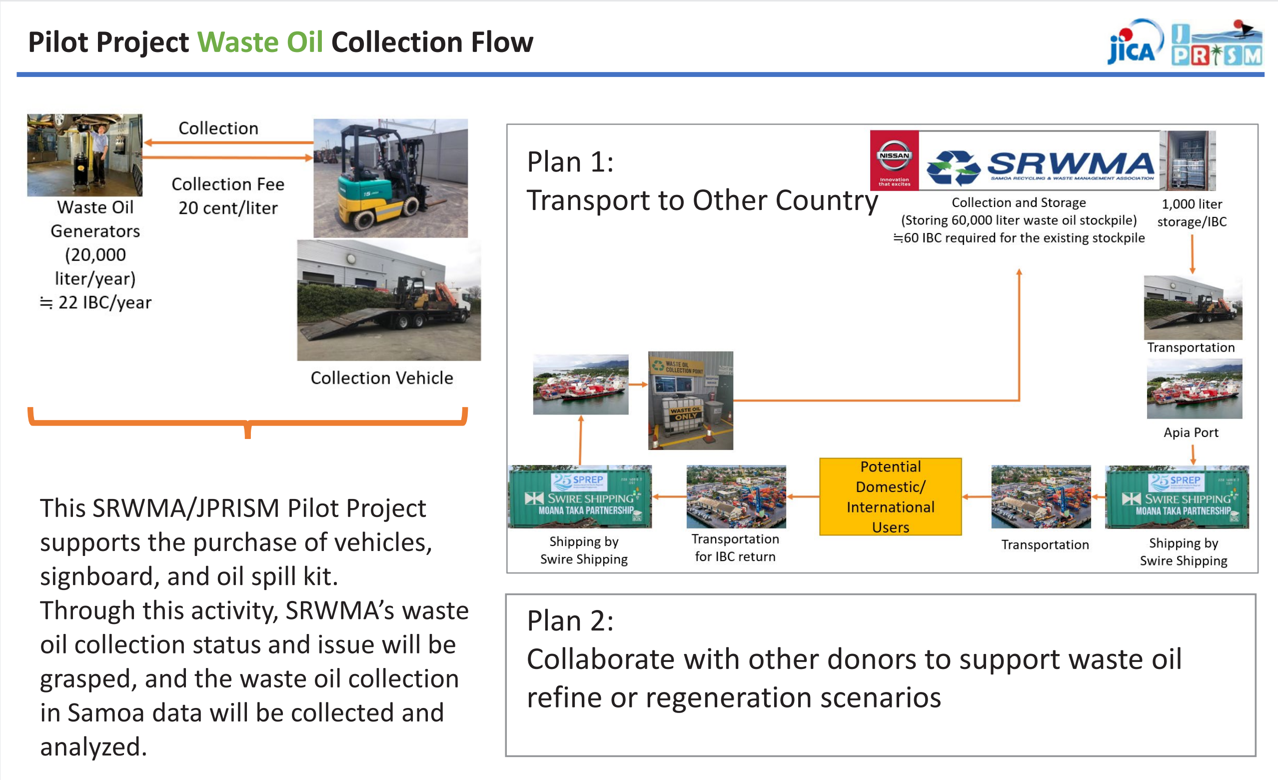


Figure 9. Waste process flow in the pilot project.

7) Expected Outcomes

The anticipated outcomes for each waste target as of May 2021 were as follows (Figure 10):

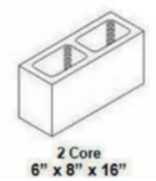
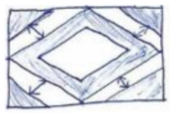
Output	Current Status	Final products from Pilot Project	
Output1: PET Bottle Recycling			
	PET Collection Cage	PET Flake ϕ 10 mm	PET Pellet 5 mm
Output2: Plastic Bricks Manufacturing			
	Stockpiled Plastics	6-inch brick	Floor/Foot Path Tile
Output3: Waste Oil Appropriate Collection and Storage			
	Stocked waste oil	Promotion of Collection	Storage in IBC tank

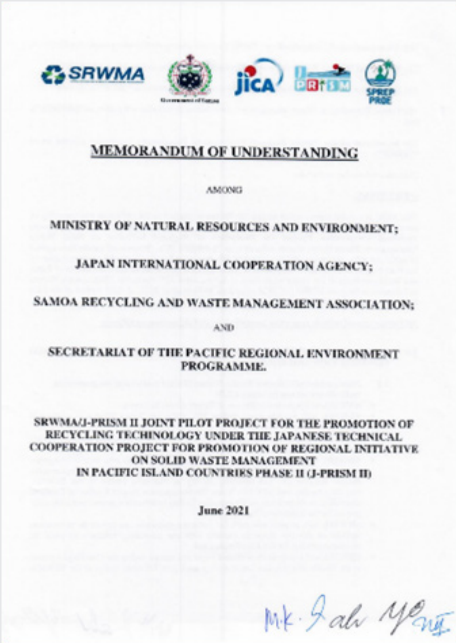
Figure 10. Expected outcomes from the pilot project.

8) Division of Roles of MOU Signers

In June 2021, JICA/J-PRISM II signed an MOU to implement a pilot project together with MNRE, SRWMA and SPREP. The division of roles of each organization specified in Figure 11. The pilot project was monitored and reviewed during the implementation period according to this division of roles.

Item	JICA	SRWMA	MNRE	SPREP
Management of collected target wastes		✓		
Information recording and reporting	✓	✓		
Project coordination and management			✓	
Ownership and operation maintenance of equipment	✓ (During implementation period)		✓ (After implementation period)	
Public awareness and education	✓		✓	
Capacity development needs	✓		✓	
Monitoring and reporting	✓		✓	
Project review and evaluation	✓		✓	✓
Sharing of information and lessons learnt	✓		✓	
Provision of technical assistance				✓

Figure 11. Division of roles during SRWMA/J-PRISM II pilot project implementation.



MEMORANDUM OF UNDERSTANDING

AMONG

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT;

JAPAN INTERNATIONAL COOPERATION AGENCY;

SAMOA RECYCLING AND WASTE MANAGEMENT ASSOCIATION;

AND

SECRETARIAT OF THE PACIFIC REGIONAL ENVIRONMENT PROGRAMME.

SRWMA/J-PRISM II JOINT PILOT PROJECT FOR THE PROMOTION OF RECYCLING TECHNOLOGY UNDER THE JAPANESE TECHNICAL COOPERATION PROJECT FOR PROMOTION OF REGIONAL INITIATIVE ON SOLID WASTE MANAGEMENT IN PACIFIC ISLAND COUNTRIES PHASE II (J-PRISM II)

June 2021

IN FURTHERANCE OF their respective goals and objectives, the Parties jointly agree to abide by the provisions of this MOU, and caused this MOU to be duly executed.

Mrs. Frances Brown-Reupena
Chief Executive Officer
Ministry of Natural Resources and Environment
Date

Mrs. Marina Keil
President
Samoa Recycling & Waste Management Association
Date

Mr. Akihiko Hoshino
Resident Representative
JICA Samoa Office
Japan International Cooperation Agency
Date

Mr. Kosi Latu
Director General
SPREP
Secretariat of the Pacific Regional Environment Programme
Date

Ms. Yoko Onuma
JICA Expert (Monitoring / 3R+Return)
J-PRISM II
Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management in Pacific Island Countries Phase II
Date

Figure 12. MOU was signed in June 2021.

Figure 13. Implementation Plan of SRWMA/J-PRISM II pilot project developed in May 2021.

9) Implementation Plan

An implementation plan for the SRWMA/J-PRISM II pilot project was developed prior to its execution (Figure 13). This document describes the implementation method, the expected outcomes, and the evaluation method of the pilot project.

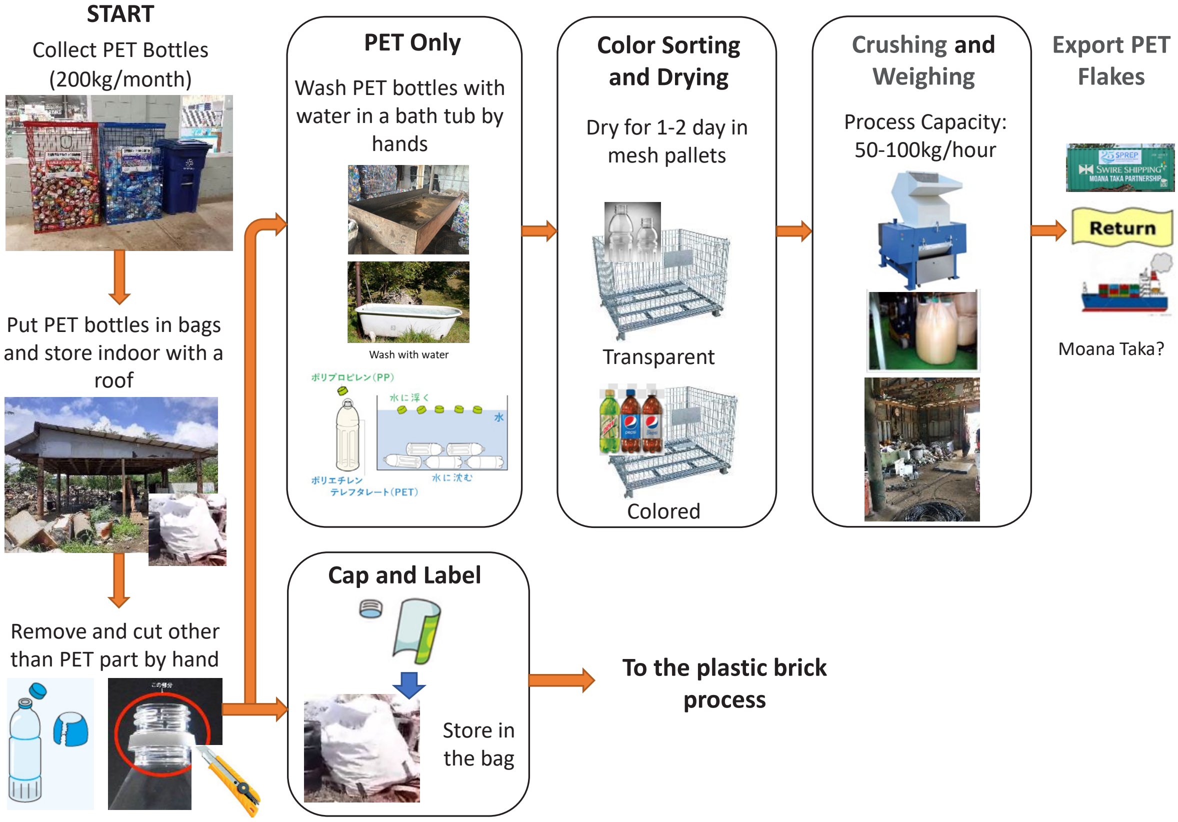
2. IMPLEMENTATION RESULTS - PLASTICS

Plastics Recycling Activities

The SRMWA/J-PRISM II Pilot Project implemented two activities on plastic recycling.

Section 2.1 of this chapter describes the implementation results of the ***Output 1: PET bottle recycling***. Implementation results of the ***Output 2: Plastic bricks manufacturing*** presented in section 2.2.

Pilot Project PET Bottles Recycling Flow



Pilot Project Plastic Bricks Manufacturing Flow

2.1 Background

SRMWA/J-PRISM II Pilot Project chose PET bottles and brick manufacturing from plastic used in air-conditioner indoor units as their target wastes. The reason for that was the status of SRWMA collection and processing work prior to this project.

1) SRWMA's PET Bottle and Air Conditioner Collection Amount Before the Pilot Project

Since 2019, SRWMA has been running the Recycling Station project – a voluntary collection of PET bottles and aluminum cans from restaurants, hotels, bars, supermarkets, and institutions in Apia.

As of November 2020, SRWMA has installed approximately 22 small cages and 23 big cages in town area. The current annual collection amount of PET bottles through the Recycling Station project is estimated at 2.4-3.6 ton/year.

In addition, SRWMA has been collecting beverage containers through organizing a School Recycling Competition, where primary schools compete for the largest amount of collected PET bottles. The first competition was organized in 2021, and has become an annual event. Approximately 3 tons of PET bottles were collected through this activity.

As a result of these two activities, it is estimated that SRWMA collects about 5.4-6.6 tons of PET bottles per year. According to the National Waste Management Strategy 2019-2023 developed by MNRE in 2017, the amount of PET bottles generated in Samoa is estimated at 422.2 tons/year. Therefore, the amount of PET bottles collected by SRWMA makes about 1.27-1.56% of the overall volume of waste PET bottles in Samoa (Figure 14).

PET bottle generation and collection	Generation and collection volume	SRWMA collection rate in domestic PET bottle generation
PET bottle generation volume in Samoa[1]	422.2 ton/year (35.18 ton/month)	-
PET bottle collection volume through SRMWA's Recycling Station project[2]	2.4-3.6 ton/year (200-300 kg/month)	0.56-0.85%
PET bottle collection volume through SRMWA's School Recycling Competition[2]	3.0 ton/year	0.71%
SRWMA's PET bottle annual collection amount and rate	5.4-6.6 ton/year	1.27-1.56%

Figure 14. SRWMA PET bottle collection amount and rate in Samoa.

SRWMA does not have a collection program for air conditioners, but since they contain a high proportion of metals than other e-waste, SRWMA member recycling companies already collect them. Therefore, it was selected as the target waste for this pilot project.

According to JICA's Data Collection Survey on Reverse Logistics in the Pacific Islands Final Report published in 2013, 48.0 tons of air conditioners were generated in 2020.

1 MNRE (2017), National Waste Management Strategy 2019-2023.
2 J-PRISM II Expert Interview and estimation.

SRWMA member companies collect about 45 tons of air conditioners annually, according to an interview conducted by the JICA expert in 2019. Accordingly, SRWMA collects 94.79% of all air conditioners as shown in Figure 15.

Air conditioner generation and collection	Generation and collection volume	SRWMA collection rate in domestic air conditioner generation
Air conditioner generation volume in 2020 in Samoa[3]	48.0 ton/year (4.0 ton/month)	-
SRWMA's air conditioner annual collection amount and rate through SRMWA member recycling companies[4]	45.5 ton/year (3.79 ton/month)	94.79%

Figure 15. SRWMA air conditioner collection amount and rate in Samoa.

2) SRWMA's PET Bottle and Air Conditioner Process Before the Pilot Project

Prior to implementing the SRMWA/J-PRISM II pilot project, SRWMA did not own any processing machinery. For this reason, SRWMA had no option but to process PET bottles using the machines owned by member companies. Since SRWMA member company has a compressor for compressing ferrous/non-ferrous scrap, SRWMA's PET bottles were also compressed using the same equipment as shown in Figure16.

Since the PET bottles are compressed without removing the label and ring, there is no need for pretreatment, which is an advantage. Prior to the 2021 Basel Convention revision, this was the standard method of exporting PET bottles in developing countries.

However, as summarized in section 1.5 of this report, due to the revision of the Basel Convention, an increasing number of countries like China, Japan are banning the import and export of compressed PET bottles depending on their domestic laws.

In view of this international trend, it is crucial for Samoa to develop a crushing and pelletizing technology which can be used to process PET bottles domestically and export them.

SRMWA member recycling companies routinely dismantle air conditioner outdoor units and manually remove copper, iron, and aluminum parts in preparation for export. However, the plastic used in air conditioners after being dismantled by hand was not treated, and left outdoors for long-term storage (Figure17). Once the storage area was full, plastic waste was transported to Tafaigata landfill site.

It was decided to procure machines that can process both PET bottles and air conditioner plastics. PET bottles and air conditioners are both made of plastic, so plastic crushers and pelletizers can be used to process both.

3 JICA (2013), Data Collection Survey on Reverse Logistics in the Pacific Islands.
4 J-PRISM II Expert Interview and estimation.

Putting PET bottles into the compressor.

Compressed PET bottles.

Figure 16. SRWMA PET bottle process prior to the SRMWA/J-PRISM II Pilot Project.

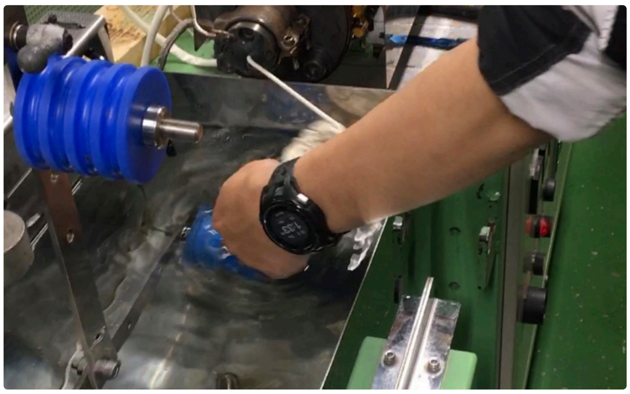
Air conditioner indoor unit stored outdoors.

Figure 17. SRWMA air conditioner process prior to the SRMWA/J-PRISM II Pilot Project.

2.2 Specifications and Selection of Machinery

J-PRISM II spent half a year (from June to December 2020) selecting crusher and extruder machines, visiting manufacturers in Japan, who demonstrated machines' performance and use. Based on the discussion with the manufacturers and plastic recyclers in Japan, J-PRISM II finalized the specs of both machines as shown in Figure 19 and 20 (see next page). Tenders and procurement of both machines were conducted by JICA Headquarters in 2021.

Crushing test using a crushing machine at a crusher manufacturer in Japan.



Pelletizing test using an extruder machine at the extruder manufacturer in Japan.

Figure 18. Machine operation check at the machine manufacturers.

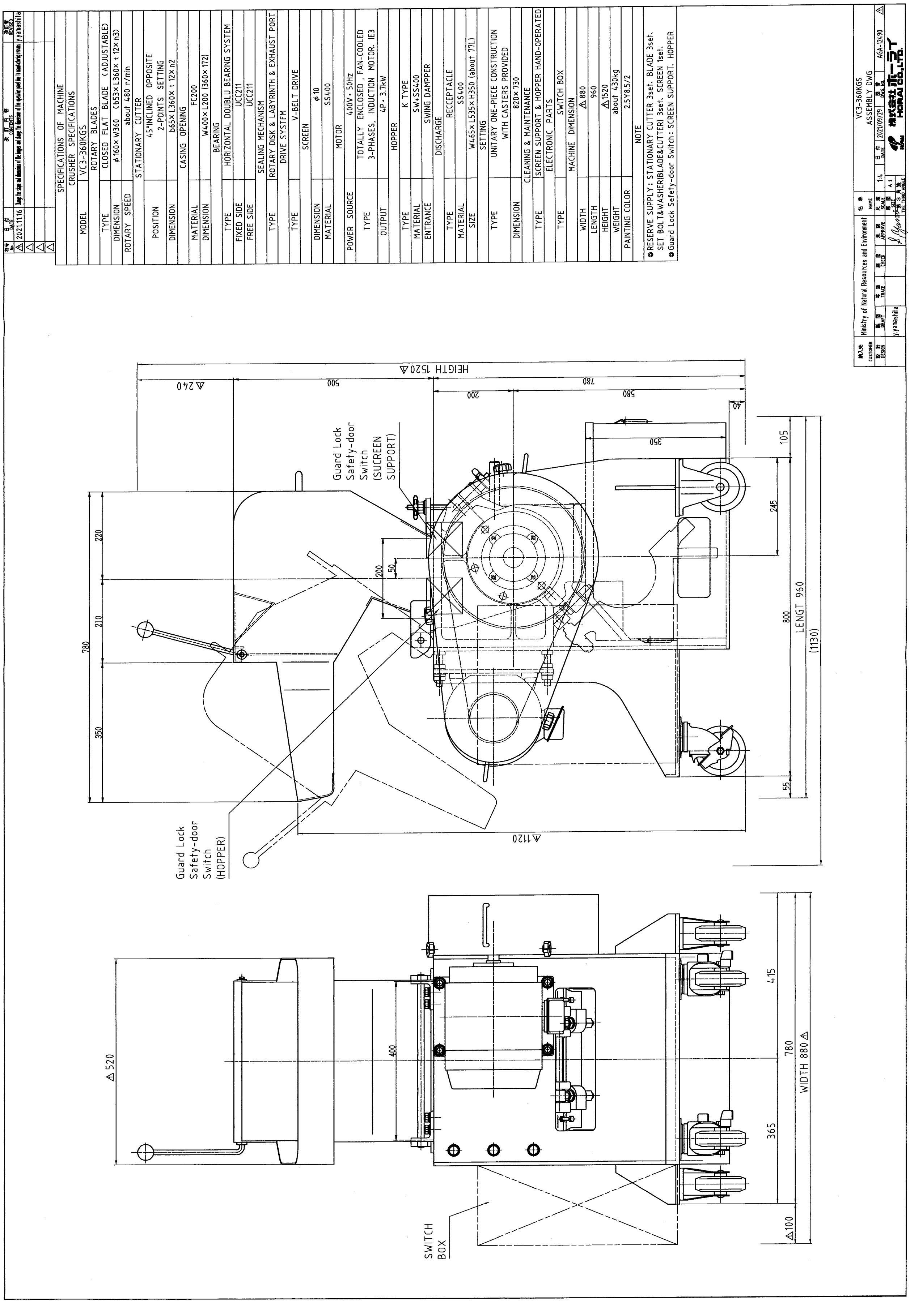


Figure 19. Crushing machine specs and drawing.

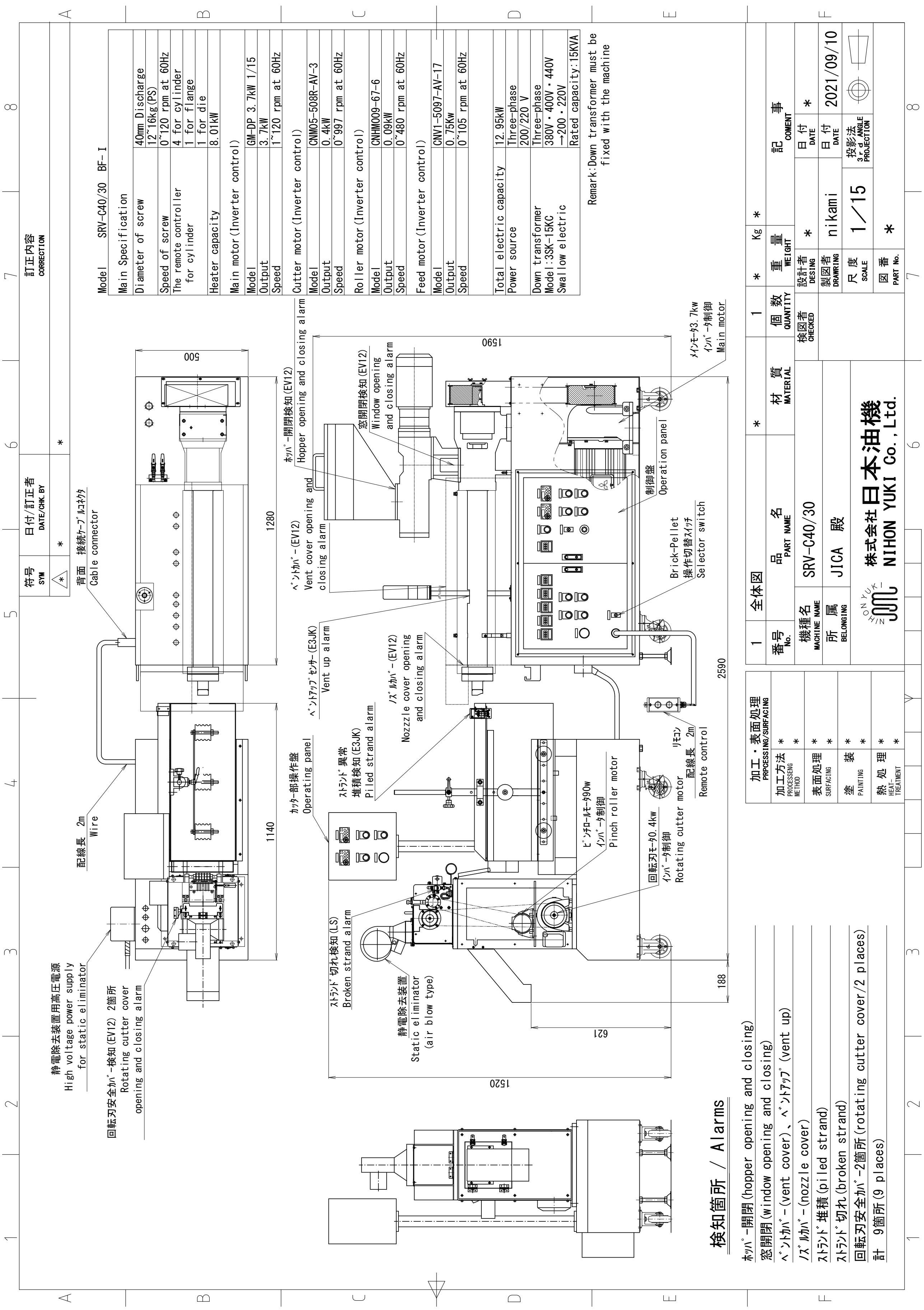


Figure 20. Extruder machine specs and drawing.

2.3 Process Flow and Layout Design for SRWMA Plastics Recycling Facility

An application to the GGP of the Japanese Embassy requesting support for the construction of the SRMWA recycling facility was launched in August 2020, with the following approval in February 2021. Construction work began in March 2021 and was completed in November 2021.

Regular meetings of SRWMA and J-PRISM II discussed the plastic recycling processing flow to be implemented in this pilot project. It was designed according to the layout of the facility. The equipment required for each process (sorting, washing, drying, storage) was procured in Samoa by J-PRISM II.

Front of the facility.

Left side of the facility.

3-phase switch and power outlet.

Inside the facility. The wall where the machines will be installed.

Figure 21. SRWMA Plastic Recycling Facility.

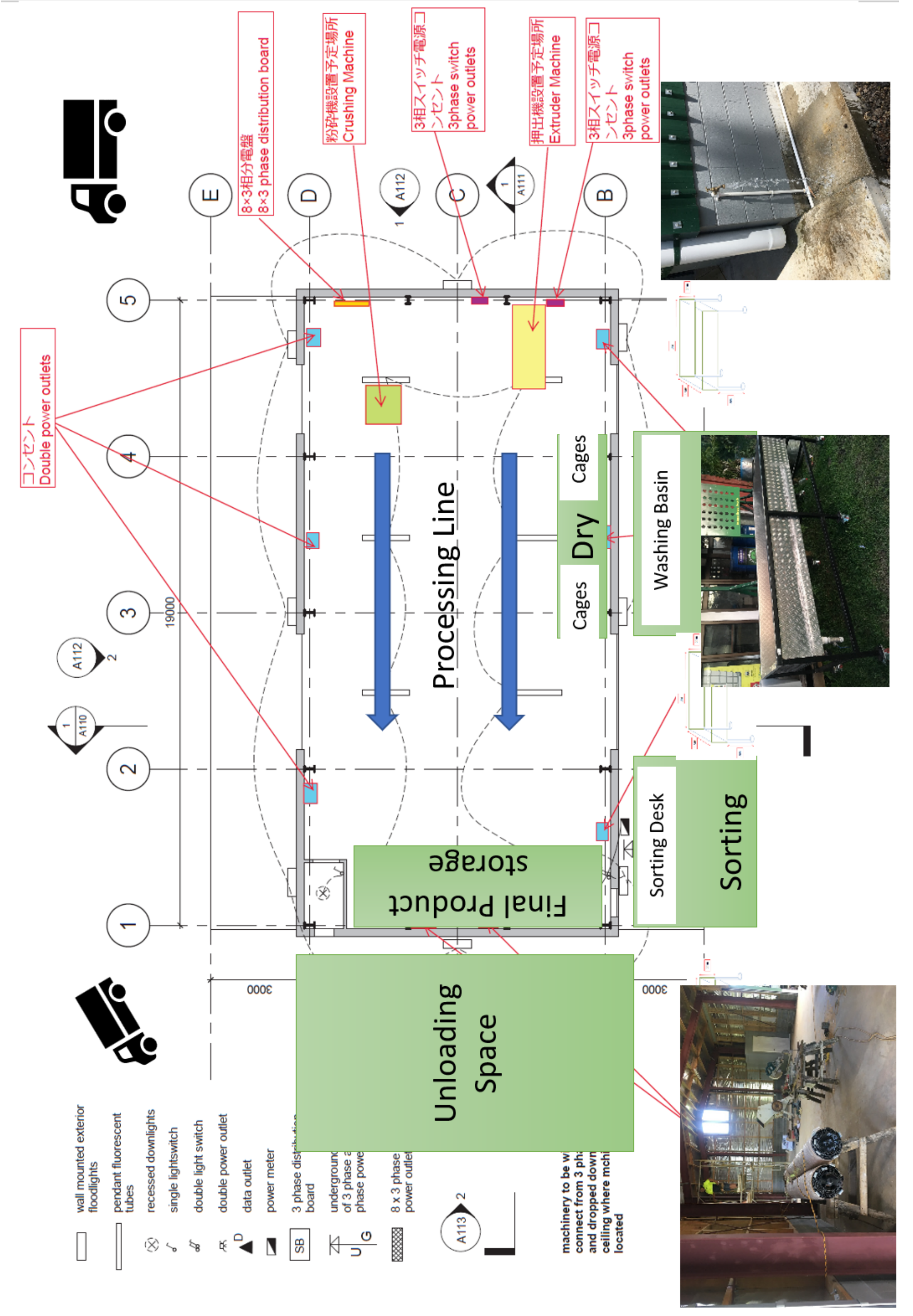


Figure 22. Facility layout design.

2.4 On-site Preparation for Extruder Machine Training

The crushing machine and the extruder machine procured in Japan arrived safely in Samoa in January 2022, and the following preparations were made at the site for the extruder operation and maintenance training to be conducted by JICA headquarters in July 2022.

1) Installation of Machinery

Following the arrival of the crushing machine and the extruder machine in Samoa in January 2022, both machines were temporarily stored at SRMWA member company Pacific Recycle Co. Ltd. As soon as the electrical wiring and water supply work at the SRWMA plastic recycling facility was completed in June 2022, SRWMA and J-PRISM II dismantled the packaging and confirmed the quantity of equipment and spare parts on site.

Move from temporary storage site at Pacific Recycle Co. Ltd. to SRWMA.

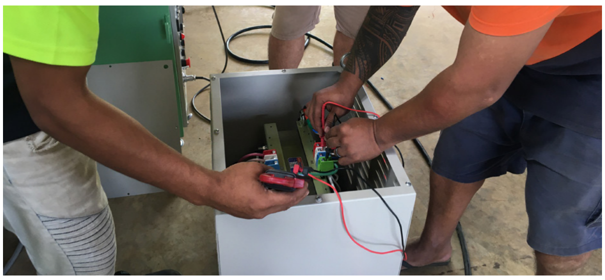
Transport wooden crates to SRWMA recycling facility.

Move to the installation site of the equipment.

Check the quantity of equipment and parts based on the packing lists.

Electric Power Corporation (EPC) connects electricity to the facility .

Inspection of the electrical wiring by electrician.



Extruder machine electrification inspection by electrician.

Connection of the hose to the extruder machine.

Figure 23. Installation of machinery to the pilot project site.

2) Types of Plastics Used in Indoor Units of Air Conditioners

Plastics used in air conditioner indoor units differ depending on the manufacturer and brand. Prior to manufacturing bricks with an extruder, it is compulsory to sort and process each type of plastic. For this reason, two-day research was undertaken in May 2022 to determine the manufacturer of the air conditioner, the type of plastic, the weight of indoor units, and sortable volume per day.

The type of plastic in air conditioner's indoor unit was identified by its plastic mark (resin identification code). There are two categories of indoor units: those without resin identification codes and those that cannot be recycled with an extruder since two or more types of plastic are used. As a result, approximately half (50%) of all indoor units were categorized as "unclassified".

Apart from that, it was determined the other half of the collected air conditioners contained the following plastic types: Polystyrene (PS) and Acrylonitrile Butadiene Styrene (ABS) having a share of about 25% each of the total amount of inspected units. These two plastic types were used as raw materials for brick manufacturing and pellet manufacturing.

Implementation Day		Work Time	Weight Sorted by Plastic Type			
			PS (kg/day)	ABS (kg/day)	Unclassified (kg/day)	Total amount (kg/day)
Day 1	23rd May (Mon)	10:00-14:30	42	49	51	**142**
Day 2	24th May (Tue)	10:00-14:30	35	22	95	**152**
		2 days total	77	71	146	**294**
		Product percentage (%)	26.2	24.1	49.7	**100**

Figure 24. Percentage of plastic types in indoor units of air conditioners.

Checking the plastic mark (resin identification code) inside the indoor unit.

Plastic mark (resin identification code) inside the red circle.

Figure 25. Air conditioner plastic mark and type check.

3) Removing Parts and Pre-cutting

As shown in Figure26, the indoor unit contains a filter, an electric equipment box, and a printed circuit board that were dismantled by hand using screwdrivers.

The size of the plastic part of an indoor unit is about 30 cm high and 70-90 cm wide on the average, which is larger than the 20 cm by 40 cm input port of the crushing machine that was procured. In order to match the inlet size of the new crushing machine, plastic parts were cut using a cutter machine owned by Pacific Recycling Co., Ltd. (Figure 26).

Removal of non-plastic components, circuit boards and screws.

Cutting the indoor unit with a cutter to match the size of the inlet of the crushing machine.

Figure 26. Air conditioner plastic sorting and cutting work.

4) Washing

Both, PET bottles and plastic parts of air conditioner indoor units, require cleaning that follows the segregation process. For this purpose, J-PRISM II commissioned a Samoan company to construct a washing tank.

This water tank was designed to be large enough for eight workers to work side by side and is 3 m in length, 1 m wide, 1 m high, and 40 cm deep. Dishwashing detergent, sponge scrubbers, and toothbrushes were used to remove dirt and foreign matter from plastics.

Washing air conditioner units in the wash tank.

Drying clean units sorted by plastic type.

Washing the caps of the PET bottle.

Dry PET bottle caps outdoors.

Figure 27. Wash and dry process.

5) Crushing

In June 2022, SRWMA operated the crusher procured from Japan and crushed the plastics by type. Raw materials prepared for the extruder training in July were the types of products and plastics illustrated in Figure 29.

Grinding PET bottles with crushing machine.

PET bottles after being crushed.

Inspection and cleaning process after the use of crushing machine

Crushing machine screen is set to crush plastics to 10mm size.

Figure 28. Operation of crushing machine started in June 2022.

Figure 29: Crushed plastic products and types.

2.5 Extruder Operation Training by Manufacturer

JICA headquarters conducted four days of online remote training (4-7 July) to provide guidance on operation and maintenance of extruders. The training was delivered by Nihon Yuki, the extruder manufacturer from Japan. As part of the training, MNRE, SRWMA, and J-PRISM II teams learned about pellet production, cleaning, maintenance, and brick manufacturing methods.

Training Content	Training Scene and Deliverable
DAY 1 (4th July, 11:00-17:00pm) ■ Extruder operation general guidance ■ Pellet manufacturing practice 1 using crushed PET bottles	 
DAY 2 (5th July, 11:00-17:00pm) ■ Pellet manufacturing practice 2 using crushed ABS air-conditioner indoor unit (a different resin from the previous day)	 
DAY 3 (6th July, 11:00-17:00pm) ■ Cleaning: removing screws and cleaning the machine ■ Checking the maintenance process	 
DAY 4 (7th July, 11:00-17:00pm) ■ Pouring into the extrusion mold step ■ Bricks manufacturing practice using crushed PS air-conditioner indoor unit	 

Figure 30. Extruder operation training in July 2022.

2.6 Machine Operation Practice and Lessons Learnt

1) Implementation Dates

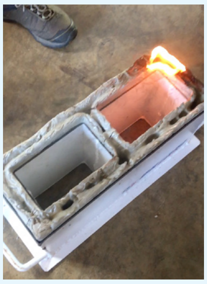
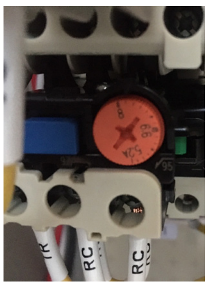
After completing the extruder training in July, SRWMA, MNRE and J-PRISM II team practiced pellet production, machine cleaning and maintenance, brick production through the pilot project implementation period as shown in Figure 31.

Date	Content of activity
28 July, 2022	Extruder cleaning
2 August, 2022	Facility and extruder voltage check
4 August, 2022	Extruder cleaning and plastic removal in brick mold
9 August, 2022	Confirmation of trouble button operation of crushing machine
18 August, 2022	Extrusion using HDPE blue bottle lid
19 August, 2022	Extruder cleaning
8 September, 2022	Pellet manufacturing using PET
9 September, 2022	Extruder cleaning
15 September, 2022	Extrusion using HDPE blue bottle lid
16 September, 2022	Extruder cleaning
13 October, 2022	Crushing machine maintenance work
20 October, 2022	Extrusion using PS air-conditioner indoor unit
21 October, 2022	Extruder cleaning
17 November, 2022	Pellet manufacturing using PET
21 November, 2022	Extruder cleaning
13-15 December, 2022	J-PRISM II handover workshop for crushing machine and extruder machine
10 February, 2023	J-PRISM II Pilot Project Implementation Results Report session

Figure 31. Machine operation practice dates.

2) Lessons Learnt from the Machine Operation Practice

The table below summarizes typical examples of problems and challenges that occurred when operating the crushing machine and extruder machine during the pilot project, and lessons learnt from them.

Date and Content	Problems and challenges that occurred during machine operation	Lessons learnt
28 July Extruder power supply troubleshooting	**There was a problem reaching the extruder set temperature:** ■ Normally, after setting the extruder's temperature, it takes about 30 minutes to 1 hour to reach the set temperature, but on this day, even after 4 hours from setting, none of the heaters reached the set temperature. For this reason, the work was canceled in the middle of the day. ■ J-PRISM II contacted the person in charge of the extruder manufacturer in Japan, and they advised to check the power supply to the facility. ■ As a result of checking the power supply to the facility, it was found that there was a problem with the 3-phase power supply from the electric company, and the EPC restored the power supply to the facility later.	From this incident it was learnt that the voltage value sent to each phase with the facility's electricity meter has to be checked, and from that day on, every time when the extruder and crushing machine are to be operated, meter shall be used to check whether there are any problems with the electricity and voltage values.
4 August Plastic removal in brick mold test	**Unsuccessful attempts to remove plastic that was stuck to the mold by heating it with a butane gas burner.** The plastic did not melt enough because of the height and depth of the brick molds.   	■ Initially, it was planned to make 6-inch brick molds (20 cm high, 15 cm wide, 20 cm long), but it was confirmed that it is difficult to remove plastic from such mold once its cooled. ■ From this experience, it was decided to practice molding smaller products next time.
9 September Crushing machine troubleshooting	**While the crusher was running, the orange trouble lamp lit up and the machine stopped:** ■ J-PRISM II contacted the person in charge of the crusher manufacturer in Japan, and they advised to check the two safety keys on the safety device. They were securely locked and in place. ■ After reinserting the two safety keys and pushing the blue limit switch in the control box, the trouble lamp went out.   	■ There was no description in the manufacturer's instruction manual on solving the problem when the trouble lamp light is on. Therefore, J-PRISM II created a separate instruction manual to describe this method of troubleshooting. ■ It became clear that it is important to set up a support system that Samoa could use to contact Japanese manufacturers in case such situation or similar occurs in the future.

18 September Extrusion challenge using HDPE blue bottle lid	**Even if the set temperature of the extruder was raised to 320 degrees or more, the plastic did not melt into a liquid state and the mold could not be filled with the plastic in a sheet form:** ■ The temperature setting of the heater was raised to 320-330 degrees, but the molten plastic was extruded in rods. After that, it was put in a wooden mold and pressed from on top, but the plastic remained to be in a shape of a tube and the tubes did not stick to each other. ■ J-PRISM II contacted the person in charge of the extruder manufacturer in Japan, and they advised if the extrusion was unsuccessful at 320 degrees, this plastic waste might not be suitable as an extrusion material. 	■ From this experience, it was learnt that there are plastics that do not become liquid even when melted due to the additive agents. ■ Since this cannot be confirmed without trying to extrude plastic using a machine, a certain amount of trial and error is expected when working with the raw material for extrusion.
20 October Extrusion method change trial using PS air-conditioner indoor unit	**Heating the mold and then extruding the plastic into heated mold** Poured hot water on the electronic grill pan and put the mold in it. 	■ It was confirmed that the surface of the melted plastic put into the heated mold became smooth, probably because the temperature of the mold was kept constant to some extent. ■ There is a need to develop a heating method to heat the mold during molding like this.

Figure 32. Lesson learnt from the machine operation.

3) Trial and Error of Plastic Molding

Figure 33 below lists molds and product examples molded in the pilot project. The stage of making the final product during this pilot project was not reached. Samoa team needs to continue practicing, produce a mold suitable for what they want to make, and extrude using the appropriate plastic.


Original Goal: 6-inch brick manufacturing.


Next goal: chair seat manufacturing.


Wooden mold for extruding the seat for a chair (mold was made by SRWMA).


An attempt to mold HDPE plastic with a bread baking mold.


Testing molding PS plastic with a toasted sandwich mold.


Experimenting with various molds.

Figure 33. Experiments with molding.

4) Machine Hand-over Workshop

Between December 13th and 15th, J-PRISM II completed a training workshop on both crushing and extruder machines, before handing over operations to its Samoan counterparts, MNRE and SRWMA. Participants of the workshop were awarded a Certificate of Completion of the workshop.


Certificate award .


Group photo.

Figure 34. J-PRISM II Handover Workshop for plastic crusher and extruder machines.

2.7 Acquisition and Succession of Machine Operation Skills

1) Extruder Work Log Book

When using an extruder, it is necessary to change and adjust settings according to the type of plastic and the difference and characteristics of the material. Therefore, J-PRISM II created a work log sheet, as shown in Figure 35, to check and refer to the settings and changes made every time when the extruder was used. J-PRISM II asked the supervisor of SRWMA to keep this record. When the machine is running, the supervisor must always give work orders to workers and keep work records. This work log binder was hung on the wall where the machine was installed so that it could be used during operation.

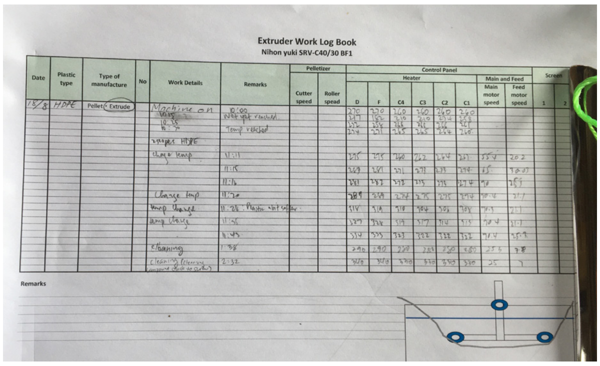


Figure 35. Example of data recording sample on a work log sheet.

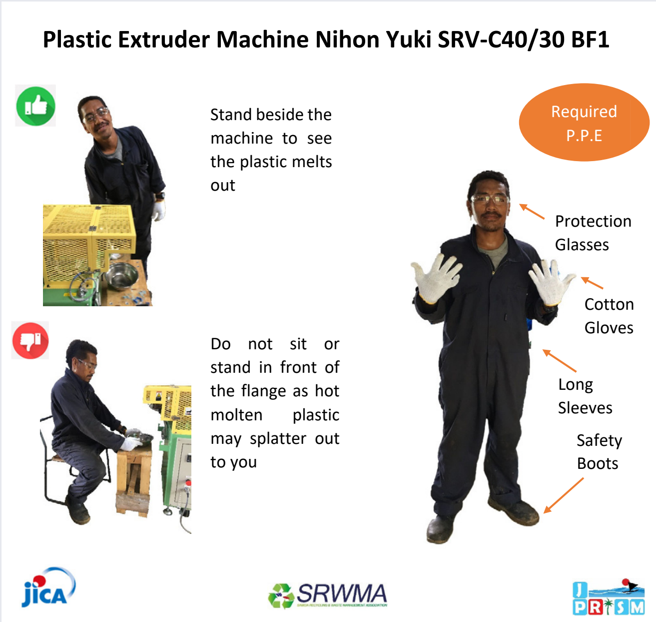
2) Operation Manual

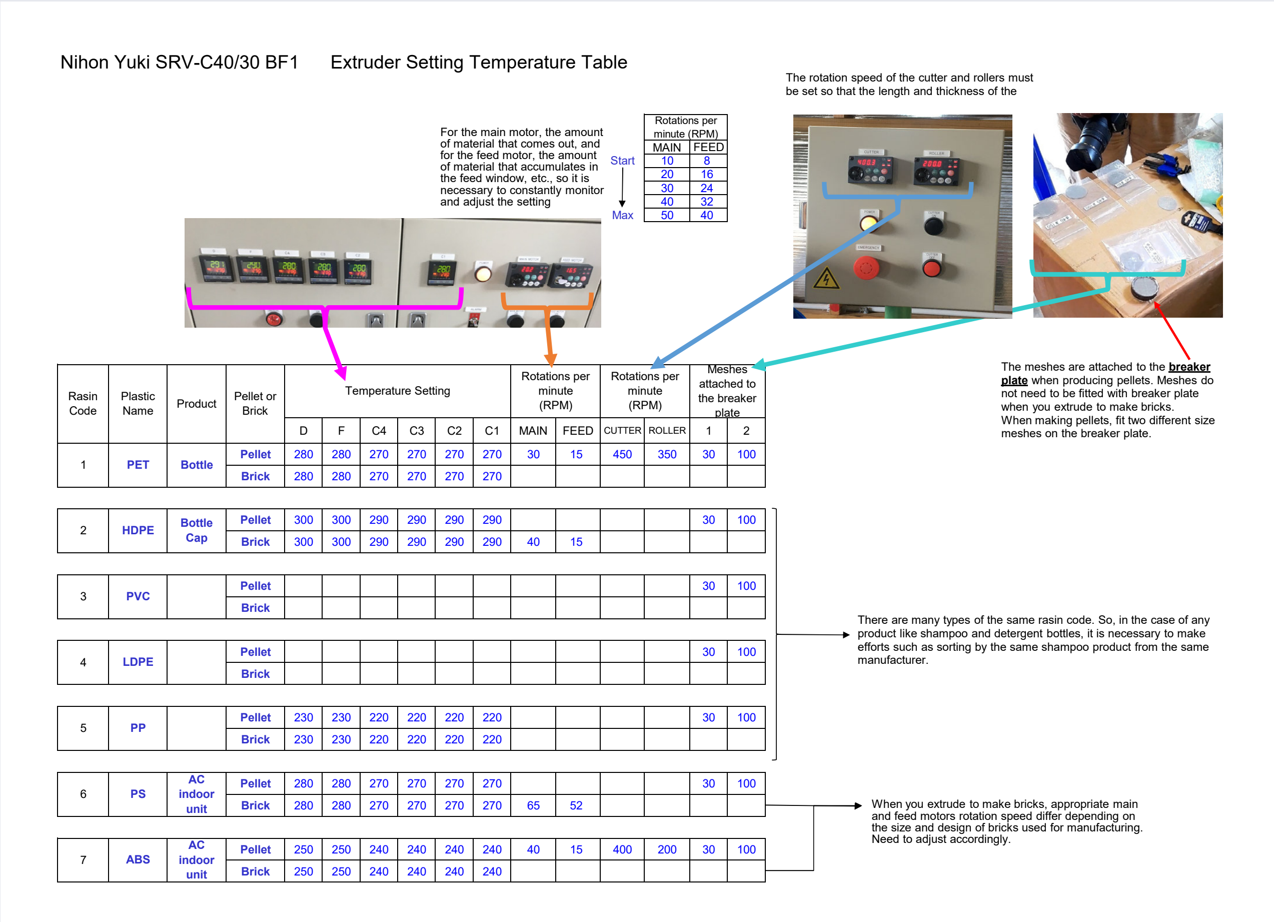
J-PRISM II confirmed that the instruction manuals of the crushing machine and extruder machine manufacturers did not explain the operation of the machines visually and in an easy-to-understand manner, so additional operation manuals were created by J-PRISM II to include the troubleshooting methods that were experienced in this pilot project. For ease of reference during operation, these manuals were hung on the wall where the machine was installed.

Figure 36. Operation manuals.

3) Signboards

Information on how to wear safety gear, how to maintain both machines, and the temperature setting table for the extruder is displayed on the signboards that are attached to the wall close to the machine.





Rotations per minute (RPM)	
MAIN	FEED
10	8
20	16
30	24
40	32
50	40

Rasin Code	Plastic Name	Product	Pellet or Brick	Temperature Setting						Rotations per minute (RPM)		Rotations per minute (RPM)		Meshes attached to the breaker plate	
				D	F	C4	C3	C2	C1	MAIN	FEED	CUTTER	ROLLER	1	2
1	PET	Bottle	Pellet	280	280	270	270	270	270	30	15	450	350	30	100
			Brick	280	280	270	270	270	270						
2	HDPE	Bottle Cap	Pellet	300	300	290	290	290	290					30	100
			Brick	300	300	290	290	290	290	40	15				
3	PVC		Pellet											30	100
			Brick												
4	LDPE		Pellet											30	100
			Brick												
5	PP		Pellet	230	230	220	220	220	220					30	100
			Brick	230	230	220	220	220	220						
6	PS	AC indoor unit	Pellet	280	280	270	270	270	270					30	100
			Brick	280	280	270	270	270	270	65	52				
7	ABS	AC indoor unit	Pellet	250	250	240	240	240	240	40	15	400	200	30	100
			Brick	250	250	240	240	240	240						

Figure 37. Signboards.

2.8 Purchase Price Confirmation - Examples of PET bottles

Since 2020, SRWMA and J-PRISM II have been collecting information on the purchase price of recycled PET bottles with recyclers and buyers in various countries through our respective networks.

From 2020 to 2022, the purchase prices of their baled PET bottles and flakes, and pellets produced from the bottles were at the rates as shown in Figure 38. However, these amounts are the average of their normal purchase price as of December 2022 exchange rate, and the actual purchase price is determined by the quality and transportation weight of each individual PET bottle. Therefore, it should be noted that the price list below does not reflect the quality of the PET bottles SRWMA currently processes, the transport volume, or the quality of the final product.

As shown in Figure 38, the purchase price for flakes and pellets is about three to five times higher than the purchase price of bale (compressed) PET bottles. For this reason, in countries like Samoa, where transportation distances to international markets are long and transportation costs are high, local recyclers should aim to increase the added value of the exported products to increase their sales price. Moreover, processing plastic into flakes or pellets makes the transportation and storage easier and more efficient. Also, processing plastic into flakes and pellets makes transportation more efficient than that of compacted bales, greatly increasing the amount of plastic that can be exported in the same 20-feet or 40-feet container.

Based on these three advantages – higher sales price, storage efficiency and larger amount of plastic to be exported – it is expected that the plastic processing in Samoa will be gradually shifting from bale to crushed or pelletized form depending on the customer's demand.

SRWMA has already contacted several recyclers in regards to PET bottles. In order to reduce the international shipping cost, SRWMA is currently planning to transport them using the Moana Taka Partnership, which is being implemented by Swire Shipping.

	Purchase Price of PET Bottles by Processing		
	Bale	**Flake**	**Pellet**
Recycler A in Japan	228-305 USD/ton	495-534 USD/ton	N/A
Recycler B in Japan	N/A	610 USD/ton	762-1,144 USD/ton
Recycler C in Malaysia	400 USD/ton	450 USD/ton	N/A
Recycler D in Australia	420 USD/ton	N/A	N/A

Bale

Flake

Pellet

Low Sales Price < < < < < < High Sales Price

Figure 38. Purchase price of PET bottles by processing type.

2.9 Quality Check and Purchase Price Obtained After Sending Samples

1) Sample Delivery

To confirm the market value of the flakes and pellets produced in this pilot project, SRWMA sent plastic samples to a Japanese plastic recycler (Recycler E in Japan) in September 2022. The plastic types, products, and properties of the plastic samples that were sent to Japan are shown in Figure 39.

No.	Plastic Type, Product and Form
1	HDPE: Bottle cap (flake)
2	HDPE: White bottle (flake)
3	HDPE: Blue bottle (flake)
4	PS: Air-conditioner Indoor unit (flake)
5	ABS: Air-conditioner Indoor unit (flake)
6	ABS: Air-conditioner Indoor unit (pellet)
7	PET: PET bottle cap (cap)
8	PET: PET bottle (flake)
9	PET: PET bottle (pellet)

Figure 39. Sample list sent to Japan.

2) Physical Properties and Screening EDX Test of Plastics

To confirm the quality of plastics sent from Samoa, Recycler E in Japan firstly performed two tests shown in Figure 40. Each test result is presented in Figures 41 and 42.

	Physical Properties Test	Screening Analysis by Energy Dispersive X-Ray Analysis (EDX)
Test items	1. Melt Flow Rate (MFR) 2. Density 3. Bending Stress 4. Bending Elastic Modulus 5. Izod Impact Testing	Check Element Items Content 1. Cadmium 2. Chromium 3. Mercury 4. Lead 5. Bromine
Test purpose	By measuring physical properties, the properties of plastics can be quantified, and important indicators for making plastic products can be obtained.	The purpose is to analyze and check compliance with the environmental regulations of the Restriction of the Use of Certain Hazardous Substances in electrical and electronic equipment Directive (EU's RoHS Directive).

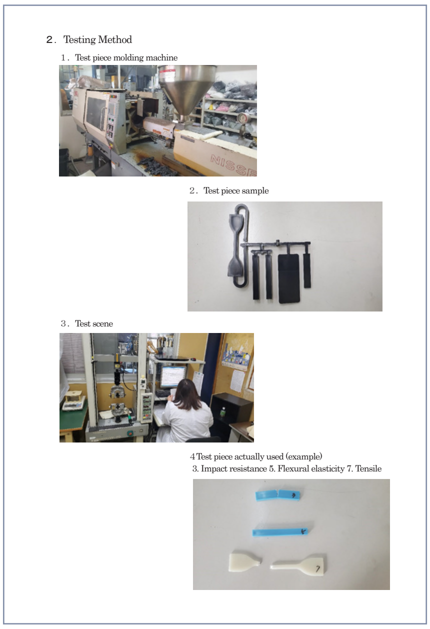
Figure 40. Plastic quality tests performed.

Recycler E in Japan has an injection molding machine in their laboratory to test the physical properties of plastics. Using an injection molding machine, Recycler E made test pieces of plastic samples (second from the top of the left photo of Figure 41 is the test piece made from the sample) and examined the fluidity, density, bending strength, etc. of the resin.

In addition, Recycler E in Japan carried out a screening analysis by Energy Dispersive X-Ray Analysis (EDX) (heavy metal content test) on each sample through a third-party research institute.

As a result, it was confirmed that all the plastic samples sent by SRWMA from Samoa were below the maximum permissible concentrations of specified hazardous substances specified by the Restriction of Hazardous Substances Directive of the European Union.

Based on these 2 test results, Recycler E in Japan determined the purchase price reported in the next chapter.



20221122 HDPE・PS・ABS **Physical properties table**

Test items	Test method	Unit	③HDPE flake *Blue*	④PS flake	⑤ABS flake	⑥ABS Pellet
MFR Melt Flow Rate	JISK7210:2014	g/10min	0.015	6.11	43.7	49.8
Density	JISK7112:1999	g/cm³	0.94	1.05	1.08	1.08
Bending stress	JISK7171:2008	MPa	34.0	——	——	——
Bendng elastcty	JISK7171:2008	MPa	1730	——	——	——
Izod Impact strength	JISK7110:1999	kJ/m²	66.3	8.1	5.7	5.3

Figure 41. Physical properties test process and result.

Test result report

承認	品質管理

ご依頼サンプル分

No.	sample name	shock value		Flexural		Pulling		MFR(g/10min)	specific gravity
		シャルピー(kj/㎡)	アイゾット(kj/㎡)	強さ(Mpa)	弾性率(Mpa)	強さ(Mpa)	切断時伸び(%)		
1	HDPE bottle cap	—	9.8	25.5	1031	22.9	314.5	8.5	0.95
2	HDPE white bottles	—	7.4	29.7	1078	36.0	17.1	1.1	0.96

Figure 42. Screening Analysis by Energy Dispersive X-Ray Analysis (EDX) Result.

3) Purchase price obtained based on the test results after sending samples

Based on the sample submission and test results introduced in sub-sections 1) and 2) above, Recycler E in Japan suggested a purchase price as shown in Figure 43.

Among the plastic samples sent for testing, the highest purchase price was assigned to ABS pellets, and was set at 1,800 tala/ton. Pellets and flakes made of light blue PET bottles could not be priced as Recycler E was unable to find a buyer for the colored PET in Japan.

①HDPE : BOTTLE CAPS (flake)

800-1,000 tala/ton

②HDPE : WHITE BOTTLES (flake)

800 tala/ton

③HDPE : BOTTLE (濃いブルー) (flake)

800 tala/ton

④PS : AC INDOOR UNIT (flake)

1,300 tala/ton

⑤ABS : AC INDOOR UNIT (flake)

1,700 tala/ton

⑥ABS : (pellet)

1,800 tala/ton

⑦PET : PET BOTTLE CAPS (cap)

1,000-1,200 tala/ton

⑧PET : PET BOTTLE (flake)

N/A

⑨PET : (pellet)

N/A

Unknown whether there is market for colored PET flake/pellet in Japan

Marked in red is a buying price by the recycler E in Japan.

No.	Plastic Type, Product and Form	Purchase Price (WST/ton)	Purchase Price (JPY/ton)
1	HDPE: Bottle cap (flake)	800-1,000 tala	40,000-50,000 yen
2	HDPE: White bottle (flake)	800 tala	40,000 yen
3	HDPE: Blue bottle (flake)	800 tala	40,000 yen
4	PS: Air-conditioner indoor unit (flake)	1,300 tala	65,000 yen
5	ABS: Air-conditioner indoor unit (flake)	1,700 tala	85,000 yen
6	ABS: Air-conditioner indoor unit (pellet)	1,800 tala	90,000 yen
7	PET: PET bottle cap (cap)	1,000-1,200 tala	50,000-60,000 yen
8	PET: PET bottle (flake)	N/A	N/A
9	PET: PET bottle (pellet)	N/A	N/A

Figure 43. Purchase price offered by Recycler E in Japan.

PET bottle flakes and pellets were produced by SRWMA from bottles discarded by one PET bottle manufacturer during the production of their water bottles. For this reason, the PET bottles were made from a single PET material and were thought to be of a high quality. However, since a buyer for the colored PET bottles could not be found in Japan, there was no opportunity to sell them to Japan.

Figure 44. PET bottles color in Samoa.

This is an economic value being judged from the perspective of the PET market limited to the Japanese market, and it may be possible for recyclers and buyers in other countries to purchase colored PET bottles in the future. Each buyer has different requirements for acceptable plastics, depending on the needs of their next customer and how they process plastics.

Based on this lesson, as one important action, MNRE and SRWMA can encourage Samoan drinking water manufacturers to use the same PET bottle quality and color (or transparent) as a way to promote PET bottle recycling and environmentally friendly design in Samoa in the future.

4) Income and Expenditure Calculation Result

Based on the purchase price of plastics that was obtained from the Recycler E in Japan, J-PRISM II calculated the income and expenditure based on the case of transportation products from SRWMA facility in Samoa to the Recycler E's facility in Japan.

Figure 45 shows the calculation results when a total of 12 tons of plastics, including 10 tons of ABS indoor unit pellets and 2 tons of PS indoor unit flakes, were transported from SRWMA in Samoa to the Recycler E in Japan in a 20-ft container.

Figure 45 calculation table does not include SRWMA's personnel costs and operation costs, but excluding these costs, the income and expenditure calculation result yields an income of 13,274 tala (=663,700 yen).

The cost of a sea freight was quoted by a Japanese shipping company that owns the Apia route to the Pacific Ocean. There are initiatives by shipping companies that offer to cover the costs of the sea freight for recyclable waste, such as Swire Shipping's Moana Taka Partnership. If SRWMA utilizes these companies' programs, the sea freight costs borne by SRWMA will be further reduced.

According to the balance calculation, given the current purchase price and currency exchange rate, it is economically feasible for Samoa to export plastic flakes and pellets.

In the future business decision will be in the hands of the SRWMA and MNRE on the Samoan side.

Sea freight cost and balance calculation between SRWMA and Plastic recycler in Japan

		Working process	Cost		Conversion to WST	Conversion to JPY
1) Sells Amount	Selling Price	ABS pellet 1,800 tala/ton*10tons	WST	18,000		
		PS indoor unit flake 1,300 tala/ton*2tons	WST	2,600		
		A) Total	**WST**	**20,600**	**20,600**	**1,030,000**
2) SRWMA Operation and Domestic Transportation Cost	Operation Cost	Collection	WST	N/A		
		Segregation, Washing	WST	N/A		
		Machine operating cost	WST	N/A		
		Labor cost	WST	N/A		
	Transportation Cost (SRWMA-Apia port)	Freight charge to Apia port including Export customs clearance fees	WST	600		
		B) Total	**WST**	**600**	**600**	**30,000**
3) Sea Freight Cost and Domestic Transportation Cost	Shipping CompanyA (Apia-Nagoya port)	Base Rate 20 feet container	USD	1,100	4,013	
		BAF (Bunker Adjustment Factor)	USD	330		
		CAIC per container	USD	50		
		Apia CHC (Container Handling Charge)	WST	138	138	
		Nagoya CHC (Container Handling Charge)	JPY	37,500	769	
	Shipping Company A Consignment Carrier (Nagoya Port to Recycler's Facility in Japan)	Import customs clearance fee, foreign cargo handling fee, drayage	JPY	88,000	1,806	
		C) Total	**WST**	**6,726**	**6,726**	**336,300**
4) Expected income: A) Sells Amount Total-(B)+C)Total Cost)			**WST**	**13,274**	**13,274**	**663,700**

Figure 45. Income and expenditure calculation chart.

2.10 Conclusions

The SRMWA/J-PRISM II Pilot Project conducted two plastic recycling activities: PET bottle recycling and brick manufacturing. Based on the results of the activities, technical aspects, economic feasibility, lessons learnt, etc., the following conclusions were drawn.

1) Technical Aspect

We aimed to learn the following three skills in plastic processing technology through the crusher and extruder machine installed at SRWMA. The table below summarizes how far the pilot project has been implemented for each plastic processing skill, the achievement levels, and future tasks.

Activity	Goal Achievement level	What was done in the pilot project and challenges to be addressed in the future
Flake Production	100% achieved	■ Mastered techniques to crush various plastics (PET, PS, ABS, HDPE). ■ Confirmed that the pilot project target amount of 200 kg/month for processing (crushing) of PET bottle recycling is achievable.
Pellet Production	70% achieved	■ Mastered techniques to produce pellets from two types of plastic (PET, ABS). ■ In the future, it will be necessary to continue practicing pellet manufacturing for other types of plastic.
Extrusion and Molding (Bricks Making)	30% achieved	■ During the brick manufacturing process, the plastic stuck to the mold could not be melted even though it was heated with a burner. For this reason, we gave up on this method of manufacturing. ■ We changed to a product that is smaller than bricks and practiced extrusion using various existing molds, but it is still at the prototype stage, and it will take some time to reach commercialization level. ■ Prototyping of "molds", improvement of mold design, mass production are future tasks.

10mm plastic flakes produced by crushing machine.

Extruder-produced plastic pellets recycled from PET bottles and plastic used in air conditioners.

Plastic stuck to the brick mold and could not be removed from the mold after cooling.

Experiments with extruding and molding various types of plastic using a variety of molds.

Figure 46. Summary of the technical aspect.

2) Business Feasibility Aspect

The following provides a summary of the economic points and lessons learnt for SRMWA's future development of the plastic recycling business.

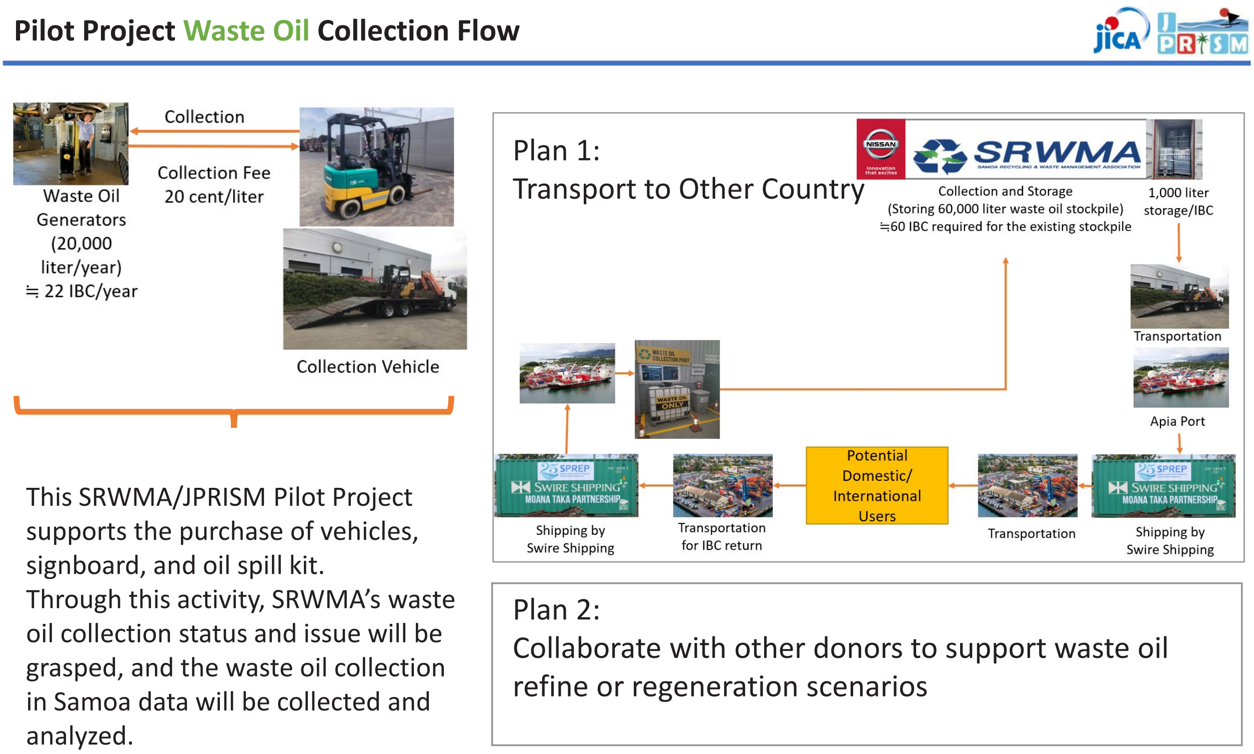
Item	What was done in the pilot project and challenges to be addressed in the future
Initial Cost	Most of the initial costs for implementing this pilot project were supported by the Embassy of Japan and JICA/J-PRISM II. ■ Facility: constructed by GGP, Embassy of Japan (WST$477,097) ■ Machine: provided by J-PRISM II (crushing machine: WST$25,922, extruder: WST$59,166) ■ Equipment and tools for facility: provided by J-PRISM II
Operational Cost	Labor costs, electricity and water costs for implementing this pilot project were covered by SRWMA. ■ In order to continue the plastic recycling business, securing worker employment, passing on techniques among them, and training chief engineers are future challenges for SRWMA. ■ SRWMA requires ongoing support from donors to hire workers.
Customer and Product Development	There are many different kinds of plastics and they have different characteristics. For this reason, it is necessary to find and secure reliable customers (recyclers, buyers, etc.) globally, select plastic types according to their needs and uses, improve processing methods, and continue to develop products.
Strengthening Technical Support Network of Plastic Recycling Experts	■ To improve the economic efficiency and technical aspects of plastic recycling in Samoa, it is important to establish a support network of plastic manufacturers and recyclers for receiving professional guidance on selecting plastic raw materials, molding products and developing recycled plastic products. ■ There is still a need for guidance from crushing and extruder machine manufacturers as well as for strengthening of local maintenance and management systems.

Figure 47. Summary of economical aspect.

3. IMPLEMENTATION DETAILD - WASTE OIL

Waste Oil Collection and Storage Activities

The SRMWA/J-PRISM II Pilot Project implemented waste oil and storage activity in two phases from 2021 to 2022. The original plan was to check the appropriate methods of collecting and storing waste oil and to consider the appropriate final processing scenarios for Samoa as follows



3.1 Background

The safe and effective management of waste oils from collecting, transporting, storing and disposal is one of the highest waste management priority issues in Samoa.

Since 2019, SRWMA has started Samoa Waste Oil Management Program (SWOMP)" as a voluntary waste oil collection program collecting from car service companies, car dealers, local manufacturers, and Institutions in the town of Apia. Through this program, there are several challenges in implementing SWOMP by SRWMA, which made it difficult to collect waste oil on a regular basis.

■ Difficulty in assigning workers and vehicles due to chronic labor shortage

SRWMA member companies have difficulty assigning their trucks and required number of workers for the SWOMP activities. In particular, it is difficult for SRWMA to attend to customers with a large volume of waste oil.

■ Lack of data collection and analysis

Before implementing SRWMA/J-PRISM II Pilot Project, waste oil has been collected from several customers, who were charged a collection fee of 20 sene/liter. But the detailed data regarding the collection time, customers list updates and balance analysis based on the SWOMP implementation was not systematically provided by SRWMA.

■ Difficulty in securing export destinations

In 2019, SRWMA visited BlueScope, a steel company in Fiji, to discuss waste oil exports from Samoa to Fiji. However, the follow-up has taken a long time, and the discussion has not been completed until now. For this reason, the actual exportable waste oil amount and necessary procedures have not been examined. As a result, SWOMP cannot make a waste oil collection strategy as a concrete business plan.

1) SRWMA's Waste Oil Collection Amount Before the Pilot Project

Based on data surveyed and estimated by JICA in 2021, the amount of waste oil generated in 2020 in Samoa is estimated to be approximately 344 tons, which is about 382,222 liters.

Figure 48 summarizes the estimated annual emissions for 2020, the amount of waste oil collected by SRWMA before the implementation of the pilot project, and the amount of waste oil after the project. As of 2021, the SRWMA collection volume is projected to be 18.9% of the total annual waste oil generation based on the estimated value for 2020.

Waste oil generation and collection	Generation and collection volume	SRWMA collection rate in domestic waste oil generation
Waste oil generation volume in 2020 in Samoa[5] (tons to liter conversion: 344ton/year × 1000liters ÷ 0.9)	382,222 liter/year	-
Waste oil collection volume through SRMWA's SWOMP project in August 2021 before SRMWA/J-PRISM II Pilot Project[6]	26,800 liter/year	7.0%
Waste oil collection amount collected in phase 1 of the SRMWA/J-PRISM II Pilot Project in September 2021[6]	45,513 liter/month	11.9%
SRWMA's waste oil collection amount and rate as of 2021	72,313 liter	18.9%

Figure 48. SRWMA SWOMP waste oil collection amount and rate in Samoa.

5 JICA (2021), Data Collection Survey on promotion of recycling plastics and other materials in Pacific Island Countries Final Report, https://openjicareport.jica.go.jp/pdf/12335428.pdf

6 J-PRISM II (2022), SRWMA/J-PRISM II Waste Oil Collection and Storage Pilot Project Implementation report Phase I, https://www.sprep.org/publications/srwmajprism-ii-waste-oil-collection-storage-pilot-project-implementation-report-phase-i

2) Phase 1 of the Pilot Project Implementation Results

Phase 1 was implemented in September 2021 over one month. During implementation, a total of 45,513 liters of waste oil was collected and stored as a result of four collection trips.

Waste oil collection at customer's yard.

Waste oil storage at SWOMP facility.

Figure 49. Waste oil collection and storage in Phase 1.

This implementation report has been compiled based on Phase 1 implementation results (Figure 50), which can be found on the SPREP website[6]. Key information presented regarding the collection and storage stage includes waste oil collection and storage results, and major issues that were identified at each stage. The report also covers the cost analysis as well as recommendations for the next phase 2 of the pilot project.

At the beginning of 2022, during the preparation of the implementation report for Phase 1 of the pilot project, it was decided to apply the knowledge gained in Phase 1 to revise the collection and storage processes of SWOMP, as well as the waste oil collection fee in Phase 2 implementation period of the pilot project. For that reason, it was planned to hold a seminar to share the knowledge of Phase 1 by inviting relevant stakeholders of SWOMP before the Phase 2 starts.

From January 2022, the number of community transmissions of COVID-19 increased in Samoa, and a stay-at-home policy was implemented, which made it difficult to continue the project as before.

Figure 50. Waste Oil Collection and Storage Pilot Project Implementation Report Phase1.

3) Oil Leakage Incidents at SWOMP Facility

Phase 2 of the waste oil pilot project was originally planned to start around February 2022, but Samoa has been in an intermittent lockdown from February to April 2022 due to the spread of COVID-19. In the meantime, there were two incidents of leakage of waste oil stored at the SWOMP facility.

Figures 51 to 53 below summarize the location, the leakage area, and the types of leaked waste oil.

There were holes in corroded oil drums stored outdoors at SRWMWA facility (Site 1), which allowed waste oil to leak into the soil. At Site 2, drums stored inside the facility fell for some reason to the rear of the facility, damaging the container and causing waste oil to leak into the soil.

Site	Location of Leak	Area	Type of Leaked Waste Oil
Site 1 (Leaked in February 2022)	1) Soil in front of facility	Length 9.9m x Width 7.5m	Engine Oil
	2) Drainage in front of and on the side of the facility	35 meters long	
Site 2 (Leaked in March 2022)	Soil behind the facility	Length 6.6m x Width 4m	Unknown (either gear oil, compressor oil, hydraulic oil, or lubricating oil)

Figure 51. Outline of waste oil leakage at SWOMP storage facility.

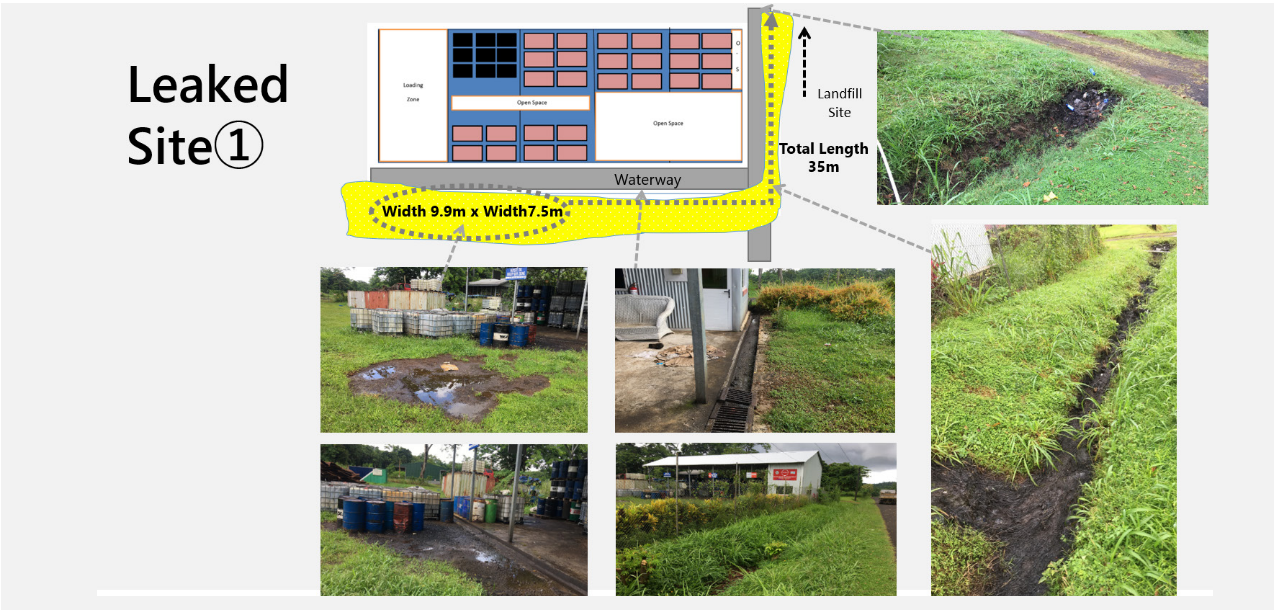


Figure 52. Waste oil leaked soil and drainage in front of and on the side of the SWOMP storage facility.

Figure 53. Waste oil leaked soil behind the SWOMP storage facility.

3.2 Formulation of Overall Implementation Activities and Cooperation with External Technical Experts

Since the removal and remediation of this oil-containing soil was the first time for J-PRISM II, we received technical advice on the implementation of landfarming and analysis of contaminated soil from external experts such as SPREP, Scientific Research Organization of Samoa (SROS), University of the South Pacific (USP), and Taisei Corporation (construction companies in Japan that carries out landfarming projects).

This chapter provides an overview of the main activities that Taisei, SROS, USP, and SPREP have undertaken to support our landfarming operations.

1) Taisei's Contribution to This Activity

Taisei Corporation is a construction company in Japan that has extensive experience in landfarming as a purification technology project related to bioremediation for polluted ground.

Through the introduction of Mr. Shiro Amano, the Senior Advisor of Environmental Management division at JICA, J-PRISM II contacted them and received reference materials and technical advice for implementing the landfarming activity in April 2022. The information received from Taisei Corporation covered the analysis of oil-containing soil samples, analysis methods for identifying oil types, soil storage methods, nitrogen and phosphorus input methods, and landfarming site set-up methods. The project was very fortunate to receive guidance from Taisei Corporation at the stage of planning the implementation details. This landfarming activities would not have been successfully implemented without their input.

Based on advice from Taisei Corporation and Oil Pollution Control Guideline[7] issued by Ministry of the Environment in Japan, the overall plan for this landfarming activity we formulated as shown in Figure 54 and 55. The details of the implementation content are summarized in Chapter 3.5.

Polluted Area	Countermeasure policy	Countermeasure target	Countermeasure methods
Soil around the facility	Ensure that there are no problems with working environment preservation due to oil odors or oil films	Remediation of oil-containing soil	Removal of oil-containing soil
			Landfarming
			Odor test
Drains around the facility	Prevent waste oil and oil-containing soil from flowing off site through drains	Prevention of oil outflow and diffusion via drains	Removal of oil containing sludge from drains
			Landfarming
			Odor test

Figure 54. Implementation activity details.

7 https://www.env.go.jp/water/dojo/oil/full.pdf

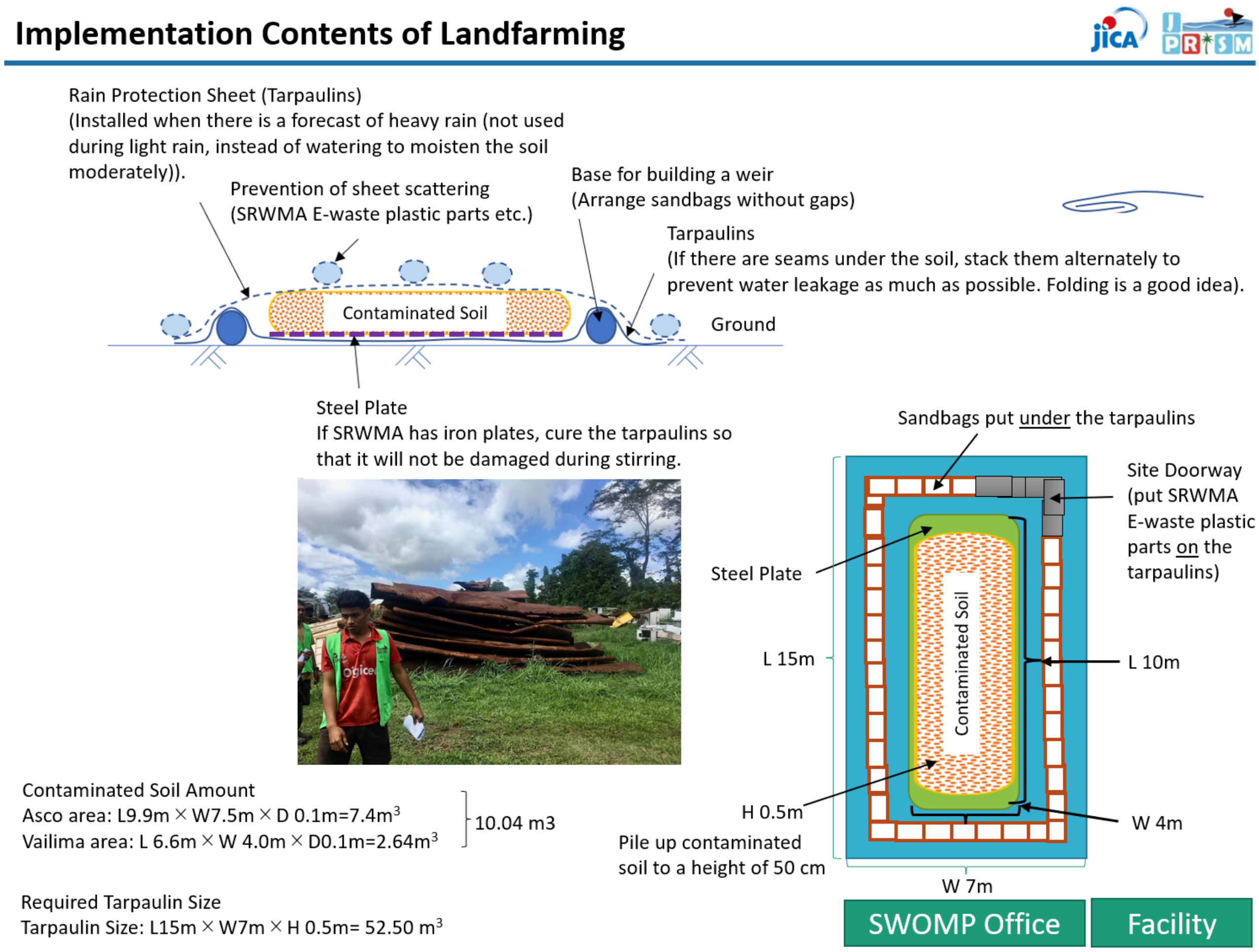


Figure 55: Landfarming site set-up plan

2) SROS Contribution to Landfarming Activity

Scientific Research Organization of Samoa (SROS) was established in 2006 to undertake scientific and technical research for the Government of Samoa and to develop new technologies with the primary aim of adding value to products to the benefit of Samoa's local industry.

The first encounter with SROS occurred during the site visit tour at their facilities organized by Waste Management & Pollution Control Programme (WMPC), of SPREP when the pilot project team received information from SROS that they were using GC-MS machine for drug testing. According to Dr Fiso Fiame Leo, Director of Technical Services Division, this GC-MS machine is an analysis machine that can be used for identifying the type of waste oil, and it was suggested to consult SROS if such analysis is required.

The first joint meeting between SROS, USP and J-PRISM II was held in June 2022, and it was confirmed that GC-MS machine of SROS will be used to analyze waste oil, with reference materials regarding detailed analysis methods and column information to be provided by J-PRISM II.

SROS, USP, J-PRISM II first meeting.

GC-MS machine owned by SROS.

SHIMADZU GCMS-QP2010SE machine

SROS is a panelist for the odor test.

Figure 56. Support for landfarming activities by SROS.

3) USP's Contribution to Landfarming Activity

The University of the South Pacific (USP) is a public university jointly established by 12 small island nations in the Pacific in 1968. The headquarters and main campus, Laucala Campus, is located in Suva, Fiji, and the Faculty of Agriculture is located at the Alafua Campus in Apia, Samoa.

Through the introduction by Ms. Evangeline Potifara, Assistant at J-PRISM II project and a graduate of USP's Faculty of Agriculture, J-PRISM II team contacted Dr. Md. Abdul Kadar, Senior Lecturer in Soil Science, and Dr. Viliame Savou, Senior Technician in Soil Science at the Faculty of Agriculture.

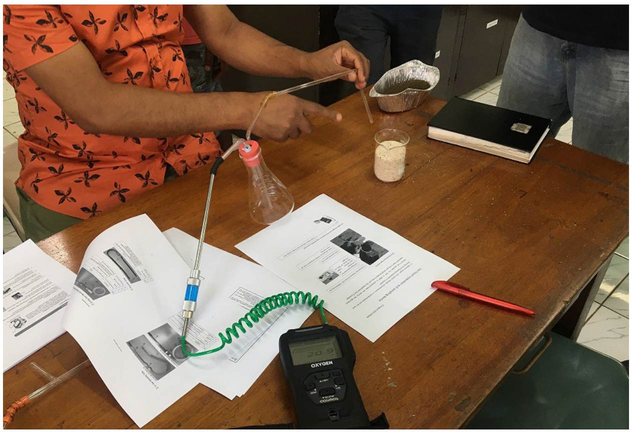
USP visited the SRWMA waste oil spill sites and provided a technical input to the J-PRISM II team on how to collect soil samples, how to transport them, and how to implement landfarming in a local way.

As landfarming begins, microorganisms consume oxygen and produce carbon dioxide when they break down oil. Therefore, daily measurements of oxygen and carbon dioxide levels in the soil are compulsory to ensure land-farming is working. For this reason, J-PRISM II will procure gas detectors to measure oxygen and carbon dioxide concentrations. Gas-liquid separators will be required to measure gas concentration without absorbing moisture from the soil. The consultation with the USP team resulted in them creating gas-liquid separators for this activity, which made it possible to collect data by landfarming.

Checking for contaminated soil.

Checking the odor of contaminated soil.

Support for making a gas-liquid separator to be installed in an oxygen/CO^2 gas detector.



Oxygen/CO^2 could not be measured without the gas-liquid separator created by USP.

Oxygen/CO^2 concentration meter measurement test using gas-liquid separator.

USP is a panelist for the odor test.

Figure 57. Support for landfarming activities by USP.

4) SPREP's Contribution to Landfarming Activity

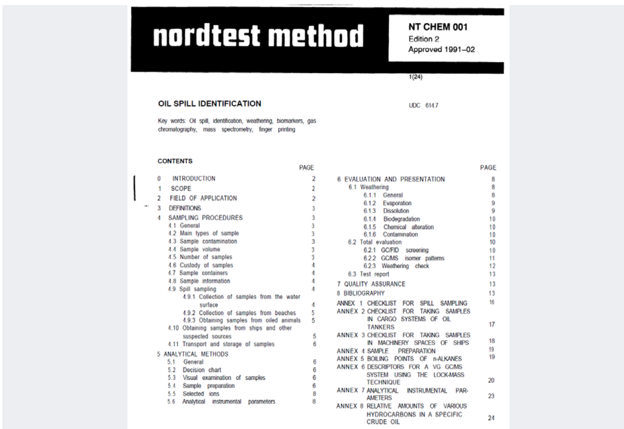
A consultation with SPREP was the first step taken by J-PRISM II after the waste oil leakage accidents. Mr. Anthony Talouli, Director of WMPC, advised us that landfarming is a simple bioremediation method that can be done in a limited period of time with a limited budget, and it is a suitable method for the Pacific.

Mr. Talouli introduced his two colleagues, who were interested in the landfarming activities: Mr. Paul Irvin, Officer from the Pacific Islands Marine Spill Response Plan (PACPLAN), and Mr. Lance Richman, Technical Waste Project

Officer, Hazardous Waste, of the Pacific – European Union (EU) Waste Management Programme (PacWastePlus). The experts provided various documents and knowledge that is useful in conducting landfarming activity.

In particular, PACPLAN plans to assist in the development of regional contingency plans and guidance for managing and remediating marine oil spills in the Pacific, so it is possible to utilize SRWMA's waste oil collection and storage activities and its lessons learnt to their activities in Samoa. In addition, PACPLAN plans to connect universities and research institutes in the region and develop human resources who can handle the analysis work in the event of an oil leak accident. It is a great honor for J-PRISM II to report that PACPLAN intends to take over the activities after this project's landfarming activities are completed.

PACPLAN participated in J-PRISM II, SROS and USP joint meeting at SROS.



nordtest method

NT CHEM 001
Edition 2
Approved 1991–02

1(24)

OIL SPILL IDENTIFICATION

UDC 614.7

Key words: Oil spill, identification, weathering, biomarkers, gas chromatography, mass spectrometry, finger printing

CONTENTS

Oil spill identification and analysis method parameter data report provided to SROS by PACPLAN.

Figure 58. Support for landfarming activities provided by SPREP and PACPLAN.

3.3 On-site Survey and Estimation of Contaminated Soil Volume

Based on the technical advice from SPREP, SROS, USP and Taisei Corporation, it was decided to implement landfarming and work on remediation of the oil contaminated soil.

Landfarming is one of the bioremediation methods, and is a method of purifying and stabilizing oil-containing soil using the ability of microorganisms to decompose mineral oils. Landfarming involves watering and treating oil-contaminated soil by turning which decomposes oil components into harmless substances such as water and carbon dioxide without using special equipment or machinery, so there is no need for post-treatment and there is little concern about further pollution.

In order to implement the landfarming, it is necessary to select and identify the survey point of the oil contaminated soil area, remove the actual contaminated soil, move the contaminated soil to the landfarming implementation site.

The on-site survey and equipment procurement required for landfarming were conducted by SRWMA and J-PRISM II from June to August 2022.

1) Determination of Oil Contaminated Soil Volume

As shown in Figure 51, the area of contaminated soil was identified as far as it could be visually determined. The next step was to determine to what depth the soil was contaminated, and the total amount of contaminated soil. To do so, 4 soil samples were taken on-site in 23 May 2022. As a result of digging up the soil at the time of sample collection, it was confirmed that the depth of the contamination was about 2-3 cm from the soil surface. Once the soil was dug with a shovel as shown in Figure 56, it was confirmed that the waste oil had remained on the surface.

Based on this, it was assumed that the depth of the contaminated soil layer to be removed was about 10 cm from the surface, and the amount of contaminated soil was estimated as shown in Figure 55 based on this assumption (Figure 55).

The abundance of oil-contaminated soil was estimated to be approximately $10.04m^3$. However, a decision was made to inspect the soil and determine the final excavation area after checking for discoloration and oil smell.

Site	Type of Leaked Oil	Amount of Contaminated Soil
Site 1 (leaked in February 2022)	Engine oil	Length 9.9m x Width 7.5m x Depth 0.1m=7.4m3
Site 2 (leaked in March 2022)	Unknown (Either gear oil, compressor oil, hydraulic oil, or lubricating oil)	Length 6.6m x Width 4.0m x Depth 0.1m=2.64m3

Figure 59. Estimation of contaminated soil volume.

Taking soil samples at contaminated Site 1.

Checking the depth of contamination at Site 1.

Taking soil samples at contaminated Site 2.

Checking the depth of contamination at Site 2.

Figure 60. First soil sampling on 23 May 2022.

2) Examination of the Possibility of Implementing Water Quality Survey

Due to the possibility that waste oil will reach groundwater from the contaminated soil in the future, the location of the groundwater borehole around the SWOMP facility in the Tafaigata landfill site was also checked. With the cooperation of the Water Resources Division of MNRE, it was found that there are four observation wells (boreholes) near the SWOMP facility, as shown in Figure 61 below.

Initially, J-PRISM II considered conducting a water quality test if it was possible to see the difference in the oil content of groundwater before and after implementing landfarming. However, due to the two following issues, the water quality test was not run this time.

- The nearest borehole from the SWOMP facility where the waste oil leaked into the soil is about 100m away. Since the distance is long, there is a high possibility that the accuracy will not be high enough to investigate the impact of the waste oil leakage.
- With a borehole depth between 35m and 42m, it is unlikely that leaked waste oil will reach the groundwater. (Oil spills occurred in February and March, but the landfarming began in mid-October. This means that the contaminated soil was not removed for six months, and leaked waste oil did not reach the depth where the groundwater can be measured.

In the future, if SRWMA considers conducting a water quality survey of the groundwater around the SWOMP facility, a borehole will be dug on the premises of the SRWMA and SWOMP facilities with a Samoa Meteorology Division drill machine through the MNRE's Water Resources Division, and the MNRE will collect the water samples and send it to SROS for the analysis. It is confirmed that it is possible to conduct a water quality survey on-site following this survey flow.

- MNRE confirmed the inland borehole at sludge area- 35m depth (free and clear not blocked)
- the front boreholes near the road at sludge area-41m depth & 42m depth (free and clear not blocked)

Figure 61. Tafaigata landfill borehole location map (yellow dots indicate borehole locations).

3.4 Landfarming Implementation Plan

Based on the advice obtained from technical experts, Taisei Corporation, SROS, USP, and SPREP, and the results of on-site surveys, it was decided to implement the landfarming in the following way.

	Details of Implementation
1. Implementation period	*May to November 2022 (6 months)* Upon completion of the J-PRISM II implementation period, landfarming will be handed over to PACPLAN, who will be supported by the Department of Foreign Affairs and Trade (DFAT) of Australia and the International Maritime Organization (IMO) in SPREP. As of 2022, they plan to continue landfarming for approximately one year, including the implementation period of J-PRISM II, to verify the effects of bioremediation in Samoa.
2, Estimated amount of contaminated soil	When the depth of the contaminated soil was confirmed at the site on 23 May 2022, the depth of the discolored soil was about 2-3 cm from the surface. For this reason, the removal range of the contaminated soil is tentatively set at "about 10 cm from the surface layer" at the following two sites. ■ Contaminated site 1 (engine oil): Length 9.9m x width 7.5m x depth 0.1m = 7.4m^3 ■ Contaminated site 2 (waste oil type unknown): Length 6.6m x width 4.0m x depth 0.1m = 2.64m^3 The abundance of oil-contaminated soil was estimated to be approximately 10.04m^3. However, a decision was made to inspect the soil and determine the final excavation area after checking for discoloration and oil smell.
3. Implementation site	The landfarming site is planned to be a vacant lot in front of the SWOMP facility (the area is about 15m long and 6m wide). It is enough space to treat even larger amounts of contaminated soil. The land slopes and lowers as it approaches the SWOMP facility.  
4. Moving waste oil containers stored outdoors	Since the intermediate bulk container (IBC) tanks and drums are still stored outdoors at Contaminated site 1, the containers will be moved inside the SWOMP facility prior to excavating the contaminated soil. SRWMA forklifts, pallets, will be used for this work. 

<table>
<tr><td>5. Excavation and removal of contaminated soil</td><td>After setting up implementation site (point 3) and moving containers stored outdoors (point 4), contaminated soil will be excavated and moved from the contaminated site and to the implementation site by heavy machinery (backhoe or forklift).</td></tr>
<tr><td>6. Classification method of contaminated soil</td><td>Initially, it was planned to conduct a Total Petroleum Hydrocarbons (TPH) test to investigate the oil content of the all oil-contaminated soil, after conducting a GC-MS test (mass spectrometry) by SROS. However, implementation of the landfarming activity was delayed to October due to delays in importing the solvents needed to conduct the GC-MS tests.

For this reason, the initial plan for the landfarming implementation method was changed, and the soil was divided into two piles for each type of waste oil. One soil pile was ready for landfarming immediately using agricultural fertilizers, and the other soil pile was left until the solvent arrived for the GC-MS tests to be conducted before the landfarming starts.
<table><tr><td>Site 1 soil+ agricultural fertilizer</td><td>Site 1 soil + waiting period until the solvent arrived and conduct GC-MS tests before starting landfarming.</td></tr><tr><td>Site 2 soil+ agricultural fertilizer</td><td>Site 2 soil+ waiting period until the solvent arrived and conduct GC-MS tests before starting landfarming.</td></tr></table></td></tr>
<tr><td>7. TPH test method</td><td>Performed by portable gas chromatography (GC) method using Shimadzu GC-MS machine owned by SROS.

However, since SROS had never analyzed the contaminated soil with the machine, J-PRISM II translated Document 3 "TPH test method by GC-FID method"[7] of Japanese Ministry of the Environment's guidelines for oil pollution countermeasures to English and provided SROS with this document as a reference.

Frequency of GC-MS analysis is as follows.
1. when excavating and removing contaminated soil
2. one week after the start of landfarming
3. once a month after that</td></tr>
<tr><td>8. Landfarming implementation method and data record keeping</td><td>Landfarming will be done according to the following plan:
■ Agitation: daily
■ Watering: daily
■ Fertilizer application: observe changes in oxygen and carbon dioxide concentrations after fertilizer is applied at the start of landfarming. If there is no or little change in the same value after applying agricultural fertilizer, add more.

Monitoring data will be collected daily for:
■ Oxygen concentration: measured daily with a densitometer
■ Carbon dioxide concentration: measured daily with a densitometer
■ Atmosphere temperature: measured daily with a weather forecast app
■ Soil temperature: measured daily with a thermometer
■ ph level: measured daily with soil ph level tester</td></tr>
<tr><td>9. Odor testing and monitoring</td><td>Panelists are scheduled to perform odor tests continuously.

The implementation frequency is the same as the implementation frequency of mass spectrometry:
1. when excavating and removing contaminated soil
2. one week after the start of landfarming
3. once a month after that</td></tr>
</table>

Figure 62. Landfarming implementation plan.

3.5 Implementation Results and Lessons Learnt

1) Implementation Dates

After setting the landfarming implementation plan, SRWMA, J-PRISM II were implementing landfarming activities until the end of the pilot project implementation period as shown in Figure 63.

Date	Content of activity
23 May, 2022	Taking soil samples at SWOMP
9 June, 2022	Ground water observation well boreholes check at Tafaigata landfill
2 June, 8 June, 28 June,13 July, 2 August, 29 September 2022	Joint meetings with SROS and USP on landfarming implementation method
26 August, 2022	Manufacture of gas-liquid separator, demonstration test of oxygen/carbon dioxide gas densitometers with USP at SWOMP site
2 September, 2022	Move outdoor storage containers and remove contaminated soil
5 September, 2022	Continue work to remove contaminated soil
15 September, 2022	Taking soil samples for the 1st Odor test at SWOMP (when excavating and removing contaminated soil)
13 October, 2022	Report of 1st GC-MS test results by SROS
17 October, 2022	Landfarming implementation started
27 October, 2022	Taking soil samples for the 2nd Odor test at SWOMP (one week after the start of landfarming)
4 November, 2022	Taking soil samples for the 3rd Odor test at SWOMP (three week after the start of landfarming)
17 November, 2022	Taking soil samples for the 4th Odor test at SWOMP (one month after the start of landfarming)
30 November, 2022	Taking soil samples for the 5th Odor test at SWOMP (last day of landfarming implementation)
30 November, 2022	Landfarming implementation ended
10 February, 2023	J-PRISM II Pilot Project Implementation Results Report Session

Figure 63. Landfarming implementation dates.

2) Excavation and Removal of Contaminated Soil, Set-up the Landfarming Site

The relocation of the waste oil containers stored outdoors and the removal of contaminated soil was carried out on September 2nd and 5th, 2022.

USP suggested that the removal of contaminated soil should be done by excavating by hand as much as possible, as there is a concern that excavating with heavy machinery would spread the contaminated soil to the surrounding area. Therefore, on September 2, SRWMA, MNRE, SROS, and USP gathered at the site and tried to remove the contaminated soil with shovels. However, it was confirmed that the soil at the site contains a lot of scoria, and that digging up the soil by hand had its limits.

Therefore, on September 5, a backhoe owned by a SRWMA member company, was sent to SWOMP, and it was used to remove the contaminated soil.

Moving containers stored outside.

Storing IBCs inside the SWOMP facility.

Storing drums inside the SWOMP facility.

Excavating contaminated soil with man-power.

Backhoe was used to excavate the soil.

Landfarming implementation site.

Moving soil with SRWMA forklift.

Landfarming implementation site after laying contaminated soil.

Figure 64. Excavation and removal of contaminated soil.

The landfarming site had to be designed in such way that the contaminated soil and leachate would not spread outside its boundaries. In addition, we repeatedly examined how to procure all the equipment locally and try finding a method that is easy to implement and economical in Samoa. Additionally, J-PRISM II was trying to determine a method that could be implemented easily and was economically feasible for Samoa, and that all the necessary equipment could be procured locally.

First, a thicker tarpaulins for heavy-duty with UV protection was procured and laid on the soil so that leachate would not leak outside the landfarming site. Next, on top of the tarpaulins, iron roof sheets owned by SRWMA were laid, and contaminated soil was placed on it. The landfarming site was outlined by sandbags filled with crushed waste glass processed by SRWMA to prevent the soil from being scattered by the wind.

The details of the installation method of the site where landfarming was carried out and tarpaulins used are shown in Figure 65. All of these supplies are readily available locally, this method is applicable not only for Samoa, but also for other Pacific Island Countries.

Tarpaulins used for landfarming

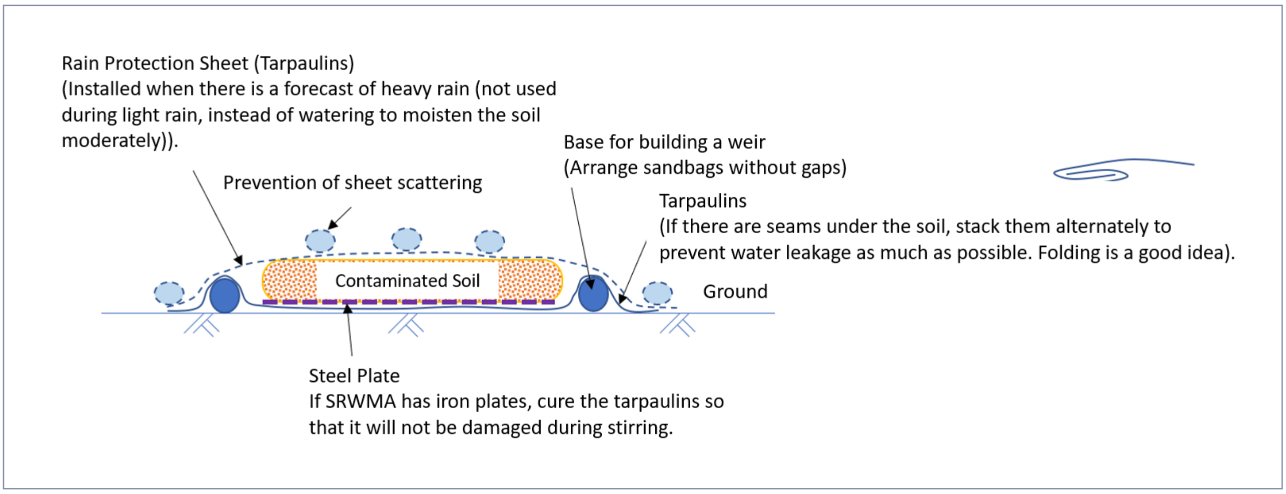


Figure 65. Structure of the landfarming site.

3) Landfarming Daily Operation Work

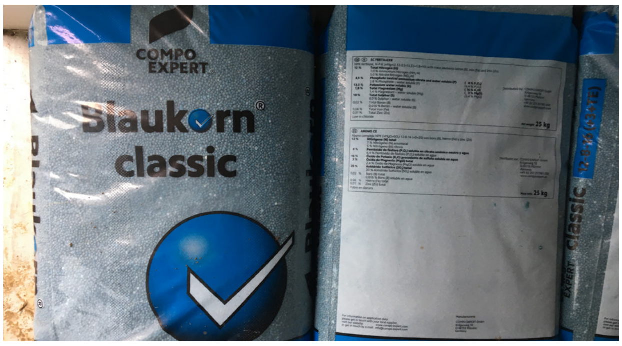
Land farming began on October 17th and ran through November 30th. The implementation details are as shown in Figure 62 point 8 “Landfarming implementation method and data record keeping”, and the following work and data record were implemented every weekday.

- Agitation: daily
- Watering: daily
- Oxygen concentration: measure daily with a densitometer
- Carbon dioxide concentration: measure daily with a densitometer
- Atmosphere temperature: measure daily with a weather forecast app
- Soil temperature: measure daily with a thermometer
- ph level: measure daily with soil ph level tester

Agricultural fertilizer was used for this landfarming activity. Technical advice from Taisei Corporation recommended using an agricultural fertilizer with a high nitrogen content, so "Blaukorn Classic 25kg (12-8-16)" fertilizer was selected. It is available at farmer stores (Figure 66).

Blaukorn Classic 25kg (12-8-16) contains 12% nitrogen. According to Taisei Corporation, the ratio example of the amount of nitrogen required is C: N: P = 100: 5 :1. If the analysis value of oil contained in the soil is 100,00mg/kg-soil, the amount of nitrogen required is 0.5g of nitrogen per kilogram of soil. Therefore, the amount of fertilizer required for this is 100,00×100/12=4.2g, so approximately 5g of fertilizer should be mixed in the soil.

The reason for using agricultural fertilizers in landfarming is that the amount of nitrogen in the fertilizer is known and it is easy to calculate the required amount of fertilizer from the amount of nitrogen specified on the fertilizer bag in a limited implementation period. It is possible to use plants instead of agricultural fertilizer which is more cost-effective. In that case, although it is necessary to specify the amount of nitrogen contained in plants, it is possible to adopt a method of adjusting the input amount of plants by observing changes in oxygen and carbon dioxide concentrations in the soil.

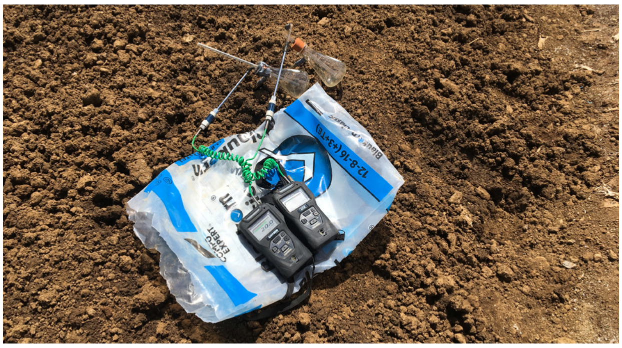


Agricultural fertilizer Blaukorn Classic 25kg (12-8-16).

Spreading fertilizer on the soil.

Agitating soil after spraying fertilizer.

All agitation and watering were done manually.



Measuring oxygen and CO^2 concentrations in soil.

Sandbags were re-arranged into two layers in the beginning of the rainy season.

Figure 66. Landfarming daily operation work.

4) Landfarming Implementation Results - Data Compilation Result

Measurement of oxygen and carbon dioxide concentration in contaminated soil

■ Purpose

The Earth's atmosphere is mainly composed of nitrogen (about 78%), oxygen (about 21%) and argon (about 0.9%). Carbon dioxide is also present in small amounts at around 0.03% (300ppm).

The principle of landfarming is to cultivate contaminated soil like a field to supply oxygen to the soil and promote contact between microorganisms and contaminants. Therefore, when landfarming works well, it is expected that the oxygen concentration in the soil will decrease and the carbon dioxide concentration will gradually increase, and the change will be confirmed by the percentage of both.

For this reason, during this landfarming experience, gas detectors used to check changes in the concentration of oxygen and carbon dioxide in the contaminated soil.

■ Introduction of Each Lane

This landfarming was carried out on soil where two different types of waste oil had leaked. The contaminated soil was divided into five lanes.

- Lane 1: The soil where the engine oil leaked. Landfarming was carried out from October 17th to November 30th.
- Lane 2: The soil where the unidentified oil leaked. Landfarming was carried out from October 17th to November 30th.
- Lane 3: The soil where the engine oil leaked. Landfarming was carried out from November 7th to November 30th.
- Lane 4: The soil where the unidentified oil leaked. Landfarming was carried out from November 7th to November 30th.
- Lane 5: The soil where the engine oil leaked. This lane 5 is soil that has been moved from Lane 3 on November 17th to have enough space to turn over the soil for Lane 3. Landfarming was carried out from November 17th to November 30th as Lane 5.

■ Implementation Results

In summary, there was no significant change in the concentrations of oxygen decrease and carbon dioxide increase in the contaminated soil throughout the one-and-a-half-month period of landfarming. The following factors are assumed as the cause of this result.

- Lack of Data on Identification of leaked oil type and TPH concentration

  As there are various types of oil, it is necessary to accurately grasp the value of the oil contained in the soil. The plan was to calculate it by GC-MS analysis, but we could not be done.

- Amount of fertilizer applied may not have been appropriate

  As the data mentioned above was not available, the amount of agricultural fertilizer input was decided according to the amount of soil in each lane, assuming an oil content amount of soil is 100,00mg/kg-soil. For this reason, there was a possibility that the input was insufficient.

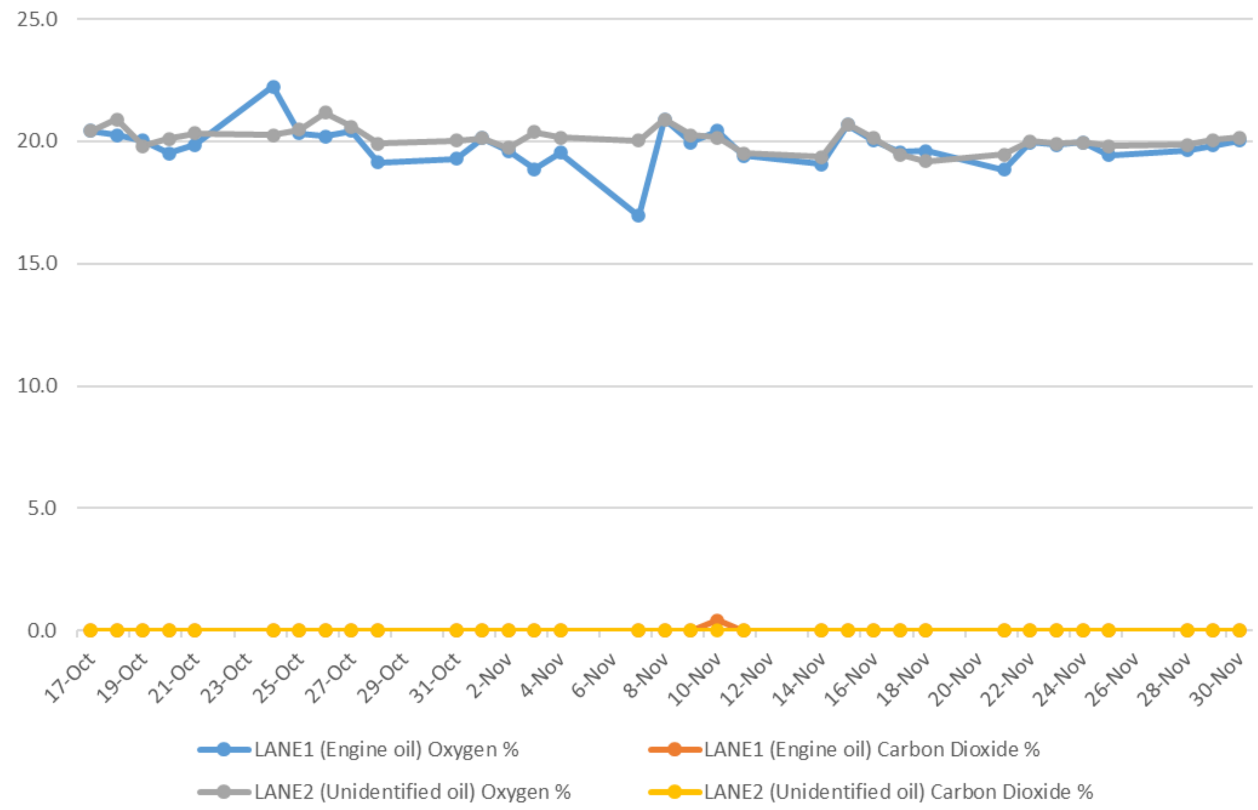


Figure 67. Changes in percent oxygen and carbon dioxide concentrations in contaminated soil (lane 1 and 2).

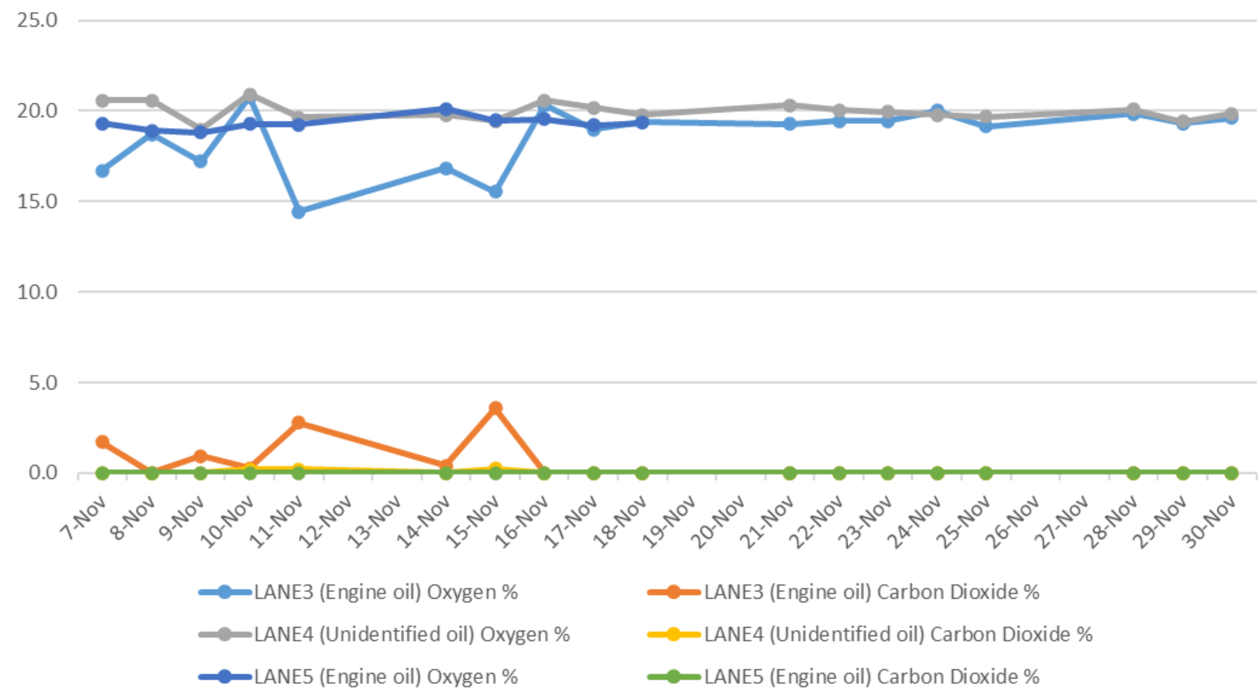


Figure 68. Changes in percent oxygen and carbon dioxide concentrations in contaminated soil (lane 3,4,5).

Lane 1 data (Site 1: Engine oil)

										Oxygen %			Carbon Dioxide %			Fertilizer Spraying	
Week	Date	Oil Type	Day	Time	Watering/Stirring	Weather	Atmospheric Temperature (degres celsius)	Soil tempearture (degres celsius)	pH reading	Upstream	Mid-stream	Downstream	Upstream	Midstream	Downstream	Added Fertilizer	Quantity
1	17-Oct	Engine Oil	1	10am	no	Clear sky	30	31	7	20.0	20.4	20.9	0.0	0.0	0.0	yes	1.89 kg
	18-Oct		2	10:47am	no	Cloudy/Sun	29	32	6.4	20.1	19.8	20.9	0.0	0.0	0.0	no	
	19-Oct		3	9:40am	no	mostly sunny	29	31	6.7	19.9	20.0	20.2	0.0	0.0	0.0	no	
	20-Oct		4	11:25am	no	Sunny clear sky	29	34.3	7.1	18.5	19.5	20.5	0.0	0.0	0.0	no	
	21-Oct		5	10am	no	mostly sunny	28	30	6.8	19.8	19.8	20.0	0.0	0.0	0.0	no	
2	24-Oct	Engine Oil	1	11am	no	Cloudy/Sunny	28	34	6.8	20.5	22.8	23.4	0.0	0.0	0.0	yes	1.89 kg
	25-Oct		2	9:30am	no	Rainy day	27	28	6.5	20.3	20.4	20.3	0.0	0.0	0.0	no	
	26-Oct		3	11:30am	no	Cloudy	28	28	6.5	19.9	19.8	20.9	0.3/0.4	0.9/1.0	0.0	no	
	27-Oct		4	11:40am	no	Raining heavily	26	26	6.9	20.9	20.3	20.1	0.0	0.0	0.0	no	
	28-Oct		5	10:30	no	Mostly cloudy/Mild showers	27	29.7	6.7	19.2	19.1	19.1	0.0	0.0	0.0	no	
3	31-Oct	Engine Oil	1	10am	yes	Sunny	29	37	7	19.6	19.2	19.1	0.0	0.0	0.0	no	
	1-Nov		2	10am	yes	Cloudy/mild showers	27	29	6.8	20.3	20.0	20.1	0.0	0.0	0.0	no	
	2-Nov		3	10am	yes	Cloudy/sunny	29	34	6.9	20.0	19.3	19.5	0.0	0.0	0.0	no	
	3-Nov		4	11am	no	sunny	29	33	6.7	19.0	18.6	19.0	0.0	0.0	0.0	no	
	4-Nov		5	10am	yes	cloudy/sunny	30	34	6.8	19.6	19.1	19.9	0.0	0.0	0.0	no	
4	7-Nov	Engine Oil	1	10:15	no	sunny	28	34	6.2	17.7	14.4	18.8	0.0	0.0	0.0	yes	3.78kg
	8-Nov		2	9:50am	yes	cloudy/rainy	28	29	6.6	20.9	20.9	20.9	0.0	0.0	0.0	no	
	9-Nov		3	10:16	no	cloudy/rainy/windy	28	31	6.8	19.8	19.9	20.2	0.0	0.0	0.0	no	
	10-Nov		4	9:48am	no	sunny/cloudy	29	30	6.1	19.5	20.9	20.9	0.0	0.7	0.6	no	
	11-Nov		5	11:30am	no	sunny	30	34	5.6	19.1	19.6	19.5	0.0	0.0	0.0	no	
5	14-Nov	Engine Oil	1	9:30am	no	sunny	30	33	6.1	19.2	18.7	19.3	0.0	0.0	0.0	yes	19kg
	15-Nov		2	9:40am	no	raining heavily	26	28	6.2	20.2	20.9	20.9	0.0	0.0	0.0	no	
	16-Nov		3	9:50am	no	cloudy/sunny	30	30	5.8	20.4	20.0	19.7	0.0	0.0	0.0	no	
	17-Nov		4	10am	yes	sunny	29	33	6	19.8	19.6	19.3	0.0	0.0	0.0	no	
	18-Nov		5	10am	no	sunny	29	31	5.9	19.9	19.6	19.3	0.0	0.0	0.0	no	
6	21-Nov	Engine Oil	1	10:30am	yes	sunny	29	32	6.6	19.5	19.2	17.8	0.0	0.0	0.0	yes	19kg
	22-Nov		2	10am	yes	cloudy/sunny	30	31	6.8	20.0	20.2	19.7	0.0	0.0	0.0	no	
	23-Nov		3	9:44am	yes	cloudy/sunny	28	34	6.8	19.9	19.9	19.8	0.0	0.0	0.0	no	
	24-Nov		4	9:44am	yes	cloudy/sunny	28	32	7.2	19.9	20.0	20.0	0.0	0.0	0.0	no	
	25-Nov		5	9:30am	yes	sunny	28	33	6.4	19.4	19.5	19.4	0.0	0.0	0.0	no	
7	28-Nov	Engine Oil	1	9:30am	yes	sunny	29	35	7	19.8	19.6	19.5	0.0	0.0	0.0	yes	19kg
	29-Nov		2	10am	yes	sunny	29	33	6.5	19.5	20.2	19.8	0.0	0.0	0.0	no	
	30-Nov		3	9:45am	no	sunny	28	33	7	20	20	20.1	0.0	0.0	0.0	no	

Figure 69. Landfarming data – Lane 1.

Lane 2 data (Site 2: Unidentified oil)

										Oxygen %			Carbon Dioxide %			Fertilizer Spraying	
Week	Date	Oil Type	Day	Time	Watering/Stirring	Weather	Atmospheric Temperature (degres celsius)	Soil tempearture (degres celsius)	pH reading	Upstream	Mid-stream	Downstream	Upstream	Midstream	Downstream	Added Fertilizer	Quantity
1	17-Oct	Unidentified	1	10am	no	Clear skies	30	31	7.1	20.0	20.4	20.9	0.0	0.0	0.0	yes	0.895 kg
	18-Oct		2	10:47	no	Cloudy/Sun	29	31	6.9	20.9	20.9	20.9	0.0	0.0	0.0	no	
	19-Oct		3	9:40am	no	mostly sunny	29	28	6.3	19.7	19.8	19.9	0.0	0.0	0.0	no	
	20-Oct		4	11:25	no	sunny clear sky	29	33	6.3	20.3	20.0	20.0	0.0	0.0	0.0	no	
	21-Oct		5	10am	no	mostly sunny	28	30	6.6	20.9	20.0	20.1	0.0	0.0	0.0	no	
2	24-Oct	Unidentified	1	10am	no	Clear skies	30	33	6.2	20.3	20.4	20.1	0.0	0.0	0.0	yes	0.895 kg
	25-Oct		2	9:30am	no	Rainy day	27	29	6	20.4	20.5	20.5	0.0	0.0	0.0	no	
	26-Oct		3	11:30am	no	Cloudy	28	29.3	6	22.0	21.3	20.2	0.0	0.0	0.0	no	
	27-Oct		4	11:40am	no	sunny clear sky	29	24	6.3	20.9	20.9	20.0	0.0	0.0	0.0	no	
	28-Oct		5	10:30	no	Mostly cloudy/Mild showers	27	29	5.8	19.8	19.0	20.9	0.0	0.0	0.0	no	
3	31-Oct	Unidentified	1	10am	yes	Sunny	29	32	7.1	19.7	20.0	20.4	0.0	0.0	0.0	no	
	1-Nov		2	10am	yes	Cloudy/mild showers	27	28	6.5	20.2	19.9	20.3	0.0	0.0	0.0	no	
	2-Nov		3	10am	yes	Cloudy/sunny	29	32	6.6	20.2	19.0	20.0	0.0	0.0	0.0	no	
	3-Nov		4	11am	no	sunny	29	33	5.4	20.1	20.9	20.1	0.0	0.0	0.0	no	
	4-Nov		5	10am	yes	cloudy/sunny	30	32	6.7	20	20.1	20.4	0.0	0.0	0.0	no	
4	7-Nov	Unidentified	1	10:15am	no	sunny	28	34	6.8	20.5	19.5	20.1	0.0	0.0	0.0	yes	1.78kg
	8-Nov		2	9:50am	no	cloudy/rainy	28	28	5.8	20.9	20.9	20.9	0.0	0.0	0.0	no	
	9-Nov		3	10:16am	no	cloudy/rainy/windy	28	31	5.4	20.4	20.0	20.4	0.0	0.0	0.0	no	
	10-Nov		4	9:48am	no	sunny/cloudy	29	29	6.2	20.2	19.8	20.5	0.0	0.0	0.0	no	
	11-Nov		5	11:30am	no	sunny	30	33	4	19.7	18.9	19.9	0.0	0.0	0.0	no	
5	14-Nov	Unidentified	1	9:30am	no	sunny	30	33	5.4	19.5	18.9	19.7	0.0	0.0	0.0	yes	9kg
	15-Nov		2	9:40am	no	raining heavily	26	28	6.4	20.9	20.9	20.3	0.0	0.0	0.0	no	
	16-Nov		3	9:50am	no	cloudy/sunny	30	30	4.5	20.2	20.2	20.0	0.0	0.0	0.0	no	
	17-Nov		4	10am	no	sunny	29	32	3.3	19.2	193.0	19.9	0.0	0.0	0.0	no	
	18-Nov		5	10am	no	sunny	29	33	4.2	19.0	19.6	19.0	0.0	0.0	0.0	no	
6	21-Nov	Unidentified	1	10:30am	yes	sunny	29	34	6.4	19.5	19.8	19.1	0.0	0.0	0.0	yes	9kg
	22-Nov		2	10am	yes	cloudy/sunny	30	31	6	19.8	20.0	20.2	0.0	0.0	0.0	no	
	23-Nov		3	9:44am	yes	cloudy/sunny	28	33	6	20.0	19.9	19.8	0.0	0.0	0.0	no	
	24-Nov		4	9:44am	yes	cloudy/sunny	28	33	6.2	19.9	20.0	20.0	0.0	0.0	0.0	no	
	25-Nov		5	9:30am	yes	sunny	28	31	5	19.6	20.0	19.8	0.0	0.0	0.0	no	
7	28-Nov	Unidentified	1	9:30am	yes	sunny	29	34	6.8	19.8	19.8	20	0.0	0.0	0.0	yes	4kg
	29-Nov		2	10am	yes	sunny	29	34	4.4	20	20.4	19.8	0.0	0.0	0.0	no	
	30-Nov		3	9:45am	no	sunny	28	30	6.9	20.1	20.2	20.2	0.0	0.0	0.0	no	

Figure 70. Landfarming data – Lane 2.

Lane 3 data (Site 1: Engine oil)

									Oxygen %			Carbon Dioxide %			Fertilizer Spraying	
Week	Date	Oil Type	Day	Time	Watering/Stirring	Weather	Atmospheric Temperature (degres celsius)	Soil tempearture (degres celsius)	pH reading	Upstream	Mid-stream	Downstream	Upstream	Midstream	Downstream	Added Fertilizer	Quantity
1	7-Nov	Engine Oil	1	10am	no	Sunny/cloudy	28	34	6.7	18.0	16.9	15.2	2.1	0.0	3.0	no	
	8-Nov		2	9:50am	no	cloudy/rainy	28	30	6.5	16.5	19.8	19.8	0.0	0.0	0.0	no	
	9-Nov		3	10:16am	no	cloudy	28	32	6.4	16.7	17.2	17.7	2.8	0.0	0.0	no	
	10-Nov		4	9:48am	no	Sunny/cloudy	29	33	6	20.9	20.9	20.5	0.0	0.0	0.8	no	
	11-Nov		5	12:45pm	no	sunny	30	37	6.4	15.5	13.1	14.7	1.4	3.2	3.7	no	
2	14-Nov	Engine Oil	1	10:55am	no	sunny	30	30	6.6	16.5	17.3	16.7	1.2	0.0	0.0	no	
	15-Nov		2	11:50am	no	raining heavily	28	29	6.9	14.8	14.2	17.6	5.7	4.4	0.6	yes	39kg
	16-Nov		3	9:30am	no	cloudy/sunny	30	30	7	20.4	20.3	20.2	0.0	0.0	0.0	no	
	17-Nov		4	11:35am	yes	sunny	29	32	5	18.2	19.2	19.5	0.0	0.0	0.0	no	
	18-Nov		5	10am	no	sunny	29	33	5.9	19.5	19.5	19.2	0.0	0.0	0.0	no	
3	21-Nov	Engine Oil	1	12pm	yes	cloudy/rainy	29	33	6.6	19.1	19.5	19.2	0.0	0.0	0.0	yes	19kg
	22-Nov		2	10am	yes	cloudy/sunny	30	31	5.8	19.4	19.7	19.2	0.0	0.0	0.0	no	
	23-Nov		3	9:44am	yes	cloudy/sunny	28	33	6.1	19.5	19.3	19.5	0.0	0.0	0.0	no	
	24-Nov		4	9:44am	yes	cloudy/sunny	28	36	6.8	20.2	20.1	19.7	0.0	0.0	0.0	no	
	25-Nov		5	9:30am	yes	sunny	28	33	6.7	19.3	19.2	18.9	0.0	0.0	0.0	no	
4	28-Nov	Engine Oil	1	9:30am	yes	sunny	29	34	7	19.8	19.8	19.9	0.0	0.0	0.0	yes	19kg
	29-Nov		2	10am	yes	sunny	29	33	5.5	19.2	19.8	18.9	0.0	0.0	0.0	no	
	30-Nov		3	9:45am	no	sunny	28	34	7	19.4	19.9	19.5	0.0	0.0	0.0	no	

Lane 4 data (Site 1: Unidentified oil)

									Oxygen %			Carbon Dioxide %			Fertilizer Spraying	
Week	Date	Oil Type	Day	Time	Watering/Stirring	Weather	Atmospheric Temperature (degres celsius)	Soil tempearture (degres celsius)	pH reading	Upstream	Mid-stream	Downstream	Upstream	Midstream	Downstream	Added Fertilizer	Quantity
1	7-Nov	Unidentified	1	10am	no	sunny/cloudy	28	34	5.9	20.9	20.5	20.3	0.0	0.0	0.0	no	
	8-Nov		2	9:50am	no	cloudy/rainy	28	28	6.4							no	
	9-Nov		3	10:16am	no	cloudy/rainy	28	31	5.7	20.9	18.8	17.2	0.0	0.0	0.0	no	
	10-Nov		4	9:48am	no	sunny/cloudy	29	32	6.6	20.9	20.9	20.9	0.6	0.0	0.0	no	
	11-Nov		5	12:45pm	no	sunny	30	36	6.5	19.8	19.5	19.6	0.0	0.6	0.0	no	
2	14-Nov	Unidentified	1	10:55am	no	sunny	30	32	6.4	20.1	19.7	19.5	0.0	0.0	0.0	no	4kg
	15-Nov		2	11:50am	no	raining heavily	28	27	6.2	19.6	20.1	18.6	0.0	0.0	0.7	no	
	16-Nov		3	9:30am	no	cloudy/sunny	30	29	6.9	20.9	20.4	20.4	0.0	0.0	0.0	no	
	17-Nov		4	11:35am	yes	sunny	29	31	5.2	20.3	20.1	20.1	0.0	0.0	0.0	no	
	18-Nov		5	10am	no	sunny	29	31	4.8	19.9	19.5	19.9	0.0	0.0	0.0	no	
3	21-Nov	Unidentified	1	12pm	yes	cloudy/rainy	29	33	6.3	20.3	20.3	20.3	0.0	0.0	0.0	yes	4kg
	22-Nov		2	10am	yes	cloudy/sunny	30	30	6	20.2	20.1	19.8	0.0	0.0	0.0	no	
	23-Nov		3	9:44am	yes	cloudy/sunny	28	31	5.8	19.9	20.0	19.9	0.0	0.0	0.0	no	
	24-Nov		4	9:44am	yes	cloudy/sunny	28	34	6.3	19.7	19.8	19.8	0.0	0.0	0.0	no	
	25-Nov		5	9:30am	yes	sunny	28	34	6.1	19.5	19.7	19.8	0.0	0.0	0.0	no	
4	28-Nov	Unidentified	1	9:30am	yes	sunny	29	34	6.8	20.2	20.4	19.6	0.0	0.0	0.0	yes	9kg
	29-Nov		2	10am	yes	sunny	29	32	6	19.3	19.3	19.6	0.0	0.0	0.0	no	
	30-Nov		3	9:45am	no	sunny	28	30	6.9	19.9	19.6	20.0	0.0	0.0	0.0	no	

Figure 71. Landfarming data – Lane 3 and 4.

Lane 5 data (Site 1: Engine oil)

										Oxygen %			Carbon Dioxide %			Fertilizer Spraying	
Week	Date	Oil Type	Day	Time	Watering/Stirring	Weather	Atmospheric Temperature (degres celsius)	Soil tempearture (degres celsius)	pH reading	Upstream	Mid-stream	Downstream	Upstream	Midstream	Downstream	Added Fertilizer	Quantity
1	17-Nov	Unidentified	4	11:35am	yes	sunny	29	34	5.1	19.5	19.2	19.2	0.0	0.0	0.0	no	
	18-Nov		5	10am	yes	sunny	29	33	4.8	18.8	18.2	19.7	0.0	0.0	0.0	no	
2	21-Nov	Unidentified	1	12pm	yes	cloudy/rainy	29	33	6.8	17.9	18.6	19.9	0.0	0.0	0.0	yes	18kg
	22-Nov		2	10am	yes	cloudy/sunny	30	35	6.7	19.3	19.4	19.1	0.0	0.0	0.0	no	
	23-Nov		3	9:44am	yes	cloudy/sunny	28	34	6.6	19.1	19.5	19.1	0.0	0.0	0.0	no	
	24-Nov		4	9:44am	yes	cloudy/sunny	28	35	7.3	20.1	20.2	20.0	0.0	0.0	0.0	no	
	25-Nov		5	9:30am	yes	sunny	28	31	6.3	19.7	19.2	19.5	0.0	0.0	0.0	no	
3	28-Nov	Unidentified	1	9:30am	yes	sunny	29	35	6.8	19.5	19.7	19.4	0.0	0.0	0.0	yes	18kg
	29-Nov		2	10am	yes	sunny	29	33	6.5	19.8	19.0	18.8	0.0	0.0	0.0	no	
	30-Nov		3	9:45am	no	sunny	28	33	7.2	19.3	19.6	19.1	0.0	0.0	0.0	no	

Figure 72. Landfarming data – Lane 5.

5) Odor Test Implementation Results

Odor Measurement of Contaminated Soil

- **Purpose**

Because odor is a sensory pollution that directly appeals to the human sense of smell, the problem is that it affects a comfortable living environment rather than impacts health.

In this case SRWMA's SWOMP facility is located in the Tafaigata landfill site, and there are no residents living nearby. The only people who are affected by the odor caused by the waste oil leakages are the employees who work at the SWOMP.

Samples from the contaminated soil were collected at fixed points before and after landfarming, and presented to the panelists to score the odor intensity and acceptance level of each soil.

- **Implementation Dates**
  - 1st test: September 15th (when excavating and removing contaminated soil)
  - 2nd test: October 27th (one week after the start of landfarming)
  - 3rd test: November 4th (three week after the start of landfarming)
  - 4th test: November 17th (one month after the start of landfarming)
  - 5th test: November 30th (last day of landfarming implementation)
- **Panelists**

SRWMA, SROS, USP, J-PRISM II

- **Implementation Results**

Soil was divided into several parts, so the implementation results will be summarized based on the odor test results of the soil heaps (started from October 17th) for the same period of landfarming. In addition, the fifth odor test was not reflected in the implementation results because there was not enough time for the samples to be circulated among the panelists.

- Engine oil had a stronger odor than unclassified oil

  Comparing the odor strength and tolerance values of soil with engine oil and soil with unclassified oil, both values were higher for the soil contaminated with engine oil.

- Odor may have volatilized in soil where unclassified oil leaked before landfarming starts

  For the soil where the unclassified oil leaked, more than half of the panelists did not detect any odor from the soil samples taken on September 15th, before the start of landfarming. Therefore, it is possible that the odor had already volatilized from the soil where the unclassified oil leaked. Also, it may have been better to use the comparison with the non-intervention soil odor when conducting each odor test. It seems that it was necessary to find a way to detect the faint odor of the soil.

- It was not fully confirmed that landfarming reduced the contaminated soil odor

  It was not confirmed that the odor of the sample was sufficiently reduced from this implementation period and method.

a) – Original form

OLFACTORY PERCEPTION TEST											
Sample No.:						**Date:**			**Time:**		
Nombre:											
Instructions: Read each question carefully and mark with an X the box you consider contains the correct answer											
Does it smell like normal earth?		**Does it smell good ground?**		**Odor intensity** Does it smell like crude oil?			**Acceptance level for odor** Is it pleasant or unpleasant?			**Does it serve to sow? (it's okay)**	
Yes	No	Yes	No	Without odor	1		Very pleasant	1		Yes	No
				Slight odor (barely perceptible)	2		Medium pleasant	2			
				Low odor	3		A little pleasant	3			
				Medium odor	4		Neither pleasant nor unpleasant	4			
				Odor a little strong	5		A little unpleasant	5			
				Strong odor	6		Medium unpleasant	6			
				Very strong odor	7		Very unpleasant	7			

Figure 73. Odor test answer sheet.

Soil sampling.

Odor check at SRWMA.

Soil sampling bottles.

Odor test in action.

Figure 74. Odor test implementation.

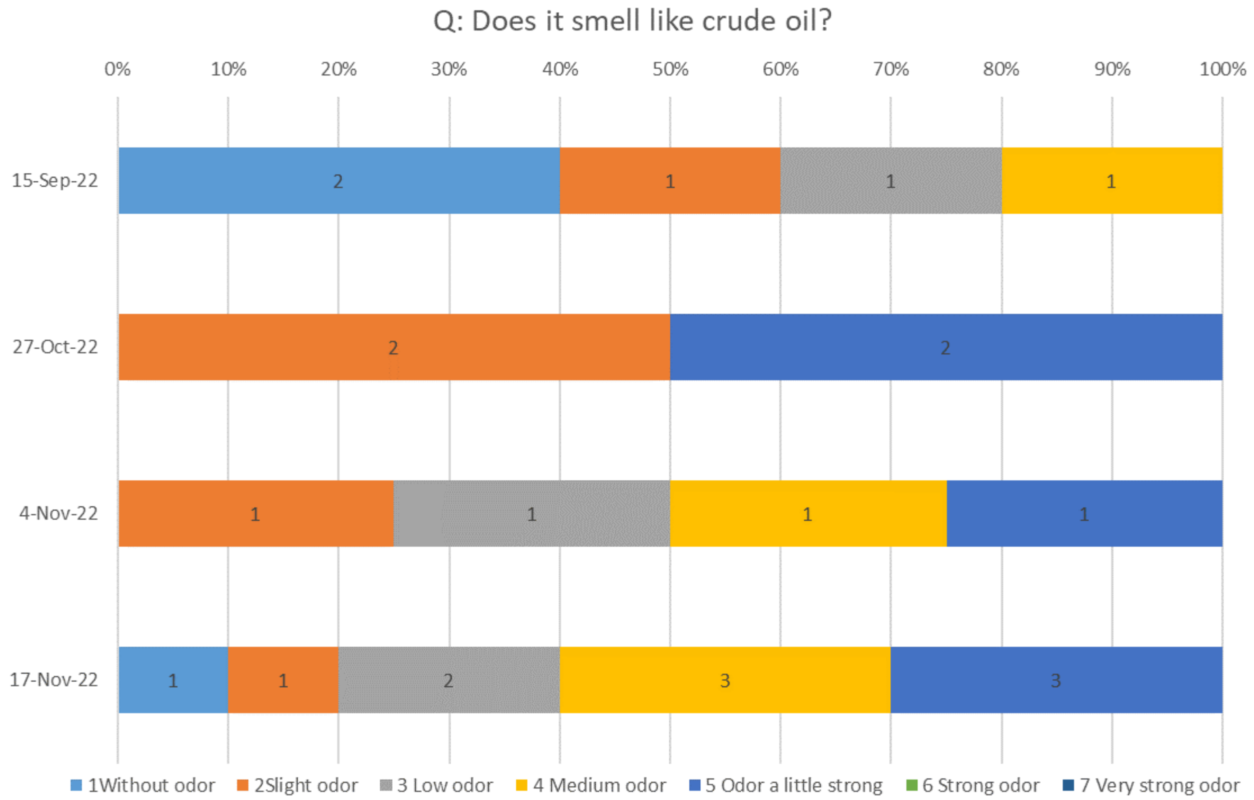


Figure 75. Odor intensity (engine oil lane1).

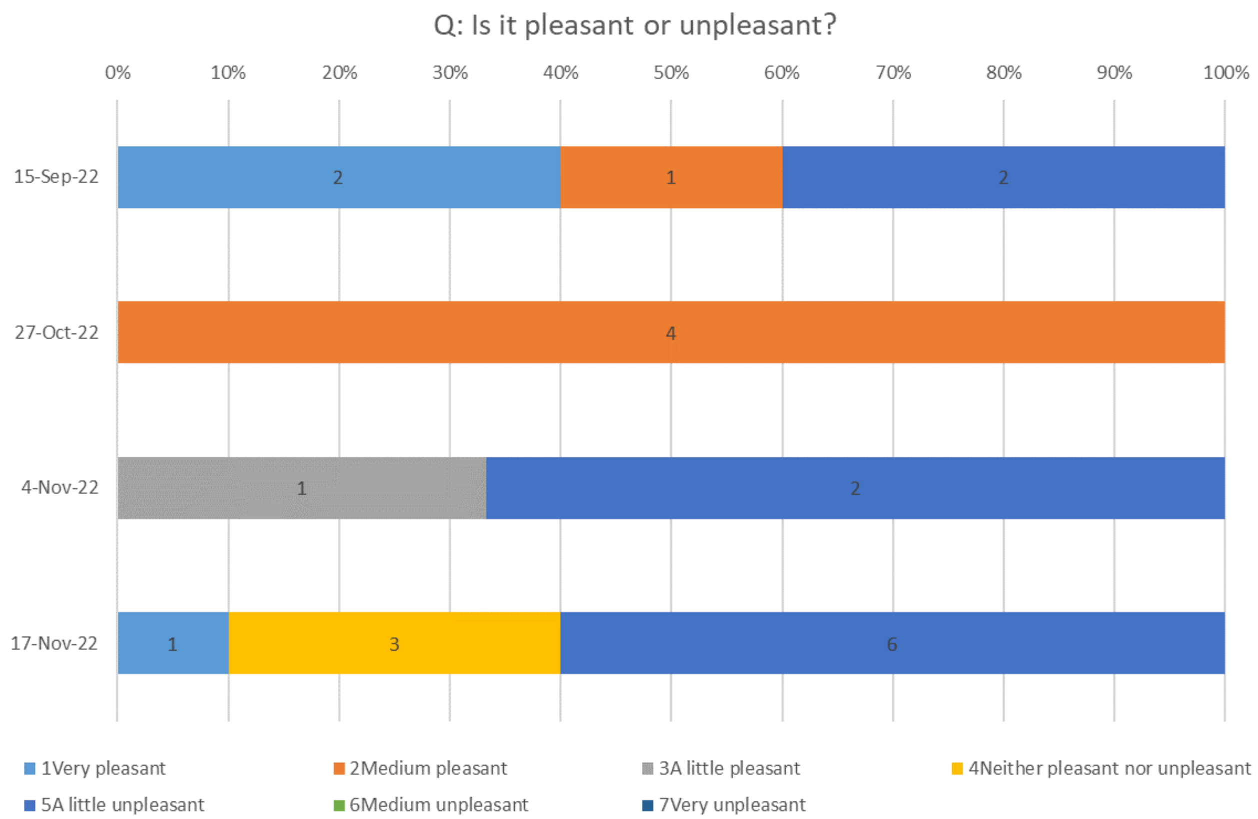


Figure 76. Acceptance level for odor (engine oil lane 1).

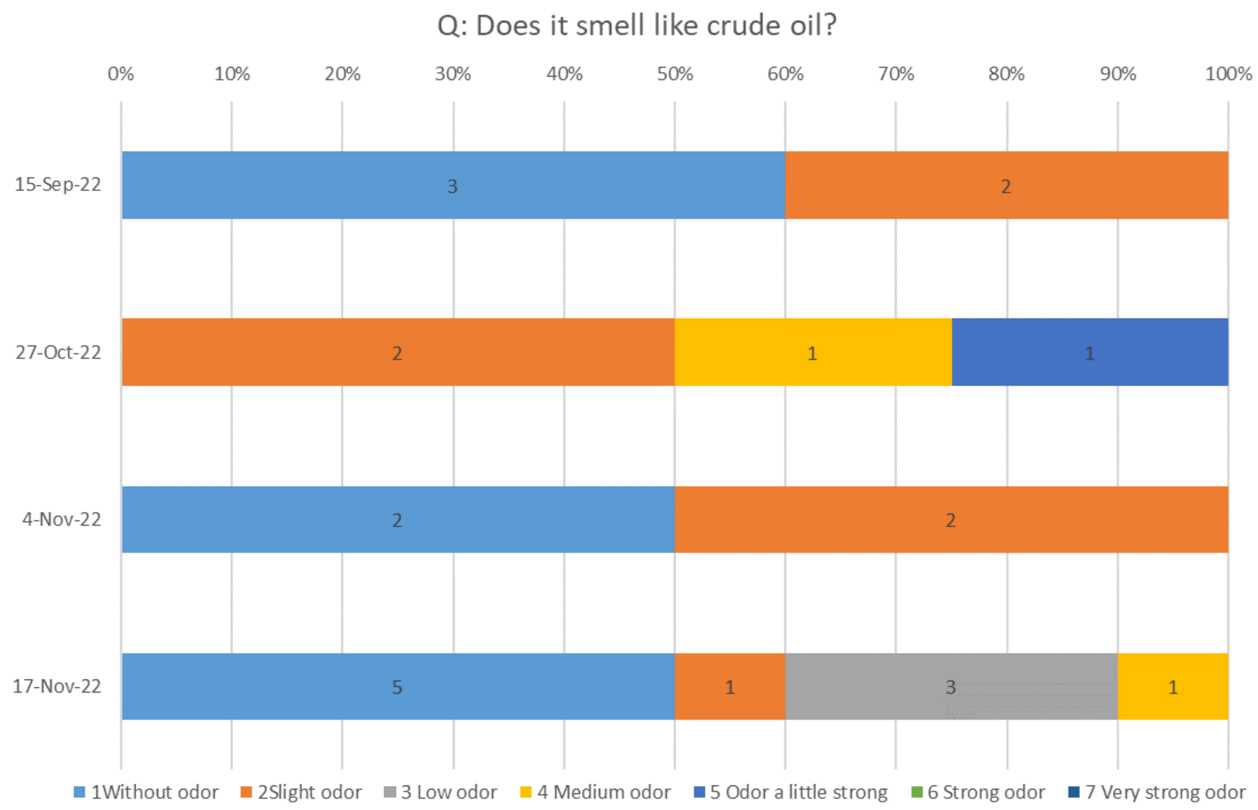


Figure 77. Odor intensity (unidentified oil lane 2).

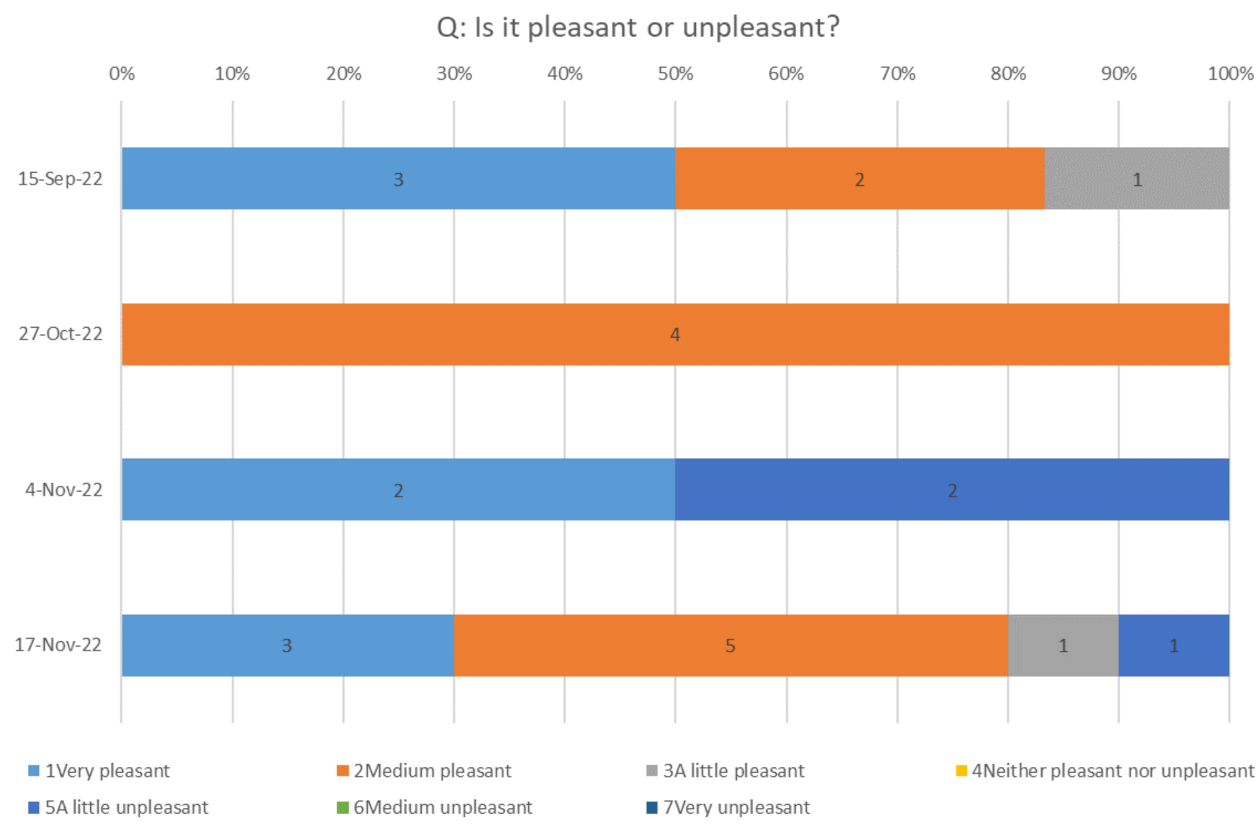


Figure 78. Acceptance level for odor (unidentified oil lane 2).

6) Contaminated Soil Samples Analysis Results

TPH Test and GC-MS Analysis

- **Purpose**

When oil-containing soil pollution occurs, it is very important to identify the type of oil in the soil with an oil odor or film when deciding on the remediation measures.

The TPH test is a method that measures the concentration of total petroleum hydrocarbons (TPH) in soil, and is a designated test method to complement the olfactory senses such as smell in soil oil contamination.

There are various ways to conduct TPH test, but as it was confirmed that SROS has a GC-MS machine, it was decided to conduct a TPH test using GC-MS method.

SROS has previously used GC-MS analysis to identify the types of narcotics, and this was the first challenge to use GC-MS to analyze the soils contaminated by leaked oil.

- **Overview of measurement methods**

The oil contained in the soil is extracted with Dichloromethane (CH2CI2), and using a gas chromatograph (GC-MS) equipped with a hydrogen flame ionization detector, all components of the oil extraction sample are separated by boiling point using a non-polar column. The chromatogram patterns of the boiling point ranges of C6-C12 (gasoline carbon range), C12-C28 (light oil carbon range) and C28-C44 (residual oil carbon range) of the recorded chromatograms and the chromatograms of each oil type Gram patterns are compared to confirm whether or not it is a mineral oil, and to identify the oil type.

- **Implementation Dates**
    - 1st test: September 15th (when excavating and removing contaminated soil)
    - 2nd test: October 27th (one week after the start of landfarming)
    - 3rd test: November 17th (one month after the start of landfarming)
    - 4th test: November 30th (last day of landfarming implementation)
- **Implementation Agency:** SROS
- **Implementation Results**

Results of the GC-MS analysis and TPH test we in intended to be used in the implementation method of landfarming, but due to the following challenges it was not possible to fully utilize the data.

- Finding it difficult to summarize conclusions in a report based on GC-MS analysis results

  The waste oil samples were sent to SROS for analysis, but we were unable to provide enough academic support for the method of conducting the GC-MS/TPH test and the task of summarizing the survey results.

Soil sampling bottles.

Typical waste oils discharged from automobiles were used as sample.

Figure 79. Odor test implementation.

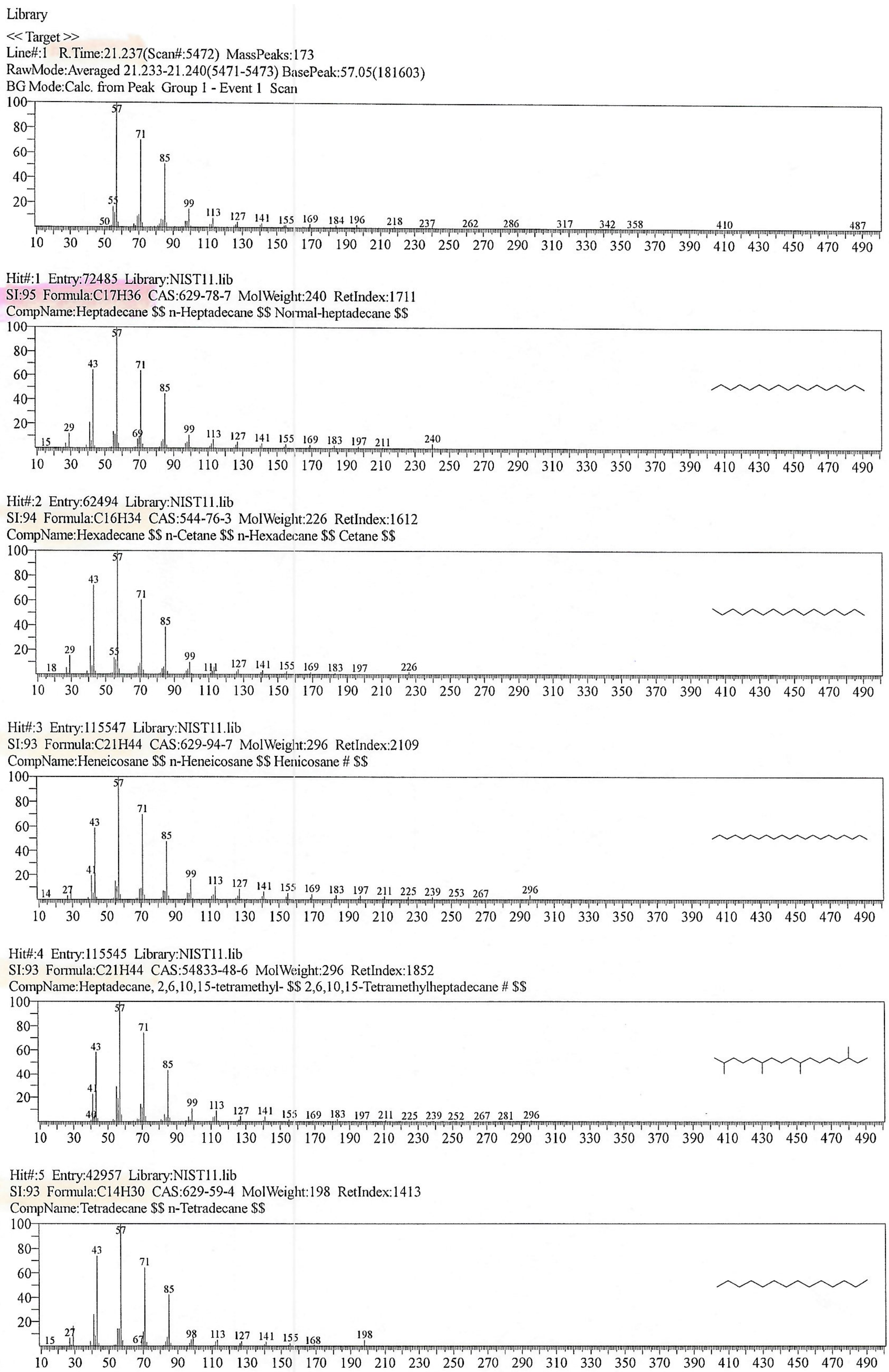


Figure 80: Contaminated soil sample test data with GC-MS

(Note: this table illustrates that $C_{17}H_{36}$ (a type of light oil) had the highest similarity index as a result of GC-MS analysis of this soil sample.)

3.6 Examination of Waste Oil Exportation Scenario

1) Export Scenario Comparison

The table below compares the conditions for accepting waste oil from the three companies contacted by SRWMA regarding the export of waste oil during the implementation of the SRWMA/J-PRISM II Pilot Project from 2020 to 2022.

All three scenarios require further consultations, and none of the scenarios resulted in export by the end of the pilot project. There will be further discussions between the parties concerned.

	SCENARIO 1: Company A Fiji	SCENARIO 2: Company B New Zealand	SCENARIO 3: Company C India
Acceptable waste oil container	■ Does not accept 220ltr drums ■ Sealed and non-compromised IBC tanks are accepted	Drums, IBCs, and ISO tanks meet the following requirements: ■ Containers should respect the ADR (6.1.3) and its 2021 update, and the usage of that container cannot exceed 5 years for shipping purposes ■ Containers should indicate the year of manufacture to control their validity	Drums, IBC tanks and flexibags are all accepted
Acceptable waste oil	Waste oil that passed the following test results	Waste oil that passed the following test results	No water content and no sediment. No rubbish and no waste clothes
Required lab test items	■ Water content ■ Ash Contain ■ Flash Point ■ Kinematic Viscosity ■ Sediment Contain ■ Density ■ PCB	Must submit analysis results from a certified laboratory: ■ Water content ■ Residues on evaporation ■ Ash ■ Flash Point ■ Density ■ PCB (which can be checked by Beilstein Test)	■ Water content ■ Flash point ■ Density ■ Viscosity
Processing method	Treating waste oil as fuel for furnaces, so it can treat mixed oil even if different types of waste oil are mixed	Company B does not process. It is processed and exported by a subcontractor in New Zealand	Waste oil is refined by Company C and used as road oil, or blended with pure oil for power generation in boilers, etc.
Cost and insurance sharing	■ Fiji domestic costs are covered by the shipper (=Company A), but will not except port fees/ duties, taxation, insurances or other government charges that may be applicable ■ Insurance required by Waigani convention should be covered by the shipper (=Company A)	Actual carrier (=Samoa side) needs to bear all costs and insurance	Shipping from Apia Port to India as well as insurance is borne by the shipper (=Company C).

Figure 81. Export scenario comparison chart.

Regardless of the scenario, waste oil falls under the category of hazardous waste under the Basel Convention and the Waigani Convention, so compliance with relevant laws and regulations is required. A key feature of the Basel and Waigani Conventions is that a transboundary movement of hazardous wastes can only take place after formal notification by the State of export, generator or exporter to the Competent Authorities of the States of export, import and transit, and upon receipt by the notifier of the written prior consent from those authorities. In addition, each shipment of wastes must be accompanied by a movement document from the point of departure through to the point of disposal.

Therefore, when exporting waste oil from Samoa, it is necessary obtain and submit the following documents to MNRE for the transboundary movement process.

- Sales Contract/Agreement between the Exporter and Importer
- Waste Description
- Completed Notification form (Basel and/or Waigani)
- Shipment schedule
- Insurance identification/confirmation of the shipment

SRWMA member companies are well-informed about the preparation of documents to comply with the Basel Convention, based on their experience of exporting waste batteries overseas.

For waste oil export, when choosing either scenario, it is necessary to calculate the balance of income and expenditure for SRWMA to make it a reality. In this pilot project, J-PRISM II tried to calculate the balance of payments for plastic recycling (Figure 45). Regarding the transport of waste oil, it will be necessary for SRMWA to make a decision, including whether it is suitable for waste oil management program business.

2) Necessity of securing containers suitable for transportation

Many of the waste oil containers currently stored at SRWMA are already outdated, so it is necessary to secure containers that can be transported safely at the time of export.

It is presumed that many of the drums and IBCs used by SRWMA to store waste oil have accumulated water at the bottom of the container because the oil has been stored for many years. It is easier to drain water from steel drums if the waste oil is first transferred into IBCs. For this reason, it is recommended that the content of the steel drums currently stored by SRWMA should be gradually transferred to new IBC tanks with steel frames in order to remove the water inside the containers safely.

In Samoa, IBC tanks and Flexible bags are not available, so they have to be purchased from neighboring countries. Therefore, it is necessary to consider which container can be procured and used at a lower cost depending on the total export volume.

200ltr steel drums.

IBC tank with steel frames.

https://www.alibaba.com/product-detail/galvanized-steel-frame-1000L-chemical-reagent_60555817254.html

Flexible bag.

https://iantaylorecuador.com/en/flexitank/

Figure 82. Typical containers for exporting waste oil.

SRWMA should incorporates the cost of pre-procurement of containers required for transportation and the cost of replacing waste oil into the waste oil collection fee charged to customers by SWOMP as necessary expenses in SWOMP operation.

3) Lab Test Implementation Check in Samoa

As shown in Figure 81, in order to be able to export waste oil, it is compulsory to obtain a laboratory-produced analysis results of samples of waste oil. However, waste oil is a liquid and falls under the category of dangerous goods, so it cannot be transported by air. Because of this, Samoa faces a major challenge when requesting analysis from overseas laboratories.

The table below is a quote from a laboratory in New Zealand on waste oil analysis. In addition to analyzing these components, the cost of transporting the samples must be borne by customer, so if a large amount of waste oil is to be exported, there is a high possibility that the cost of analysis will be high depending on the number of samples required.

TEST AVAILABILITY	SAMPLE QTY	Testing price (GST excl.)	Testing price TTC (GST incl)
Water Content	40ml	$ 58.00	$ 66.70
Flash Point		$ 65.00	$ 74.75
Ash		$ 65.00	$ 74.75
Density		$ 23.00	$ 26.45
Residue on Evap		$ 60.00	$ 69.00
Package subsamples + sned via courrier to hills		$ 70.00	$ 80.50
Set up fee per batch of samples		$ 150.00	$ 172.50
Per sample		$ 180.00	$ 207.00
TOTAL NZD			**$ 771.65**

Figure 83. Example of lab test quote.

Therefore, it is very important to use every opportunity to conduct analysis in. SROS is a certified laboratory institute and it can provide analysis on the following items on waste oil sample:

- Water Moisture content - $30
- Viscosity - $75
- Density - $75
- Flash Point - currently not available

As described above, in order to export the waste oil collected in Samoa, it is necessary to select the processing and final destination scenario and then proceed with discussions among the parties while resolving each of these issues.

In the second phase of waste oil collection and storage activities, the content of activities shifted to landfarming for the purpose of soil remediation due to the waste oil leak that occurred in 2022, as a result there was not enough time to use export scenario and cost analysis comparison using these final disposal methods. However, during the implementation period of the pilot project, it is considered to be a certain achievement that we have reached the point where we can compare possible scenario options for exporting the waste oil currently being collected by SRWMA in Samoa.

4) Handover of Waste Oil Activities to Other projects in SPREP

The waste oil activity implemented under the pilot project of J-PRISM II will be completed, but this activity will be taken over by other projects, PACPLAN and Sustainable Waste Actions in the Pacific (SWAP) of SPREP. With the support of other projects, we expect that appropriate national waste oil management system and a facility operation that prevents waste oil leakage set-up for Samoa will be promoted based on the knowledge and lessons learnt from this SRWMA/J-PRISM II Pilot Project.

3.7 Conclusions

Regarding the waste oil activity, SRWMA and J-PRISM II collected and stored waste oil in Phase 1, which was implemented in September 2021. In Phase 2, which was carried out from May to November 2022, landfarming was implemented as a remediation measure after a waste oil leak occurred at SWOMP facility. In addition, during both implementation periods, all scenarios of exporting to the companies who have established contact SRWMA and J-PRISM II were explored.

Based on these implementation results of Phase 1 and 2, the conclusions and lessons learnt for each waste oil treatment phase are summarized below.

1) Technical Aspect

Technical points and lessons learnt from the implementation of the pilot project on waste oil collection, storage, landfarming and exportation scenario are summarized below.

Process	Action Needed	What was done in the pilot project and challenges to be addressed in the future
Collection	Securing supplies necessary for collection	■ The collection of waste oil always requires Hiab trucks with belts to safely transport the waste oil, forklifts, pallets, and pumps. ■ In order for SWOMP to be able to secure this equipment, it is necessary to include it in a collection fee charged to customer.
	Risk management of waste oil leakage	Waste oil leaked from 2 drums during the loading at the customer's yard. It was confirmed that drums that had been stored outdoors for a long period of time easily leaked due to the impact of the movement.
	Identification of waste oil type	■ SWOMP does not have a form for customers to complete and submit a request for waste oil collection. Therefore, SRWMA cannot receive accurate information about the type pf waste oil that SWOMP collects in advance. ■ SRWMA needs to create SWOMP collection request form.
	Confirmation of MSDS (Material Safety Data Sheet)	■ In addition to submitting a collection request form, customers should be required to submit an MSDS sheet to SWOMP before collection. ■ It will provide information that can be used to ensure safety of SWOMP workers as well as workers employed at the time of export.
	Improving SWOMP collection fee charge method	■ Since current SWOMP collection fee system is 20 sene per liter, it is necessary to weigh and record each drum/IBC tank one by one. Undeniably this work becomes one of the most challenging and time-consuming stages in SWOMP operation. ■ SRWMA needs to revise the collection fee system based on the number of drum/IBCs. This revision is to omit the weighing work on-site.
	Assigning Required workers and supervisor	■ Based on the implementation of Phase 1, SRWMA must allocate 4-8 workers depending on the collection volume. ■ In addition, 1 supervisor must always monitor the workers and record the collection data.

Storage	Securing supplies necessary for storage	■ We confirmed forklift, pallets, pumps, and cleaning and occupational safety items are always needed in waste oil storage. ■ In order for SWOMP to be able to secure this equipment, it is important to account for it in customer's collection fee.
	Reinforcement of waste oil leakage prevention measures	■ Waste oil leaked from 25 drums and 1 IBC tank during the unloading and storing at the SWOMP facility. It was confirmed that drums and IBCs that had been stored outdoors for a long period of time easily leaked due to the impact of the movement and slippery container surface. ■ While unloading the waste oil container at the SWOMP facility, instead of unloading it inside the facility on the concrete floor, it was lowered to the ground in front of the facility and then moved inside the facility. In addition, the waste oil containers were stored outdoors for a long period of time as a temporary storage area before being moved to the facility. It was confirmed that the soil surrounding the SWOMP facility became the cause of soil contamination due to the leakage of waste oil due to the habit of working as described above. ■ It is necessary for SWOMP to set up unloading area to prevent waste oil leakage and take measures to prevent waste oil leakage within the SWOMP facility.
	Assigning required workers and supervisor	■ Based on the implementation of Phase1, SRWMA must allocate 4-7 workers depending on the storage volume. ■ In addition, 1 supervisor must always monitor their work and record the storage data.
Landfarming	Continuing landfarming operation	■ It was confirmed that landfarming can be carried out with equipment that can be procured in Samoa. ■ However, the data obtained during the implementation period did not show that the soil contamination level had been improved. ■ The lesson learnt from this is that when implementing landfarming, it is necessary to establish a method for measuring the TPH concentration (a method for determining the amount of oil present in the soil), and to accurately ascertain the input amount of agricultural fertilizer required for soil remediation. ■ Since the implementation period of this landfarming effort was short (one and a half months), we hope that the landfarming and soil remediation level check will be ongoing for at least six months to one year.
	Improving odor Test implementation method	■ Odor test can be implemented in Samoa. ■ However, some of the soil samples had very weak odors, and it has become clear that it was difficult for panelists to accurately determine the presence of odors in some cases. ■ The lesson learnt from this odor test is that comparison with a "control" sample is necessary to make sense of the experimental results. In the present odor test, sufficient measures were not taken for comparison with the control sample, and this point needs to be improved.

Landfarming	Strengthening GC-MS analysis and TPH test implementation support system	■ It was confirmed that the contaminated soil could be analyzed with the GC-MS machine used by SROS. ■ It was the first trial to identify the oil type, so the analysis work took time, and we could not fully identify the oil type and create a report on the analysis results. ■ The lesson learnt from conducting the GC-MS analysis this time is that, as a research institute in Samoa, SROS possesses analysis equipment capable of analyzing waste oil type, so it will be possible to establish an analysis laboratory that covers not only Samoa but the entire Pacific region in the future. For this reason, it is recommended to collaborate with research institutes and universities in neighboring countries and strengthen capacity development to improve the ability to analyze waste oil.
Export	Continuing discussions and selecting for the most appropriate export scenario for SWOMP	■ During the implementation of this pilot project, we did not reach the stage of selecting the most desirable export scenario from the three existing options. ■ It is necessary to visit each recycler's facility and select the optimal export scenario and destination for SRWMA and SWOMP from an environmental and economic point of view. Once a scenario is selected, it becomes possible to calculate the income and expenditure accordingly.
	Securing supplies necessary for export	■ It is necessary for SWOMP to procure new waste oil storage containers (drums/IBCs/flexible bags) that can withstand international shipment. ■ The current SWOMP facility also does not have facilities to store water and sludge after removing them from the waste oil storage containers. ■ Residues such as water and sludge collected from waste oil storage containers must be mixed with soil in landfarming to purify the oil content, and other measures must be taken so that SWOMP can self-treat them onsite.

Figure 84. Summary of technical aspect.

2) Business Feasibility Aspect

Based on the implementation of this pilot project, the economical points and lessons learnt for SWOMP waste oil management business are summarized below.

Item	What was done in the pilot project and challenges to be addressed in the future
Initial Cost	In this pilot project, J-PRISM II covered part of the initial costs for waste oil collection, storage, and landfarming. Therefore, other initial costs required for SWOMP are considered as follows: ■ Initial cost to thoroughly implement waste oil leakage prevention measures in SWOMP operations and facility ■ Waste oil storage container and the storage space for export ■ Residue treatment facility and implementation space
Operational Cost	The current SWOMP waste oil collection fee of 20 sene per liter does not reflect the following operation costs: ■ Expenses related to export ■ Operation costs on waste oil leakage prevention measures, storage facilities, residue processing facilities ■ Operating costs for the operation of SWOMP and facility for waste oil leakage prevention measures, storage, and residue treatment ■ It is necessary to re-calculate the operational costs including these uncovered costs

Figure 85. Summary of economical aspect.