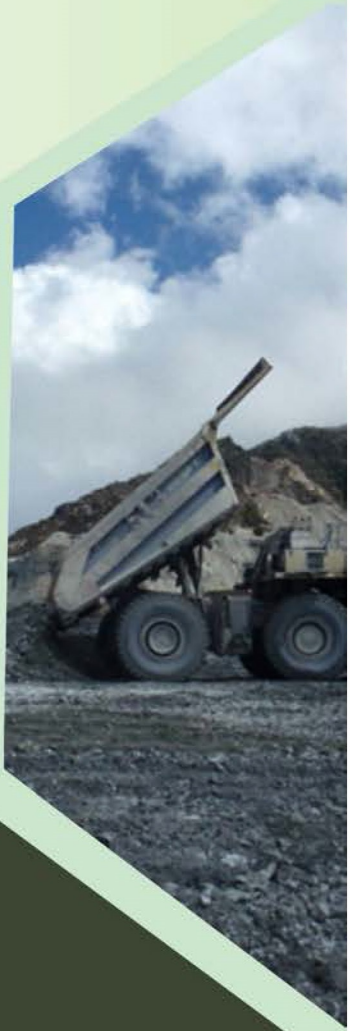
EXTERNAL ENVIRONMENTAL AUDIT 2017

EXECUTIVE SUMMARY

Prepared for :

PT FREEPORT INDONESIA
Affiliate of Freeport-McMoRan



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EXECUTIVE SUMMARY

The 2017 External Environmental Audit is the 8th audit since 1996 as PTFI's voluntary commitment written in its 300K AMDAL. It is aimed to review the environmental management in PTFI's Contract of Work area and its implementation compared to the previous audit in 2014 in compliance with the national environmental law, regulations and standards, adequacy of strategies to achieve best management practice, and effectiveness of the environmental management system toward continuous improvement. This initiative represented a form of independent concern to appreciate the environmental management responsibilities that go beyond compliance requirements.

PTFI's plans for decommissioning of Grasberg open pit in 2019 and the transition to underground mines as the sole source of ore was an important consideration in this audit. During this transitional period, the current mine plan shows a decrease in daily ore production to 150,000 ton/day with re-handle of an ore stockpile and a gradual increase to current production levels beginning in 2020 and onwards. An additional consideration is the potential reduction of production due to the recently introduced progressive export tariff for copper concentrate.

In January 2014, copper concentrate production was reduced to 40% of the normal production rate due to the Government's adoption of Government Regulation No. 1 of 2014, Regulation of Ministry of Energy & Mineral Resources No. 1 of 2014 and Regulation of Ministry of Finance No.6/PMK.011/2014, which sought to impose duties on exports of copper concentrates at such a high level that such actions resulted in a de-facto export ban. After several months of discussions between the Government and PTFI, was allowed to resume export of its concentrates in August 2014 after entering into a Memorandum of Understanding with the Government of Indonesia. As a result, in 2014 PTFI exported at a reduced level of only 532,900 WMT of copper concentrate with the export level increasing in 2015 and 2016 to 1,084,300 WMT and 1,225,600 WMT, respectively.

Another important issue that has been noted is the ending of the initial term of the Contract of Work for operation-production in 2021, and the continuing engagement of PTFI to work with the Government to ensure an extension of operations to 2041. According to Mining Law No 4/2009, any CoW issued before 2009 remains valid until the contract expires. As part of these discussions and Government regulatory developments, the Government and PTFI are in the process of negotiating a conversion and extension of operations to 2041 through the issuance of *Izin Usaha Pertambangan Khusus* (IUPK) scheme, which would also provide for assurance of legal and fiscal certainty in the same manner as provided for under the CoW. For PTFI this conversion is proposed to take place as soon as an agreement is reached on the terms of such extension According to these discussions, the first ten year extension will be granted upon documentation of the agreement, and the second ten-year extension would be assured, subject to completion of required formalities. This will require revisions to certain decrees and regulations, which are not yet consistent with the understanding between the parties. For PTFI whose long term strategic plan has already been developed and is being partly implemented in the form of underground mine development, if the parties fail to reach an agreement, then it will influence PTFI's long-term planning.

The audit focused on seven (7) strategic environmental issues which were defined and selected based on interest and perception of stakeholders, including the national government, the provincial government, district governments, and the community (including local communities). The issues are 1) Grasberg mine closure program, 2) Underground mining operations, 3) Tailings management, 4) Water quality and quantity, 5) Waste management, 6) Air quality and climate change issues, and 7) Reclamation & Biodiversity. This external environmental audit did not address social, economic or cultural issues.

Grasberg mine closure program

The primary focus of this audit is the immediate closure issues associated with completion of the Grasberg open pit and associated overburden stockpiles as described in the PTFI's Mine Closure Plan (2015) which addresses closure in 2021.

Wanagon overburden stockpile

The need to mitigate ARD generation and releases from the Upper Wanagon Overburden Stockpile (UWOBS) to the river system is a high-level concern issue needing to be further addressed as part of the overall Surface Mine Detailed Closure Implementation Plan prepared by PTFI. Although surface ARD streams from the Upper Wanagon stockpiles (mainly Koteka and Kaimana) and HSZ piles are neutralized in drainage channels, sumps and by alkalinity in the rivers, precipitated metals are in a form that pose a high potential risk to the receiving environment because they are more likely to be more readily re-dissolved and potentially bioavailable.

The impacts of ongoing erosion from the Lower Wanagon Overburden Stockpile (LWOBS) include consumption of ModADA and estuary physical storage capacity impacting levee construction, rapid downstream advance of sediment deposition, bed aggregation and increased pressure on achieving safe freeboard as well as increasing occurrence of Potentially-Acid Forming (PAF) sediments in the upper ModADA, and expansion of the area requiring active management to mitigate localized surface ARD (as evident by orange staining). It is recommended to add additional resources and management attention to accelerate and ensure the successful stabilization of the LWOBS and effectively complete closure of the Koteka and Kaimana stockpiles.

Closure Water Management

According to PTFI's approved Mine Closure Plan surface water from the Grasberg region will continue to drain south through either the Amole dewatering drift to the mill or to the HEAT road and eventually into the Aghawagon River. Surface drainage systems and sediment ponds will be constructed during operation to minimize the flow of water into the Grasberg open pit and the associated underground mines (Grasberg Block Cave, Kucing Liar and Big Gossan). These drainage systems and sediment ponds will remain after mine closure. Major surface flows will be directed to the HEAT road, or the mill water collection system (Amole drift and Ertsberg drains). During the post Grasberg open pit period and during the mine closure period any identified ARD stream is planned to be collected and directed to a lime neutralization plant.

Advances have been made in regards to developing post-closure water balance and water quality predictions since the last audit in 2014. Specifically, these have involved development of a water balance for the underground workings (including seepage from the Grasberg open pit) and a current study underway to develop geochemical source terms for the associated water quality model.

Underground mining operation

The potential impacts of underground mining operation are ARD generated from waste rock, subsidence due to block caving operation, mine water quality and quantity, and the potential impact of mine exhaust air quality to the environment at the surface around exhaust tunnel. In the case of PTFI, temperature difference between exhaust and ambient air seems to be the only parameter of concern.

Underground ARD Waste Rock Management

The underground Waste Rock Management from DMLZ and GBC development involves storage of Non-Acid Forming (NAF) rock in the Kasuang and CIP waste stockpiles, while any Potentially Acid Forming (PAF) waste rock identified from ARD model is sent to ore crushers in Mill and Concentrating Plant. Only limited amount of PAF waste rock will be handled in the waste rock dump.

Geochemical ARD Block Model for GBC has been improved since the 2014 audit. In 2017 ARD Block Model the NAF material is 41.8% of the total material which is an increasing portion compare to 28.9% in the 2014 model. Regular updating and accuracy improvement of ARD block model is recommended.

Surface subsidence

Subsidence due to underground block caving can change surface topography and natural streams patterns, lower groundwater levels, reduce vertical thickness of the aquifer, reduce permeability and porosity of the aquifer, and potentially generate surface & groundwater contamination in the subsided area. Current and future subsidence is associated with the East Ertsberg Skarn System (EESS) and Grasberg Block Cave (GBC). Subsidence in East Ertsberg Skarn System (EESS) began to form during mining operation in Intermediate Ore Zone (IOZ) and Deep Ore Zone (DOZ) and will continue when Deep Mill Level Zone (DMLZ) is in operation. When the Grasberg Block Cave operates in the future, the subsidence area on the surface will be at the Grasberg open pit area.

Current measurements of displacements at the existing subsidence area are conducted by several methods, including manual observation by using photography with helicopter, monitoring with LiDAR (Light Detection and Ranging) method using radio waves, and monitoring with Interferometric Synthetic Aperture Radar (Insar) method by satellite which can detect any changes in millimeter scale. The deformation measurements are very accurate. The analysis of GBC subsidence predicts the crack lines of the subsidence using numerical methods that combine simulation using Lattice Grain Cellular Automata (LGCA) and Discontinuum Finite Element (DFE) methods based on information of structural geology, geotechnical data, and geological model.

According to the PTFI Mine Closure Plan (2014), the subsidence areas above the underground mines will be left in their natural formations for safety reasons. Access to these areas will be restricted by berms to minimize risk to anyone traveling in the area in the future. Accumulated drainage is expected to be collected so that it discharges from the AB Tunnel. The simulated crack lines of GBC in 2020 will be extended to the overburden stockpiles area (Cartenzweide stockpile/Bali stockpile). The instability of overburden stockpiles has the potential to expose the PAF materials that have already been encapsulated during OB dumping operation. There is also prediction that crack lines may extend in radial directions and possibly affect the Upper Wanagon OBS Area. Those potential risks should be addressed comprehensively by PTFI in more detailed contingency mitigation plan.

The GBC subsidence model need to be continuously improved and verified with the subsidence model developed in EESS. And it is recommended to develop procedure and contingency plan to address crack lines extension to the Grasberg OBS as the failure of OBS dump will affect the environmental concern on slope failure and exposure of PAF materials.

Exhaust air from mine ventilation system

Besides gas content, the temperature and humidity are important parameter in mine ventilation system because they are related to working condition in the mine. In the ventilation network air temperature is influenced by the activities that generate heat such as blasting, diesel engine as well as friction of air flow. When discharging to the environment and mine ventilation air is treated as 'emission' from underground mine, it is expected that there will be no issues on gases and particulate content because OHS standard for ventilation air is quite strict to secure the miners' health and safety. But in the case of underground mines in highland, the temperature difference between ventilation discharge and ambient air could become environmental concern. Regularly measure and document the potential impact of ventilation air in exhaust tunnels and the surrounding near field environment are recommended.

Underground mine water management

In general, most of underground mine water in PTFI comes from dewatering drilling holes and seepages. A small part comes as cave water which is rainfall that infiltrates through caves to draw-points. Prediction of water balance from underground mine activities indicate that water flows through AB Tunnel increases from 1.3 m^3/s to 3.37 m^3/s, including groundwater from Kucing Liar Block Caving. Water routes are also predicted for DOZ, DMLZ, and GBC underground mine dewatering. Ditch observed in AB Tunnel is effective to deliver the water from underground working area through portal by gravity, however the ditch as visually observed has not been built in proper construction and could fail if hit by underground equipment. It was also observed that sediment and water quality control facility outside AB Tunnel portal was not effective to reduce the TSS of underground mine water since the size and capacity were too small for the actual mine water discharge. Improvement is necessary and discussions continue with regulators and external experts about aspirations to meet the effluent standard for gold and copper mining operation as stated in the Decree of Minister of Environment No. 202 of 2014.

Tailings Management

The current PTFI tailings management system, using riverine transport of tailings to an engineered deposition area in the lowlands, was the product of two comprehensive tailings management alternative evaluations managed by Golder Associates in 1994 and 1997. The recommended management option, agreed to and approved as part of the 300K AMDAL, involved engineered north-south levees designed to control and manage the lateral extent of the tailing impact zone and to maximize retention of the tailings material on shore. The ModADA represents the single largest environmental risk from the PTFI operations. This risk is manifested in potentially acute environmental impacts associated with levee overtopping or levee embankment breach. Depending on the location of the overtopping event or breach, discharge of tailings outside of containment could be significant. This situation is further complicated where the tailings river or other large bodies of water are situated at the upstream edge of the levee embankment. There are also potential long-term chronic impacts to be managed (i.e., surficial deposition of pyrite being oxidized and potentially affecting surface water quality). Both flow and water quality sampling of seeps along these locations as well as other seepage locations on both levees should be continued and, in some cases, increased when seep volumes warrant. The monitoring and sampling of these seeps should also continue to be managed through the PTFI SOP process.

In the upper ModADA (MA240-265), the area of localized sporadic orange surface staining, first observed in mid-2016, has increased to approx. 500ha. Sampling and geochemical testing of these sediments show the presence of a thin surface layer of low geochemical Factor of Safety material requiring remedial works, which are already underway. In the lower ModADA (MA 45-117), the areas of ponded water adjacent to both levees has increased in volume. Perching of the main sediment flow channels through the area continues, increasing the potential for large uncontrolled rapid inflows of water/sediment into lower ponded areas adjacent to the levee with subsequent rapid loss of levee freeboard. The West Levee from WMA-55 to WMA-117 (i.e. WMA-70 Pond area) is currently ponding a significant volume of water (estimated up to 50 million cubic meters). This pond is situated immediately adjacent to the upstream levee embankment. It is recommended to perform a stability analysis for the west levee from WMA-55 to WMA- 117, additional geotechnical foundation condition testing (as required), and instrumentation and monitoring. Based on the results of this analysis, additional fill placement on the toe buttress or upstream construction to widen the crest of the embankment should be considered.

At the ModADA land boundary (K5-P5), the geochemical properties of the bedload sediment indicate that up to approximately 25% of the material exiting the ModADA to the estuary is geochemically classified as PAF. Geochemical staining suggesting the presence of sulfides appears to be increasing in the ModADA. WMA265 and WMA 190 are examples of this condition and warrant active blending with higher pH material to neutralize the impact to the ModADA. It is recommended to continue evaluating the influence of the Wanagon OBS erosion in relationship to the increase of staining in the ModADA and coordinate the closure plan for the WOBS to reduce erosion impacts in the ModADA.

Water Quality and Quantity

Surface Water Quality

The tailings acid rock drainage (ARD) control protocol and geochemical monitoring of the tailings implemented at PTFI continue to be effective in protecting surface water quality in the receiving rivers, as demonstrated by circum-neutral pH (Figure 3 10) and low dissolved metal concentrations, specifically copper, recorded at the Pandan Lima and Kelapa Lima monitoring locations in ModADA for the period 2014-2017. The continued low dissolved copper levels in the ModADA subsequent to initiation of low grade stockpile processing (2015) demonstrate that processing of the low-grade stockpile and commensurate dissolution of oxide phases is not negatively impacting water quality in the receiving environment.

Managing surface water and control of suspended solids in the Wanagon River associated with erosion/scour of the Lower Wanagon OBS continues to be a challenge. A closure design for the Lower Wanagon Overburden Stockpile has been developed and this work is underway, consisting of regrading, building of water conveyance channels, limestone cover and subsequent revegetation. TSS A6. Tailings Management Plan Map concentrations continue to be elevated due to closure works on the Wanagon overburden stockpile not being sufficiently advanced. A plan has been developed with regulators to address Lower Wanagon construction and sediment control.

Closure of Wanagon OBS is recognized by PTFI as a priority. However, progress over the past 3 years has been slower than the original schedule in reclaiming the Lower Wanagon OBS, mainly owing to labor and security issues. Given the potential negative effects of high sedimentation on the downstream area, including the ModADA, it is recommended that PTFI continue to pursue the closure and reclamation works for the Lower Wanagon OBS following the agreed plan and schedule.

Groundwater Quality

The groundwater regime in the vicinity of ModADA and Timika is a high priority for PTFI and local communities to ensure ModADA operation does not negatively impact groundwater resources in Timika. Extensive modelling and monitoring studies of the groundwater system to the west of the ModADA and in Timika have been conducted in the past 3 years. The groundwater monitoring program has focused on sulfate in groundwater as this is the only parameter showing significant concentrations and can be used as a conservative tracer in groundwater.

As follow up to a recommendation in the 2014 External Audit, additional groundwater wells have been installed and a groundwater assessment and modelling study in the West Levee and east Timika area has been conducted. This study has confirmed that Ajkwa River and Kwamki Lakes are gaining water bodies and act as a hydraulic barrier between any seepage from the ModADA and the groundwater system at Timika. The modeling results suggest that lowering of the lakes will mitigate the extent of the groundwater sulphate plume to the west of the ModADA. As a result, a mitigation strategy has been developed and implemented that involves active management of the water levels in these lakes to increase capture of sulphate from shallow groundwater and thereby limit the spatial extent of the elevated sulphate plume and potential impacts to shallow wells being used by local residents in the eastern part of

Timika. Increasing flow-through and lowering of the lake (KL-28) water levels was initiated in mid-2016 to enhance the hydraulic barrier between the ModADA and Timika.

Continued monitoring and analysis of the groundwater data from installed wells to the west of the ModADA, as well an additional new monitoring well in Timika, are underway to provide further inputs to model. Documentation of the monitoring data subsequent to installation of the trench at KL-27, and possibly addition of another syphon at KL-38, should continue in order to facilitate a more robust assessment of the efficacy of this management strategy as well as providing more representative model calibration/verification data.

Storm water Management

Storm water management in the mill area is a challenge due the high rainfall conditions (up to 10 meter/year) that are common for the area. The Macken Ditch on the west and the Markovich Ditch on the eastern side of the mill area are the existing structures to manage surface water and stormwater flow. The Macken Ditch is the primary surface water control artery in the mill area and designed to pass the 100-year storm event. The Macken Ditch is immediately adjacent to the break in slope along the near vertical steep mountain slopes that pose geotechnical hazards including slope failures and debris slides exacerbated by the physical erosion associated with high rainfall conditions. During the audit site visit a constriction in the Macken Ditch was observed at a point when the ditch becomes covered, adjacent to the mill. Water was spilling from this point under low precipitation/low flow conditions and therefore this section of the ditch will not convey the 100-year storm event. It is recommended for PTFI to conduct maintenance and/or reconstruct the constriction point adjacent to the mill to ensure the 100-year event can be accommodated in this section of the Macken Ditch. Without an upgrade to increase capacity in this section of the ditch, future flooding of the eastern area of mill is probable.

Extensive work has been conducted at the Dewatering Plant (DWP) under the Effluent Action Plan and the Stormwater Management Plan. Central to both of these plans was the commissioning of a large new thickener. Advances have also been made over the last 3 years in re-grading of the DWP facility surfaces to better direct water to sumps and extension of concrete surfaces. These upgrades have enhanced the ability to collect stormwater runoff and capture TSS/concentrate in the settling ponds prior to discharge of the dewatering plant supernatant to the estuary. During the audit site visit, an upset condition was observed in the DWP area with concentrate being found outside the designated storage/containment areas (barns and emergency containment ponds). This upset condition did not result in any release of material to the environment. Although the improved water management plan for the DWP described above reduces the risk of the loss of containment outside the facility, during a large storm event such large volumes distributed over a large area of the DWP could overload the water management system and potentially be transported outside the facility and ultimately be discharged to the estuary.

Waste Management

The PTFI external environmental audit in 2017 concluded that waste management remains a central theme for the annual PTFI internal environmental inspection program. The focus of audit in 2017 was in particular on waste management (segregation, temporary storage,

transfer and disposal); chain of custody (COC) system; contamination of inert and lined landfills and waste management analysis or review.

According to the types of waste generated and its handling practices at PTFI, there are 3 (three) groups for waste management and handling activities that will be addressed in this audit report, namely: a) Hazardous Waste Management; b) Non-hazardous Waste Management; and c) Wastewater Treatment

Hazardous Waste Management

Existing COC system for waste management is able to track the transfer process from each waste handler within PTFI until final waste processor (PPLI or Wastec). But full utilization of this COC system has not been applied for medical waste and used oils due to differences in nature of handling process for these wastes compared to other hazardous waste. Waste tracking from THWS Cargo dock to final waste processor has not been utilized. Waste tracking features in this COC system has not been granted to some key waste handler in THWS 32, Tembagapura Hospital, and mine maintenance. Therefore, they develop their own waste logbook which are already captured in the COC system

Efforts for reducing hazardous waste are required. In order to update these practices with improvements or challenges that are relevant with this waste management, it is recommended to review and conduct analysis of hazardous waste generation vs. production trend and other waste management evaluation/review. Waste stream audit need to be done to update current waste stream data regarding the type, generated source and amount of hazardous waste at the PTFI operation. And it is advised to hold a workshop session for key functions for the COC system improvement, such as Environmental Department, SHE representative at relevant division, MIS (developer of COC software), FM representative, KPI representative and other relevant functions. It is also recommended to develop contingency plans on waste management in case of the damage of waste facilities by natural disasters (landslides or floods), permit expiration or withdrawal of authorized waste transporter, collector and processor as well as security issues for transporting waste from highland to lowland.

Non-hazardous Waste Management

Solid waste

In general, domestic waste generation is approximately 3 L/person/per day. Specific waste generations from various activities or source were not yet available. Meanwhile domestic waste generation from service cluster have been collected, however figure of generations factor for evaluating higher waste generation have not been made. Waste generation from either waste generators activities or locations can be used as a performance indicators of undertaken waste reduction effort. Waste segregation has been initiated but not completed due to other major issues. It is recommended to continue and upscale the program.

It is recommended to provide figure of generation factor for evaluating higher waste generation in order to focus on the most probable reduction opportunity. Master plan of Solid Waste Management should be renewed and updated to address development of PTFI and to identify opportunity for improving resource recovery and 3 R program (composting, plastic

recycling, metal recycling, and biodiesel from used cooking oil) to reduce waste being sent to landfill.

Potential contamination of leachate from acid forming overburden on non-hazardous waste landfill in Koteka has been observed during the audit. Some area of MP 73 landfill (approximately 40% of total landfill) were being used as temporary laydown area for Central Service Engineering (CSE) Department for the last 5 years. Drainage channel to prevent run off water infiltrating to landfill body is not installed as mentioned in landfill engineering design. Some rainwater was trapped in MP38 domestic waste landfill's cell near the outlet to LTP facility.

To prevent potential contamination in Koteka landfill, it is recommended to improve waste separation before final disposal in landfill and avoid ARD entering domestic waste cells. It is also recommended to review the MP 73 landfill design based on this circumstance and specification of landfill as per Ministry of Public Works regulation No. 03 year 2013, built drainage channel to prevent run off water infiltrating to landfill body.

Wastewater Treatment

PTFI has improved its performance in domestic wastewater treatments. New regulations on standard of domestic wastewater has been issued but not yet adopted to replace the current permits that refer to the superseded regulations. Wastewater discharge has been found at about 60% of water usage. PTFI need to have water footprint evaluation and water consumption reduction plan specially to meet limit of 100 l/person/day water generation that is regulated by Regulation of MoEF No. 68/2016.

Contained rainwater in the landfill cell near the outlet to LTP resulting in increased potential for leachate infiltration to groundwater. From annual RKL report, it is found that conductivity of groundwater has been increasing in the last 9 years. Influence of SO_4 infiltration from tailing river looks more dominant rather than leachate pollution. Further study need to be done to identify the source of this increasing conductivity of ground water whether potential leachate infiltration or SO_4 infiltration from tailing river or other unknown sources.

It was confirmed that LTP was being operated by approximately 6 hours per day because lack of work instruction of LTP operation. Even though LTP has met discharges parameter, it is recommended to operate it as a continuous process as designed. Biological process in LTP may be disturbed when the operational schedule is only 6 hours per day.

Air Quality and Climate Change Issues

Stationary source emissions are monitored for compliance as required by the applicable permit. In general, air pollution units are capable of meeting the maximum concentration of parameters as stipulated in the relevant regulations (particulate, SOx, NOx) except for NOx emissions from some select diesel generators for producing electricity. PTFI needs to continue to implement the action plan agreed to with regulators to solve NOx emission issues from diesel power plant in highland. Replacement planning to maintain emission control performance is needed.

Reclamation and Biodiversity

Reclamation/Revegetation Activities

The term reclamation at PTFI is actually used in two different contexts, i.e., reclamation of disturbed post-mining sites in highland areas, and reclamation on tailings deposition and other substrate in the lowland and estuary areas. Both types of reclamation involve the two important aspects of revegetation (i.e., providing seedlings, planting, producing and applying compost etc.) and monitoring. In general, PTFI has demonstrated strong commitment in conducting reclamation/revegetation and monitoring, both in the highland and lowland areas.

In accordance with the mine closure concept, overburden stockpiling areas should be stabilized both geotechnically and geochemically, and wherever possible revegetated using native plants. Most of the highland area which has been used for mining should be returned to the ecological conditions similar to previous pre-mining conditions. There is variation in reclamation success rate among sites in the highland areas. Highland reclaimed areas include the sites of Bunaken, Bali, Blitar, Cartenz, Surabaya, Menado, Batu Bersih, Koteka and others. The structure and function of reclaimed, revegetated areas are evaluated by comparison to conditions in unmined, surrounding areas as natural reference sites.

PTFI continues to conduct experiments and trials to improve reclamation techniques and increase revegetation success. Current practice involves the use of local species for revegetation (*Deschampsia klossii*), use of limestone reject as medium, use of cocopot as seedling container; formulation of a surface binding agent in hydroseeding to improve media, and use of GIS technology for planning and monitoring. Challenges related to revegetation include the difficulty of planting *Deschampsia klossii* on steep slopes, and the availability of equipment in conducting hydroseeding. A major challenge in revegetation is in ensuring the availability of seedlings that are ready to be planted.

Reclamation (i.e., planting) activities conducted by PTFI in the lowland areas include planting on the ModADA tailings deposition and double levee area, planting of mangroves in the estuary, and planting of disturbed/cleared areas in the forests surrounding Kuala Kencana. In addition, certain areas near the old levee where tailings are no longer being deposited continue to be managed to grow various crops and forestry products on historical tailings deposits. Lowland monitoring has shown the potential for natural succession to take place on tailings deposition. As observed in the ModADA, *Phragmites karka* has been found to be the main pioneer species. Successful natural succession observed in the double levee area (between the old and new west Levees) also supports the tenet that tailings can be successfully reclaimed.

Natural mangrove colonization has occurred on the newly formed mud banks in the Ajkwa estuary, while in addition, planting efforts are also underway. As in the highlands, a main challenge in revegetation is in ensuring the availability of seedlings/plant stock to be planted. More effective planting techniques have been found through experiments and trial-and-error, e.g., it has been found that direct planting of natural mangrove propagules is more effective than planting nursery grown ones.
Continued experiments are required to improve plant/soil/growing media preparation and planting techniques. In addition, a comprehensive analysis and synthesis of existing

reclamation monitoring data should be conducted in order to better understand the biological and physical phenomena of reclamation, and conduct continuous improvement of techniques.
Biodiversity and Natural Ecosystems

The concept of biodiversity implies variation at the ecosystem, species, and genetic levels. The CoW area of PTFI is of significant importance from a biodiversity and conservation point of view, as it encompasses a wide range of ecosystems within an altitudinal gradient beginning from sea level to above 4,000 meters elevation. Ecosystems between the coastal area and the alpine and nival ecosystems in the highlands include flat, alluvial plains and dense montane forests.

PTFI has executed various programs related to the monitoring and conservation of biodiversity, including dissemination of its importance through education/public awareness and research. These efforts have also received external appreciation through a number of recognitions and awards. At present, efforts have been made to set up permanent transects in several locations; however, there are still problems related to the intensity and frequency of sampling due to technical, and in some cases, security reasons.

The impact of mining activities, specifically tailings deposition, on biodiversity in the lowland and estuaries is monitored routinely by PTFI's Marine and Coastal Monitoring division. The taxonomic groups monitored include fish, invertebrates, and plankton. In the general, data have shown that there are no significant differences in abundance and diversity of fish and invertebrates caught by trawling in the Ajkwa estuary compared with reference estuaries located away from the estuary receiving tailings deposition. As with the case of highland monitoring data, these data need to be further analyzed, synthesized and interpreted in order to gain a comprehensive picture of the ecological phenomena occurring as a result of mining and tailings deposition.

Current threats to natural ecosystems within the CoW area include the clearing of forests/natural vegetation on steep slopes by locals (particularly around Tembagapura) to cultivate crops, and illegal tree felling inside forests or reclaimed areas in the lowlands. These anthropogenic threats are of course part of a complex social phenomena involving local or newly arrived communities, and the problem is being addressed accordingly by PFTI, e.g., through community empowerment and partnership programs.

The issue of biodiversity and the sustainability of natural ecosystems has of course become more important in light of global environment/climate change. In this context, PTFI could benefit from quantifying and valuating ecosystem services, including measuring and collecting baseline data on carbon stock and carbon sequestration in the variety of ecosystems within the CoW area.

Review on Regulatory Aspect

The review on regulatory aspect of the environmental audit of PTFI is to examine and to determine the extent to which PTFI's environment-related activities has fully complied with all obligations on environmental management. PTFI has undertaken an inventory of laws and regulations which become the legal reference and perspective on environmental management that PTFI has been conducted to date and in the future. Although not all of the laws and regulations provide specific guidelines and arrangements regarding PTFI's environmental

management activities, PTFI has initiated to undertake this inventory to obtain a normative framework for conducting comprehensive environmental management. This initiative represented a form of independent concern to appreciate the environmental management responsibilities that go beyond compliance requirements.

In the dynamics of mining activities of PTFI, the Ministry of Environment and Forestry issued a letter of reprimand through Letter of Director General of Spatial Planning of Forestry and Environmental Governance No. S-563/PKTL-PDLUK/2015 on Warning and Order to PTFI to Compose Environmental Documents, in order to evaluate the significant environmental impacts of PTFI activities that have not been included in the AMDAL 300K document. The environmental document referred to the letter of reprimand is the Environmental Evaluation Document (DELH). Draft of the DELH on the Changes of Mining Business Activity and the Support Facilities from the documents of Regional AMDAL of the Expansion Plan of Copper-Gold Mining Activities and Its Supporting Activities up to A Maximum Capacity of 300,000 Tonnes of Ore Per Day (300K) in the Administrative District of Mimika, Irian Jaya Province has been submitted by PTFI to the Ministry of Environment and Forestry and discussed in the assessment meeting of the Technical Team of the Central Commission of AMDAL Evaluation on December 14th, 2015. In line with the issuance of Regulation of the Minister of Environment and Forestry No. P.102/Menlhk/Setjen/Kum.1/12/2016 on Guidelines for the Preparation of Environmental Documents for Businesses and/or Activities that Have Business and/or Activities License but Not Have Environmental Documents, on August 1st, 2016, the DELH of PTFI was improved through the letter of Director General of Spatial Planning of Forestry and Environmental Management No. S-587/PDLUK/ALHDI/PLA-4/8/2016. The improvements of DELH of PTFI done based on the defined scope of evaluation as well as the input and suggestion which are given by the Technical Team. The improved DELH has been submitted by PTFI to the Secretariat of the Central Commission of AMDAL Evaluation in January 2017. Up to now there has been no decision on PTFI's DELH approval but considering the scope of the study which is covering 21 (twenty-one) changes in PTFI's activities would have implications to the environmental management and monitoring conducted by PTFI.